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Research Paper

Diseases affecting livestock production mediate landscape scale of a changing pasture regime in Lake Mburo Conservation Area, Uganda

Nina Pius Mbuya [1]*, Mugisha Samuel [1], Basuta Gilbert Isabirye [1], Eseza Kateregga [2]

[1] Department of Biological Sciences, Makerere University-College of Natural Sciences, Kampala Uganda
[2] School of Economics, Makerere University, Kampala Uganda
**Corresponding author E-mail: piusm.nina@gmail.com*

Abstract

This study investigated whether spatial disparities in pastoral herd sizes across rangelands from Lake Mburo National Park (LMNP) boundary was responsible for a changing pasture regime. A midst growing concern that cattle diseases associated with wild ungulates outside the protected areas impose limitations on pastoralist household income, the affected communities respond by overstocking as an adaption to disease risks. Therefore, increasing cattle stock holding among pastoralists living at the park boundary was suspected to be facilitating the disappearance of forests in Lake Mburo Conservation Area (LMCA). We applied ecosystem approach in a cross-sectional survey design to assess whether impact of diseases transmitted at the nexus of wildlife and livestock play intermediary role in the emerging spatial pattern of pasture regimes in LMCA. Paired sample t-test was used to examine the mean differences of animal populations between managed and unmanaged pasture and interpreted with Geo-eye satellite data of a typical landscape of savanna ecosystem of LMCA. The results revealed a significant difference ($p < 0.05$) in the distribution of wild species of animals between managed and unmanaged pasture. Spatial variation in population abundance of wild animals between distance zones was also reflected in the distribution of average household stockholding as well as cattle mortalities along a distance gradient from LMNP boundary. These findings could guide evidence based monitoring of long term effects of changing pasture regimes on pastoralist livelihood systems around LMCA. For example, future research should consider complementarities and overlap of the diets of wild ungulates and cattle at the nexus of wildlife and livestock interface. This will provide an understanding of how wildlife presence in rangelands can lead to either favorable or adverse changes in the fauna as far as the domestic livestock species of cattle and small ruminants are concerned.

Keywords: *Animal Density; Cattle Disease Risks; Spatial Pattern; Pasture Regime; Uganda.*

1. Introduction

The vegetation cover in rangelands around LMNP in south western Uganda has been changing rapidly from acacia savanna to open grassland with some patches of bear ground in most affected areas. This change of vegetation structure in a predominantly cattle production area signals some level of degradation. If this situation is not monitored, it could lead to enduring decline in the capacity of range ecosystem around LMNP to supply forage, water, fuel, wild food, and biodiversity habitat and tourism opportunities. Information regarding the drivers of changes observed in vegetation structure and decisions that communities living around LMNP, as well as their development partners need to take are currently not available. Planning for a sedentary grazing system which most pastoralists in LMCA have adopted will require understanding of the theoretical ecological paradigms that have emerged over time. For instance, the concept of mobility paradigm has largely benefited from understanding the significant association between mobility and ecological health of range ecosystems, especially in societies where nomadic pastoralism is practiced. However, the situation is different in regard to factors accounting for vegetation structure and ecological function of a rangeland ecosystem. Several ecological studies undertaken in different arid and semi-arid lands reveal that vegetation structure, ecological function and nutrient cycling dynamics of a rangeland are more significantly influenced by climate compared to grazing and other internal ecological processes (Walker et al., 1981; Behnke, Scoones, and Kerven 1993; O'Connor and Roux 1995; Behnke and Abel, 1996; Hiernaux, 1996). This study acknowledges that climate is a strong mediator in changing rangeland vegetation structure, but also appreciates that besides climate there could be some micro-disturbances at the intermediate level.

In south western Uganda communities encounter wild species of ungulates grazing with cattle in private lands (Rannestard et al., 2006; Ocaido et al., 2006, 2008). During ecological stress animals congregate around limited resources. In turn, this results in a stiff competition between domesticated and wild species of ungulates. What is more, the interaction which occurs between wild ungulates and cattle in such circumstances often facilitates the transmission and spread of diseases affecting livelihoods. Adopting measures to reduce pressure on pasture and water, while ensuring that household income is not compromised by economic limits diseases impose on livestock production remains an uphill task; a dilemma, not to say the least.

