



Leopard Ecology & Conservation
Annual Report
2021

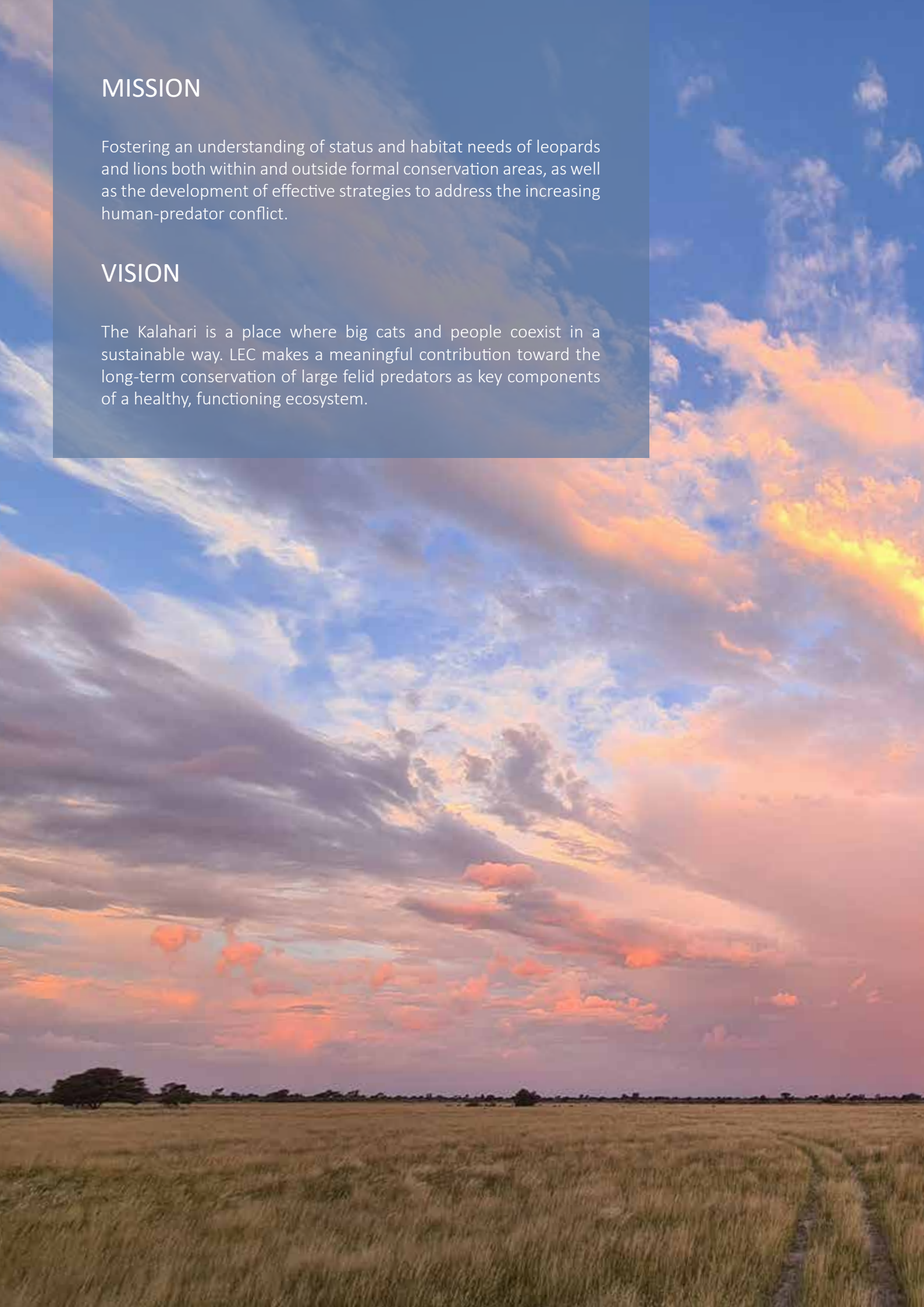


MISSION

Fostering an understanding of 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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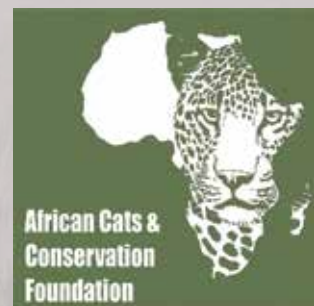
Leopard Ecology & Conservation Trust

Botswana



People and Wildlife Trust

Botswana



African Cats & Conservation Foundation (ACACF)

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A list with explanations of the abbreviations is provided on page 41.

A map showing most of the places mentioned in the text can be found on page 42.

LETTER FROM LEC FOUNDER: MONIKA SCHIESS-MEIER



“

I am proud that we as a team did not let ourselves be diverted from our path even during these difficult times.

MONIKA SCHIESS-MEIER, Founder and Director

No one thought that the pandemic would dominate our lives so much and for so long. And we still don't know where it will take us. In such times, it is often difficult to set priorities, because long known structures have changed. But it also gives us the opportunity to reconsider ourselves. To check if the priorities are still right.

I am very proud that we as a team have never lost our focus, even in these times. Together, we have tried step by step to achieve our goals within the bounds of what is possible. In 2021, we were able to achieve great milestones, to initiate new collaborations and innovative projects so that we can continue to spread our message to our community and beyond.

Together, we overcome many obstacles. And as conservationists we are used that our journey is rocky. We stand together and support each other with positive and trusting thinking and action.

With this in mind, I am pleased to present you the annual report for 2021.

M. Schiess-Meier





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 **Education & Community 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 a conservation-based horse race. LEC is particularly proud of the relationship which has developed over the past 20 years with the local community.

2021 IN NUMBERS

Organisation



21 years operational

22 individuals from Botswana working at field site in Khutse GR

3 international collaborations
4 external trainings for LEC staff
6 international post graduate students

35 sightings of leopards

17 predation events by leopards

Leopards



4 collared leopards

567 sightings of lions older than 6 months

145 sightings of collared lions

113 predation events by lions.

Lions



5 lion matings

4 lion litters with **9** cubs

81 GPS-fix clusters from collared lions investigated for a total of

32 hunting events recorded



Community and Education

400 m² of garden is net-shaded.

5 different vegetables

40 individuals from the community trained in tree planting

130 indigenous trees planted in the community



152 dogs vaccinated against rabies

32 cats

88 visits to cattle posts

poisoning risks workshop: **10** farmers

20 hoof-trimming equipment borrowed



194 farms interviewed for the extended cattle post survey in

55 cattle posts outside our study area

168 hours of volunteered time from the Community Conservation Club to LEC projects



Promoting young talents

7 learners from Botswana were invited into the Park

7 school children were awarded in a school prize giving ceremony

1797 sets of tracks.

371 km² spoor-sampled every month.

Research



96 camera traps collecting

82'541 images

over an area of **480** km²

RESEARCH PROGRAMME

Research Overview

Research is one of the funding 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 apprehend the entity of existing and new elements 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.

Progress in 2021

As it happened for 2020, the Covid-19 pandemic has slowed down our plans. The supply of material, such as collars and batteries, was limited and we had to adapt our activities to the new constraints, as everyone in the world. Our aim to host new students and researchers had to be delayed to 2022.

However, LEC has managed to continue the core research activities throughout the year and further improved on many project protocols, introducing new tools and methodologies. In the following sections, we provide a summary of what LEC team has achieved and worked on in respect to the above-mentioned projects in 2021.

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

Since 2000, LEC has continued monitoring 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. In 2021, we continued our long-term data collection on the vegetation and climate. Both aspects are interconnected and have major impact on the whole ecosystem of the Kalahari which is characterized by an extremely fragile equilibrium. On a larger scale, we are interested in monitoring the climatic changes in our study area and to better understand how wildlife, and large carnivore in specific, adapt and cope with such changes.

The vegetation map by Mishra et al. 2014 provides a good classification and distribution of the vegetation structure within our study area. In 2021, we continued to collect fixed-point landscape photographs on a monthly basis. Since the beginning of the extensive spoor and prey survey in October 2021, we have defined additional locations for the fixed-point photos outside the protected area and along its western boundaries.

The peak fire season of Botswana typically begins in mid-August and lasts around three months. In 2021, NASA satellites reported a total of 21,668 VIIRS (Visible Infrared

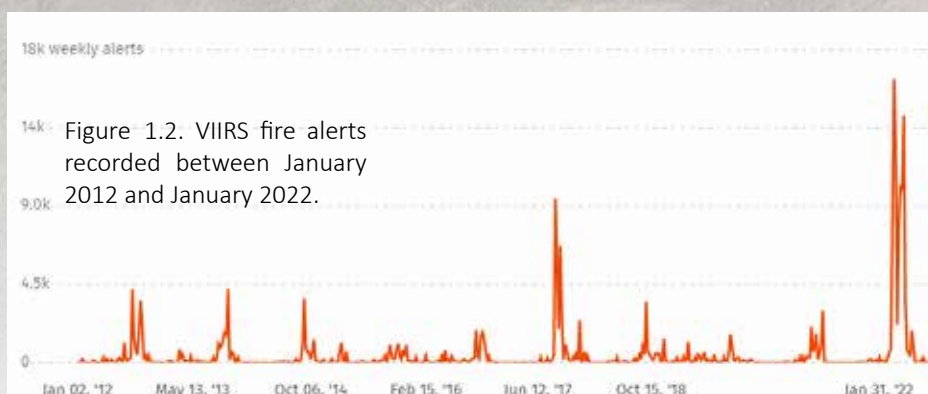
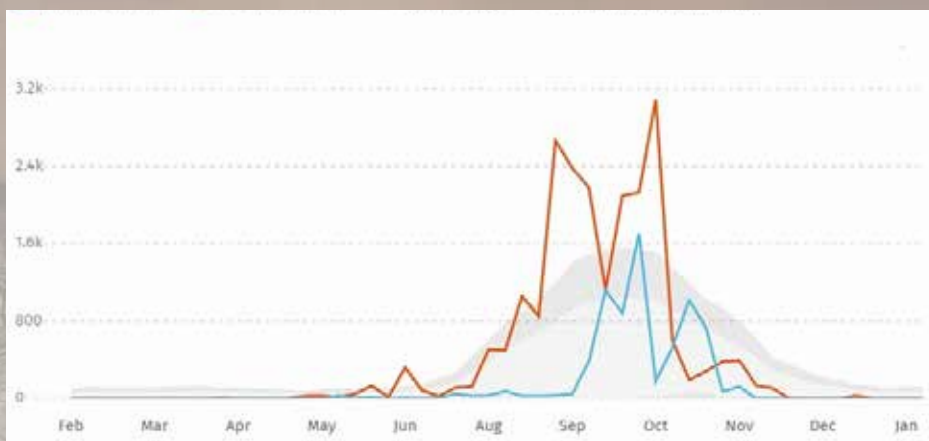
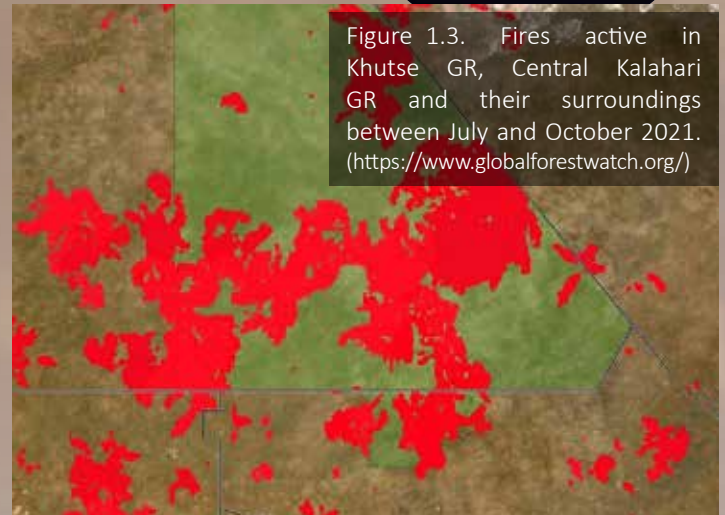


Figure 1.2. VIIRS fire alerts recorded between January 2012 and January 2022.

Imaging Radiometer Suite) fire alerts, considering high confidence alerts only. This is an unusually high number compared to previous years (Fig.1.1 and Fig.1.2, <https://www.globalforestwatch.org/>). Between July and October, we experienced extensive wild fires which burned a large portion of Khutse GR and the southern section of CKGR (Fig.3). The peak was between the end of August and beginning of September. In 2019 and 2020, we recorded small isolated fires close to cattle posts or along the major roads. As for the rest of the country, the reason behind this increase in fire events is the above-average fuel load due to the good rains recorded between November 2020 and February 2021. The dry winds in August have helped the spread of very quick fires which were hard to control. Nevertheless, the fast fires were extremely beneficial for the ecosystem as they reduced the fuel load (grasses) without impacting bushes and trees and allowing faster regrowth of edible grasses. Moreover, such fires were driven by winds alternating in direction leaving large grazing areas untouched for the herbivores to feed on.

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 2020–2021 austral seasonal year.

