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The impact of livestock grazing on forest structure, ground flora and regeneration of disturbed areas in Mau Forest

Technical Note No. 30

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June, 2023

Cover Caption:
A young herds boy driving livestock into Kedowa Forest block in Mau Forest Complex.

Photographs by: Jared Mullah

ISBN: 978-9914-723-01-4

Published by:
Kenya Forestry Research Institute
P.O. Box 20412-00200, Nairobi Kenya,
Tel:+254-724-259781/2, +254-722-157414, +254-20-2010651/2
E-mail:director@kefri.org
Website:www.kefri.org

Layout & Design: Evans Abuje and Dorothy Ochieng

Printed by: Fiesta Works Agencies

Acknowledgement

The authors acknowledge Director Kenya Forestry Research Institute Dr. Joshua Cheboiwo - for financial resources and logistical support used in carrying out this study. The authors thank KEFRI RVERP Eco-region Research Programme - Londiani staff namely; Richard Siko, Michael Oduor, Gervas Nyaguti and Joel Imbue for undertaking data collection.

Various officers from different institutions are acknowledged for contributing their knowledge during the field surveys. We appreciate Community Forest Associations (CFAs), farmers and pastoralists, and staff of Kenya Forest Service (KFS) in stations at Mau forest for participating in the study and sharing information.

We sincerely thank the Director KEFRI - Dr. Joshua Cheboiwo for his invaluable input. The KEFRI Editorial team namely: Paul Tuwei, Dorothy Ochieng, Elema Mohammed, Leonida Cherotich, and Josephine Wanjiku are acknowledged for editing this guideline. Contribution of Patrick Kwiriga is also acknowledged.

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Summary

Domestic livestock grazing is an important activity that supports livelihoods of hundreds of forest adjacent communities in Kenya. It has been reported that domestic livestock grazing is one of the main causes of forest loss in the Mau Forest Complex. The present study aims to answer two questions. First, what is the density of livestock grazing in the forest? Second, what is the impact of livestock grazing on regeneration capacity of Mau forest? The study was conducted in the Eastern and South West blocks of Mau Forest in 2013 and 2015 covering selected grazed and non-grazed areas in Likia, Kiptunga, Kuresoi, Kedowa, and Londiani forest stations. The study found that livestock grazing in forests during the study period comprised of cattle, sheep, goats and donkeys. The highest livestock density was 557 per beat recorded in Eastern block and lowest of 297 recorded in South west block. Total livestock counted in the forest were 256 cattle, 579 sheep, 276 goats and 154 donkeys. However, this density data may have under-estimated the actual livestock densities due to: incompleteness; inconsistency in grazing permit records; lack of breakdown of permits into livestock types; and omission of certain livestock types from the records. The study showed that species richness was lower in the grazed areas than in areas without grazing. The study further showed that livestock favour establishment and growth of unpalatable plant species at the expense of palatable ones. For instance seedlings of palatable species such as *Prunus africana, Olea africana,* and *Dombeya torrida* were completely missing in the grazed areas indicating that livestock grazing can indeed alter the floristic composition of a forest. Livestock grazing leads to seedling removal, trampling, and establishment affecting the Mau forest plant communities and therefore must be carefully considered in the formulation of future management plans of the Forest.

1.0 Introduction

1.1 Background

Forests and woodlands are estimated to occupy 650 million ha or about 22% of the total land area of Africa, which corresponds to about 17% of the global forest cover (FAO, 2001). According to the FAO (2001), forests of the East Africa region account for 21% of forest area of Africa. However, the annual rate of deforestation in the region has increased from 0.7% during the period between 1981 and 1990 (FAO, 1993) to 1% between 1990 and 2000 (FAO, 2001). Kenya has annual deforestation rate of 0.8% (FAO, 2001) and intensity of forest loss over the last decades has been severe in the country's highlands. The main agents of deforestation include; agricultural expansion, livestock grazing, collection of firewood, charcoal production, and forest fires. Such depletion of forest vegetation is particularly severe in the key water towers in Kenya (KWTA, 2014) significantly lowering the forest resource base. This depletion will consequently have a major impact on other natural resource uses and sectors of the economy such as; agriculture, water resource, energy, and biodiversity conservation. Forests and woodlands are predominantly common-pool resources or open access resources in the country, hence resulting in wide-spread over-exploitation and thus leading to environmental problems such as; soil erosion, soil nutrient depletion, moisture stress, deforestation and overgrazing (Mullah, 2016).

