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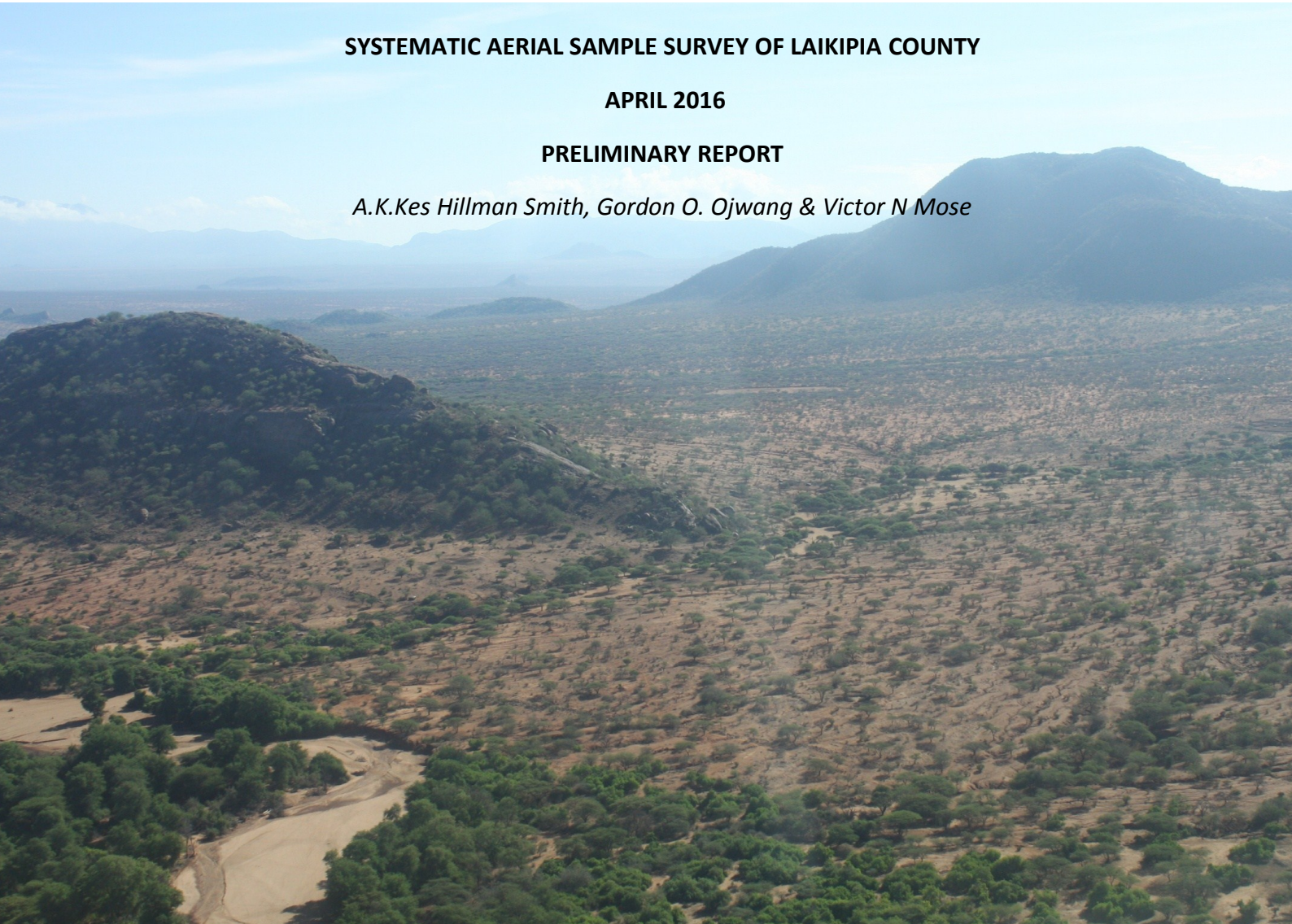
*Government of Kenya,
Directorate of Resource Survey & Remote Sensing*

SYSTEMATIC AERIAL SAMPLE SURVEY OF LAIKIPIA COUNTY

APRIL 2016

PRELIMINARY REPORT

A.K.Kes Hillman Smith, Gordon O. Ojwang & Victor N Mose



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INTRODUCTION

A systematic aerial sample survey of Laikipia County (9666km²) was carried out in April 2016 by Kenya's Directorate of Resource Survey and Remote Sensing survey teams in partnership with the Laikipia Wildlife Forum and Mpala Research Centre using funds from United States Agency for International Development (USAID). This report presents the preliminary results, and is the basis for further analysis and application.

The Laikipia upland plateau between Mount Kenya (5199m) and the Aberdare highlands (3999m) is an important area for Kenya. As a semi-arid savannah it is well suited to pastoral livestock production and ranching, which is compatible with wildlife. Dominated by livestock it also has wildlife abundance second only in Kenya/Tanzania borderlands, notably the renowned Masai Mara National Reserve. As a consequence, tourism has become an important land use and income generator for Laikipia.

Much of Laikipia is part of the Ewaso drainage system, which forms a continuous landscape for many species, linked with the conservancies and National Parks and Reserves in the more arid savannah of Meru, Isiolo and Samburu counties. Much of the plateau (approximately 70%) is characterized as arid and semi-arid rangelands. Within this important wildlife and biodiversity landscape there are a diversity of land tenure arrangements, land and water use and rangeland management practices. Much of the land is privately owned.

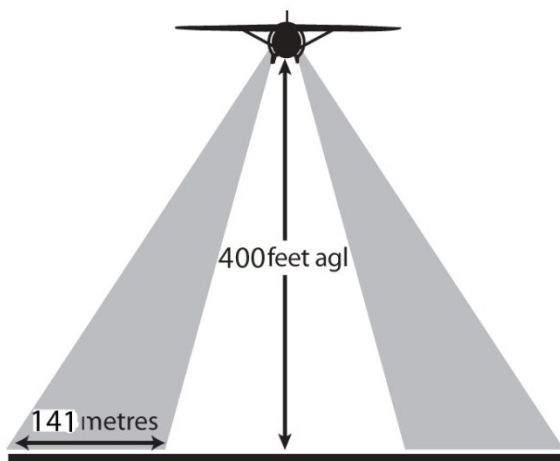
Increasingly, the present system of land use is challenged by demands from neighbouring counties outsiders on Laikipia's natural resources (grass and water), and increasingly on, and by major national infrastructure development projects (described in Vision 2030). These include major power lines, roads, rail lines and oil pipelines (LAPPSET) and water capture and management project

Accurate data can inform Laikipia stakeholders in support of decision-making for management, tackling persistent problems (like rangelands carrying-capacity) and long term physical and spatial planning. Systematic aerial surveys have been carried out in Laikipia since 1985 using basically the same method. The most recent previous survey of this kind was in 2012 and up-dated information was needed. Repeating the same method enables a long term monitoring and analysis of trends of livestock, wildlife, land use, habitats and threats. Systematic Aerial Sample Survey, the SRF system of Norton Griffiths 1978, is also the most cost effective way of obtaining a wide range of objective information systematically over the whole area.