As showed in Figure 1.4, the total recorded rainfall (670 mm) was above the average (426 mm) for the last 20 years, confirming the trend observed in 2020 after the scarce rains of 2018 and 2019. In Figure 1.5, the chart is presenting the rainfall and temperature values per month. February 2021 was the most rainy month with a total of 283 mm (42%). The highest mean temperatures have been reached in November 2020 (26.1°C) as it happened in November 2019 (28.1°C).

Khutse GR and CKGR do not have any natural surface water during the driest months. Certain species are more dependant to surface water than others and their behaviour and movement ranges are strongly affected by surface water availability. Since the migratory corridors have been partially blocked (i.e. fences on the north, east and south-east boundary of CKGR) or are increasingly impacted by human activities (i.e. cattle post farming), the role of artificial waterholes is a major concern

for conservation strategies in the area. Artificial waterholes may provide the needed water for herbivores and predators which cannot migrate as in the past, but, simultaneously, change the fauna and flora communities of the ecosystem. The presence of artificial waterholes has caused the expansion of elephant range to the southern part of CKGR. In the last five years, it is possible to observe elephant bulls throughout the year, while in the past they used to pass through temporarily during their dispersal. Elephants have impacted enormously Khutse GR in the last years. Many trees have been destroyed and Molose and Moreswe have been seriously damaged on several occasions limiting water availability for the other species in the area, including lions and leopards. Most of the elephants are bulls and as observed in 2020, they move in groups of 4–6 individuals. The greatest herd recorded in 2021 consisted of 44 individuals at Molose pan on the 16th November 2021. Groups of more than 30 individuals were recorded on seven others occasions. In 2020, the biggest herd was of 26 individuals.

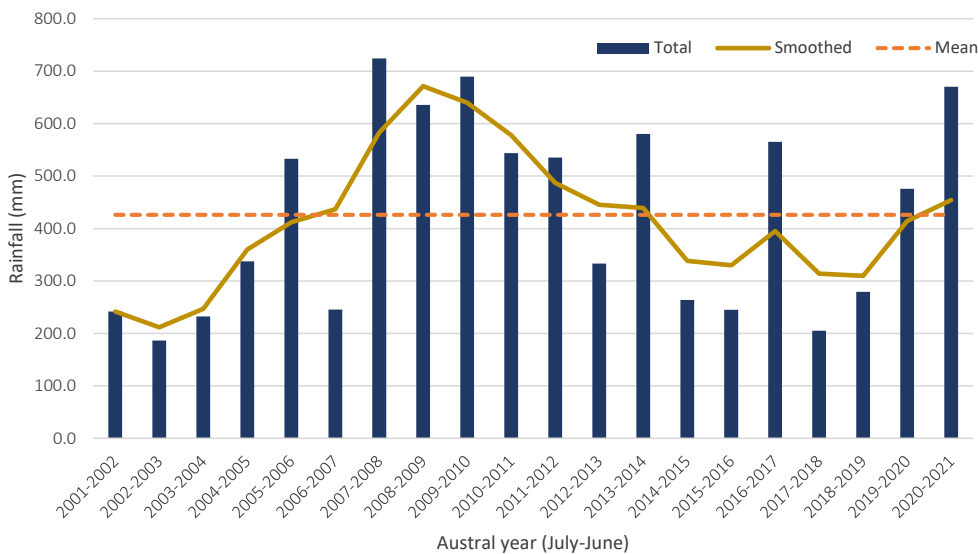
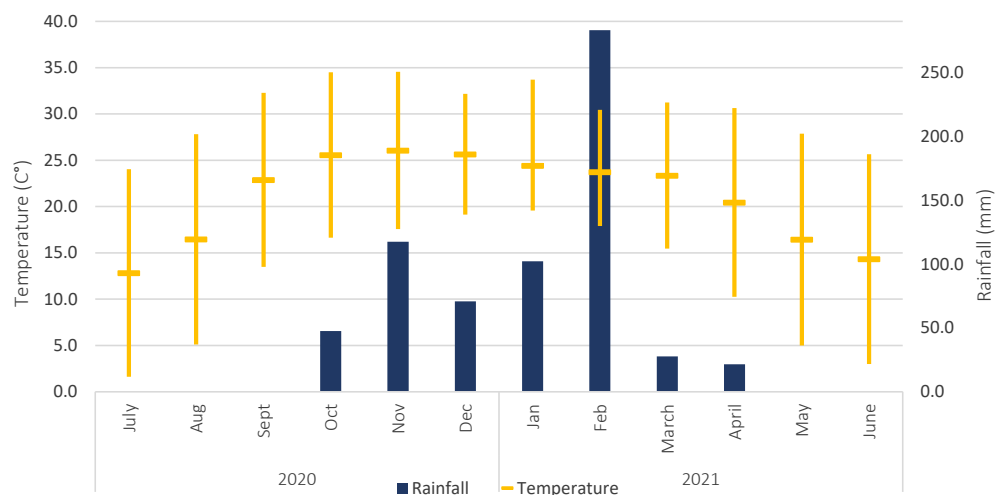


Figure 1.4. Annual rainfall recorded at the LEC research station (histogram). To highlight the trend within variable rainfall data these were smoothed (line) using a three-point weighted interpolation where annual rainfall (R) is the product of the current year’s rainfall (R0) as well as the previous and following year’s values (R-1 and R+1 respectively) ($R = 0.25 \times R-1 + 0.5 \times R0 + 0.25 \times R+1$).

Figure 1.5. 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.



Project 2. Prey Availability

As observed for all carnivores, prey populations and their status have a critical role in the status of leopard and lion populations in the Kalahari. Changes in the prey availability have an impact on the immediate and long-term viability of large carnivores, especially in the harsh habitat of the Kalahari. Therefore, LEC continues monitoring the relative abundances of key prey species in the study area. To achieve such a complicated task due to the local low densities, LEC is developing and testing different methodologies in Khutse GR.

In October 2021, LEC has started the extensive prey and spoor count inside and outside Khutse GR. The survey has been carried out every four years since 2000. This survey collects data on spoors on a fixed set of routes driven monthly for one year (see Fig. 2.1). Simultaneously, the team records any direct observation of preys along routes and at pans. In comparison with the past surveys, the first novelty is that all tracks of prey species are collected as well. That will allow us to compare estimates generated from the direct counts with the estimates derived

from the spoor survey. 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. In 2021, 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. Finally, all data collection has been implemented through a customized Cybertracker app (see also p. 30).

In 2021, we also completed our first camera-trapping pilot survey (details in Leopard Demographics). The pilot did not produce sufficient data to estimate prey abundances but it provided some further insight in the distribution of the key preys and when they are active the most. Duiker and steenbok are the most present prey species in the sampled area (480km² between Khutse GR and CKGR). Concerning large herbivores, the main prey species captured on camera-traps were gemsbok and red hartebeest. Such results are suggesting that lions are preying according to availability as the gemsbok is the main prey at kill sites.

Project 3. Predation

In September 2021, with the new collaborative study with Max Planck (MPI-AB) researchers, we decided to try to determine the successful rate of lion hunts. One possible method to assess this, is to follow 24-hour-long tracks of collared lions to detect any attempted hunt. This method will provide us with an estimate of how often lions try to hunt a prey, including small ones, and how often they are successful in the hunt. Results will be shared in 2022.

We also continued collecting predation data opportunistically, through the lion resightings, visiting ad hoc GPS clusters of collared lions, and by responding to livestock predation reports. The failure of many collars has impacted our possibility to increase our predation data compared to past years. Leopard predations are particularly difficult to detect as the preys are generally smaller and hidden to other predators. We have some translocated leopards

collared and this has provided data to compare to 2020. However, the fact that all of them have moved far away from our study area has reduced our opportunities to follow them and detect their kills.

Consequently, the data displayed in Tables 3.1 and 3.2 are limited by many factors as mentioned above. Nevertheless, it is important to note certain patterns:

- As observed in 2019 and 2020 the lion predations inside the reserve shows that the main prey species are gemsbok and eland. The two species together represent more than 50% of the recorded lion predations.
- The preliminary data from the long follow does not indicate an increase in the number of recorded predation events on smaller species. This was a concern raised in the past years when predations were mainly detected by visiting large GPS clusters. Such method tend to favour finding large prey

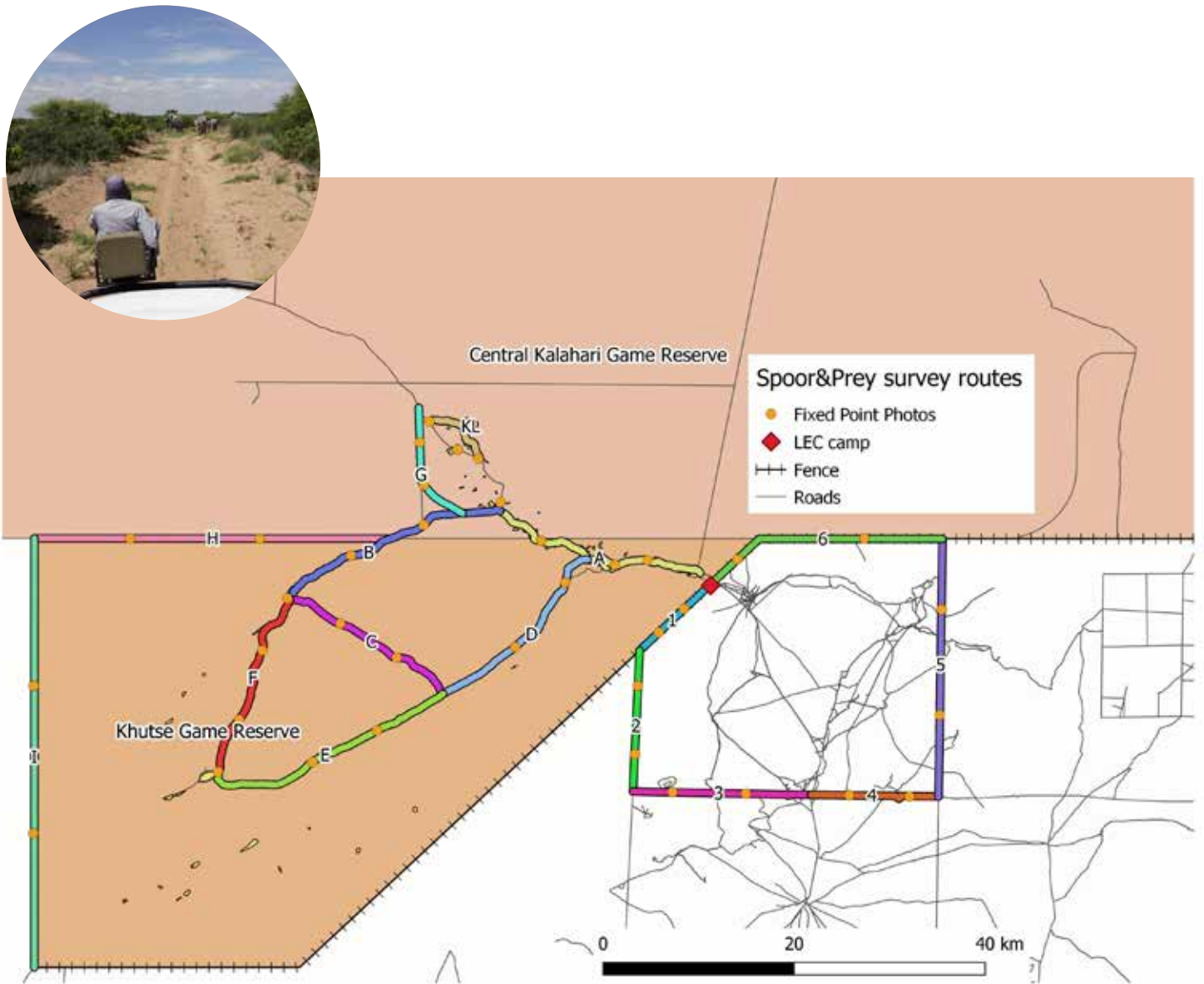


Figure 2.1 Map of the routes sampled monthly

- species over small prey as the lions need more time to consume the prey before moving away.
- Lion predations are mainly recorded in 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.
- Recorded predation events by lions outside the Reserve peaked during the wet season, the peak in July is due to the livestock killed caused by Peggy's cubs after they lost their mother.
- Leopard predations inside the reserves include only small to medium-sized preys. The biggest recorded prey species is a springbok. Outside the reserve, Lucky was responsible for the kill of most of the recorded kills including juveniles of cattle, horse and donkey. Both Rena-PF023 and PF024 have had limited impact on livestock since they left the reserve and the herders visited in the related areas have reported no increase in livestock losses due to leopards.

