LEWA WILDLIFE CONSERVANCY

A UNESCO World Heritage Site inscribed in 2013

BORANA CONSERVANCY

Conservation and Wildlife Department

Mid – Year Report 2023

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EXECUTIVE SUMMARY

The rhinos on Lewa–Borana Landscape (LBL) increased from a total of 255 recorded last year to the current population of 262 (132 black and 130 white rhinos). This was occasioned by 11 births (3 black and 8 white rhinos) and 4 deaths (all black rhinos). Based on the inter-calving period for black (2.7 years) and white rhinos (2.5 years), we anticipate 14 calves for each species this year. We carried out an ear-notching exercise of 42 rhinos (20 black and 22 white) and fixed 7 of them with Long Range Wide Area Network (LoRaWAN) transmitters. This exercise increased the number of identifiable black (63%) and white (67%) rhinos surpassing the 60% target as per the Black Rhino Action Plan (BRAP). We reintroduced supplemental feeding to *Zaria*, *Kitui* and *Sonia* early in the year which was later suspended after fairly significant rains were received. The evidence files for the black and white rhinos stood at 30% and 45% respectively while we target to achieve 100% by the end of the year.

The lion population stood at 56 individuals comprising 33 adults, nine sub-adults, and 14 cubs. The lion pride territories overlapped but each pride maintained a specific core area. We deployed a LoRaWAN collar and a contraceptive to one female lion. A total of 36 mortality cases of wildlife were recorded with lions contributing 83% of these. We also documented eight incidences of livestock depredation in the neighbouring community areas caused by lions, hyenas and leopards.

Most of the Ungulates had a minimum of 20% offspring, including juveniles and young, and their capacity for growth ranged from moderate to high. By use of the National Grevy's zebra database for unique identities, we captured a total of 349 unique individuals of which 95 were foals. The Annual Wildlife Census for the landscape documented a reduced number of buffaloes and elands, possibly occasioned by the prolonged drought recorded last year. However, the majority of species continue to record a body condition score of above 3.0. We also collared three Grevy's zebra to monitor their movements across the landscape and beyond.

We recorded 5 matriarchal family groups of elephants comprising 113 individuals and 18 lone bulls on the landscape. We have recorded a total of 269 instances of fences being broken and 16 incidents of elephants crawling, with most of them occurring along the exclusion zone fence lines. The occurrence of conflicts between humans and elephants in nearby communities and excluded areas continues to be a significant concern for conservation. Along with other efforts to mitigate

these conflicts, it is crucial to respond proactively to such situations, as elephants always find new ways to break through fences.

During our annual grass assessment, a significant difference in mean biomass across the years was observed, which slightly increased this year probably occasioned by the considerable rains received by the middle of the year. It was also noted no significant difference in mean biomass across the four management units. There was a significant variation in mean diversity but no difference across the management units was noted. This means that while there were observable changes in diversity over the years, the differences between the management units were not statistically significant but remained relatively consistent over the years. Previous data has also shown at least 60% vegetation cover which comprises grass, forbs, shrubs and trees. The normalized Difference Vegetation Index (NDVI) earlier indicated low greenness, which slightly improved in the second quarter because of the rains. We also recorded a total of 7 alien and/or invasive species. We intervened and significantly reduced the spread of *Datura stramonium*, *Argemone mexicana*, and *Datura ferox* which were the most widespread.

The LBL birds' checklist currently comprises 492 species of 83 families, representing over 43% of the 1,152 total species in Kenya. At present, we possess evidence files for 79% of the species. During the bi-annual global e-bird count, which is led by Cornell University, 176 and 89 species were recorded in Lewa and Borana Conservancies, respectively. This puts Lewa at the third spot and Borana at the eleventh spot for birding hotspots in Kenya. The National Waterfowl Census conducted by the National Museums of Kenya (NMK) in February recorded a total of 2,476 individuals of 30 species of waterbirds on the landscape. This year, the largest population of Grey Crowned Crane recorded was 86, less than 108 individuals recorded same period last year. Monthly raptor surveys recorded an average of 44±9 individuals of 27 species with the highest recorded number being 70 individuals.

We recorded a total of 53 pancake tortoises and 23 terrapins, bringing the total number to 186 and 46 respectively, in LBL and neighbouring community conservancies. We also created awareness among the community conservancies on the importance of protecting the habitat to ascertain the survival of these species.

Implications for management

- Future ear-notching exercises should be done every year to reduce the number of rhinos that are independent and 'clean' in the population until we hit 80%, after which a two to three years interval can be adopted.
- There is a need to intensify monitoring on the western side of the landscape as well as along the southern wildlife migratory corridor to account for all lions within the landscape. The challenge has been acquiring a dedicated vehicle to revert to the usual daily carnivore monitoring.
- During the drought, buffaloes and elands were the most vulnerable ungulates. Therefore, it is likely that supplemental feeding would be targeted towards them during dry periods.
- Through our partners, continue to engage the WILDBOOK team to develop a 21st-century stripe identity software that will quicken image processing and allow near real-time monitoring of Grevy's zebra dynamics.
- With increased cases of elephant incidences in *Ethi* and *Mutunyi* villages, there is a need to upgrade the *Ethi* fence line to a predator-proof fence with stingers and put up a 2-metre short fence with outriggers in the *Mutunyi-Ntirim* community fence line to reduce conflicts.
- Continue with the mechanical methods of removing invasive species to keep them at a manageable level.

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1.0 INTRODUCTION

This report provides details of the activities undertaken by the Conservation and Wildlife Department of the LBL in the first half of 2023. The period was characterised by a slight increase in rainfall (266mm) compared to the same period in 2022 (181mm). This led to an increase in forage levels, and therefore the rhino supplementary feeding programme to the threatened and vulnerable individuals was discontinued.

The Hydrological survey commissioned in 2022 continued to produce both ground and surface water situational reports which continue to elicit exciting questions that will be discussed once the final reports are out to the stakeholders before the end of the year. Due to inconsistencies in rainfall patterns and adverse effects of climate change in the region, we have introduced the idea of outgrowing hay and lucerne to some of our community members as a way of supporting their agri-business livelihood as well as supporting vulnerable wildlife species in future.

The landscape remains an important residence for wildlife species of key conservation concern. We continue to undertake research and monitoring for the critically endangered raptors and water birds and the herpetofauna species targeting pancake tortoise and terrapins within LBL and its contiguous areas.

There is a need for sustained focus on herpetofauna in the region, as detailed data on their dynamics is crucial in developing their national recovery and conservation action plans. In recovering woody vegetation, a management document is currently being developed with support from Natural State, to define/detail the 'Theory of Change' and chart management of the recovery strategy with the aim to achieve and maintain a 30% of tree cover, contained within exclusion zones, in future. We continue the identification and eradication of invasive and alien species on the landscape. Below, we give a detailed account of various thematic areas under Research and Monitoring (R&M) and discuss the activities of the veterinary unit as well as those of the Conservation Education Programme during the period.

2.0 RESEARCH AND MONITORING SECTION

This section elaborates about the activities undertaken in the period on wildlife research and monitoring within LBL.

2.1 Rhino Monitoring

The population of rhinos on LBL increased from 255 (133 black and 122 white) at the end of 2022 to 262 (132 black and 130 white) at the end of June 2023 following 11 births (3 black and 8 white) and 4 deaths (all black).

2.1.(i) Black rhino population performance

The population of black rhinos reduced from 133 in 2022 to 132 by the end of June 2023 after 3 births and 4 deaths. *Annita* (6.4 years) was euthanized after sustaining severe back injuries, *Kipchoge* (5.8 years) died due to predation by lions, *Senewa Calf 2* (1-month-old) and *Moomoo Calf 3* (2 days old) died due to predation by hyenas.

The LBL black rhinos average inter-calving period is 2.7 years. Ten rhinos that calved between August 2019 and the second quarter of 2021 are projected to calve before the end of the year, with two having already calved. The remaining eight are expected to calve in the second half of the year. Four more rhinos *Subira* (9.1-year old), *Sekelai* (9.0-years old), *Nalotu* (8.9 years old), *Nailepu* (8.5 years old) and *Nasieku* (7.8 years old) are projected to calve for the first time, bringing the total number of black rhinos expected to calve in the second part of the year to fourteen females. We anticipate a total of 14 calves by the end of the year. The tables below show the black rhino births and deaths respectively:

Table 2.1.1 Black rhino births on LBL in 2023

#	Calf name	Date of birth	Sex	Dam	Sire
1	*Waiwai Calf 9*	1-Jan-23	U	*Waiwai*	*Lucky*
2	*Moomoo Calf 3*	13-Mar-23	U	*Moomoo*	*Walib*
3	*Calisto Calf 7*	27-May-23	F	*Calisto*	*Roy*

Table 2.1.2 Black rhino deaths on LBL in 2023

#	Rhino name	Age at death	Sex	Cause of death
1	*Senewa Calf 2*	1 month	U	Predation by hyena
2	*Annitah*	6.4 years	F	Euthanized due to severe back injuries
3	*Kipchoge*	5.8 years	M	Predation by a lion
4	*Moomoo Calf 3*	2 days	U	Predation by a hyena

2.1.(ii) White rhino population performance

The population of the white rhino increased from 122 in 2022 to 130 by the end of June 2023 after 8 births were recorded. *Safari* (8 years old) gave birth to her first calf, bringing the total number of breeding females to 33. The table below shows the White rhino birtsh in the period:

Table 2.1.3 White rhino births on LBL in 2023

#	Calf name	Date of birth	Sex	Dam	Sire
1	*Safari Calf 1*	5-Jan-23	U	*Safari*	*Motonto*
2	*Nduta Calf 2*	18-Apr-23	U	*Nduta*	*Mia*
3	*Rosie Calf 5*	13-May-23	U	*Rosie*	*Muya*
4	*Lucille Calf 4*	17-May-23	U	*Lucille*	*Gordon-65*
5	*Queen Calf 5*	31-May-23	U	*Queen*	*Muya*
6	*Namunyak calf 2*	7-Jun-2023	F	*Namunyak*	*June*
7	*Ramadhan Calf 6*	12-Jun-2023	U	*Ramadhan*	*Ruby*
8	*Naserian Calf 5*	20-Jun-2023	U	*Naserian*	*Hatari*

It is expected that 14 rhinos, who gave birth between August 2019 and the third quarter of 2021, will give birth again before the year ends. Four of them have already given birth. This is because the LBL white rhino typically has an average inter-calving period of 2.5 years. The remaining ones are expected to give birth in the second half of the year.

2.1.(iii) Sighting frequency

The average sighting frequency (SF) for Black and White rhinos was 2.8±0.15 days and 2.0±0.10 days respectively. This is within the critical sighting frequency of 3 days in the LBL.

2.1.(iv) Notable shifts in home ranges

Mulezi, an 8.2-year-old male black rhino, moved from the southeastern side of Borana to the Ngare Ndare forest in the second quarter of 2023 as shown in the figure below:

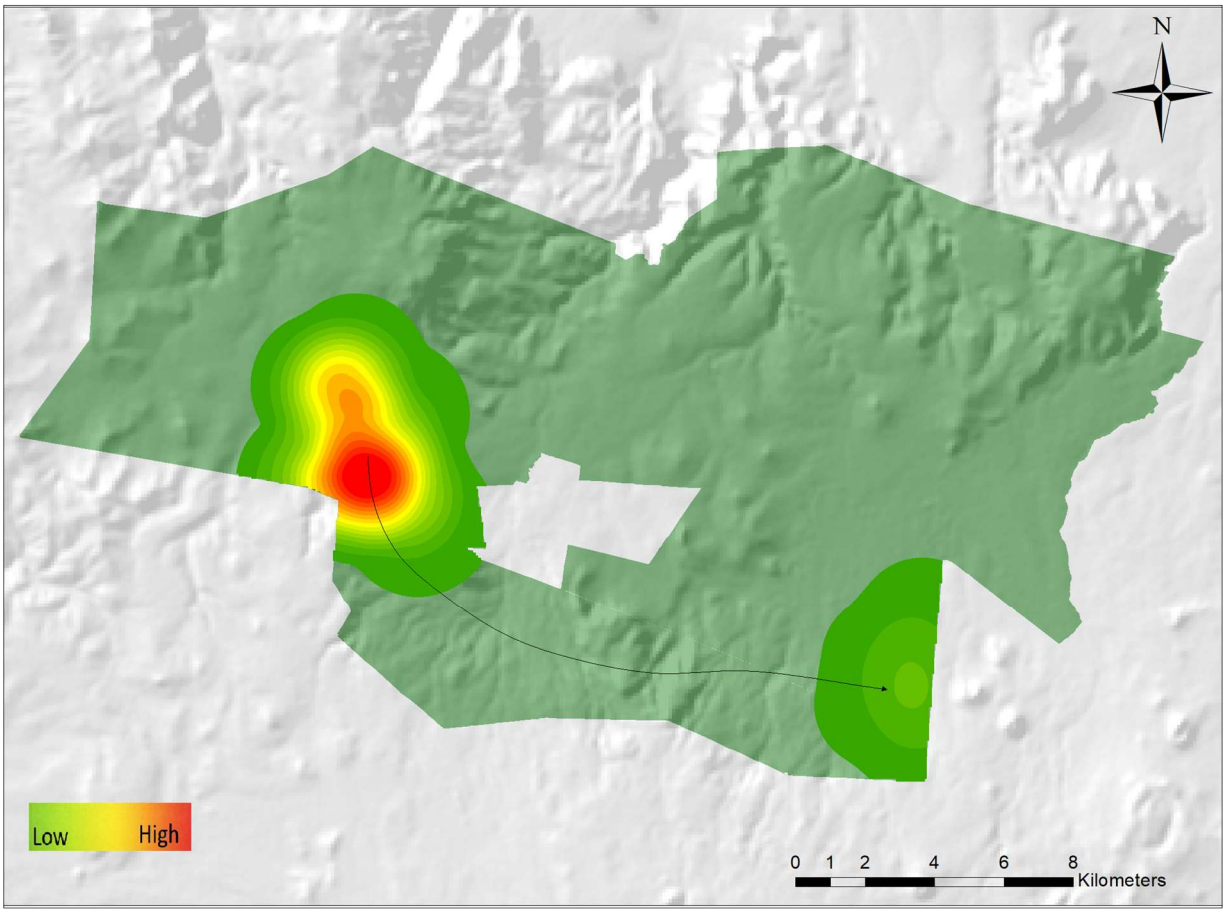


Figure 2.1.1 Changing home ranges for *Mulezi*

2.1.(v) Vet interventions

Two post-mortems were done on two black rhinos to determine their causes of death. A postmortem was done on *Annitah's* carcass to determine the extent of injuries after she was euthanized. It revealed that she had suffered severe back and leg injuries, preventing her from standing, which was most likely caused by a male in a mating attempt. A postmortem was also done on *Kipchoge's* carcass which had been partially eaten by lions. Results showed that the liver was harder in consistency due to chronic pathological conditions and the worm load was higher than normal. Liver samples were taken to the Lancet laboratory for a definitive determination.

Seven rhinos (4 black and 3 white) were reported with minor injuries, where all recovered. Out of the seven, two were males (1 black and 1 white) who sustained injuries from territorial fights.

2.1.(vi) Ear notching exercise

The LBL rhino ear notching exercise was conducted in the first quarter of the year and targeted 20 black and a similar number of white rhinos. The overall objective of the exercise was to ensure over 60% of individual rhinos can be independently recognized by the rhino monitoring team at all times as outlined in the Kenya Black Rhino Action Plan, 2022-2026, under the Biological Monitoring and Management component. The exercise was jointly carried out by the Kenya Wildlife Service (KWS), Lewa Wildlife Conservancy (LWC), Borana Wildlife Conservancy (BWC), Wildlife Research and Training Institute (WRTI), and Association of Private and Community Land Rhino Sanctuaries (APLRS).

A total of 43 rhinos were immobilized, with 42 rhinos (20 black and 22 white) successfully ear notched surpassing the target of 40 rhinos. In Borana, 10 rhinos were ear notched while 32 were ear notched in Lewa. Six of the 42 candidates were fitted with LoRaWAN transmitters. One adult male black rhino known as *Antonio* was also fitted with the transmitter, bringing the total number of rhinos fitted with transmitters to 7. The table below shows numbers per site:

Table2.1.4: Break down of rhinos successfully ear-notched

Species	Lewa		Borana		Total
	Male	Female	Male	Female	
Black rhino	6	5	5	4	20
White rhino	11	10	1	0	22
Total					42

After the ear-notching exercise, the number of identifiable black and white rhinos increased to 63% and 67% respectively. This is above the target of 60% as outlined in the Black Rhino Action Plan.

2.1.(vii) Supplementary feeding

Three rhinos namely *Zaria*, *Kitui* and *Sonia* had been reintroduced to the supplementary feeding program early this year after their body conditions deteriorated. However, the feeding program

was later suspended after a significant amount of rainfall was received at the beginning of the second quarter which led to improvement of forage quality and quantity.