METHOD

The survey was flown 14-19th April, at the end of the dry season, in order to repeat the standard of past years, to maximise comparability in assessing trends, and to be able to measure and plot the time of maximum pressures on the land from grazing. This year the count was later than in other years because of the seasonal perturbations linked to climate change and the heavy rains that made the dry season later than usual.

Two Cessna Caravan aircraft of DRSRS flew the survey, based out of Mpala Ranch. Each had a full crew (pilot, front seat observer and two rear seat observers) plus the LWF consultant and an MRC student who were taking GPS linked photographs of the land throughout. They also recorded start and end times of transects.



Target strip widths demarcated by the parallel rods on the wing struts on either side of the plane were 141 metres each side, totalling 282m per aircraft when flying at 400 ft above ground level. Height above ground is measured and maintained using a radar altimeter. Rear seat observers count only those animals that are seen between the rods, though they may also make note of group sizes of key species when the group extends beyond the rods. This focuses the attention of the observers to make it less likely for them to miss animals and gives a precise measurement of the area sampled. At the same time the front seat observer is recording other parameters of habitat, land use and state of vegetation and the aircraft log and altitude.

Parallel transects were flown north south over the entire survey area at a spacing of 2.5 km apart which gave a sampling intensity of 10.54%. Transects were sub-divided at 5 km sub-unit intervals. Changing sub-units are recorded en-route and all observations are therefore noted within named sub-units. Distributions are plotted linked to the centre point of each sub-unit. Photographs are taken of groups larger than 10 animals and re-counted later to increase accuracy. Average flying speed was 200 kph.

Transect length multiplied by strip width gives the area counted and population estimates were calculated using a formula known as the Jolly Method 2 (Jolly, 1969 in Norton Griffiths 1978), and by both DRSRS using "FORTRAN" and by African Conservation Centre testing a flexible method they have developed using the statistical programme, "R", which can then be used subsequently for further in depth analyses.

Raw data and preliminary analyses are currently stored at DRSRS and at Mpala Research Centre with reports also available at LWF. Easy accessibility for raw data will be developed according to the data managers LWF and MRC, and in consultation with major users.

Technical parameters for reference from DRSRS are:

CENSUS IDS:	1602
PERIOD OF SURVEY:	APR-14-2016 to APR-19-2016
APPROXIMATE STRIP WIDTH	0.282 KM
INTERVAL	2.50 KM
TRANSECT SUB-UNIT SPACING	5.0 Km
NUMBER OF TRANSECTS IN POP (N)	512.40
NUMBER OF TRANSECTS FLOWN (n)	54.00
NUMBER OF SUB-UNITS IN SAMPLE	735.00
TOTAL AREA	9,666.45KM SQ
AREA SAMPLED	1,018.71KM SQ
SAMPLING FRACTION	10.54 %

RESULTS

Livestock and wildlife numbers are given in Table 1:

Table 1: Ministry of Mining, Directorate of Resource Surveys and Remote Sensing (DRSRS)

Summary of Aerial Survey 2016 for LAIKIPIA COUNTY

SPECIES NAME	Sample SUM	Pop. Estimates	Pop. Variance	Pop. Stnrd Error
Cattle All	26,295	249,510	297,642,261	17,252
Cattle Free Range	22,912	217,409	300,419,573	17,332
Cattle Paddock	3,284	31,161	29,338,743	5,416
Cattle Tethered	93	882	65,520	255
Camel	731	6,936	14,984,291	3,870
Sheep&Goat	57,557	546,153	2,942,504,269	54,244
Buffalo	769	7,296	5,916,966	2,432
Dikdik	6	56	775	27
Eland	52	493	80,954	284
Elephant	350	3,321	577,879	760
Elephant Bones Grey	3	28	220	14
Elephant Bones NR	15	142	1,399	37
Grants Gazelle	276	2,618	255,231	505
Thompsons Gazelle	380	3,605	1,340,032	1,157
Gerenuk	26	246	10,366	101
Giraffe Reticulated	211	2,002	272,816	522
Hippo	4	37	1,264	35
Hyena	2	18	321	17
Impala	1,140	10,817	4,786,333	2,187
Hartebeest	31	294	23,049	151
Kudu	34	322	19,817	140
Lion	2	18	156	12
Oryx	73	692	53,474	231
Ostrich	15	142	3,875	62
Rhino	36	341	80,816	284

Warthog	61	578	10,427	102
Waterbuck	39	370	26,221	161
Zebra Burchells	3,127	29,671	23,485,334	4,846
Zebra Grevy's	63	597	33,994	184

These results when compared with previous survey results over the period from 1985 to the present, (see Table 2) and can be summarised as:

- * Livestock are by far the most numerous mammals, over 12 times more numerically, and with a biomass over 3 times more than all wildlife combined. They are widely distributed throughout, even in areas that aim to have only wildlife, such as Laikipia Nature Conservancy.
- * Cattle, at nearly 250,000, have increased 66% since 2012, 137% since 2001 and 95% since 1985. Shoats at over 546,000 have increased 44% since 2012, 126% since 2001 and 93 % since 1985. In other words Livestock have doubled over the 30 year survey period with the most rapid increase being since 2001.
- * Camels have increased over 800% over the 30-year period and donkeys over 400%. This could be symptomatic of a move of pastoralist cattle into the area from the north, and a risk reduction strategy. It could also be linked to an increase in their use in tourism.
- * Total large herbivore wildlife numbers combined are virtually the same in 2016 as they were in 1985, unlike wildlife numbers in many other areas of Kenya. But certain species are declining.
- * Elephants have doubled since the 1985 estimate but have not changed significantly since 2012 and their numbers within Laikipia may also be affected by movements in and out of the area in response to rainfall, forage availability and human activities. No fresh carcasses were seen and the proportion of combined stage 3 and 4 bones seen to live elephants was 1:21.
- * Buffaloes have increased. The 2016 population estimate is 2-3 times that of 1985, but figures between do not show a steady increase, though there have been fluctuations. This high number may have been influenced by clumped distribution.
- * Gazelles appear to have decreased over the past 30 years but increased since 2012. Thomsons Gazelles have decreased at a faster rate than Grants Gazelles. Grants in Laikipia have now been re-classified as Bright's Gazelle (*Nanger notata*) but for ease of long term comparison are referred to here as Grant's.
- * Giraffe numbers are similar to those of 1985 but were lower in 2001 and 2012 than currently.
- * Impala show a similar trend.
- * Hartebeest, eland, oryx and ostrich have decreased over the 30 years, with hartebeest and eland numbers extremely low in 2016.

