Lewa Wildlife Conservancy

Research & Monitoring Annual Report 2005

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A big thank you to the security field personnel and other staff who give logistical support and facilitation to the Department.

EXECUTIVE SUMMARY

A number of research and monitoring activities were carried out on Lewa Wildlife Conservancy (LWC) by the Research and Monitoring Department in 2005 aimed at answering specific management questions and to provide long term data on performance of species and habitats.

Black rhino

The population of black rhinos stood at 45. There were five births representing a growth rate of 12.5%. Age at first calving was 7.3 years while mean inter-calving interval was 2.7 years (N=39 births). A comparison of LWC's population against standard benchmarks for evaluating performance of black rhinos (age at first calving, inter-calving interval, percentage of calves in the population, sex ratio) revealed that the population performance was above average. Body condition reduced for all rhinos because of the drought. Two rhinos were ear-notched to assist with identification.

It was recommended that the 9.8 year old bull – Stella, be moved out of LWC due to regular fights he was having with two other breeding bulls. Similarly, the estimated carrying capacity (ECC) was 50, and is almost being reached. Hence, there will be need to explore options to maintain the population at below ECC if the rhinos' breeding performance is to be maintained. Similarly, the sex ratio should be maintained at 1 male:>1 female.

White rhino

The population of white rhinos stood at 37. There were two births in the year and four deaths. Age at first calving was 7.9 years and inter-calving interval was 2.5 years (N=37 births). The performance of white rhinos on LWC was sub-optimal due to the biased sex ratio in favour of males. *Consequently, it was recommended that Kingi, Muya, Nengotiei and Warges should be moved out of LWC.*

Grevy's zebra

The Grevy's zebra population stood at 448 compared to 435 in 2004. At least 75 foals were born in the year. Survival rate of these foals at the close of the year was 72% which was higher than in 2003 and 2004. However, this rate is expected to further reduce as monthly foal patrols continue in 2006, and foals are monitored through to one year.

Twenty six Grevy's zebra and 36 Plains zebra died during the year. 83% of these deaths were predation related. Analysis of lion scat revealed that lions were preferentially killing Grevy's zebra compared to Plains zebra. Predation continued to be a major factor limiting recruitment rates of Grevy's zebra. *It was recommended that lion numbers be reduced on an adaptive management technique through translocation and contraception in collaboration with the Kenya Wildlife Service. The remaining population of lions should then be managed at the appropriate level.*

General Wildlife Monitoring

The annual game count showed that there were variations in the trend of key species when compared with previous years. Waterbuck and eland increased by 123% and 56% respectively while the populations of oryx and ostrich reduced by 42% and 29% respectively. Elephants continued to utilise LWC as a dry season feeding ground that resulted in extensive destruction of the vegetation. *It was recommended that further exclusion zones be established to protect key black rhino habitats against elephant destruction.*

Rainfall

LWC received 287 mm of rainfall. This was below the long term mean rainfall of 545 mm. This resulted in poor forage availability. Consequently, supplementation of the feed of rhinos and other key species with Lucerne was initiated. *LWC should maintain the policy of supplementing the feed of rhinos especially the lactating females together with other key species whenever there is a dry spell*.

Range Management

Cool fires were applied in five blocks to remove the moribund grass material. Pre- and post-burn monitoring was done in these blocks to assess the impact of fire. Most of the trees showed signs of coppicing and shooting after the fire. *It was recommended that in future, only cool fires should be effected on LWC. Such fires cause minimal damage to the trees, remove the moribund grass material and maintain the grass biomass to low levels for an extended period of time compared to hot burns.*

Community Livestock Grazing

Over 3,000 heads of community livestock were allowed access to LWC to graze down and trample the moribund grass material on blocks that otherwise would have been subjected to prescribed burning. Such grazing reduced the biomass of grass by a significant margin. *It was recommended that for meaningful reduction of biomass of grass, cattle should be allowed in Pennisetum stramineun/P. mezianum dominated blocks when the grass is relatively green.*

Illegal Road Network

Over 80 km of illegal tracks were mapped in September 2005. This translated to massive destruction of vegetation. *It was recommended that off road driving should not be allowed, except by management when monitoring, capturing or treating key wildlife species*.

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1.0 RHINO MONITORING

1.1 Status and performance of black rhinos on LWC, December 2005

The population of black rhinos on LWC stood at 45 animals. There were 15 calves (0≤3 years), 10 sub-adults (3≤6 years) and 20 adults (>6 yrs) (Table 1.1). The sex ratio of males:females was 1:1.3 with 4 unsexed calves.

Five calves were born in 2005 (Figure 1.1). Stumpy, Mawingo, Zaria, Sonia and Natumi gave birth to their seventh, fifth, fourth, third and first calves respectively (Appendix 1). It was predicted that six females will calve in 2006. These were: Samia, Nashami, Oboso and Waiwai – 3rd generation; Juniper – 2nd generation; and Solio – 1st generation. Calving prediction is based on the respective females' mean inter-calving interval and calving at 7 years (Macdonald, 2001) for females that have not calved before. Apart from 2001 when only one calf was born, at least two calves have been born annually since the El Nino rains of 1998 (Figure 1.1; Appendix 1).

Table 1.1: Sex and age classes of black rhinos on LWC, December 2005

Age class	Males	Females	Not sexed	Sub-total
Calves (0≤3) years	7	4	4	15
Sub-adults (3≤6 years) unless calved	4	6	-	10
Adults (>6 years)	7	13	-	20
Grand total	**18**	**23**	**4**	**45**

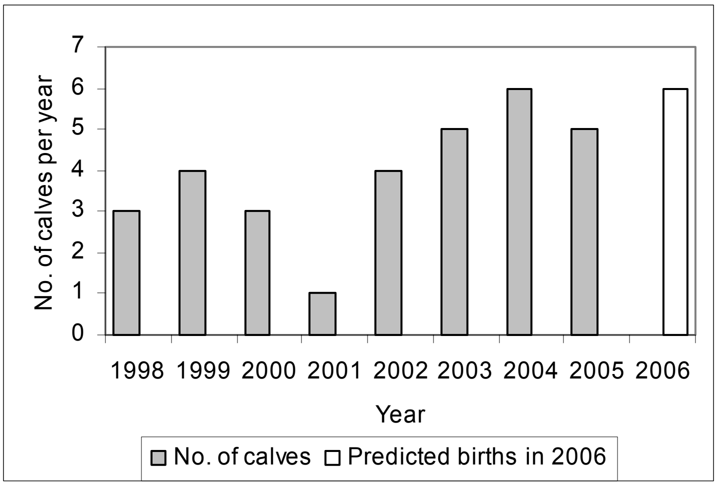

Figure 1.1: Number of black rhino calves born per year on LWC since 1998

Most of the second and third generation females have calved either once or twice in their lifetime. However, two females (Solio - 30 years; and Stumpy - 37 years), both founder animals of the population of LWC have each calved seven times. Stumpy may still calf once more before natural attrition takes over considering that the lifespan of black rhinos in the wild is approximately 40 years (Macdonald, 2001).

1.2 Benchmarks for assessing the performance of black rhino populations

There are various forms of biological data on rhinos that if collected and analysed systematically, can inform decisions about the management of populations. In addition, the resulting demographic and reproductive output can be used to compare the performance of different populations over time on a scale of standard benchmarks (Table 1.2) (Adcock 1999; du Toit *et al*., 2001). These benchmarks include: average annual growth rates; rhino density; mortality rate; adult sex ratio; inter-calving interval; percentage of females calving per year; age at first calving; and proportion of calves in the population.

When LWC's black rhinos are compared against these benchmarks, it is evident that the performance of the population is above average (Table 1.2).

Table 1.2: Benchmarks for rhino population performance - adapted from Adcock (1999) and du Toit *et al*., (2001)

Population indicators	Very poor-Poor	Poor-Moderate	Moderate-Good	Good- Excellent	Lewa
Bio. G.R.	<2.5%	2.5 – 5.0%	5.0 – 7.5%	>7.0%	**12.5%**
Mot.R	>4%	-	-	-	**-**
SR	1M:<1F	1M:<1F	1M: 1F	1M: >1F	**1M:1.3F**
ICI	>3.5 yrs	3.5 – 3.0 yrs	3.0 – 2.5 yrs	<2.5 yrs	**2.7 yrs**
%FC	<29%	29 – 33%	33 – 40%	>40%	**38.5%**
AFC	>7.5	7.5 – 7.0 yrs	7.0 – 6.5 yrs	>6.5 yrs	**7.2 yrs**
%CP	-	<28%	=28%	-	**33%**

Key:
Bio. G.R. – Biological growth rate
Mot.R – mortality rate
SR – Sex ratio
ICI Average inter-calving interval
%FC – Percentage of females calving per year
AFC – Age at first calving
%CP – Proportion of calves (<3 years) in population

1.2.1 Biological growth rate

Rhinos are large bodied or K-selected species with low reproductive rates. They have a maximum intrinsic rate of increase of about 9-9.4% per annum (Emslie, 1999).
Taking into account mortality and natality rates, a population that has an average growth rate >7%[1] is considered to show excellent performance (Table 1.2).

From 2004-2005, LWC's rhinos had an average growth rate of 12.5% implying that the population is increasing at maximum rate. This is consistent with similar positive growth rates recorded from 1992 to 2003 when calculated on a 3-year moving average (Okita, 2004). Similarly, this growth rate is higher than the 5% metapopulation growth rate targeted in Kenya's Black Rhino Strategy Plan, 2001-2005 (KWS, 2003).

[1] This growth rate may however be misleading in small populations where addition or removal of one animal is equivalent to a high percentage.

If LWC's growth rate is sustained, options to reduce excess animals will need to be considered since the Conservancy's ecological carrying capacity (ECC) may be lower than 50 animals as estimated by KWS (1993). This is due to destruction and reduction of key rhino habitats by elephants observed over time.

1.2.2 Inter-calving interval

The average inter-calving interval (ICI) calculated for 9 females whose calving history was well known, was 2.7 years representing "moderate to good performance" (Table 1.2). Average inter-calving intervals for individual females ranged from 2.0-3.6 years (Figure 1.2). Specific females, for example Mawingo, Juniper and Zaria had reduced their inter-calving intervals to the "excellent" scale i.e. less than 2.5 years (Table 1.2; Appendix 1).

Extended inter-calving intervals were initially recorded in females introduced in the Conservancy in 1984. However, over time, such females have managed to reduce their inter-calving intervals considerably (Figure 1.3). This may be due to the fact that the founder population of females has overcome the initial translocation stress and adapted to the Conservancy's environment.

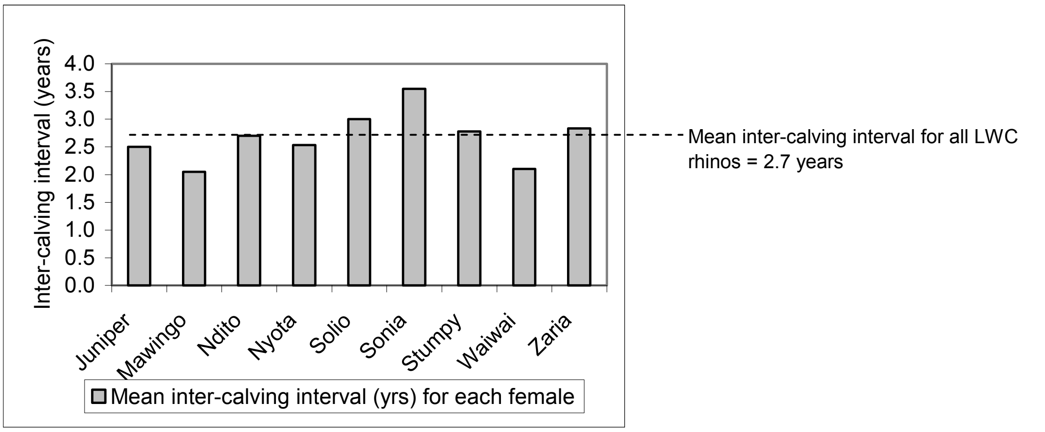

Figure 1.2: Average inter-calving interval for LWC rhinos (n=9)

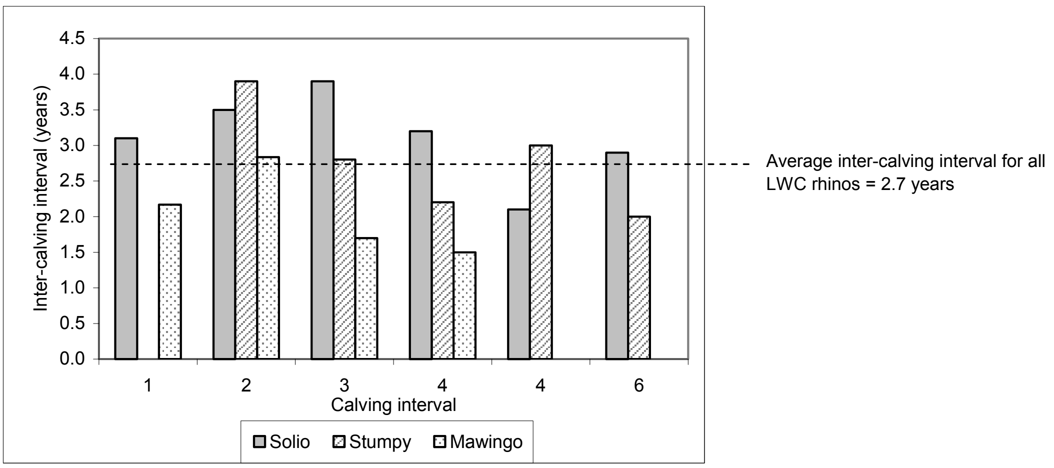

Figure 1.3: Comparison of inter-calving intervals for three females introduced on LWC showing the relative reduction in the inter-calving intervals

1.2.3 Age at first calving

Age at first calving (AFC) was calculated for seven females (3 second generation and 4 third generation animals) born on LWC. The average age at first calving was 7.2 years which implied sub-optimal performance[2] (Table 1.2). However, a comparison of the seven females showed that the third generation animals' AFC was between "good" and "excellent" categories (Table 1.2; Figure 1.4). For example, Seiya's AFC was 5.5 years which could be among the youngest[3] rhinos to have calved in Kenya. This suggests that LWC's rhinos have the potential to perform even better as more third generation animals graduate to breeding age.

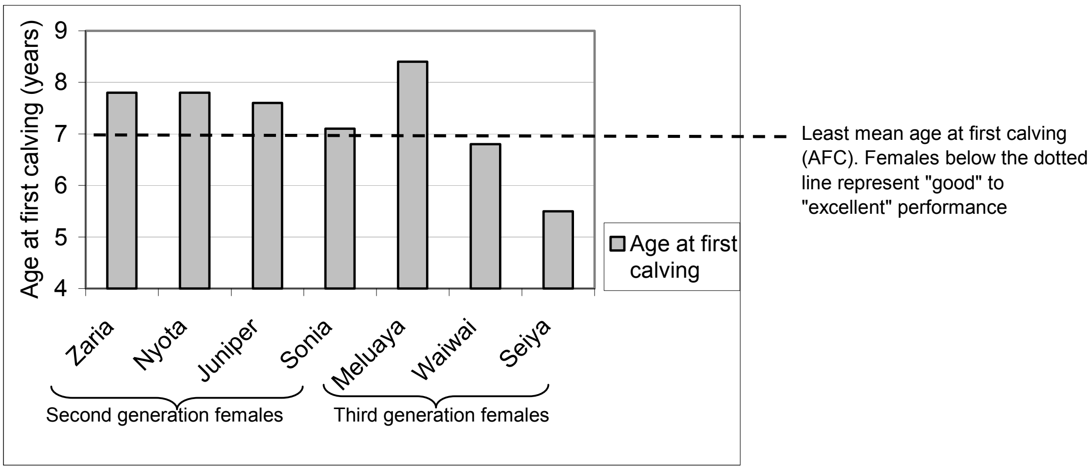

Figure 1.4: Age at first calving (AFC) for second and third generation rhinos on LWC

1.2.4 Percentage of females calving and proportion of calves in the population

A total of five calves were born on LWC in 2005 translating to 38.5% of breeding females (Table 1.2) calving in the year. Similarly, 33% of the population comprised of calves less than 3 years old. These percentages are on the higher side of the "moderate-good" scale of rhino population performance bench marks (Table 1.1; Table 1.2; Figure 1.5).

1.3 Overall performance of black rhinos on LWC, 1995-2005

Since 1995, 37 calves have been born in the Conservancy. Within the same period, four animals have been translocated out and 11 animals have died from various causes (Figure 1.5). The current population of 45 animals is close to the estimated ECC of 50 (KWS, 1993). Therefore, in future, removals to other suitable areas will be necessary to maintain the population at below 50 if LWC is to remain a viable breeding sanctuary for black rhinos.

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[2] In ideal situations, female black rhinos mature at 7.0 years (Macdonald, 2001)

[3] Subsequent to this, another third generation female calved on LWC in February 2006 at 5.4 years. This female could be the youngest to have ever calved in Kenya.

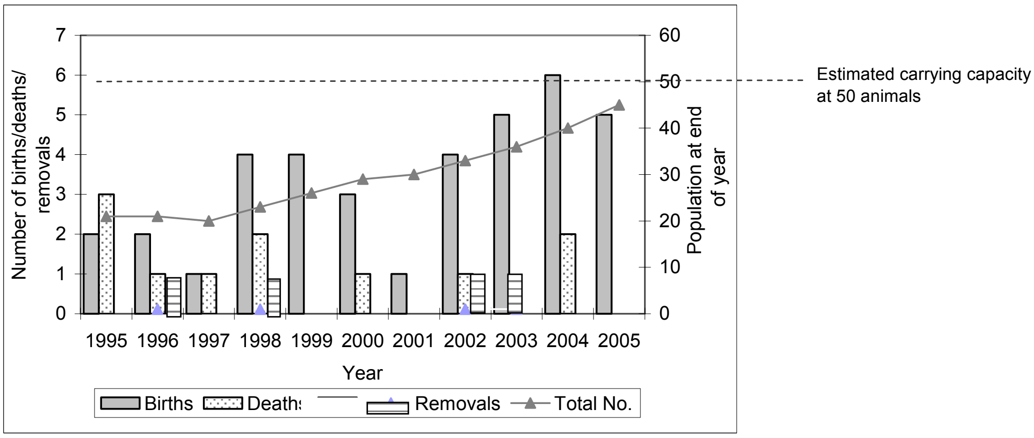

Figure 1.5: Trend in black rhino population including births, deaths, introductions and removals on LWC, 1995-2005

1.4 Distribution of breeding female black rhinos

The southern side of LWC holds the largest number (40%) of breeding black rhinos (Figure 1.6). The females include Sonia, Zaria, Ndito, Seiya, Oboso and Samia. These females have extended their areas of utilization into the former Manyangalo Ranch which was incorporated in LWC in 2004. There is a wide variety of black rhino browse in the Ngare Ndare Forest Reserve and the Manyangalo Ranch. However, a large influx of livestock into the Forest in 2005 may have trigged this shift.

Thirty seven percent of females have established their home range on the western side of the Conservancy. Stumpy, one of the breeding females in LWC has had her home range in the western side since she was translocated to LWC (Figure 1.6). These areas are dominated by *Acacia drepanolobium* that forms the main feed of rhinos. Similarly, the area encompasses one of the main exclusion zones that have been in place since the inception of the Conservancy.

Mawingo, Meluaya, Juniper, Natumi and Waiwai have established their home ranges in the central and northern parts of the Conservancy (Figure 1.7). In particular, Mawingo has remained in the *A. brevispica*, *A. mellifera* and *A. tortilis* dominated areas next to Anna's House. Solio has the largest home range (43.3km^2) that stretches from the slopes of Isiolo Valley to the western side of the Conservancy.

Large overlaps in home ranges were observed in all the females, which is common with breeding female black rhinos (Macdonald, 2001).

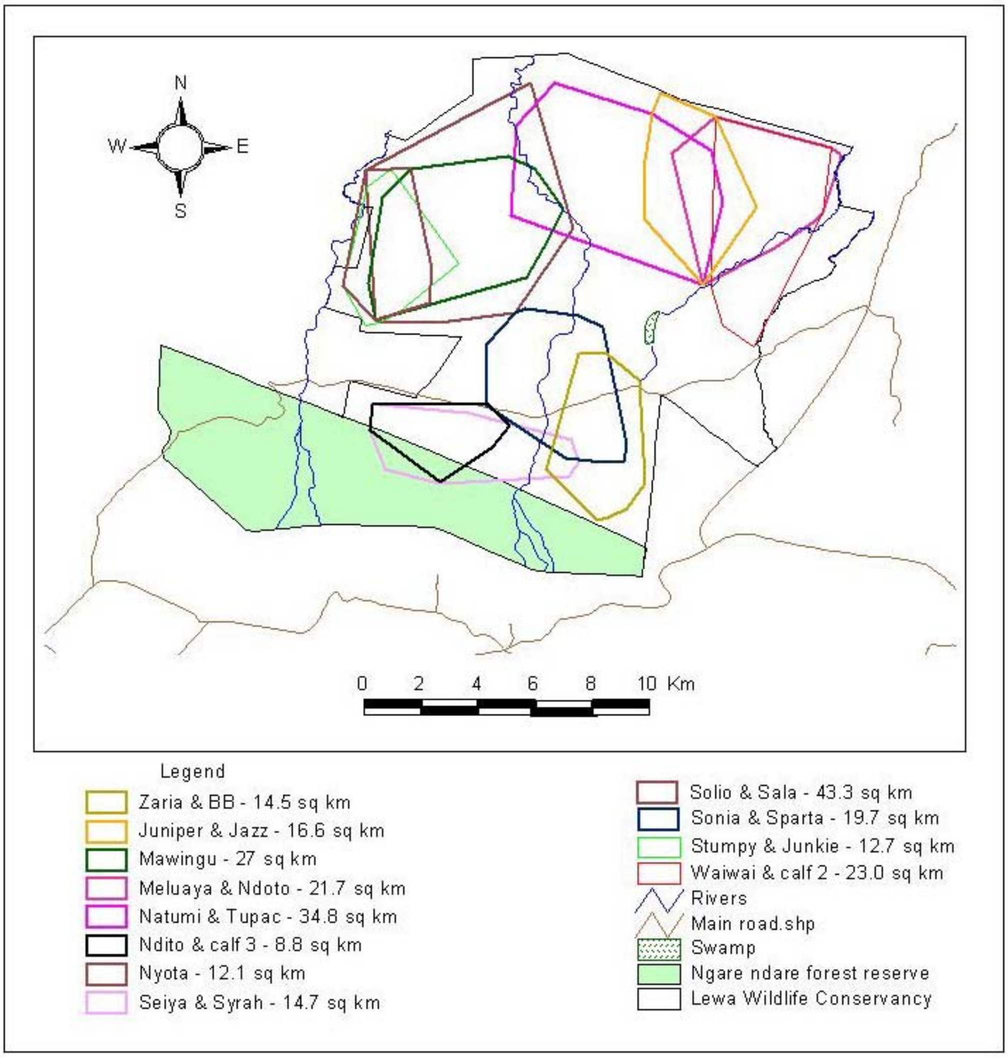

Figure 1.6: Ranging areas of breeding female black rhinos on LWC, 2005 (generated using minimum convex polygon by removing 5% of the outlier points in ArcView 3.2)

1.5 Breeding male black rhinos

Breeding male black rhinos were evenly distributed on LWC (Figure 1.7). James had his home range in the Forest Reserve while Ibong's home range was in the Soboiga Plain with extensions into the Forest. Melita, Amuri and Stella were in the northern part while Mutane was in the western side. James had the smallest home range (9.4 km^2) probably due to plenty of browse and water resources within his territory. At 10.6 km^2, Stella's home range was confined between Amuri and Melita's territories such that he was constantly being fought by the two older breeding males.

Lucky, who graduated into adulthood in 2004 established his territory in the eastern and central part of LWC hence his survival on LWC appeared to be assured. In the previous years, Lucky used to inhabit the Ngare Ndare Forest where he was constantly getting pushed between James and Ibong's territories. Similarly, he also used to get pressure from Melita to the North (Figure 1.7).