Forest grazing is widely practiced in water towers of Kenya and is a very important element of household income in many forest adjacent communities as their livelihoods depend on livestock and forests. Severe shortage of feed sources is the major constraint to livestock production making rural communities increasingly dependent on remnant forest stands.

1.2 Problem statement

Water towers in Kenya are preferred grazing lands (Mullah, 2016). Previous studies shows that aggregate monetary value of fodder resources (browse and grazing) was KES 7 billion for Mt. Elgon and Mau Forest Complex (Langat *et al.,* 2018) indicating significant contribution to the local economies especially during dry seasons. Several studies have documented the impacts of livestock grazing on vegetation in woodlands and grasslands (Hardy *et al.,* 1999; Mligo, 2006; Sun *et al.,* 2011; Deng *et al.,* 2014; Koerner & Collins, 2014). However, there is a knowledge gap with regard to impacts of livestock grazing on plant species composition in afromontane forests (Reed & Clokie 2000). In East Africa, studies have been conducted in Mt. Kilimanjaro (Kikoti and Mligo, 2015), Central Highlands of Ethiopia (Woldu and Suleem, 1999) and Mt. Elgon Uganda (Reed and Clokie, 1999). However, limited research has been conducted on Kenyan water towers. This study therefore aims to bridge the information gap on impacts of livestock grazing on forest floor vegetation in the Mau Forest ecosystem in Kenya.

Objectives of the study were therefore to establish:

i. Type and numbers of domestic animals that are grazing in Mau Forest
ii. Effect of livestock grazing on forest ground flora and regeneration
iii. Which plant species are most susceptible to livestock grazing

2.0 Study Methods

2.1 Study area

Mau Forest is located in the western highlands of Kenya and represents the largest remaining Afromontane forest in the country covering about 400,000 ha (Kinyanjui, 2011). The forest comprises seven blocks primarily consisting of broadleaved tree species and bamboo forest, the latter in regions above 2400 m above sea level (a.s.l.) (Ngeno, 1996). The western highlands forest landscape is characterized by high densities of human and livestock populations (Herrerro *et al,* 2014; Robinson *et al.,* 2014). Apart from smallholder crop-livestock production systems there are large scale tea plantations in Mau Forest area (Baldyga *et al.,* 2008). The Mau Forest is used for fuelwood collection, livestock grazing, and timber production which is mainly harvested from commercial forest plantations (GoK, 2009; Olang *et al.,* 2011). Previous studies have shown that these human related activities have led to: loss of biodiversity; changes in tree composition and richness; invasion by alien plant species; and loss of catchment services (Kinyanjui, 2011; Mullah *et al.,* 2011 and Mullah *et al.,* 2014). The study was conducted in the Eastern and South West Blocks of Mau Forest in 2013 and 2015 covering selected grazed and non-grazed areas in Likia, Kiptunga, Kuresoi, Kedowa, Londiani, and Sururu forest station sites.

2.2 Mapping livestock density in the forest

Records on licensing of livestock grazing and revenue collection between 1998 and 2013 were collected from all forest stations within the study area. A baseline census survey on the livestock densities in eastern and western Mau, was also conducted.

Three field surveys were conducted between 2013 and 2015 in both wet season and dry season in selected site clusters. The clusters were selected based on indicators which were expected to influence the livestock densities, their impacts, plant species densities and livestock types (Table 1). The surveys used stratified household survey early morning as they enter the forest to; identify domestic livestock types present, quantify livestock holdings at the entry points, and within the forests. The livestock surveys were conducted to gather information on livestock numbers, and livestock types.

Field data gathered from this livestock census was corroborated with monthly grazing licensing data in combination with additional plant census to detect the impacts of livestock grazing on forest regeneration and plant species diversity.

2.3 Field vegetation measurements

Using stratified random sampling, transect lines were laid out in east, west, north and south direction in each forest block to determine the species composition, abundance, density, and diversity of woody plants. At every 100 m along each line in the forest, plots of 20 x 20 m were used to identify and record live woody plant species (trees/shrubs).