2.1.(viii) 2023 Evidence files

Preparation of auditable rhino evidence files began early in the year, and so far 45% of white rhinos and 30% of black rhinos on the landscape have been photographed. Camera traps were deployed in the forest to capture elusive rhinos that range in the thick section of Ngare Ndare forest. The preparation of evidence files is set to be completed by the end of the year.

2.1.(ix) Conclusion and recommendations

Discussions with WRTI and KWS are underway to ensure the black and white rhino ECC is done before the end of the year. Future ear-notching exercises should be done every year to reduce the number of clean and independent animals in the population.

2.2 Predator Monitoring

Management of predators plays a pivotal role in conservation due to the intensive management requirements of closed and semi-closed protected areas. Knowledge of the status, behaviour, and interactions of apex predators can assist in effective management decisions which ensure ecosystem functionality.

The predator monitoring activities included monitoring lion movement and dispersal events, human-carnivore conflicts, and livestock depredation. Data collected provides a basis on which proactive management is done as well as informs relevant government agencies on policy formulation.

2.2.(i) Population performance

The lion population on LBL stood at 56 individuals comprising 33 adults, nine sub-adults, and 14 cubs. Plans are underway to continue the contraceptive program, with one already being implanted. The same lion that was implanted was also fixed with a LoRaWAN-enabled collar which, however, malfunctioned. The collar will be replaced once more collars are available. The table below shows the LBL lion population structure:

Table 2. 2.1: Lion population structure on LBL

	Adults Males	Adults Females	Sub adults Males	Sub adults Females	Cubs	**Total by Pride**
Sarah's pride	1	6	2	2	5	16
Dalma's pride	0	2	1	2	2	7
Cat-tail coalition	6	0	0	0	0	6
Ntulele coalition	4	0	0	0	0	4
Carissa pride	0	1	0	0	0	1
Florence pride	0	9	2	0	7	18
A coalition of three males	4	0	0	0	0	4
Total by sex	**15**	**18**	**5**	**4**	**14`**	**56**

2.2.(ii) Spatial ecology

Lion territories were mapped through sightings data using ArcMap 10.8.0. These territories overlap during mating season but each pride maintained a specific core area. All the prides have restricted their movement within the landscape, demonstrating the importance of protected areas, as shown in the figure below:

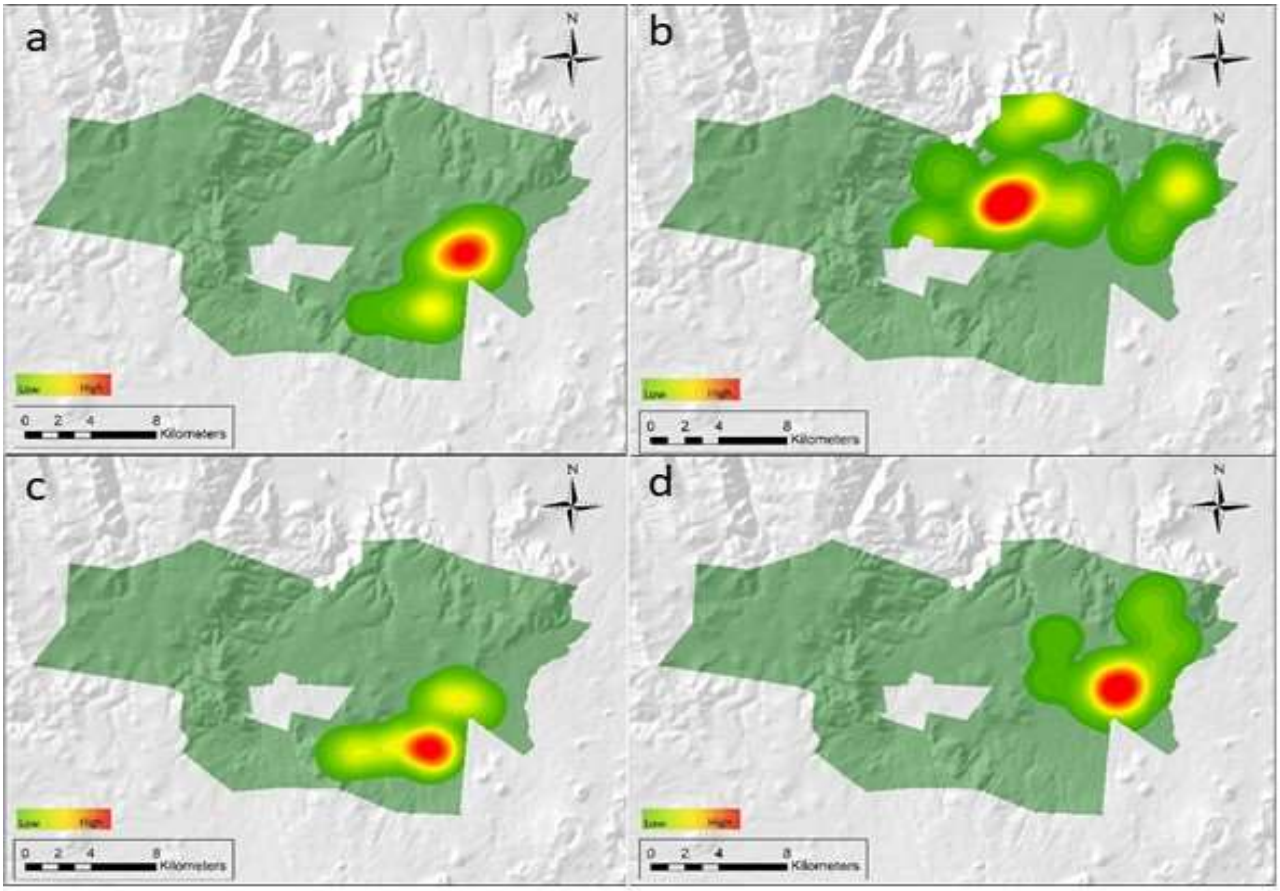


Figure 2.2.1: Ranging areas of **a)** *Dalma's* pride, **b)** Sarah's pride, **c)** *Ntulele's* coalition, and **d)** *Cat-tail's* coalition

2.2.(iii) Human carnivore conflicts

Eight incidences of livestock depredation were recorded over the last six months, leading to the loss of two goats, two sheep, and four cows. Lions, hyenas and leopards were responsible for all the cases.

2.2.(iv) Wildlife mortality

A total of 36 mortality cases of wildlife were recorded during the last six months. Predation by lions was the main cause of deaths which contributed 83.3% while the rest of the causes accounted for 14% as shown in the figure below:

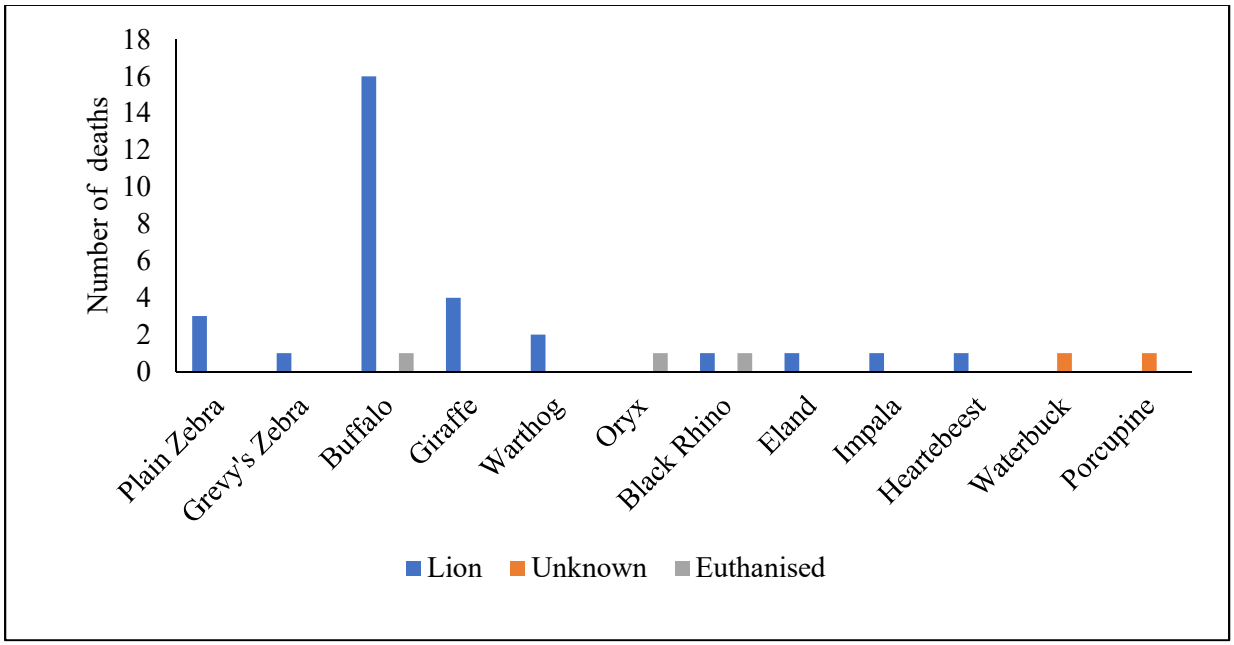


Figure 2.2.2: Causes of wildlife mortality on LBL

2.2.(v) Prey selectivity by Lions

To assess prey preference and selectivity by lions, Jacobs Index (D) was used (Jacobs, 1974).

D=r-p/r+p-2rp; where r is the proportion of the total number of kills of a particular species and p is the proportional availability of the prey species killed. Jacob's index ranges between – 1 (highly avoided) and +1 (highly selected). Of the nine-prey species, buffalo, giraffe and warthog formed the main diet, Beisa oryx and waterbuck were completely avoided, while the rest were least preferred by the lions as shown in the table below:

Table 2.2.2: Jacob's Index (D) values calculated for nine prey species on LBL

Species	Total population	Kills	Jacob's index (D)
Plains zebra	1731	3	-0.6
Grevy's zebra	359	1	-0.3
Buffalo	715	16	0.8
Giraffe	138	4	0.7
Eland	245	1	-0.1
Beisa Oryx	285	0	-1.0
Waterbuck	224	0	-1.0
Warthog	157	2	0.4
Impala	1523	1	-0.8

2.2.(vi) Scats analysis

Prey hair ingested by predators normally passes undamaged through the digestive system of the predator and can be collected in the form of scats. Prey hair in the scats can be cleaned, mounted and compared to reference hairs housed at the laboratory. A total of 13 scat samples from lions were collected and are in the process of being analyzed. We will report in our subsequent reports on the outcome of the analysis.

2.2.(vii) Conclusion and recommendations

Given the high reproductive capacity and survival rates of the cubs for the LBL lions, there is a need to expedite the contraceptive exercise as well as the lion collar exercise to assist in monitoring their spatial temporal trends. Collar data is also useful in locating kills and scats for diet analysis.

There is a need to intensify monitoring on the western side of the landscape as well as along the southern wildlife migratory corridor to account for all lions within the landscape. The management is focused on tackling the challenge of securing a dedicated monitoring vehicle to enable effective daily carnivore monitoring.

2.3 Ungulate Monitoring

The key metrics used to evaluate the population performance of wild ungulates are age and sex structure (Skalski, 2005). We collected these key metrics on a subset of Grevy's zebra (*Equus grevyi*), Plains zebra (*Equus quagga*), buffalo (*Syncerus caffer*), Beisa oryx (*Oryx beisa*), hartebeest (*Alcelaphus buselaphus lelwel*), giraffe (*Giraffa Camelopardalis reticulata*), and eland

(*Taurotragus oryx*), in addition to their body condition scores (BCS). We also analysed the movement of wildlife through the four migratory gaps that are monitored using camera traps placed at the Mount Kenya Endpass, Marania Underpass, Mount Kenya Underpass, and the Northern gaps. We collared three female Grevy's zebra to monitor their spatial temporal movements.

2.3.(i) Ungulates performance

Apart from giraffes, all the other species we monitored had at least 20% of combined juveniles and young. The growth potential was medium for the majority of the species, apart from Grevy's zebra, in which the adult males to females ratio was 1:1. The recommended levels for stable populations are 30% for the combined juveniles and young and at least medium growth potential (Rubenstein 2010). We continue to monitor how these changes shift based on the rangeland conditions. The figures below show the proportion of females to adult males and the young and juveniles monitored:

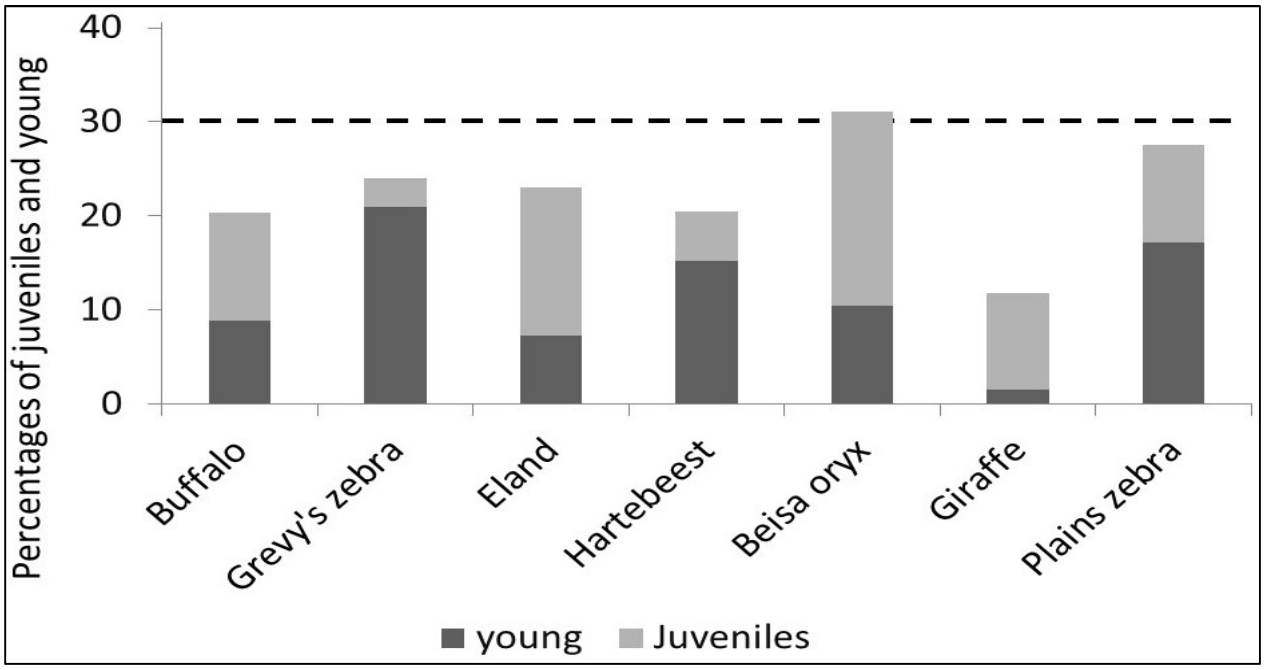


Figure 2.3.1: Proportion of young and juveniles for ungulate species monitored. The dotted black line indicates the 30% recommended level for stable populations

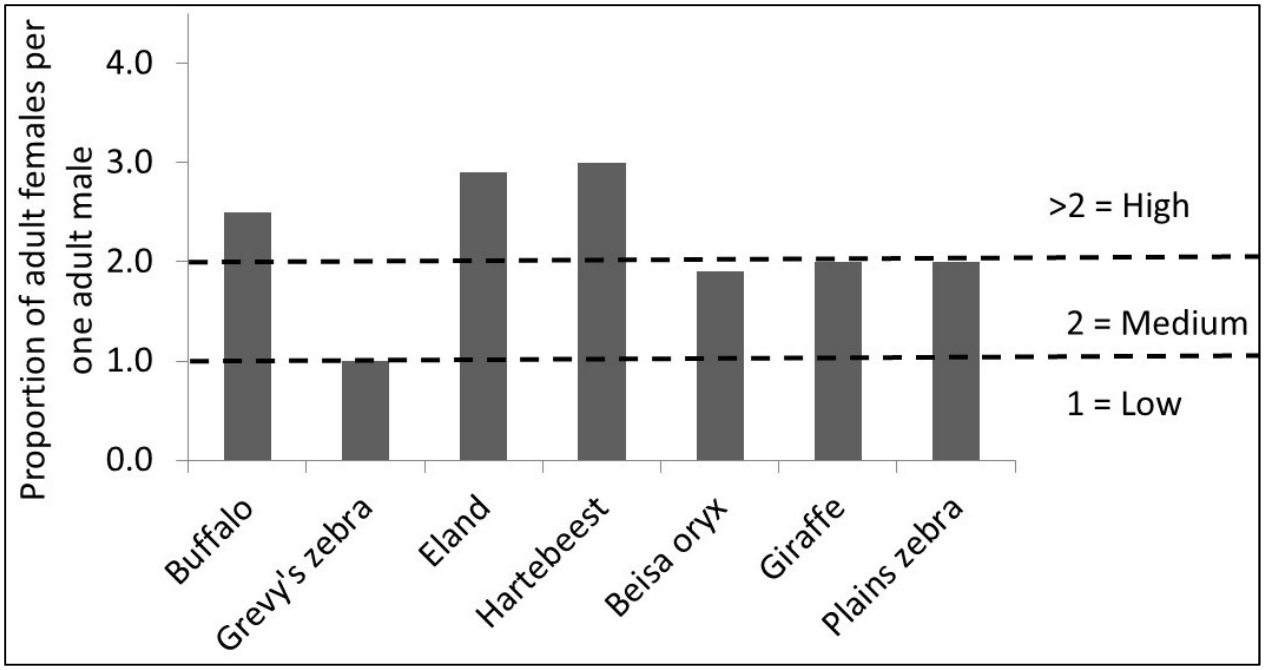


Figure 2.3.2: Proportion of adult females per one adult male. The dotted black lines indicate levels of various growth potential, i.e., Low, Medium and High.