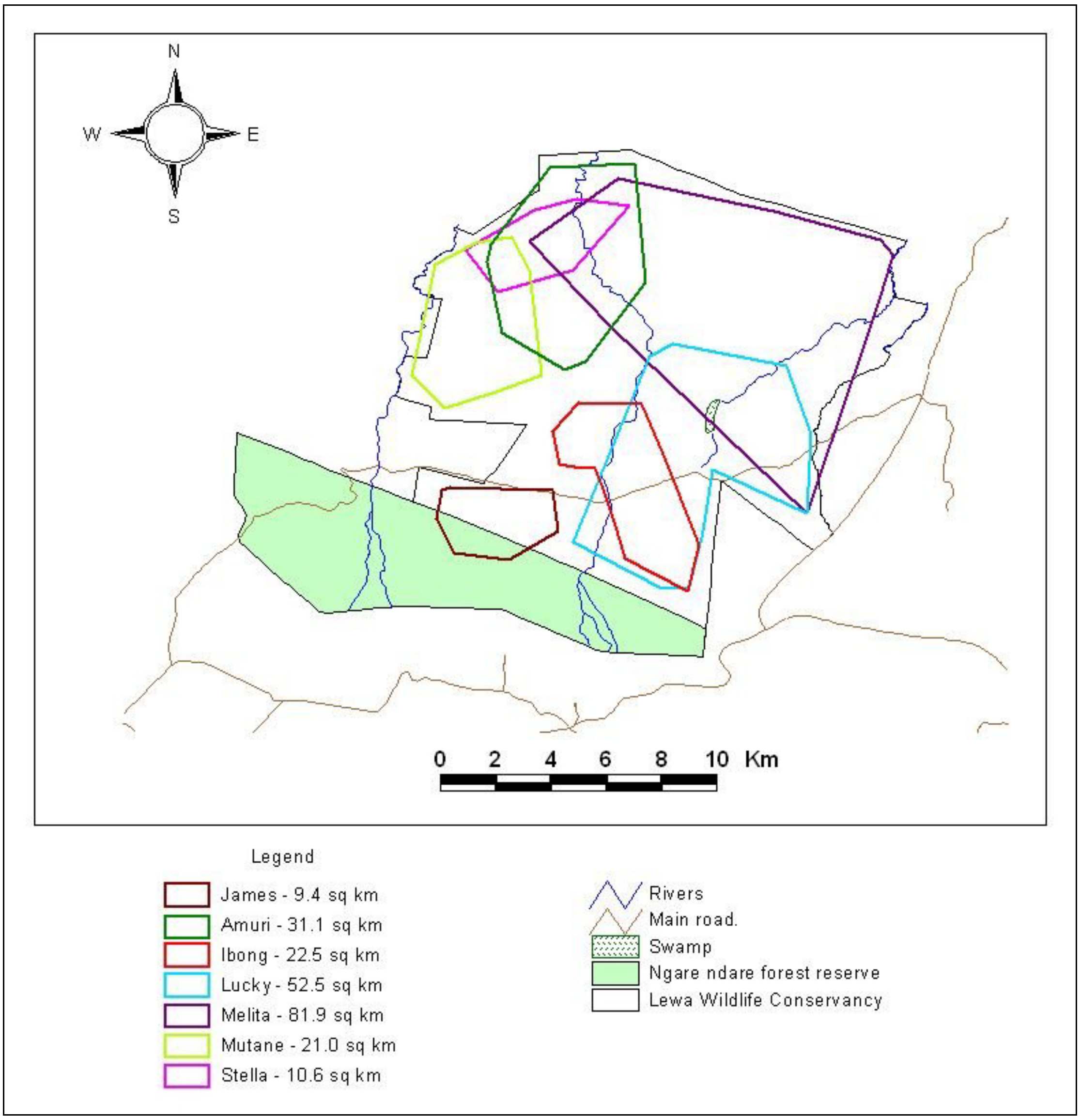

Figure 1.7: Ranging areas of breeding male black rhinos on LWC, 2005 (generated using minimum convex polygon by removing 5% of the outlier points in ArcView 3.2)

1.6 Translocation

There were no translocations undertaken during the year. However, it is recommended that Stella should be moved out of the Conservancy as he has been fought on several occasions by Melita and Amuri in his attempt to assert his dominance. As a result, Stella's home range is among the smallest when compared to all the other breeding males.

Batira's interaction with other breeding males should be closely monitored as he may experience similar pressure from Melita and Amuri as he graduates into adulthood.

1.7 Ear notching

To enhance identification of rhinos, two sub adult male black rhinos; Folly and Sparta were ear notched in June 2005 (Figure 1.8). A total of 12 black rhinos have been ear-notched. Plans are underway to ear-notch a further eight rhinos in order to eliminate clean rhinos and make all rhinos identifiable.

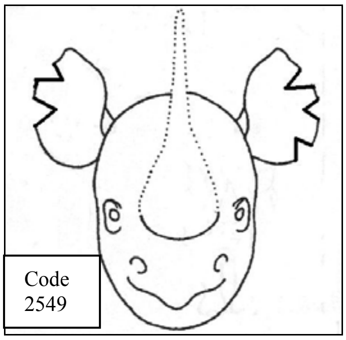

Figure 1.8a: Ear notching pattern of Sparta

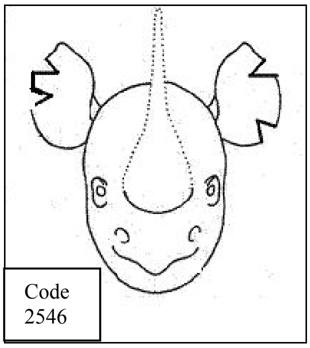

Figure 1.8b: Ear notching pattern of Folly

1.8 Rhino body condition scores

Rhino body condition scoring system follows a standardized 5-point description scale as described by Reuter and Adcock (1998) and adopted by the African Rhino Specialist Group (AfRSG). The descriptive scale assesses the body condition of rhinos for fatty deposits on different body regions specifically: neck, shoulder, ribs, spine, rump, abdomen and tail base. A scale of 5 represents a rhino in excellent health while 1 represents an emaciated rhino.

All rhinos on LWC appeared to have reduced their body condition probably due to low availability of browse following poor rains[4] recorded in the year (Table 1.3). Solio and stumpy, the oldest females with an estimated age of 30 and 37 years respectively were in their late lactation period and this would have contributed to their poor body condition.

[4] In January 2006, the diet of most of the black rhinos was supplemented with Lucerne and horse cubes as the April 2006 rain was awaited. All the targeted rhinos in the feeding programme took the supplements with little or no encouragement.

Table 1.3: Black rhino body condition scores, September 2005

No.	Rhino Name	Sex	Breeding condition	Age (years)	March 2005 scores	September 2005 scores
1	Zaria	F	Late lactation	17.8	3+	3+
2	Solio	F	Late lactation	30	3	3
3	Natumi	F	Early lactation	7.3	4	3+
4	Mawingo	F	Non–lactating	16.6	4-	3+
5	Rhinotek	F	Sub adult	4.4	4-	3+
6	Ndito	F	Mid-lactation	16	4	3
7	Juniper	F	Late lactation	17.5	3+	3
8	Sonia	F	Late lactation	14.4	3+	3
9	Samia	F	Sub adult	7.3	4	4
10	Nyota	F	Non–lactating	14.1	4	3+
11	Oboso	F	Sub adult	5.3	4	4
12	Tana	F	Sub adult	5.3	3	3-
13	Waiwai	F	Early lactation	10.5	3	3+
14	Maxxine	F	Sub adult	3.6	4	3+
15	Stumpy	F	Late lactation	37	3+	3
16	Sala	F	Calf	2.3	3+	3
17	Melita	M	Adult male	22	4-	4
18	Stella	M	Adult male	9.8	4	3+
19	Nasha	M	Sub adult	5.2	4	3+
20	Lucky	M	Adult male	9.8	4	4
21	Folly	M	Sub adult	3.6	4	3+
22	Ibong	M	Adult male	20.7	4	4
23	Mutane	M	Adult male	17	4	4
24	Amuri	M	Adult male	18.7	4	4
25	Junkie	M	Calf	2.3	3+	3

1.9 White rhino population performance

The population of white rhino on LWC as at December 2005 stood at 37. The population comprised of 11 calves (0≤3 years); 7 sub adults (3≤6 years); and 19 adults (>7 years). The sex ratio was skewed towards the males (1 female:1.12 male). Eleven of the males had attained the breeding age compared to eight females (Table 1.4).

Table 1.4: Sex and age classes of white rhinos on LWC, December 2005

Age class	Males	Females	Not sexed	Sub-total
Calves (0≤3) Yrs	4	5	2	11
Sub-adults (3≤6) yrs unless calved	3	3	-	6
Adults (>7 years)	11	8		19
Grand-total	**18**	**16**	**2**	**36**

1.9.1 Births

Two calves were born to Ngororika and Jakwai in May and July respectively. However, Ngororika's calf did not survive as it was a still birth.

1.9.2 Deaths

In 2005, a total of four white rhinos died from different causes. Giant, a breeding male died from injuries sustained in a fight with an elephant. Samawati, a sub adult male died after he was fought by a dominant male black rhino. The horn of the male was subsequently trimmed. Ngororika gave birth to a still born in May while one of the sub adult males translocated from Solio Ranch to LWC in 2004 fell into a ditch and did not survive.

1.10 Translocations

Four rhinos were moved from LWC to other conservation areas while one calf was rescued from Solio Ranch and moved into the Conservancy in January 2005. Four rhinos that were brought in from Solio Ranch in 2004 appeared to have settled and adapted well to their new habitat. They teamed up with LWC rhinos and were reported together on a daily basis.

It was recommended that for future translocations out of LWC, Kingi, Nengotiei, Warges and Muya should be moved. This would reduce the bias that is in favour of males.

1.11 Population performance indicators

Age at first calving

The average age at first calving (AFC) calculated for five females whose history was known was 7.9 years. Murembo (1st generation) calved at 6.0 years while Rinta (2nd

generation) calved at 7.7 years (Figure 1.9). Three females, Murembo, Ngororika and Songare have each calved six times while Rinta has calved twice (Figure 1.10).

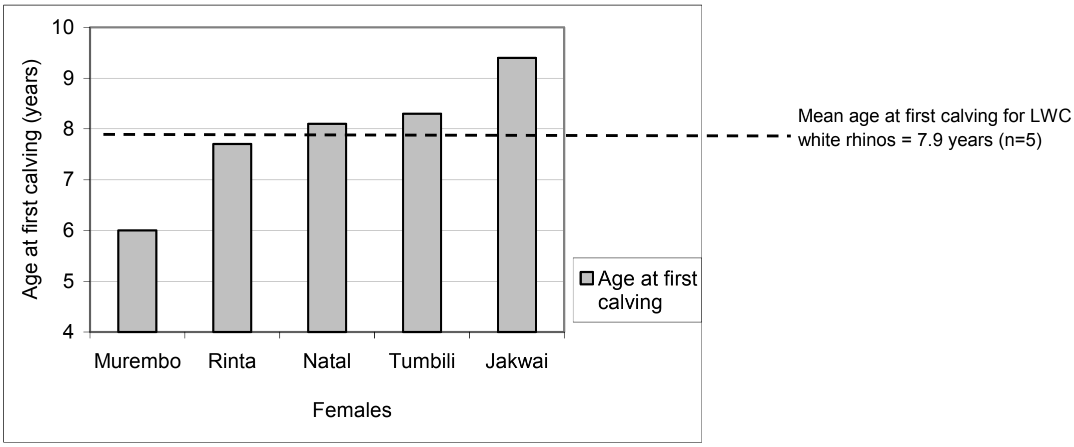

Figure 1.9: Age at first calving for white rhinos on LWC (n=5)

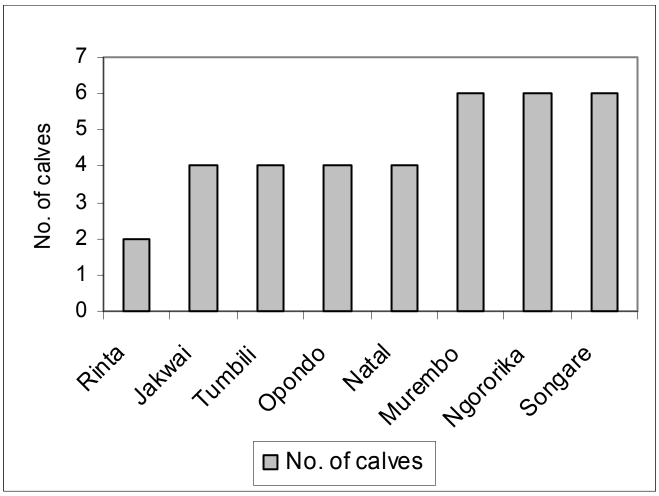

Figure 1.10: Number of calves born per female white rhino on LWC (n=8)

Inter-calving interval

The mean inter-calving interval calculated for the eight breeding females was 2.5 years. The mean inter-calving interval for the respective females ranged from 2.2-2.9 years (Figure 1.11).

1.12 Overall performance of white rhinos on LWC, 1995-2005

Since 1995, 33 calves have been born in the Conservancy while seven have been moved in from other conservation areas. Similarly, within the same period, 10 animals have died in the Conservancy while 11 have been translocated out (Figure 1.12). The Conservancy has therefore been a key donor of white rhinos to other areas. This status can further be enhanced if the biased sex ratio can be reduced and more females introduced.

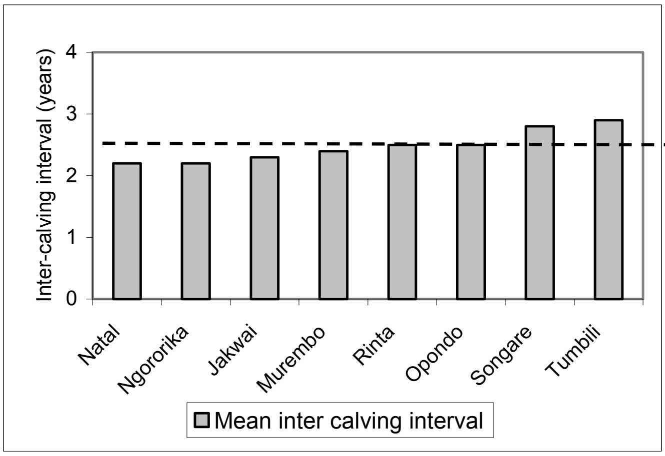

Figure 1.11: Average inter-calving interval of female white rhinos on LWC

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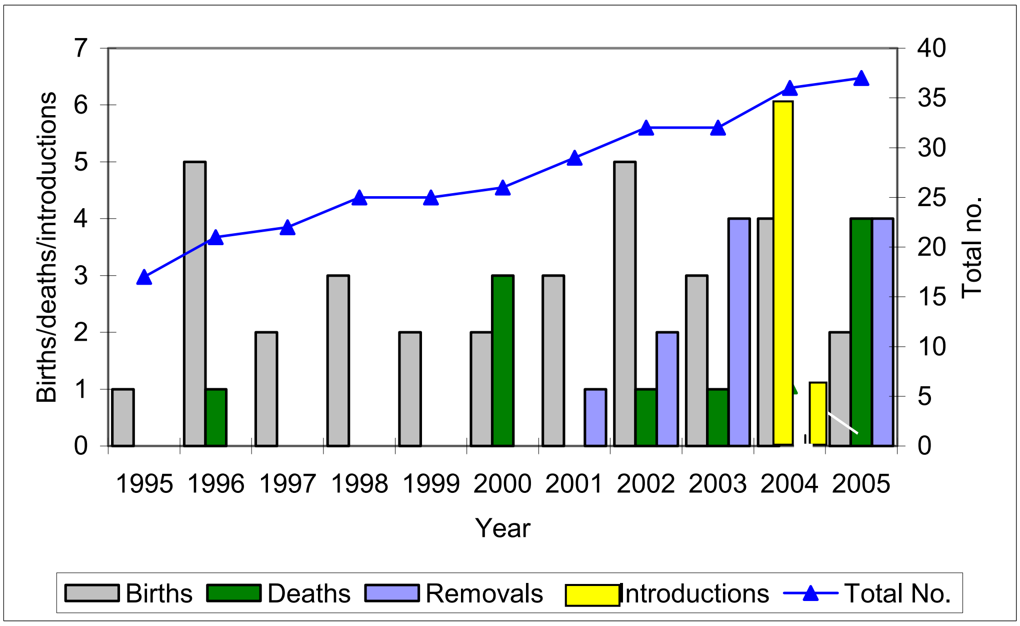


Figure 1.12: Trend in white rhino population including births, deaths, introductions and removals on LWC, 1995-2005 (total number of rhinos are plotted on the secondary Y-axis

1.13 Breeding females home ranges

The home ranges of breeding female white rhinos expanded to a great extent in the year (Figure1.13). The females extended the areas of utilization to rocky hills and valleys on the central and northern parts of LWC to track down the few patches of nutritious grass due to low forage availability following poor rains in the year.

It is interesting to note that the central part of LWC i.e. to the west of the Swamp was not preferred by the females, yet the area was subjected to prescribed burning to remove the moribund grass and encourage utilisation by plains game. However, white rhinos are bulk grazers and hence the tendency to prefer high grass biomass areas in the northern, eastern and western parts of the Conservancy.

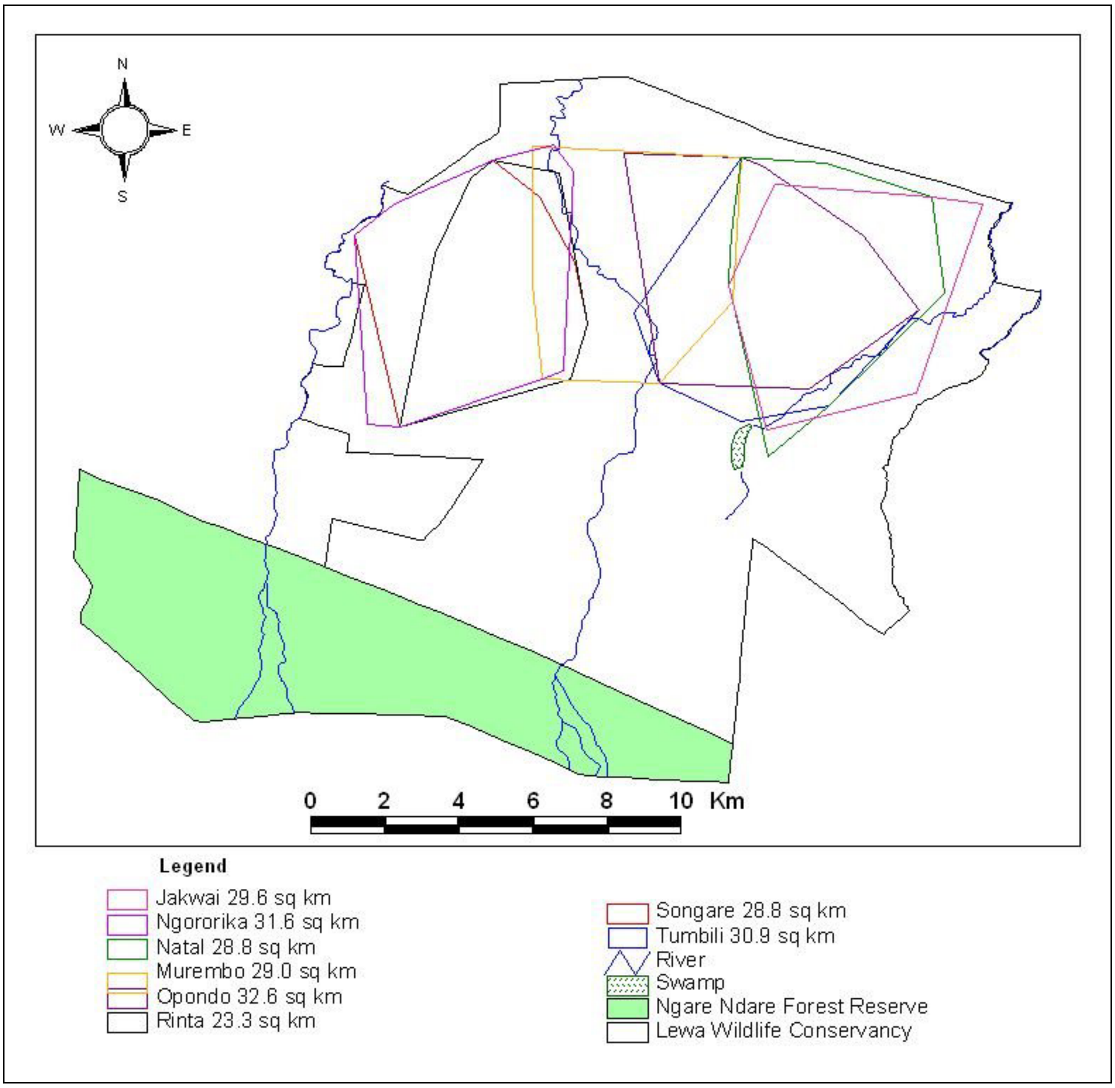


Figure 1.13: Ranging areas of breeding female white rhinos on LWC, 20005 (generated using minimum convex polygon by removing 5% of the outlier points in ArcView 3.2)

1.14 Breeding males home ranges

The ranging areas of breeding males were noted to overlap to a great extent (Figure 1.14). Despite this overlap, the males were rarely reported together except for Nengoitei and Imado.

Chuma, one of the oldest and founder males, was experiencing pressure from the younger bulls and hence remained in areas along the Lewa river. Lari and Kingi were noted to have the biggest home ranges whereas Warges home range was the smallest.

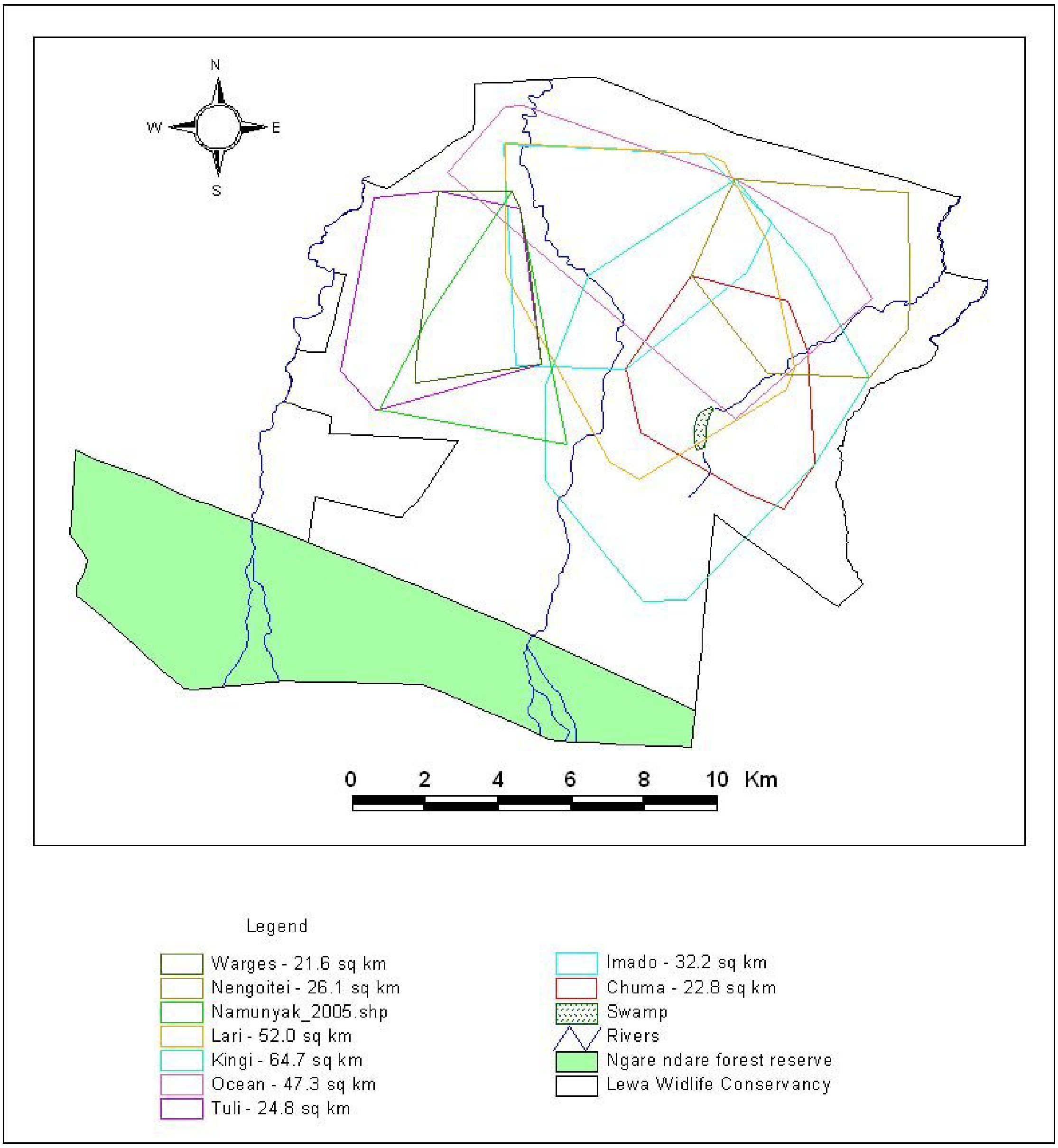


Figure 1.14: Home ranges of breeding male white rhinos on LWC, 2005 (generated using minimum convex polygon by removing 5% of the outlier points in ArcView 3.2)

2.0 GREVY'S ZEBRA RESEARCH AND MONITORING

2.1 Background

The numbers of Grevy's zebra have declined precipitously in their entire range in the past few decades. Similarly, populations of Grevy's zebra that reside inside protected areas including LWC where livestock are excluded have been performing sub-optimally (Figure 2.1).