Table 2: Wildlife and livestock Population Estimates for Laikipia County

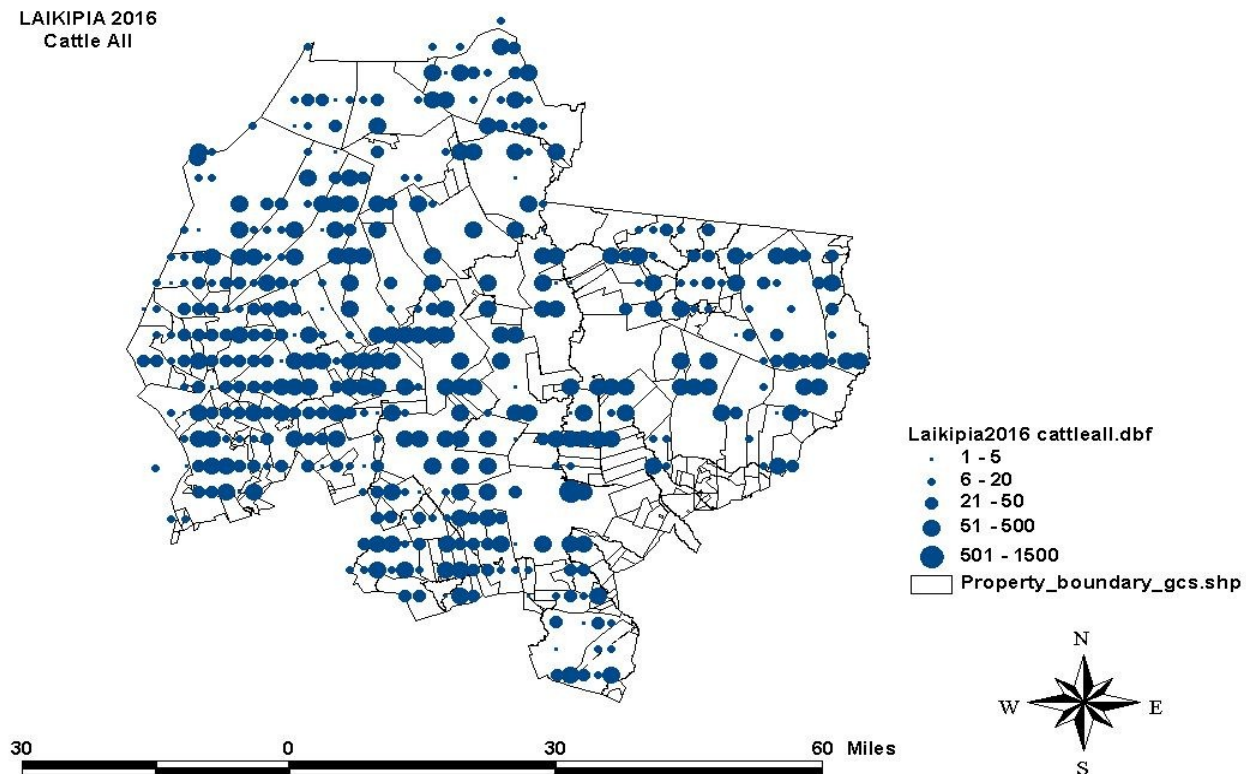
Population estimates for Laikipia County from aerial sample survey compared								
	2016		2012	2016&12	2001	2016&01	1985	2016&85
SPECIES	POPULATION	STANDARD	POPULATION	%	POP.	%	POP.	%
	ESTIMATE	ERROR	ESTIMATE	CHANGE	EST.	CHANGE	EST.	CHANGE
Cattle	249,510	17,252	149,910	66	105,118	137	127,735	95
Sheep & Goats	546,153	54,244	380,312	44	241,867	126	283,459	93
Camel	6,936	3,870	4,150	67	3,697	88	742	835
Donkey	2,675	410	1,454	84	2,496	7	525	410
Buffalo	7,296	2,432	2,071	252	1,684	333	2,318	215
Eland	493	284	1,525	-68	2,099	-77	6,467	-92
Elephant	3,321	760	3,493	-5	1,844	80	1,648	102
Ele bones stage 4	28	14						
Ele carcasse st.3	142	37						
Grants Gazelle	2,618	505	1,940	35	9,402	-72	6,123	-57
Thompsons Gazelle	3,605	1,157	687	425	3,918	-8	6,775	-47
Gerenuk	246	101	88	180	236	4		
Giraffe Reticulated	2,002	522	1,105	81	1,727	16	1,902	5
Hippo	37	35						
Impala	10,817	2,187	2,144	405	4,443	143	10,253	6
Hartebeeste	294	151	359	-18	1,104	-73	3,786	-92
Kudu	322	140						
Oryx	692	231	702	-1	446	55	1,286	-46
Ostrich	142	62	226	-37	576	-75	905	-84
Rhino	341	284						
Warthog	578	102	374	55	716	-19	163	255
Waterbuck	370	161	59	527	150	147	36	928
Zebra Burchells	29,671	4,846	24,887	19	27,544	8	20,217	47
Zebra Grevys	597	184	614	-3	897	-33	416	44
Hyena *	18	17						
Lion *	18	12						

* SRF surveys are not the best method to count species like hyena and lion and estimates are undercount

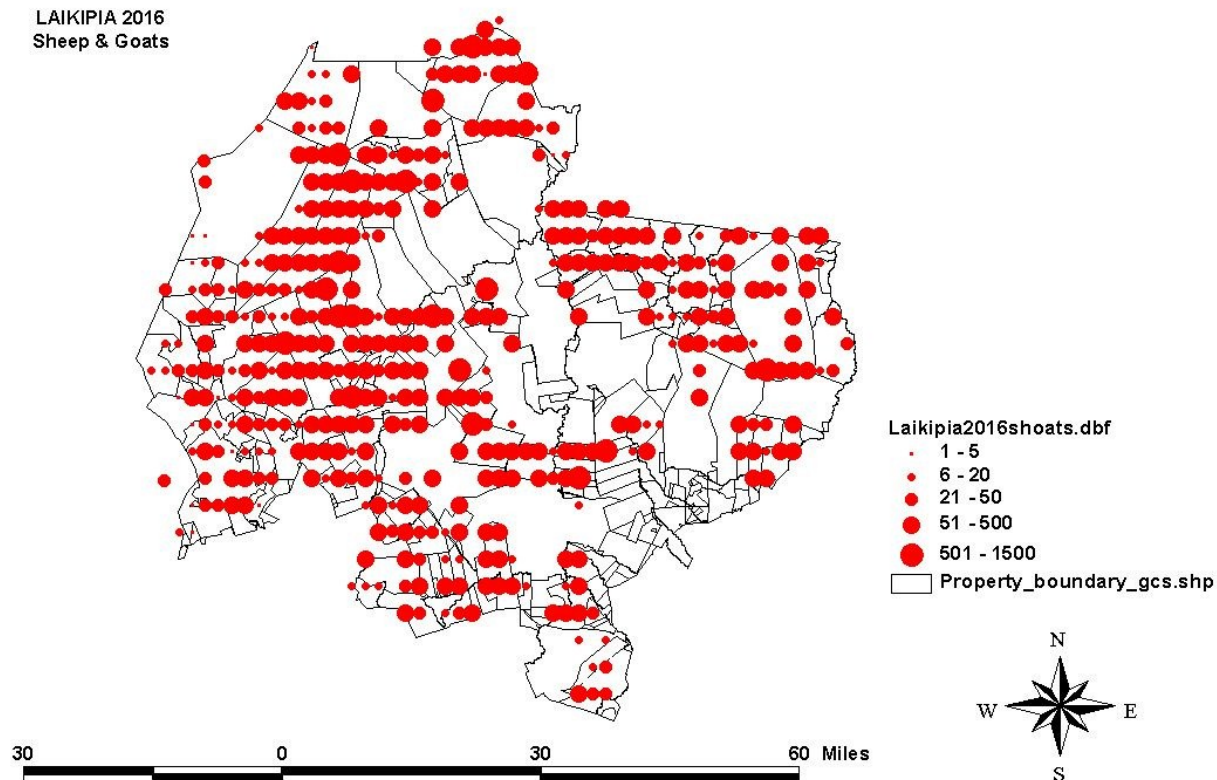
- Burchell's Zebra numbers are higher in 2016 but their overall trend is fairly stable. After livestock they are the most numerous and widely distributed grazing herbivore.
- Grevy's Zebra are 44% higher than in 1985 but are currently lower than in 2001 and 2012 and their population is only 2% of that of Burchell's Zebra. Their numbers in Laikipia could be explained by wide-ranging movement within their northern Kenya territory
- Warthog and Waterbuck appear to show increases over the period but warthog are notoriously difficult to get accurate estimates of, since they can hide in burrows and inevitably give considerable variation in estimates.