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 (<i>Orycteropus afer</i>)	1						1	
Baboon (<i>Papio sp.</i>)	3				1		4	
Blue wildebeest (<i>Connochaetes taurinus</i>)	5						5	
Cattle (<i>Bos taurus</i>)		17		6		5		28
Donkey (<i>Equus asinus</i>)	1	9		1			1	10
Duiker (<i>Sylvicapra grimmia</i>)			1				1	
Eland (<i>Taurotragus oryx</i>)	8		2		2		12	
Gemsbok (<i>Oryx gazella</i>)	22		6		1		29	
Giraffe (<i>Giraffa giraffa</i>)	1				1		2	
Hartebeest (<i>Alcelaphus buselaphus</i>)	4						4	
Horse (<i>Equus ferus</i>)		9				1		10
Kudu (<i>Tragelaphus scriptus</i>)	2		3				5	
Ostrich (<i>Struthio camelus</i>)	1				1		2	
Porcupine (<i>Hystrix africaeaustralis</i>)	6		1				7	
Springbok (<i>Antidorcas marsupialis</i>)	1						1	
Steenbok (<i>Racipherus campestris</i>)			1				1	



Table 3.2. Livestock predation by leopards inside and outside the reserve.

Species	adult		subadult		juvenile		TOTAL	
	in	out	in	out	in	out	in	out
Cattle (<i>Bos taurus</i>)						1		1
Donkey (<i>Equus asinus</i>)						1		1
Duiker (<i>Sylvicapra grimmia</i>)	3	1					3	1
Horse (<i>Equus ferus</i>)						1		1
Mongoose (<i>Mungos sp.</i>)	1						1	
Porcupine (<i>Hystrix africaeaustralis</i>)	5*						5	
Springbok (<i>Antidorcas marsupialis</i>)	1						1	
Steenbok (<i>Racipherus campestris</i>)		1						1
Striped polecat (<i>Ictonyx striatus</i>)	1						1	
Warthog (<i>Phacochoerus africanus</i>)	1						1	

* includes one predated porcupine with status "unknown"

Project 4. Predator Movement and Habitat Selection

Movement is one of the fundamental processes that impact an animal's fate, the population dynamics, and the structure of ecosystems. To best understand how to manage landscapes and the wildlife in them, it is necessary to gain insights into the drivers and patterns of animal movement and how they respond to their environment and habitat. As such, the primary aim of this project is to investigate patterns of space use and habitat selection patterns of leopards and lions, through the monitoring of movement patterns of collared individuals. This includes both resident animals and those translocated into the study area.

Resident individuals

Lions

Genevieve Finerty in her PhD thesis "Connecting the dots: Ecology, Movement & Conservation of Lions Across the Kalahari-Kavango Landscape" has analysed the extensive LEC lion movement dataset produced over the last 20 years. Two of her PhD chapters focus exclusively on the lion population in the Khutse GR and CKGR as a unique insight into movement and space use in a semi-arid environment. To best understand space use and movement in this system, it is important to understand how to best use the statistical tools available to generate conservation insights. Lions in the Kalahari exhibit extensive movements, and Genevieve uses this as an example to explore how structure (e.g. autocorrelation) implicit in movement data can impact the estimation of key space-use metrics for conservation. The results suggest that methods for estimating home ranges that do not consider autocorrelation may substantially underestimate home range sizes. This has clear implications for applied conservation as home range estimates are often used as the basis for management decisions, such as reserve design. This chapter is in preparation to be submitted to the *Journal of Applied Ecology*, where we hope it will be of use to conservation practitioners and researchers alike. The other chapter focuses on how lions respond to temperature and water availability by using a novel framework adapted from the field of thermal biology. In this chapter, Genevieve uses thermal performance curves (which measure how fitness related traits vary over a range of thermal values) to show that lions

exhibit water-dependent responses to temperature when moving through semi-arid savannah landscape. Lions in the Kalahari are a particularly interesting system to study response to temperature and water, given the semi-arid environment and the diurnal and seasonal range of climatic variables and extent of movement animals in this system exhibit. Much of Africa is predicted to experience increased temperatures and changes in patterns of rainfall, making this a critical element of fundamental predator ecology to understand if we are to predict long-term viability for lion populations following climate change. This chapter is in preparation for submission to the journal *Current Biology*.

Shani Baumgartner, MSc Student, focused her study on the activity patterns of lions in the semi-arid environment of the Kalahari and on how such patterns differ according to the sex. The study made use of the LEC long-term dataset on fine-scale activity, which spans an impressive period of time and numbers of individuals due to the collaring efforts over the years. The study was split into two analyses. The first part consisted of understanding which circumstances influence the probability of lions in the Kalahari to be active. The second part investigated what factors influenced the extent of this activity once lions were active. The results confirmed that lions were highly constrained in their movement by hot temperatures. Rainy days, high moon illuminations and other lions close by reduced the lions' probability to be active, as well. Various landscape features such as the distance to the closest water source showed significant influence on activity too. Interestingly, female and male lions in our study often showed a different strength of response to many environmental and social variables. As hypothesized, the study showed that many different variables must be considered when trying to see patterns in activity of lions. Such key information is helpful for conservation strategies, especially in ecosystems where climate change and human-built landscape features can have a major impact.

Leopards

In 2021, LEC has continued searching for resident leopards to collar to be able to understand how these cryptic predators move and thrive in such

harsh environment. As in the past, collaring has been challenging in our study area. Leopard densities are very low and their territories between the largest of the species. Call-up playbacks and other attractant had a limited success. At the end of November, we managed to collar a resident female by free-darting her after hours of careful tracking from our field team. Camera traps, opportunistic observation and the extensive spoor and prey survey have partially confirmed the activity areas of certain individuals. In 2022, we hope to be able to gather more detailed data on leopard behaviour by improving and innovating our field techniques such as the identification of the different individuals from their spoor through a specific algorithm named “FIT” and artificial intelligence developed in collaboration with WildTrack. Collaring efforts will continue in 2022, with the introduction of some new techniques, including making use of call-up stations (calls played through a loud-speaker designed to attract any leopards that are in audio range) and the Remote Darting Device, developed by the Workshop of the Physics Institute at the UZH in collaboration with LEC. We expect that these two techniques, used in combination, may improve our success rate in targeting this particularly elusive species. In the meantime, we anticipate that our other survey techniques, in particular the camera trapping project (see the Project in Focus), will provide an alternative method for gathering data on leopards in the study area.

Translocated individuals

Lions

In 2021, the DWNP did not translocate any lions from outside LEC study area to Khutse GR. The only individuals captured and moved have been the three female cubs (LF068, LF069 and LF070) of Peggy after she was shot in July 2021. The three cubs were initially moved back inside Khutse GR but they quickly came back outside and started killing livestock. At the end of July, LF068 and LF070 were darted and moved to Bape in CKGR. The third sister moved back to Khutse 1 and joined Sarah and Verity. Thanks to the collar deployed on LF070, we could monitor her gradual return to Khutse before going outside

the reserve with the sister LF068. In December 2021, DWNP translocated LF070 to Sunday pan in northern CKGR, but she rapidly left the protected area and has been roaming in the cattle farms in Hainaveld since then (Fig. 4.1).

Leopards

In 2021, two leopard females (Rena and PF024) were translocated by DWNP into our study area. Both leopards were considered problem animals and came from southern Botswana. We managed to collar both individuals to monitor their post-release movements. As it happened for many other translocated individuals, they both moved south outside of the reserve establishing their new home ranges in cattle post areas. Similar pattern has been observed with Lucky (Fig. 4.2), a translocated male leopard released in November 2020. In March 2021, he left the protected area and started his journey south reaching the town of Molepolole, before returning north at the end of June. He was shot by farmers in July.

Collaring translocated individuals provides us essential information on their movement behaviour and allow us to monitor the final outcome of each release. Moreover, it offers us the opportunity to provide information to the community to limit possible livestock loss and, consequently, conflicts between carnivores and farmers.

In 2021, MSc student, Vera Alessandrello, has started analysing LEC telemetry data to investigate the consequences of a translocation event on the movement patterns of leopards in the Kalahari region. She will compare the movement patterns of translocated individuals to the one of the residents, treated as the control group. She will look at how the spatial behaviour of translocated leopards changes over time to better understand whether they were able to establish home ranges, return to the capture site or show extensive roaming behaviour. This is an exciting project that will harness the long-term efforts of LEC in monitoring leopards post-release from translocations to generate insights into the impact of such management practices on wild leopards.

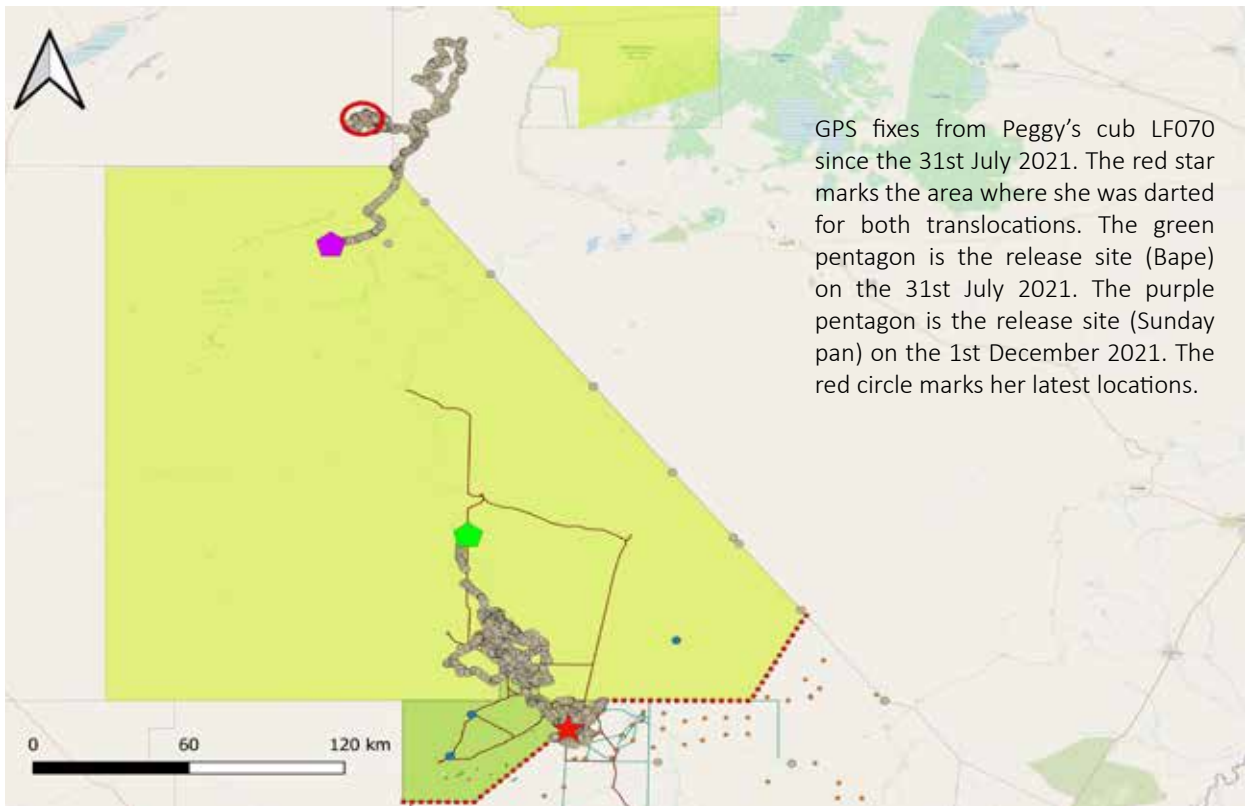


Figure 4.1. Map of movement LF070.