Nevertheless, LWC holds between 17-23% of the remaining population of wild Grevy's zebra. This population is protected and is not faced with human pressures characteristic of other populations in Northern Kenya (Williams, 2002). Therefore, under natural conditions, LWC's population should have optimum reproductive rates.

Like any other animal population, the temporal changes in abundance of LWC's Grevy's zebra should be a balance between the four primary processes of population dynamics, namely; natality, immigration, mortality and emigration. Since this has not been the case, determining biotic and abiotic factors that could be limiting the growth of LWC's population provides a benchmark to compare and understand why declines are even more dramatic outside protected areas where Grevy's zebra, pastoralists and their livestock share the same range (Low *et al.*, 2005; Rubenstein *et al.*, 2005).

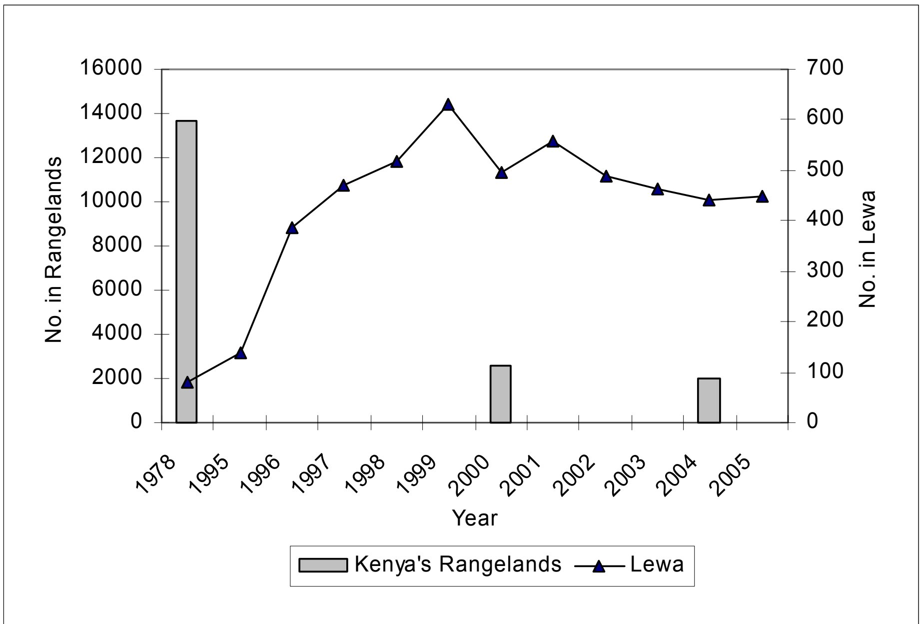


Figure 2.1: Grevy's zebra population trends on LWC and in Kenya's rangelands, 1978 & 1995-2005

In collaboration with key partners, we have attempted to elucidate the patterns of fluctuations in abundance being observed in Grevy's zebra population on LWC by focussing on the following key areas:

1. Determining natality, survival and recruitment rates of foals and juveniles together with mortality incidences of the all age classes in the population by following known individuals that are either collared in the case of Plains zebra and lactating females for Grevy's zebra.

2. Interspecific interaction including rates of competition with Plains zebra; rates of predation; parasitism; and disease.
3. Influence of environmental factors in relation to patterns of drinking, state of vegetative components i.e. spatial and temporal quantity and quality of fodder that relates to rates of exploitation of food resources and thickness of bush.

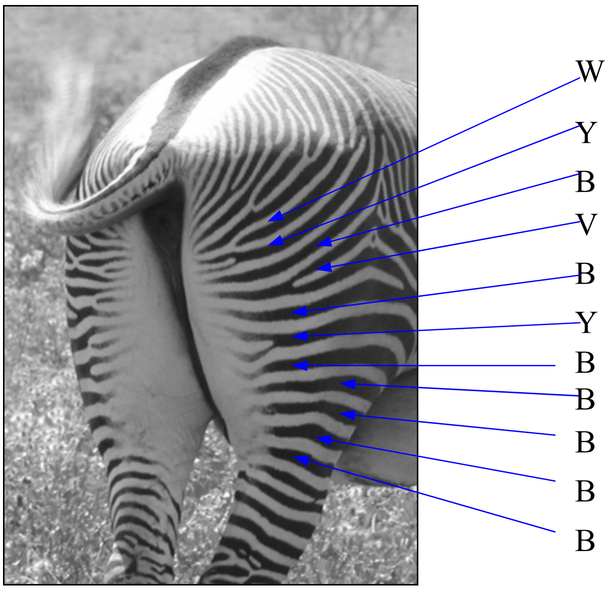
The specific questions being addressed by LWC's Grevy's zebra research and monitoring are:

1. *What factors are limiting the growth of Grevy's zebra population on LWC?*
To answer this question, information is needed on foal survival and recruitment rates, inter-birth interval, rates of age specific mortality and their causes, rates of predation, health and interspecific competition with Plains zebra.

2. *What relevant management interventions should LWC management undertake to encourage Grevy's zebra population growth in the Conservancy?*

2.2 Methods
Monthly foal patrols were undertaken throughout 2005. The right rump of each lactating female Grevy's zebra was digitally photographed. Photographs of juveniles were also taken. Stripe patterns of the rump were then coded (Rubenstein, 1986; Ginsberg, 1988) and used to identify individuals since the stripes represent an ideal natural identification system, unique to an individual, and invariant over a lifetime (Klingel, 1969) (Figure 2.2).

The identity of each individual was then searched in a computerised database containing a catalogue of at least 85% of all Grevy's zebra on LWC. A sort command in the database ensures thumbnails of all possible matches and those with partial matches are displayed on the computer screen for easy identification. The right match was updated and new individuals added accordingly (Low *et al*., 2005).



Identification code: WYBVBYBBBBB

Figure 2.2: An example of stripe pattern of Grevy's zebra, shown for a territorial male in LWC ('B' = Bar, 'V' = Vee, 'E' = Eye, 'W' = Wedge, 'X' = Chromosome, 'D' = Dash, and 'Y'

2.3 Results and discussion

2.3.1 Grevy's zebra numbers

A combined aerial and ground census of large mammals was conducted in February 2005 where 448 Grevy's zebra were counted compared to 435 in February 2004 representing a marginal increment. In addition there were 44 births and 36 confirmed deaths of Grevy's zebra of all age classes between the two counts. Furthermore, 18 of the 19 foals in the 0-6 month age bracket that were suspected dead as at December 2004 were actually confirmed dead in 2005.

By combining births and mortalities in 2004, a total of 424 Grevy's zebra should have been counted in February 2005. However, emigration and immigration through the elephant gap were not actively monitored. Similarly, like in the previous years, it was not possible to detect all kills due to thickness of bush, height of grass and the scavenging nature of bones by hyenas hence the possible variation.

2.3.2 Survival and recruitment rates of foals born in 2004

There were 44 foals born in 2004. Out of these, 7 foals were confirmed dead by December 2004. Similarly, 18 more foals were confirmed dead in 2005 during the monthly foal patrols. Therefore, as at December 2004, the survival rate of foals born in that year was 43% (N=19) (Figure 2.3).

Monthly foal patrols continued in 2005 to determine the survival rate of the 19 foals that survived in 2004. Eight of these foals were confirmed dead in 2005 implying that the overall survival rate of foals born in 2004 was about 25% i.e. only 11 foals were recruited to yearlings. This overall survival rate is slightly lower than the 27% registered in 2003 (Figure 2.3). These scenarios are alarming since Rubenstein *et al.,* (2005) demonstrated that the population of Grevy's zebra on LWC can only increase if the current rates of predation are reduced and infant survival is raised to over 50%.

2.3.3 Survival and recruitment rates of foals born in 2005

There were 75 foals born in 2005 compared to 59 and 44 born in 2003 and 2004 respectively (Figure 2.4). The sex ratio of births was 1:1. Ten of these foals were confirmed dead by December 2005. A further 11 foals were suspected dead at the close of the year. The majority of the dead and suspected dead foals were in the 0-6 month age bracket (Figure 2.5) confirming the vulnerability of young foals to predation probably due to their poor anti-predator behaviour (Ginsberg, 1988; Rowen, 1992; Rubenstein, 1996).

Based on the results of 2003 and 2004 where all the suspected dead foals at the close of each respective year were actually confirmed dead in the following year, the 11 foals suspected dead at the end of 2005 were assumed to be dead. This implied that the survival rate of foals born in 2005 at the close of the year was 72% (N=54). This rate was higher than 58% and 43% recorded at the end of 2003 and 2004 respectively.

Monthly foal patrols will continue in 2006 to determine the fate of the 54 foals that survived in 2005. It is predicted that the overall survival rate of 2005-born foals will be higher than in 2003 and 2004 because of the higher number of foals born in the year.

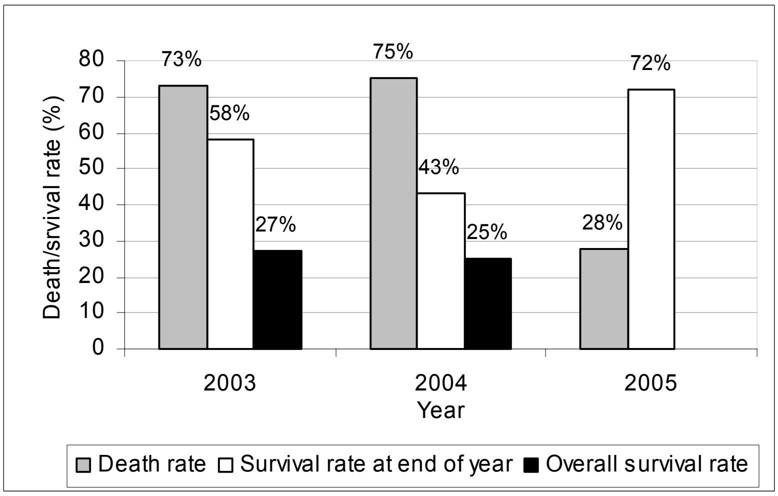


Figure 2.3: Comparison of survival rate of Grevy's zebra foals born on LWC, 2003, 2004 and 2005

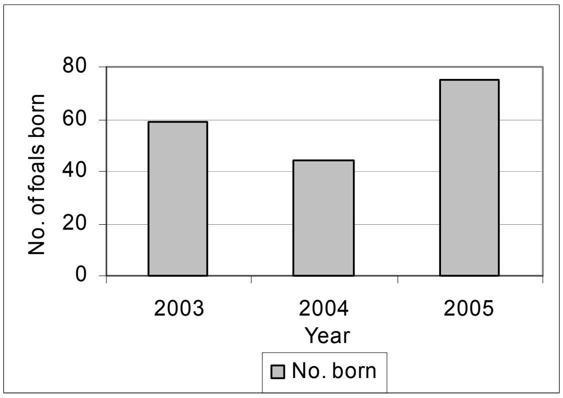


Figure 2.4: Comparison of Grevy's zebra foals born in 2003, 2004 and 2005

Figure 2.5: Number of dead and suspected dead Grevy's zebra foals per age class, 2005

2.3.4 Timing of foaling

Except for May - June and December when less than five foals were born in each month, the majority of births were spread throughout the year and did not appear to coincide with the rainy season (Figure 2.6). This contrasted with 2003 and 2004 when most foaling occurred during peak rainfall (Low *et al.*, 2004; Low *et al.*, 2005). This could be due to the fact that although the females had conceived in 2004, the poor rains received in 2005 led to a lack of synchrony in foaling periods.

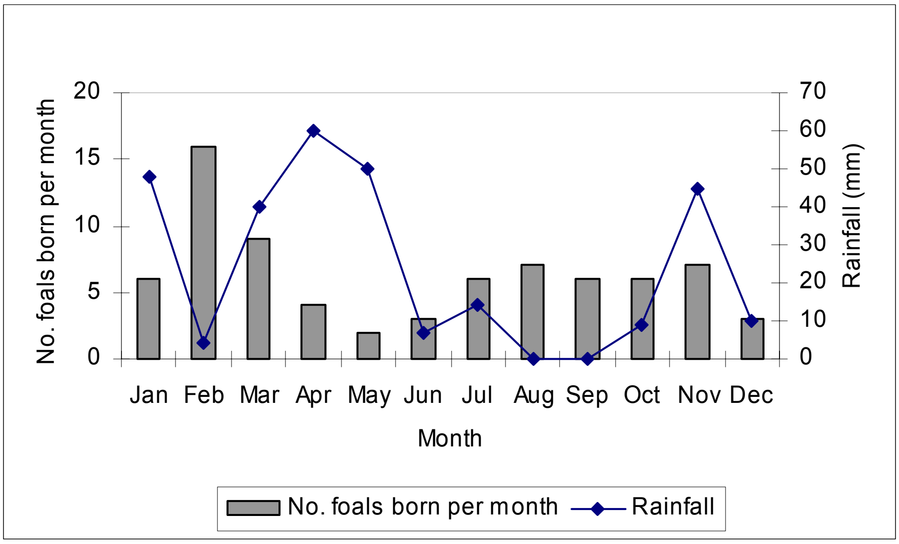


Figure 2.6: Number of new Grevy's zebra foals recorded per month on LWC, 2005

2.3.5 Inter-foaling interval

Inter-birth interval was calculated for 69 females whose foaling history since 2001 was known. The average inter-foaling interval was 19 months. 29% (N=20) of the females assessed had an inter-birth interval of 14-15 months with 14 of these having an inter-birth interval of 14 months. This implied that post-partum oestrus occurred successfully 7-10 days after parturition in the 14 females. Only 7% (N=5) of the females had an inter-birth interval >24 months (Figure 2.7).

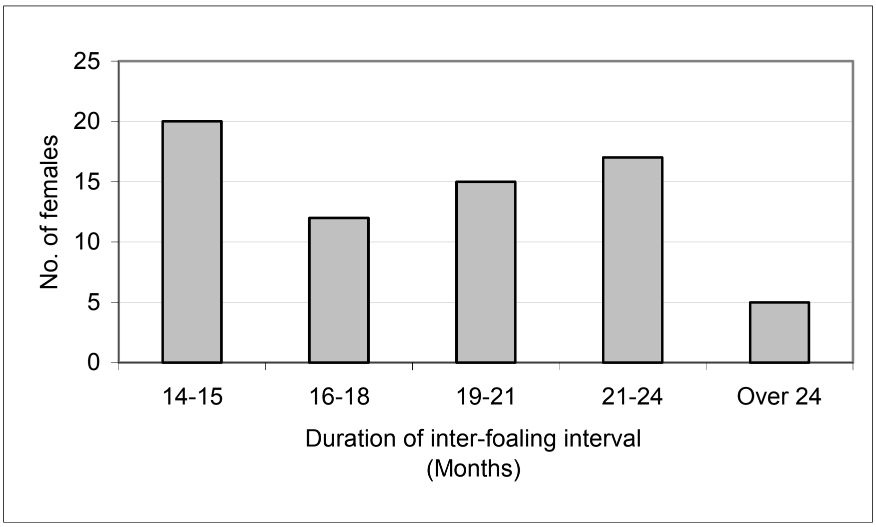


Figure 2.7: Proportional inter-birth intervals for Grevy's zebra (N=69)

2.3.6 Distribution of lactating females in 2005

In 2005, foals in the 0-3 month age bracket frequently formed nursery herds near Mbogo Camp, between the Swamp and David's House, Marania, Matekenya and Airstrip areas. As they graduated to 3-6 m and 6-12 m age bracket, they utilised the Swamp and Matekenya with higher frequency (Figure 2.8).

Areas preferred by lactating females in 2005 were relatively open and offered ideal refuge against predators. In particular, Matekenye and Airstrip blocks were subjected to prescribed burning resulting to a reduction in thickness of bush, hence were avoided by predators. This demonstrates the positive effect that prescribed burning has in improving visibility for breeding females closer to water.

Marania and Mbogo Camp areas had short grass as a result of intensive grazing by LWC's livestock. Similarly, these areas were close to the Marathon Finish that had water throughout the year and was dominated by Increaser I and II grass species--mainly *Cynodon* spp and *Digitalia scalarum* (Rubenstein, 2003, *personal communication*), that are essential in production of equid milk. These findings are in line with previous studies where foals in the 0-3 month age bracket formed kindergartens in areas close to water (Ginsberg, 1988; Rowen, 1992) and with low security risk. Dispersal from such areas occurs when foals graduate into 3-6 month age bracket as their mothers seek bulk feed.

2.4 Mortality rates of wildlife

Ninety-six animals comprising of different species were confirmed dead in 2005. These comprised of 26 Grevy's zebra, 36 Plains zebra and 34 comprised of other wildlife species (Figure 2.9). These death rates contrasted with 2004 when there were more Grevy's zebra that died compared to Plains zebra.

Adult animals contributed to a large number of reported deaths. 83% of the total kills were predator-related with lions causing the highest number of deaths (Figure 2.10).

Ninety-two percent of the Grevy's zebra deaths were thought to be caused by lions with only 8% attributed to cheetahs. This rate was higher compared to Plains zebra where 75% of deaths were lion-related. However, the rate of predation by cheetahs was the same in the two species. Hyenas did not appear to cause the actual killing of zebras but scavenged on the kills (Figure 2.10 and Figure 2.11).

Foals less than 3 months and adults contributed most to dead Grevy's zebra. There was a similar proportion of suspected deaths of foals of the same age in the same period (Figure 2.5). Most of the kills were reported along Lewa River, Matekenye and Wilderness areas (Figure 2.12) that were core Grevy's zebra areas. These were the same areas where the majority of the sightings of lions were encountered in the year (Section 3.8).