Distributions

LAIKIPIA 2016
Cattle All



LAIKIPIA 2016
Sheep & Goats

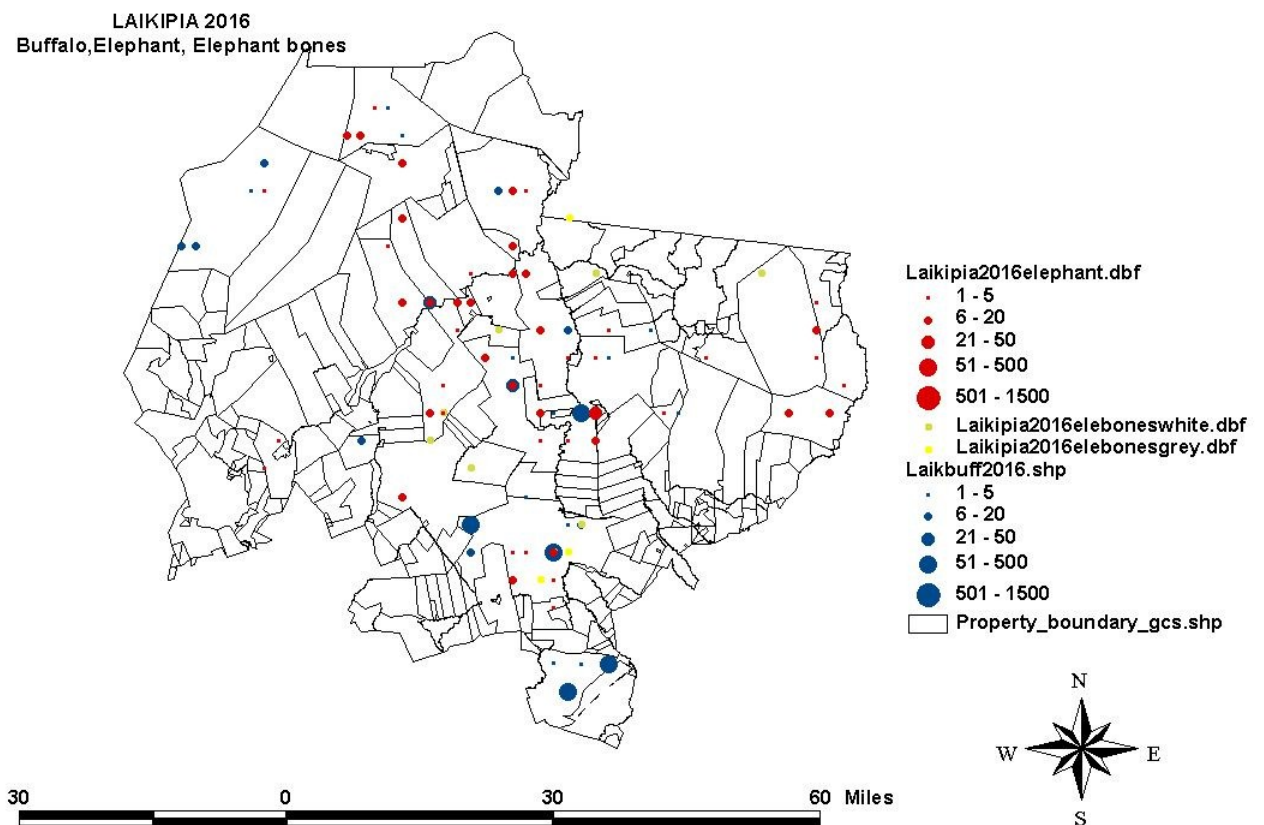


Distribution maps are plotted here with symbol sizes based on fixed sub divisions of numbers of animals per sub-unit to give a realistic comparison of relative numbers per sub-unit.

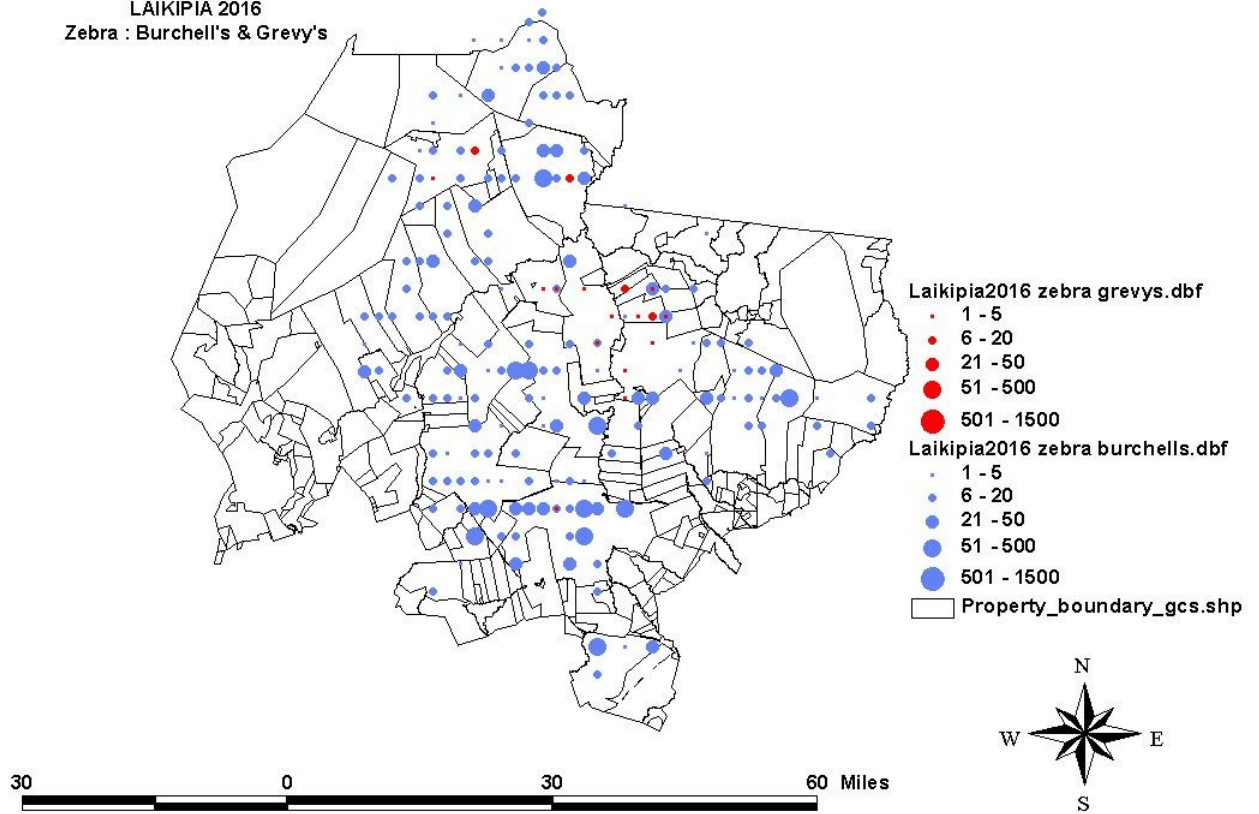
Cattle are distributed throughout the area. Those fairly evenly distributed in the south west are predominantly in paddocks. Others are either ranched or are mobile pastoral cattle.

