Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

BIODIVERSITY STATUS OF MOUNT ELGON FOREST EOSYSTEM

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions

February 2018

This programme is funded
By the European Union

Kenya Forestry Research Institute
(KEFRI)

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BIODIVERSITY STATUS OF MOUNT ELGON FOREST EOSYSTEM

CHAPTER ONE

BACKGROUND INFORMATION

1. Introduction

Mount Elgon Forest Ecosystem is one of Kenya's five major water towers and the second highest mountain in the country. It is an important catchment for River Nzoia which drains into Lake Victoria and River Turkwel which drains into Lake Turkana. It is also the source of River Malakisi, which flows from Kenya into Uganda. The forest ecosystem is a biodiversity hotspot of global significance, supporting several endemic plant and animal species. It was declared a Biosphere Reserve by UNESCO in 2003 in recognition of its significance as a water tower and biodiversity reservoir. The ecosystem is gazetted as a montane forest reserve (73,705 ha) managed by the Kenya Forest Service, a national park (16,916 ha) managed by the Kenya Wildlife Service and a nature reserve (17,200 ha) managed by Bungoma County Government. Over the years, the area surrounding the forest ecosystem has experienced a surge in human population mostly as a result of immigration, increasing the human population density to about 600 people/km^2. A majority of these are poor peasant farmers who depend on the forest for most of their subsistence needs. Consequently, most of the households that live 0-3 km from the forest have converted large swaths of the mixed montane forest that borders community land into farmland significantly reducing the forest cover. The situation has led to considerable levels of forest disturbance and degradation, which have significantly affected the floristic and structural composition and water catchment functions of the forest ecosystem. It is suspected that loss of forest cover may have adversely impacted the ecosystem's faunal diversity as well, but there is no empirical data to support this.

A number of resource management strategies have been proposed with a view to stemming further forest degradation, but striking a balance between conservation and resource use has remained a daunting task. Moreover, the ecosystem is not a homogenous landscape. It is made up of at least four discrete eco-climatic zones that support different plant and animal communities. The situation calls for a management arrangement that reflects the ecological diversity of the ecosystem. Such an arrangement must demonstrate sound understanding of the status of forest vegetation and its capacity to support faunal diversity. Several attempts have been made in the past to characterize the biodiversity of the forest ecosystem, but most of them have not taken a holistic assessment approach. Perhaps some of the best attempts include assessment of the diversity of woody perennials and bird species of the ecosystem by Katende et al. (1990), land use mapping and biodiversity survey by van Heist (1994) and a survey of resource use across the mountain by forest adjoining communities by Scott (1994). One common feature of these assessments is that they were conducted well over two decades ago and may therefore not provide the best scenario of the present biodiversity status. Moreover, it is not clear how different ecosystem management regimes (forest management by KFS in the forest reserve versus wildlife conservation by KWS in the national park) within the forest ecosystem have

impacted biodiversity status over the years given that there is no physical barrier in the boundary between the forest reserve and the national park.

Improved understanding of the biodiversity status and its distribution is a key step in developing sustainable ecosystem management strategy for this forest ecosystem. The Kenya Forestry Research Institute in collaboration with the Kenya Wildlife Service, Kenya Forest Service, National Museums of Kenya, Rongo University and Nature Kenya carried out an assessment of biodiversity in all ecological of the forest ecosystem in May 2017 with a view to establishing the present biodiversity status and distribution within the forest ecosystem. The assessment focused on floral diversity targeting lower and higher plants, and faunal diversity targeting lower mammals, large mammals, herpetofauna, and birds. The objective of the assessment was to determine the occurrence and distribution of both flora and fauna in different forest types and ecological zones. And borrowing from previous studies, assess how past ecosystem disturbances and management regimes may have impacted species distributions and associations. Data generated from this assessment is expected to provide information necessary for developing appropriate strategies for the conservation and sustainable management of the forest ecosystem.

1.1 Physiography

Mount Elgon Forest Ecosystem sits on an extinct volcano that rises to an elevation of 4,321 m above sea level, straddling the border between Kenya and Uganda. It is located 01^{o} 07′ 06″ N and 34^{o} 31′ 30″ E about 100 km north-east of Lake Victoria. Its highest peak is Wagagai, which is located in Uganda at 4321 m. The highest peak on the Kenyan side is Koitobos who elevation is 4,222 m above sea level (Figure 1). The forest ecosystem is the source of Rivers Nzoia, Turkwel and Malakisi. Despite its height, the average slope angle of the mountain is less than 4 degrees giving it very gentle slope. The mountain is the oldest of the East African volcanoes, resting on the dissected pen plain of Precambrian bedrock of the Trans Nzoia Plateau. Its soils are from the Andisol order developed in volcanic ejecta, according to FAO classification.

The climate of Mount Elgon is cool and moist to moderate dry. It has a bimodal pattern of rainfall with annual rainfall of 1,400 – 1,800 mm. The rains come in March to May and September to November. The dry seasons run from June to August and from December to March. The mean average temperature ranges between 14^{o}C and 24^{o}C. The forest ecosystem supports various habitat types and rare species on slopes reaching an elevation of over 4,000 m above sea level. It also support an adjoining human population of about 2 million people, a majority of whose livelihoods and economic activities depend solely on the goods and services that they derive from this forest ecosystem.

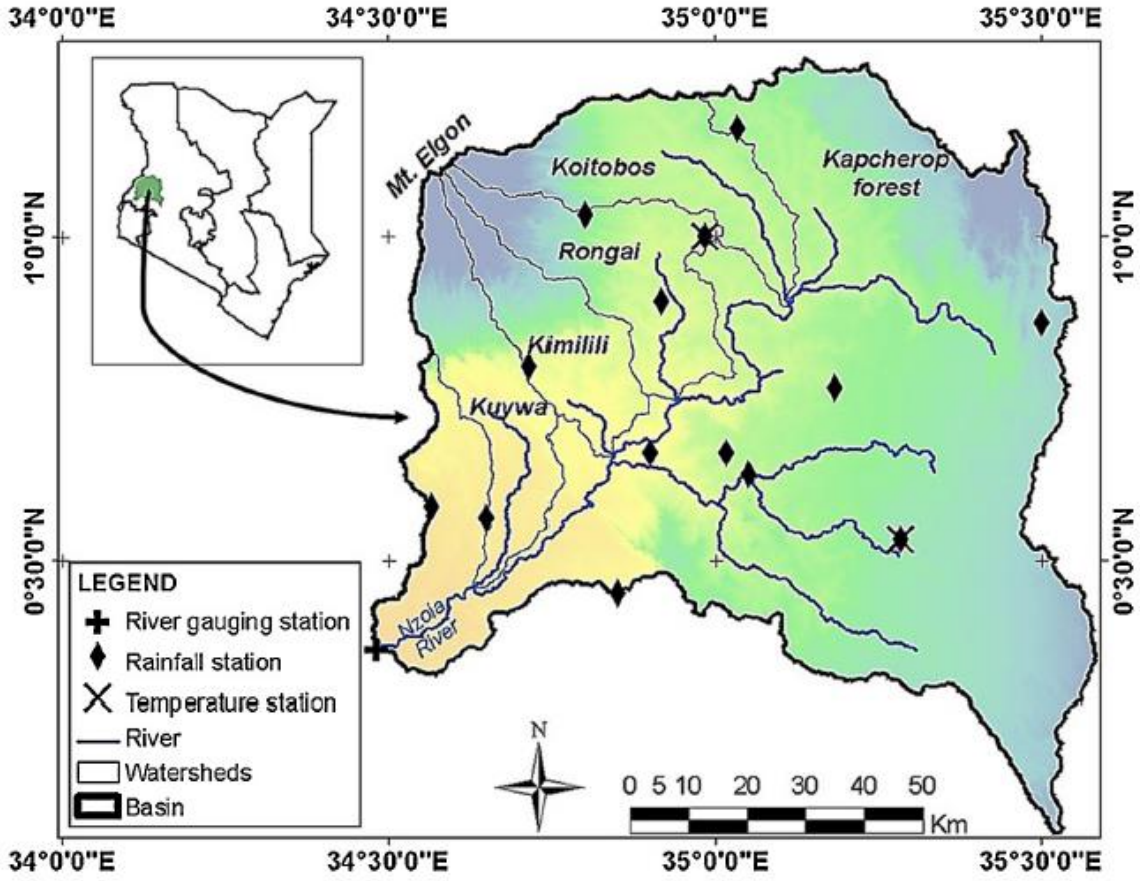


Figure 1: A physiographic map of Mount Elgon Forest Ecosystem showing its peaks, catchments and drainage basins (*Source*: Musau *et al*., 2015)

1.2. Vegetation

Although largely considered a mixed montane forest, Mount Elgon Forest Ecosystem comprises at least four discrete ecological zones characterized by different vegetation communities, namely: mixed montane forest, bamboo and low canopy forest, sub-alpine montane heath and alpine moorland. These vegetation types vary with altitude. The mountain slopes are covered with Elgon olive *Olea hochstetteri* and *Aningueria adolfi-friedericii* in the wet mixed montane forest. At slightly higher altitude, the floristic composition changes to Elgon olive *Olea hochstetteri* and *Podocarpus gracilior* forest, and then to a *Podocarpus* and bamboo *Arundinaria alpina* zone. Higher up is a *Hagenia abyssinica* zone and then moorland with heaths *Erica arborea* and *Philippia trimera*, tussock grasses such as *Agrostis gracilifolia* and *Festuca pilgeri*, and herbs such as *Alchemilla, Helichrysum, Lobelia*, and the giant groundsels *Senecio barbatipes* and *Senecio elgonensis*. The floral diversity and associations in the national park include giant *Podocarpus spp*, cedar trees *Juniperus procera* and Elgon olive *Olea hochstetteri* trees in the lower zone, as one moves up this changes to cedar *Juniperus procera*, pillarwood *Cassipourea malosana* and elder trees *Sambucus adnate*. Further higher up are pure stands of *Podocarpus gracilior* in the bamboo *Arundinaria alpina* zone and many orchids. Of the 400 plant species recorded in this forest ecosystem, *Ardisiandra wettsteinii, Carduus afromontanus, Echinops hoehnelii, Ranunculus keniensis* and *Romulea keniensis* are of particular significance because they are high altitude broad-leaf montane forest species.