2.3.(ii) Grevy's zebra survival rates

We used the National Grevy's zebra database to analyse the Grevy's zebra photos for unique identity. We captured 349 unique individuals of which 95 were foals. Of these foals, 49 were born within the first 6 months of the year and distributed in various age and sex categories as shown in the table below:

Table 2.3.1: Age and sex distribution of Grevy's zebra foals

Sex	**Age category**			
	(0-3) months	(3-6) months	(6-12) months	**Total by sex**
Male	4	8	11	23
Female	4	13	9	26
Total by sex	8	21		**49**

2.3. (iii) Grevy's zebra collaring on the LBL

a) Collaring

With the help of the Kenya Wildlife Service (KWS) resident veterinarian, we deployed 3 units of GPS Iridium collars to three female Grevy's zebra, one in Borana Wildlife Conservancy and two in Lewa Wildlife Conservancy as shown below:

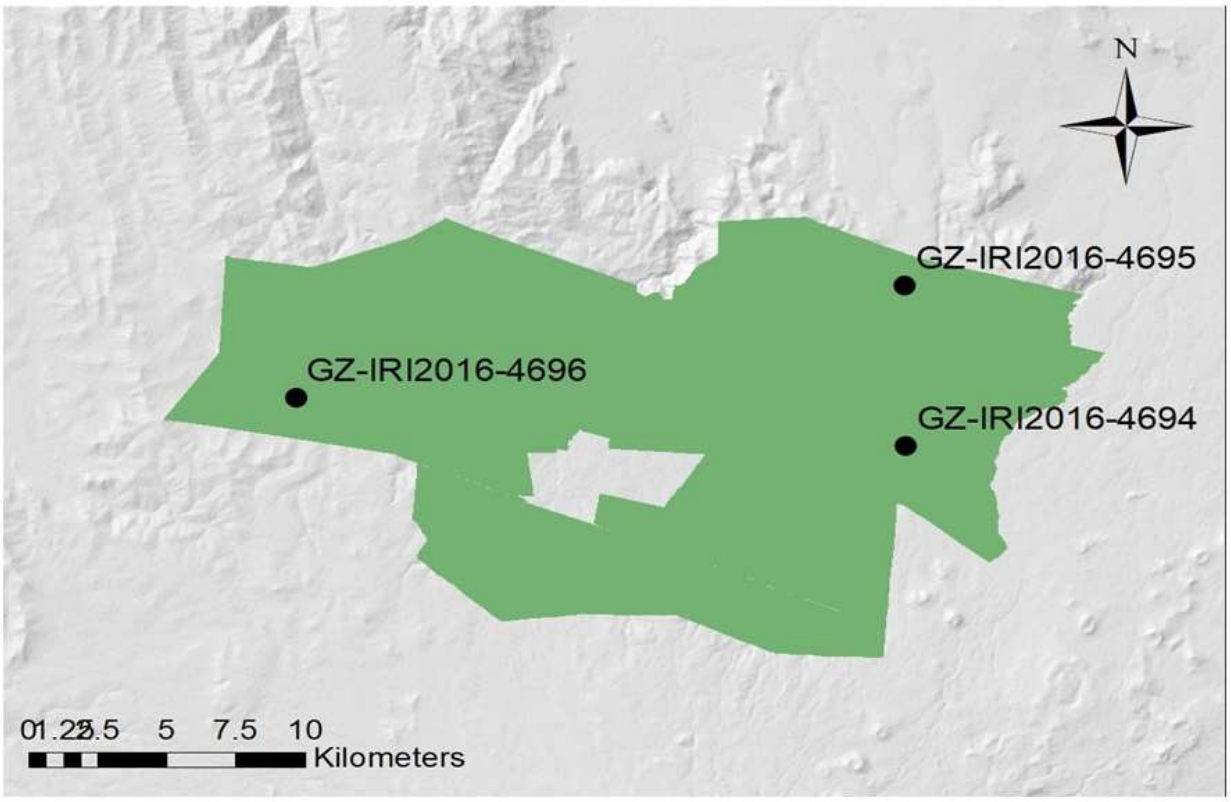


Figure 2:3.3: Locations of where the Grevy's zebra were collared

The collaring was occasioned by the observed pronounced movement of the Grevy's zebra from Lewa to Borana and back both in the third quarter of 2022 and the first quarter 2023, which was unusual in the past, leading to a shift in counts per location in the periods as shown below:

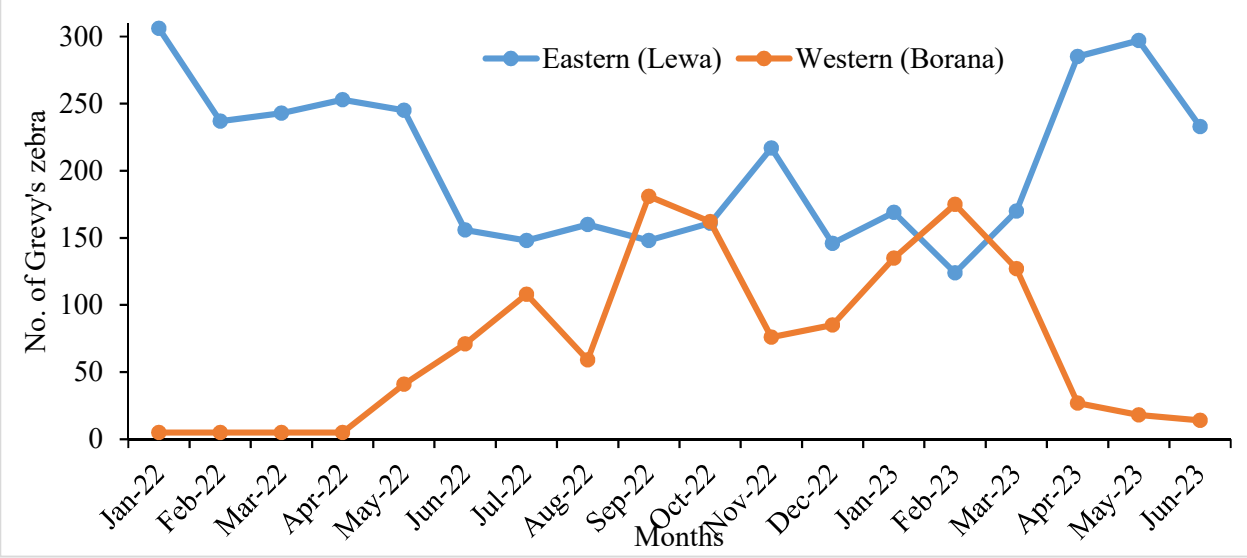


Figure 2.3.4: Grevy's zebra population trends per monthly counts 2022-2023 on LBL

Traditionally, the two properties were connected by an approximately 10 metres migratory gap until 2015 when the fence between the two properties was removed to ease connectivity and allow more space for wildlife movements. Both sides of have been receiving rainfall at different times which might have triggered the observed movements, not documented in the past when the two conservancies were only connected by a narrow migratory gap. The movement was evidenced by the comprehensive monthly patrols on both sides of the landscape.

b) Outcome

The collared Grevy's zebra have moved substantially within the two conservancies, though, all have maintained the respective part of the landscape they were collared in as shown below:

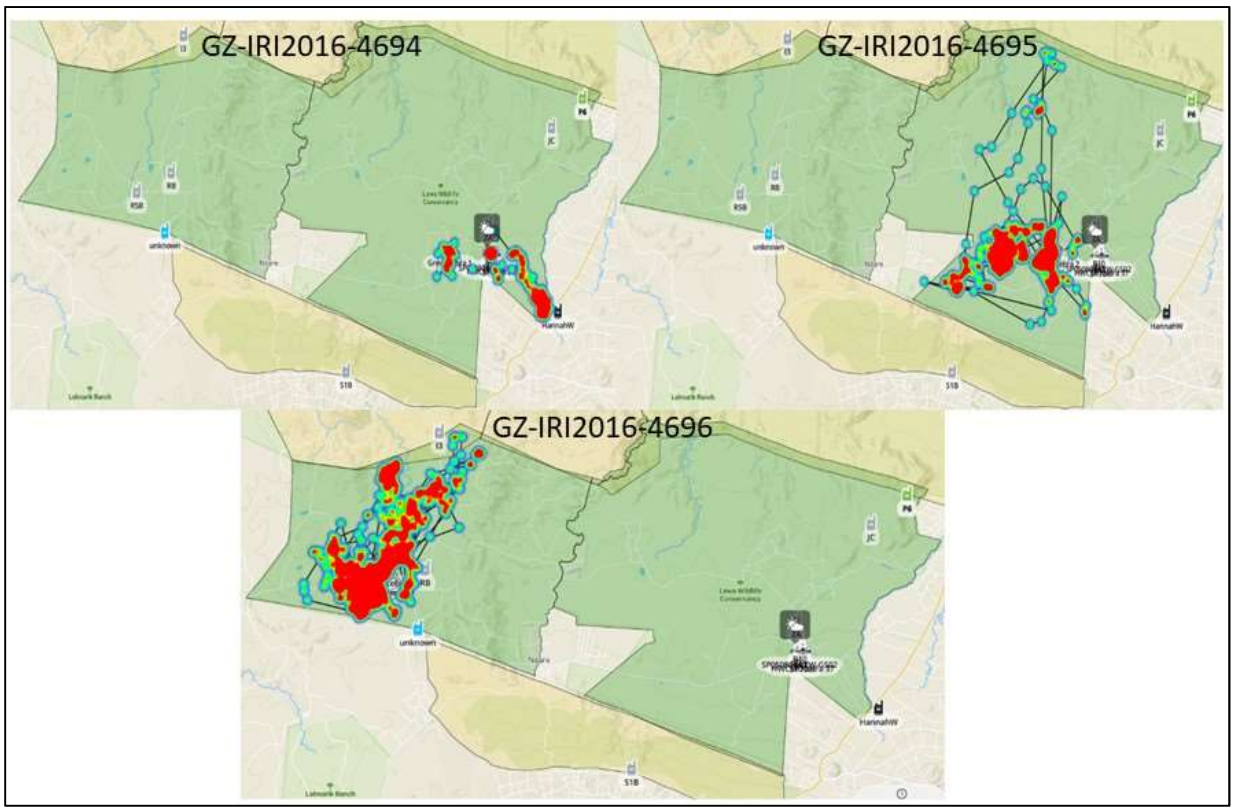


Figure 2.3.5: Movements of the three collared female Grevy's zebras (GZ-IRI2016-4694, GZ-IRI2016-4695, and GZ-IRI2016-4696), as viewed on the Earthranger).

The graphs below show the relationship between Grevy's zebra dispersal and rainfall, where an increase in rainfall increased the concentration of Grevy's zebra on either side of the landscape.

Where rainfall overlapped, Grevy's zebra concentration increased on Lewa, showing a possibility of preference for Lewa because of its low altitude as shown in the figures below:

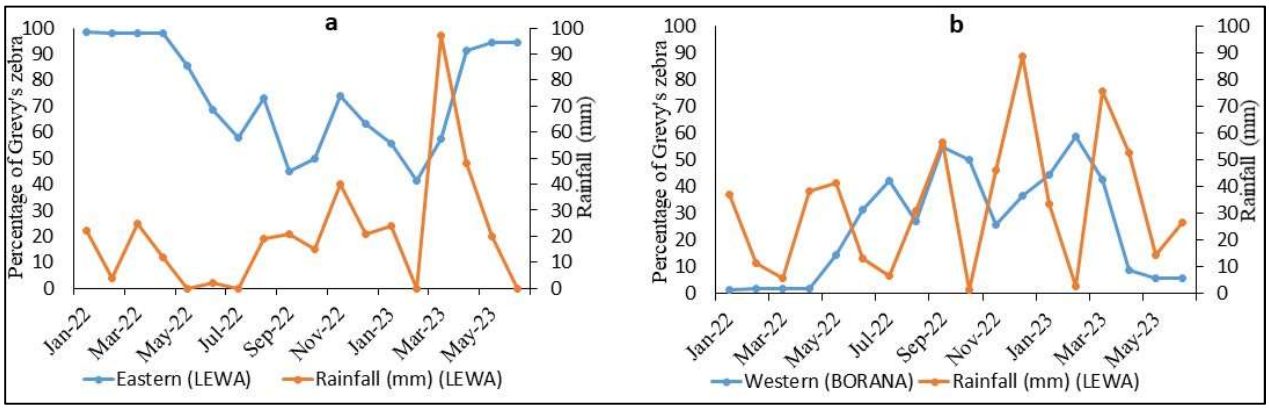


Figure 2.3.6: Relationship between the Grevy's zebra and rainfall on a) Lewa and Borana Wildlife Conservancies

2.3.(iv) Annual wildlife count

We completed the annual wildlife census for the landscape. Data indicated a sharp drop in the buffaloes and elands population possibly occasioned by deaths due to the prolonged drought recorded last. More details can be found in Kaaria et al., 2023 (unpublished) report upon request. The table below shows the trends of selected indicator species as per the annual game counts:

Table 2.3.2: Game count results for the indicator species from 2016 – 2023

Species	Year							
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Eland	280	192	322	291	245	358	331	245
Beisa oryx	179	220	178	227	307	239	247	285
Buffalo	1220	1391	1623	1753	2086	2153	1901	715
Giraffe	273	251	127	167	178	172	119	138
Hartebeest	30	62	64	64	93	91	92	100
Plains zebra	1262	1236	1228	1484	1599	1561	1557	1731
Grevy's zebra	299	292	308	313	331	322	310	359

2.3.(v) Body condition scores (BCS)

Rainfall is a key environmental factor that influences the productivity of rangelands, which intern influences wildlife fat reserves as well as their behavioural ecology (Hempson, et al., 2015; Stephenson, et al., 2020). Despite low rainfall last year (181mm) and the drought that extended to this year, a majority of species continue to record a BCS of above 3.0 apart from buffalo which

has a bigger proportion of 3.0. We will continue monitoring the progress and advise if the body condition drops further.

Table 2.3.3: Species Body Condition Scores (BCS)

Body Condition Score (BCS)	Species						
	Buffalo	**Beisa Oryx**	**Eland**	**Giraffe**	**Hartebeest**	**Plain's zebra**	**Grevy's zebra**
5 (Obese)	0	0	0	0	0	0	0
4	0	8	17	84	29	83	80
3.5	35	62	68	16	57	13	17
3	60	30	15	0	14	4	3
2.5	5	0	0	0	0	0	0
1(Emaciated)	0	0	0	0	0	0	0

Values against the body scores represent the percentage of individuals of a given species

2.3. (vi) Movement of wildlife through the migratory gaps

Corridors are critical for the maintenance of ecological processes including allowing for the movement of animals and the continuation of viable populations. By providing landscape connections between larger areas of habitat, corridors enable migration, colonization and interbreeding of plants and animals (Noss, 2004).

We monitored wildlife movement through designated migratory routes using infrared camera traps. Below is the comparison of wildlife movements through these migratory gaps for the first half of the year.

a) Mount Kenya Endpass

A total of 4,659 wildlife crossing events were recorded which was significantly higher compared to 2,432 crossing events recorded in the same period in 2022 ($\chi^2 = 699.41$, df = 1, p = 0.0001) (Figure 2.3.7). Elephant crossing events were reduced by 26 which were not significant ($\chi^2 = 1.2519$, df = 1, p = 0.2632). A total of 2,795 wildlife crossing events were recorded towards Mt.