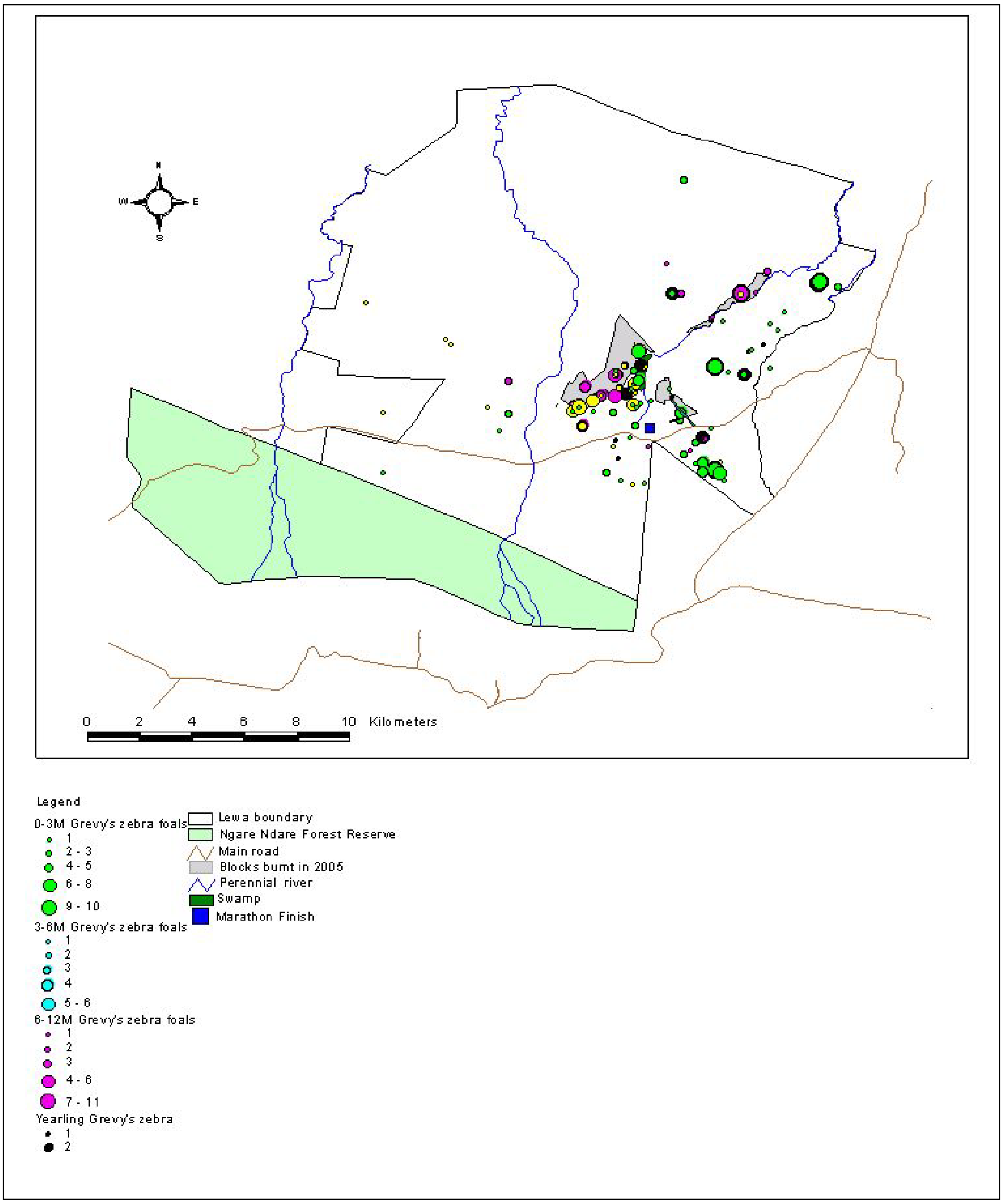


Figure 2.8: Distribution of Grevy's zebra foals on LWC, 2005

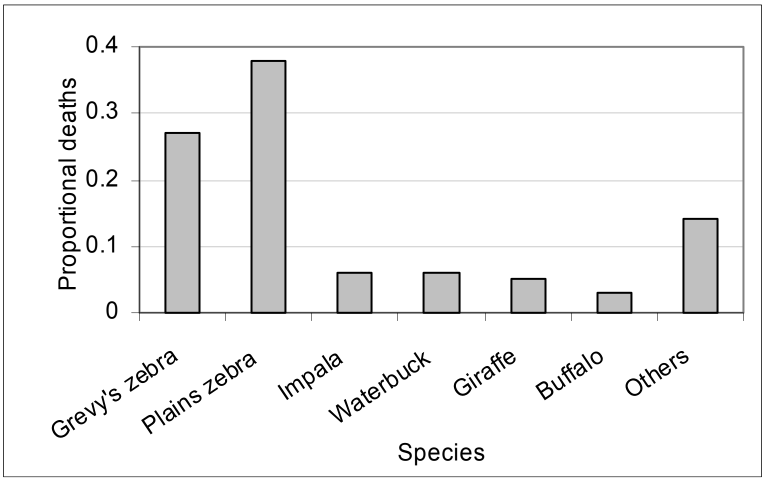


Figure 2.9: Proportional predation of species on LWC, 2005

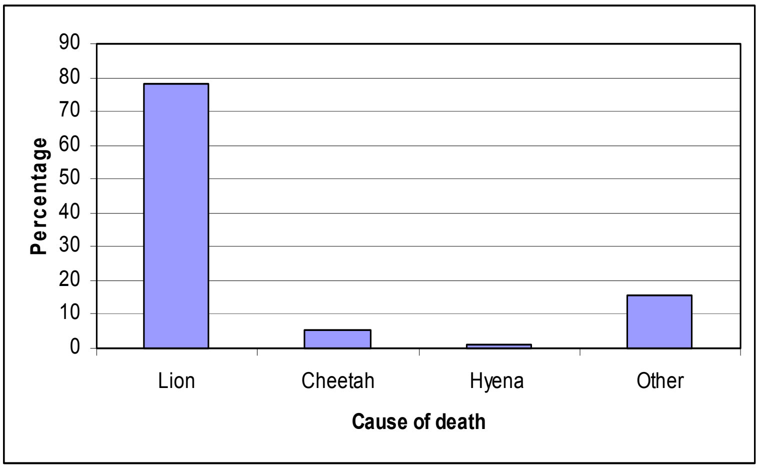


Figure 2.10: Cause of death of animals on LWC, 2005

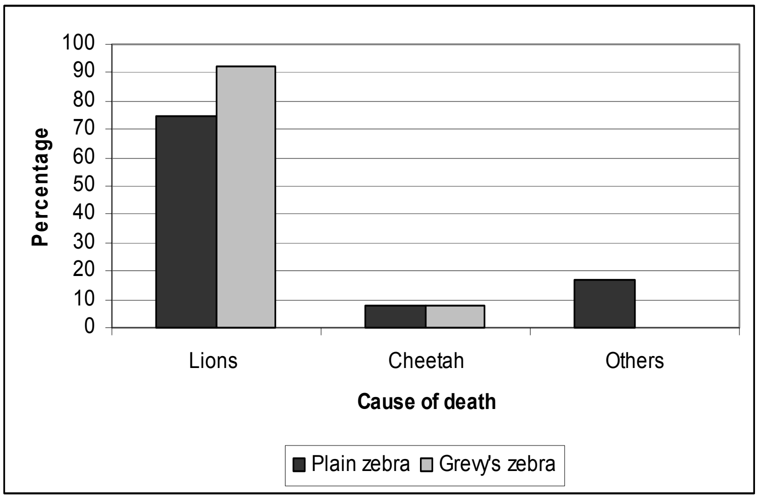


Figure 2.11: Cause of death of Plains zebra and Grevy's zebra on LWC, 2005

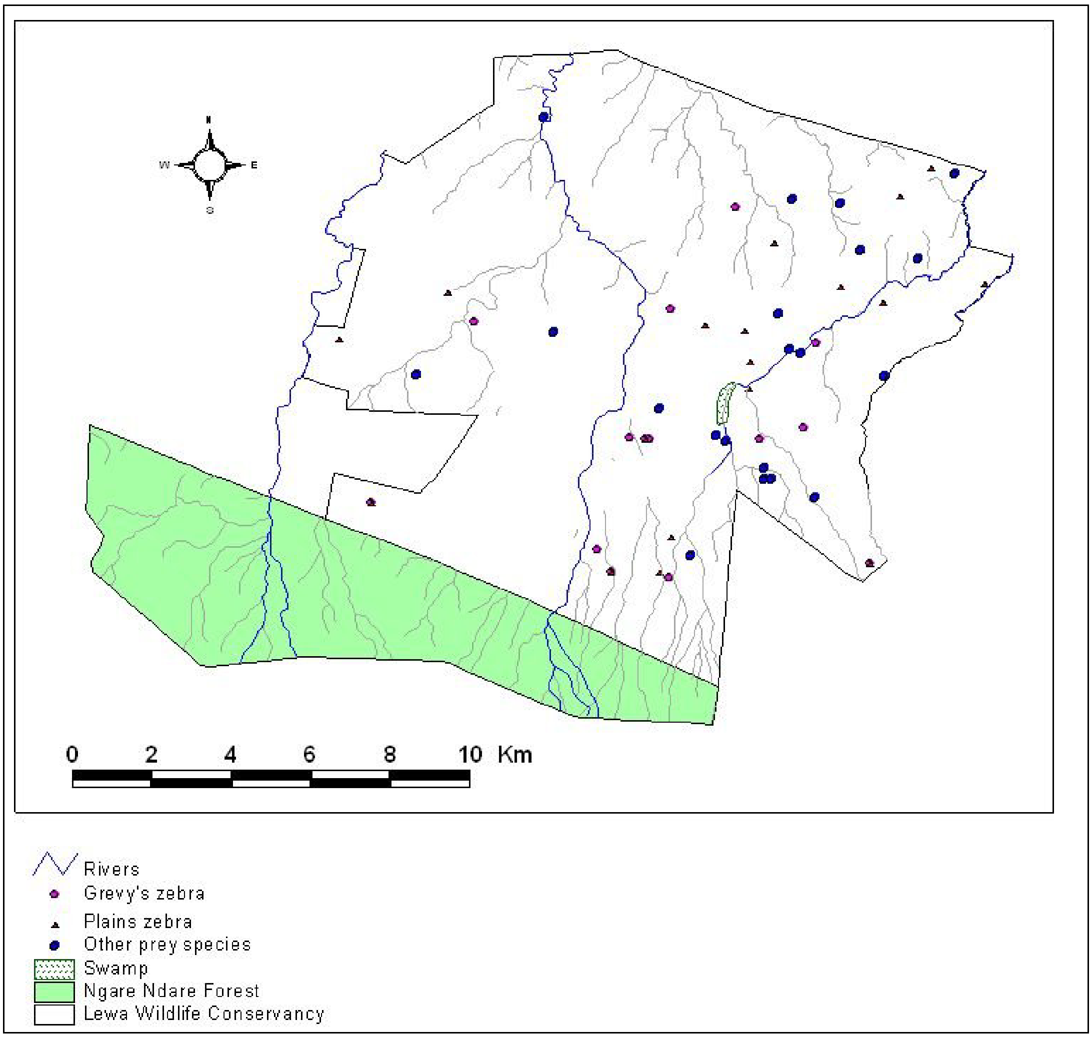


Figure 2.12: Location of kills on LWC, 2005

3.0 PREDATOR PROJECT ON LEWA

The main objective of the predator project on LWC is to determine the impact of predators (specifically lions) on the population of Grevy's and Plains zebra. This is done by tracking on a daily basis the location of collared lions, identifying the individuals using the whisker pattern and collecting scat for later analysis of the prey hair content.

3.1 Lion population on LWC

The lion population on LWC has historically been low, with only a few individuals sighted within the Conservancy in 2002. However, the population had increased to 25 resident lions by October 2004 (Njonjo, 2004). This population however decreased to 16 resident lions in 2005 when some individuals moved to Borana and Mukogodo Forest.

3.2 Collared Lions on LWC

In 2005, there were six lions fitted with operational radio collars. These were:

i. Males 250 and 251. The two were always sighted together.
ii. Male 216 and his male counterpart
iii. Lioness 331 and her 3 cubs that were 1.6 years old as at December 2005
iv. Lioness 254 and another lioness both with 3 cubs each aged 2 years and 1.7 years respectively as at December 2005. This was the typical pride that was noted. However, there were no resident males within this pride.

3.3 Lion Identification

All lions have spot patterns on their faces that are unique to each lion just like human finger prints. They are further arranged in visible rows as shown in Figure 3.1. Only the upper two rows, A and B are used for identification.

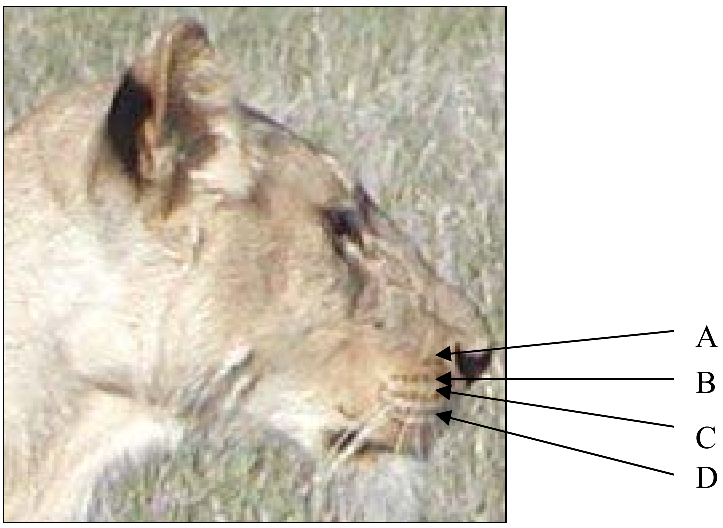


Figure 3.1: Spot markings of lions used for identification

Row A has 0 to 4 spots and it's the position of these spots in relation to row B that gives the identity of an individual lion as described by Njonjo (2004). For example, the ID code of the lion in Figure x is L2: 2/3. The 2/3 denotes the position of the spots on row B. Using this technique, a database of all lions on LWC has been established.

3.4 Collection of scat
Lion scat is difficult to find. The following are some of the ways in which scat was collected:

- Monitoring of collared individuals until they produced scat. This method was however time consuming.
- Locating exact areas where lions were resting. Scat was then searched around the place after the lions had relocated to another place.
- Kills were located and scat searched around them. This proved to be the most effective method.
- Scat was also collected opportunistically on roads.

3.5 Scat analysis
Once the scat was collected from the field, it was dried in open air and then stored in a freezer bag. All the field notes were transferred to the freezer bags accordingly. To loosen and clean the hairs, the scat was soaked in hot water mixed with an equal proportion of 70% ethanol for five minutes. Ethanol helped to clean hairs by removing fatty emulsions or bacterial infection. Hairs were then actively picked from the cleaned scat for about 15 minutes. They were kept in a Petri dish filled with 100% ethanol to further clean the hairs. Hairs were then picked from the Petri dish using a pair of forceps and placed in a freezer bag with appropriate labelling.

3.6 Hair analysis
Twenty hairs from each sample were selected for mounting and identification. Only hairs that had a root were mounted on microscope slides. Mounting was done using a DPX moutant and cover slips placed over the sample.

Hairs were then observed under a light microscope at x10mg where the basic configuration of the hair i.e. relative widths of the medulla and cortex were used to distinguish between hairs of different animals (Njonjo, 2004). The hairs were similarly compared with a reference hair collection that is being developed to ensure accuracy. This reference hair collection will act as a database for future references since it is comprised of hairs uprooted from known species of animals.

3.7 Results
Zebras were the main prey species of lions with Grevy’s zebra contributing the highest proportion of the predated species. 54% of the analysed hairs comprised of Grevy’s zebra compared to 30% Plains zebra (Figure 3.2). Further, 16% of the hairs belonged to other prey species, specifically impala and warthog (Figure 3.3).

One major assumption made is that the amount of hair found in the scat is a reflection of the actual proportion of animals being predated. Taking this into consideration, it is evident that Grevy’s zebra were killed more than Plains zebra. These results contrast with mortality rates gathered by security field personnel that reported more Plain’s zebra kills compared to Grevy’s zebra (Section 2.4). However, the results are consistent with similar findings from hair analysis in 2004 that demonstrated that lions were preferentially more Grevy’s zebra when compared with Plains zebra.

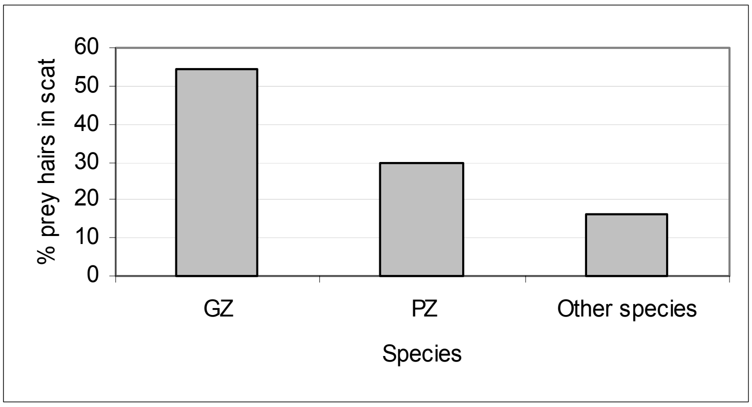


Figure 3.2: Percentage of prey species predated by lions

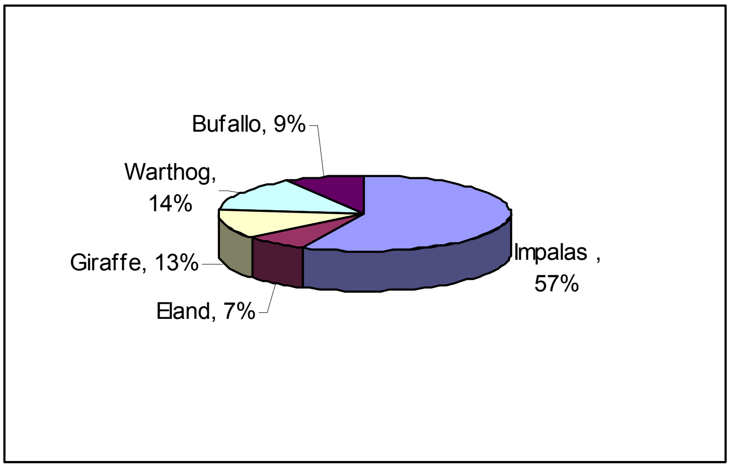


Figure 3.3: Percentage of other bovid hairs found on lion scat

3.8 Home ranges of lions on LWC

Lioness 331 had the smallest home range (51.4 km^2) compared to lioness 254 (101 km^2) (Figure 3.4), all calculated using 95% minimum convex polygon. This was probably due to the fact that lioness 331 had younger cubs compared to lioness 254 and her associate. Hence, lioness 331 tended to move less.

However, when the home ranges were generating by removing 50% of the lionesses' outlier values, the ranging areas reduced considerably and demonstrated that the core areas were in the central LWC (Figure 3.4). Apparently, these are the same areas that were preferred by lactating Grevy's zebra. This may have contributed to the high predation rates on Grevy's zebra observed in the year. Home ranges of lions may range between 20-400 km^2 depending on prey density (Estes, 1991).

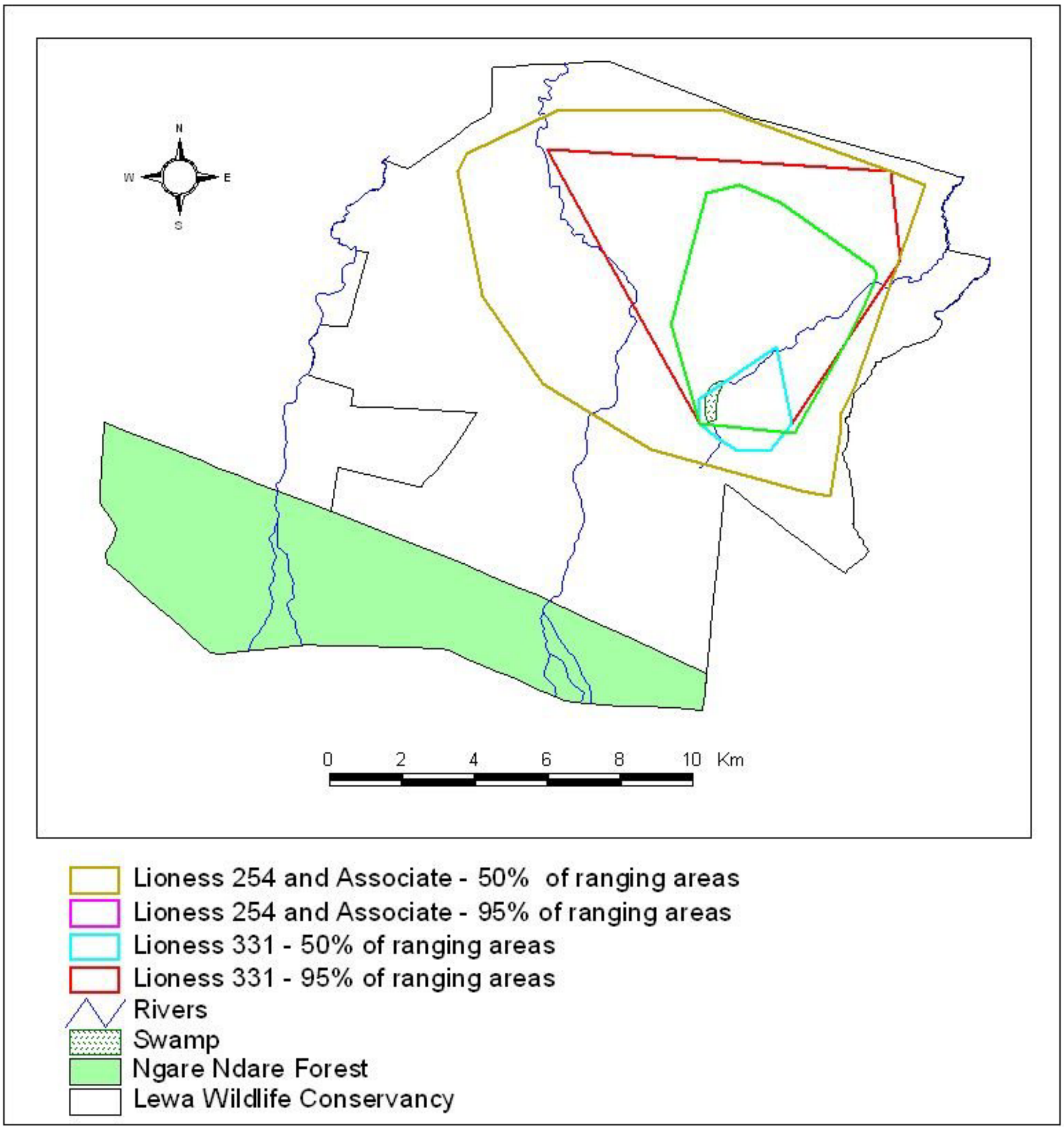


Figure 3.4: Home ranges of lionesses on LWC, 2005 (generated using minimum convex polygon by removing 5% and 50% of the outlier points in ArcView 3.2 Software)

Males 216, 250 and 251 had large areas of utilization compared to the females (Figure 3.5) when calculated using 95% minimum convex polygon. Like with the lionesses, the ranging areas of males decreased considerably when the polygons were generated by subtracting 50% of the outlier points (Figure 3.5). There was however a huge overlap among all the different lions on the Conservancy.

The males home ranges covered areas along Lewa River and the Swamp, hence posing a big threat to the survival rates of Grevy's zebra foals.

Most of the kills reported on LWC were associated with lioness 254 who had teamed with another un-collared female and their six cubs hence the possible cooperation and effectiveness in hunting large bodied animals.

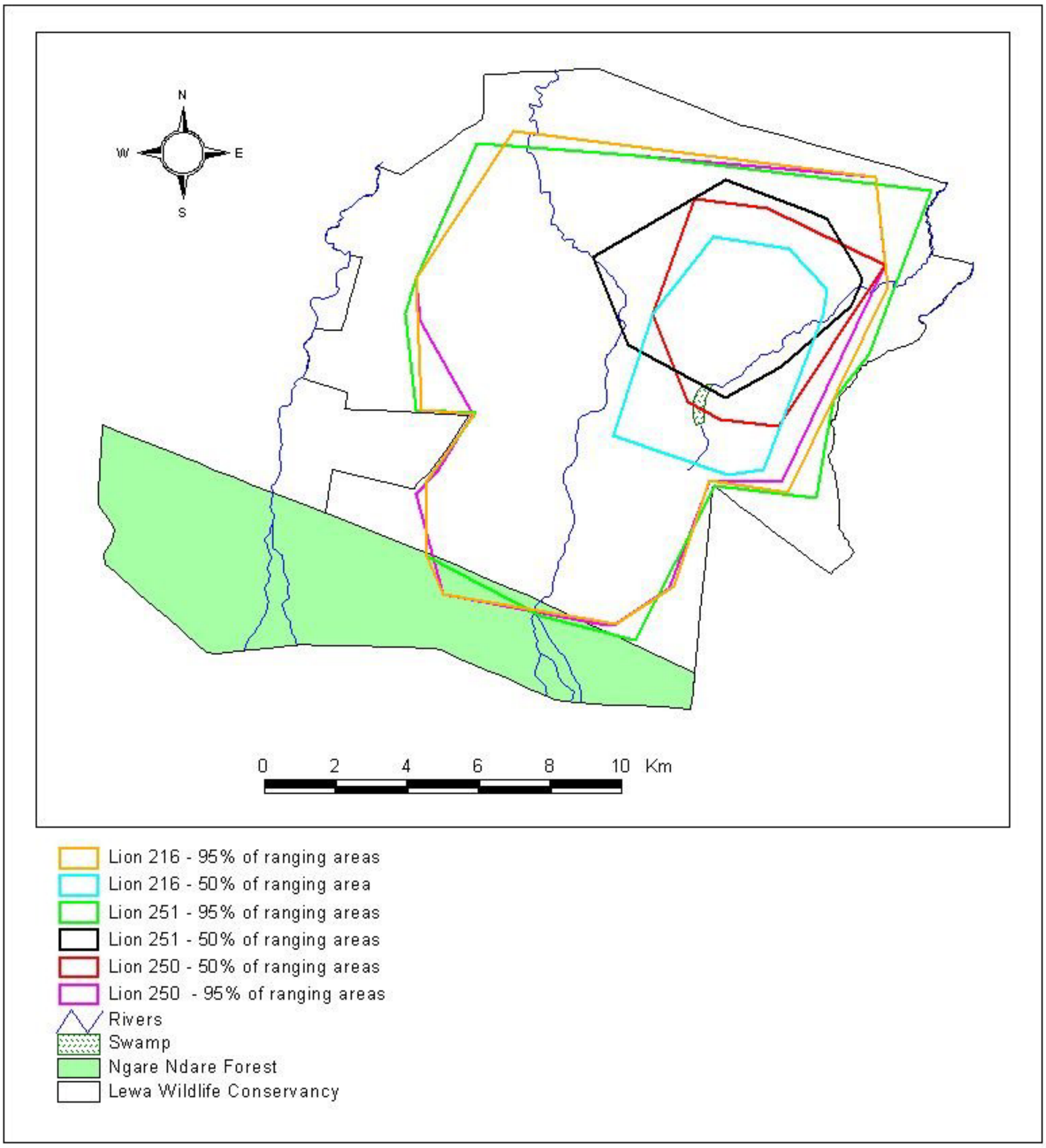


Figure 3.5: Home ranges of male lions on LWC, 2005 (generated using minimum convex polygon by removing 5% and 50% of the outlier points in ArcView 3.2)

4.0 REVIEW OF THE LESSER KNOWN SUB-POPULATIONS OF GREVY'S ZEBRA IN NORTHERN KENYA

4.1 Background to the survey

The continued decline in numbers and range of Grevy's zebra in Kenya has raised great concern amongst many interested stakeholders. As a result, joint surveys and monitoring initiatives have been carried out by various organisations in the past few years aimed at documenting the spatial and temporal distribution, and movement patterns of Grevy's zebra in their range. Most of the current initiatives are concentrated in LWC and a few community-owned lands under the umbrella of the Northern Rangelands Trust (NRT). Little is known about sub-populations of Grevy's zebra that live in isolated areas of their range since they are least monitored.

Below is a summarised version of findings from a two-weeks survey carried out in July by a joint team from Marwell Zoo, LWC, NRT, Kenya Wildlife Service (KWS) and the local communities aimed at providing a snapshot of information on the lesser known and more vulnerable populations of Grevy's zebra in northern Kenya (Woodfine *et al*., 2005).

4.2 Objectives of the survey

The survey was based on the premise that the last comprehensive survey of Grevy's zebra carried out in 2000 estimated about 2,500 animals in their entire range. In 2004, a workshop that brought together concerned stakeholders including local communities, estimated that Grevy's zebra have further declined to between 1,567 and 1,976. However, participants in the workshop lacked updated knowledge about the numbers of Grevy's zebra that reside in the isolated northerly parts of Kenya. A rapid review was therefore necessary.

The objective of the review was to:-

1. Provide contemporary information on the persistence of Grevy's zebra in pockets of their range and advice planners on the merits of a more comprehensive survey work as a prerequisite to conservation planning.

4.3 Methods

The expedition supported by Dutch Zoos Help Foundation though Marwell Preservation Trust was undertaken between 7th and 19th July 2005. The nine-member team in two cars followed a planned route where Grevy's zebra were likely to be encountered (Figure 4.1). In each target area, the team interviewed the local inhabitants about the presence of Grevy's zebra and their behaviour in terms of exploiting the range for food and water, their likely location, perceived threats and other wildlife species. The team later verified these reports either directly or indirectly, and assessed habitat suitability and presence of livestock.

4.4 Results

Close to 200 Grevy's zebra were individually counted in this 2,500 km long expedition (Table 4.1). The majority of the zebras were encountered to the north west of Barsalinga near Lodongokwe. This population comprising of crèches of foals appeared to be living in harmony with livestock and the local Samburu community. Encouraging numbers were counted in Baragoi and South Horr although these populations appeared to be threatened by stiff competition from large herds of livestock and reportedly from hunting for food and traditional medicine by one community residing in the area. The least number of Grevy's zebra was encountered in areas around Sibiloi National Park. There were reportedly no Grevy's zebra in Illeret and Sabarei areas as a result of livestock and hunting pressure. Spoors of 14 Grevy's zebra were counted one morning in Kargi/Karole water hole whereas up to six animals were counted during a night watch in a water hole next to Mt Baio to the west of Laisamis.