A comparison of vegetation cover maps of the forest ecosystem over the past four decades shows that mixed montane forest cover has decreased by one third, while the area under crop cultivation with the forest has increased from zero to 9,582 ha during the period. The area under alpine moorland also declined during the period raising concerns over the consequences that this may have on the survival of species endemic to this vegetation type. Cases of overgrazing by cattle, sheep, and donkeys in the sub-alpine montane heath were also noted to inhibit natural forest regrowth and in the process create an artificial climax with grasses that ended up resembling, but were not moorland. The situation has created an ecological habitat may not been conducive for sub-alpine montane heath species.

1.3 Birds

Birds are often one good indicator species of the ecological status of a given ecosystem. For Mount Elgon Forest Ecosystem, however, most bird surveys have only recorded the presence or absence of species, with a mention of their ecological status. The ecosystem is considered as home to at least 144 bird species. Some of the most important among these include Jackson's francolin, the eastern bronze-naped pigeon, Hartlaub's turaco, the Tacazze sunbird and the endangered lammergeier, due to their restricted range. Of the recorded 144 species, 25% are forest specialists with the rest being forest generalists. Of the forest generalists, 29% are forest visitors, which implies that over 70% of the birds were forest-dependent species. Some the forest visitors are suspected to stay within the open grassland vegetation of the forest.

1.4 Mammals

The forest ecosystem is home to elephants, buffaloes a variety of small antelope and duiker (*Sylvicapra grimmia*), bushbuck (*Tragelaphus scriptus*) as well forest monkeys, including the black-and-white colobus (*Colobus guereza*) and blue monkey (*Cercopithecus mitis*), red-tailed monkey (*Cercopithecus ascanius*), hyrax (*Heterohyraz brucei*), leopard (*Panthera pardus*) and hyena. Generally, the populations of large animals have become increasingly scarce since the large increase in human populations in and around the mountain in the 1980s and 1990s.

Overall, IUCN have listed 37 faunal species in the area as "globally threatened" (22 mammal, 2 insect and 13 bird species, of which nine species are endemic), making the area a priority site for species conservation. Most this information was obtained from surveys of Mount Elgon biota carried out between 1991 and 1995. As a result of these surveys, Mount Elgon was provisionally ranked amongst the top ten most species rich forests in Kenya.

1.5 Tourist attractions

Mount Elgon Forest Ecosystem has a variety of scenic features with the potential to attract tourism. These include cliffs, caves, waterfalls, gorges, mesas, calderas, hot springs, and mountain peaks. The most popular among these are vast caves where frequent night visitors such as elephants and buffaloes come to lick the natural salt found on the cave walls. Kitum cave, with overhanging crystalline walls, is one of those caves frequented by salt-licking elephants.

Activities that attract tourism on the mountain include

- Vehicle circuits leading to animal viewing areas, the caves and Koitobos peak.
- Self-guided walking trails

- Hiking to Endebess Bluff and Koitoboss Peak
- Primate and bird watching
- Cave explorations
- Camping photography

CHAPTER TWO

FLORISTIC AND STRUCTURAL COMPOSITION OF THE VEGETATION OF MOUNT ELGON FOREST ECOSYSTEM

By

John Otuoma, Eliud Macharia, Rachel Shena, Bartholomew Okemwa and BophinesSewe

Abstract

We assessed the floristic and structural composition of the vegetation of the Kenyan side of Mount Elgon Forest Ecosystem. The assessment covered the mixed montane forest, bamboo low canopy forest and the sub-alpine heath. It employed a nested experimental design. Each vegetation zone was stratified into vegetation types. Data were collected using stratified systematic sampling. Three transects of 1km each were laid in each vegetation type. Sample plots were laid along each transect at intervals at 300m. A total of 116 species of vascular plants from 55 families were recorded in the three vegetation zones. Woody species richness decreased with increase in altitude, while herbaceous species richness increased with altitude. The mixed montane forest had 80 plants species of which 21 were woody and 59 were herbaceous. The bamboo zone had 53 plants species, which comprised 17 woody and 36 herbaceous species. The sub-alpine heath had 51 plant species, of which nine were woody while 42 were of herbaceous life-forms. The sub-alpine heath forest had fewer seedlings (10,400 seedlings per ha) than the mixed montane forest (10,800 seedlings per ha) and the bamboo zone (24,800 seedlings per ha). The sub-alpine heath and the bamboo zone had lower sapling density (400 to 800 saplings per ha) than the mixed montane forest (2,400 saplings per ha). The variation in stem density among the three vegetation zones (175.2±47.28 and 304.1±58.89) was not statistically significant (p = 0.222). Similarly, the variation in mean stem DBH among the three vegetation zones (28.06±15.42 cm and 63.67±14.21 cm) was not significant (p = 0.239). The variation in mean canopy height among the three vegetation zones (10.97±2.76 m and 20.47±2.76) was also not statistically significant (p = 0.17). The basal area of the three vegetation zones ranged between 30.42±24.11 m^2 per ha and 58.69±22.22 m^2 per ha, and was also not statistically significant (p = 0.716). A comparison of the floristic and structural composition of the forest reserve, national park and areas occupied by indigenous forest-dwelling communities indicated that the forest reserve had a higher species richness than the national park and areas dwelt by indigenous communities. However, the stem density and basal area of the two management zones were no significantly different, even though trees of the forest reserve were relatively taller.

2.1 Introduction

The vegetation of Mount Elgon Forest Ecosystem is distributed in four ecological zones, namely: mixed montane forest, bamboo forest, sub-alpine montane heath and alpine moorland vegetation (Howard, 1991). Each of the four zones comprises a vegetation community with unique floral characteristics and structural outlook. The floristic and structural variation arises from rapid change in elevation from the base of the mountain to its peak. The mixed montane forest begins at the slopes of the mountain at about 2,200 m above sea level where the forest borders

community farmlands and extends to 2,500 m above sea level where it meets the bamboo zone (Mwaura, 2011). The bamboo zone comprises a low canopy forest, which begins at about 2,500 m above sea level and stretches up to 3,000 m above sea level (Bakamwesiga et al., 2005). The sub-alpine montane heath commences at about 3,000 m above sea level and extends to 3,500 m above sea level. The alpine moorland zone begins at 3,500 m above sea level and stretches to the peak of the mountain at an elevation of 4,222 m above sea level (MUIENR and NMK, 2005). Earlier studies indicated that the mixed montane forest is covered primarily with *Olea hochstetteri* and *Aningeria adolfi-friedericii*, while the bamboo low canopy forest comprises mainly *Podocarpus spp* and *Arundinaria alpina* (Bakamwesiga et al., 2005). There is a transition zone between the bamboo vegetation and the sub-alpine montane heath, which comprises a dense mixed stand of *Hagenia abyssinica* and *Juniperus procera* (Tweedie, 1975). The sub-alpine montane heath and the alpine moorland are covered with *Erica arborea* and *Philippia trimera*, tussock grasses such as *Agrostis gracilifolia* and *Festuca pilgeri*, herbs such as *Alchemilla*, *Helichrysum*, *Lobelia*, and the giant groundsels *Senecio barbatipes* and *Senecio elgonensis* (Howard, 1991).

Over the past four decades, the mixed montane forest has been highly degraded as a result of clear-felling operations. Some of the clear-felled areas have been encroached into by forest adjoining communities for crop cultivation causing a 30% decrease in the area under mixed montane forest (Hinchley, 2003; Musau et al., 2015). During the same period, the area under sub-alpine montane heath has decreased by 25% as a result of logging of merchantable trees species, such as *Juniperus procera*; and over-stocking of livestock by indigenous forest dwelling communities (Howard, 1991). These changes in vegetation cover and land use have caused a significant shift in forest cover. The lower zone under mixed montane forest is increasingly being lost to crop cultivation, while the bamboo vegetation is expanding into both the upper zone of mixed montane forest and the lower zone of the sub-alpine montane heath. Despite the emerging shift in vegetation cover, little effort has been made to understand the impact of vegetation cover change on floristic and structural composition of the four vegetation zones of this forest ecosystem, if any. Moreover, given these changes in vegetation cover, it is important to compare the floral and structural attributes of the vegetation in the forest reserve to that of the national park, where vegetation cover has remained largely unchanged.