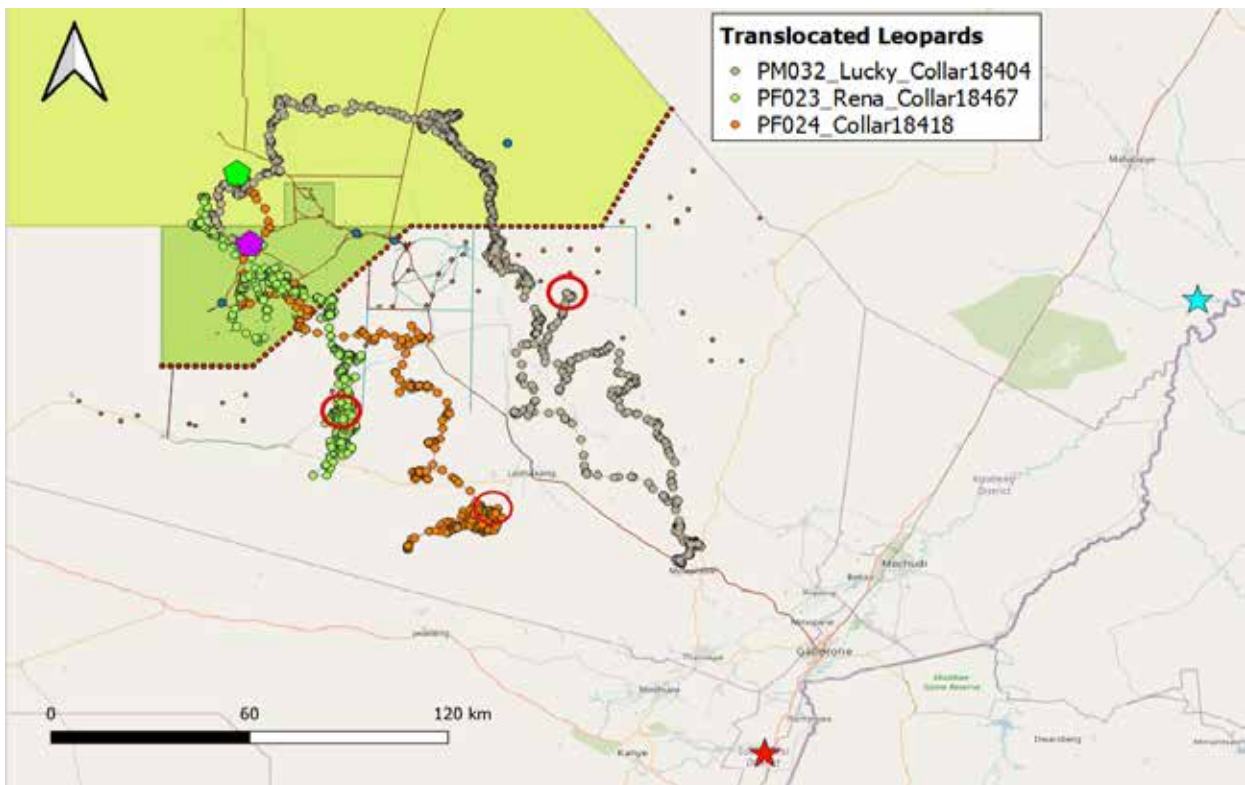


Figure 4.2. Map of movement Lucky, Rena and F024. GPS fixes from the three translocated leopard (Lucky, Rena and PF024). The red star marks the capture site for Lucky and PF024. The blue star marks the capture site for Rena. The green pentagon is the release site (Kukamma waterhole) for PF024. The purple pentagon is the release site (Molose pan) for Lucky and Rena. The red circle marks their latest locations.

Project 5. Predator Demographics - Leopards

Leopard geographic range is the widest among large cats, yet their secretive behaviour makes leopards one of the most difficult carnivores to study. This is particularly true in the Kalahari where the low leopard densities, lack of roads and the open landscape makes leopard monitoring extremely challenging. Since 2000, LEC has combined local tracker skills and telemetry to unveil the secrets of these amazing predators. In the recent years, we have been trying to evaluate new field monitoring techniques which can provide further data to fill the existing gaps.

LEC wish to set up a large-scale camera trap grid in Khutse GR for estimating the leopard population and investigating the activity patterns of leopard and other mammals. Among the numerous benefits of camera-trapping using a grid, there is the key advantage of sampling homogeneously the study area. This is of extreme importance for us as the limited road network inside Khutse GR reduce the effective coverage provided by other methodologies, such as the spoor and prey survey. At the end of 2020, a 3-month camera-trap study pilot was started and it was completed in 2021 in collaboration with Snapshot Safari, a project of the University of Minnesota Lion Center (www.lioncenter.umn.edu/snapshot-safari/). The purpose of the pilot was to understand the feasibility and the potential output of camera-trapping in Khutse GR as well as to determine how to fine-tune the survey design and protocols. A total of 96 single camera-trap stations were set up according to a grid covering an area of 480km². The cameras produced more than 80'000 images which, after being processed by an algorithm and crosschecked by volunteers via Zooniverse, gave a total of 6'318 capture events (see also p. 31). The total number of leopards captured by the cameras was insufficient to estimate any relative abundance for the species. We could identify the areas where most images of leopard were obtained, confirming the presence of certain leopard individuals in such areas (Figs. 5.1, 5.2). Finally, the pilot provided the needed results concerning the constraints we have to take into account for the final survey. In 2022, LEC aim to finalize the camera-trap survey design in collaboration with WildCRU, CREEM and ORI.

In 2021, we continued to collect data on leopard opportunistically. All direct sightings of collared and uncollared leopards were recorded. Figure 5.3 clearly shows the main difference between observations of collared individuals comparing to uncollared. Direct sightings of uncollared leopards are limited in numbers and strongly related to leopard hotspots in areas where LEC vehicles are moving more often for research activities. Such evidence shows the importance of combining different methodologies, such telemetry, tracking and camera-trapping, to have a better understanding of the ecology of the leopards in Khutse area. In addition, the extensive spoor and prey survey is providing data on leopard presence and relative abundance in comparison with the historic data from the previous surveys of LEC. Since October 2021, we recorded leopard tracks on all the survey routes except





for the western boundary and the eastern routes outside the protected areas (Fig. 5.3). When the tracks quality was sufficiently good, we collected data using WildTrack protocols.

As a rough minimum estimate for 2021 based on tracks, camera-trap pictures and direct sightings we may have the following leopard presence in LEC core research area (excluding translocated individuals):

- 1 male and 1 female (Sutswane) with 1 female cub between Motailane and Khutse Gate (including Khutse pan)
- 1 subadult female (Inkara) moving in the area between Khutse 1, Motailane, road D and road C.
- 1 male and 1 female between Motailane and Khankhe
- 1 male and 1 female around Kukama area
- 1 male (Schlitzor) and 1 female along the upper cutline and Gope road
- 1 male between Molose and Moreswe
- 1 male along the Khutse-CKGR cutline, west of Molose

In 2021, we were able to monitor four leopards by deploying four GPS collars. As mentioned in Project 4 above, three were translocated (one released in 2020 and two in 2021). The other collared leopard is Inkara, a resident subadult female.

Lucky

Lucky (PM032) was an adult male translocated from Moroekwe farm in Otse area. He was released with collar at Molose waterhole on the 20th November 2020. Lucky was a large male (70kg) who was preying cattles in Otse farmland. Since his release in Khutse GR, he has been moving extensively across the protected area entering CKGR and moving East towards Sekaka waterhole before leaving the reserve on the 2nd March 2021. After a brief period at the

cattle posts close to Kaudwane, he moved south reaching the residential suburbs of Molepolole. Towards the second half of June he moved back North. He reached the cattle posts north of Salawje where he was shot on the 16th July because a herder tried to scare him off a cattle calf Lucky freshly killed. Lucky attacked the man and was shot. Lucky was probably unable to successfully hunt medium to large wild preys due to his age and teeth conditions. During his period inside the reserve, we recorded only porcupine kills as his preys.

Rena

Rena (PF023) is an adult female from Tuli block (Dovedale Game Ranch). She was captured as she was killing game farmed at the ranch. She was released with a collar at Molose on the 1st August 2021. After exploring Molose surroundings, she moved south and left the reserve on the 15th September 2021. She reached the outskirts of Takatokwane where it seems she established her new homerange in a densely vegetated area between cattle posts. In 2021, the farmers in her new homerange area were approached and none of them reported any increase in livestock losses due to predation. She was observed feeding on steenboks and duikers.

PF024

PF024 is an adult female translocated from Moroekwe farm in Otse, the same farm where Lucky (PM032) was captured. PF024 was supposed to be responsible for a great number of cattle calves. She was released on the 15th September at Kukamma waterhole. During her release she was approached by a male leopard who initially attacked her and later just followed her. There were no negative consequences from that interaction. Nevertheless, after just two weeks, on the 2nd October 2021, she crossed the Khutse GR fence and moved south. She established her new homerange close to Ditshegwane village at 18 km west of Lethlakeng.

Inkara

Inkara (PF025) is a subadult female resident in Khutse GR. LEC team collared her after the veterinarian was able to free-dart her as she was not scared by the car. The collar was placed on the 30th November but unluckily she lost it on the 17th December. We preferred to leave the collar slightly larger as she is still growing, so she might have pulled it off using the branches to hook it, as evidences on site suggested. She is a relaxed leopard who could be an ideal study animal to follow. On the collaring day, the team could observe her successfully hunting a mongoose. This is a sign that she was not bothered by the vehicle. The GPS fixes collected from the collar show that she is active between Khutse 1 pan and the block south of Motailane.



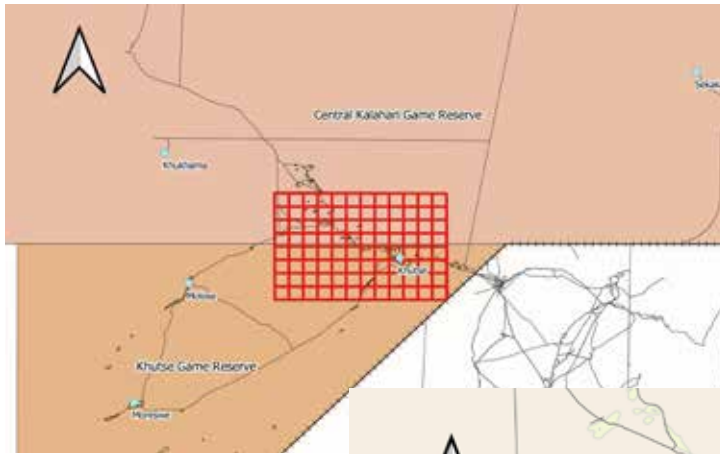


Figure 5.1. Camera-trap survey grid during the pilot phase in relation to LEC study area.

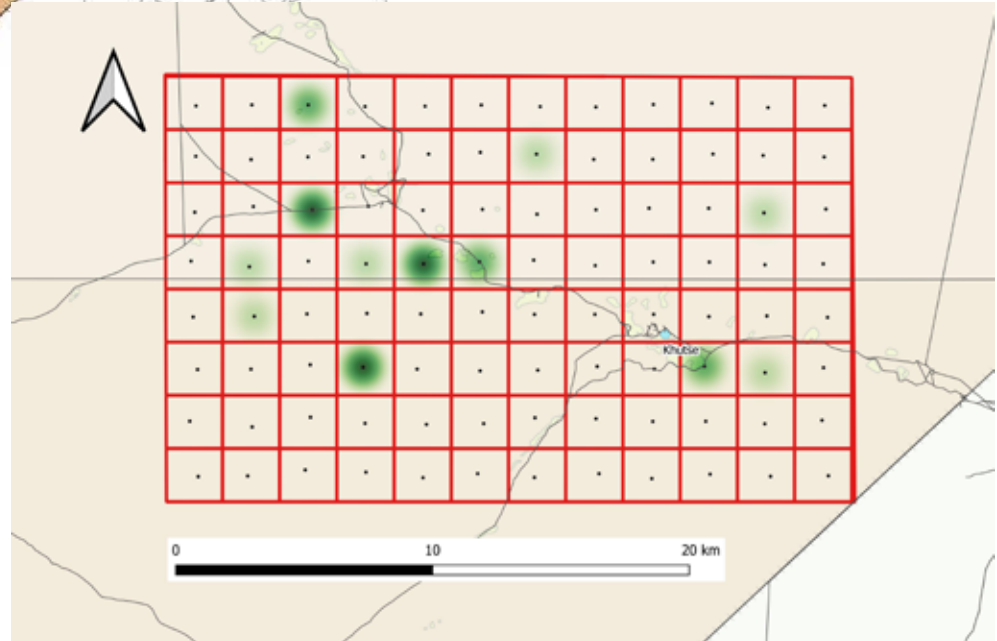


Figure 5.2. Leopard images per camera-trap station obtained during the pilot. The intensity of the green buffer around the camera-trap (black dot) represents the number of leopard images produced at that station.