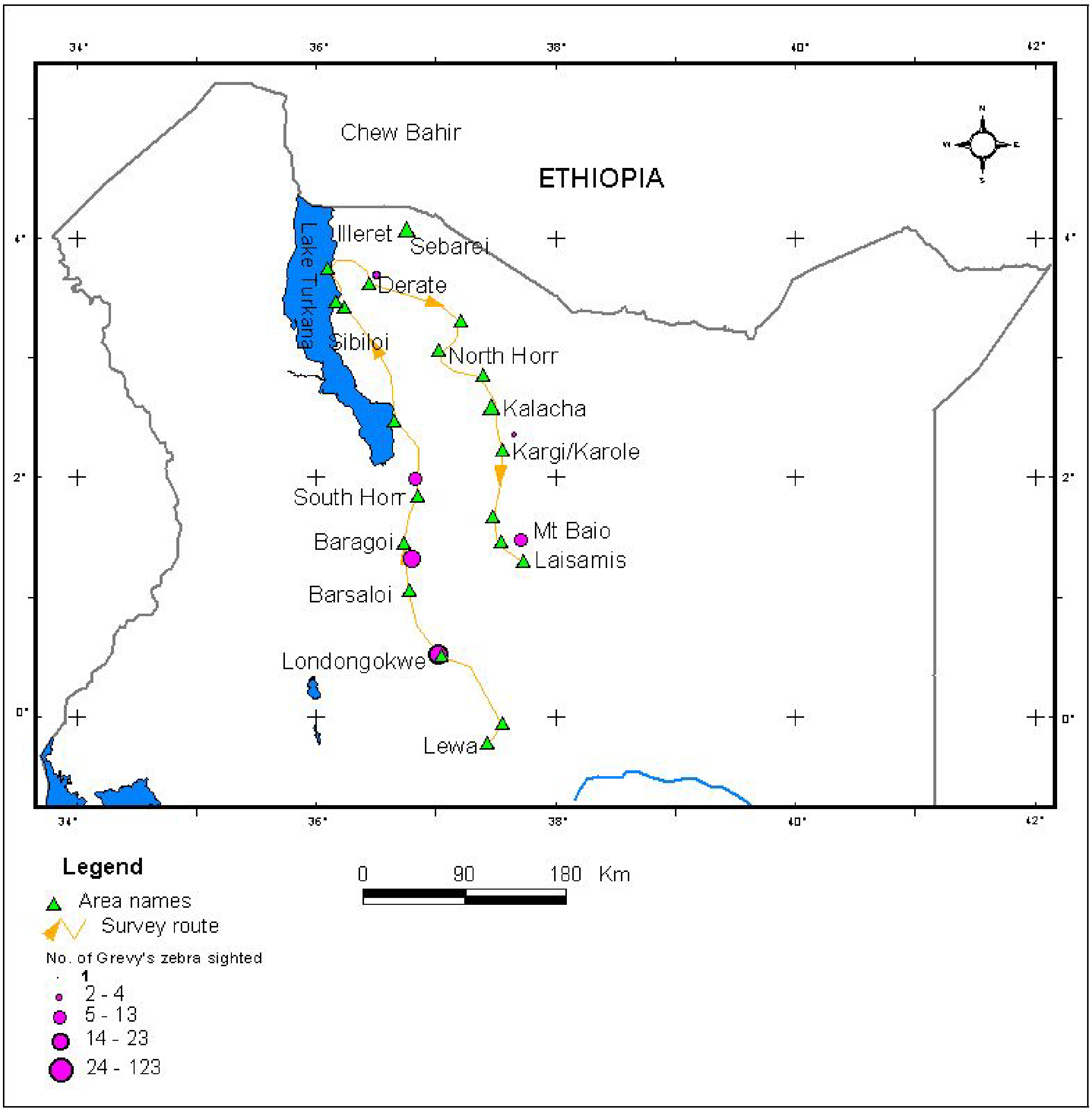


Figure 4.1: Map of northern Kenya showing areas surveyed for Grevy's zebra, July 2005

Table 4.1: Summary of findings at each location visited

Location	Habitat	Reported Grevy's zebra	No. zebras/ spoor sighted	Herd composition	Utilisation of resources & movements	Perceived threats	Livestock sighted	Other wildlife reported	Other wildlife confirmed
Lodungokwe	Tracts of open grassland in Acacia dominated woodland and scrub		61 32 21 3 2 1 3	3 foals, 2 yearlings 2 foals, 2 yearlings 9 foals 3 bachelor males 2 bachelor males Territorial male Unidentified adults	Graze in open grasslands in the day; drink at Centre dam evening; go to hills at night; population migratory	Appear not to be disturbed by livestock and humans	Goats Camels Donkeys Cattle	Cheetah Lion	Leopard Gerenuk Dik dik
Barsaloi	Degraded; majority dense dwarf shrub	10 4	Fresh spoor of 10; fresh spoor of 2 single zebra	-	Drink in nearby dam and sections of river	Competition with livestock & degraded resources	Goats Camels Donkeys Cattle		Dik dik Grant's gazelle Warthog Ostrich
Baragoi/El Barta Plains	Large tracts of open habitat interspersed with areas of open woodland/scrub; areas of good quality pasture		13 2 3 2 3	Unidentified adults Mare and yearling 3 bachelor males Unidentified adults Territorial male, mare, 0-3 month foal	Drink in dam east of Baragoi; graze the El Barta Plains; probable connectivity with animals in Ilaut	Turkana hunters		Eland Impala	Black-backed jackal Plains zebra Beisa oryx Grant's gazelle Gerenuk Ostrich Secretary birds
South Horr/ Kurungu	Tracts of open habitat	1	2 5 6	Mare and young foal 3 adults, 2 foals 5 adults, 1 yearling	Flowing water at Kurungu	Turkana hunters; Livestock in valleys and on hills leaving zebras relatively undisturbed		Cheetah Leopard Lion Kudu	Baboon Golden jackal Gerenuk Impala Ostrich Hyena African wild cat
Sibiloi NP/ Illeret		7	-	-	Go out of park to north & east and return to pasture in park during dry season	Poaching in the north; hunting by Turkana to the south			

Location	**Habitat**	**Reported Grevy's zebra**	**No. zebras/ spoor sighted**	**Herd composition**	**Utilisation of resources & movements**	**Perceived nature of threats**	**Livestock sighted**	**Other wildlife reported**	**Other wildlife confirmed**
Derate/Sabarei (possibly most northern population in Kenya)	Lava hills with natural springs and seasonal grazing	7	4	Unidentified	Drink from natural springs and seasonal grazing; probable connectivity with Sibiloi population	Competition with livestock during dry season			Beisa oryx Ostrich Grant's gazelle
North Horr/ El Gade	Sparse grazing resources	Periodic sightings	No evidence	-	Go to Huri hills during dry season; reported movement to Maikona & Kalacha due to persistent drought in North Horr	Hunting by Gabra for medicine and by Wata for food; competition with livestock			Grant's gazelle Ostrich
Kalacha	Lava hills and salt pan	Herds of up to 10	Spoor from 2 animals		Access to water in the gullies of Chalbi desert every 3-4 days; grazing in Huri Hills; estimated movement of 30km between water & grazing				
Kargi/Karole	Reasonable quality grazing in dune system; vegetation in hills to east of Karole not examined	40-50 at Karole water	1 Spoor	Territorial male At least 14 animals including spoor of 4 foals	Natural springs at Karole & grazing in hills to east and dune system to west;	Grazing in hills to east of Karole where conflict between Rendille & Gabra means no competition from livestock			Black-backed jackal Grant's gazelle Ostrich Spotted hyena Cheetah
Silango Ya Legima/Mount Baio	Large tracts of good quality pasture 18km north of Legima dam	200 use Legima dam during rains	2 1 1 6 A lot of spoor and studpiles near dam	1 mare & foal Territorial male Territorial male Unidentified	Drink from Legima dam; graze 18 km on plain north of dam and another plain approx. 18 km east of dam	Livestock unable to grazing areas because of distance from dam therefore competition threat reduced	Camels and goats by dam		Giraffe Cheetah Spotted hyena Beisa oryx Gerenuk Grant's gazelle Ostrich

4.5 Key issues and way forward

A number key issues and recommendations emerged from the expedition:

1. In most of the areas surveyed, competition for food and water from livestock appeared to be the main threat facing Grevy's zebra.

2. Hunting Grevy's zebra for food and medicinal purposes appeared to be a big threat in Baragoi, Illeret and Sabarei areas.

3. As a start, the traditional use of Grevy's zebra by communities residing in these areas and indeed the entire Grevy's zebra range should be considered before development of any strategic plan for the conservation of this species.

4. The sub-populations of Grevy's zebra in Sibiloi National Park, North Horr and Chalbi Desert were the most elusive and appeared to be the most isolated and vulnerable to hunting. Urgent action needs to be taken to determine their status. The Kenya Wildlife Service in the Park would be most useful in future monitoring of Grevy's zebra in the Park. Similarly, further work is needed to establish the status and long term viability of Grevy's zebra in the eastern Chalbi Desert, Maikona and Huri Hills. It appeared unlikely that Grevy's zebra do not persist any further north of Kenya, except for animals that utilise the hot springs in Chew Bahir Desert in Ethiopia occasionally crossing the border to Sabarei.

5. There is possible connectivity of Grevy's zebra populations in Baragoi, South Horr, Mt Baio, Kargi and Laisamis areas through Ilaut. These areas are inhabited largely by communities that do not utilise Grevy's zebra. It is important to extend survey work to these areas to determine population sizes and if viable, establish Grevy's zebra monitoring for conservation purposes in these areas.

6. Other species of wildlife tended to be present where Grevy's zebra were found, suggesting that refuge areas remain and that conservation action for this flagship species might accrue additional benefits for biodiversity management.

5.0 EARTHWATCH INSTITUTE PROJECTS ON LWC

Summaries of the Earthwatch Institute (EWI) Projects on LWC in 2005 are shown in Appendix 2. The Grevy's zebra and Plains zebra Project has collected data on the Conservancy since 2000 while the Water and Habitats Projects gathered data in 2005.

Meetings involving LWC, Principal Investigators of Habitats and Water Projects and Field Director of EWI in Samburu were held in June and December 2005. In these meetings, the management of LWC expressed keen interest for each EWI project to provide a summary of objectives, means of achieving the stated objectives and accomplishments as at December 2005 so as to assist the Conservancy in meeting its wildlife management objectives. All the projects agreed to submit the summaries to the LWC Research Department by the end of the year. Despite this, reports of the Water and Habitats Projects have not been received to date. In light of this, the future activities of EWI on LWC are in the process of being reviewed.

6.0 GENERAL WILDLIFE MONITORING

6.1 Census data

One of the main objectives of the Research Department is to provide long term data on the trend of wildlife species and habitats. Data on the temporal and spatial distribution of wildlife is gathered in two main ways:

1. Annual game count through combined ground and aerial census.
2. Security field teams' daily reports on the location, herd size and structure of key species encountered during daily patrols. Such reports are collated to determine temporal and spatial distribution patterns of focal species.

The game count figures summarised for the last six years are shown in Table 6.1

Table 6.1: Census data of wildlife species on LWC, 1999-2005

SPECIES	Feb-99	Feb-00	Jan-01	Jan-02	Feb-03	Feb-04	Feb-05	% increase/ decrease
BEISA ORYX	141	126	84	86	62	85	49	-42
BUFFALO	245	238	125	161	203	233	255**	+9
BUSH BUCK	6	0	0	0	~20	>20	>20	
CHEETAH	10	4	21	10	7	8	7***	
ELAND	299	228	151	121	108	137	214	+56
ELEPHANT	170	193	150	28	157	216	297	+38
GERENUK	16	4	17	15	11	7	9***	
GIRAFFE	240	237	236	245	215	177**	173	
GRANT GAZELLE	176	132	162	192	167	261	258	-1
GREATER KUDU	30	13	38	37	33	36	20***	
HIPPO	0	0	1	2	2**	2	2	
HARTEBEEST	45	28	9	7	4	2	2	
HYENA	-	-	-	-	-	>20	>20	
IMPALA	825	733	627	749	760	679	836	+23
JACKAL	0	0	0	0	>15	>12	>12	
KLIPSPRINGER	8	0	0	0	>8	>6	>6	
LEOPARD	10	0	1	7	>8	>8	7***	
LION	11	0	8	20	18	28	24***	
OSTRICH	85	84	119	98	65	68	48	-29
RHINO, BLACK	25	26	29	29	32	36	40	+11
RHINO, WHITE	28	32	30	31	32	32	39	+22
SITATUNGA	12	0	21	21	16	16	14	-13
WARTHOG	367	304	88	194	136	129	170	+32
WATERBUCK	220	474	149	170	64*	52	116	+123
ZEBRA, BURCHELL	1756	1467	1264	1039*	1025	1102	1094	-7
ZEBRA, GREVY'S	632	497	556	487	462*	435	448	+3
		Key						
		>	greater than					
		~	approximately					
		*	census after individuals translocated **out** of Lewa					
		**	census after individuals translocated **into** of Lewa					
		0	species present but not seen during count					
		***	collated from daily security and tour operators' reports					
		-	Not estimated					

By comparing 2005 and 2004 wildlife numbers (Table 6.1), results indicate that there were significant variations in the population of some key wildlife species. The population of Beisa oryx and ostrich registered the highest decrease of 42% and 29% respectively (Figure 6.1). Sitatunga dropped by 13% probably due to predation. Plains zebra dropped by 7% while Grevy's zebra showed a marginal increment of 3% (Figure 6.2).

Waterbuck and eland showed the highest increase of 123% and 56% respectively (Figure 6.3). This may be attributed to a large cohort of calves born in late 2004 and early 2005. The increase in waterbuck population is quite significant considering that LWC lost over half of the species' population in the 1999-2000 drought. Like giraffe, buffalo remained relatively constant although 20 animals were moved into the Conservancy from Lake Nakuru National Park in 2004 (Table 6.1; Figure 6.3).

The population of elephant in the Conservancy at a given time depends on the season. The Conservancy was extremely dry in February 2005 and hence the high population of elephants (Figure 6.4). Most of these elephants were in cow-calf herds. Large numbers of elephants translated into extensive damage to vegetation and hence the importance of establishing exclusion zones (Section 7.3).

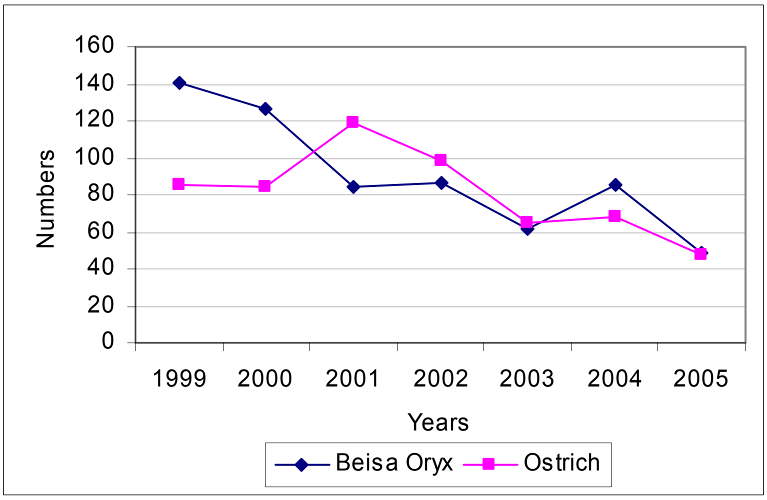


Figure 6.1: Trend in Beisa oryx and Ostrich numbers, 1999-2005

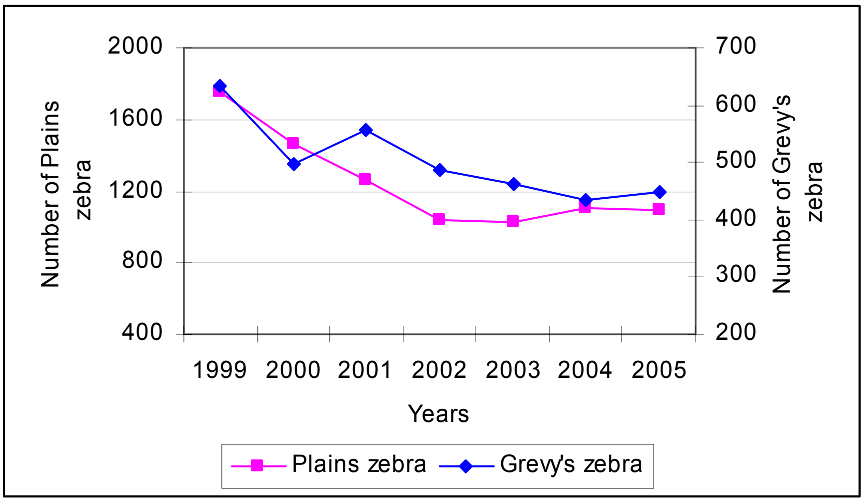


Figure 6.2: Trend in Plains and Grevy's zebra numbers, 1999-2005

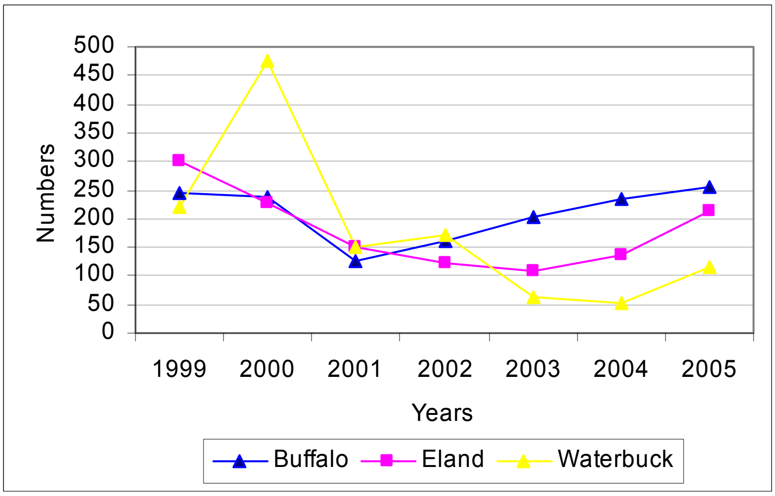


Figure 6.3: Trend in population of buffalo, eland and waterbuck, 1999-2005

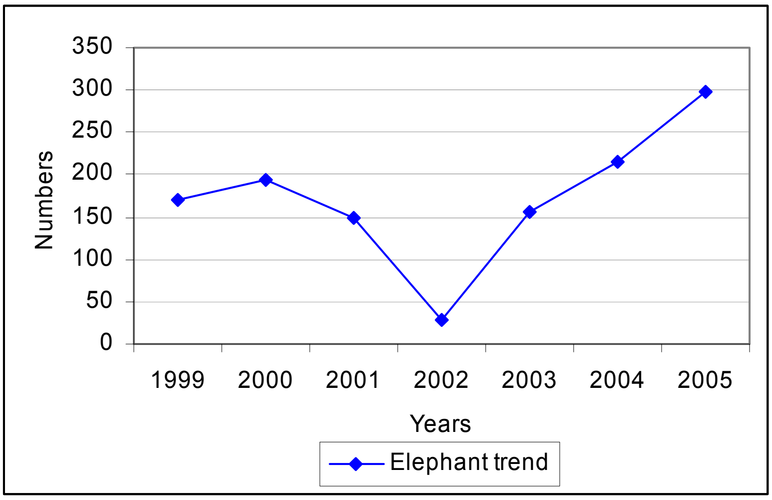


Figure 6.4: Trend in elephant numbers, 1999-2005

6.2 Distribution of key species

6.2.1 Elephant

Just like in the previous years, elephants continued to utilize LWC as a dry season feeding ground. In 2005, high densities of elephants were frequently encountered in Isiolo valley, Dadaboi, Mombasa and along Lewa River. Similar large herds were sighted in Ngare Ndare Forest Reserve. These areas had high densities of prime browse and permanent water. Other areas that were preferred included Mlima Mbogo, Fumbi, Matunda and Luai ya Manyangalo. All these areas were dominated by *A. drepanolobium, A. tortilis, A. xanthophloea* and *A. nilotica* woodlands that are preferred by elephants.

6.2.2 Giraffe

Sightings of giraffes were reported all over LWC with high densities occurring in areas dominated by Acacia woodlands including the former Manyagalo Ranch, Wilderness, Fumbi, Mlima Nyeusi and Sambara areas. Most the Acacia trees in these areas have experienced high browsing pressure leading to stunted growth over time.

6.2.3 Buffalo

Buffaloes were noted to have formed three big herds with over 70 animals in each herd. One herd utilized central and southern parts of LWC including Ngare Ndare Forest. Another herd utilized Dadaboi, Fumbi, Morani and Meza areas with the third herd utilising the western part of LWC. Sightings of solitary bulls and small bachelor male herds were common in the central and eastern parts of the Conservancy. The northern part of the Conservancy was also home to a small population of buffaloes. Areas preferred by buffaloes had high biomass of grass and permanent water.

6.2.4 Kudu

Kudus are shy antelopes and were restricted to the valleys in Morani, Dadaboi, Mlima Kali, Isiolo Valley, Anna's House and along Sergoi River. All these areas form the hilly and rocky kopje units of LWC, they are inaccessible and have less traffic disturbance demonstrating that kudu favour relatively less disturbed habitat.

7.0 ECOLOGICAL MONITORING

7.1 Rainfall

Rainfall in LWC follows a bimodal distribution pattern with long rains falling during the months of March to May while the short rains are received over the months of October to December.

Rainfall was recorded on 11 stations distributed across the Conservancy. Rainfall reports were sent to the Lewa Gate on a daily basis. This information was later collated and summarised by the Research Department.

In 2005, the highest amount of rainfall was recorded at Lewa Headquarters (326mm) while the least rainfall was received at Lewa Safari Camp (163mm).

A total of 286mm of rainfall was recorded during the year. This figure was way below the total amount of rainfall received in 2004 (587mm) and the long-term mean rainfall of 545 mm. Very low rainfall was received in the October-December rainy season compared to 2004 (Figure 7.1). The poor rains received in 2005 resulted to low availability of forage. This ultimately influenced the spatial and temporal distribution of most plains game that preferred to utilise the steep slopes and valleys as opposed to the relatively open plains.

The highest monthly rainfall of 60mm was received over the long rains in April while the least rainfall (7mm) was recorded in July. There was no rainfall in the month of June and August.

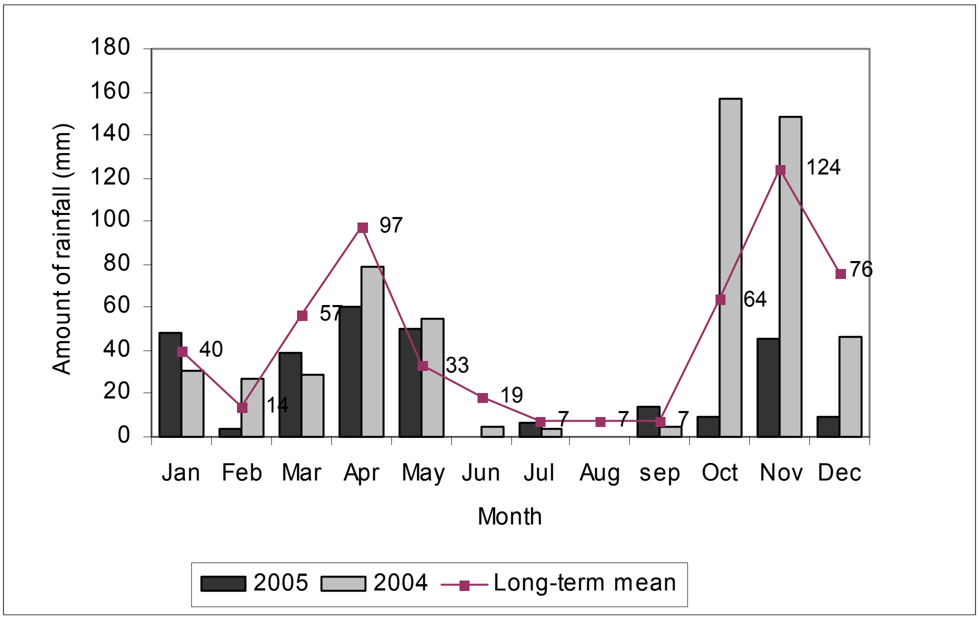


Figure 7.1: Amount of rainfall received in 2005 and 2004 in relation to the long-term mean rainfall on LWC

7.2 Vegetation monitoring

The main aim of vegetation monitoring on LWC is to provide trends in the condition of both grass and woody vegetation habitats. Data generated is important since it guides strategies for habitat improvement.

Three types of vegetation monitoring activities are carried out on LWC. These are:-

i. Grass assessment
ii. Woody vegetation monitoring
iii. Prescribed burning
iv. Fixed-point photography

7.2.1 Grass assessment

The questions being addressed by grass assessment on LWC are:

1. *How can the pasture on LWC be improved for grazers?* – Data is needed on the spatial distribution of biomass of grass in order to determine areas to be subjected to prescribed burning or intensive livestock grazing to remove the accumulated moribund and unpalatable residues of herbaceous material.

In general, methods available for answering this question have been described in Botha (1999) and Trollope (1999). Grass assessment was conducted on 28 vegetation monitoring blocks. Results of the assessment are shown in Table7.1.

Results

Results indicated that there was considerable decrease in grass biomass on blocks in rocky and hilly areas (Morani, N.E.Fuzz, Dadaboi, Mlima Kali and Mlima Nyeusi) compared to blocks on open plains (Serghoi, Halvors, Sambara and West of Kiboo's). This was attributed to low rains received over the whole year leading to poor growth of grass material. Therefore, most grazers extended their areas of utilization to hilly places that that had sparse patches of Decreaser[5], and Increaser I[6] and II[7] grass species.

In an attempt to remove the moribund grass material, Sambara, Meza and Matunda blocks were grazed by community livestock in selected months in 2005. The livestock gained entry into the Conservancy on a daily basis. On the other hand, Fumbi, Mtego ya Twiga and Mlima Tanki were burnt in 2004. Grazing and burning reduced considerably the standing crop of grass.