A good understanding of the present vegetation cover and its floral composition is useful in designing management strategies for the forest ecosystem with a focus on conservation of biodiversity in different vegetation zones. For instance, the continued decrease in the area under montane heath and moorland could have grave consequences for the survival of species endemic to them. We assessed the floristic and structural composition of Mount Elgon Forest Ecosystem with a view to understanding the floral and structural attributes of different vegetation zones and how this varies from the forest reserve to the national park and also in areas occupied by indigenous forest dwelling communities. Findings of the assessment are expected to assist forest managers and policy makers in designing sustainable management strategies for this important forest ecosystem.

2.2 Materials and methods

2.2.1 Study area

The assessment was carried out in Mount Elgon Forest Ecosystem in May 2017. The forest ecosystem is an afro-montane forest located in western Kenya between latitudes 1^{o} 08′ 00″ N and longitudes 34^{o} 33′ 00″ E at an elevation of between 2,200 and 4,222m above sea level (Mwaura, 2011). The area has a cool and moist climate characterized by a mean temperature of 16^{o}C. It receives a bimodal rainfall of 1,500 – 2,000mm per year with dry seasons between June and August and December and March (MUIENR and NMK, 2005). There are four forest vegetation types from the slopes of the mountain to its peak, namely: a mixed montane forest, bamboo low-canopy forest, sub-alpine montane heath forest, and alpine moorland. The ecosystem comprises a forest reserve and a national park. The upper zones of the forest reserve support an indigenous forest-dwelling community, which relies on livestock production (MUIENR and NMK, 2005). The lower zones support forest adjoining farming communities, whose population density is currently estimated at about 600 people / km^2 (Petursson et al., 2006). Some of the resources that they obtain from the forest include herbal medicine, fuel wood, pasture for livestock, timber, construction poles, fibre, and indigenous fruits and vegetables (Scott, 1994).

2.2.2 Study design

The assessment employed a nested experimental design. It was carried out in three vegetation zones, namely: the mixed montane forest, bamboo zone and sub-alpine heath forest. Since the vegetation zones cut across most of the forest's administrative units, the assessment covered different forest management blocks, which served as sub-blocks, namely: (i) Kaberua Forest Block, a moderately disturbed forest block managed by the Kenya Forest Service (KFS) as a forest reserve; (ii) Sossio Forest Block, an area gazetted and managed by KFS as a forest reserve but settled by indigenous forest dwelling communities; and (iii) Mount Elgon National Park, a gazetted national park managed by the Kenya Wildlife Service. Assessment was done using line transects. Three transects of about 1km each were laid per sub-lock. Sampling involved stratified systematic sampling. Sample plots of 20m by 10m were laid at intervals of 300m along each transect. The 20m by 10m main plot was used to assess woody plants ≥ 10cm in DBH. A 5m by 5m sub-plot was nested within the main plot and used for assessing saplings, shrubs and lianas of DBH 2.0cm - 9.9cm. Grass and other herbaceous plants were assessed in 1m by 1m sub-plots that were nested within the 20m by 10m plot.

2.2.3 Data collection

Data were collected on plant species types, stem diameter at breast height (DBH) and canopy height. Counts were made of saplings, seedlings and erectile herbs. Estimates were made of the percentage ground cover of grass and creeping herbs.

Plate 1: Rapid vegetation assessment in the sub-alpine montane heath forest during biodiversity assessment in Mt Elgon Forest Ecosystem in May 2017

2.2.4 Data analysis

The data that were obtained from the field were used to derive plant species richness, species diversity and evenness, stem density, basal area and mean canopy height. Species diversity was calculated using the Shannon diversity index, while species evenness was calculated using the Simpson index. Analysis of variance was used to test for significance of the variation in plant species diversity, stem density, basal area and canopy height at 5% significance level in Genstat statistical software version 17. Post hoc tests were carried out to detect significant differences among means using the Ryan–Einot–Gabriel–Welsch Multiple Range Test at 5% significance level.

2.3 Results

2.3.1 Floristic composition

2.3.1.1 Species richness

A total of 116 plant species from 55 families were recorded in the three vegetation zones of the forest ecosystem. Trees and shrubs were the most abundant, while ferns and tree seedlings were the least represented plant life-forms (Figure 1).

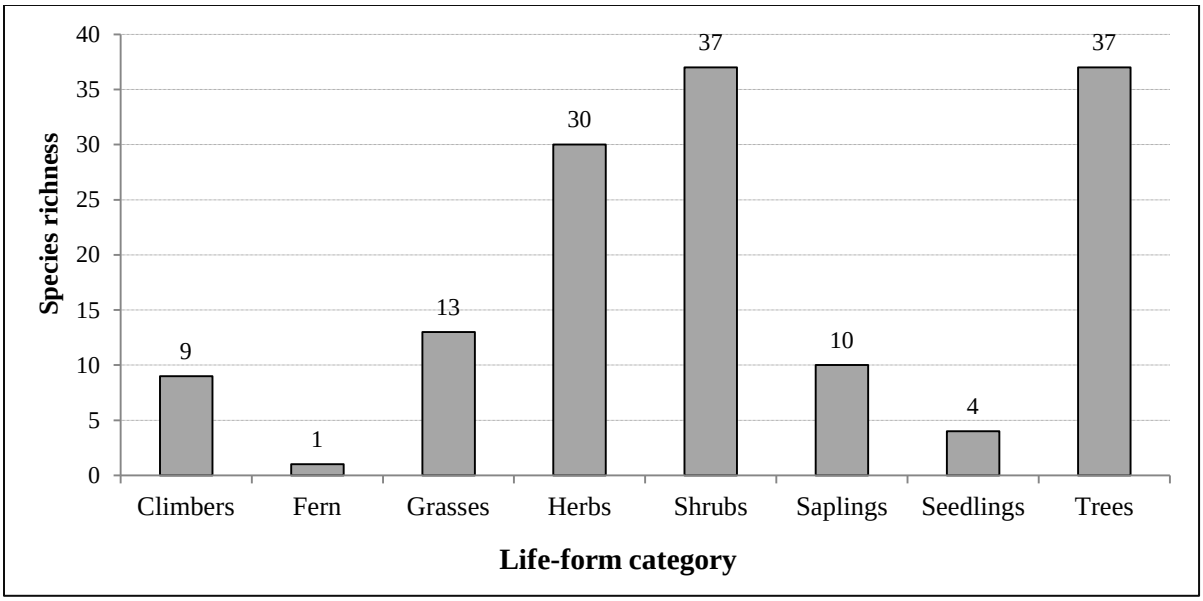


Figure 1: Plant species representation by life-form categories in Mount Elgon Forest Ecosystem

Analysis of species distribution by vegetation zones indicated that the mixed montane forest had the highest number of plant species, a majority of which were shrubs. It was also the only vegetation zone without ferns (Table 1). The sub-alpine zone had the least number of plant species. It was also the only vegetation zone without tree seedlings. The bamboo zone was the vegetation zone with all the plant life-form categories (Table 1). Species richness among climbers, shrubs, saplings and trees appeared to decrease with increase in altitude, with the mixed montane forest having the highest species richness and the sub-alpine zone having the least (Table 1). However, species richness among grasses increased with altitude.

Table 1: Plant species distribution by life-form categories in three vegetation zones of Mount Elgon Forest Ecosystem

Life-form category	**Species richness in vegetation zone**		
	Mixed montane forest	**Bamboo zone**	**Sub-alpine heath**
Climbers	8	4	1
Ferns		1	1
Grasses	7	8	10
Herbs	16	15	17
Shrubs	22	17	14
Saplings	6	4	2
Seedlings	2	2	
Trees	26	11	10
Total no. of species	**80**	**53**	**51**

2.3.1.2 Species diversity and evenness

The mixed montane forest and bamboo vegetation had relatively higher species richness that the sub-alpine health forest, but the latter had a significantly higher Shannon diversity index (p =

0.014) (Table 2). This suggested that many of the 80 plant species in the mixed montane forest had relatively fewer individuals, which lowered their relative abundance. On the other hand, most of the 51 plant species in the sub-alpine heath forest had relatively more individuals, which raised their relative abundance. Similarly, the bamboo zone had a lower species diversity index, implying that the number of individual plants among most of its 53 plant species was relatively smaller than that of the sub-alpine zone.

The Simpson's index of evenness indicated that the variation in species evenness among the three vegetation zones was not significant (p = 0.539). However, the sub-alpine zone had a relatively higher index than the rest (Table 2), suggesting that its species were more evenly spread than those of the mixed montane forest and bamboo zone. The mixed montane forest had the lowest species evenness. Overall, all the three vegetation zones had fairly low species evenness.