The dilemma is, "pastoralists around Lake Mburo National Park are forced by their situation to either choose to reduce their herd

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size and ease pressure on range resources, or increase their herd size to manage risks associated with diseases and hang on being pastoralists". Partially informed by previous studies, showing that livestock diseases are the most economic constraint affecting livestock farmers (Ocaido et al., 2009) in the region, pastoralist households in areas perceived to be most affected by diseases attributed to wild animals have responded by increasing their herd size. Thus, overstocking is increasingly becoming a common practice around LMNP.

There is a concern that much as overstocking is a very old practice among pastoralist societies in Africa, as risk management strategy, it appears to be influencing herd splitting which in turn becomes a drive toward cutting down the trees for pasture to grow in south western Uganda. Indeed a review of studies carried out in United States have attributed environmental degradation livestock production activities (Gowri and Nierenberg, 2008), with United Nations Environmt Programme (UNEP) report showing that in sudan rangelands expansion on cattle production led to deforestation (UNEP, 2007. The aim of this paper was to apply ecosystem approach in a cross-sectional survey design to assess whether impact of diseases transmitted at the nexus of wildlife and livestock play intermediary role in the emerging spatial pattern of pasture regimes in LMCA. Consequently, we tested the hypothesis that pastoralists' attempt to benefit from economy of scale and escape limits that diseases transmitted at wildlife-livestock interface impose on livestock productivity, by expanding the number of stockholdings, is influencing spatial pattern of pasture regime in LMCA.

2. Materials and methods

2.1. Description of study area

The research was carried out in the Lake Mburo Conservation Area (LMCA), which comprises Lake Mburo National Park, villages and pasture lands from June 2012 to October 2013. The LMCA in Uganda's cattle corridor is part of the wider Kagera ecosystem which extends from Rwanda through north western Tanzania to south western Uganda. Once an expansive rangeland for Ankole cattle (*Bos indicus*) grazing, the LMCA is currently experiencing rapid population increase and associated land cover change that is impacting negatively on rangeland resources, human health and livestock health, rural livelihoods and the local economy in general (Ocaido et al., 20009). In particular restricted movements with cattle due to land privatisation, coupled with the presence of wild animals on private farms/ranches, are imposing significant limits on cattle production in the region. For the people of south western Uganda, livestock production is a cherished source of livelihood, with over 90 % of the households keeping livestock largely in mixed farming systems.

2.2. Sampling design and techniques

The sampling frame for this study comprised all smallholder farmers in the six target zones within Lake Mburo Conservation Area in south western Uganda. We chose a household as the sampling unit. The six zones were systematically established along a distance gradient from Lake Mburo National Park boundary, with each zone covering 4km length along the gradient. Accordingly, stratified random sampling technique was employed to generate the required samples, where each zone along the gradient formed a stratum. A sample size (n) of 364 households was arrived at (95% confidence level) using a formula adapted from Kothari (2004) for determining a sample from an infinite population.

$$n = \frac{Z2 \times (P) \times (1 - p)}{D^2}$$ where

n = Size of sample;

Z = 1.96 as per the table area under normal curve for the given confident level of 95.5%;
(P) = 0.5 being the proportion of defectiveness in the universe;
(1 – p) = the proportion of non-defectives/success;
D = 0.05 the level of acceptable error margin
Substituting the figures in the equation:

$$n = \frac{(1.96 \times 1.96) \times (0.5) \times (1 - 0.5)}{(0.05 \times 0.05)} = 364$$

Hence, the minimum sample of 364 calculated formed a basis for random selection of 61 households in each zone, giving a total of 366 samples which the study used.

2.3. Data collection

A mixed quantitative and qualitative data collection strategy (Creswell and Plano, 2007) was used with appropriate tools for a survey study design to gather information.

2.3.1. Socio-economic data

Socio-economic data was collected using both observation data sheets and semi-structured questions in questionnaire interviews. A semi-structured questionnaire was used to collect data on key variables from approximately 61 sampled pastoralist household heads in each of the 6 zones. Data were collected on household demographic characteristics, the number of cattle holdings, household location from park boundary, major constraints to cattle production and their respective pathways, history of cattle grazing with wild animals, pasture management practices and inventory of cattle mortalities in the past year. To achieve this, we trained and deployed interviewers, who were fluent in the local language (runyankole), for data collection using one month recall period for costs associated with diseases control (Onwujekwe et al., 2010).