Multistage simple random sampling procedure was used to select first, the forest adjacent villages and secondly ten percent of the CFAs member respondents from the selected adjacent villages were randomly selected from a total members list. Closed and open ended questions were administered on farmers and pastoralists and herders encountered in the study area on the forage plants.

Based on discussions with the farmers/pastoralists, the species were categorized into palatable and unpalatable. Desirability of each species was also recorded based on these discussions.

Table 2.1: Bio-physical and past land use characterization of the study sites

Site	Characterization
Likia extension	• Area rehabilitated and protected from grazing for 5 years • Neighboring areas under grazing • Open areas grazed by pastoralists and small holder crop-livestock
Kiptunga	• Ogiek territories where no grazing license administered • Grassland (glades) • Livestock numbers • Grazing permits not issued
Kuresoi, Kedowa and Londiani	• Previously under NRC (non-residential cultivation) activities • Open forest land • Forest edges • Livestock numbers
Sururu	• Previously under NRC activities • Open forest land • Grazing by pastoralists and smallholder mixed farmers • Livestock grazing permits issued

3.0 Results

3.1 Livestock ownership, types, and numbers

Livestock production was found to be a key production system for both pastoralists and agro pastoralists (mixed farming) since livestock was considered the main asset upon which livelihood in the study area, especially for pastoralists depend. Livestock species reared in the study area included; cattle, goats, sheep, and donkeys. Within the study area, pastoralists reared dominantly cattle, sheep while agro-pastoralists reared dominantly cattle. According to 90% of respondents in the mixed farming systems and pastoralists during interview indicated that the major feed source available for the entire livestock in the study area are natural grasses, bushes, shrubs, and trees from Mau Forest. Our preliminary results indicate livestock are herded together and grazed in the forest, glades, farms and communal lands depending on time and season of the year. Cattle were the most important livestock type and are kept mainly for milk and meat production. Results indicated some variations between density of livestock grazing in the forest and the number licensed to graze in the forest (Table 2). Some livestock types such as donkeys and goats, though not legally allowed to graze in the forest also formed part of the number captured in all stations under this census survey except Sururu.

The livestock grazing is a source of revenue to KFS for the local communities are charged monthly fees for grazing in designated forest areas. The number of livestock grazed in the forest can therefore be imputed from revenue collected as a proxy. Revenue records from all the stations except Sururu and Likia stations were incomplete, and had no breakdown as to livestock type therefore were not included in our analysis. Revenue data from Sururu Station were used to illustrate the use information as proxy for number of livestock.

Revenue collected from grazing fees from sheep and cattle were below Ksh 20,000 between 1998 and 2006 (Figure 1b). However, there was a sharp rise in grazing fees to above Ksh 20,000 in 2007 but both dropped to zero in 2008. The was no grazing fees collected from sheep till 2013 but the cattle grazing fees shot to Ksh 50,000 between 2009 and 2010 then dropped to zero in 2011 then shot up to Ksh 160, 000 and in 2012 dropped to Ksh 30,000.

The survey revealed that the low revenue corresponded with peak political and national election calendar during which some communities just refuse to pay grazing fee. It was also alluded by our respondents that this trend and reason apply to other four stations.

There was big variance between the information provided by the records and the actual data collected for the two years of the study indicating that grazing fee record cannot be used to provide reliable estimate of livestock which grazed in these forest station.

Furthermore due to the inconsistences in the whole revenue trend being so significant, it cannot be used to develop grazing management plan for these forest blocks.