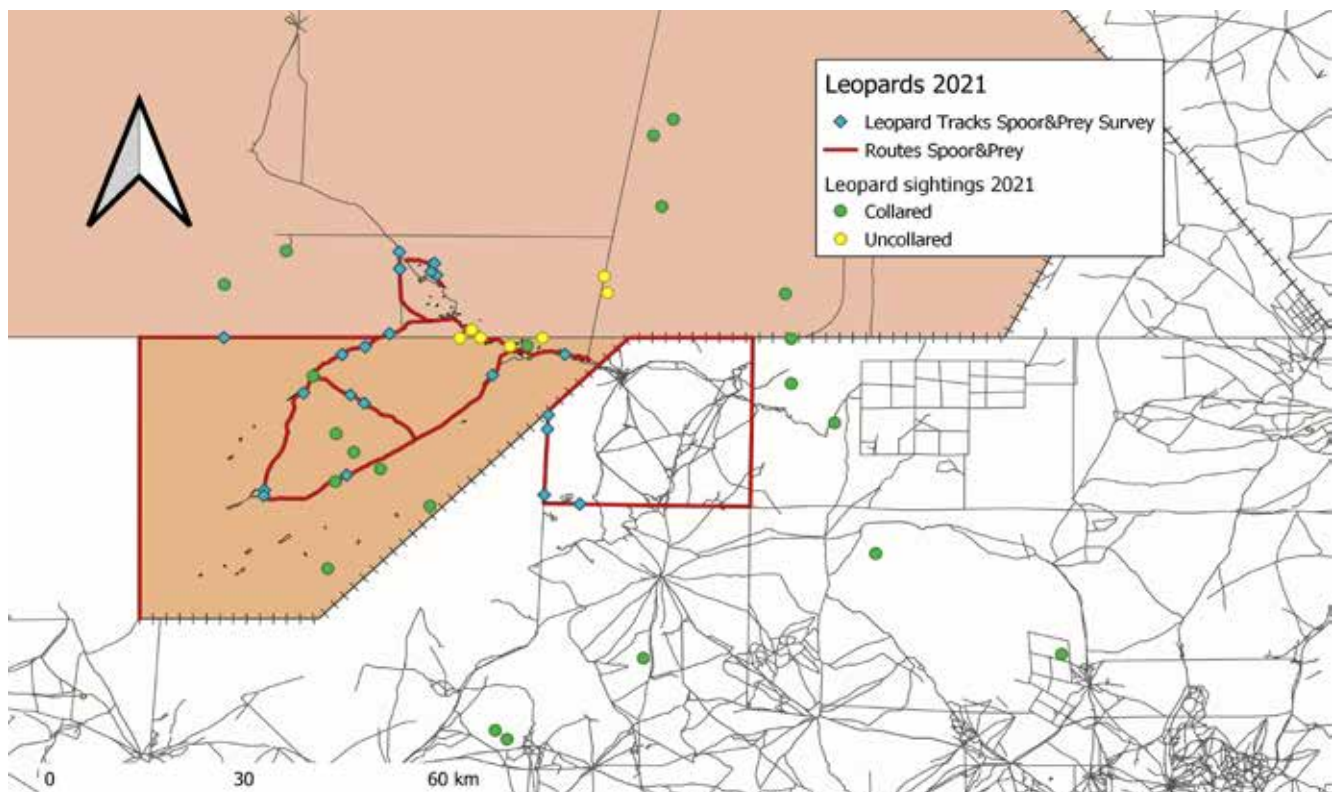


Figure 5.3. Map collecting evidences of leopard presence in the study area. All direct sightings are plotted (green-collared individuals; yellow-uncollared) as well as leopard tracks (blue) detected during the spoor and prey survey from October to December 2021. Tracks detected opportunistically are not included in the map.



Project 5. Predator Demographics - Lions

Lion population structure may change rapidly in the Kalahari ecosystem. Prides cover large territories and low prey densities force lions to move long distances for hunting with seasonal shifting of the core activity areas. For this reason, it is important to have a long-term monitoring study of the population structure and demographic rates. The resighting protocols implemented by LEC in combination with the population estimates obtained from the spoor and prey surveys can provide an early warning system for changes in the status. Due to the low densities of lions in our study area and the limited number of roads within, the use of GPS collars is fundamental to guarantee the required number of observations to correctly monitor the prides and the population trends.

Lion collaring 2021

To achieve a good coverage of lions from the Khutse population, we aim to collar at least one female in each pride group, one male from each coalition, and one individual from each dispersing group. As lions are social animals, by visiting collared individuals we are also able to see the members of their group they associate with. The females allow us to track the permanent residents in the park as well as the reproduction rates, the males tell us who has tenure with the females, and for how long, while the dispersing groups provide information on where and what routes our individuals take when they leave their natal prides. Like in 2020, we experienced repeated collar technical failures which impacted enormously on the monitoring of new prides. Moreover, the availability of veterinarians within Botswana has greatly reduced the temporal windows for captures. Even if our tracking team has spent extensive hours to search for new individuals to collar, it seems the encounter rate of tracks to follow has reduced comparing to the past years. This is the first alarm bell of a possibly shrinking population. In 2022, we aim to continue our collaring operations testing new collars developed directly with the manufacturers. The rate of collar failure is an issue we aim to solve promptly.

As not all individuals in a group are together all the time, we need to visit collared individuals regularly to gather information about the group as a whole. In 2021, we have collected the data according to the resightings protocols redesigned in 2020. The collected data are comparable with the long-term database of LEC and in addition it allowed us to better evaluate the sampling effort for our targeted resightings of collared individuals. Our goal is to resight each group a minimum of twice per month, and that during the resighting we collect as much relevant data as possible on the group demographics. According to the behaviour of each individual and its location in the study area, it may take several attempts before a direct observation is achieved. Collar failures have quite an impact as we don't simply lose the possibility to locate the animals, but it also forces us to wait several months before we can sedate and collar the same individual again. Collaring operations are done following the most up to date ethical and technical protocols, and we do not want to sedate an animal twice in a limited time to avoid any risks for its health and impact on its behaviour. The resighting protocols have helped in the quality of the data management as well, in the next phase we aim to move all data collection on a Cybertracker customized app to reduce the time investment in data entry and eliminate errors in the data entry phase from paper to excel (see p. 30). Finally, the ID kits for all study animals have been kept updated. The data and photo archives have been reorganized to facilitate the usage of the collected data LEC researchers and collaborators.

Meet the class of 2021

East Khutse Pride

The East Khutse Pride is made up of five related adult females, four of which are sisters from the same litter, and their cubs. The pride has been resident in the eastern part of Khutse since around 2012, although they were born into the Molose Pride in ~2007 (Verity) and 2010 (Notch, Nina, Peggy, Sarah), and dispersed east when they were subadults and left their natal pride. In the last two years, we observed Nina and her three male cubs spending more time further north in the CKGR, in the Khankhe pan area. In 2021, four of the adult females and one cub had collars in different periods of the year (See Appendix 1).

2021 has brought great changes in the pride structure. Peggy was collared in February after the GPS collars from Notch and Nina stopped communicating. Peggy was moving with her three female cubs born in January 2020. Unluckily Peggy was shot as a problem animal outside the reserve in July, two of the three cubs (LF068 and LF070) were successively translocated to CKGR as they were targeting livestock and LF070 was collared at that stage. The third cub (LF069) joined independently Verity and Sarah, and they are now hunting together. LF068 and LF070 were successfully hunting wild preys until they decided to go outside the reserve. LF070 was finally translocated to north CKGR where we monitor her remotely via GPS collar. Verity and Sarah were observed mating with Snooks and Rocket but their litters did not survive. They have well accepted LF069 and they are hunting together in Khutse 1 pan area. Notch has not been observed in the last months of 2021. Nina and the three male cubs (born in September 2021) are in great condition and they move mainly in the area between Mahurushele and Kukamma waterhole in CKGR, with seldom visits to Khutse 1. We recollared Nina in August 2021 and managed to follow her and the three cubs extensively. The coalition of Snooks and Rocket were still in tenure over the East Khutse Pride for the whole of 2021, even if it seems they have spent more time further west towards Molose than in 2020.



Snooks and Rocket



Snooks and Rocket have been the prime males for Khutse GR in the last years. We think they are probably eight years old and brothers. In 2021, they seem to have moved their core activity area further west towards Molose waterhole where they were observed initially in 2018. They are probably the fathers of all the litters recorded between Molose and East Khutse prides in the last two years. In 2020, the two males were often seen together during observations, while in 2021 often we would find them apart. Rocket can cover long distances during his patrols across Khutse GR. He has been recorded going as far north as Kukamma waterhole in CKGR where other adult male lions are present. Snooks had lost condition during the dry months in 2020 but he fully recovered and he has kept an optimal body condition across the 2021. Both Rocket and Snooks have continued hunting livestock outside the reserve.

Molose Pride

Molose pride was once known as the largest pride in Khutse GR, but since 2016 the group has collapsed due to younger cohorts dispersal and the natural death of some adult individuals. In the last 5 to 7 years the presence of elephants at Molose waterhole, core of the ancient Molose pride, has been constantly increasing with an enormous impact on the pan, the water availability and the animal community dynamics in the area. In the past, lions were often found around the waterhole for hours if not days. While now lions seem to approach the pan only when the elephants are not present and shifted their presence further away from the waterhole.

Nevertheless, 2021 was a comforting year for the lions at Molose. Alice and Alexa, two adult sisters we have observed since cubs, had successfully raised six cubs born in October–November 2020. They are skittish lions but successful in their hunting. The two sisters are almost always observed together and they are protective towards their cubs. After losing two litters between 2019 and 2020, it seems they have succeeded with raising six out of seven cubs in 2021. Alice’s collar was replaced in August as the battery was close to its end. Snooks and Rocket have been observed with the two lionesses and their cubs, confirming that they are most probably the fathers of cubs. Other known adult females (LF041 and LF047) and two unidentified adults have been seen moving in Molose area and interacting with the coalition of Rocket and Snooks.



In comparison to 2020, we observed that Rocket and Snooks have been outside alone more often. They seem to know well the risks to be found outside the reserve during daylight and they show clear movement patterns where they move outside the reserve mainly during the night. In 2021, for the first time we recorded an impressive behaviour from Rocket. He moved a complete carcass of a cattle calf for more than 2 km to bring it across the fence and consume it inside the protected area.

After the deadly interaction with Aaron and Moses, a pair of younger males, in March 2020, we did not observe any sign or serious wound on Rocket or Snooks to prove any further violent interaction with other males challenging their dominance in 2021.



Kukamma Dispersal Group

At the end of 2020, we collared a male lion (Spiderman; LM091) who was seen in the area close to Kukamma waterhole together with another male (John; LM092) and a female (Levia; LF071). The three lions were probably 3–4 years old and dispersing from their natal pride.

In 2021, the collar data allowed us to confirm our hypothesis of dispersal. Spiderman has covered huge distances within the area in CKGR between Kukamma waterhole and Gope village. Resighting became more complicated due to the fact that he would be often extremely far from any of the park roads. Nevertheless, he was observed often with John, who is probably his brother. Spiderman was seen with Levia and an older female at the beginning of 2021.

As predicted, it seems Levia separated to increase her chances to mate with unrelated males.

The group that was present at the darting was made up of two young males and a young female, all believed to be around 3–4 years in age and most likely related. Their group composition and age indicate that this is a group of subadults recently dispersing from their natal pride. Within the next year or so it is likely the female will separate from her male relatives to seek out her own territory and a chance to breed with unrelated males.

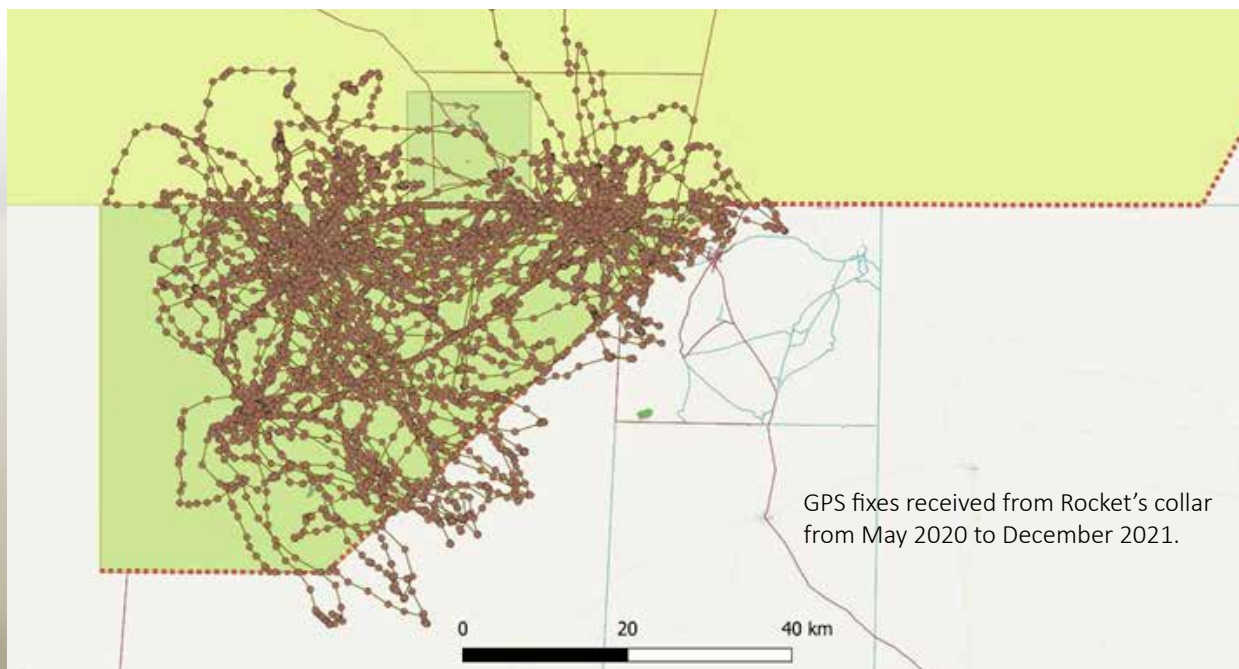
We hope to be able to continue receiving collar data till the males might have established their own territory. This data would be a great contribution in the existing knowledge on social dynamics in Kalahari lions.

Kukamma Waterhole Pride

Kukamma waterhole resulted as a hotspot of lion activity in 2021. The increased presence of elephants at Molose waterhole might have pushed lions towards Kukamma waterhole which was created in 2018. Alice, Rocket and Nina with her three cubs have been moving in the area on several occasions. In September, we found a group of four lions hunting in the waterhole surroundings. We managed to collar the adult female (Naledi; LF073) while the adult male (LM094) was very fast in escaping any darting opportunity. Naledi is a 7–8-years-old female in her prime leading two subadults (a male and a female). The collar failed after just one month, but during that time we could record a successful hunt on an impressively big eland bull. We hope to be able to recollar her in early 2022.