2.3.2. Animal data

Animals ranging freely on private farms/ranches were surveyed on 3 transect lines laid perdicular to the northern boundary of LMNP. Each transect line was pre-selected and defined by UTM Easting (X-coordinate) read from the topographic sheet map of the area at a scale of 1:50,000. The distance between the three transects was about 15 km to avoid multiple counting of the wild ungulate herds during the survey period. The wild ungulate survey was carried out along a gradient from LMNP boundary upto 24 km between June 2011 and July2012.

A team of 15 surveyors (with a post-secondary education level), were trained how to use Garmin 12 XL GPS (Global Position System) receivers to identify and count wild animals within 500 m on each side of a given transect line. All the 15 wildlife surveyors were deployed about the same time at 1 km interval along the shorter (15 km) transect and 2 km interval along the 2 longer transects (24km). The time period, for counting wild ungulates, was limited to 0700 – 1100 hours in order to maximise the types and numbers of wild ungulates identified and counted before the animals retired to shades under the bushy vegetation due to warming temperatures towards the afternoon period. Each transect line was surveyd twice for the presence of wild ungulates in each trip for three trips.

The wild species of animals spotted within 500m radius from the transect line were counted and recorded, as well as the dominant vegetation type in the habitat where they are sighted. It was assumed that animals were normally distribution in two broadly defined habitats (managed pasture and unmanaged pasture) during the study period. Managed pastures were largely open grasslands with *Bracharia spp*, *Sporobolus spp* and *Loudesia spp* as the dominant vegetation types. Similarly, the unmanaged pastures were largely woodlands dominated by *Acacia gerandii* and *Acacia hockii*, as well as a few patches of thicket clumps.

2.4. Data processing and analysis

All sampling data generated using semi-structured part of the questionnaire were validated and coded after completion of the survey. The data were entered on the computer and analyzed using the statistical software package for social sciences (SPSS) Version 17.0. First phase of the analysis focused on measures of central tendency regarding the distribution of wild animals, household stockholdings and cattle mortalities in six zones along a gradient from LMNP boundary. Paired sample t-test was used to examine the mean differences of animal populations between managed and unmanaged pasture. Analyzed information was interpreted in light of Geo-eye image showing savanna grassland of Lake Mburo ecosystem. Both quantitative and qualitative information were triangulated to enhance the significance of the study findings, especially in terms of its implications for policy.

3.5. Ethical considerations

This study was designed to feed into one of the specific objectives of IDRC funded zoonotic project in the Department of Biology, Makerere University. Accordingly, institutional ethical clearance was granted by Uganda National Council for Science and Technology (protocol approval number HS 807). In addition, local leaders as well as sub-county chiefs supported the initiative, while the respondents gave their consent prior to filling in the questionnaire. Individual interviews were only started after the purpose of the study had been clearly explained to the participant who then took part in the study from an informed perspective.

3. Results

The results of cross-sectional survey showed that unlike distant communities from the park, households in the village enclaves within 0-8 kilometres range from LMNP boundary had comparatively larger herd sizes (Table 1). The reasons given by the respondents for overstocking include disease constraints and associated higher rates of stock off-take for household income needed to meet high expenditures on drugs and veterinary services. Apart from diseases, drought and predation were also mentioned among factors affecting livestock production.

Table 1: Cattle Population Distribution by Distance Zones from LMNP Boundary

			Household stocking levels	
Distance	Sum (n)	% Proportion	Mean (95% CI)	Std Error
0 - 4	5503(60)	17.60	91.7167	10.45545
4 - 8	8830(58)	28.20	152.2414	18.60484
8 - 12	5500(64)	17.60	85.9375	5.83605
12 -16	3901(60)	12.50	65.0167	4.83878
16 - 20	4027(62)	12.90	64.9516	6.27391
20 - 24	3524(62)	11.30	56.8387	4.17005

Most importantly, the respondents indicated in the interviews that diseases were the major constraints to cattle production around LMNP. Majority, 77% (282/366) of the respondents were bothered about diseases infecting their livestock. The results of Table 2 suggest that the impact of cattle diseases that reduce the income of pastoralist households, when farmers incur higher overall cost of livestock production, was felt mostly by communities adjacent to LMNP. For instance 55.7% of the respondents located within the first three zones (a distance range of 12 km) from park boundary pointed out that diseases were the major constraints to cattle production compared to only 44.3% in the remaining zones within 12 km to 24 km range. This difference was statistically significant ($p < 0.05$).