Kenya forest which was significantly higher than the 1,864 crossing events recorded towards the Mt. Kenya underpass in the first half of 2023 ($\chi^2 = 186.04$, df = 1, p = 0.0001) (Figure 4.9).

b) Marania Underpass

A total of 219 wildlife crossing events were recorded which was significantly lower than the 656 crossing events recorded in the same period in 2022 ($\chi^2 = 218.25$, df = 1, p = 0.0001) (Figure 2.3.7). In the same period, elephant crossing events were reduced by 485 crossing events which were significant ($\chi^2 = 335.56$, df = 1, p = 0.0001) (Figure 2.3.8). A total of 124 wildlife crossing events were recorded towards the Mt. Kenya end pass which was significantly higher than 95 crossing events recorded towards the Mt. Kenya underpass in the first half of 2023 ($\chi^2 = 3.8402$, df = 1, p = 0.0500) (Figure 2.3.9). The underpass recorded a significant drop in crossing events following the malfunction of the camera which was successfully replaced.

c) Mount Kenya Underpass

A total of 1,756 wildlife crossing events were recorded which was significantly lower than the 2,086 crossing events recorded in the same period in 2022 ($\chi^2 = 28.345$, df = 1, p = 0.0001) (Figure 2.3.7). In the same period, elephant crossing events were reduced by 361 crossing events which were significant ($\chi^2 = 131.61$, df = 1, p = 0.0001) (Figure 2.3.8). A total of 844 wildlife crossing events were recorded towards Mt. Kenya end pass which was not significant compared to 912 crossing events recorded towards the Ngare Ndare forest in the first half of 2023 ($\chi^2 = 2.6333$, df = 1, p = 0.1046) (Figure 2.3.9).

d) Northern gap

A total of 11,257 wildlife crossing events were recorded which was significantly higher compared to 8,269 crossing events recorded in the same period in 2022 ($\chi^2 = 457.24$, df = 1, p = 0.0001) (Figure 2.3.7). In the same period, elephant crossing events increased by 997 crossing events which were significant ($\chi^2 = 109.27$, df = 1, p = 0.0001) (Figure 2.3.8). A total of 5,494 wildlife crossing events were recorded towards out of Lewa to the north which was significantly lower than 5,763 crossing events recorded towards Lewa from the north in the first half of 2023 ($\chi^2 = 6.428$, df = 1, p = 0.0112) as shown in the figures below:

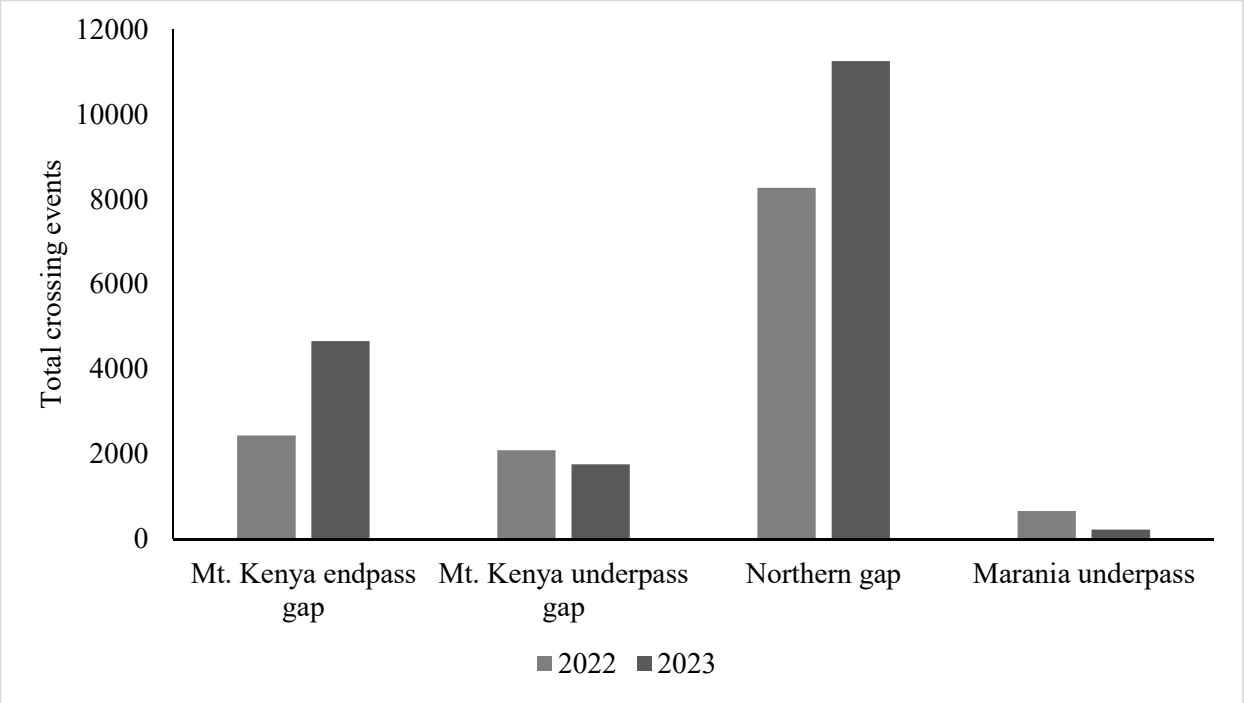


Figure 2.3.7: Total crossing events for all species

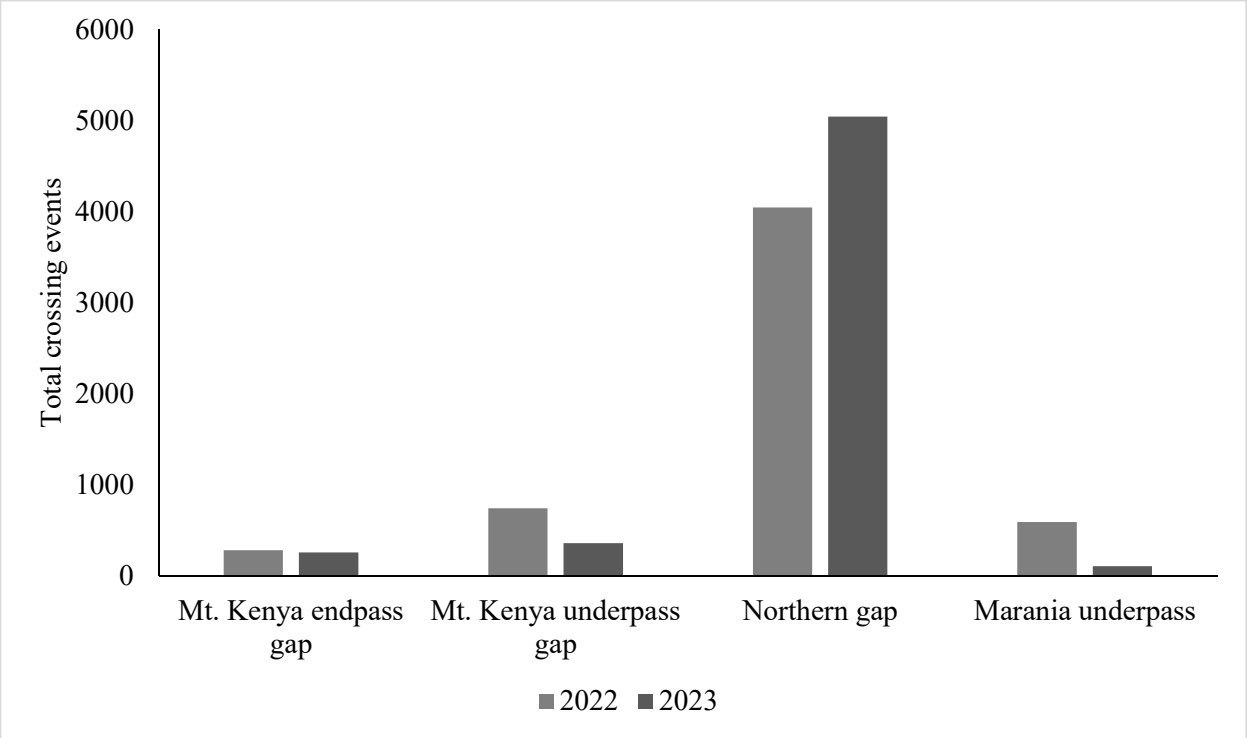


Figure 2.3.8: Total elephant crossing events

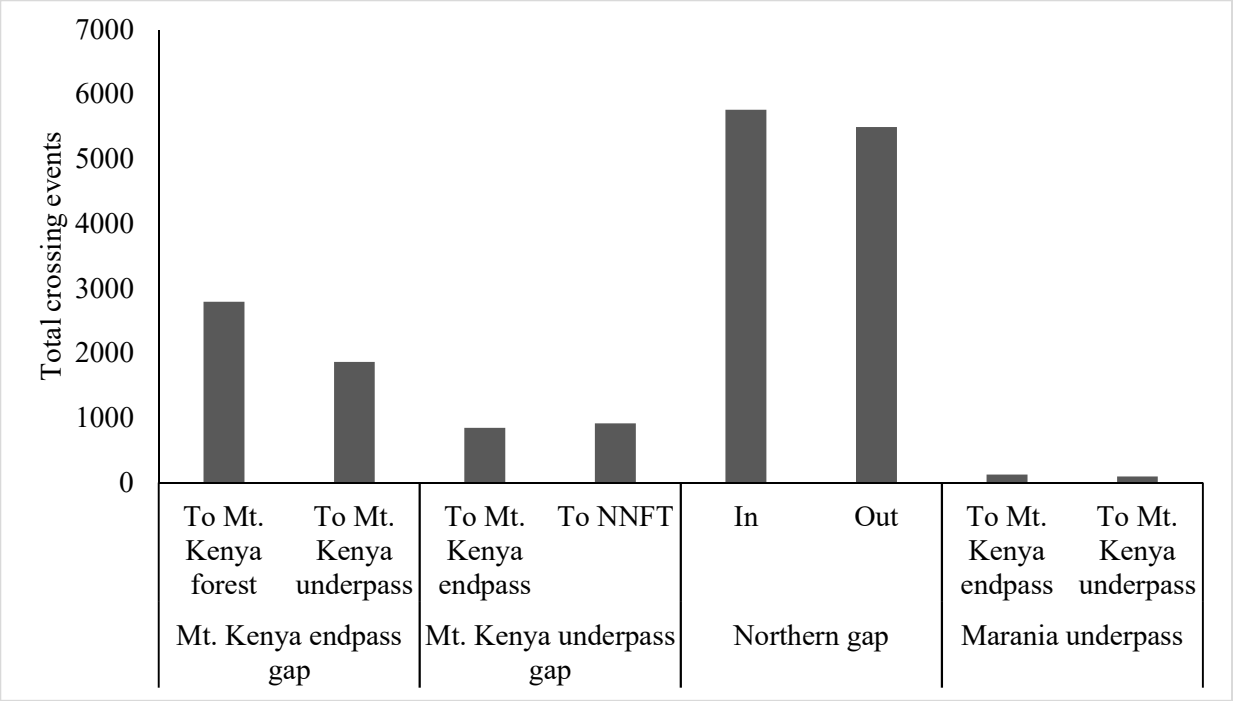


Figure 2.3.9: Total directional crossing events for all species

The Mt. Kenya elephant corridor recorded an increase in wildlife crossing activity and diversity for the first half of the year. This has especially been observed at the Mt. Kenya endpass where we observed an increase in predator activity underpinning the importance of migratory corridors. Rainfall distribution and seasonality mostly drive animal migration and dispersal (Bartzke, et al., 2018). Rainfall received in the first half of the year might have contributed to the increased wildlife movements into Lewa from the North through the northern gap.

2.3.3 Conclusion and Recommendations

Buffaloes and elands are the most affected ungulates species during the drought in this landscape, hence, a likelihood for targeted supplementally feeding during the dry periods. Being a species of key conservation concern, Grevy's zebra monitoring at the individual level remains a priority. We continue to engage the WILDBOOK team in developing a 21st-century stripe identity software that will quicken image processing and allow near real-time monitoring of Grevy's zebra dynamics.

2.4 Elephant Monitoring

The African elephant (*Loxodonta africana*) is a herbivore ranging over large areas to obtain food and water to sustain its large body mass. The species is mainly found in the forests and rangelands of Kenya playing a significant role in structuring natural vegetation in these ecosystems (Western, 2004; Dublin et al., 1986; Cumming et al., 1997). As a result of robust conservation innovation measures and increased awareness, Kenya's elephant numbers have increased despite the ever-increasing human population and habitat fragmentations (King, et al., 2011, Codron, et al., 2011). On LBL, most human-elephant conflicts happen along border lines as breakages into neighbouring farms, and a number of monitoring and mitigation measures have been implemented including the collaring of problem individuals which are monitored on the ErathRanger platform.

2.4. (i) Population demographics and trends in fence breakages

We documented 5 resident matriarchal family groups namely; *Sanaipei* (15), *Saba* (14), *Cointreau* (27), *Namaqua* (30), and *Naisula* (27). We also documented 18 lone bulls.

A total of 269 fence-breaking and 16 crawling incidences were recorded on the landscape. Out of these, 71% (n=192) occurred on the exclusion zone fence lines while 29% (n=77) were on the main boundary fence lines. All 16 crawling incidents occurred on the exclusion zone fence lines. The most affected fence line was the southwestern boundary along the Ethi community of the landscape as shown in the figure below:

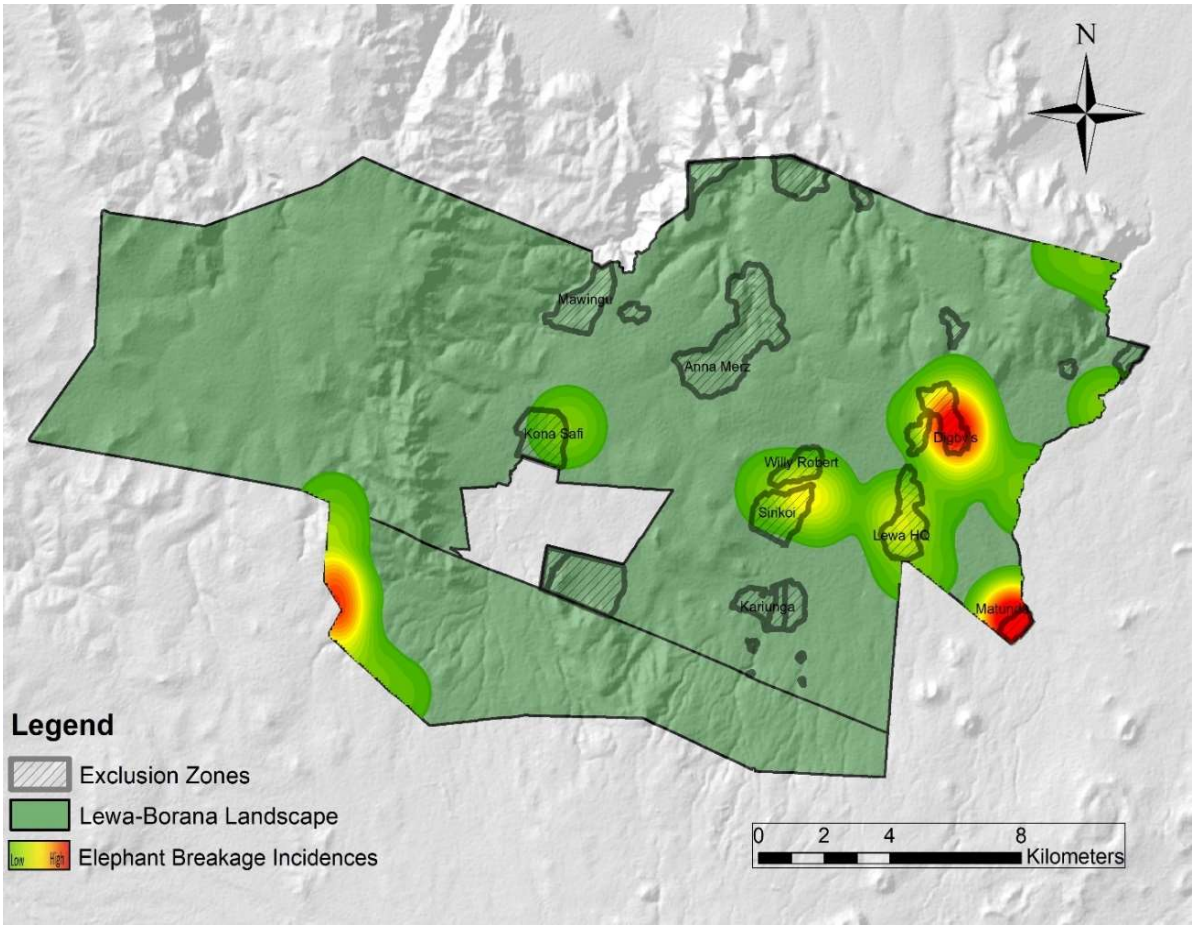


Figure 2.4.1: Heat map of elephant's breakage incidences on LBL, Jan-June 2023

Within the Lewa conservation area, *Digby's and headquarters exclusion fences* were the most affected, due to the elephants preference during the dry periods as shown in the figure below:

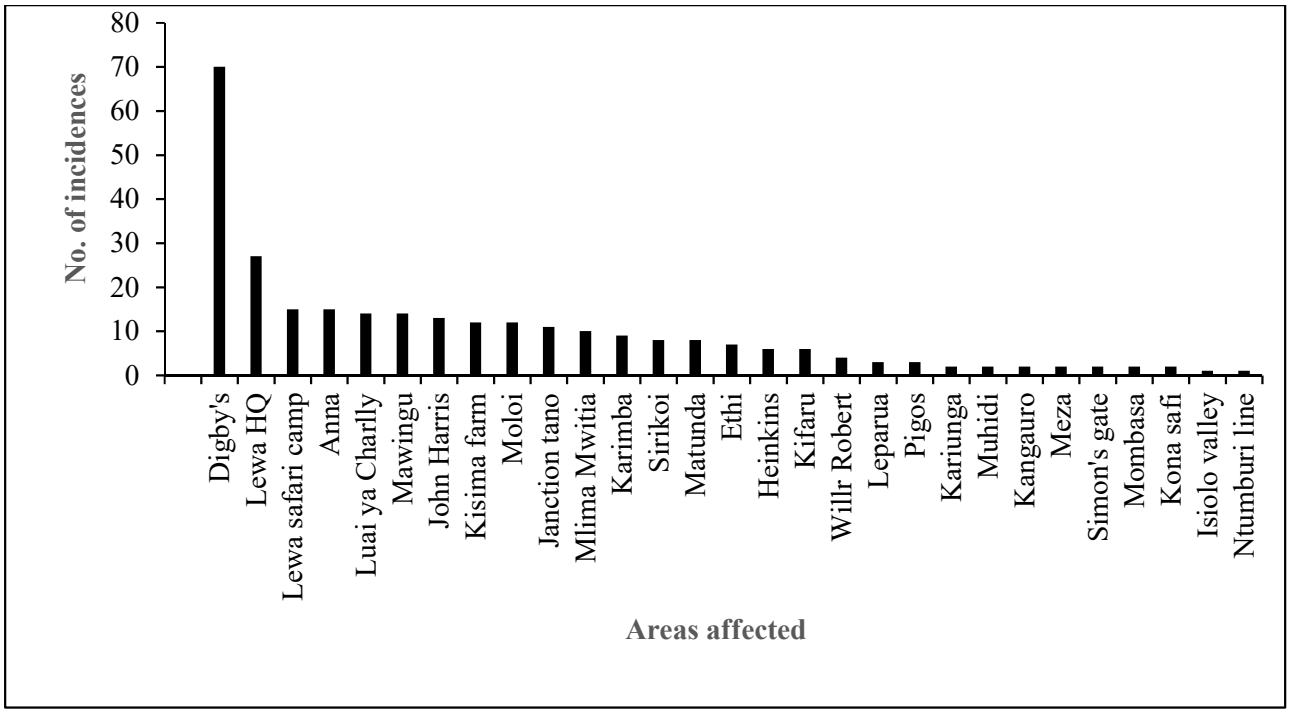


Figure 2.4.3: Incidences of breakages in various exclusion zones

Out of the 18 resident bulls, *Mjasiri, Odongo, Tyson,* and *Sahara* were identified as the most persistent fence breakers. Even though *Mjasiri* and *Tyson* had their tusks trimmed in the past, they remain persistent fence breakers using their forelimbs, trunks, and shortened tusk. The figure below shows the cumulative incidences of breakages per identified individuals in the period:

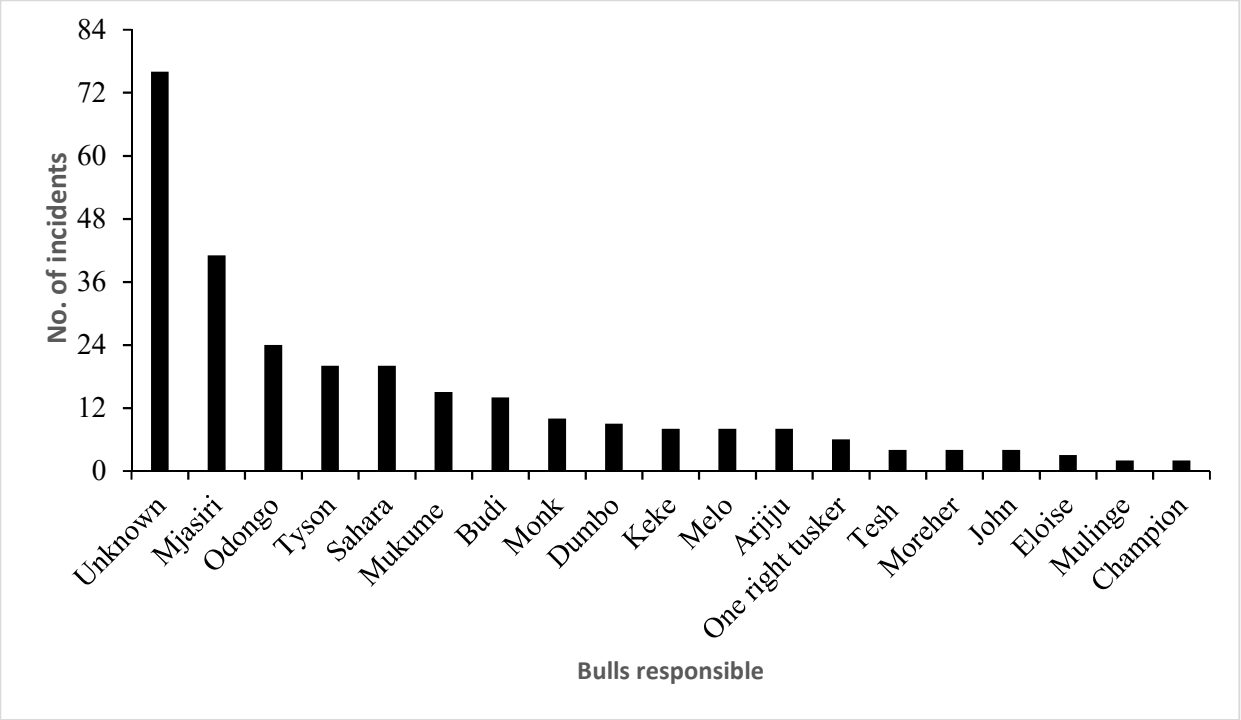


Figure 2.4.3: Distribution of breakage incidences per elephant bull

2.4.(ii) Conclusion and Recommendations

Human-elephant conflicts will continue to be a major conservation concern in communities neighbouring their ranging areas. A proactive response to conflicts remains the best way to manage these conflicts, as elephants will always learn new ways to break fences (Mutinda et al., 2014).

With increased cases of elephant incidences in *Ethi* and *Mutunyi* villages, there is a need to constantly upgrade the *Ethi* fence line with stingers and put up a 2-metre short fence with outriggers along the *Mutunyi-Ntirim* community fence line to reduce conflicts.

There is a need to continuously explore efficient and engaging conservation technologies to enhance elephant monitoring and surveillance such as Google Nest, drones, and collars.

Explore a compatible elephant database that will assist in capturing demographic data on all resident and non-resident elephants in the area.

2.5 Avifauna Monitoring

Birds community are key in maintaining viable ecosystems that also support human life in numerous ways (Sekercioglu et al., 2016). Some of these services include pest control, seed dispersal, pollination, nutrient cycling, soil formation and ecotourism (Deng & Yimam, 2020). Birds are also arguably the best-studied group of vertebrates on the planet and are observed by millions of passionate birdwatchers worldwide (Sekercioglu et al., 2016).

We monitor bird populations on LBL to build long-term datasets to provide useful information on their ecological state. During this period, we updated the bird checklist of LBL and Il Ngwesi community conservancy and conducted monthly surveys on waterbirds and raptors.

2.5.(i) LBL Bird Checklist

The LBL birds' checklist has 83 families comprising 492 species. This represents over 43% of the 1,152 total species found in Kenya (Lepage, 2023). We collaborated with LBL and NNFR birder's club to take photos to update our evidence files for the birds in the landscape, which now stands at 79% up from 78% in 2022.

We also participated in the first bi-annual global e-bird bird count for 2023 led by Cornell University, in celebrating the World Migratory Bird Day. We recorded 176 and 89 species in Lewa and Borana Conservancies respectively. The Lewa and Borana Wildlife Conservancies were ranked 3rd and 11th birding hotspots in Kenya respectively (eBird, 2023).

2.5. (ii) Waterbirds survey

Waterbirds are crucial in maintaining the diversity of other organisms by controlling pests, being effective bioindicators of ecological conditions, and acting as sentinels of potential disease outbreaks (Green & Elmberg, 2014). We monitored waterbirds on LBL to provide early warning information on the landscape water changes that could negatively affect species or ecosystems (Amat & Green, 2010).

The monthly waterbird survey recorded an average of 1,175±81 individuals of 42 species. January recorded the highest count of 2,476 individuals of 30 species while April recorded the least count

of 711 individuals of 24 species. [1]Simpson's Diversity Index (SDI) (Okpiliya, 2012) recorded a value of 0.7479, indicating a high diversity of waterbirds on LBL.

We also participated in the National Waterfowl Census for Kenya led by the National Museums of Kenya (NMK) in January and recorded a total of 2,476 individuals of 30 species of waterbirds. The figure below shows the monthly results of the monthly waterbird survey in the period:

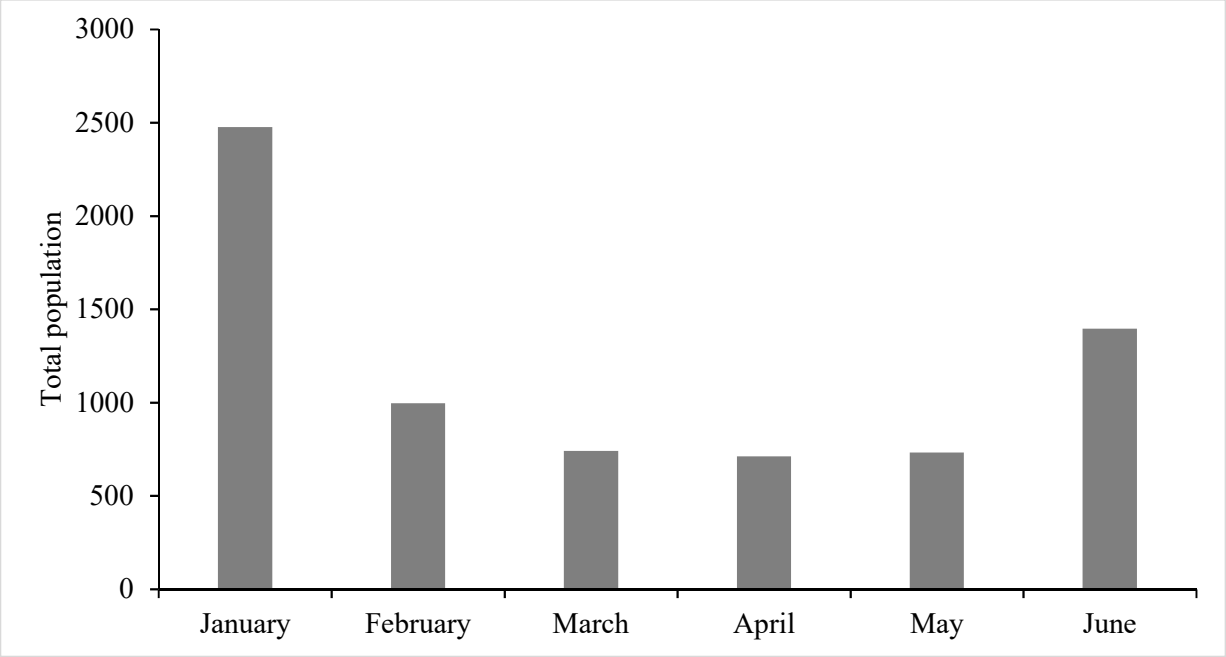


Figure 2.5.1: Monthly waterbird population from January - June 2023

2.5. (iii) Grey Crowned Crane survey

The Grey Crowned Crane (GCC) is classified as endangered by the IUCN Red List of Threatened Species (IUCN, 2023). It is therefore a species of critical conservation concern on LBL as well as at the National level. During the monthly surveys, June recorded the highest count of 86 individuals while May had the lowest count of 20 individuals. A total of 4 chicks were recorded and their monitoring is ongoing. We participated in Kenya's second countrywide census of the Grey Crowned Crane which was conducted between February and March. Lewa wildlife conservancy recorded a total of 55 individuals, Borana Conservancy had zero records and the neighbouring Ethi farms recorded 106 individuals. The Kenyan population is reliably estimated to lie between 8,500-10,000 individuals (Wamiti et al., 2023). Future countrywide surveys will

continue at 5-year intervals (Wamiti et al., 2023). The figure below shows the results of GCC surveysin the period:

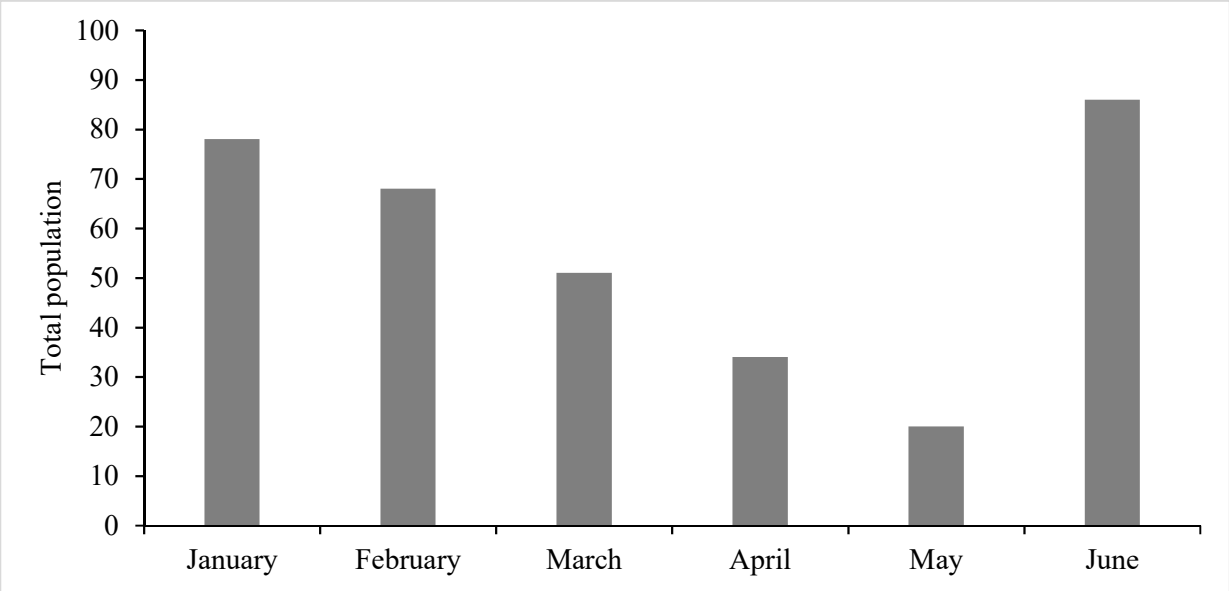


Figure 2.5.2: Total Grey Crowned Crane population from January - June 2023

2.5.(iv) Raptors survey

Raptors are indicator species that play an important ecological role in controlling populations of rodents and other small mammals (HawkWatch International, 2023). Monitoring their population trends provides a cost-effective and efficient means of detecting environmental change, allowing us to take conservation action that is driven by the latest scientific data (HawkWatch International, 2023).

Monthly raptor surveys on LBL recorded an average of 44±9 individuals of 27 species. March recorded the highest number (70) of individuals of 15 species, while June recorded the lowest count (24) of 9 species. Diversity was calculated using SDI which indicated a higher diversity (D = 0.8902) of raptors on LBL.

Eight nests were monitored where three were for the Tawny eagle (one incubating and the other two had one chick each, which fully fledged successfully), two for the Martial eagle (one repairing nest and the other one incubating), one for Bateleur (one chick present) and two for Secretarybird (incubating). The figure below shows the results of the raptors surveys in the period:

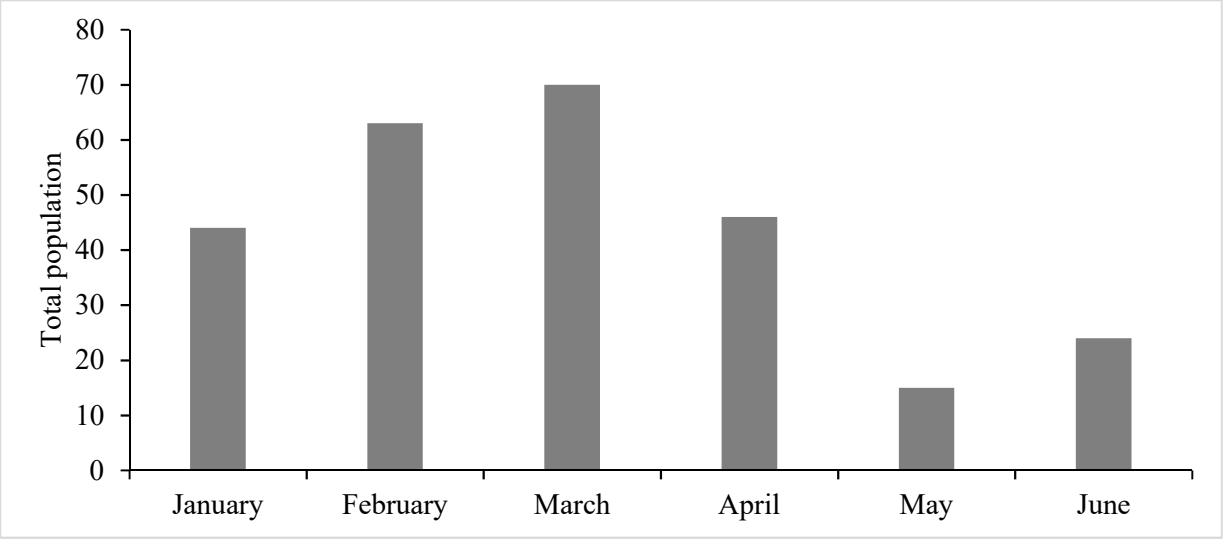


Figure 2.5.3: Total raptors population from January - June 2023

2.5.(v) Il Ngwesi Bird Survey

We conducted a bird survey for the wet season and recorded 120 different bird species. An active nest for the Tawny eagle with one chick was identified and mapped. In addition, we also identified an active roosting site for vultures. The checklist of the birds of Il Ngwesi Conservancy is currently at 235 bird species.