[5] Decreaser Species – Grass and herbaceous species which decrease when rangeland is under or over utilised

[6] Increase I Species – Grass and herbaceous species which increase when rangeland is under utilised or selectively grazed

[7] Increase II Species – Grass and herbaceous species which increase when rangeland is over utilised

Table 7.1: Biomass of grass (kg/ha.) on the 28 vegetation monitoring blocks on LWC, 2000 – 2005

MU	Block Name	2000	2001	2002	2003	2004	2005
P	Lenjoro	1208	3818	3781	6568	6415	5034
RH	Mlima Tanki	3589	4805	5655	6890	2848	3893
RH	Mlima Loishimi	1156	3550	4004	5715	6008	6264
P	Dam Mkora	3931	5595	5079	7701	7201	4004
P	Serghoi	5804	7072	7479	4004	4969	5162
RH	Meza	4186	5350	7429	10022	8356	2978
RH	Morani	4322	6292	7072	10262	7303	7098
P	Halvors	4604	4570	7919	6676	5375	5534
RH	N.E. of Fuzz	749	1005	2057	4739	6270	5002
RF	Ian's Bridge	1187	3628	4937	6784	6644	5774
P	Matunda	3781	4638	5319	7943	7871	6649
P	Kona Mbaya	***	3589	7303	9486	8411	7847
F	Williams Hse	2443	3270	3391	5002	4742	5002
F	Sobuiga	4328	4805	3589	6703	2761	4467
RH	Mlima Simba	1363	1305	1695	4502	3968	5288
RH	Dadaboi	683	1801	1853	4433	3033	3781
P	Sambara	3471	4150	2489	5833	4502	6810
RH	Mlima Kali	2627	1695	2156	4937	4114	3628
RH	Mlima Nyeusi	4114	5193	5066	8411	7573	6994
RF	Kisima	5066	4398	5130	6942	7376	7404
RH	Mlima Mbogo	2581	2349	3818	7529	***	5443
P	Shamba	3589	4937	6514	8343	7725	***
RH	Mawingu	4885	5225	5950	9189	9695	6863
F	Kahawa	2210	2805	2935	7404	7288	5534
P	Mtego ya Twiga	***	4937	6622	***	2387	5625
RH	West of Kiboos	4969	4904	5921	7603	6345	6595
P	Fumbi	4467	6320	7750	8728	3956	4871
RH	Mombasa	1502	2396	3589	10002	5104	6376

Key: Burnt blocks (grey) Grazed blocks (orange)
MU – Management unit types
P – Plains
RH – Rocky Hills
RF – Riverine Forest
F - Forest

7.2.2 Burning and woody vegetation monitoring

Introduction

In January 2005, cool fires were applied to several blocks within LWC. The main objective of applying cool fires was to reduce the extent of damage on the *A. drepanalobium* trees that dominated the targeted blocks. Similarly, cool fires ensure that low biomass of grass is maintained for an extended period of time especially if burning is done just after the rains when grass is still green.

The blocks targeted for burning were along the Airstrip and Lewa River, Matekenye (west of Swamp) and Bomb Campsite (Figure 7.2). These blocks had a grass biomass of >6000kg/ha., they had moribund grass material and were dominated by Increaser I grass species (*Pennisetum stramineum*) and hence qualified for burning (Trollope, 1999).

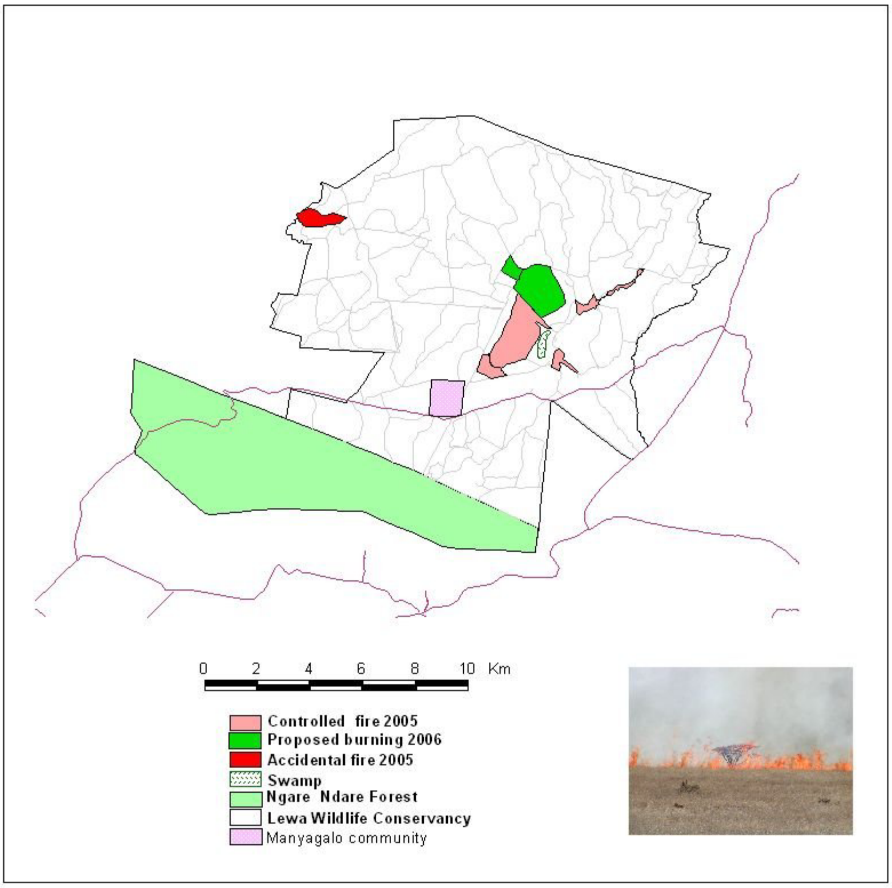


Figure 7.2: Areas burnt on LWC, 2005

Post burn woody vegetation assessment

A post-burn survey was conducted on the Airstrip block in order to determine the effect of the cool fires on the woody vegetation. Systematic random sampling was used to lay out the four sampling plots with each plot measuring 20x20 m. A distance of 200m was maintained between any two plots. All the trees within the plots were tagged, identified and their heights recorded.

After burning, on each plot, the following data, and characteristics of the condition of all the trees and shrubs were recorded:

- Species name
- Density of trees by species
- Height of tree
- Whether coppicing, shooting or coppicing/shooting
- All the seedlings and shrubs were counted and the species identified.

Results
The dominant tree species on all the surveyed plots was *A. drepanolobium* whereas *Hibiscus* spp. was the dominant shrub (Table 6.2).

Table7.2: Abundance of tree species on surveyed plots

Tree species	%
Acacia drepanolobium	95
Rhus natalensis	3
Acacia xanthophloea	2

Shrub species	%
Hibiscus spp	73
Lycium spp	10
Aspera spp	11
Maerua spp	3
Asparagus spp	3

Results indicated that there was 100% reduction in tree height on all surveyed trees (Figure 7.3). However, all the trees were alive and were coppicing, shooting or coppicing/shooting even though they had suffered top kill (Figure 7.4). *A. drepanolobium* recorded a high number of coppicing and shooting trees implying that it has a high resistance to fire.

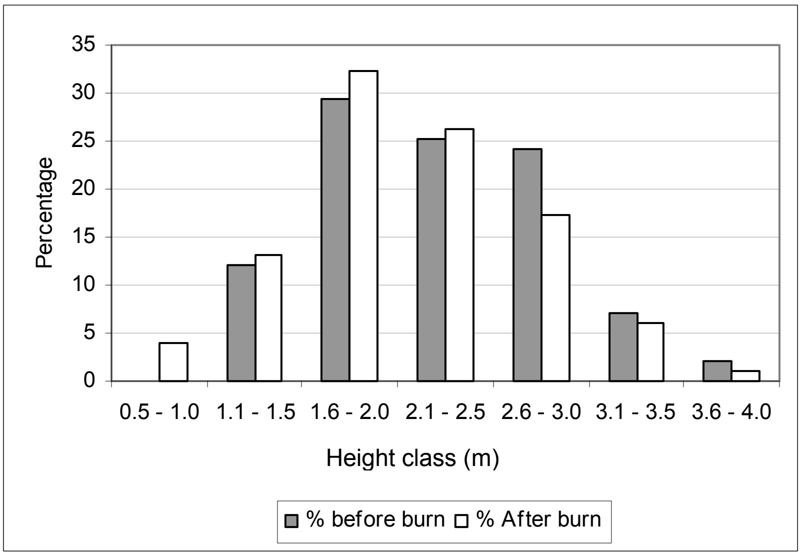


Figure 7.3: Comparison of height classes before and after the burn, LWC

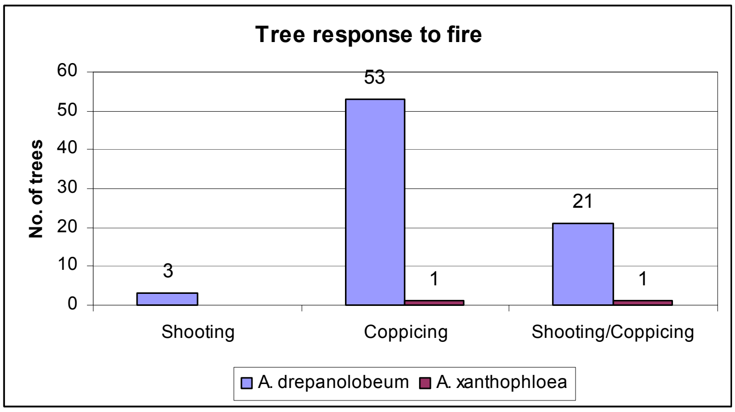


Figure 7.4: Response of trees to fire on burned blocks on LWC, 2005

Trees >2.5m high appeared not to be significantly affected by fire and showed high rates of shooting. Conversely, trees and shrubs less than 1m generally suffered the greatest top kill. The trees were noted to be recovering through coppicing from the base implying that cool fire temperatures' rarely reach lethal levels and do not kill the rooted portions of trees. Similarly, the rise in temperature during burning is very brief and rarely lasts for over five minutes (Edroma, 1984).

A total of 19 *A. drepanolobium* seedlings were counted after burning in all the four sampled plots. This was as a result of changes induced in the soil surface, which favoured germination of seeds. The resulting ash enriched the soil giving the seeds a better chance of germination. The increased temperature following fire may also have broken dormancy and stimulated germination (Gillon, 1983).

Conclusion

The overall conclusion to be drawn from this assessment indicated that cool burns cause minimal destruction to woody vegetation. Such burns have the potential of changing the structure of the woody vegetation by promoting coppicing and shooting. Such coppices and shoots are within the reach of small browsers. It is therefore recommended that in future, only cool fires should be applied on LWC.

7.2.3 Fixed - point photography

Vegetation changes over time due to changes in browsing pressure and rainfall patterns. It is imperative that such changes are recorded on a yearly basis to demonstrate trends.

In LWC, the main objective of fixed-point photography is to provide a permanent visual record of vegetation changes on each of the 28 fixed-point photography areas - representing different plant communities, across years. Fixed-point photographs are taken in the 4 main compass directions in September every year. All photos are then archived in relation to years and vegetation community.

In 2005, vegetation changes from the photography exercise varied between vegetation communities compared to 2004. Areas along the riverine forest, the rocky hills and valleys were severely impacted by large aggregations of elephants that utilised LWC as a result of low rainfall received in the year. Some other areas that were not preferred by elephants however showed minimal vegetation change.

7.3 Exclusion zones

7.3.1 Background

LWC was primarily established in 1984 as a black rhino sanctuary. Since then, the numbers of elephants utilising the Conservancy in the dry season has more than doubled, leading to massive destruction of woody vegetation especially along the riverine forests. LWC has therefore adopted a policy of establishing exclusion zones aimed at excluding the megaherbivores in order to protect the riverine forest and black rhino habitats from destruction.

Exclusion zones serve several purposes including:-

1. Maintaining the excluded area as key black rhino habitats and refuge by excluding elephants and giraffes while allowing other smaller herbivores to go under the 7-8 feet high electric fence.
2. Increase the diversity and abundance of other species including birds, insects and reptiles by offering a wide niche overlap.
3. Ensure regeneration of woody vegetation destroyed be elephants hence maintenance of aesthetic value of the landscape
4. Play a key role in the source-sink population dynamics.

7.3.2 Results

As at December 2005, about 20 km^2 (slightly under 10%) of LWC, but excluding Ngare Ndare Forest Reserve was under exclusion zones (Figure 7.5). Areas to be considered for more exclusion zones are also shown. These areas were chosen because they have unique woody vegetation habitats that may soon be destroyed elephants. Similarly, black rhinos have recently expanded their ranging areas to the proposed *Acacia nilotica* and *Hibiscus* spp dominated Matunda/TM block (Figure 7.5). An extension of Willy Robert's exclusion zone is necessary to protect the existing degraded *A. drepanalobium* and *A. xanthophloea* trees.

7.3.3 Conclusion

It is recommended that more exclusion zones be established where appropriate with particular focus on key black rhino habitats and riverine areas in order to maintain LWC as a key breeding area for black rhinos.

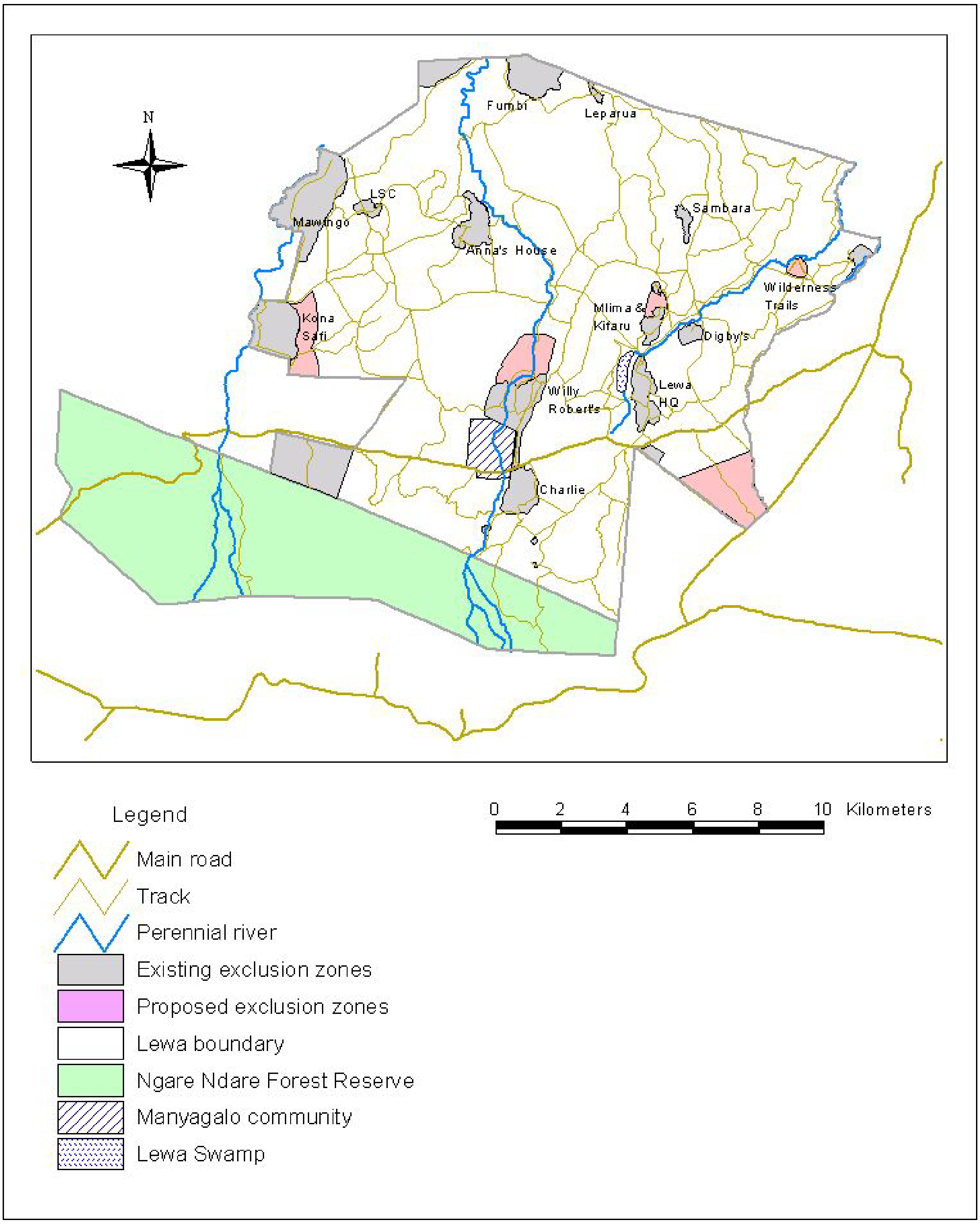


Figure 7.5: Location of existing and proposed exclusion zones, December 2005

8.0 COMMUNITY LIVESTOCK GRAZING

The prevailing drought in 2005 brought a lot of challenges relating to livestock grazing in the community areas adjoining LWC. As a result, a collaborative grazing programme was formed that allowed community livestock to graze in the Conservancy on specific blocks that had moribund grass >5000kg/ha and that would otherwise would have been subjected to prescribed burning.

In collaboration with the selected committee from the community and LWC personnel, a protocol for livestock grazing was drawn. The protocol laid down rules and regulations governing the grazing programme and penalties for defaulters. This kind of controlled grazing is presently being incorporated as part of the Conservancy's rangeland management programme that will be operated hand in hand with the annual prescribed burning programme. Currently, communities are in the process of organising themselves to form and register Community Based Organisations (CBOs) that will have guiding principles in the manner that they will exploit grass on LWC. Similarly, this exercise will act as a tool for community development in the respective areas.

8.1 Methods

Grass assessment was carried out in the targeted blocks before and after grazing. Specific blocks that were on the edge of the Conservancy, and that had grass biomass >5000 kg/ha were thus subjected to grazing. Similarly, in order to be compatible with LWC's high end tourist product, the selected blocks were those that did not intrude on tourist's wildlife experience.

The aim was to concentrate large herds of cattle in small blocks. This would ensure fast removal and trampling of the dead grass material. Over 3000 head of cattle were grazed in the following blocks: Rugusu, Airstrip, Chemichemi ya Manyagalo, Mlima Faru, Kona Safi and Mawingo areas, Sambara, Fumbi and Meza areas (Figure 8.1).

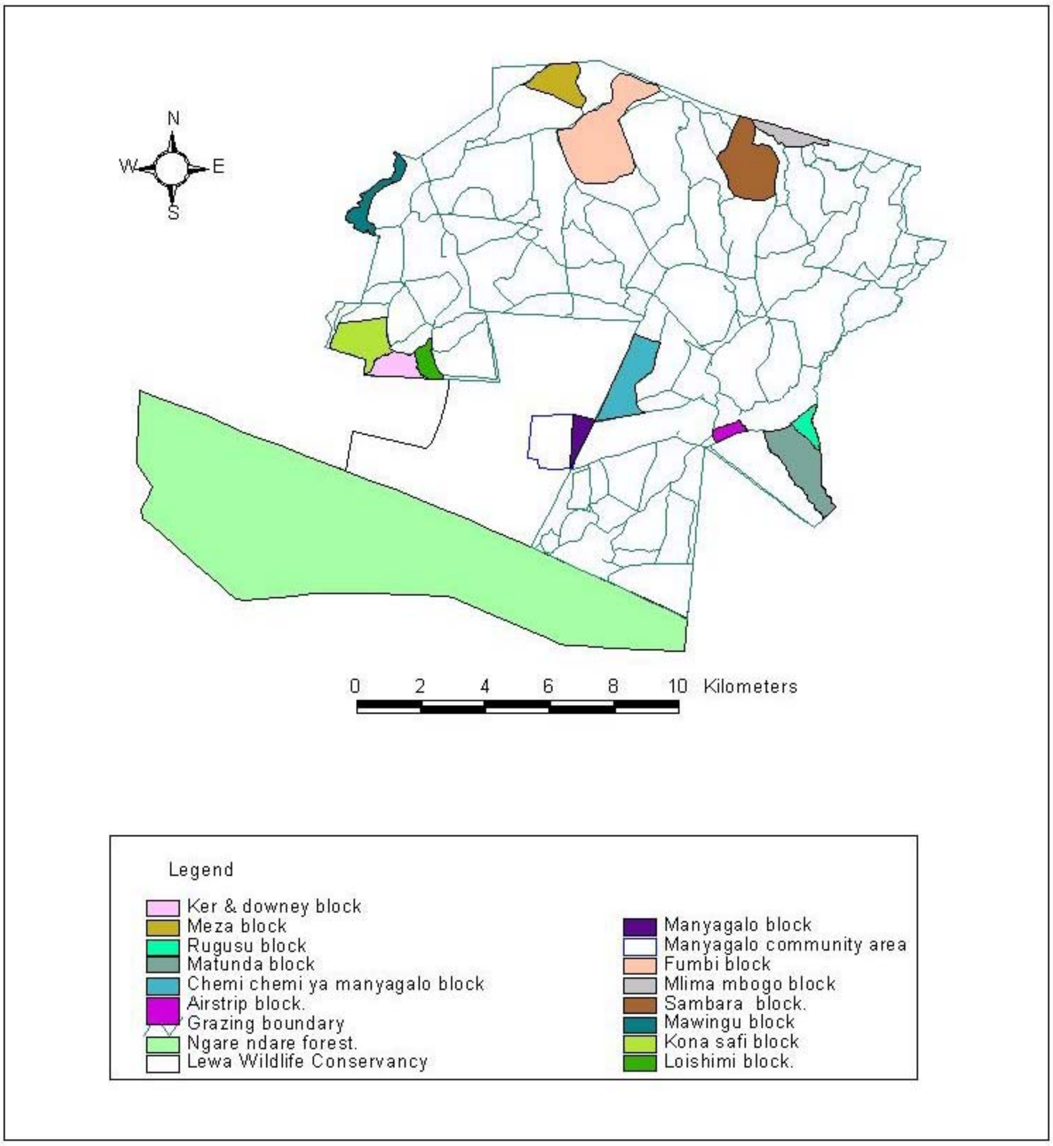


Figure 8.1: Areas subjected to community livestock grazing on LWC, 2005

8.2 Results and discussion

Grass biomass reduced considerably in all the grazed blocks compared to blocks that were not grazed (Table 8.1). The biomass of grass was reduced more in areas that were grazed when grass was relatively green. Therefore, it is recommended that *P. stramineum* and *P. mezianum* dominated black cotton soil areas should be grazed when the grass is relatively green for livestock to have a meaningful effect. Again, large herds of livestock should be concentrated and grazed in small blocks to attain a high degree of trampling.

Livestock grazing did not appear to influence the feeding pattern of wildlife especially the plains game. Similarly, the ranging areas of rhinos appeared not to be influenced by the presence of livestock as their sightings used to be reported in blocks being grazed. However, Ngare Ndare Forest Reserve was similarly grazed by large herds of livestock whose numbers were not actively controlled. This appeared to have disturbed the ranging areas of the Forest rhinos that started utilising the northern edges of the Forest and the former Manyangalo Ranch with a high frequency.

Table 8.1: Comparison of grass biomass before and after grazing, 2005

Block Name	Grass biomass before grazing	Grass biomass after grazing	% decrease	Average herd size	Comments
Rugusu	5880	3138	46	290	Grazed by TM, Matunda & Subuiga livestock
Airstrip	8000	5774	28	314	Combination of TM, Matunda & Subuiga livestock
Chemichemi Manyangalo	7091	5420	24	229	Manyagalo cattle only
Kona Safi	6406	3305	48	800	Ngare Ndare livestock
Meza	6457	3410	47	1300	Leparua livestock
Manyagalo Gate	7123	5815	18	197	Manyagalo cattle
Mawingo	6863	4128	40	800	Sangaa & Ngare Ndare livestock
Fumbi	5178	4329	16	300	Leparua livestock
Sambara	6817	5722	16	723	Leparua livestock

9.0 ILLEGAL ROADS NETWORK ON LWC

9.1 Background

All roads disturb the natural vegetation in an area and hence they should be placed as discreetly as possible. Like other conservation areas, three types of roads exist on LWC. These are:

1. Tourist roads: The primary purpose of these roads is to offer tourists the opportunity to experience the best of the natural resources of the Conservancy. These roads can be accessed by all vehicles of LWC.

2. Management roads: Although these roads are few on LWC, they have less vehicle pressure and should only be used for management or security purposes. These roads should be less conspicuous than tourist roads and should not be accessed by tourist vehicles.

3. Fire breaks: Fire is used as a management tool to remove the moribund and unpalatable grass material. However, accidental fires do occur in the dry season leading to considerable destruction of flora. The existing fire breaks should be regularly maintained. When combined with tourist and management roads, they should act as effective fire breaks.

A fourth but unplanned category that emerges in conservation areas is the illegal roads network. Illegal roads have several impacts to the environment including (Eagles, *et al.*, 2002):

i. Negative impact to vegetation that ultimately leads to degradation and loss
ii. Damage to archaeological sites
iii. Soil compaction and erosion due to roads that cut across the contours
iv. Ruins the aesthetic value of the landscape
v. Disturbs wildlife behaviour
vi. Increases the risk of fire.