The vulnerability of pastoralist households situated closer to the national park (LMNP) is further evidenced by the relatively higher number of cattle mortalities compared to the number of cattle death toll recorded far away from the park boundary (Fig. 1).

Table 2: Community Perceptions Regarding Factors Constraining Livestock Production

		Distance gradient from LMNP boundary					
Parameters		0 - 4	4 - 8	8 -12	12- 16	16-20	20-24
	Total N	n=60	n=58	n=64	n=60	n=62	n=62
Diseases	282 (77%)	54 (19.1%)	55 (19.5%)	48 (17%)	44 (15.6%)	42 (14.9)	39 (13.8)
Drought	68 (18.6%)	03 (4.4%)	02 (2.9%)	13 (19.1%)	13 (19.1%)	18 (26.5%)	19 (27.9)
Predation	09 (2.5%)	02 (22.2%)	01 (11.1%)	02 (22.2%)	02 (22.2%)	01 (11.1%)	01 (11.1%)
Others	07 (1.9%)	01 (14.3%)	00 (0%)	01 (14.3%)	01 (14.3%)	01 (14.3%)	03 (42.9%)

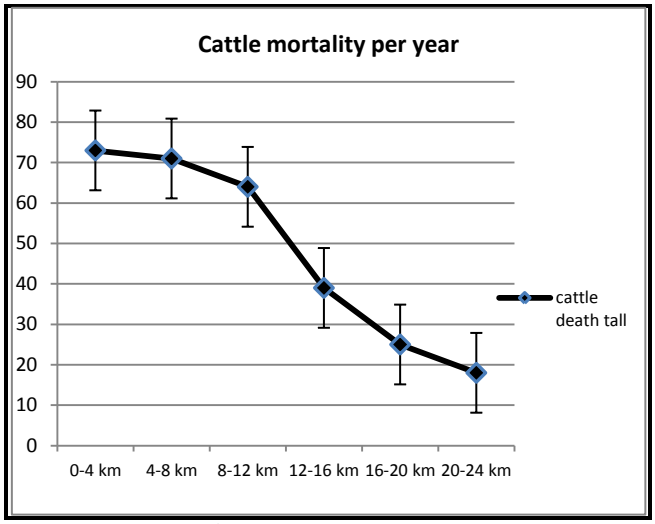


Fig. 1: Spatial Trend of Monthly Average Cattle Mortalities per Square Kilometer around LMNP

Faced with the high risks of diseases affecting livestock production, 73% of the respondents from randomly chosen pastoralist households mentioned that cattle farmers in the region often overstock in order to managed risks (mainly diseases and droughts) and consequently avoid stepping out of pastoralism.

Of all disease risk pathways mentioned during the interviews, wild animals are perceived to be the major culprits. The respondents cited wild animals as the main vehicle of diseases transmission to their livestock, especially because large herds of wild animals can move extensive between farms in one day. The communities around LMNP believe that wild animals have infections and are tick infested. Accordingly, the respondents were also able to identify disease transmission pathways, which we categorized as shown in Table 3.

Table 3: Pathways of Disease Transmission as Perceived by Study Participants

Parameters	Distance from LMNP boundary (in km)					
	0-4	4-8	8-12	12-16	16- 20	20-24
Wild animals	2 (70%)	1 (37.9%)	47 (75.8%)	25 (78.1%)	21 (65.6%)	6 (60%)
Cattle grazing in national park	16 (26.7%)	03 (5.2%)	13 (21%)	02 (6.3%)	02 (6.3%)	01 (10%)
Cattle movements between herds	2 (3.3%)	3 (5.2%)	2 (3.2%)	5 (15.6%)	7 (21.9%)	2 (20%)
Overstocking	00 (0%)	1 (1.7%)	00 (0%)	00 (0%)	2 (6.3%)	1 (10%)

The pastoralists believe that most of the animals they blame for transmitting diseases affecting livestock production are permanent residents on private land. In particular, zebra, impala and buffalo are considered to be tick infested, and often transmit zoonotic diseases such as brucellosis to their livestock when they interact. The respondents were asked to mention the animals they regularly see in their farms and the neighborhood in general (Table 4).