The map of sheep and goats shows a high density in the areas outside the ranches and small holder agricultural areas and a very low density in the areas managed for combined livestock production and wildlife. This can be compared with maps of land use and rangeland status.

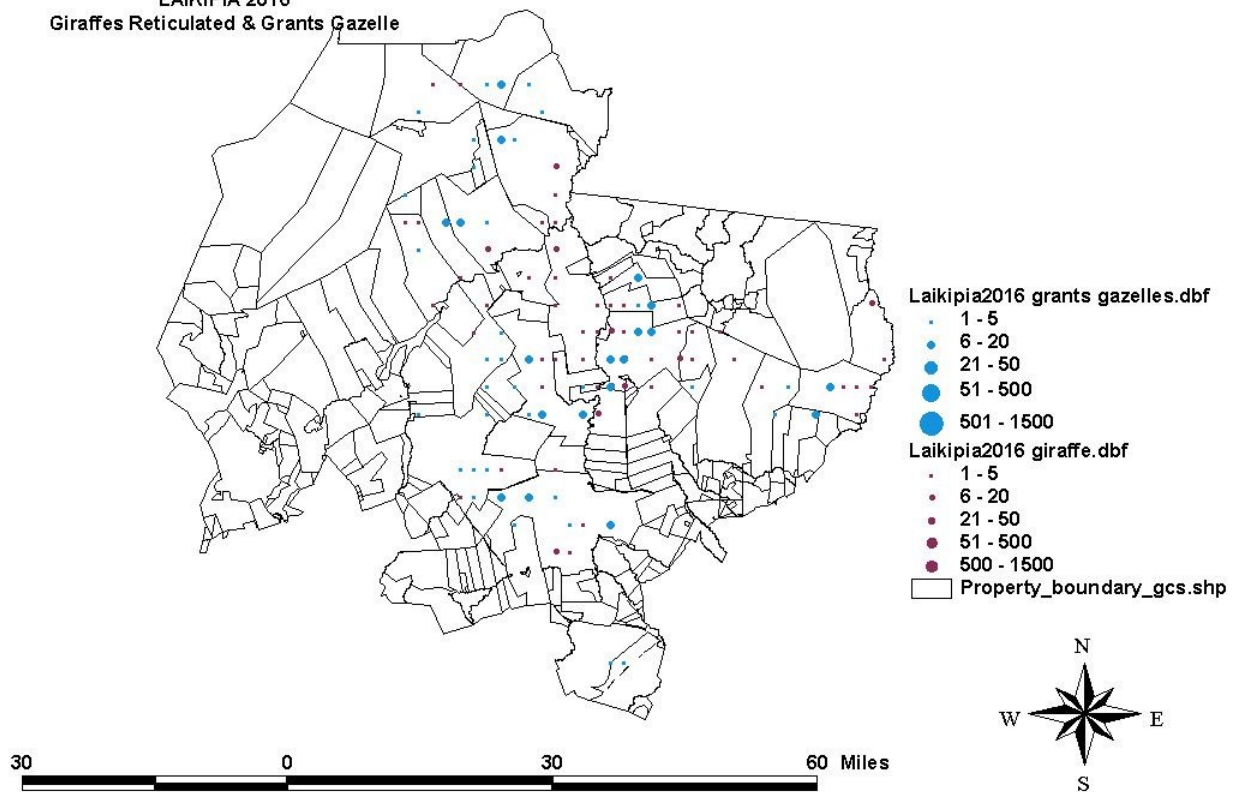
The maps of elephants, giraffe, zebra and buffalo indicate the wildlife friendly areas, and their negative correlation with the main livestock concentration areas. Wild herbivores however, have a range of different food resource requirements and differing habitat selections. Burchell's Zebras are the most widely distributed and, as grazing species, will have food resource requirements similar to those of cattle, but their numbers have been relatively stable and appear to be increasing.



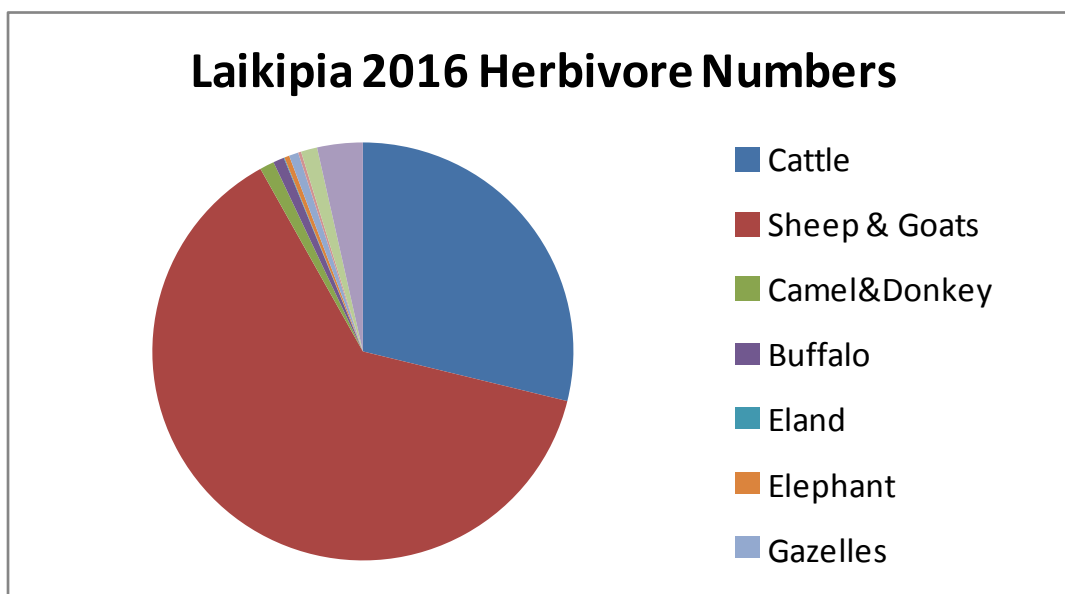
LAIKIPIA 2016
Zebra : Burchell's & Grevy's