2.5.(vi) Conclusion and Recommendations

The avifauna monitoring indicates a high diversity of birdlife on the landscape. There is a need to continuously update the bird's checklist both on LBL and the surrounding landscapes of Ilngwesi and Leparua Conservancies since they are most adjacent and share common dispersal areas.

2.6 Herpetofauna Monitoring

Herptiles are reptiles and amphibians and they are widely spread across the globe. They inhabit terrestrial and aquatic ecosystems forming secondary consumers and essential prey for numerous tertiary consumers (Heatwole et al., 2018). Notwithstanding being widespread, they are among the most threatened vertebrates globally due to pet trade, pollution, climate change, habitat loss, and degradation (Thomson, 2016).

2.8.(i) Habitat surveys

We collaborated with the NMK, KWS, Northern Rangelands Trust (NRT) and Turtle Survival Alliance (TSA) to conduct pancake tortoise (*Malacochersus tornieri*) and terrapins (*Pelomedusa neumanni*) surveys on the landscape. The figure below shows the areas surveyed on LBLB and NRT conservancies:

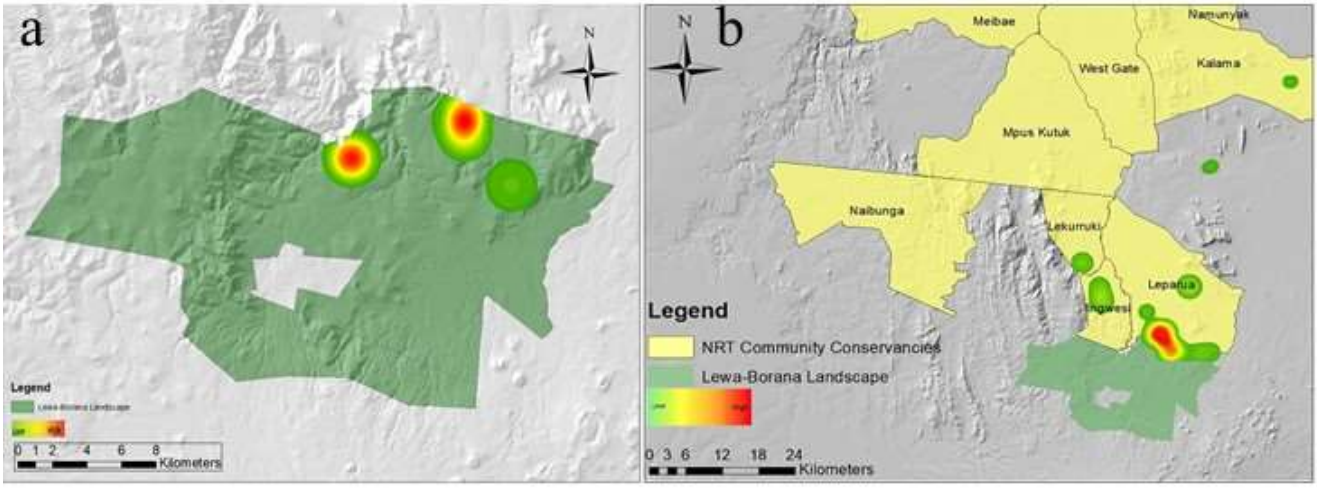


Figure 2.6.1: Heat map showing the hotspots for **a)** terrapins and **b)** pancake tortoises on LBL and NRT Community Conservancies

By mid-2023, the population of pancake tortoises (PT) and terrapins (TR) stood at 186 and 46 respectively, following 53 PT and 23 TR sighted by mid this year as shown in the table below:

Table 2.6.1: Number of Pancake tortoises and Terrapins sighted per area from 2021

Area Name	**Number Sighted**		**Mortalities**		**Total by Area**	
	PT	**TR**	**PT**	**TR**	**PT**	**TR**
Lewa – Borana landscape	80	46	2	0	78	46
Leparua Community Conservancy	21	0	0	0	21	0
Lekurruki Community Conservancy	10	0	0	0	10	0
Nasuulu Community Conservancy	7	0	0	0	7	0
Kalama Community Conservancy	11	0	0	0	11	0
Il-Ngwesi Community Conservancy	20	0	0	0	20	0
Leparua community areas	37	0	0	0	37	0
Total by Category	**186**	**46**	**2**	**0**	**184**	**46**

We captured 20 pancake tortoises in LBL. Few mortalities were noted which were attributed to trampling by herbivores while feeding.

During these surveys, we held awareness meetings with the management of the community conservancies on the identification, habitat and protection of the species. We also held an awareness meeting with Kalama, Nasuulu, Lekurruki, Il Ngwesi and Leparua Community Conservancies. This awareness meeting was meant to appraise the communities on the status, habitat and importance of protecting the species. This was the first step in the plan to develop a species recovery plan for Pancake tortoises in collaboration with relevant stakeholders.

2.6.(ii) Conclusion and recommendation

We have successfully created a datasheet for the pancake tortoises and terrapins for both the private and community conservancies. To ensure their survival and prevent extinction, it is crucial to educate residents in these areas on how to maintain and conserve them given that the majority of them were sighted on their conservancies.

2.7 Rangelands Monitoring

Rangelands are vast natural landscapes that are dominated by grasses, shrubs, and forbs and are used primarily for grazing wildlife and livestock. Rangelands constitute about 40% of the earth's land surface, which makes them crucial by virtual of the diversity they hold (Herrera et al., 2014; Thalen, 2012). This year, we monitored grass biomass, diversity and cover, as well as the forbs diversity.

2.7.(i) Grass and forbs assessment

The primary goal of the annual grass assessment on the LBL is to provide insight into the changes and state of the grass and other herbaceous cover and provide an overall insight into the range condition and possible management interventions. The grass biomass (standing crop) was estimated by dropping a calibrated 1.5kg pasture meter (DPM) and recording the mean settling height (in centimetres) of the disc. The mean height was converted to biomass estimates (Kg/ha) using a modelled regression equation developed by Botha, 1999. Additionally, grass and forbs species composition was determined using a pin-hit after every 1 metre along a 100m transect.

2.7.(ii) Results and discussion

Results indicate a significant difference in mean biomass across the years (2011-2023) ($F_{(1, 406)} = 5.598$, $p = 0.0184$) (Figure 2.7.1). Generally, biomass has been decreasing occasioned by the low

erratic rains in the landscape for the last two years. However, this year's biomass has slightly increased possibly due to the considerable rains received by June. In 2023 there was no significant difference in mean biomass across the four management units (F – Forest, RV – Riverine, R – Rocky, and P – Plains) ($F_{(3, 30)} = 1.661$, $p = 0.196$). The figure below shows the trends of the mean biomass levels:

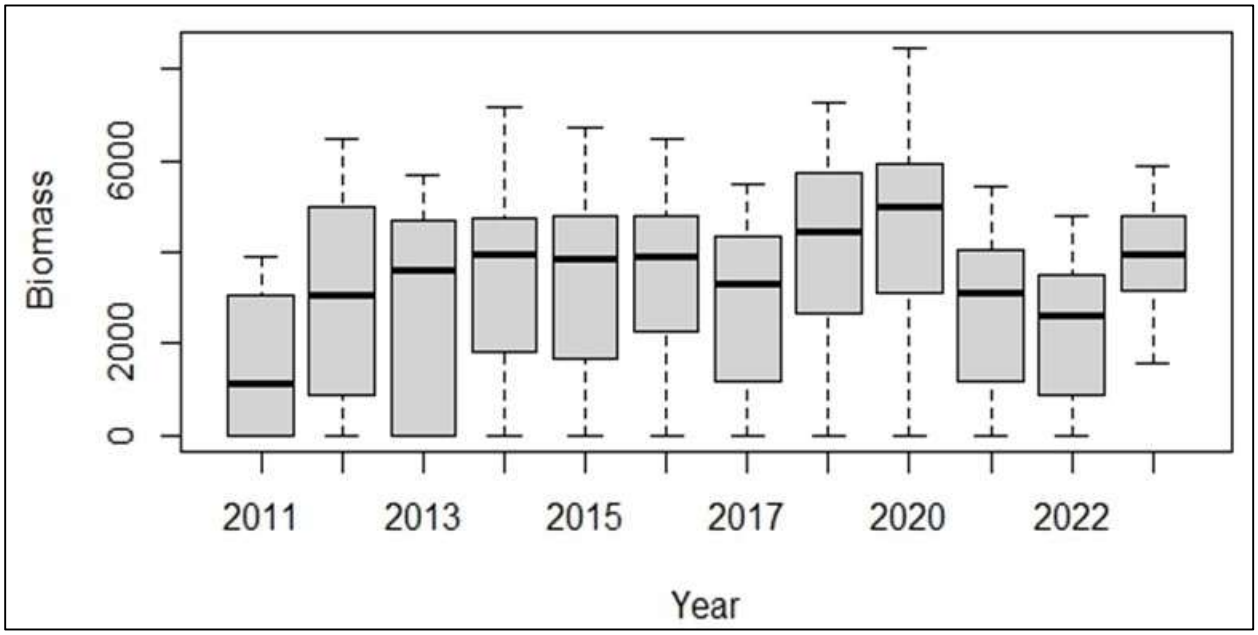


Figure 2.7.1: Annual fluctuations in mean grass biomass from 2011 – 2023

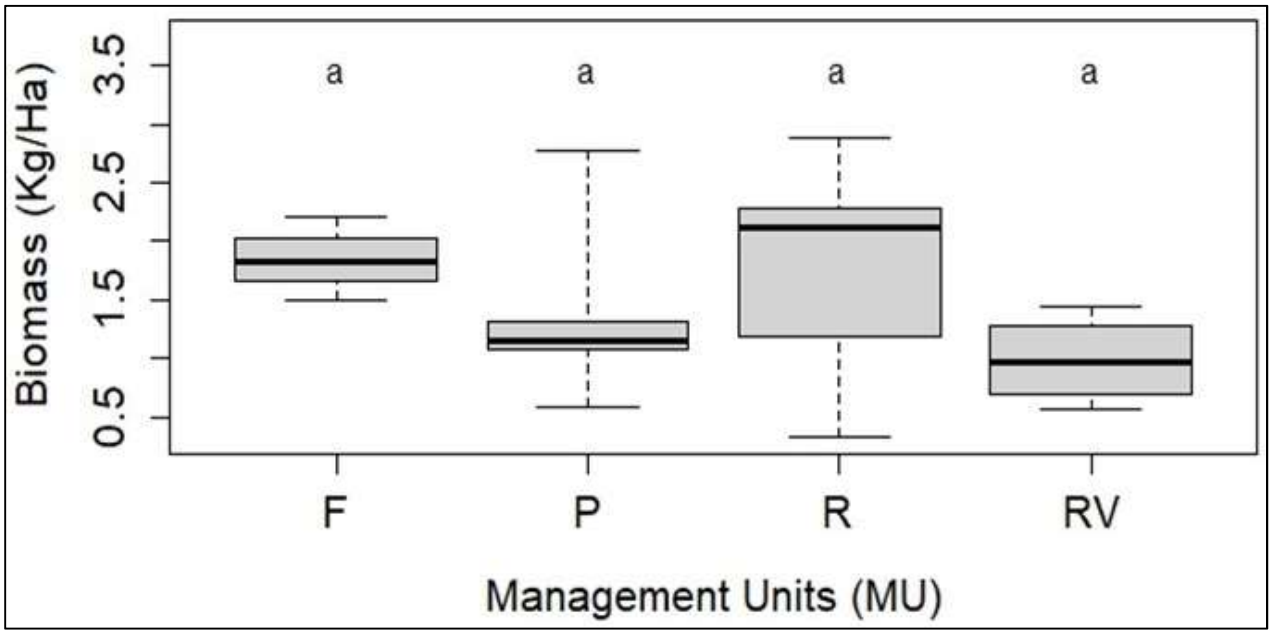


Figure 2.7.2: Mean grass biomass across management units in 2023

There was a significant variation in mean diversity across years (2011 – 2023) ($F_{(1, 406)} = 92.42$, $p = 0.0001$). The current year had slightly higher diversity due to higher rainfall, compared to the last two years in the same period. The figure below shows trends in annual fluctuations in grass diversity for the last few years:

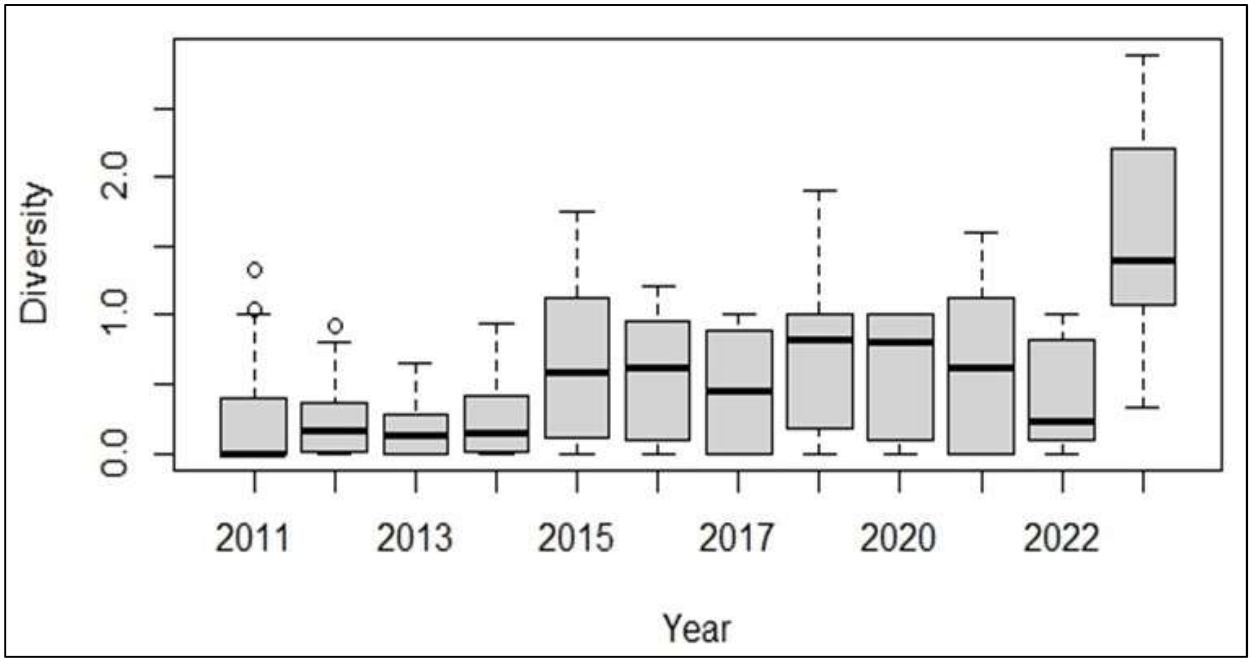


Figure 2.7.3: Annual fluctuations in mean grass diversity from 2011 – 2023

Forest and Rocky management units recorded slightly higher diversity during the year compared to the rest, though the differences were not significant (MU) ($F_{(3, 30)} = 2.266$, $p = 0.101$). In many instances, rocky and forested habitats record higher species diversity because rocks and trees protect the ground against direct sunlight thus preserving moisture and creating a favourable environment for vegetation growth (Prato & Fagre, 2010; Lunney & Hutchings, 2012). The figure below shows the mean grass diversity across the four management units:

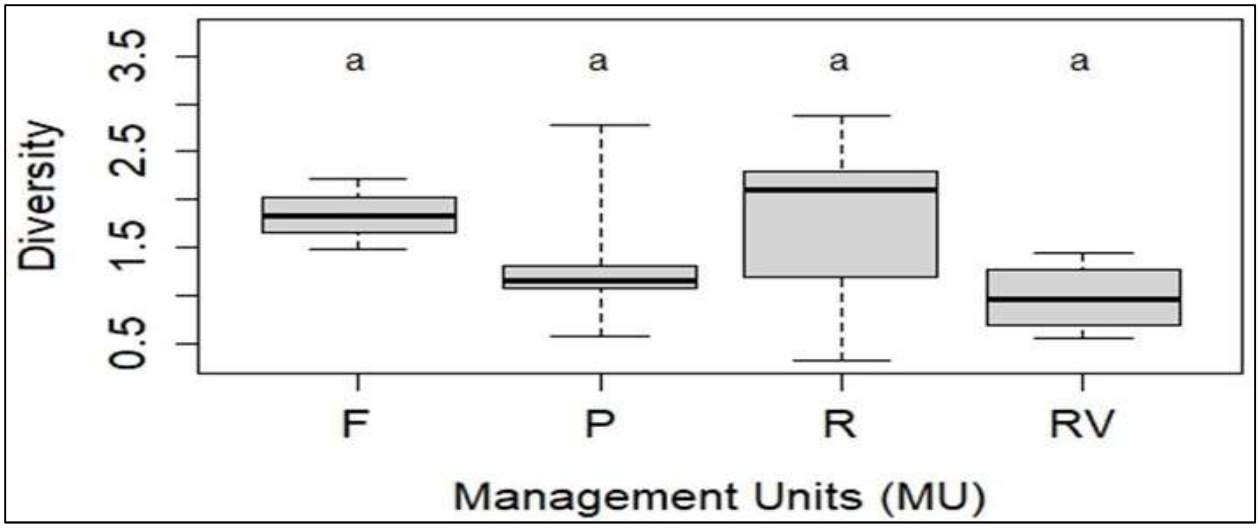


Figure 2.7.4: Mean grass species diversity across management units in 2023

The percentage of grass and forb cover compared to other species across the management units was 60%, with the forest unit bearing a higher percentage of plant cover, as shown in the figure below:

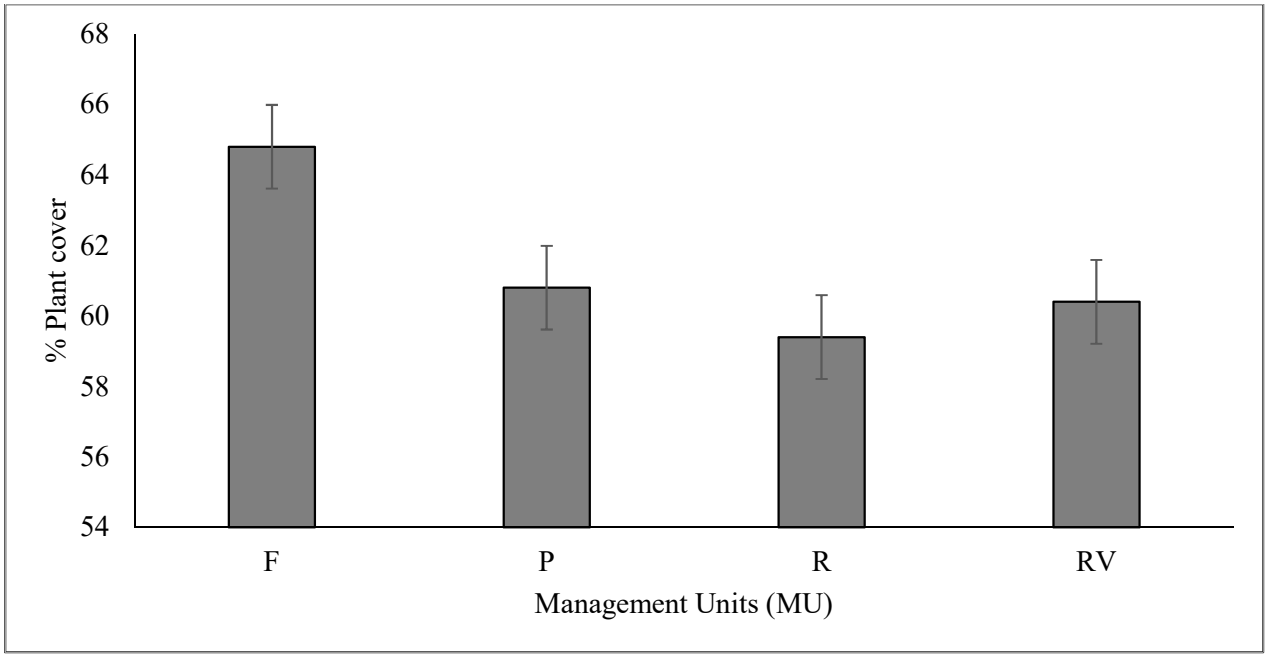
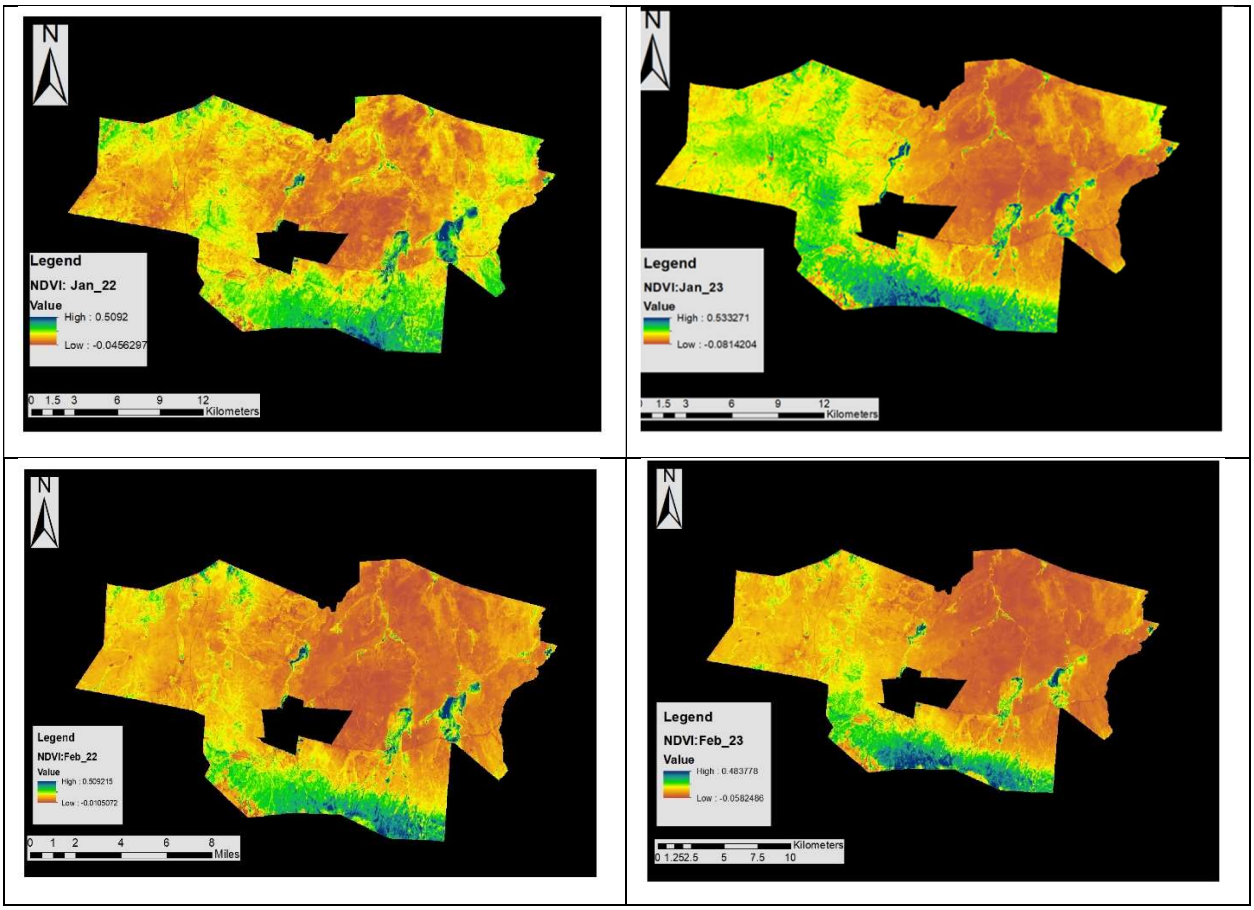


Figure 2.7.5: Mean percentage plant cover across management units in 2023

2.7. (iii) Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) is a widely-used metric for analyzing the health and density of vegetation by quantifying their level of greenness. It measures the difference

between near-infrared (NIR) data which vegetation strongly reflects, and red (R) light which vegetation absorbs (Lemenkova, 2015, Maringa, 2018). The NDVI ranges from -1 to +1. The higher the NDVI value, the denser and healthier the vegetation is. We downloaded free Landsat 8 imageries from the United States Geological Survey (USGS) Earth Explorer platform and produced NDVI maps using ArcMap 10.8.2 to compare the level of greenness between 2023 and 2022. The maps show that the year 2023 was more greener and healthier especially from April to June compared to the same period in 2022. The NDVI images also show that Ngare Ndare Forest and Borana Conservancy were healthier compared to the Lewa section of the landscape in most of the months. The figures below show the results of NDVI:



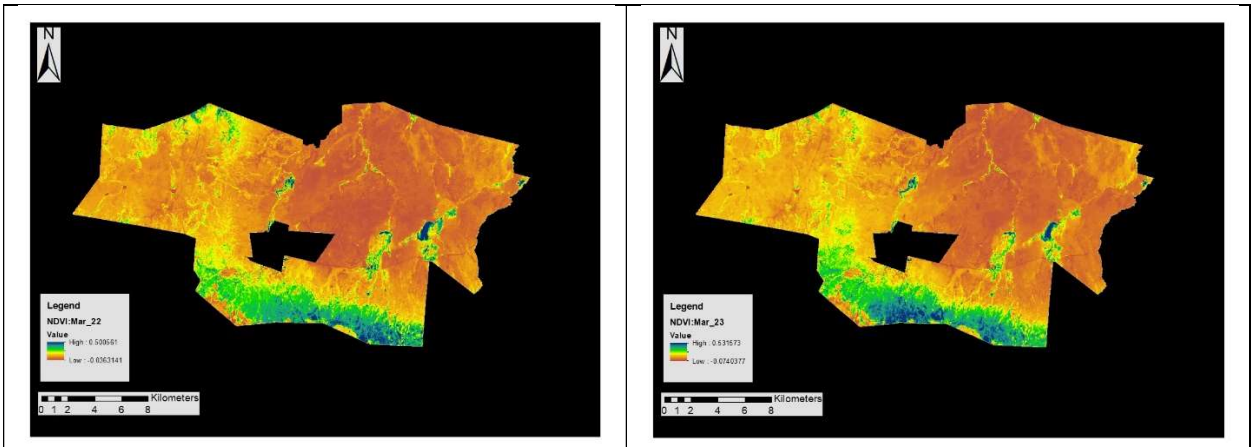
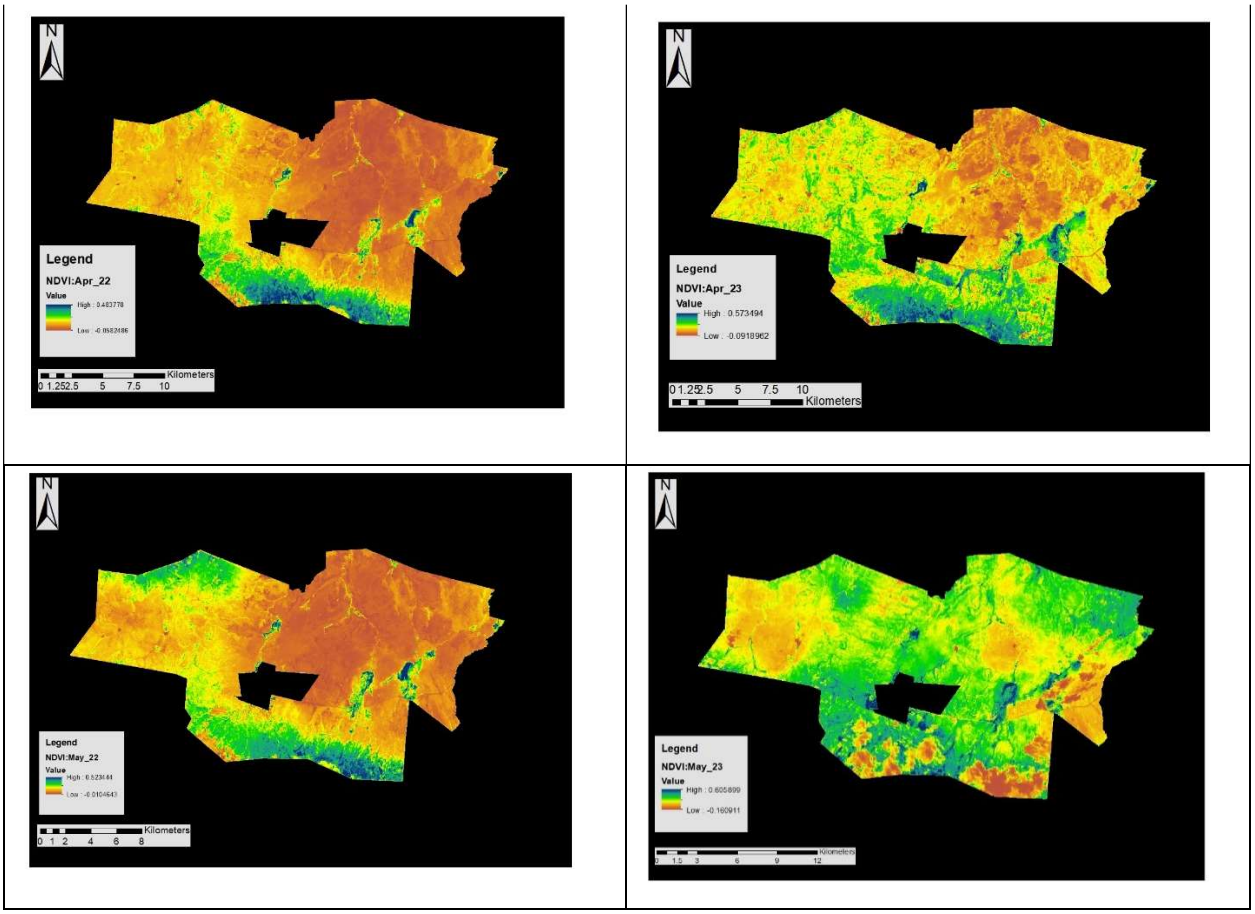


Figure 2.7.6a: Comparison of NDVI for the Lewa - Borana Landscape in the year 2022 and 2023



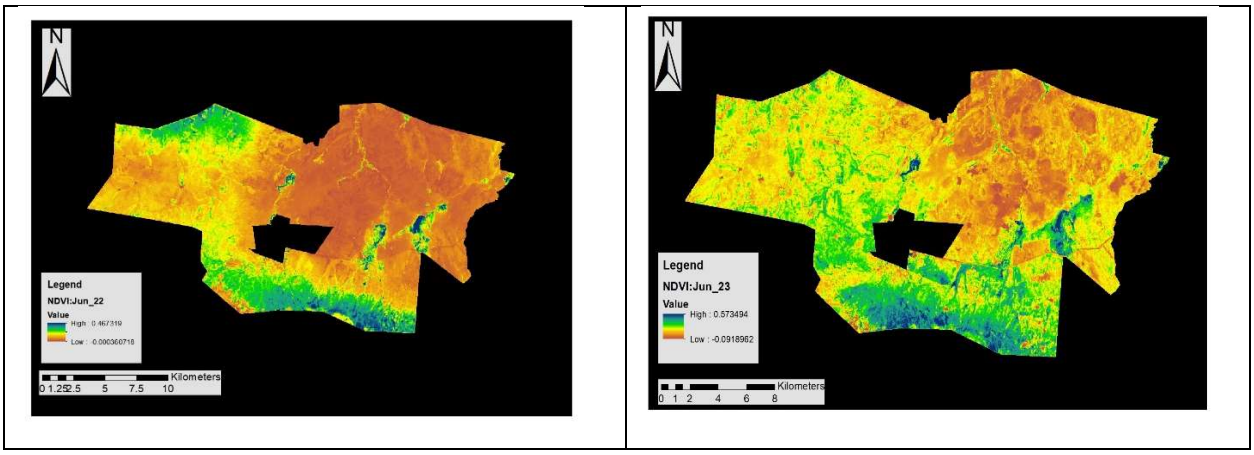


Figure 2.7.6b: Comparison of NDVI for the Lewa - Borana Landscape in the year 2022 and 2023

2.7. (iv) Alien and invasive species management

Alien species are plants that have been introduced into an ecosystem outside their native range. These species become invasive when they reproduce and spread quickly thus dominating and displacing other native species in a landscape (Pullaiah & Ielmini, 2021).