Based on this information, wildlife surveys were carried out to further assess the claim pastoralists were making that animals transmitting disease to their cattle are often attracted to their farms

by freshness of flush grass in burnt open areas. Accordingly, the results of animal population survey, focusing on species distribution and abundance, revealed higher mean population abundance in managed pasture (open grassland) compared to unmanaged pasture.

This is particularly true for zebra and impala populations, which are also the most dominant large species of wild ungulates found grazing routinely with cattle in the private farms/ranches around LMNP. Figure 2 provides the details of animals' distribution in two broadly defined habitats (managed pasture land and unmanaged pastureland) during the study period. Managed pastures were largely open grasslands with Bracharia spp, Sporobolus spp and Loudesia spp as the dominant vegetation types. Similarly, the unmanaged pastures were largely woodlands dominated by Acacia gerandii and Acacia hockii, as well as a few patches of thicket clumps.

Table 4: Animals perceived to be causing problems to farmers in LMCA

		Habitat	perceived abundance				
Observed animals	Scientific name	Dominant vegetation	1	2	3	4	Period
Zebra	*Equus burchelli*	Open woodland	0	0	14	352	year round
Impala	*Aepyceros melampus*	Acacia/grassland	0	0	54	312	year round
Bush buck	*Tragelaphus scriptus*	Bush lands	97	233	26	10	year round
water buck	*Kobus ellipsiprymnus*	Wetlands	41	90	118	117	year round
Common Duiker	*Sylvicapra grimmia*	Grassland	2	84	146	134	year round
Warthogs	*Phacochoerus ethiopicus*	Grasslands	88	167	50	61	Seasonal
Buffaloes	*Syncercus caffer*	Thickets	79	122	120	45	Seasonal
Eland	*Taurotragus oryx*	Grasslands	93	167	67	39	Seasonal