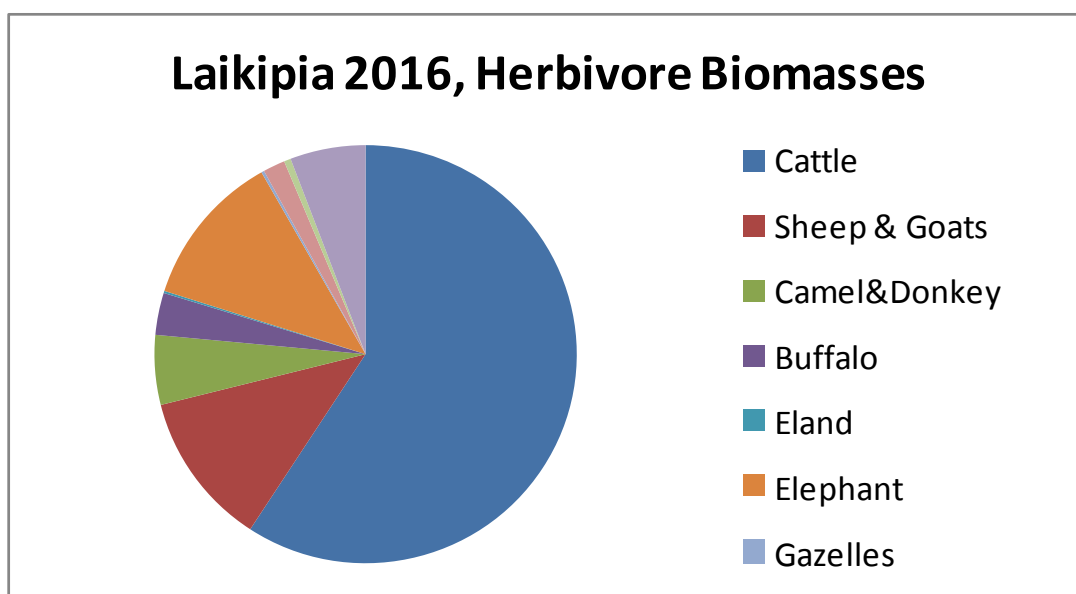
LAIKIPIA 2016
Giraffes Reticulated & Grants Gazelle



Numbers and Biomasses



A comparison between main herbivore numbers and biomasses, calculated as in Table I in Appendix, gives a graphic indication of the proportions of different herbivores and their relative quantities of resource requirements. Sheep and goats dominate numerically, with cattle as the second largest number.

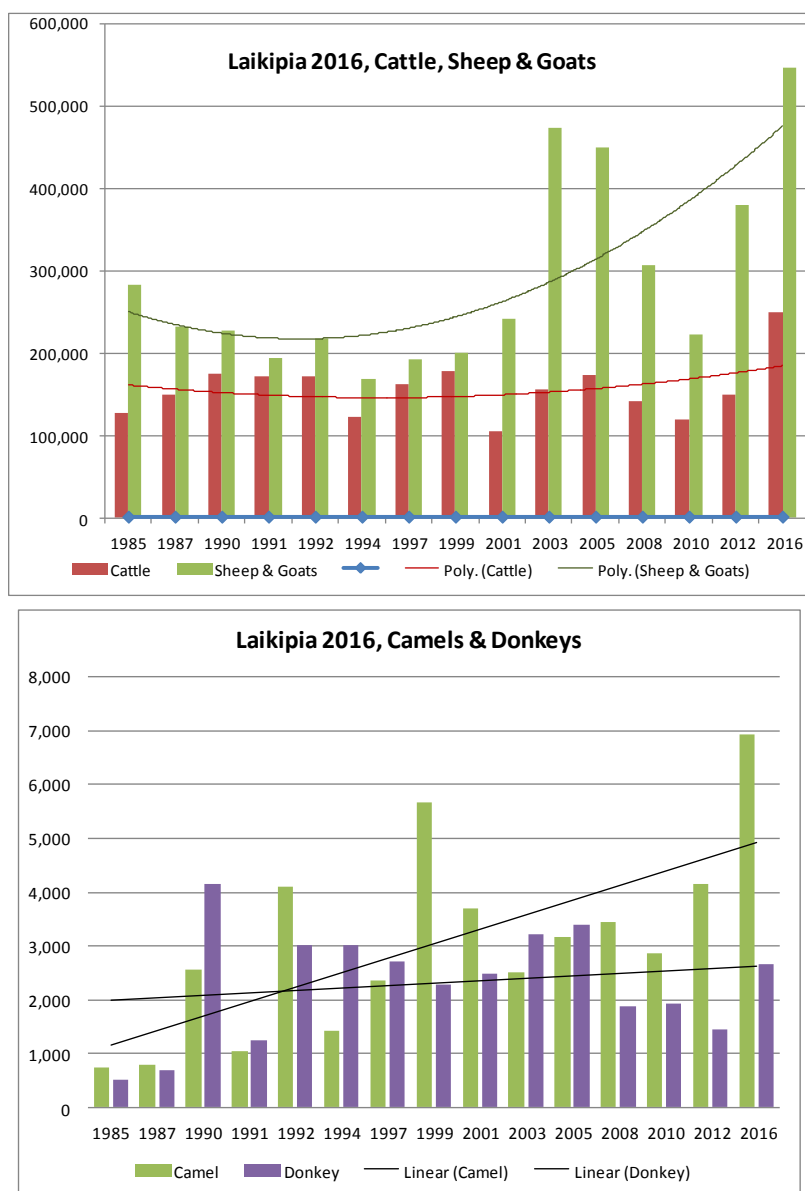


But when plotted as biomasses, calculated by population numbers times average body weight (Georgiardin et al 2007, Hillman Smith et al 1993, Kingdon 2001), cattle are the largest biomass, with the greatest food requirements from the habitat. Large bodied wild herbivores such as elephants also show an increase in contribution to the overall herbivore population when plotted as biomass.

The different herbivore requirements can also be examined in terms of their food types, such as grazers, browsers and mixed feeders and even within any one type, species selection can be refined to show how a range of species can co-exist compatibly in the same area.

Numbers over time

Population estimates over time from the same method of Systematic Sample Count Survey are given in Table 3, and presented graphically for the main species.