Table 3.1: Number of livestock recorded and licensed in the study areas in Mau Forest

Station	Cattle	Sheep	Goats	Donkeys
Sururu	726 (115)	46 (0)	0 (0)	0 (0)
Kiptunga	174 (203)	123 (120)	108 (0)	46 (0)
Likia	336 (0)	88 (0)	53 (0)	90 (0)
Sorget	326 (219)	61 (0)	157 (90)	11 (0)
Kedowa	438 (323)	261 (97)	100 (0)	7 (0)

( ) stands for number of livestock indicated in the grazing fee records

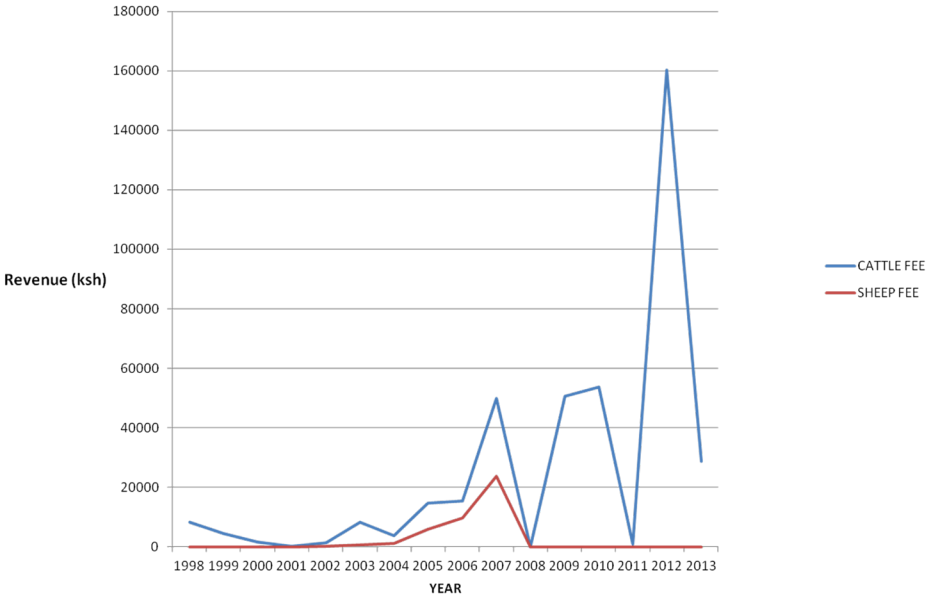

Fig 3.1: Fifteen years trend in total revenue from grazing permits in Sururu stations

3.2 Impact of grazing on forest ground flora

Table 3.2 gives the occurrence of plant species in the grazed and non-grazed areas during the wet and dry seasons in the year 2013 and 2015. The results show a clear pattern of association between some plants and grazing. Palatable tree species like *Dombeya torrida, Prunus africana, Syzyguim guineense,* and *Olea africana* were completely missing in areas under intensive grazing in Likia and Sururu blocks. On the other hand, some shrubs such as *Cyathea humulis, Vernonia auricurifela, Rhus natalensis, Salanam terminale, Leonatis mallisimu* among others were strongly associated with livestock grazing. The herbal community also showed the same trend with species such as *Cissampelos preira* present in grazed areas and *Cyphostema orondo* found only in non-grazed areas. The results show that high grazing pressure may change plant species diversity mainly by decreasing the abundance of palatable herbaceous species and degradation of forest understorey leading to reduction in tree

regeneration. Abundance and relative frequency of different species also varied between grazing and non-grazing areas (Table 3.3). In some forest areas like Kiptunga regenerated saplings of palatable tree species such as *Prunus africana, Olea africana,* and *Dombeya torrida* among others had to be physically protected against browsing to survive.

Table 3.2: Plant species in grazed and non- grazed plots (NOG) in the study areas Mau Forest

Plant species	**Grazed**	**Nongrazed**
Halleria lucida	1	1
Dombeya torrida	0	1
Rapanea sp.	1	1
Juniperus procera	0	1
Mkarakinga(kik)	0	1
Prunus africana	0	1
Bersama abyssinica	0	1
Olea africana	0	1
Syzyguim guinees	0	0
Paveta garddeniitolia	0	0
Digitaria horizontalis	1	1
Cynodon dactylon	1	1
Phyllanthus fischeri	1	1
Kyllinga bulbosa	1	1
Cyperus alternifolius	1	1
Oxalis obliquifolia	1	1
Glycine wyghtii	0	1
Hibiscus ludwidii	1	1
Cyathula polycephla	1	1