Table 2: Shannon diversity index and Simpson's index of evenness in the mixed montane forest, bamboo zone and sub-alpine montane heath in Mt Elgon Forest Ecosystem

Ecological zone	**Species richness**	**Shannon index**	**Simpson index**
Mixed montane forest	80	1.158 ± 0.226 $_a$	0.018 ± 0.008 $_a$
Bamboo forest	53	0.681 ± 0.143 $_a$	0.053 ± 0.035 $_a$
Sub-alpine heath	51	1.928 ± 0.356 $_b$	0.068 ± 0.027 $_a$
p value		0.014	0.539
l.s.d.		0.636	0.119

2.3.1.3 Key woody species within vegetation zones

There were 21 woody species in the mixed montane forest, of which *Neoboutonia macrocalyx* and *Casearia battiscombei* were the most abundant within the forest reserve (Table 3). *Ekebergia capensis, Aningeria adolfi-friedericii* and *Celtis africana* were also represented in large numbers. In the national park, *Ficus thonningii* and *Podocarpus falcatus* were the most dominant in the mixed montane forest. The populations of *Croton microstachyus*, *Olea europea* subsp *caudata* and *Trichocladus ellipticus* were also large.

The bamboo zone had 17 woody species, of which *Podocarpus latifolius, Bersama abyssinica* and *Neoboutonia macrocalyx* were the most abundant within the forest reserve. The dense mixed stand that begins within the bamboo zone in the forest reserve and extends into the sub-alpine zone had mainly *Podocarpus latifolius, Schefflera abyssinica, Bersama abyssinica* and *Afrocrania volkensii*. The bamboo zone within the national park had *Podocarpus falcatus* and *Dovyalis abyssinica* as the most dominant woody species. The populations of *Teclea nobilis* and *Diospyros abyssinica* were also high. The bamboo zone in areas dwelt by indigenous forest communities in Sossio had *Podocarpus falcatus* and *Podocarpus latifolius* as the key woody species.

The sub-alpine heath forest had nine woody species. *Juniperus procera, Erica arborea* and *Rapanea melanophloeos* were the most dominant within the forest reserve. *Hageniaabyssinica* and *Hypericum keniense* were also represented. The sub-alpine vegetation within Sossio had

*Hypericumkeniense, Oleaeuropea*subsp*caudata, Juniperusprocera* and *Nuxiacongesta* as the key species. The sub-alpine zone in the national park comprised mainly grasses.

Table 3: Key woody species of different vegetation zones of Mt Elgon Forest Ecosystem

Vegetation zone	**Woody species richness**	**Forest area**	**Vegetation type**	**Key woody species (listed from most abundant to least abundant)**
Mixed montane forest	21	Forest reserve	Open natural forest	*Neoboutoniamacrocalyx, Caseariabattiscombei, Ekebergiacapensis, Aningeriaadolfi-friedericii, Celtisafricana*
		National Park	Open natural forest	*Ficusthonningii, Podocarpusfalcatus, Croton microstachyus, Oleaeuropeasubspcaudata, Trichocladusellipticus*
Bamboo vegetation	17	Forest reserve	Closed natural forest	*Podocarpuslatifolius, Bersamaabyssinica, Neoboutoniamacrocalyx*
			Dense natural forest	*Podocarpuslatifolius, Scheffleraabyssinica, Bersamaabyssinica, Afrocraniavolkensii*
		National Park	Closed natural forest	*Podocarpusfalcatus, Dovyalisabyssinica, Tecleanobilis, Diospyrosabyssinica*
		Sossio	Open natural forest	*Podocarpusfalcatus, Podocarpuslatifolius*
Sub-alpine heath	9	Forest reserve	Wooded grassland	*Juniperusprocera, Erica arborea, Rapaneamelanophloeos. Hageniaabyssinica, Hypericumkeniense*
		Sossio	Wooded grassland	*Hypericumkeniense, Oleaeuropeasubspcaudata, Juniperusprocera, Nuxiacongesta*
		National Park	Grassland	-

2.3.1.4 Key herbaceous species within vegetation zones

The mixed montane forest had 59 herbaceous species, of which *Pennisetum clandestinum, Cyperus articulates* and *Setaria plicatilis* were the dominant grasses, while *Hypoestes forskhalii* and *Galinsoga parviflora* were the dominant herbs within the forest reserve (Table 4). In the national park, *Cyperus difformis* and *Oplismenus hirtellus* were the dominant grasses, while *Hypoestes forskhalii* and *Achyranthus aspera* were the most abundant herbs.

The bamboo zone had 36 herbaceous species, of which *Ushania alpina* and *Pennisetum clandestinum* were the dominant grasses, while *Hypoestesforskhalii* and *Cyathulapolycephala* were dominant herbs within theforest reserve (Table 4). *Ushaniaalpina* was the dominant grass, while *Hypoestesforskhalii* and *Achyranthusaspera* were dominant herbs in the national park. In Sossio, *Pennisetumclandestinum* and *Adropogongayanus* were the most abundant grasses, while *Centellaasiatica* and *Hypoestesforskhalii* were the most dominant herbs in the bamboo zone.

The sub-alpine heath had 42 herbaceous species, of which *Cyperus difformis, Cyperus kyllinga, Cyperus articulates* and *Digitaria scalarum* were the abundant grasses, while Alchemilla *rothii,*

Oxalis comiculata and *Satureja biflora* were the most abundant herbs within the forest reserve (Table 4). *Cyperus articulates, Cyperus kyllinga* and *Digitaria scalarum* were dominant grasses, while *Commelina benghalensis* and *Tephrosiauniflora* were dominant herbs within the national park. In Sossio, *Pennisetumclandestinum, Cyperus articulates* and *Adropogon gayanus* were the dominant grasses, while *Centella asiatica, Impatiense pseudoviola* and *Oxalis comiculata* were the most abundant herbs.

Table 4: Key herbaceous species in different vegetation zones of Mt Elgon Forest Ecosystem

Vegetation zone	**Herbaceous species richness**	**Forest area**	**Life-form**	**Key herbaceous species (listed from most abundant to least abundant)**
Mixed montane forest	59	Forest reserve	Grass	*Pennisetumclandestinum, Cyperus articulates, Setariaplicatilis*
		Forest reserve	Heb	*Hypoestesforskhalii, Galinsoga parviflora*
		National Park	Grass	*Cyperusdifformis, Oplismenushirtellus*
		National Park	Heb	*Hypoestesforskhalii, Achyranthusaspera*
Bamboo vegetation	36	Forest reserve	Grass	*Ushania alpina, Pennisetumclandestinum*
		Forest reserve	Heb	*Hypoestesforskhalii, Cyathulapolycephala*
		National Park	Grass	*Ushania alpina,*
		National Park	Heb	*Hypoestesforskhalii, Achyranthusaspera*
		Sossio	Grass	*Pennisetumclandestinum, Adropogongayanus*
		Sossio	Heb	*Centellaasiatica, Hypoestesforskhalii*
Sub-alpine heath	42	Forest reserve	Grass	*Cyperusdifformis, Cyperuskyllinga, Cyperus articulates, Digitariascalarum*
		Forest reserve	Heb	*Alchemilla rothii, Oxalis comiculata, Satureja biflora*
		National Park	Grass	*Cyperus articulates, Cyperuskyllinga, Digitariascalarum*
		National Park	Heb	*Commelinabenghalensis, Tephrosiauniflora*
		Sossio	Grass	*Pennisetumclandestinum, Cyperus articulates, Adropogongayanus*
		Sossio	Heb	*Centellaasiatica, Impatiensepseudoviola, Oxalis comiculata*

2.3.2 Structural composition

2.3.2.1 Seedling and sapling density

The seedling density of the forest ecosystem ranged between zero and 24,800 per ha. No seedlings were recorded in both the national park and in the indigenous community dwelling zone of Sossio in all the three vegetation zones. Thus, all the seedlings recorded were found in the forest reserve. The sub-alpine heath forest had relatively fewer seedlings than the mixed montane forest and the bamboo zone within the forest reserve (Table 5). Sapling density, on the other hand, ranged between zero and 2,400 per ha. Saplings were recorded in all the three vegetation zones, except the Kaberua part of the mixed montane forest (Table 5). The sub-alpine

heath forest and the bamboo zones had relative lower sapling density (400 to 800 saplings per ha) than the mixed montane forest (2,400 saplings per ha).

Table 5: Seedling and sapling density in different vegetation zones of Mt Elgon Forest Ecosystem

Vegetation zone	Forest area	Seedlings per ha	Saplings per ha
Mixed montane forest	Forest reserve	10,800	
	National park		2,400
Bamboo zone	Forest reserve	24,800	800
	National park		400
	Sossio		400
Sub-alpine heath	Forest reserve	10,400	400

2.3.2.2 Stem density, DBH, canopy height and basal area

The stem density of woody stems ≥ 10 cm DBH ranged between 175.2±47.28 and 304.1±58.89 cross the three vegetation zones (Figure 2). The variation was, however, not statistically significant (p = 0.222). Similarly, the variation in mean stem DBH among the three vegetation zones (28.06±15.42 cm and 63.67±14.21 cm) was not significant (p = 0.239) (Figure 2). The variation in mean woody canopy height among the three vegetation zones (10.97±2.76 m and 20.47±2.76) was not statistically significant (p = 0.17) (Figure 2). Woody canopy height appeared to decreased with increase in altitude with the mixed montane forest having the highest and the sub-alpine montane heath recording the lowest (Figure 2).