We could not identify Naledi as any of the cubs from East Khutse pride or Molose pride. Nevertheless, as Kukamma is right on the fringe of the range of the former Molose Pride, it is probable Naledi is a remnant of that pride. It is also possible they came from a group from North CKGR not part of our current study area. Genetic analysis could give further insights.





LF041 and LF047

In 2021, we could not have certain confirmation of observations of females LF041 and LF047, two sisters born in 2013 and related to Alice and Alexa. Nevertheless, we suspected that the two females observed with Rocket on two occasions in proximity of Molose pan could be LF041 and LF047. The territory is the same and the age and body structure fit their description. Unluckily, they moved too fast to obtain good quality pictures to confirm their ID. If the two females are LF041 and LF047, they continue overlapping with Alice and Alexa's territory, but both from direct observations and track monitoring we never recorded the 4 females moving together. We hope to be able to collar one of these females in 2022.

Peanut

Former study animals not seen in 2021. Sekaka waterhole has been an important water source for wildlife in the last years, unluckily it has stopped working in September 2020. Peanut and his pride were mainly moving around this waterhole. The faulty collar and the absence of roads in the area made it impossible to observe them in 2021 despite our efforts to visit the area.

Project 6. Human-Predator Conflict

We continued working in strict collaboration with the DWNP Problem Animal Control office in Kaudwane. Livestock losses are recorded and shared, as well as any presence of collared lions and leopards in the cattle post areas. Our research team is in charge to approach farmers who lost livestock anytime we record a livestock predation. It is an opportunity to share their knowledge of predator ecology and explain how to better manage the livestock.

In 2021, the Community & Education and Research teams worked together to complete the extended cattle posts survey in the area surrounding Khutse GR. The survey is the first systematic social science survey carried out across this area which includes most of the cattle posts potentially affected by wildlife around Khutse GR. Leejiah Dorward, a postdoctoral researcher at the University of Bangor, assisted LEC on designing the questionnaire to survey the current status of the cattle posts and livestock management techniques as well as creating an up-to-date baseline on the perceived extent, impact and trends in livestock predation in our study area. A key section was focused on herders' attitude towards the different predators. Such research is aimed to provide further insight in the human-carnivore conflict and

tailor our conservation activities in the community. Finally, by sampling both cattle posts we have been working with for many years as well as cattle posts where we have had no direct interventions, we aim to evaluate if our education work has had an impact in promoting human-carnivore coexistence. The survey was completed in the last quarter of 2021 and more than 200 interviewees have been approached. Results will be shared in 2022.

In Africa, the use of poison by communities affected by human-wildlife conflict has drastically risen in the last years. Botswana is not immune from this trend and, as LEC, we trained all our field staff and many local stakeholders to identify, record and manage potential cases of poisoning. The training has been carried out in collaboration with EWT. Since the training in March, we detected two cases of poisoning which we were able to report and manage to limit the impact on wildlife and the community. Both cases affected mainly jackals and domestic dogs in the area of Mahuhumo. The Community and Education team has organized workshops in the area to educate on the risks and impact of poison (see Community & Education section).

We are now part of a network to manage any poisoning event across Botswana. This should facilitate the use of resources to counteract poisoning, educate communities, manage animal rehabilitation and assist police in persecuting the perpetrators.



Collaborations and Students

In the past year, the pandemic continued to impact our capacity to host both international researcher and students as well as those from Botswana. Nevertheless, we moved forward with our existing collaborations and were also able to establish new relationships to develop some exciting upcoming projects.

We continued to play an active role within the Botswana Carnivore Forum (BCF); a forum for researchers and conservationists working on carnivores to share findings and expertise and play a collective advisory role for the DWNP. LEC has contributed data and expertise towards key aspects of carnivore conservation strategies across Botswana and was asked to review the Leopard Management Plan prepared by DWNP in December 2021. A discussion table should take place in early 2022. The final document will be a key tool in the management of leopard populations in Botswana. LEC also contributed historic spoor count data for lion population estimates across Botswana, as we did for the leopard in 2020. The final report should be finalized in 2022.

Our collaboration with WildTrack has continued throughout 2021 with the aim to create a complete library of all our study animal prints. Data we collect contributes toward the development of a statistical algorithm to identify leopards and lions from their footprints as well as a global Artificial Intelligence software effort for identifying species from their prints. Both efforts are progressing as a direct result of the material we provide. LEC is a member of the WildTrack Specialist Group and regularly attends meetings to network and scope opportunities to contribute to wider conservation efforts in this field.

In September 2021, we began data collection for the LEC and Max Planck Institute – Animal Behaviour (MPI-AB) collaborative project on social behaviour in lions. MPI-AB principal investigators (Dr Finerty, Dr Borrego) and LEC share the same goals to generate insight into lion behaviour in the semi-arid Kalahari setting. A new research assistant and three experienced trackers have been trained to collect data on cooperative hunting in lions using an integrated approach involving traditional San tracking and satellite telemetry. The same team has been involved in two additional components to the project. The first is the investigation of clusters of GPS fixes clusters as predictors of successful hunting events. The second is the “long follows” of tracks over a 24-hour period of collared lion individuals to assess the precise movements and activity patterns between two GPS fixes and to detect any attempted kills or events when animals feed on small prey.

In 2021, LEC continued the collaboration with Snapshot Safari for its pilot camera-trap survey. As part of this collaboration, volunteers from all over the world participated in classifying the species “captured” on the images. This was the first citizen science experience for

LEC and it was a resounding success. In just two weeks, through the LEC page on the Zooniverse platform, the volunteers cross-checked more than 80’000 images to detect and classify the animals moving in front of the camera-trap. The collaboration gave good exposure to LEC activities and saved an invaluable number of hours for our research team. The results of the pilot study allowed us to better understand the constraints and potential of a camera-trap survey in LEC study area. LEC will fine tune the design for a full-scale camera-trap survey planned for 2022. This survey will involve other national (ORI) and international partners (WildCRU, CREEM).

As a joint effort between the research and the C&E team, an extensive cattle post survey was designed in collaboration with Dr Leejah Dorward, a social science researcher based at Bangor University. His expertise in social science surveys was fundamental in designing the questionnaire used to interview the herders around Khutse GR. The survey aims to determine the status of the cattle posts and what factors will be important drivers in the coexistence between wildlife and livestock farming in the area.

The latest collaboration LEC has initiated in 2021 is with Zoom Torino and its foundation. Zoom Torino is a zoological garden which is interested in using technical expertise to support conservation and research projects around the world. LEC and Zoom have started a pilot beekeeping project. The initial focus is on honey production as a tool to provide sustainable livelihood in the community. In the long-term, LEC is interested in exploring how bee keeping can have a role in habitat restoration around cattle posts and how bee fencing can be used to limit rising human-wildlife conflict.

In 2021, Genevieve Finerty successfully defended her PhD thesis “Connecting the dots: Ecology, Movement & Conservation of Lions Across the Kalahari-Kavango Landscape”. The publications resulting from her thesis are under final revision. Her results have already been useful for supervising other students and have provided a deeper understanding of the lions in the Kalahari.

Shani Baumgartner has successfully completed her Masters project at the UZH. Her study on “Sex-specific activity patterns of lions in the semi-arid Kalahari” was co-supervised by Prof Arpat Ozgul and Genevieve Finerty. The thesis received the top marks. LEC is assisting Shani to publish the results in a scientific journal. The collaboration between LEC and Prof Ozgul’s group has been so successful that a new student, Vera Alessandriello, has started her Masters project under the supervision of Genevieve and Dr Gabriele Cozzi. Vera will focus on movement patterns in translocated and resident leopards to help us understand the implications of translocation on key movement patterns.



PROJECT IN FOCUS.

NEW INTEGRATED TOOLS FOR LEC RESEARCH AND CONSERVATION ACTIVITIES

The last two years events have deeply changed society and the way of working. Such unexpected changes have accelerated and stressed the need to be dynamic, flexible and innovative. Since its foundation, LEC has aimed to achieve such requirements to be able to make a real impact in the local and international community. In 2021, the team has continued exploring new methodologies and tools to improve and refine the projects long-term setups. As most of our projects have their strength in their data sets covering a span of more than 20 years, our major concern is to innovate our protocols without affecting the comparability of the datasets from the single years. Bringing new methodologies and tools in our research activities requires training for our staff and pilot phases to evaluate the feasibility and effectiveness of the new tools. In the following section, we present a few examples of our holistic and integrated approach in innovating our research and conservation strategy.

“

It was the first time that I was following lion tracks for such long distances. It was great to see what they have done the day before and the data collection was clear and easy thanks to the CyberTracker app

MPHO TSHIAMA, LEC Tracker



“

CyberTracker LEC app has improved our data collection because now I can enter the data faster and without the risk of making mistakes when I note data in the field and when I enter them on the laptop. Not having to scribe many information allows me to focus on the tracks.

POGISO “AFRICA” ITHUTENG, Field Assistant and Lead Tracker

CyberTracker

The CyberTracker initiative (<https://cybertracker.org/>) has been developed by Louis Liebenberg and his colleagues to provide tools to facilitate research activities aimed at conservation. To fulfil such a mission CyberTracker has focused on two aspects: the certification and valorisation of community field knowledge, such as tracking skills, and the creation of an easy customizable software for field data collection. CyberTracker software is being used worldwide by indigenous communities, in protected areas, scientific research, tracking science, citizen science, environmental education, forestry, farming, social surveys and crime prevention.

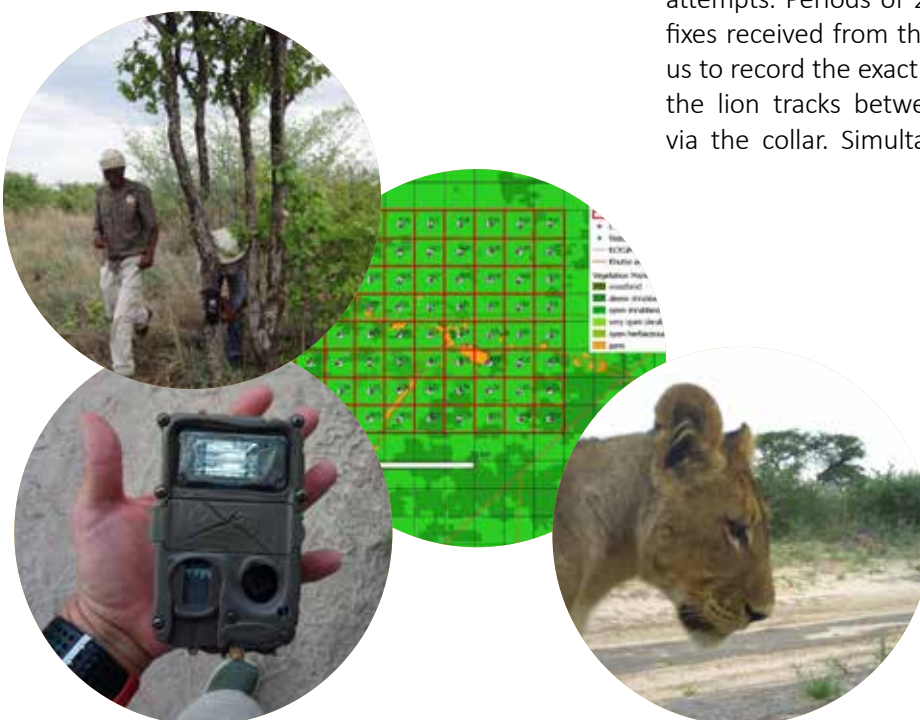
In 2021, LEC invited Cybertracker assessor, Adriaan Louw, to Khutse GR for a workshop on tracking techniques and to evaluate our trackers for a third time. The Kalahari trackers are among the best trackers in the world and therefore it is no surprise that Louis Liebenberg started the CyberTracker projects after his experience with the trackers in Botswana. The workshop had the objective to facilitate the transmission of enormous knowledge from the most experienced trackers to the new recruits in LEC. Moreover, Adriaan has showed how such knowledge can be explained through the behaviour of the animal producing the track and how even the most experienced tracker must be attentive to novelty. During the training the team detected cat-like spoor which were initially classified as African wild cat, but the gait and distance between tracks were not fitting with the ones of a wild cat. After long discussion, it was suggested that the tracks were

from a serval. Serval are extremely rare in our environment and just recently LEC could publish evidence of its presence in our study area (Finerty et al. 2019). Luckily, we could retrieve images of serval from our pilot camera trap survey and prove to the trackers their presence and how they look like. During the evaluation, we encountered the serval track again and it was recognized by all trackers. This is a clear example of how at LEC we integrate local ancient skills with new technologies to unveil the ecology of the Kalahari.