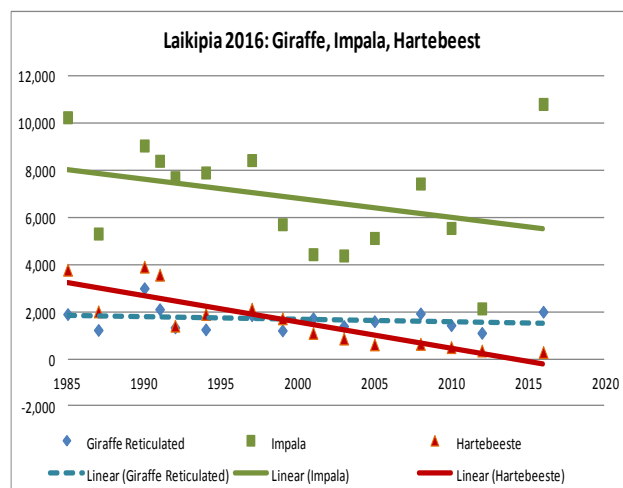
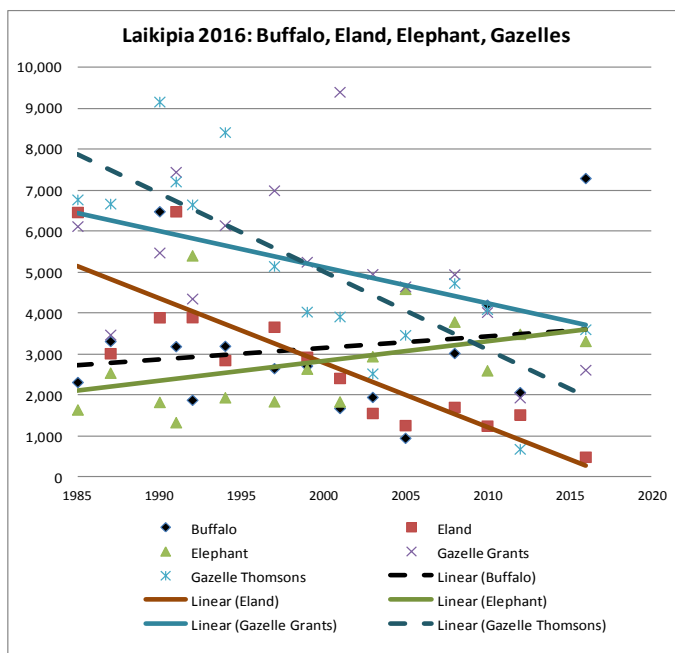


Livestock graphs show the changing figures over time, with the highest increases being in sheep and goats and camels, but the larger numbers being in cattle and shoats.

	1985	1987	1990	1991	1992	1994	1997	1999	2001	2003	2005	2008	2010	2012	2016
Cattle	127,735	149,678	175,534	172,712	172,777	122,964	163,119	177,781	105,118	156,312	174,132	141,225	119,977	149,910	249,510
Sheep & Goats	283,459	232,752	227,165	194,707	218,280	169,364	192,585	200,739	241,867	473,856	448,871	306,134	222,735	380,312	546,153
Camel	742	807	2,551	1,046	4,090	1,418	2,371	5,678	3,697	2,520	3,176	3,436	2,873	4,150	6,936
Donkey	525	702	4,149	1,246	3,015	3,018	2,726	2,293	2,496	3,208	3,406	1,878	1,936	1,454	2,675
Buffalo	2,318	3,318	6,485	3,192	1,884	3,200	2,655	2,717	1,684	1,953	955	3,026	4,205	2,071	7,296
Eland	6,467	3,020	3,898	6,485	3,901	2,854	3,667	2,933	2,417	1,562	1,265	1,709	1,252	1,525	493
Elephant	1,648	2,546	1,832	1,337	5,409	1,945	1,847	2,645	1,844	2,947	4,592	3,792	2,603	3,493	3,321
Gazelle Grants	6,123	3,476	5,479	7,449	4,354	6,145	6,997	5,254	9,402	4,956	4,653	4,949	4,025	1,940	2,618
Gazelle Thomsons	6,775	6,672	9,162	7,213	6,653	8,418	5,150	4,035	3,918	2,529	3,468	4,735	4,097	687	3,605
Gerenuk		491		154	490	72	319	144	236	325	301	151	36	88	246
Giraffe Reticulated	1,902	1,229	3,000	2,110	1,338	1,254	1,856	1,209	1,727	1,395	1,601	1,931	1,432	1,105	2,002
Impala	10,253	5,320	9,054	8,405	7,709	7,909	8,436	5,714	4,443	4,389	5,131	7,441	5,556	2,144	10,817
Hartebeeste	3,786	2,019	3,916	3,574	1,413	1,909	2,131	1,724	1,104	865	619	641	504	359	294
Kudu *				96			75	0	83	46	9	-	0	0	322
Oryx	1,286	825	2,694	709	1,149	618	1,385	1,128	446	1,390	1,115	1,486	1,315	702	692
Ostrich	905	895	952	991	659	1,090	284	523	576	391	380	587	297	226	142
Reedbuck *				0	0	0	0	0	83	0	0	0	0	0	0
Warthog	163	895	3,826	1,628	1,685	763	825	469	716	363	770	1,077	495	374	578
Waterbuck	36	438	844	1,273	735	236	621	279	150	37	416	294	306	59	370
Zebra Burchells	20,217	26,286	33,378	35,357	30,649	34,109	35,859	32,725	27,544	36,372	32,309	29,852	19,775	24,887	29,671
Zebra Grevys	416	298	17	691	678	181	870	1,002	897	948	3,326	2,554	135	614	597
Hippo *				0			0	36	0	0			0		37
Rhino **				421			178	63	258	222			162		341
Hyena *				0			0	0	8	0			18		18
Lion *				0			47	0	0	28			45		18
Ele.carcasse Fresh 1				0			0	0	0	0			0		0
Ele.skel. Rot p. st.2				0			0	9	0	0			18		0
Ele.skel.White st.3				26			9	9	75	9			153		142
Ele bones Grey st. 4				44			178	18	33	0			54		28
* Species with low numbers or cryptic behaviour are difficult to census accurately with this type of survey.															
** Rhinos are mainly in sanctuaries and precisely known															

Table 3 Laikipia Population Estimates from Systematic Sample Surveys 1985 – 2016

(From Ojwang & Wargute 2011, Kinnaird et al 2012 & DRSRS this survey)



Graphs of key wildlife show Giraffe numbers staying stable between 1985 and 2016 but Impala and Hartebeest numbers decreasing overall, despite a somewhat anomalously high

figure for Impalas in 2016. Hartebeests declined seriously from 3,786 in 1985 to 294 in 2016. Hartebeests are short grass grazers.

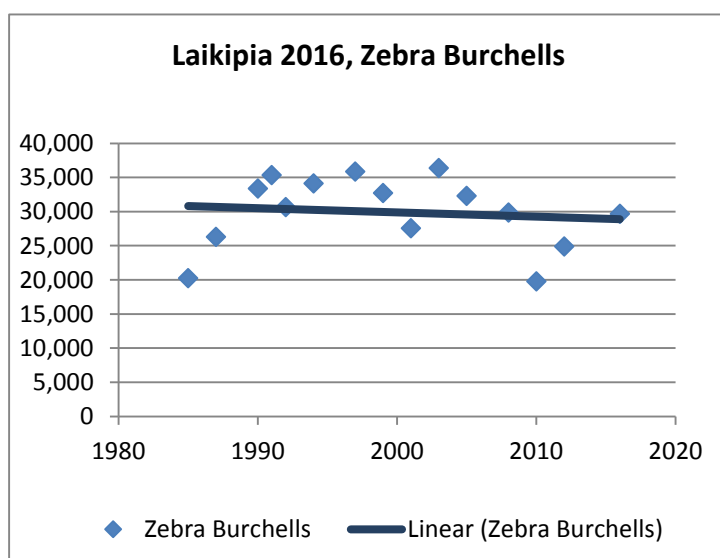
Buffaloes and elephants have increased overall and elephants will vary seasonally since they move larger distances than most other species throughout the Ewaso Ngiro Basin drainage system. Carcass ratios of elephants, relating numbers of carcasses or skeletons with the numbers of live +dead are good indicators of levels of poaching. (Douglas-Hamilton & Hillman (1979) For the years where carcass counts were done ratios are as follows:

1991 1997 1999 2001 2003 2010 2016

Ratio of Dead:Live Elephants

1:20 1:11 1:74 1:18 1:328 1:13 1:21

The larger the number of live elephants per dead is a sign of less deaths, though it may also be influenced by a migration into the area. 1997 and 2010 showed a high proportion of elephant carcasses and skeletons, but none were fresh.