*Note: Note present=1, Less abundant =2, Abundant =3, Highly abundant =4

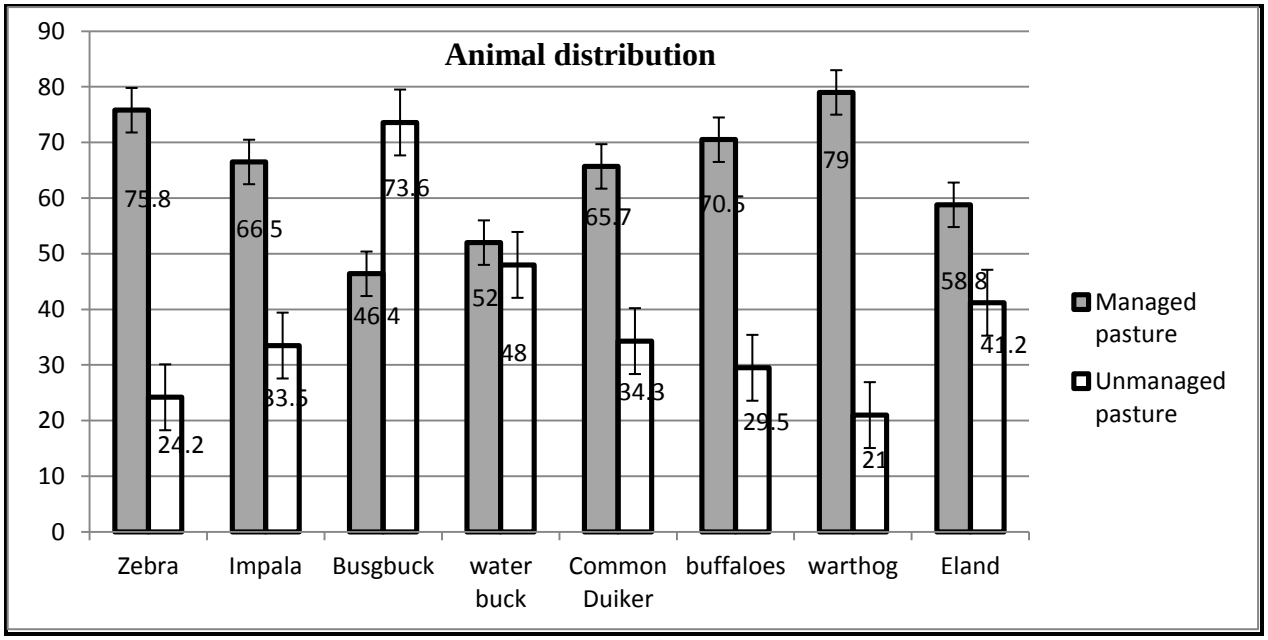


Fig. 2: Distribution of Wild Species of Animals in Various Landscapes

Most animals recorded were sighted in open savanna grasslands, with a few appearing in less and/or undisturbed rangelands dominated by acacia vegetation and some patches of thickets as well as scrubs. Zebra and impala were the most abundant wild species of animals sighted along a distance gradient from the park boundary, accounting for 80% of all animals recorded. Figure 3 shows that these two species of wild animals were widely distributed in the rangelands of LMCA, with higher populations mean occurring at the park boundary, but declining progressively further north of LMNP. A similar trend is reflected in the estimated cattle mortality per year along a distance gradient from LMNP (Fig. 1).

We also noted the levels of land clearance and main reasons communities around LMNP were cutting down trees and the results are summarized in Table 5.

In the end, these results together with the general observations made on pasture regimes were interpreted and explained in light of Geo-eye satellite data showing a typical landscape of Savanna ecosystem of LMCA. Figure 4 provides a visual distinction between managed and managed pasture divided by the tarmac road, Masaka-Mbarara highway.

Evidently, rangelands bordering Lake Mburo National Park were more degraded compared to the rangelands further north of the park.

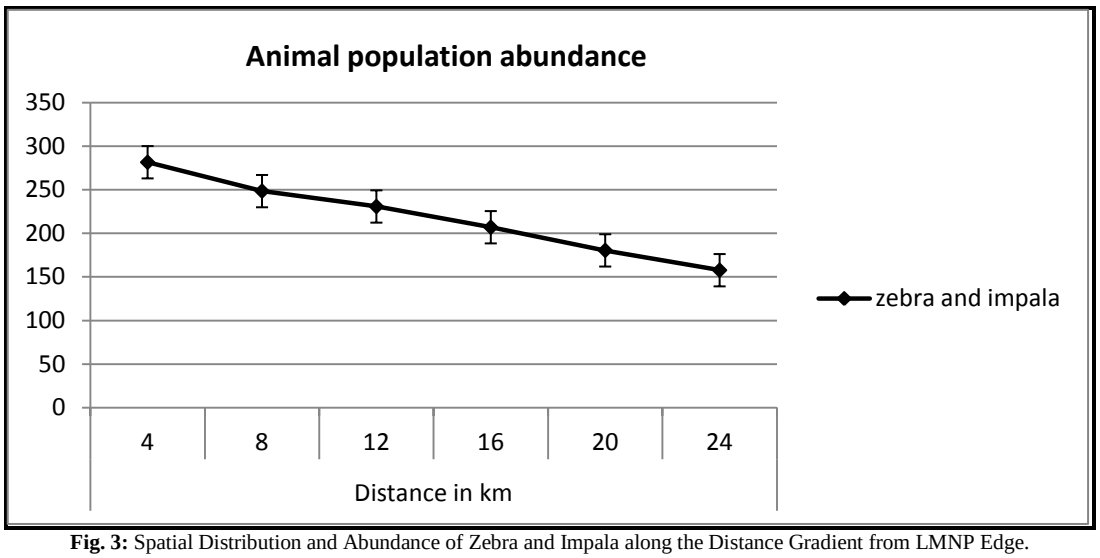


Fig. 3: Spatial Distribution and Abundance of Zebra and Impala along the Distance Gradient from LMNP Edge.