Even though tourism provides direct economic benefits from wildlife and biodiversity, seemingly without the environmental impacts of more consumptive industries like mining and forestry (Goodwin, 1996), the environmental hazards to vegetation as mentioned above cannot be underestimated. In the Maasai Mara for example, tracks increased by 30% between 1991 and 1999. The majority of such an increase was from unofficial off road tracks (Karanja, 2003). Samburu and Buffalo Springs National Reserves in northern Kenya are not an exception and there are massive tracks of illegal roads especially on the flat plains adjacent to Ewaso Ngiro River.

In 2005, there was high proliferation of illegal roads from tourism activities that caught the attention of the management of LWC. It is against this background that the Research Department was tasked with mapping the entire illegal roads network. Results were used to raise the awareness of tourist operators, driver guides and managers of tourist facilities on the extent and impact of such roads in LWC.

9.2 Results

A total of 82 km of illegal roads were mapped (Figure 9.1) representing an increment of about 30% when compared to the existing legal network of about 240 km. The highest concentration of the network was in the central part of Lewa - Kiwanja ya William, Mlima Makutikuti and the Archaeological site, along Lewa River and Mlima Lenjoro areas.

In particular, the illegal road network in Mlima William area had developed due to increased demand for cheetah sightings. The northern network has resulted from increased lions' visitation while sun-downer activities in Mlima Makutikuti and Mugumo have led to development of roads that cut across the contours.

These extensive illegal road networks translate into massive destruction of vegetation and possible disturbance to wildlife behaviour especially large predators including lions and cheetahs since they are most sensitive to disturbance (Muthee, 1992). Such disturbances may lead to a reduction in the carrying capacity of species especially black rhinos as they attempt to seek refuge in the relatively undisturbed areas (Karanja, 2003).

9.3 Recommendations

Off road driving should not be encouraged except by management when monitoring, capturing or trating of key wildlife species. This must be regulated as stipulated in the current "LWC Standards". Cars should not use the same tracks on a regular basis while going off road as this makes tracks more conspicuous. Again, if it has rained, there should absolutely be no0 off-road driving unless it is critically important.

Zonation is crucial and areas where no further roads should be developed are shown in Figure 9.1. These areas represent key black rhino habitats.

It is recommended that a road network should be opened on the eastern side of Fumbi and Sergoi Plains. This will make the two areas more accessible to tourists and reduce the pressure on roads on the central area of LWC.

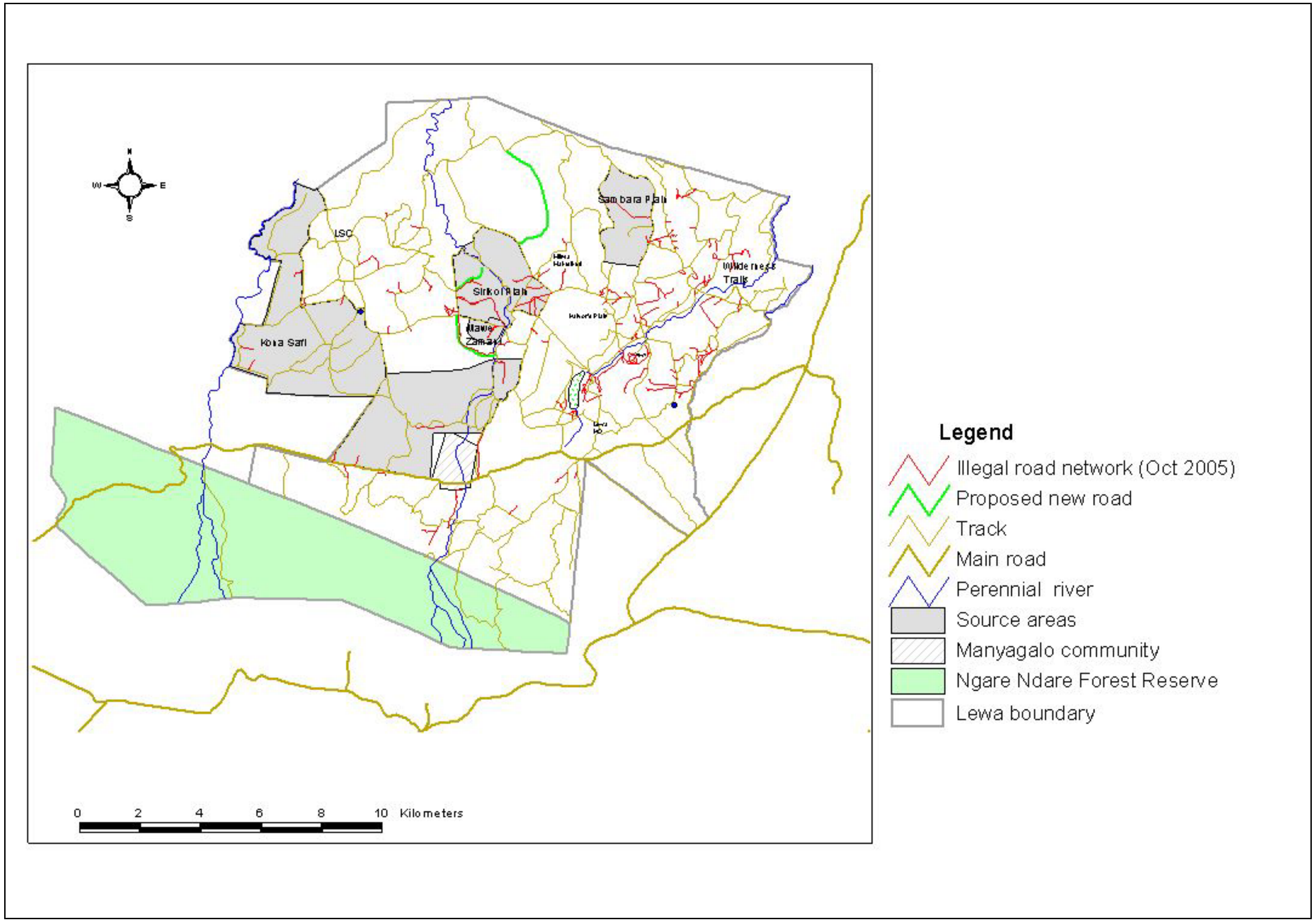


Figure 9.1: Illegal roads network and proposed new roads, October 2005

10.0 TRAINING

In collaboration with the Northern Rangelands Trust (NRT), members of the Research Department participated in a five-day wildlife and ecological monitoring training exercise targeting Sera Conservancy security personnel. Within the same period, eight 500m long vegetation monitoring transects covering the different habitat communities were also established. 20x20 m quadrants were set up every 100 m along each transect. These quadrants will be used as reference areas to gather woody vegetation data. Similarly, two local community members who will be gathering basic woody vegetation, herbs and grass data on the transects and quadrants were also identified. The two assisted in setting up of the vegetation transects and gathering initial basic data.

If successful, the wildlife and vegetation surveys being tested in Sera will act as a model in which the NRT will launch similar surveys in other Trust's member areas.

Data gathered from wildlife and vegetation surveys will help the Sera management to detect trends in the following areas:

1. Wildlife population numbers in wet and dry seasons within the Conservation Area and the surrounding areas
2. Relative abundance of wildlife populations within Sera Conservancy
3. Livestock numbers in buffer areas surrounding the Conservancy
4. Human occupation in the buffer areas surrounding the Conservancy
5. Threats to wildlife from poaching and human-wildlife conflict
6. Levels of security for wildlife, people and livestock in the Conservancy and immediate surroundings
7. Vegetation resources within the Conservancy and the surrounding buffer areas and,
8. Changes in ecosystem health and resource availability as perceived by the community.

It is anticipated that in future the LWC research team will work closely with NRT to make follow-ups for Sera wildlife and vegetating survey work together with other areas where similar work might be established in future.

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APPENDIX 1: BREEDING PERFORMANCE AND CALVING PREDICTION FOR BLACK AND WHITE RHINOS ON LWC – 2005

BLACK RHINO

No.	Code	Name	Date born	Age (yrs)	Mother	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	Age at 1st calving (yrs)	Calving Intervals 1	2	3	4	5	6	7	Mean calving interval/ female
1	2509	Juniper	28/6/88	17.7	Juno																										7.6	3.2	2.3	2.2	2.3	-	-	-	**2.5**
2	507	Mawingo	1/6/89	16.8	Solio Cow																										**	2.2	2.8	1.7	1.5	-	-	-	**2.1**
3	2530	Meluaya	25/1/96	10.1	Juniper																										8.4	-	-	-	-	-	-	-	**-**
4	2523	Ndito	1/1/90	16.2	Solio Cow																										9.3	3.2	2.2	-	-	-	-	-	**2.7**
5	2517	Nyota	1/12/91	10.1	Stumpy																										7.8	2.7	2.4	-	-	-	-	-	**2.5**
6	2505	Solio	1/1/76	30.2	Solio Cow																										**	3.1	3.5	3.9	3.2	2.1	2.9	2.3	**3.0**
7	2516	Sonia	23/8/91	14.5	Solio																										7.1	4.7	2.4	-	-	-	-	-	**3.6**
8	2504	Stumpy	1/1/67	37.2	Solio Cow																										**	**	3.9	2.8	2.2	3.0	2.0	-	**2.8**
9	2528	Waiwai	4/7/95	10.7	Solio																										6.8	2.1	-	-	-	-	-	-	**2.1**
10	2514	Zaria	9/3/88	18.0	Solio																										7.8	3.4	3.0	2.1	-	-	-	-	**2.8**
11	2533	Nashami	16/7/98	7.6	Stumpy																										7.6	-	-	-	-	-	-	-	**-**
12	2536	Natumi	26/9/98	7.4	Solio																										6.7	-	-	-	-	-	-	-	**-**
13	2534	Samia	10/9/98	7.5	Sonia																										-	-	-	-	-	-	-	-	**-**
14	2541	Oboso	09/10/00	5.4	Zaria																										5.4	-	-	-	-	-	-	-	**-**
15	2538	Seiya	26/4/99	6.8	Ndito																										5.5	-	-	-	-	-	-	-	**-**

Mean age at 1st calving = 7.3 **Mean inter-calving interval = 2.7**

WHITE RHINO

No.	Code	Name	Date born	Age (yrs)	Mother	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	Age at 1st calving (yrs)	Calving intervals 1	2	3	4	5	6	7	Mean calving interval/ female
1	2511	Murembo	1/1/76	30.2	Solio Cow																										6.0	2.9	2.6	1.9	2.8	1.8	-	-	**2.4**
2	2513	Natal	1/1/89	17.2	Natal Cow																										8.1	2.3	2.2	2.2	-	-	-	-	**2.2**
3	2515	Ngororika	1/1/81	25.2	Solio Cow																										**	2.0	2.2	2.6	2.1	2.1	-	-	**2.2**
4	2518	Opondo	1/1/86	20.2	Natal Cow																										**	2.3	2.6	2.5	-	-	-	-	**2.5**
5	2519	Songare	1/1/80	26.2	Solio Cow																										**	4.0	2.2	4.0	2.0	2.0	-	-	**2.8**
6	2521	Tumbili	1/1/86	20.2	Natal Cow																										8.3	2.2	3.2	3.4	-	-	-	-	**2.9**
7	2504	Jakwai	1/1/87	19.2	Solio Cow																										9.4	2.2	2.9	1.9	-	-	-	-	**2.3**
8	2507	Rinta	3/6/94	11.7	Ngororika																										7.7	2.5	-	-	-	-	-	-	**2.5**

Mean age at 1st calving = 7.9 **Mean inter-calving interval = 2.5**

Key:
- (green) *Year female born*
- (blue) *Quarter of the year calf born*
- (red) *Future calving based respective female's last inter-calving interval*
- (yellow) *Future calving based on respective female's mean inter-calving interval*
- (magenta) *Expected date of first calving (@ 7 years)*
- ** *History unknown*

APPENDIX 2: EARTHWATCH INSTITUTE PROJECTS ON LWC, 2005

ZEBRAS OF KENYA: UNRAVELLING THE RELATIONSHIP BETWEEN GREVY'S AND PLAIN ZEBRA IN LEWA WILDLIFE CONSERVANCY

Joseph N. Kirathe, Dan Rubenstein, Nick Oguge and Geoffrey Chege

Background

The numbers and range of the endangered Grevy's zebra (*Equus grevyi*) have greatly declined dramatically throughout over the last two decades (Williams and Low, 2004, Fig.1). With only around 2000 individuals remaining in Kenya and close to 150 individuals in Ethiopia, the animal has disappeared in Somalia, Eritrea and Djibouti (Williams, 2002). Most of the remaining population is patchily distributed within the former range (Williams, 2002). The reasons for the Grevy's demise have been shown to be human driven impacts. Pastoral community population increase and their livestock within the Grevy's range may have contributed a great deal. Lewa wildlife Conservancy has at least 17-23% of the wild Grevy's population. This population is very critical as it is the only one protected free from negative human impact unlike other populations in Kenya. The population rose to a maximum of 632 individuals in 1999 and thereafter started oscillating at a declining rate (Fig.1). As the Lewa Grevy's population is protected with little human impact, it is expected to have optimum reproductive rates. In addition, the population can act as a control to measure performances and be used to predict mitigation factors on populations occurring outside protected areas. With performance of Grevy's zebra population being not as expected in Lewa, there is need to determine their limiting factors. Competition with plains zebra (*Equus burchellii*) (Rubenstein, 2004) and predation by lions (Njonjo, 2004) have been determined as the factors limiting population growth. Determining why declines are occurring on protected area i.e. Lewa, will help us understand the dramatic declines in areas where Grevy's shares resources with livestock and humans.

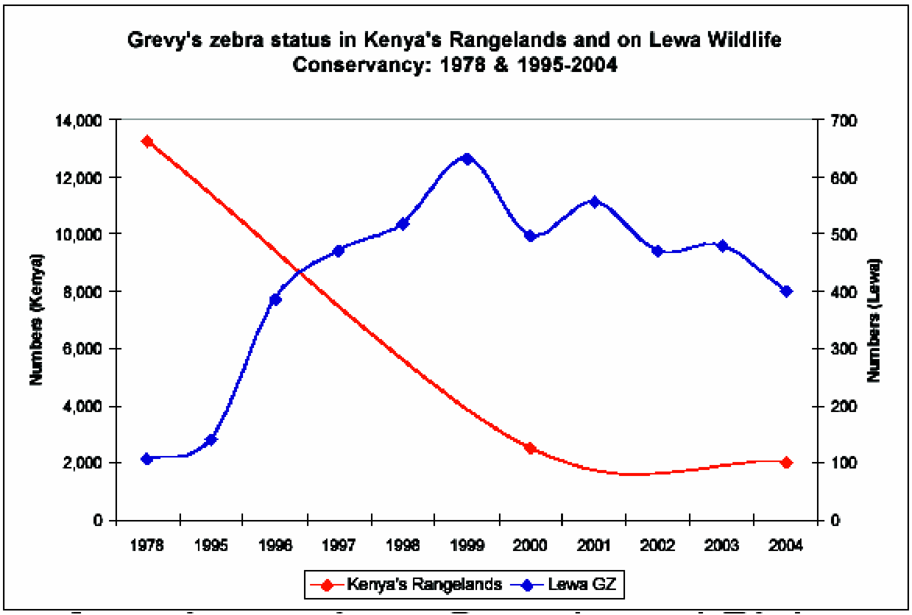


Fig.1. Population trends in Lewa Wildlife Conservancy and Kenyan rangeland

Goal: Lewa-Earthwatch zebra project tries to understand what limits Grevy's zebra population growth on Lewa where there is less human/livestock impact. Management mitigation developed that will enhance population on Lewa thus can be put in practice for population also living outside protected areas.

Objectives

a) ***Monitor zebra populations & movements on a spatial-temporal base to determine habitat use***.
Five census (Fig.2) 'loops' are driven once a fortnight and all Grevy's and plains zebras seen within 250 m. of the road are counted aged and sexed. This enables us to estimate demographic structure and determine habitat quality and use.

b) ***Monitor zebra reproduction, survival & demography.***
Zebra are radio-tracked every month and individuals associating with them photographed. By using their stripes--'Natures' Natural Bar Code herd mates are repeatedly located, age and sex determined for specific survival rates. In addition, known individual zebra movements and associations are obtained. The strength of social bonds and the nature of, and fidelity to, individual home ranges are obtained for known zebras.

c) ***Monitor drinking and foraging success of both Grevy's & plains***.
Fine grained data feeding and water drinking behaviour in order to evaluate the strength of interspecific competition.

d) ***Monitor body health & impact of gastro-intestinal parasites***.
Zebra scat is collected and after isolating nematode eggs via flotation technique we count nematode eggs and asses parasite loads and prevalence in both species of zebra.

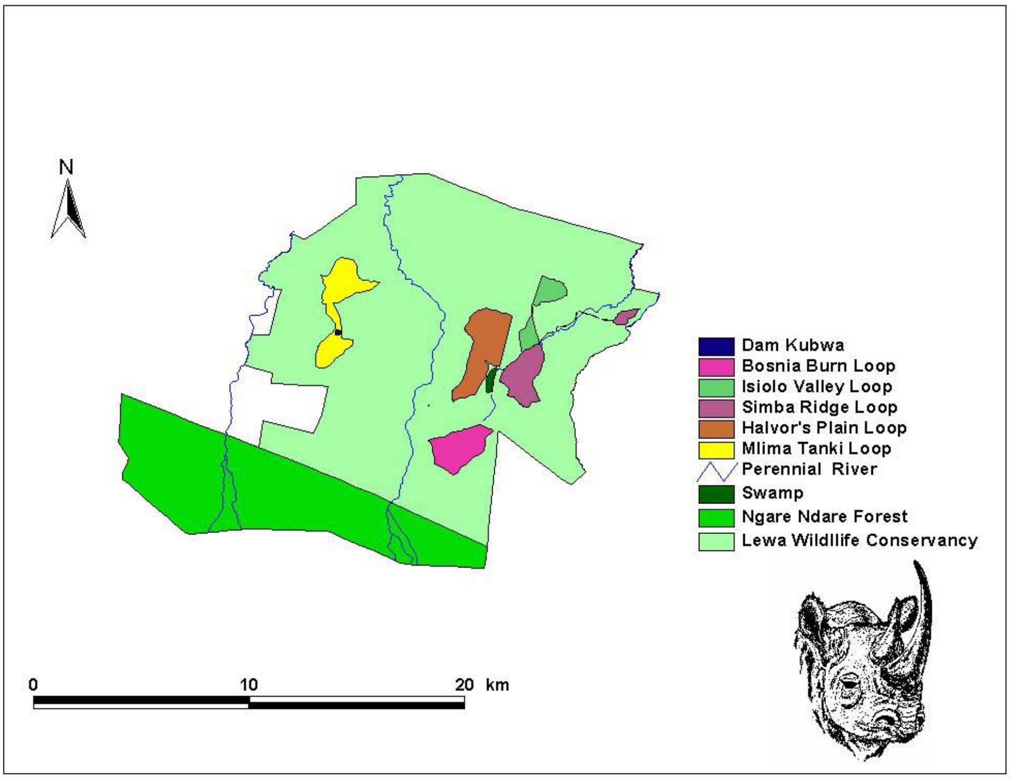


Fig. 2. Census loops on Lewa Wildlife conservancy

Results and discussions

Distribution, abundances and population structure of zebra.

Mean average encounter rates of Grevy's zebra on the five loops was 134 ± 56 standard deviations from January to October 2005 (Fig.3). Plains zebra were encountered at a mean average rate of 254 ± 123 standard deviations in five census loops from January to October 2005 (Fig.3). This gives a ratio of 1 male to 1 female for Grevy's zebras and 1 male to 2 females in plain zebras. The ratio tabulates to 1 stallion male to 3.2 plains females when bachelors males are not included. Bachelor males contribute 31 percent of Grevy's population and 15 percent of the plain zebra population. Significant differences in monthly sighting between 2004 and 2005 of both zebra species within the loops were detected Sign rank test ($F=0.28$, $n=7$, $p<0.005$) for Grevy's and ($F=0.78$, $n=7$, $p<0.005$) for plains zebra. These differences could be attributed to difference in weather conditions. There was more rain in year 2004 than year 2005 making the zebras roam far and wide for graze.

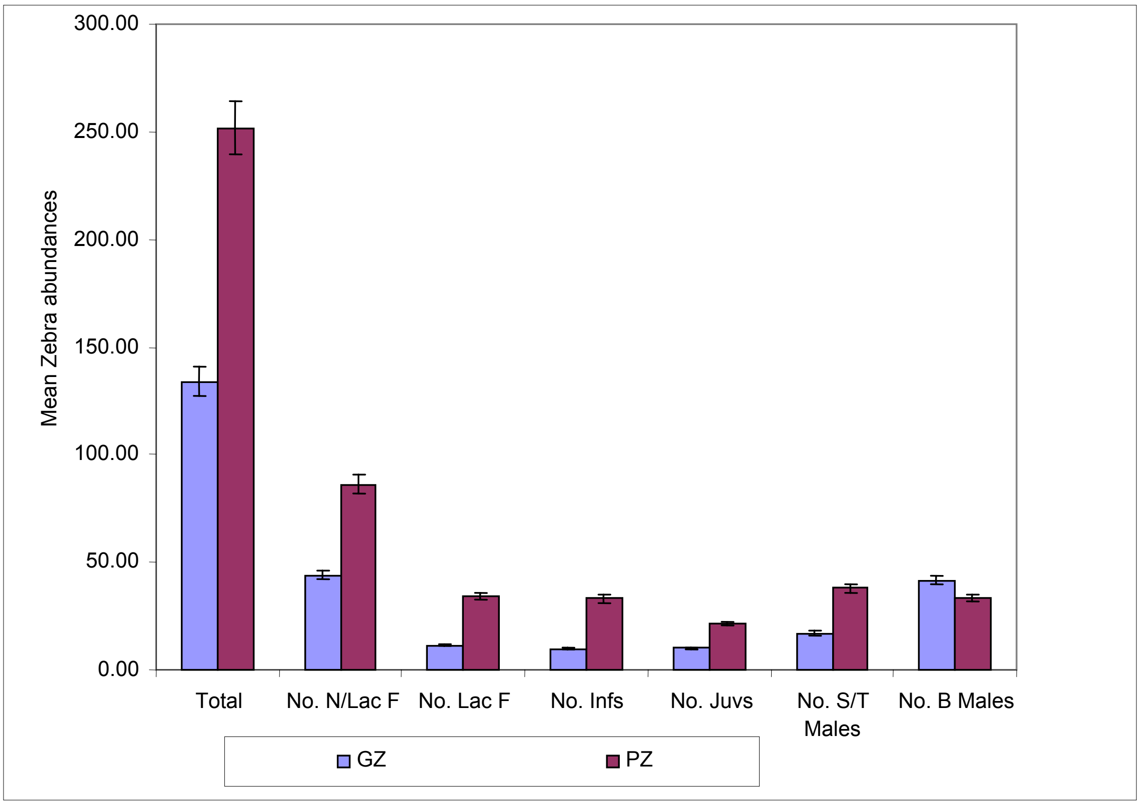


Fig.3. Population structure of plains and Grevy's Zebra on Lewa Wildlife Conservancy

On average, there were 10 Grevy's zebra foals (range 3-15) encountered within the loops every month (Fig. 3). This includes all ages from 0-12 month-old foals. Grevy's zebra foals were encountered every month from January to October. The number of foals represents about 7 percent of the total population, giving a ratio of 1 foal per 5.4 adult female. Foals and with juveniles (1 year and 2 year old) combined contribute 15 percent of the population.

There were 33 plains zebra foals (range14-63), as determined from loop census data (Fig.3). This is 13 percent of the loops population, giving a ratio of 1 foal per 4 females. All immature combined contribute 22 percent of the loop population.

Seasonal Patterns of Habitat Use

In the past we have shown that Grevy's and plains zebras prefer the same 'light bush' or moderately open habitats. Numbers co-vary such that when one species is common so is the other. It appears that each areas of high biomass attract both species which favours competition between them (Rubenstein et al., 2004). This year we show that each of our loops differs in vegetation quality (% green) and quantity (vegetation height) (Fig. 4).

Vegetation quality also shows seasonal differences that vary depending on habitat. Grass is greenest in the wet season but vegetation abundance shows little difference between wet and dry seasons. Halvor's plain has the highest quality of vegetation, whereas grass is most abundant in the Isiolo valley.