Cybertracker software was introduced to LEC data collection in 2021. The research team created a customized app for the new extensive spoor and prey survey which started in October. The app was designed to speed up the data collection in the field reducing the risks of wrong transcription of GPS coordinates and other fine details. Since 2021, we started recording all prey tracks as well and, therefore, we needed a faster and precise data entry while in the field to be able to complete the routes within the time limits. Once back at camp the data are downloaded from the smartphones to the laptop where they can be easily checked, visualized and corrected if needed. Manual data entry is therefore not needed anymore, giving more time to research assistant to focus on other tasks.

The success of the app and the potential of the CyberTracker software motivated us to expand to other data collection protocols among our projects. We created another customized app using CyberTracker to collect data for the long-follows project on lions in collaboration with MPI-AB. The project aims to determine the success rate in hunting for the studied lions taking in consideration also small-sized prey, generally under-detected, and unsuccessful attempts. Periods of 24 hours are selected from the GPS fixes received from the collar via satellite. The app allows us to record the exact track of the tracker while he follows the lion tracks between two hourly GPS fixes obtained via the collar. Simultaneously, we can record any event

or behaviour (e.g. hunting, resting, etc.) the tracker recognizes from the track. Such fine scale data, provides a better understanding on how the animal moves and the main activities within the 24 hours. More precise estimates of mean daily travel distances (day ranges) for the species in our study area will improve the quality of the population size estimates derived from the spoor and prey survey through the Formozov–Malyshev–Pereleshin (FMP) formula.



“

The Kalahari is a land of discoveries and hidden secrets. It's a great reward when by listening to the people or following a leopard you manage to grasp even a smaller new insight in this very fascinating environment.

ALESSANDRO ARALDI, Field Research Coordinator



The trackers and research assistants have quickly learned how to use the apps as they are designed to be intuitive and require limited knowledge of English. In this perspective, our aim was to upskill our trackers in research and to create a more direct bridge between the data collectors and the researchers using the data. We started in 2020, when we initiated the collaboration with WildTrack (www.wildtrack.org) for individual spoor identification. In this project, our trackers collect images of tracks via an app on mobile device. Such images are directly uploaded on a server to build a library needed to refine the algorithm and the artificial intelligence software designed to identify the single animal from its tracks.

Camera Trapping and Zooniverse

In 2021, we explored ways to involve more of the public in our research process. Many projects have now benefited from “citizen science” initiatives. Citizen science is scientific research conducted, in whole or in part, by amateur scientists on a volunteer basis. The benefits are generally two. Firstly, it is the ability to process great amounts of simple data in a short time. Secondly, it plays an important role in educating and sharing research and conservation matters with the public.

When we finished the fieldwork for our camera-trapping pilot, in collaboration with Snapshot Safari, we opened a LEC page on Zooniverse (www.zooniverse.org), a citizen science platform, to involve the public in the classification of the images. The platform guides the volunteers through a very simple process to identify the animal in the image. Each

image is classified by several volunteers till it reaches a determined consensus. In less than three weeks, all images were classified and constant interaction with the volunteers gave great exposure to the project. The amount of time saved for the researchers in the field has been gigantic (see also p. 16).

EWT Poisoning Event Management Training

The key in modern wildlife conservation is to anticipate potential new threats or trends in the existing ones. As we know, human-wildlife conflict has rapidly increased in the last 20 years as human populations are growing and countries are consuming land for economic development. One of the most ancient and spread lethal approach to deal with “problem animals” is poisoning. In the recent years strong chemical poisons have become easily available to the general public without proper education on the related risks. We understood the need to train to identify potential poisoning scenes. In collaboration with DWNP and local police group, we organised a training with Andre’ Botha from EWT for the LEC field team on how to recognize poisoning evidences in dead animals and how to proceed to limit the damages, secure the area and provide the needed information to law enforcement authorities (see also p. 26, 35).

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.

The restrictions put in place by the Botswana Government to curb the pandemic, has certainly shaped what has been possible for the C&E team in 2021. Many of the projects that were adjusted last year, have now continued to run in a more controlled environment. We were not able to host any large events such as the popular horse race, but feel we were still able to achieve our goals in teaching farmers about horse health and providing important training on hoof maintenance. We must commend the team for remaining positive and taking each project adjustment into their stride.

Education & Capacity Building

LEC recognises that education and capacity building empowers individuals to gain competencies and skills that can make the community more effective and sustainable, thus providing developmental opportunities to the community. Limitations due to the pandemic meant that we had to adapt to comply with health protocols.

At the beginning of the year, the Kaudwane Community Conservation Club planted pilot vegetables in the garden; spinach, carrots, beetroot and chillipepper to experiment viability before a full scale production. The harvest was satisfactory and the vegetables were sold to the community. Unfortunately, we couldn't proceed further with planting due to delays in the water connection. Activities are set to resume in the new year when Water Utilities connect us. Midway through the year, LEC organised a one day horticulture training for CCC members. The training was aimed at equipping CCC members with relevant horticultural skills in theory and in practice. This was necessary as the garden's daily activities are run by the CCC, while LEC and VDC plays the advisory role. The club, which consists of six volunteers has been assisting LEC to implement projects in the community.

The 2021 World Nature Conservation Day focused on the ecological importance of trees to the environment and we introduced tree planting in the community. LEC donated two fruit trees (one indigenous, one exotic) to each of the five volunteers from the six wards in Kaudwane (total 60 trees), and one tree for shade to be planted in each of the six wards. Prior to being given the trees, the 30 participants went through a one day training on general tree planting



and management from transplanting until fruit bearing stage.

LEC continues to support the activities at Kaudwane Primary School. The school has now taken full responsibility for the selling of clothing items. The second hand clothes are sourced by LEC and donated to the school to raise funds that go directly to supporting the empowerment of the learners' activities.

In an effort to effectuate the social responsibility of LEC, every year LEC take seven indigenous students who have shown the most improvement in their studies, to a different environment that aims to motivate them to continue to work hard in their studies. In April, seven students were taken for a two-day game drive in Khutse GR and CKGR. The children were taken on a tour of the reserve by Africa Ithuteng and Keolebetse Otukile. Two teachers from Kaudwane Primary School also joined in the tour.

Community Support & Development

LEC in collaboration with local veterinary office carried out a rabies campaign in Kaudwane and surrounding cattle posts. This project aims to promote the welfare of domestic dogs as a way of reducing transmission of diseases from dogs to humans and local livestock. This year, we were unable to collaborate with the MAWS (Maun Animal Welfare Society) and utilize

their foreign veterinarian services for spaying. But we did collaborate with Kaudwane Veterinary office and successfully vaccinated 152 dogs and 32 cats against rabies. Plans for 2022 are likely to shift focus from MAWS and engage the local veterinarian to carry out dog sterilization.

To further engage farmers on issues of good animal husbandry, LEC hosted a horse project for the purpose of imparting conservation education and encourage improved animal welfare practices. The 2021 horse race project was adjusted to only a horse evaluation in order to keep the project running and continue engaging farmers in animal welfare. 24 horses were entered into the evaluation and 12 farmers participated in the training.

As we continue to empower farmers and herders, through education and capacity building, this year we held a farmers workshop in the Mahuhumo cattle post as a response to the two poisoning incidents that took place in proximity of the Mahuhumo cattle post within a short period of time. The poison workshop was in collaboration with DWNP, Special Support Group of the Botswana Police (Anti-poaching Unit) and the Problem Animal Control division of DWNP. The workshop was aimed at educating farmers about the dangers of poison use and the impact on secondary victims – which can include domestic animals - and environmental destructions during this process. A total of nine farmers attended the workshop. Since our workshop was held, we have had no further reports of poison being used in Mahuhumo cattle post. We continue to monitor the area carefully. Plans are underway for 2022 to offer the workshop to other cattle posts (see also p. 26, 31).

2021 saw an introduction of a new community project. LEC in collaboration with Zoom Foundation and the Kaudwane community has initiated a small-scale beekeeping pilot project. Asa, a local bee keeper has been engaged with running the project with assistance of six other individuals from the community. Yari from Zoom Foundation trained the six community members on management of bees including use of bee keeping equipment. The pilot project will continue for one year, during which it will enable us to manage the risks and identify any deficiencies before substantial resources are committed. In November 2022, we will have a good idea on what level we can expand the project.



COMMUNITY & EDUCATION.

PROJECT IN FOCUS: BEES AND TREES

Our time in Khutse has seen the increasing decline of natural fuels as the population increases and the need for firewood grows. LEC team is in the process of creating a solar cooker that can be constructed affordably for use in the community to encourage the use of solar energy over wood. However, in the interim, we see it as our ethical duty to educate the community on the importance of trees and the role they play in our environment, therefore the theme for World Nature Conservation day in 2021 was to plant trees in the village of Kaudwane. The tree planting aims to create awareness about the need to preserve the environment and natural resources and encourage tree planting in the community and replenish what has been lost.

The trees introduced were both indigenous and exotic, allowing for fruit trees to bear fruit and for pollination to feed insects in the area. Working hand in hand with the tree project is the re-introduction of beekeeping into this area. There are records of this activity in the past, and we were very lucky to meet a local beekeeper in Kaudwane, Asa Segootsane, who grabbed the opportunity to assist us in a pilot bee project.

Partnering with Zoom (registered today as Zoom Foundation) in Italy, we have been able to build a pilot project with two active hives. The pilot project will be monitored over a 12-month period to assess the trends, note the challenges and monitor progress over the seasonal changes.

The short-term goal of the beekeeping project is to promote the sustainable harvesting of a natural resource being honey, upskill local members on keeping bees and in turn create job opportunity with bee products. The long term goal will look at using bee fences to assist in human wildlife conflict.

This is an exciting project that we hope to build on once the pilot is complete in November 2022. Yari Roggia of Zoom Foundation has been instrumental in the mentorship in this project, from virtual training to a physical training in November, we look forward to what this project will produce and how we can expand it in the near future.





INTERVIEWS.

ASA SEGOOTSANE & PATELE TSA MONWELO

Asa Segootsane

Beekeeper



Can you give us a background on your beekeeping experience?

I first heard about the business of beekeeping on the local radio and the realization that bees can be kept and you can create an income from them really interested me. One day, a swarm of bees arrived in my homestead and settled in an unused toilet cubicle. I approached the crop production officer to enquire about training in beekeeping, he told me I couldn't apply for training on my own. I therefore rounded a group of interested people together and we applied for training. We were sent to Sebile for training and the Lethlakeng bee officers came to Kaudwane to demonstrate how to catch a swarm, we were lucky that day and caught a swarming colony, and from that day I started to keep my own bees.

What do you enjoy about beekeeping?

I am a farmer, I enjoy keeping animals – so bees are like another one of my animals like cows, chickens, goats or dogs.

How do you think this project can grow?

There are two important things; 1) we need to introduce more flowering plants to ensure food for the bees all year round, and 2) further training focusing on expansion and management of multiple hives – currently I have limited knowledge on how to grow the hives.

What have you learnt from the LEC pilot project? Any highlights?

Over the years since my hives failed, I have always wanted to keep bees again. When LEC approached me to restart this project, it made me smile as I was given another chance to succeed. I have learnt new methods for extracting honey from the combs. And I also learnt that your best chance of success will come from a captured swarm as they will perform better than a relocated established colony. Our trainer, Yari, was also able to learn from us when we showed him how we knock on the hive to hear where the combs are full.

What is your dream for the beekeeping project?

My dream will be to one day own a small shop that stocks all the bee products like honey, wax, candles, nail varnish and body cream. When I close my eyes, this is what I see. I love honey, it is good for the body, I'd like to have enough that I can also keep some for myself to stay healthy and young.

“

Volunteering exposes you to many opportunities and gives you purpose.

PATELETSA MONWELO, CCC Chairman

Pateletsa Monwelo

Kaudwane Community Conservation Club (CCC) Chairman

What was the biggest challenge in 2021 in your role as CCC chairman?

The main challenge was a lack of water which stalled the progress of the community garden. Another challenge was theft, people sneaking in at night and taking produce. LEC assisted with placing camera traps which stopped the theft. Members also lacked skills in vegetable farming, which caused anxiety, but after receiving training they grew in confidence.

What was your greatest achievement in 2021?

A highlight was the successful trial in the garden which allowed us to harvest vegetables for sale and donations to the elderly. The never-ending support from LEC provides a strong relationship in the community which promotes growth and support to Kaudwane village.

What do you enjoy about CCC?

Being a member of CCC you have access to training and interactions with stakeholders including LEC. This gives you the opportunity to be exposed to different experiences. I am delighted by the support of LEC, the volunteers are not seen as people who can't achieve, they are recognised as important members and receive no bias for lack of education or skills.

Which project do you think had the greatest impact in 2021?

The garden is where I find peace, and where I learn every day. For me, this was where the most effort went and is our greatest achievement.

Do you think the tree planting project was a success? And why?

Judging by the volunteers who participated, it was a success. The training taught the people the benefits of growing a tree and motivation of shade and fruit means these trees are being well looked after. The feeling in the village is that people are interested, and they want to know the criteria so they can also grow trees.

Have you learnt anything since joining CCC – if so, what?

Other than gardening skills, I also learnt about water preservation in the garden, such as using plastic bottles dug into the ground to feed roots – this is important knowledge for a water scarce area.