The basal area of the three vegetation zones ranged between 30.42±24.11 m^2 per ha and 58.69±22.22 m^2 per ha, with the bamboo vegetation recording the highest and the sub-alpine montane heath the least. The variation was, however, not statistically significant (p = 0.716). These results suggest that the bamboo low canopy forest had fewer woody stems than the mixed montane forest and the sub-alpine montane heath, but its woody stems had much higher mean DBH than those of the other two vegetation zones. Thus, the bamboo forest ended up recording a higher basal area than the mixed montane forest and the sub-alpine montane heath (Figure 2).

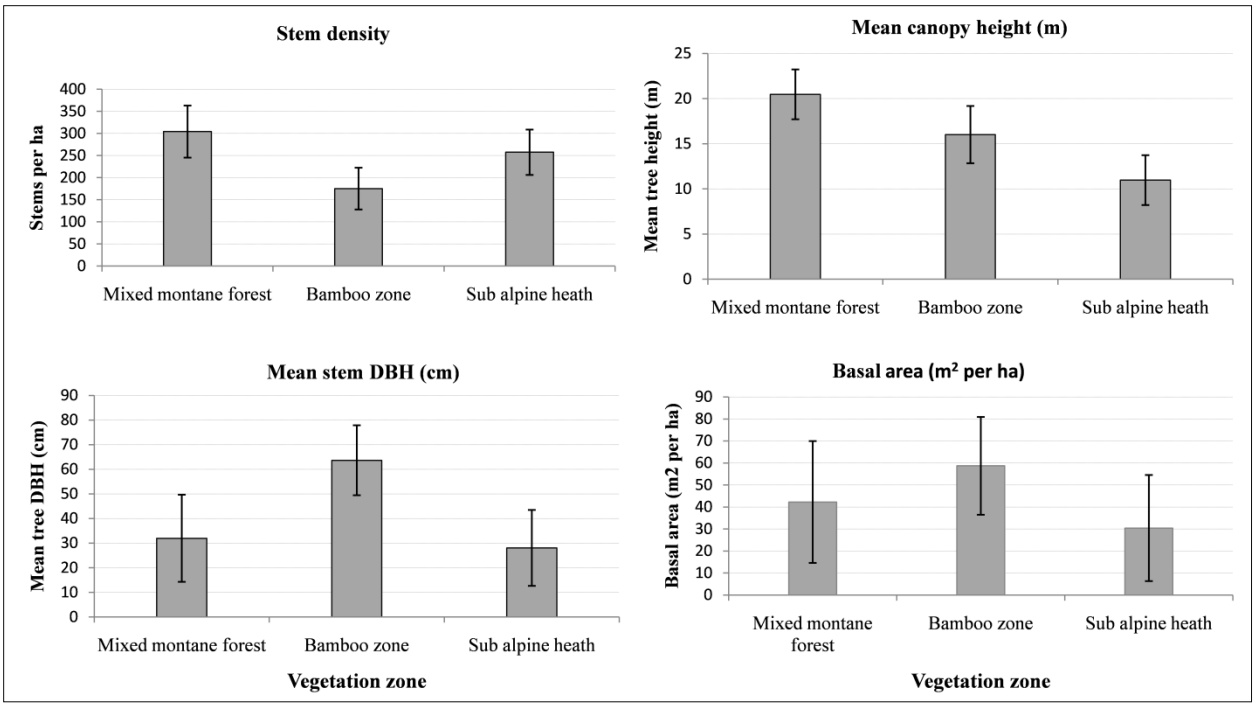


Figure 2: Stem density, mean DBH, mean canopy height and basal area of woody plants ≥ 10 cm in DBH in three vegetation zones of Mount Elgon Forest Ecosystem

2.3.3 Comparing floristic and structural composition under different management regimes

2.3.3.1 Species richness and diversity

Although the forest reserve, national park and areas occupied by indigenous forest dwelling communities in Sossio were all within the same forest ecosystem and were subjected to similar ecological conditions, the forest reserve had a higher species richness than the national park and areas dwelt by indigenous communities in Sossio (Table 6). Similarly, the forest reserve had significantly higher species diversity and species evenness than the national park and areas dwelt by indigenous communities (Table 6). Areas dwelt by indigenous communities had relatively higher species evenness than the national park.

Table 6: Analysis of species richness, species diversity and evenness in areas under different resource management regimes in Mount Elgon Forest Ecosystem

Forest area	**Species richness**	**Shannon index**	**Simpson index**
Forest reserve	93	$2.274 \pm 0.130_{b}$	$0.231 \pm 0.035_{b}$
National park	47	$0.719 \pm 0.129_{a}$	$0.024 \pm 0.002_{a}$
Sossio	39	$0.798 \pm 0.156_{a}$	$0.153 \pm 0.043_{ab}$
p value		0.009	0.032
l.s.d.		0.724	0.154

2.3.3.2 Woody species richness, stem density, DBH, canopy height and basal area

A comparison of woody species richness among different management regimes across respective vegetation zones indicated that the forest reserve and the national park had similar woody species

richness within the mixed montane forest. However, the forest reserve had a higher woody species richness than both the national park and areas occupied by indigenous forest dwelling communities within the bamboo zone (Table 7). The national park and areas dwelt by indigenous communities had similar woody species richness within the bamboo zone. In the sub-alpine heath forest, the forest reserve had higher woody species richness than areas dwelt by indigenous communities. The national park was largely devoid of trees in the sub-alpine heath.

There was a variation in stem density among the three forest management regimes. However, it was not statistically significant. The national park had a relatively higher stem density than the forest reserve within the mixed montane forest (Table 7). In the bamboo zone, the forest serve had a higher stem density than the both the national park and areas dwelt by indigenous forest communities. In the sub-alpine montane heath, the forest reserve had a higher stem density than areas dwelt by indigenous forest communities.

Trees in the forest reserve had relatively larger diameter than those of the national park within the mixed montane forest zone (Table 7). However, in the bamboo zone, trees in areas occupied by indigenous forest dwelling communities had significantly larger stem diameter than those of both the national park and the forest reserve. Trees of the national park had also larger stem diameter than those of the forest reserve. In the sub-alpine heath forest, trees in areas occupied by indigenous forest dwelling communities had relatively larger stem diameter than those of the forest reserve.

Among trees found in the mixed montane forest zone, those of the forest reserve were significantly taller than those found in the national park (Table 7). In bamboo zone, however, trees found in areas occupied by indigenous forest dwelling communities were relatively taller than those of the national park and the forest reserve. Those of the national park were relatively taller than those of the forest reserve. In the sub-alpine heath forest, trees found in areas occupied by indigenous forest dwelling communities were relatively taller than those of the forest reserve.

There was no significant variation in basal area among the three management regimes. However, the forest reserve had a relatively higher basal area than the national park within the mixed montane forest zone (Table 7). In the bamboo zone, trees in areas occupied by indigenous forest dwelling communities had relatively larger basal area than those in the national park and the forest reserve. Those in the national park also had relatively larger basal area than those in the forest reserve. Similarly, in the sub-alpine heath forest, trees in areas occupied by indigenous forest dwelling communities had relatively larger basal area than those in the forest reserve.

Table 7: A comparison of woody species richness, stem density, DBH, canopy height and basal area in areas under different forest management in Mount Elgon Forest Ecosystem

Ecological zone	Forest area	Woody species richness	Stems ha-1	Mean DBH (cm)	Canopy height (m)	Basal area (m^2 per ha)
Mixed montane forest	Forest reserve	12	89.3 ± 18.3 $_a$	46.0 ± 1.48 $_a$	30.7 ± 2.0 $_b$	18.1 ± 2.8 $_a$
	National park	12	125.7 ± 5.2 $_a$	32.4 ± 1.8 $_a$	19.5 ± 1.9 $_a$	13.1 ± 3.81 $_a$
Bamboo	Forest reserve	11	83.3 ± 25.5 $_a$	53.7±20.7 $_a$	15.0 ± 3.5 $_a$	21.2 ± 11.5 $_a$
	National park	7	78.1 ± 3.1 $_a$	77.0 ±38.8 $_a$	17.9 ± 1.6 $_a$	97.7 ± 84.9 $_a$
	Sossio	7	49.3 ± 0.7 $_a$	145.7 ± 48.2 $_b$	27.2 ± 3.1 $_a$	112.6 ± 55.1 $_a$
Sub-Alpine	Forest reserve	7	137.5 ± 28.2 $_a$	24.2 ± 5.3 $_a$	9.5 ± 1.9 $_a$	9.6 ± 4.5 $_a$
	National park	-	-	-	-	-
	Sossio	4	100 ± 1.0 $_a$	44.3 ± 7.7 $_a$	16.4 ± 3.2 $_a$	12.6 ± 3.8 $_a$

2.4 Discussion

2.4.1 Floristic composition

The vegetation of Mount Elgon Forest Ecosystem has been relatively well studied over the years, particularly in the period between 1930s (Bullock, 1933) and 1990s (Howard, 1991; Van Heist, 1994; Davenport et al., 1996). One common finding from these earlier studies, which the present assessment has confirmed is that the vegetation of the forest ecosystem is distributed in four discrete altitudinal zones, with largely distinct plant species associations. An interesting feature of these earlier vegetation studies is that they have reported different number of plant species from this forest ecosystem (Bakamwesiga et al., 2005). The most common number of plant taxa has been given as 400 species for the whole forest ecosystem, covering both the Ugandan and Kenyan sides of the ecosystem. This particular assessment recorded only 166 species of vascular plants. The assessment was carried out on the Kenyan side only and it entailed a rapid estimation of floral diversity in three out of the four vegetation zones of the forest ecosystem. Thus, the number of plant species recorded in this assessment is a fair representation of the floristic composition of the Kenyan part of the forest ecosystem. Moreover, a number of earlier studies derived their taxa from a compilation of collections carried out by different studies over several decades (Bakamwesiga et al., 2005).