Plant species	Grazed	Nongrazed
Karanchoe densiflora	1	1
Hypostess forskhali	1	1
Centella asiatica	1	1
Bidens pilosa	1	1
Erigeron sp.	0	1
Cyathea humulis	1	0
Vernonia auricurifela	1	0
Rhus natalensis	1	0
Solanum terminale	1	0
Leonatis mallisimu	1	0
Lippia javanica	1	0
Dovyalis abyssinica	1	0
Maytenus leterophyla	1	0
Senna didymobotrya	1	0
Acanthus eminens	1	0
Clutia abbyssinica	1	0
Zeheneria scabra	1	1
Rubus steudneria	1	0
Cissampelos pereira	1	0
Cyphostema orondo	0	1
Physalis peruvian	0	1
Wild passion	1	0
Scutia myrtina	1	0

0 stands for absence and 1 stands for presence

Table 3.3: Densities and frequencies of plant species recorded in Mau Forest

Plant species	Counts		Relative Frequency		Relative Density/plot	
	Grazed	Non-grazed	Grazed	Non-grazed	Grazed	Non-grazed
Digitaria horizontalis	250	490	27.84	52.92	41.67	81.67
Cynodon dactylon	68	93	7.57	9.99	11.33	15.42
Phyllanthus fischeri	1	23	0.06	2.48	0.08	3.83
Kyllinga bulbosa	15	18	1.67	1.94	2.50	3.00
Oxalis obliquifolia	59	112	6.57	12.10	9.83	18.67
Cyathula polycephala	0	96	0.00	10.31	0.00	15.92
Crassocephalum viteellinum	1	40	0.06	4.27	0.08	6.58
Hibiscus ludwigii	1	18	0.11	1.94	0.17	3.00
Karanchoe densilflora	0	46	0.00	4.91	0.00	7.58
Hypoestes forskahli	0	79	0.00	8.48	0.00	13.08
Centella asiatica	0	48	0.00	5.18	0.00	8.00
Bidens pilosa	0	8	0.00	0.81	0.00	1.25
Glycine wyghtii	0	2	0.00	0.22	0.00	0.33
Urtica massaica	0	3	0.00	0.32	0.00	0.50
Cyathea humulis	13	132	1.39	14.64	2.08	21.92
Vernonia auricurifela	1	57	12.50	16.82	0.08	9.42
Acanthus eminens	0	2	0.00	0.60	0.00	0.33
Rhus natalensis	0	17	0.00	5.06	0.00	2.83
Solanum terminale	1	1	25.00	0.30	0.17	0.17

Plant species	Counts		Relative Frequency		Relative Density/plot	
	Grazed	Non-grazed	Grazed	Non-grazed	Grazed	Non-grazed
Leonatis mallisima	0	1	0.00	0.30	0.00	0.17
Lippia javanica	0	127	0.00	37.65	0.00	21.08
Clutia abyssinica	0	19	0.00	5.65	0.00	3.17
Dovyalis abyssinica	0	4	0.00	1.04	0.00	0.58
Maytenus leterophyla	0	1	0.00	0.30	0.00	0.17
Senna didymobotrya	0	6	0.00	1.79	0.00	1.00
Verbena bonariensis	0	1	0.00	0.30	0.00	0.17
Dombeya torrida	0	3	0.00	21.43	0.00	0.50
Halleria lucida	1	2	12.50	16.07	0.17	0.38
Pavetta gardeniifolia	3	5	37.50	37.50	0.50	0.88
Juniperus procera	1	2	12.50	16.07	0.17	0.38
Syzygium guineense	0	1	0.00	5.36	0.00	0.13
Zehneria scabra	0	14	0	11.67	0.00	2.33
Rubus steudneri	0	20	0	16.25	0.00	3.25
Cissampelos pereira	0	23	0	18.75	0.00	3.75
Cyphostema orondo	0	15	0	12.50	0.00	2.50
Ipomoea hildebrandtii	0	8	0	6.67	0.00	1.33
Physalis peruvian	0	1	0	0.42	0.00	0.08
Periprocalinea folia	0	3	0	2.08	0.00	0.42

The study showed that species richness was lower in the grazed areas than in areas without grazing. In grazed areas ferns, herbs, and other grasses were less common as compared to non-grazed areas. A comparison between an area protected from grazing and a neighbouring site with continuous grazing indicate that a difference in the species richness of the herbal community can be seen as early as 3 years (Figure 3.2).