A total of 7 alien and/or invasive species namely Thorn apple (*Datura stramonium*), Long-spined thorn apple (*Datura ferox*), Long-spine cactus (*Opuntia exaltata*), Prickly pear (*Opuntia ficus-indica*), Khaki weed (*Alternanthera pungens*), Mexican prickly poppy (*Argemone Mexicana*), and Mathenge *(Prosopis juliflora*). We managed to reduce the spread of *Datura stramonium*, *Argemone mexicana*, and *Datura ferox* mechanically by uprooting burying as shown in the figure below:

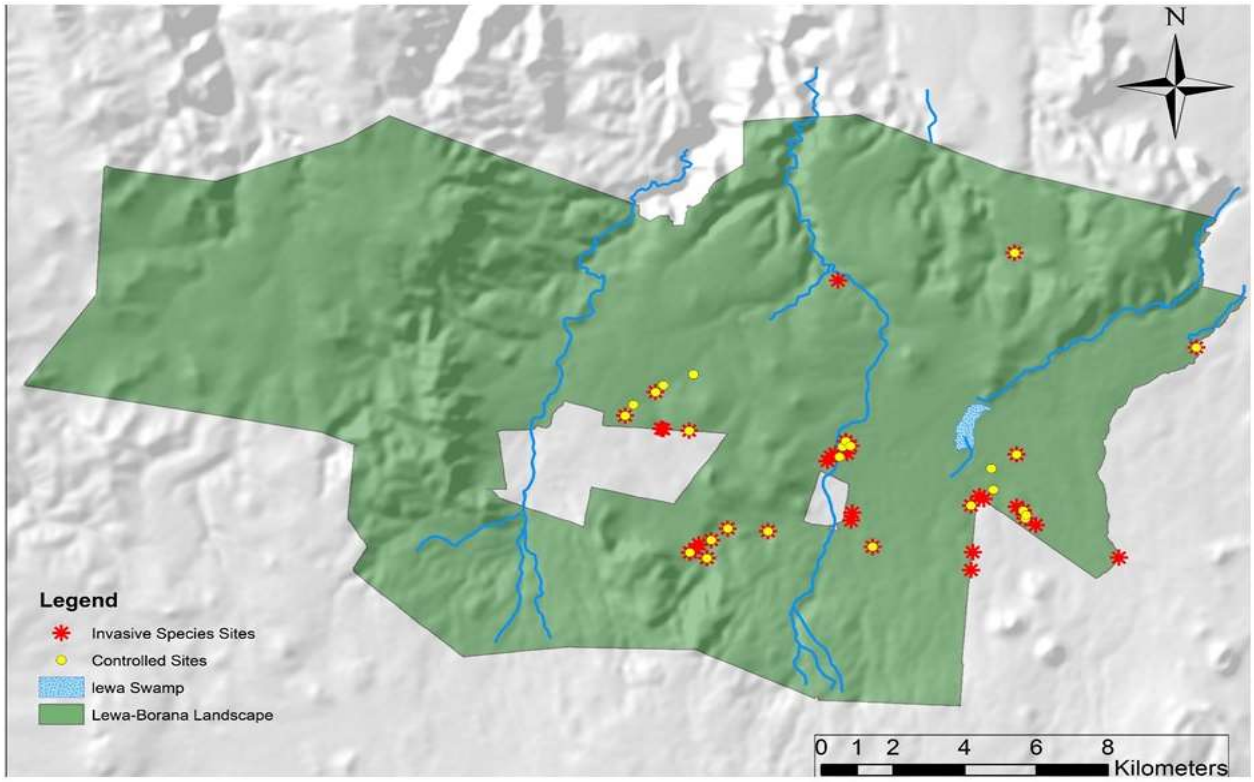


Figure 2.7.7: Shows the occurrence of the alien/invasive species in general and the controlled sites.

2.5. (v) Conclusion and recommendations

Invasive species can negatively affect rangeland conditions leading to reduced vegetation cover and altered species composition. We recommend continuing with mechanical removal to keep them at a manageable level.

2.8 Hydrological Monitoring

2.8. (i) Rainfall

The first half of the year 2023 received an average rainfall of 266 mm, which was slightly above the long-term (1975-2022) average of 232±12mm, and significantly higher than the 181mm received in 2022 for the same period. In both data periods, the Borana side received more than the Lewa side of the Landscape. The cumulative average rainfall trends on the landscape are as shown below:

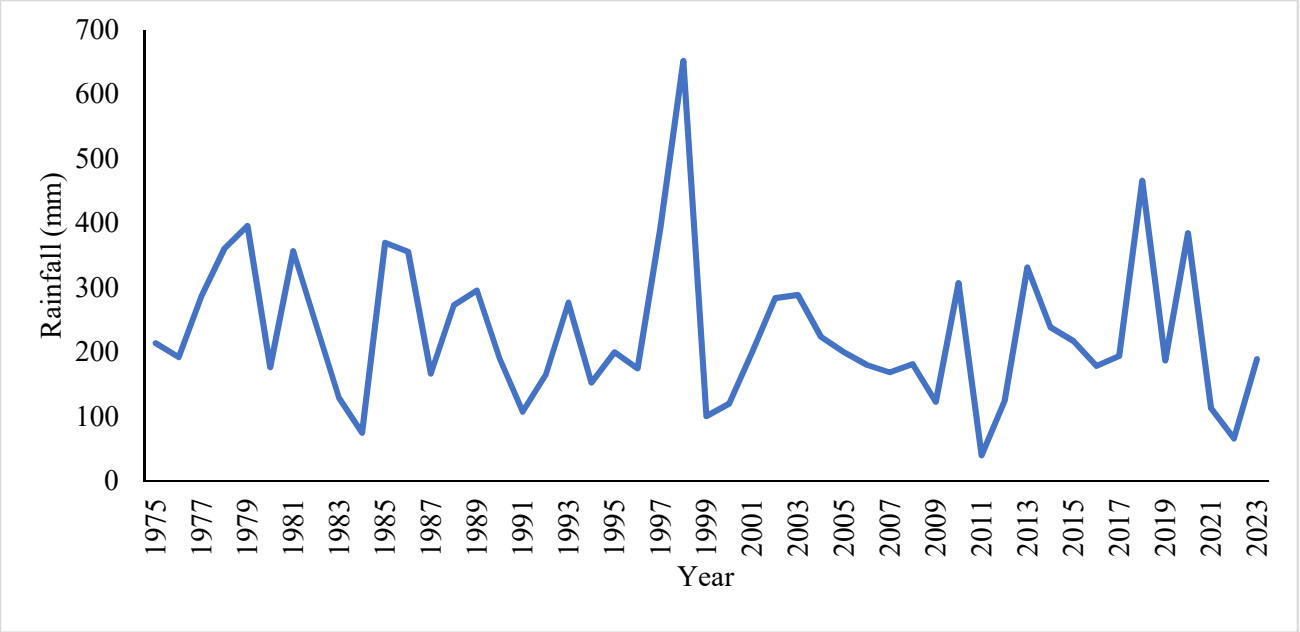


Figure 2.8.1: Cumulative rainfall January-June, 1975-2023

2.8. (ii)Spring monitoring

We monitored the flow rates of the Ngare Ndare and Ngare Nyting rivers using automated River Gauging Systems (RGSs). The data collected from the three RGSs has been computed to generate the rating curve/stage-discharge equations. The Centre for Training and Integrated Research in ASAL Development (CETRAD) has completed the calibrations for the RGSs and is currently finalizing an official handover and training on spring monitoring for Lewa. The flow rate was higher in the Ngare Ndare River compared to the Ngare Nything River. This was attributed to higher rainfall received at Ngare Ndare forest thus increasing spring volume as seen in figure 2.8.2 below;

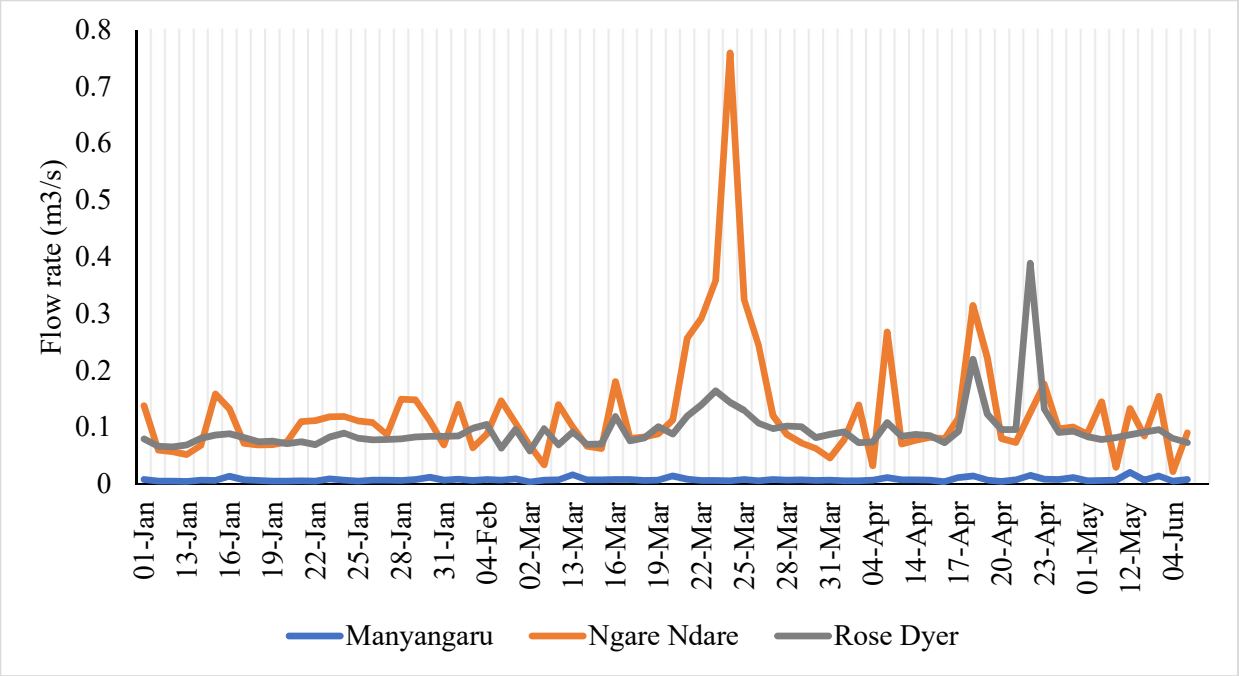


Figure 2.8.2: Flow rates by 3 RGS on Ngare Ndare and Ngare Nyting rivers

2.8. (iii) Weather monitoring

The Automated Weather Stations (AWS) stationed on both sides of the landscape have been recording important weather data. These include humidity, temperature, pressure, rainfall, irradiation and dewpoint. The relative humidity increased with rainfall and vice versa as seen in Figure 2.8.3a & b. The atmospheric pressure decreased with an increase in temperature as seen in figures 2.8.4a & b. More interpretation will be done as we accumulate data and after the scheduled training on reporting and monitoring climate metrics by the CETRAD.

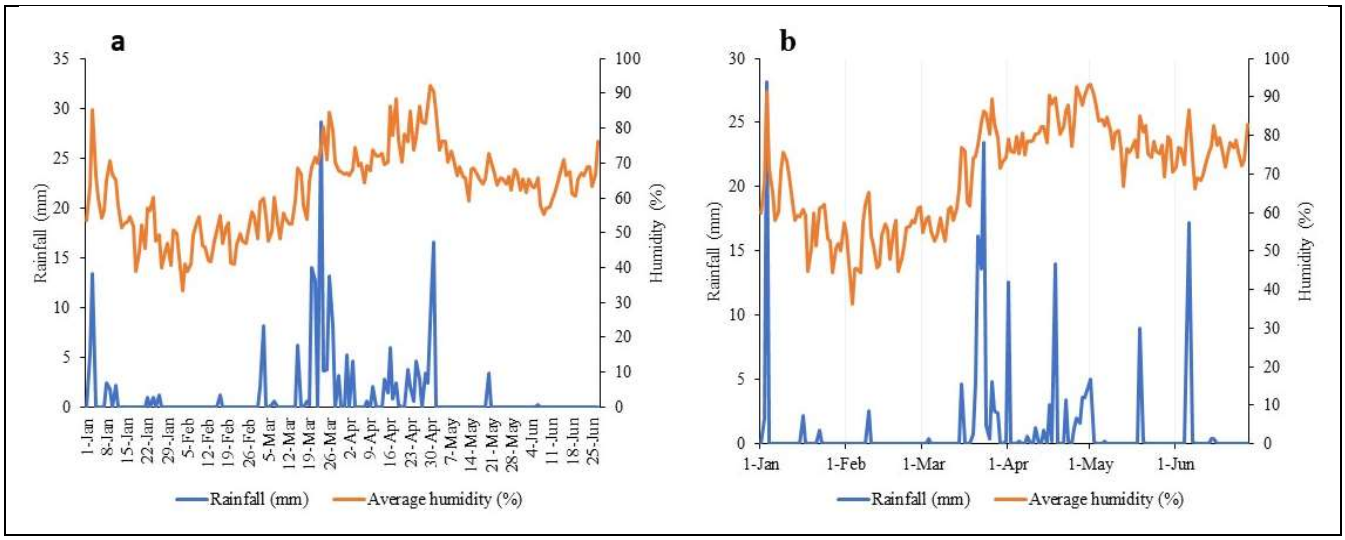


Figure 2.8.3a) Lewa rainfall and average humidity from January - June 2023 and **b)** Borana rainfall and average humidity from January - June 2023.

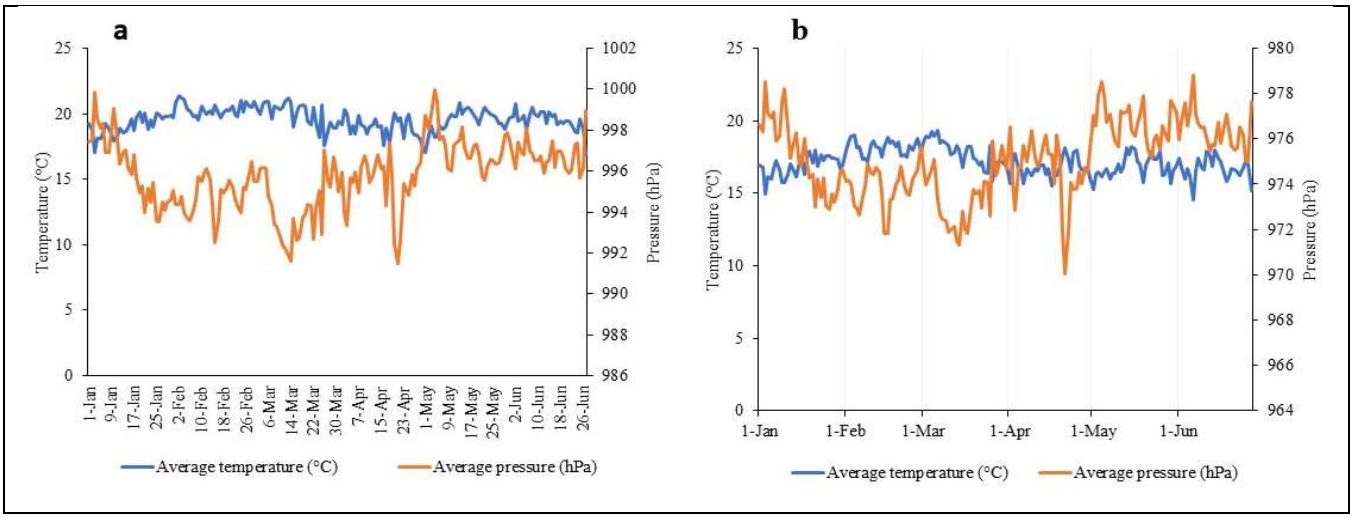


Figure 2.8.4b) Lewa average temperature and pressure from January - June 2023 and **b)** Borana average temperature and pressure from January - June 2023

2.8. (iv) LBL Hydrological survey

The comprehensive hydrological survey for LBL and neighbouring areas in partnership with local WRUAs is currently ongoing. The survey is being led by water resource consultant, Rural Focus Limited. The data collection was conducted between September 2022 and April 2023, capturing ground and surface water resource data as well as hydro-metrological data. Groundwater isotopic analysis and full chemical analysis of both surface and groundwater were completed in May 2023. The reports covering groundwater, surface water and climate/rainfall have been generated by the

consultant. Currently, the consultant is preparing to share the reports and organize a forum for presenting the findings to the involved stakeholders.

3.0 CONSERVATION EDUCATION PROGRAMME

In the first half of the year, the CEP hosted 70 school groups with a total of 2,005 individuals. We organised and led a cleanup exercise in Manyangalo village to celebrate World Environment Day and visited 16 schools for outreach activities with a total of 1,153 learners. We also distributed 1,600 seedlings to 9 schools during the period while delivering conservation lessons to students, teachers and parents.

We conducted three workshops for school leaders where we reached out to 27 teachers and 24 school Principals from the Lewa-supported schools. The workshops focused on how to integrate conservation education into the school curriculum. We also conducted training on utilizing simulations to enhance Science, Technology, Engineering and Mathematics (STEM) courses. This was attended by 45 teachers from Lewa-supported schools and other neighbouring institutions.

During this period we expanded the CEP exhibits room, upgraded the CEP garden, and constructed the waste holding unit and the glass bottle recycling exhibits. Two interns were engaged in the program to help them gain hands-on experience while also supporting program activities.

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