Table 5: Provides Summary of Field Observations Made During the Study

Land clearing	Main reason(s)	Scale	Personal assessment	Distance Zone in km
Intensive	Open space for pasture and wood for timber and charcoal	Large	Degraded rangeland with open grass lands and banana plantations dominating the area.	Distance range of 0 -4 km from LMNP
More intensive	Wood for charcoal, open space for pasture and crop cultivation	Large	Degraded rangeland with open grasslands, human settlements and crop cultivation.	Distance range of 4 -14 km from LMNP
Less intensive	For pasture, crop cultivation and settlement	Medium	Largely intact woody vegetation with grass in closed thickets	Distance range of 14 -24 km from LMNP

Source: Field observation survey, 2013

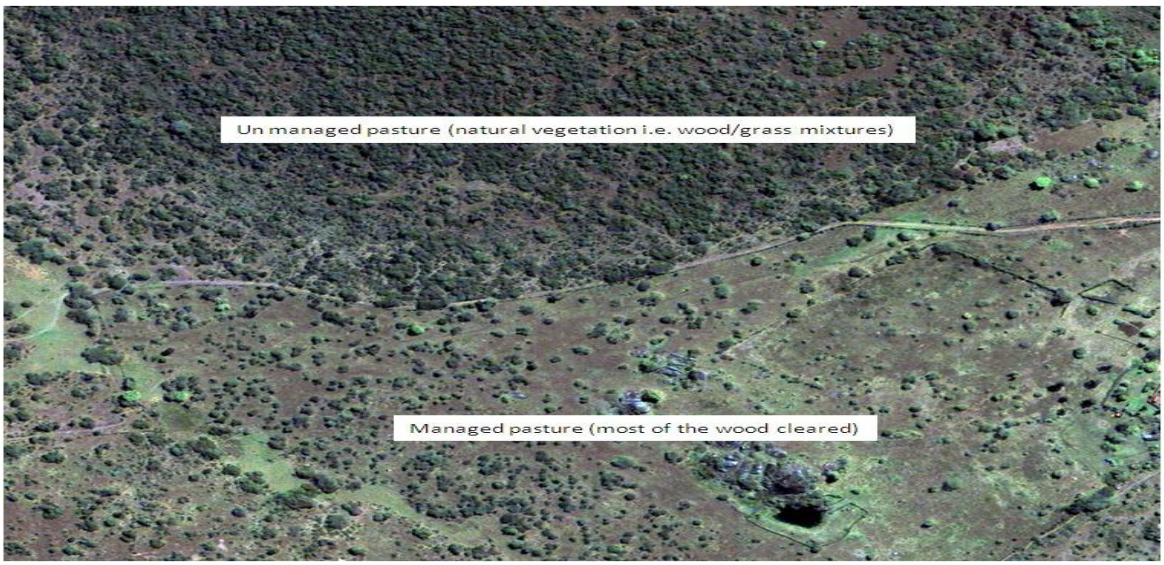


Fig. 4: Changing Landscape of Managed and Unmanaged Pasture in Rangeland Ecosystem

4. Discussion

The results of this study showed that most pastoral lands adjacent to the park have been cleared of woody vegetation. This phenomenon is driven in part by the need to open up space for cattle grazing not only due to increasing herd size, but also due to shrinking grazing areas as crops increasingly occupy traditional dry season grazing areas in the valley bottoms. Other factors influencing vegetation loss include charcoal burning to supplement household income, as well as petty trade on firewood which is a common source of energy in rural settings. The open grassland with some patches of bear ground in highly degraded areas within LMCA is an emerging trend that extends beyond 10 km range from the park boundary. However, rather intact, less open grasslands with acacia vegetation became evident as we moved farther away from the park boundary, across the Masaka-Mbarara highway. Thus, cattle kept in rangelands bordering LMNP are more likely to experience food shortage due to insufficient forage availability.

Although food shortage and diseases are some of the known natural ways through which animal populations have been put under ecological balance (Okarma et al., 1995; Hudson et al. 1998; Aguirre et al. 1999; Albon et al. 2002), pastoralists in south western Uganda blame diseases not on cattle population (overstocking) but on populations of free ranging wild species of animals. In this study, overstocking is evidently one of the ways pastoralists respond to minimize the impact of diseases and other ecological factors constraining cattle production. However, cultural practice of maintaining large herds of cattle as a sign of high social status is also perceived to be having some mild influence on overstocking. Most respondents were convinced that by opening up more

space, through clearance of woody vegetation, there would be sufficient forage to support cattle population in ways that are more profitable to the farmer. On the contrary, this is further attracting wild species of animals into the private farms, and hence the cycle of disease risk pathways continues. Indeed if wild animals are the real culprits, then the communities adjacent to the park are apparently using their local ecological knowledge subjectively. Studies have shown that in a situation where less resilient species is man's preferred choice, human intervention could lead to overstocking of such species. Unfortunately overstocking has become a major drive around LMNP toward vegetation clearance to open up more space for grass.