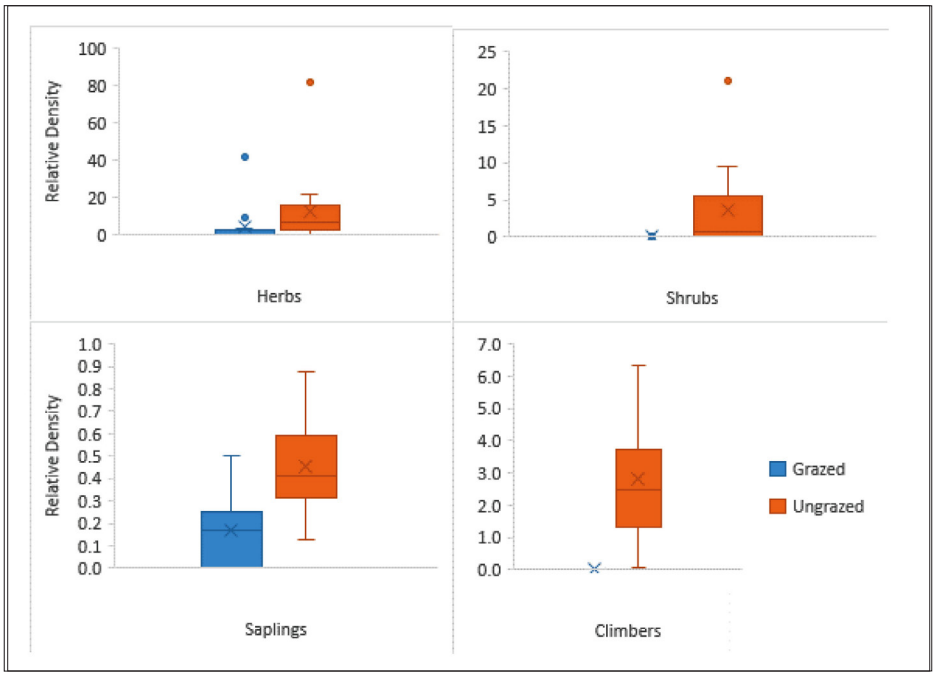

Figure 3.2: Box plots showing the average relative densities per species type

4.0 Discussion

Respondents in the study area keep more than one livestock types namely; cattle, donkeys and sheep which are mainly grazers and goats which are browsers. Pastoralists reared dominantly cattle, goats, and sheep while agro-pastoralists reared dominantly cattle. Most of the respondents (83%) preferred mixed stocking with two or more types of livestock with different feeding, ranging, production, disease and drought resistance, and reproductive characteristics therefore maximizing yield and providing long-term security for herder by using available resources. A large number of livestock entering Mau forest were from pastoralist area. During the dry season livestock mainly browse resources such as trees, bush and shrubs in Mau forest. In addition to these, crop residue and hay are used in the mixed farming systems to supplement forest grass.

These findings agree with previous studies by Nigatu *et al.,* 2004 and Giday *et al.,* 2018 who found that animal density was a key management variable that influenced plant species diversity and composition. The results also indicate that certain plant species seem to be less abundant in both grazed and non-grazed areas and the cause for this could not be explained by our preliminary study.

The total species richness was lower compared to richness recorded in larger afromontane forests in central and southern highlands of Ethiopia. This could be due to intense grazing and browsing effects from large number of livestock entering the forest. The results show that selective defoliation may have affected species composition by lowering the ability of palatable or more morphologically-exposed species to produce seeds. Similar situation has been reported by Gidaya *et al.,* (2018) who found that animal density was a key management variable that influenced plant species diversity and composition.

5.0 Conclusion

This is the first preliminary study that combines a historical approach with an analysis of plant density to investigate impact of livestock grazing on the forest floor conditions in Mau Forest. It shows that although grazing is not a primary driver of forest disturbance in the Mau Forests, it prevents re-growth of woody vegetation.

Due to inconsistency in the records of grazing permits, it was not possible to determine the livestock densities over ten year period in the study areas. These results are however informative and can be used as a baseline to formulate more concrete studies targeting understanding of the livestock numbers, feed availability in the forest, and impacts on ecology of forest ecosystem.

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ISBN 978-9914-723-01-4