Eland numbers have seriously decreased. They also appear to have moved from areas where they were previously known. Grants and Thomson's gazelles have decreased, with Thomson's showing the steeper rate of decrease.

Burchell's Zebra, as the most numerous and widely distributed wild herbivore, have remained relatively stable in number, though the 30 year trendline shows a very slight decline. Grevy's Zebra remain at around 2% of Burchells Zebra numbers in Laikipia, but may be more further north in the more arid areas.

Land Use and Habitat Status

Land use and status of the habitat in terms of cover, greenness, water availability, erosion, agriculture etc., are recorded by the Front Seat Observer and GPS linked photographs were taken at 2 second intervals throughout the whole survey. These landscape parameters are still to be analysed in detail and will be presented later.

DISCUSSION

This is a draft preliminary report aimed at giving an idea of the type of results from the 2016 survey and the trends over time that can be inferred from this type of survey. The report shows how long time sampling surveys in a series can be used to monitor the status of key indicators of landscape integrity and health in Laikipia.

The Laikipia Wildlife Forum and the Mpala Research Centre have various forms of this information readily available and accessible. They have formed a small coalition of interested landscape and conservation stakeholders who will direct further analysis and management of this data. This team will be instrumental in directing further monitoring and detailed research towards answering the needs of Laikipia stakeholders and County departments for sustainable management, spatial planning and land use decisions.

Figures prove that Laikipia is a valuable and successful land use system for both livestock and wildlife. Total numbers of wild herbivores have largely remained the same throughout the 30-year period, while in much of the rest of Kenya, wildlife density and numbers have dropped considerably over the same period for similar areas. It shows that the combination of livestock ranching and pastoralism on private lands (community or individual) is a successful model for both wildlife conservation and livestock husbandry. It is also an area where considerable private and non-profit investments have conserved endangered species (rhinos) in sanctuaries. Laikipia's reputation as a wildlife tourism destination has increased dramatically over this same period, and tourism forms an important component of the economy. The tourist wildlife experience is amongst the most varied in Kenya and the associated benefits of "tourism" in this landscape in terms of Corporate Social Responsibility, Education, Research, Employment, and Taxation is believed to be among the highest in Kenya.

Still, this year's results also raise issues that must be addressed. With livestock numbers increasing so dramatically and the loss of habitat and the degradation of rangelands, we must continue our vigilance for what this means to biodiversity, land use sustainability and landscape integrity. It is important that monitoring and further investigation is carried out as guided by stakeholder requirements and that information is available and used by Regional County Governments in their planning and project selection and implementation.

Questions that have arisen from a preliminary group of Laikipia stakeholders include:

- Of the cattle in the survey area, how many are owned and managed within stocking rates compatible with the habitat and how many are illegal grazers?
- Shoats are counted as one type by aerial survey as it is difficult to distinguish sheep from goats in the time needed for the survey. However sheep are grazers and goats are mixed feeders and opportunistic browsers. What are the ratios in different areas and what effects are they having on the rangelands?
- Could browsers (including elephants) be used to reduce the woody vegetation that increases with overgrazing, or are these largely unpalatable or invasive species?
- Laikipia has proved to be an important area for wildlife, but certain wildlife species are seriously declining. Why? Is it related to the types of food resource they rely on or as a result of other issues?
- Certain areas are extremely valuable wildlife habitats and water catchments, but are under threat. This information could be used to contribute to tackling these threats and the potential loss of these habitats/catchments before it is too late.
- Elephants are slightly increasing and can still benefit from being a wide-ranging species. No fresh carcasses were seen and the older carcasses were largely in areas where their range was continuous with more agricultural land use. But Human/Elephant Conflict is also increasing. How do we reconcile the increase in elephant numbers and increasing conflicts with people?
- How much is human wildlife conflict an issue, and how do we use this information to help reduce this conflict.
- How can this information assist the role of County Wildlife Conservation and Compensation Committees?
- There are several different land use models applied in different parts of Laikipia, with different economic drivers and objectives. How can this information be used to help advice land stewards on maximizing public benefits from private lands?
- There are several mega infrastructure development projects being planned for the region. How do we ensure that this information is part of Government decision-making and investment in these projects?
- How much of this information do we want to use to address indicators of landscape health and vitality?
- How does this information impact wildlife use rights on private lands and across the landscape?
- How can this information be used to influence the selection of goals and objectives in the County's next 5-year Integrated Development Plan. Will the County adopt goals and objectives of land use that are compatible with wildlife conservation, biodiversity conservation, and sustainable rangelands?

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APPENDIX I

Population estimates and Biomasses for Laikipia County 2016, from aerial sample survey					
SPECIES	2016		Average Weight(kg) (Kg)	BIOMASS (Kg)	Type of Feeder
	POPULATION ESTIMATE	STANDARD ERROR			
Cattle	249,510	17,252	207	51,648,570	Grazers
Sheep & Goats	546,153	54,244	19	10,376,907	Mixed
Camel	6,936	3,870	600	4,161,600	Browsers
Donkey	2,675	410	200	535,000	Grazers
Buffalo	7,296	2,432	389	2,838,144	Mixed
Eland	493	284	295	145,435	Mixed
Elephant	3,321	760	3125	10,378,125	Mixed
Grants Gazelle	2,618	505	43	112,574	Browsers
Thompsons Gazelle	3,605	1,157	21	75,705	Grazers
Gerenuk	246	101	40	9,840	Browsers
Giraffe Reticulated	2,002	522	736	1,473,472	Browsers
Hippo	37	35	1300	48,100	Grazers
Impala	10,817	2,187	42	454,314	Grazers
Hartebeeste	294	151	110	32,340	Grazers
Kudu	322	140	130	41,860	Browsers
Oryx	692	231	150	103,800	Grazers
Ostrich	142	62	120	17,040	Mixed
Rhino	341	284	1500	511,500	Mixed
Warthog	578	102	60	34,680	Mixed
Waterbuck	370	161	158	58,460	Mixed
Zebra Burchells	29,671	4,846	166	4,925,386	Grazers
Zebra Grevys	597	184	200	119,400	Grazers
Total Wild herbivore	63,442			21,380,175	kg
Total Livestock	805,274			66,722,077	kg