Only a few of the respondents were concerned about drought as being a threat to livestock production in south western Uganda. The experience of pastoralists in south western Uganda regarding drought is apparently different from those of their counterparts in northern Kenya (Gufu, 2001) and Ngorongoro conservation area inTanzania (Galvin et al., 2004) where drought is a major constraint to livestock production. Among the respondents who cited drought as a major concern, majority of them were from communities located further north of Lake Mburo National Park. Of the 68 who responded in the affirmative, as few as 18/68 (26.5%) expressed concern about drought in communities located within 12 km from park boundary, while as many as 50/68 (73.5%) were from communities located farther away from the park boundary. The different perspectives of LMCA residents on drought could be attributed to the fact that communities adjacent to the park rear more drought resistant local breed of cattle, *Bos indicus*, and often have access to water and pasture in the national park during stressful weather conditions. Unlike park adjacent communities, we observed that communities living far away from the park boundary rear more exotic breed of cattle (mainly of Friesian origin) than local cattle breeds which dominated park adjacent zones. The exotic breeds of cattle are usually susceptible to hot weather conditions (excessive heat), as well as limited pasture and fresh water which characterize a drought situation. Therefore, views expressed by participants revealed real concerns for the development of pastoralist communities in south western Uganda. Although some farms/ranches now have cross breed cattle, especially crosses between Ankole cattle and Friesian/Borana, their population is generally low and did not vary significantly between distant zones. Another concern, thought mild, was predation which is generally spread across various landscapes throughout the study area. Although predation was not a major issue for pastoralist communities, reported cases across six zones suggest that predator species of wild animals roam the entire study area.

Surprisingly, the most affected park adjacent communities were not in favour of the national park being fenced to keep animals off private farms/ranches. In our focus groups discussion we posed a question, "Would you like the national park management to fence off the protected area?" The responses varied significantly, with participants from areas adjacent to the park preferring that the gazetted area should remain unfenced, while those from communities situated far away from the park were in favour of the park being fenced. Those in favour of the park being fenced argued that it would deter animals from escaping into their private lands, while stopping those who encroach with their cattle into the protected area from contracting and spreading livestock diseases. Encroachment of people and their livestock into the protected areas is not unique to LMCA, but a common occurrence in most African rangelands (Marcotty et al., 2009). Consequently the opinion held by park adjacent communities resonates with a general attitude pastoralist societies in Africa have regarding wildlife habitats.

Overall our findings contributed to the understanding of complexity of wildlife-livestock interactions at the nexus of diseases transmission and changing pasture regime, which is critical in determining the extent of micro-scale landscape vulnerability of pastoralist communities in Lake Mburo Conservation Area. In other words, this study showed that park adjacent communities are at greater risk of animal diseases, as well as economic losses associated with the degraded environment compared to communities situated far away from the park boundary. Accordingly, the information regarding complex disease interaction between wildlife and livestock, and how that interaction impacts on various components of a rangeland ecosystem could open a new horizon of knowledge, especially for pursuing viable options for managing shared resources between wildlife and livestock, as well as diseases control.

5. Conclusions

The results of this study clearly demonstrated a spatial variability of cattle herd populations between distance zones from the park boundary further north of LMNP. This spatial variability in cattle populations was also associated with the population of wild species of ungulates, whose population abundance decreased with increasing distance from LMNP. Indeed the interface of cattle and wild ungulate populations within the context of high risk of diseases transmission partly explained the significant change in pasture regime. There was some evidence that risk of diseases attributable to wild animals' presence in cattle grazing systems is among the critical factors driving change in pasture regime in Lake Mburo Conservation Area. This trend, if left unchecked over time, could lead to a very severe environmental degradation and subsequently perpetuate poverty among pastoralist communities neighboring LMNP. Further research should consider complementarities and overlap of the diets of wild ungulates and cattle at the nexus of wildlife and livestock interface. This will provide an understanding of how wildlife presence in rangelands can lead to either favorable or adverse changes in the fauna as far as the domestic livestock species of cattle and small ruminants are concerned.

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