Although this assessment confirms that the vegetation of Mount Elgon Forest Ecosystem is distributed in distinct altitudinal zones, some of the species associations that were reported by earlier studies appear to have changed over the past three decades. For instance, the woody species association of the mixed montane forest had been reported to comprise *Olea hochstetteri* and *Aningeria adolfi-friedericii* (Howard, 1991), buy this assessment found *Neoboutonia macrocalyx* and *Casearia battiscombei* as the most abundant woody species. *Ekebergia capensis*, *Aningeria adolfi-friedericii* and *Celtisafricana* were also represented in large numbers. This observation indicates that *Olea hochstetteri* is no longer a key species of this vegetation zone. The most likely cause of the variation in woody species associations in this vegetation zone is

heavy logging operations of the 1990s, which targeted members of the family Oleaceae. This finding suggests that the interactions between forest adjoining communities and forest resources over the past three decades may have caused changes in the floristic composition of this particular vegetation zone. There was no change, however, in plant species associations of the bamboo zone. The dominant species remained *Podocarpus spp* and *Arundinaria alpina.* Similarly, there was no change in woody species associations of the transition zone between the bamboo zone and the sub-alpine heath. As reported by earlier studies (Tweedie, 1975), the species association of the transition zone remained a dense mix of *Hagenia abyssinica* and *Juniperus procera*. In the sub-alpine montane heath, however, the herbaceous species associations appeared to have changed over time. Earlier studies reported tussock grasses such as *Agrostis gracilifolia* and *Festuca pilgeri*, herbs such as *Alchemilla*, *Helichrysum*, *Lobelia*, and the giant groundsels *Senecio barbatipes* and *Senecio elgonensis* as the dominant herbaceous life-forms (Howard, 1991). This particular assessment identified *Cyperus difformis, Cyperus kyllinga, Cyperus articulates* and *Digitaria scalarum* as the most abundant grasses, and *Alchemilla rothii, Oxalis comiculata* and *Satureja biflora* as the most common herbs in the sub-alpine heath. The most likely cause of change in herbaceous species association in this vegetation zone is heavy grazing by livestock from indigenous forest-dwelling communities.

2.4.2 Forest conservation status and species diversity

The Shannon diversity indices of this forest ecosystem have brought out an interesting scenario regarding the relationship between forest conservation status and species diversity. For instance, the national park, which has not suffered as much anthropogenic disturbance as the forest reserve, had a lower Shannon diversity index than the forest reserve and indigenous forest dwelling community areas, such as Sossio. The scenario supports the intermediate disturbance hypothesis (Wilson, 1994), which states that lack of site disturbance, the case in the national park, leads to a lower species diversity because plant species that are favoured by prevailing environment conditions tend to dominate and outcompete the less favoured ones. This makes the less favoured species vulnerable to competitive exclusion. Similarly, high levels of disturbance, like the case in areas occupied by forest dwelling communities, leads to the elimination of less favoured species hence lowering species richness. Moderate disturbance, the case in the forest reserve, leads to a situation whether both environmentally dominant species and rare taxa get a chance to establish. This perhaps explains why the forest reserve, which was moderately disturbed, had higher species diversity.

2.4.3 Stand structure

The stem density of the mixed montane forest of this forest ecosystem was relatively lower than the case in most moist tropical forests. The stem densities of the bamboo zone and the sub-alpine montane heath were, however, within the expected range given that tree growth in these vegetation zones tends to be affected by low temperatures and permafrost in the upper zone of the sub-alpine heath. Low stem density of the mixed montane forest was perhaps caused by enormous levels of logging over the past three decades without significant natural forest regrowth. The mean stem DBH, mean canopy height and basal area of the trees of this forest ecosystem were also relatively lower than expected, further suggesting that past logging operations may have affected the forest's structural outlook. For instance, it was interesting to note that the mean DBH, mean canopy height and basal area of trees in the sub-alpine zone were not significantly different from those of trees in the mixed montane forest and yet the former

generally tends to have trees of smaller stature and while the latter normally has large forest trees. The mean stem DBH, mean canopy height and basal area of the sub-alpine zone were, however, within the expected range for sub-alpine heath forest in moist tropical forests.

2.4.4 Floral and structural composition in the forest reserve and national park

The two management zones were located within the same ecological zones, namely: mixed montane forest, bamboo zone and sub-alpine heath forest. The forest reserve had higher species diversity than the national park. The stem density and basal area of the two management zones were no significantly different, but trees of the forest reserve were taller than those of the national park. The results show that the forest serve, which was under controlled resource utilization, appeared degraded but it still had a higher floral diversity than the national park, which was under exclusive resource conservation. This suggests a possible case of overstocking of herbivores within the national park, whose net effect may have been similar to over-exploitation of resources in the forest reserve. The observation indicates that exclusive resource conservation in a national park, if not supported by adequate stocking levels of wildlife, may be quite similar to unsustainable resource extraction in a forest reserve.

Conclusion

Woody species associations of the mixed montane forest of Mount Elgon Forest Ecosystem have changed over the past three decades. Current species associations comprise largely intermediate successional species, such as *Neoboutonia macrocalyx* and *Casearia battiscombei*. The situation is suspected to have been caused by heavy logging operations that occurred in 1990s, which removed most of the formerly dominant *Olea hochstetteri* and *Aningeria adolfi-friedericii*. The herbaceous species associations of the sub-alpine montane heath also changed over the same period. The most likely cause of this change is heavy grazing by livestock from indigenous forest-dwelling communities. However, the species of associations of the bamboo zone and the mixed dense vegetation in the transition zone between the bamboo zone and the sub-alpine heath did not change. As a result of heavy logging in the mixed montane forest, its stem density and basal area decreased to an extent that they were not significantly higher than those of the bamboo zone and the sub-alpine heath anymore. There was a possible case of overstocking of wildlife in the national park, which led to habitat degradation. The park had lower species diversity than the forest reserve and yet it was protected from resource exploitation, while the latter was exposed to all manner of resource exploitation. Overall, the forest ecosystem has retained most of its floral composition, but lost a great deal of its structural outlook due to unsustainable resource off-take levels.

References

Bakamwesiga H, Masinde S, Muasya M, Mwachala G, Muthoka P and Malombe I (2005). Flora of Mount Elgon Ecosystem. In MUIENR and NMK, Baseline survey of the biodiversity resources of Mount Elgon ecosystem. Mount Elgon Regional Ecosystem Conservation Project (MERECP)

Bullock AA (1933). The flora of Mt. Elgon. Bulletin of Miscellaneous Information, Royal Botanic Gardens, Kew, 1933 (2): 49-106.

Davenport T, Howard P, and Dickinson C (eds) (1996). Mt. Elgon National Park Biodiversity Report. Forest Department, Kampala.

Howard PC (1991). Nature Conservation in Uganda's Tropical Reserves. Forest Department, Ministry of Environment Protection Uganda.

Hinchley D (2003). Assessment of experience gained in collaborative management of a protected area: Mount Elgon National Park, Uganda. Mount Elgon Conservation and Development Project, Uganda.

MUIENR and NMK (2005). Baseline survey of the biodiversity resources of Mount Elgon ecosystem. Mount Elgon Regional Ecosystem Conservation Project (MERECP)

Mwaura A (2011). Mt Elgon Transboundary Ecosystem. Western Conservation Area, KWS, Kenya.

Petursson JG, Vedeld P and Kaboggoza J (2006). Transboundary biodiversity management challenges: The Case of Mt. Elgon, Uganda and Kenya.

Scott PJ (1994). Assessment of natural resource use by communities from Mount Elgon National Park. Technical Report No. 15. Mount Elgon Conservation and Development Project, Ministry of Natural Resources, Uganda.

Tweedie EM. (1975). Habitats and checklist of plants on the Kenya side of Mt Elgon. *Kew Bulletin* 31: 227-246.

Van Heist M (1994). Land Unit Map of Mount Elgon National Park. IUCN Technical Report, Uganda.