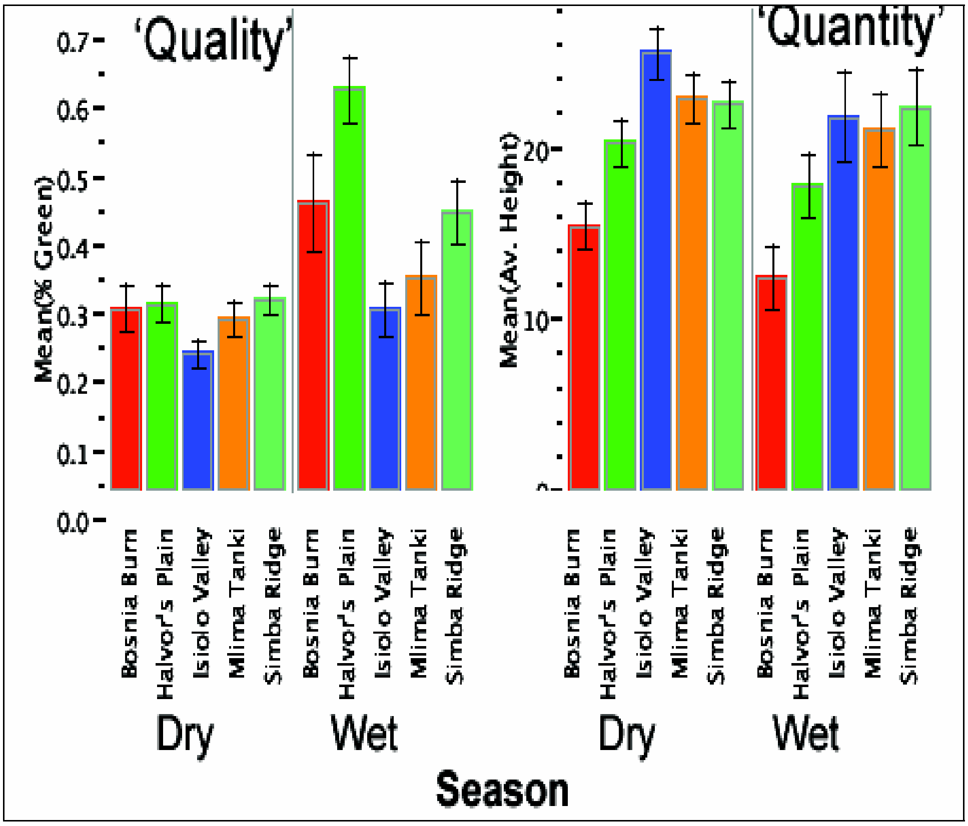


Fig.4. Seasonal variation of grass abundance and quality within the five Census loops on Lewa Wildlife conservancy

The distribution of zebras depicts these seasonal variations of quality and abundance of vegetation. During dry season, zebras adopt a more even distribution on most of the loops with either species showing dominance at one place or the other (fig.5). In wet season the zebras are more concentrated to Halvor's Plain, Mlima Tanki and along Lewa River.

Interestingly, each zebra species respond differently to spatial-temporal patterns of vegetation. Grevy's zebras show the greatest relative abundance on Halvor's plain and actually outnumber plains zebras there during the dry season (GZ/PZ ratio). Plains zebras dominate the area around Mlima Tanki year round (absolute numbers and GZ/PZ ratio, Fig.5). Consequently, extensive range overlap is mitigated by season habitat preferences that appear to be determined by slight variations in diet.

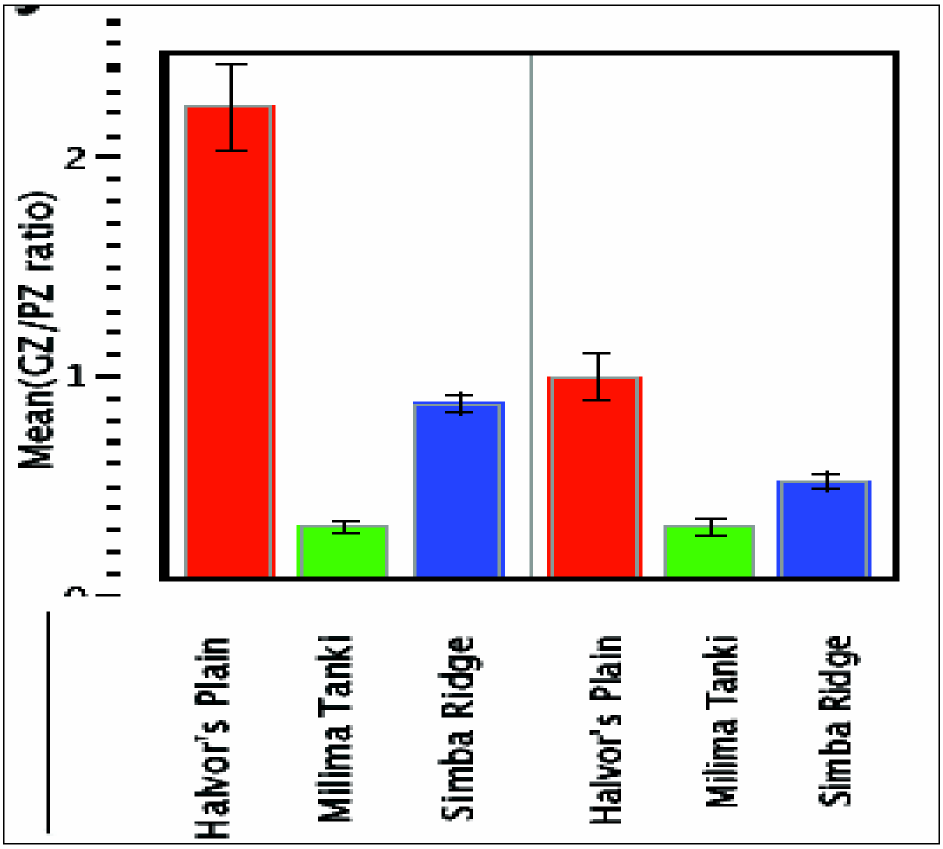


Fig. 5. Habitat zebra abundance ratios in both wet and dry season in Lewa Wildlife Conservancy

Survival rates

Last year we showed that Grevy's zebras are the preferred prey of lions. Although Grevy's and plains zebras were preyed upon with equal frequency, plains zebras are 4 times as abundant. Five collared plain zebra were followed all year around and their home ranges determined (Fig.6). The home ranges size increased extensively by over 50 % this year (2005) than was last year (2004). This could be attributed to the extended dry conditions making the harems to move far between grazing and drinking places.

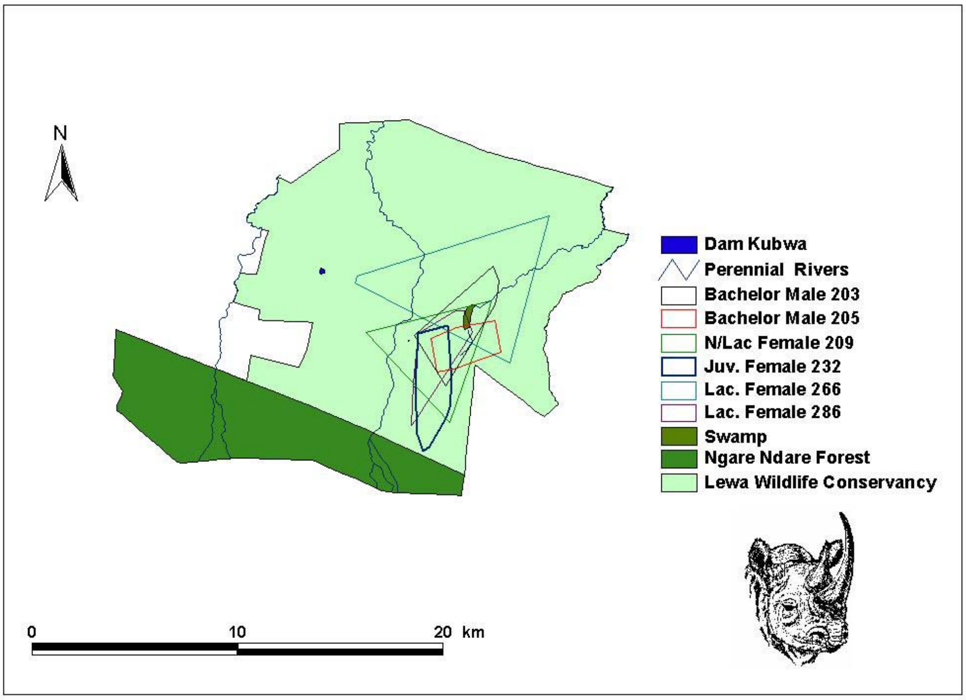


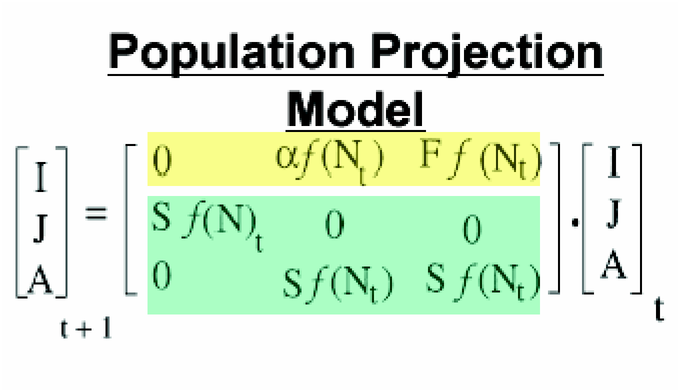
Fig. 6. Home ranges of collared plain zebras

In addition, to repeatedly locating radio collared plains zebra harems, all neighbours were photographed and identified. This provided age specific survival rates of which was compared with those collected by Lewa scientists for Grevy's zebras (Table 1). It is apparent that Grevy's zebra infant survival rates are very low compared to plains zebra.

Table 1. Survival patterns of different age classes of Grevy's and plain zebra on Lewa Wildlife Conservancy

Stage Class	Grevy's zebra	Plain zebra
Infants	27%	55%
Juveniles	85%	82%
Adults	87%	89%

By incorporating these survival patterns along with birth rates and inter-birth intervals into a two sex, stage-structured population projection model below, we can forecast population sizes 30 years from now in the conservancy. When we do this we see that while plains zebras will increase (Fig. 7), Grevy's zebra numbers will continue to decline (Fig.8). If survival rates of infant are increased to 50 % for Grevy's, the population will start increasing at a good rate (Fig.9).



Population Projection Model
Natural Factors
• Rainfall -→ Production
• Density – Dependence fN_t [ ]
α— age 1st reproduction
F — fecundity
S — annual survival
Anthropogenic Factors
• Fertility Control
(-) fecundity
(+) survival
• Harvesting
(-) N_t

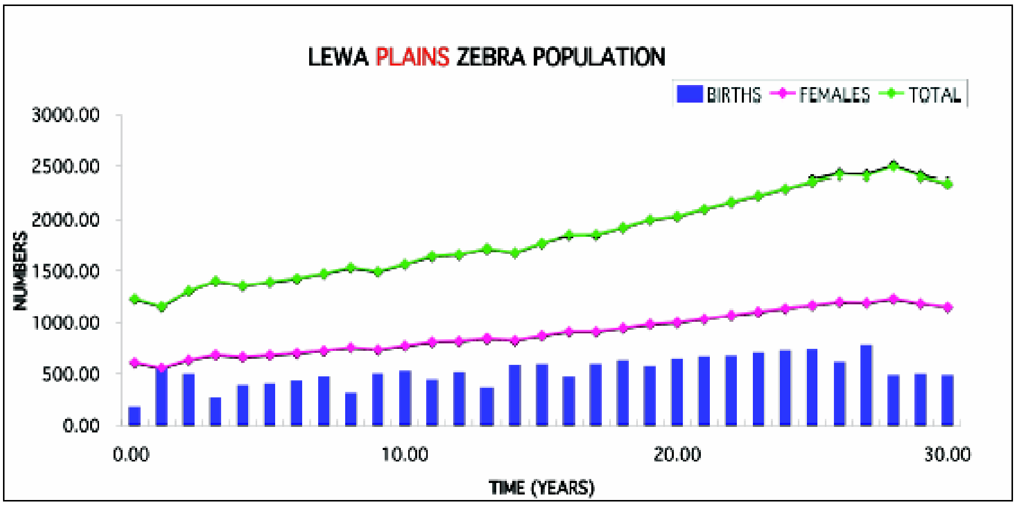


Fig.7. Population projection on plains zebra in Lewa Wildlife Conservancy

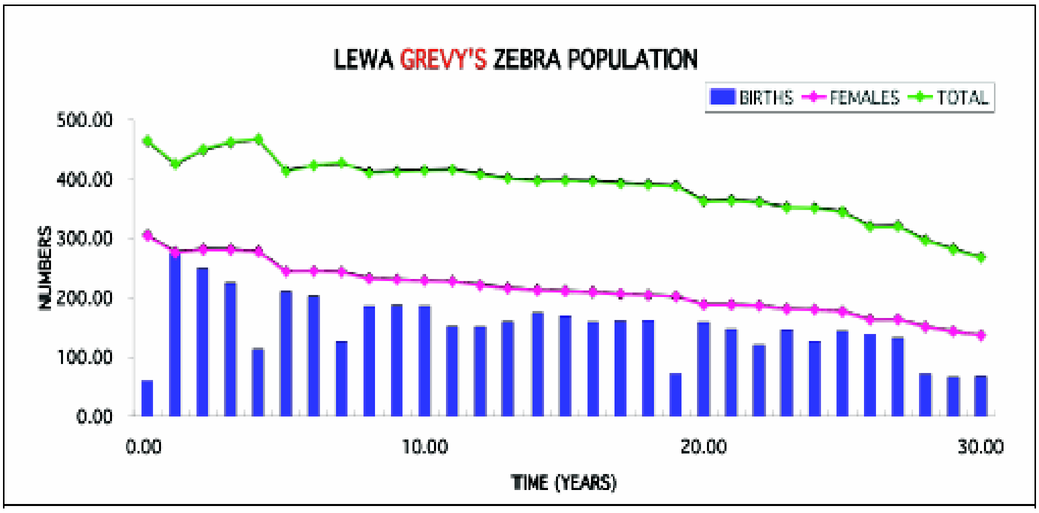


Fig.8. Grevy's zebra projection in Lewa Wildlife Conservancy

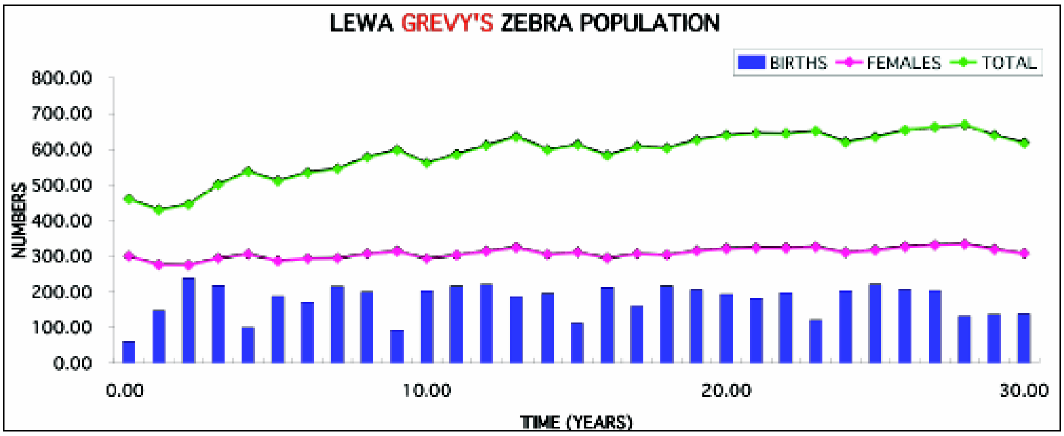


Fig.9. Population projection of Grevy's if infant survival rate is increased to 50% in Lewa Wildlife Conservancy

Patterns of drinking. Both species of zebras visit watering points throughout the day, but they concentrate their visits to the morning. During wet seasons 50% of Grevy's zebras drink by 9:30 am; similarly 50% of plains zebras are finished drinking by 9:45 in the morning. During the dry season, drinking is more evenly throughout the day. It is not until 10:45 am that 50% have finished (fig.10). Given that pastoral herders tend to arrive with their livestock at watering points outside conservancies in the late morning, it appears that both species of zebras will have to alter their natural tendencies to coexist with livestock unless human activities are modified.

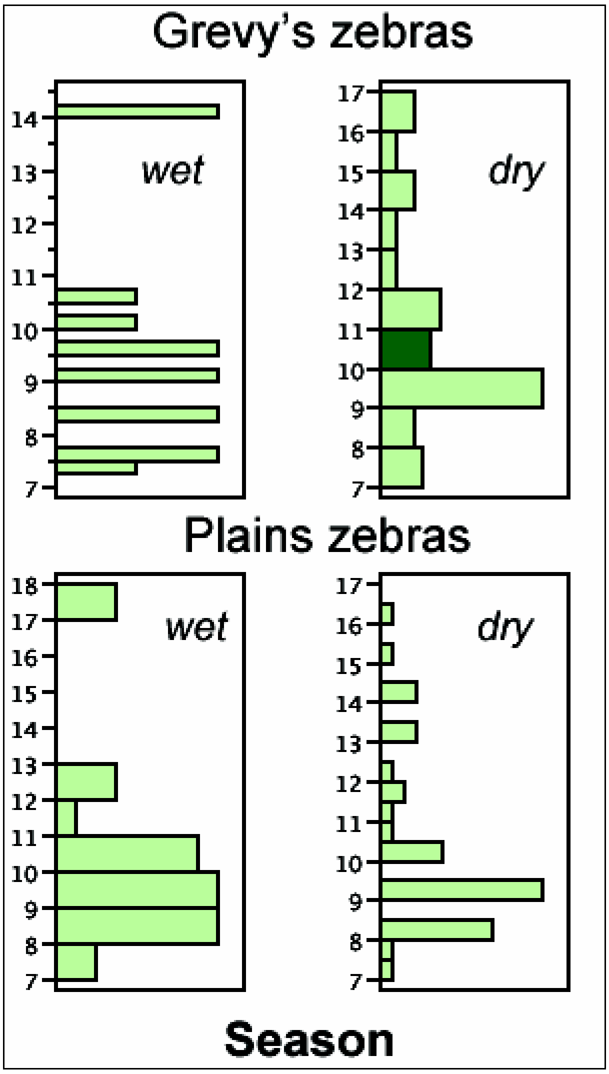


Fig.10. Drinking habits of plains and Grevy's zebra on Lewa Wildlife Conservancy

Body health and parasite load

Elvin parasite genus were identified in the zebra dung (scat) samples collected from the field. Of the 11 genus, Trichostronglus, Strongle-type, tapeworm egg and Dictyocaulus arnifieldi dominated the samples with 54%, 22% 7% and 6.5 % respectively. Fasciola, Parascaris, Draschia/habrenema and Oxyuris occurred in very low amounts.

There was a weak correlation between zebra body health score and parasite load Pearson correlation (r=0.027, p=0.005) in Grevy's and plain zebra (p=0.032, p=0.005). Indicating that parasite load may have less impact on adults health. However, higher parasite load was recorded in plains than Grevy's zebras (Fig.11).

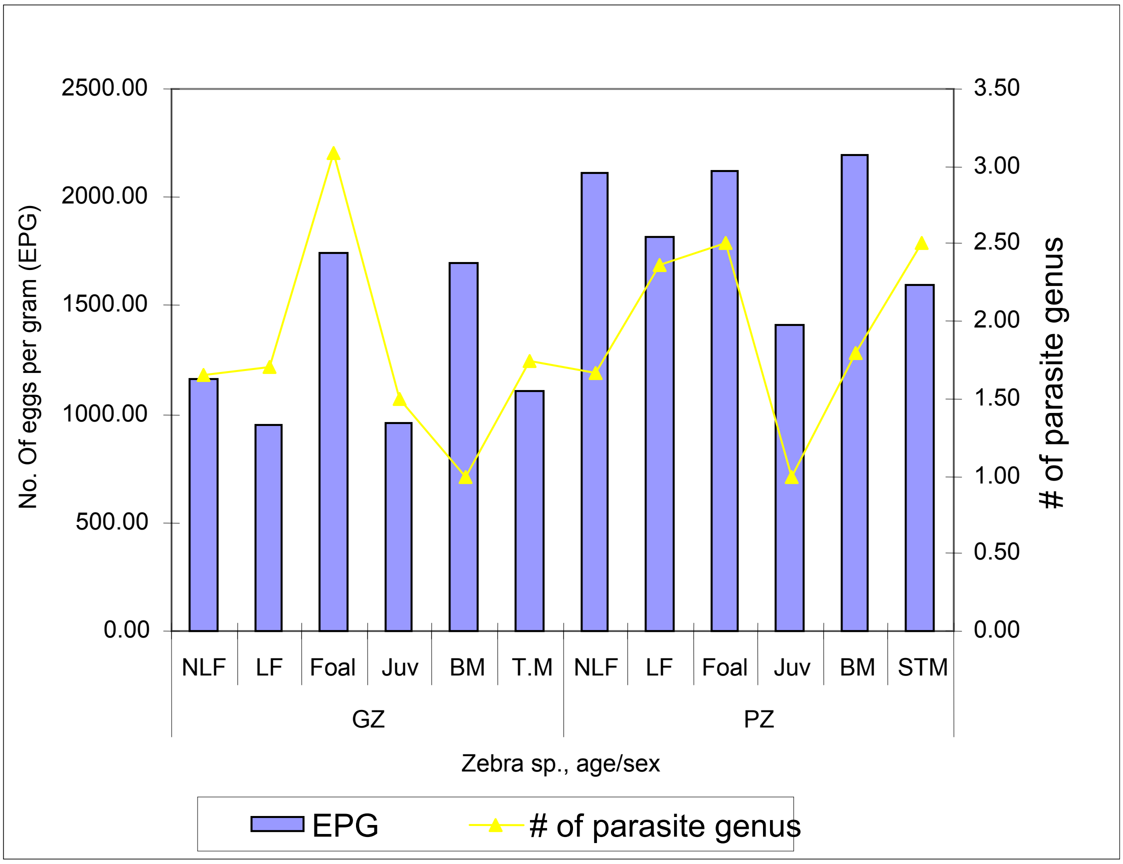


Fig.11. Parasite infestation on Plains and Grevy's on Lewa Wildlife Conservancy

High parasite load and diversity was recorded in foals and especially for Grevy's (Fig.13). This could be another factor contributing for low survival rates and hence low recruitment.

Conclusions

Previous data have shown how plains and Grevy's zebra interact naturally as they use Lewa's range. Indications are they do compete with plains having an upper hand when the herd together grazing as they have similar habitat preferences (Rubenstein et al., 2004). This year, there indications that both species tend to aggregate in similar habitats while showing small seasonal habitat preferences which mitigate extensive competition.

Preliminary data shows that both species tend to drink early morning hours. This put them in conflict with pastoral communities who tend to visit watering points with their livestock at similar hours up North in the community land. A change of this behaviour by the pastoral communities or else the animals may mitigate this.

Predation is still a big threat to the survival of Grevy's population in Lewa. This is due to low survival rates of foals and hence low recruitment rates. Parasite infestation to foals may contribute a great deal to their survival rates. Means and ways need to be devised to boast infants recruitments rates to around 50% and thus ensure population build-up.

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WILDLIFE HABITATS PROJECT

To identify and quantify wildlife habitats is based on species 'life requirements. Satellite imagery, vegetation survey and secondary data will be used to generate thematic layers to the different habitats in GIS database. In addition, field investigations are conducted to examine habitat of the defined wildlife species relevance to the life requisites. The project aims at characterizing vegetation and habitats in Lewa while applying ground truthing techniques.

Selected vegetation parameters including composition of trees / shrubs and herbaceous as well as height and percent ground cover along transect. Detailed tree data including height and diameter at breast height are determined to quantify plant volume and biomass. Grass is measured using pasture disc meter. Uniform vegetation quadrants are used for convenience and to allow data comparison. These datas are collected during the two seasons (wet and dry) to capture ephemerals. In addition, wildlife utilization and distribution will is determined within the transects/quadrants.

The Wildlife habitat project runs three teams in Lewa. With the help of Lewa research department, the project has designed permanent plots for vegetation monitoring. A comprehensive report will be provided to Lewa.

COMMUNITIES, WILIDLIFE AND WATER PROJECT

Their main aim of the project is to look at water availability, physico-chemical parameters and microbiology of water. Estimates of quantities of water available are obtained from calculations based on river, dam and pods morphology. This being done at different times of the year to capture seasonal variations.

Water samples are collected from the dams, river sources and at various places along the course. Samples collected are analyzed for conductivity, ph, temperature, oxygen using portable digital meter. The samples are further analyzed in the laboratory for heavy metals, pesticides residues, cyayotoxins, enteric pathogens (*E. coli* and *Salmonella*) and as well for macro parasites. In addition, aquatic biodiversity (*phytoplankton*) and utilization is being quantified.

In Lewa, water project conducted 4 expeditions. They were able to establish 31 sampling points both in Lewa and it's environ. They have been able to collect and analyze some data and isolated some organism some of which are pathogenic. A full report on physico-chemical parameters and preliminary findings on microbiology will be presented to Lewa.