Do you have any future ideas for CCC projects?

We need a poultry business – this is an opportunity we can explore as there is a gap in the market.



APPENDIX I

Table Leopard Telemetry. Animals monitored by LEC during 2021.

ID	name	origin	first collared	date removed	notes
PF023	Rena	Translocation	1 August 2021	on animal	
PF024		Translocation	15 September 2021	on animal	
PF025	Inkara	Resident	30 November 2021	17 December 2021	She lost her collar. Collar retrieved.
PM032	Lucky	Translocation	26 February 2018	16 July 2021	Shot as problem animal on the 16 July 2021

Table Lion Telemetry. Animals monitored by LEC during 2021.

ID	name	group	first collared	date removed	notes
LF018	Notch	East Khutse	6 June 2013	12 February 2021	Random communication and fixes since 23 Dec 2020. Retrieved by remote drop-off on 23 March 2021.
LF026	Sarah	East Khutse	3 November 2021	on animal	
LF027	Nina	East Khutse	18 April 2019	on animal	Collar stopped communicating 11 Jan 2021. Collar retrieved by remote drop-off 8 March. Recollared 25 August 2021.
LF028	Peggy	East Khutse	12 February 2021	5 July 2021	Shot as problem animal on 5 July 2021
LF060	Alice	Molose	24 July 2019	on animal	collar replaced on 25 August 2021
LF070		East Khutse	30 July 2021	on animal	collared when translocated first time. Collar adjusted on 16 Oct 2021.
LF073	Naledi	Kukamma WH	03 September 2021	3 October 2021	Collar drop off system failure and collar retrieved
LM085	Rocket		20 May 2020	on animal	
LM091	Spiderman	Kukamma DG	10 December 2020	on animal	

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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.

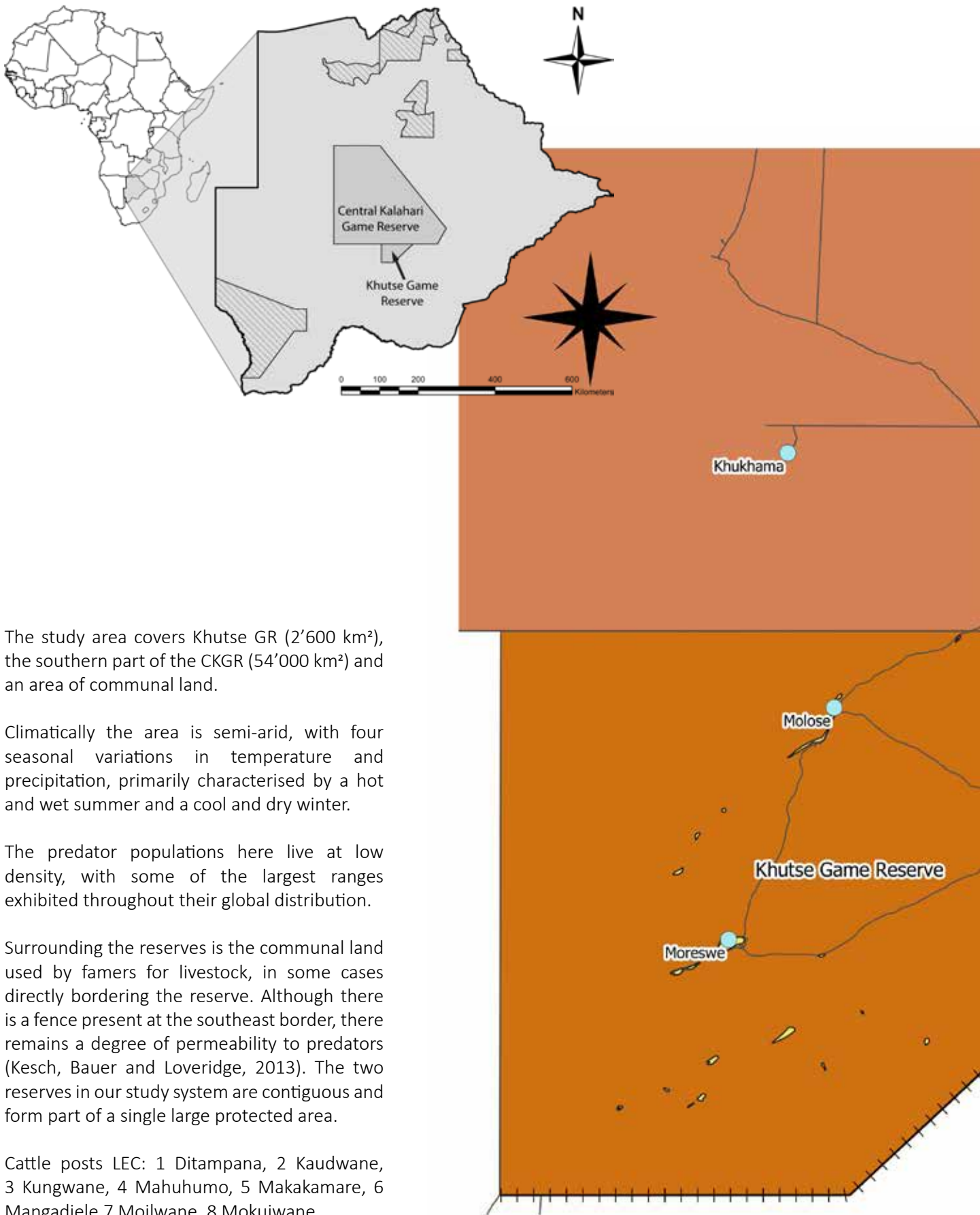
Finally, our success is a direct result of the dedication shown by all members of the Leopard Ecology & Conservation team, both in Botswana and Switzerland, as well as the numerous individuals associated with this project.

ACACF African Cats & Conservation Foundation
ANFT Act Now for Tomorrow
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
EWT Endangered Wildlife Trust
GR Game Reserve (as in Khutse GR)
LEC Leopard Ecology & Conservation
MPI-AB Max Planck Institute – Animal Behaviour
NP National Park
ORI Okavango Research Institute
VDC Village Development Committee
VIIRS Visible Infrared Imaging Radiometer Suite
UZH University of Zurich



STUDY AREA



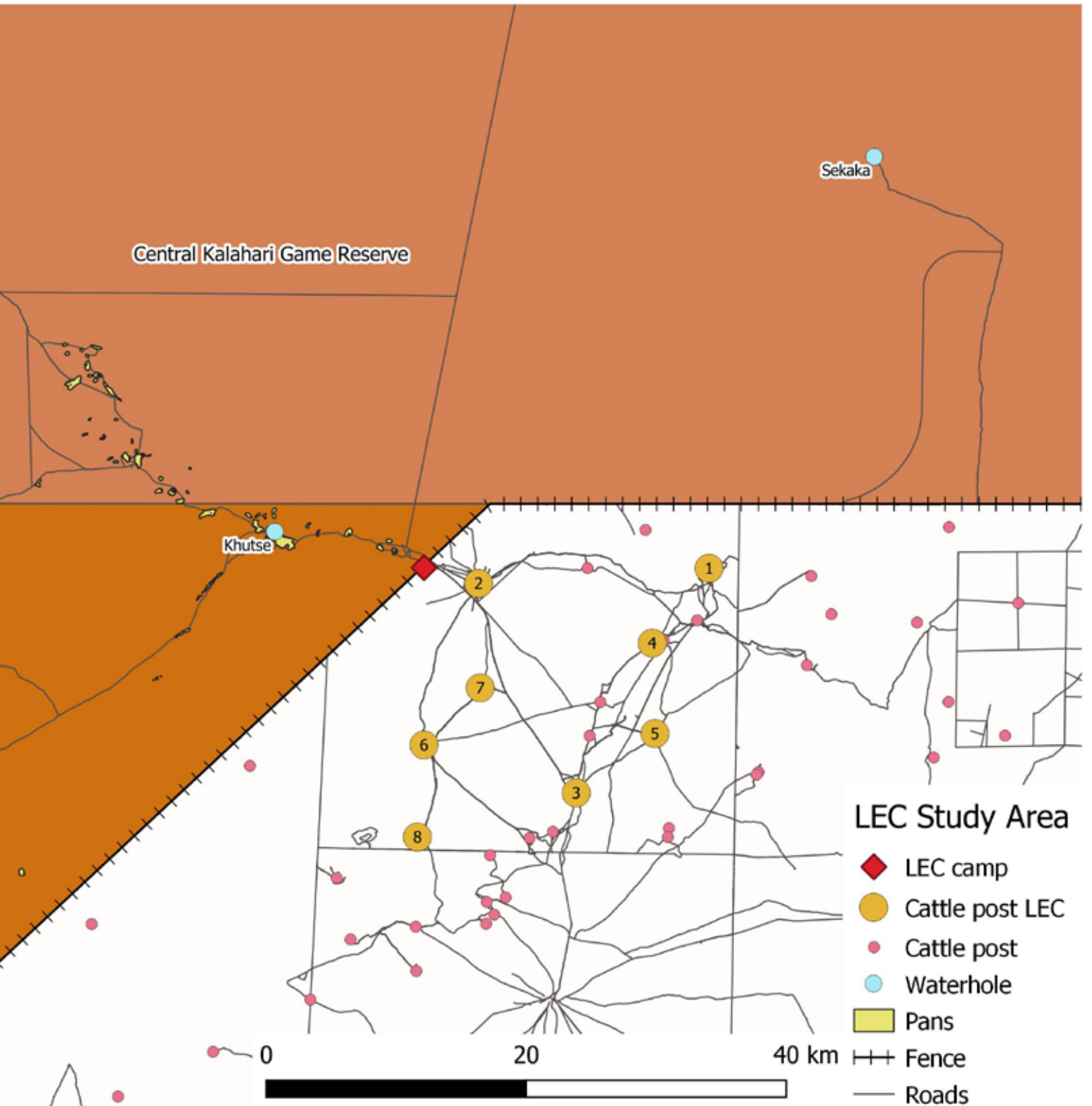
The study area covers Khutse GR (2'600 km²), the southern part of the CKGR (54'000 km²) and an area of communal land.

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 Mangadieie, 7 Moilwane, 8 Mokujwane



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
- Balone Trevor, BSc, research assistant, Botswana
- Dr Finerty Genevieve, head of research, UK
- 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 Moispodi, 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, housekeeping supervisor and administrator, Botswana
- Ithuteng Masente, camp maintenance and vehicles assistant, Botswana
- Ithuteng Pogiso Africa, field research assistant and tracking team leader, Botswana
- Kegakilwe Ditshupo, housekeeping, Botswana
- Kegakilwe Phana Segametsi, BAcc, administration and accounts manager, Botswana
- Köpfler Marianne, administration, University of Zurich, Switzerland
- Majafe Kobe, maintenance supervisor, Botswana
- Mamou Mosepele, tracker, Botswana
- Mokgwathi Kefilwe, BBA, education & community programme assistant, Botswana
- Monnaanoka Supula, tracker, Botswana
- Motsididi Komano, community & education administration assistant, Botswana
- Mosikare Neo, cook and housekeeper, Botswana
- Mosweu Kebaabetswe Alfred, BBA, community & education programme officer, Botswana
- Mpofu Ronald, gardener, Botswana
- Nkadima Phalatsa, senior tracker, Botswana
- Otukile Keolebetse, education & community liaison officer, Botswana
- Podidaroma Sokwa, tracker, Botswana
- Schiess Philipp, IT specialist, Zurich, Switzerland

- Seganaphofu Duela, contracted driver, Botswana
- Senz Sylvia, lic. phil.I, public relations, Switzerland
- Speedy-Dusty, project dog, 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, University of Minnesota, USA
- Botha Andre, Endangered Wildlife Trust EWT, South Africa
- Dr Leejiah Dorward, 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 Gosiamo, 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
- Prof. Weibel Robert, GIS, UZH, Switzerland
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- WildTrack, USA
- Prof. Zucchini Walter, Department of Economic Sciences, Georg August University Göttingen, Germany

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- 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
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- Mrs Mercy Munyadzwe, Regional Wildlife Officer Molepolole
- Department of Veterinary Services, Letlhakeng

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- 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

- Van der Weyde, L.K. et al. (2021) 'Collaboration for conservation: Assessing countrywide carnivore occupancy dynamics from sparse data.' Diversity and Distributions. 2021;00 pp.1-13
- Finerty, G. (2021) 'Connecting the dots: ecology, movement and conservation of lions across the Kalahari-Kavango landscape.' University of Oxford, PhD Thesis.
- Baumgartner, S. (2021) 'Sex-specific activity patterns of lions in the semi-arid Kalahari.' University of Zurich, MSc Thesis.
- Finerty, G., (2021) 'Thermal Performance in Lions.', Seminar Dept of Behaviour, Ecology and Evolutionary Science, University of Zurich. Oral presentation.

Collaborating Institutions from Botswana in 2021

- 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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- 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
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- Kupferschmied Basil, Switzerland
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- Familie Lüthi, Switzerland
- Meister Claudia, Switzerland
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- Schäfer André, Switzerland
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