Wilson JB (1994). The intermediate disturbance hypothesis of species coexistence is based on patch dynamics. New Zealand Journal of Ecology 18 (2): 176-181.

Plant species checklist for the mixed montane forest, bamboo zone and the sub-alpine montane heath of Mount Elgon Forest Ecosystem (Kenyan side)

No	**Botanical name**	**Plant Form**	**Family**
1	*Acacia lahai*	Tree	Mimosaceae
2	*Acanthus eminens*	Shrub	Acanthaceae
3	*Acanthus pubescens*	Shrub	Acanthaceae
4	*Achyranthusaspera*	Herb	Amarathaceae
5	*Adropogongayanus*	Grass	Graminae
6	*Afrocraniavolkensii*	Tree	Cornaceae
7	*Ageratum conyzoides*	Herb	Compositae
8	*Agrocharis incognita*	Herb	Umbelliferaceae

9	*Albiziagummifera*	Tree	Mimosaceae
10	*Aningeriaadolfi-friedericii*	Tree	Sapotaceae
11	*Aristridamutabilis*	Grass	Graminae
12	*Artemisia afra*	Shrub	Compositae
13	*Basella alba*	Climber	Basellaceae
14	*Bersamaabyssinica*	Tree	Melianthaceae
15	*Bidenspilosa*	Herb	Compositae
16	*Buddleia polystachya*	Shrub	Loganiaceae
17	*Casearіabattiscombei*	Tree	Flacourticeae
18	*Cassipoureamalosana*	Tree	Rhizophoraceae
19	*Celtisafricana*	Tree	Ulmaceae
20	*Centellaasiatica*	Herb	Umbeliaceae
21	*Cestrum aurantiacum*	Shrub	Solanaceae
22	*Chlorophytumspp*	Herb	Liliaceae
23	*Cissampelospareira*	Climber	Memispermaceae
24	*Clerodendrumjohstonii*	Shrub	Verbenaceae
25	*Clutiaabyssinica*	Shrub	Euphorbiaceae
26	*Commelinabenghalensis*	Herb	Commelinaceae
27	*Conyza floribunda*	Herb	Compositae
28	*Crassocephalummontuosum*	Herb	Compositae
29	*Crassocephalumvitellinum*	Herb	Compositae
30	*Crotalaria agatiflora*	Shrub	Papilionaceae
31	*Croton microstachyus*	Tree	Euphorbiaceae
32	*Cyatheamanniana*	Fern	Cyatheaceae
33	*Cyathulapolycephala*	Herb	Amaranthaceae
34	*Cynodondactylon*	Grass	Graminae
35	*Cyperus articulates*	Grass	Cyperaceae
36	*Cyperusdifformis*	Grass	Cyperaceae
37	*Cyperuskyllinga*	Grass	Cyperaceae
38	*Cyphostemmamaranguense*	Climber	Vitaceae
39	*Digitariascalarum*	Grass	Graminae
40	*Diospyrosabyssinica*	Tree	Ebenaceae
41	*Dombeyagoetzenii*	Tree	Sterculiaceae
42	*Dovyalisabyssinica*	Shrub	Flacourtiaceae
43	*Drypetesgerrandii*	Tree	Euphorbiaceae
44	*Ehretiacymosa*	Tree	Boraginaceae
45	*Ekebergiacapensis*	Tree	Meliaceae
46	*Erica arborea*	Shrub	Ericaceae
47	*Eucleadivinorum*	Tree	Ebenaceae
48	*Euphorbia granulata*	Herb	Euphorbiaceae
49	*Euphorbia obovolifolia*	Tree	Euphorbiaceae
50	*Fagaropsisangolensis*	Tree	Rutaceae
51	*Faureaspp*	Tree	Myrtaceae
52	*Ficusthonningii*	Tree	Moraceae

53	*Galinsogaparviflora*	Herb	Compositae
54	*Glycine wightii*	Climber	Papilionaceae
55	*Hageniaabyssinica*	Tree	Rosaceae
56	*Hallerialucida*	Tree	Scrophulariaceae
57	*Helichrysumodoratissimum*	Shrub	Compositae
58	*Hibiscus calyphyllus*	Shrub	Malvaceae
59	*Hibiscus fuscus*	Shrub	Malvaceae
60	*Hyparrheniarufa*	Grass	Graminae
61	*Hypericumkeniense*	Tree	Guttiferae
62	*Hypoestesforskhalii*	Herb	Acanthaceae
63	*Impatiens pseudoviola*	Herb	Balsaminaceae
64	*Indigoferaerrecta*	Shrub	Papilionaceae
65	*Juniperusprocera*	Tree	Cupressaceae
66	*Justiciaflava*	Herb	Acanthaceae
67	*Kalanchoedensiflora*	Herb	Crassulaceae
68	*Leonotismollisima*	Shrub	Labiatae
69	*Macarangakilimandscharica*	Tree	Euphorbiaceae
70	*Microglosapyrifolia*	Shrub	Compositae
71	*Mimulopsisalpina*	Shrub	Acanthaceae
72	*Neoboutoniamacrocalyx*	Tree	Euphorbiaceae
73	*Nuxiacongesta*	Tree	Loganiaceae
74	*Oleacapensis*	Tree	Oleaceae
75	*Oleaeuropeasubspcaudata*	Tree	Oleaceae
76	*Oplesmenushirtelus*	Grass	Graminae
77	*Oxalis comiculata*	Herb	Oxalidaceae
78	*Phillipiakeniensis*	Shrub	Ericaceae
79	*Plectranthusluteus*	Shrub	Labiatae
80	*Plectrunthusbarbartus*	Shrub	Labiatae
81	*Podocarpusfalcatus*	Tree	Podocarpaceae
82	*Podocarpuslatifolius*	Tree	Podocarpaceae
83	*Polygonumsenegalense*	Herb	Polygonaceae
84	*Prunus Africana*	Tree	Rosaceae
85	*Rapaneamelanophloeos*	Tree	Myrsinaceae
86	*Rhamnusprinoides*	Shrub	Rhamnaceae
87	*Rubusapetalus*	Shrub	Rosaceae
88	*Rubussteudneri*	Shrub	Rosaceae
89	*Sambucusafricana*	Shrub	Caprifoliaceae
90	*Saturejabiflora*	Shrub	Labiatae
91	*Scheffleraabyssinica*	Tree	Araliaceae
92	*Scutiamyrtina*	Shrub	Rhamnaceae
93	*Senecioalgonensis*	Climber	Asteraceae
94	*Seneciohandensis*	Climber	Asteraceae
95	*Seneciomanii*	Shrub	Compositae
96	*Setariaplicatilis*	Grass	Graminae

97	*Solanumincanum*	Shrub	Solanaceae
98	*Solanumindicum*	Shrub	Solanaceae
99	*Solanumspp*	Shrub	Solanaceae
100	*Spilanthus Mauritania*	Herb	Compositae
101	*Sporoboluspyramidalis*	Grass	Graminae
102	*Stephaniaabyssinica*	Climber	Menispermaceae
103	*Symphytumofficinale*	Herb	Boraginaceae
104	*Tagetesminuta*	Herb	Compositae
105	*Tecleanobilis*	Tree/Shrub	Rutaceae
106	*Tephrosiauniflora*	Herb	Asteraceae
107	*Trichocladusellipticus*	Tree	Hamamelidaceae
108	*Urticamassaica*	Shrub	Urticaceae
109	*Ushaniaalpina*	Grass	Graminae
110	*Vernoniabrachycalyx*	Shrub	Compositae
111	*Vernoniagalamensis*	Herb	Compositae
112	*Vernonialasiopus*	Shrub	Compositae
113	*Vernoniaspp*	Shrub	Compositae
114	*Warburgiaugandensis*	Tree	Canellaceae
115	*Xymalosmonospora*	Tree	Monimiaceae
116	*Zehneriascabra*	Climber	Cucurbitaceae

CHAPTER THREE

DISTRIBUTION OF HERPETOFAUNA ACROSS VEGETATION ZONES OF MT ELGON FOREST ECOSYSTEM

By

Domnick Victor Wasonga and John Opiyo

Abstract

There are information gaps on the effect forest degradation on the distribution and abundance of reptiles and amphibians in Mt Elgon Forest Ecosystem. A study of reptiles and amphibians of the forest ecosystem was conducted with a view to determine their distribution and abundance across vegetation types. The vegetation types included mixed montane forest, bamboo zone and sub-alpine heath. The methods used included time-limited searches, pitfall trapping and opportunistic sampling. A total of 10 species including three amphibians and seven reptiles were recorded. Species richness declined from mixed montane forest to the bamboo and sub-alpine heath. Anthropogenic influence had a negative effect on species abundance. Degraded forest sites tended to have fewer populations of reptiles and amphibians than intact zones. The study suggests that degradation of herpetofaunal habitats poses a serious conservation challenge for reptiles and amphibians in this forest ecosystem.

3.1 Introduction

The forests of East Africa are generally thought to consist of two non-overlapping herpetofauna (Vonesh, 2001). These include the twin assemblages of an eastern extension of the Congo-Guinean forest block stretching from Cameroon to western Kenya and the Eastern Arc Mountains and the East African coastal forests. Despite pressures such as human population increase leading to forest loss as demand for agricultural land increases, detailed studies of these globally biodiversity hotspots have only progressed slowly in the last few decades. However, this knowledge is increasingly becoming important as an integral part of Kenya's rich biodiversity.
Anecdotal reports indicate that the remnant forests of East Africa are important refuges for reptiles and amphibians. Howell (1993) reviewed the Eastern Arc fauna fairly recently, but few studies have examined the herpetofauna of the Congolean block associated forests in East Africa since Loveridge (1935, 1942a, 1942b, 1957). These eastern relicts include the transboundary Mt. Elgon ecosystem and Kakamega Forest in Kenya, besides Budongo, Bwamba, Kibale, Bwindi and Mabira in Uganda. Some of the recent attempts to address this gap the herpetofauna of Bwindi in southwestern Uganda and Kakamega Forest have been inventoried (Drewes and Vindum, 1994; Lötters et al., 2007; Wagner et al, 2008).

In this report the herpetofaunal diversity in four distinct eco-climatic zones is examined in Mt Elgon ecosystem. Mt Elgon is one of the five major water towers in Kenya and a listed Important Bird Area (IBA). Despite this no comprehensive herpetofaunal work has ever been done. It is against this background the present study was initiated as part of a broader biodiversity assessment. This study aimed to determine the distribution and influence of vegetation on

herpetofauna assemblages. It was predicted that there is change in amphibian and reptile composition along the eco-climatic zones.

3.2 Methods

Sampling of amphibians and reptiles was carried out for a period of 12 days from 4th – 16th May 2017. A stratified approach based on four eco-climatic zones in Mt Elgon was used in selecting sampling locations namely: natural forest, bamboo, sub-alpine and alpine zones. In each zone, systematic searches were carried out along each transect by a team of two researchers walking at a speed of 1 km/hr. Time limited searches (TLS) as described by Karns (1986), Heyer et al. (1994) and Sutherland (1996) was used. All possible amphibian and reptile microhabitats such as wetlands, under leaves debris, on trees, decomposing tree stumps and logs were intensively searched for one man hour per sample. To supplement the search efforts, trapping with pitfalls along drift fences was employed: X-shaped drift fence/pitfall trap arrays (Corn, 1994) with segments of 5m length were used. The pitfall traps consisted of 5 litre plastic buckets flush with the ground; with a total of five (5) buckets in every trap station. Traps were set for three days (trap nights). Checking was done once every morning not later than 0830h. Night sampling was also carried out mainly targeted at amphibians and other nocturnal herpetofauna at suitable wetlands in Kaberwa area. This lasted approximately two hours between 18.00 – 20.00 hrs.

Additional data was obtained from opportunistic observations from areas outside prescribed sampling protocols. Species were identified according to Channing and Howell, 2006 (amphibians) and Spawls et al, 2002 (reptiles). For each animal observed, we recorded the identity, counted the number of individuals and noted the habitat. Where necessary, voucher specimens were euthanized and deposited at the National Museums of Kenya.
Data was analyzed using EstimateS 9.1.0 statistical software. Using 100 randomized runs, species richness in each sampling block was calculated based on ICE (Incidence-based Coverage or presence-absence estimator).

3.3 Results

A total of 10 species including three amphibians and seven reptiles were observed in Mt Elgon in May 2017 (Table 1). The natural forest had the highest species richness (six species) followed by bamboo (three species). The lowest species richness was recorded in the sub-alpine and alpine zones with two species each. Grauer's puddle frogs were the most abundant within the natural forest. On the other hand, one of the rare species was the Alpine lizard with only a single individual documented in the meadow grassland. Other species which were only recorded in singletons were Montane side-striped chameleon, Jackson's forest lizard and Striped skink. Some of the species documented from Mt Elgon are shown in Figure 2.

One of the general characteristics of ecological communities is that the number of species accumulates with increasing area sampled. In the present study, the sampling appeared rather incomplete across all the sampling blocks. None of the species curves reached asymptote as would be expected in a complete inventory (Figure 1A–D). This trend remained unchanged even when data from all the four sampling blocks were pooled together (Figure 1E).

Table 1. Observed number of species in Mt Elgon in May 2017

Species	**Eco-Climatic Zone**				**Species Abundance**
	Forest	Bamboo	Subalpine	Alpine	
Phrynobatrachus graueri	27	0	0	0	**27**
Amietia nutti	12	5	0	0	**17**
Trioceros hoehnelii	6	0	0	0	**6**
Trioceros ellioti	1	0	0	0	**1**
Philithamnus battersbyi	1	0	0	0	**1**
Adolfus jacksoni	1	0	0	0	**1**
Trachylepis striata	0	12	1	0	**13**
Xenopus borealis	0	10	0	0	**10**
Trachylepis varia	0	0	8	11	**19**
Adolfus masavensis	0	0	0	1	**1**
Species Richness	**6**	**3**	**2**	**2**	**10**

3.4 Discussion

Reptiles and amphibians are highly secretive, making their detection rate generally slow and unpredictable. It has also been documented that some species can go for long periods without food under aestivation (Spawls et. al., 2002). One of the key factors that influence detectability of herpetofauna is seasonal variation; for instance, amphibians are considered more abundant during the rainy season. Therefore, a complete species inventory for a given site is usually based on long-term studies. In Mt Elgon, the available literature indicates that there are about 58 species including 40 reptiles and 14 amphibians (e.g. National Museums of Kenya & Makerere University, 2004; Lötters et al 2006). A compilation of the current checklist is presented in Appendix 1. This reveals that the data obtained in the current assessment is under-representative of the expected herpetofauna of Mt Elgon.

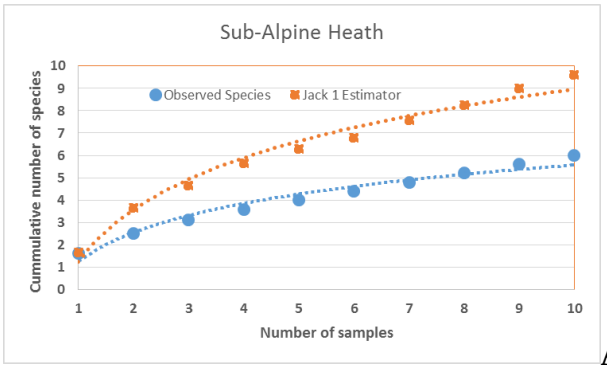
Species turnover along habitat and/or altitudinal gradients is a research area gaining momentum in Eastern Africa and elsewhere. A recent study in Taita Hills documented an inverse relationship between herpetofauna diversity and abundance and elevation Kenya (Malonza & Veith, 2011).A study of birds of the eastern Arc Mountains in Tanzania revealed a clear distinction between lowland and montane assemblages (Romdal & Rahbek, 2008). However, a study of the amphibian fauna of Monts Doudou in Gabon only revealed moderate evidence of altitudinal effects (Burger et al 2004).In yet another study in Mt Kenya, a clear ecological separation of some species was supported even though no clear species richness pattern emerged (Malonza, 2015). In the present study, only six species were documented in the sub-alpine heath eco-climatic zone compared to 46 in the mixed montane forest. Some species, e.g. the Genus *Adolfus*, tend to show a distinct ecological separation from the mixed montane forest to the sub-alpine alpine zone. *Adolfus jacksonii* was documented within the mixed montane forest (2,372m a.s.l.) while *Adolfus masavensis* was restricted to the sub-alpine zone (about 3,372 m a.s.l.). Even though the current data was not sufficient to determine any elevational correlation, species richness was higher in the natural forest (2,086–2,270m a.s.l.) but decreased towards the sub-

alpine and alpine eco-climatic zones (2,922–3,406m a.s.l.). This is perhaps due to the general limitations of behavioural thermo-regulation mechanisms of herpepetofauna species.

There are other factors that, either positively or negatively, influence the distribution and abundance of herpetofauna. Anthropogenic activities such as cattle grazing, charcoal burning, logging, cultivation, wild fires and land clearing for settlement are considered threats to the conservation and management of reptiles and amphibians. Most of these threats were documented in Kaberwa and Sosio forest blocks of Mt Elgon. Mt Elgon National Park (not adequately sampled in the current study) could perhaps offer the best comparative data to determine the effects of these activities. Illegal off-take of reptile and amphibian species for trade e.g. Central African Rock Python also pose serious conservation threats.

Mt Elgon Torrent Frog and other expected species

Based on literature, there are additional four species that were expected but not revealed in the present study. These include Mt Elgon montane torrent frog (*Arthroleptides dutoiti*) Newmann's Terrapin (*Pelomedusa neumanni*) Lionate blind snake (*Afrotyphlops lineolatus*) and Gold's tree cobra (*Pseudohaje goldi*). In particular, the status of the stream dwelling Mt Elgon montane torrent frog which was last documented in 1960s has remained highly uncertain, despite targeted efforts from 2001–2017.It is not clear whether this is due to deterioration of the stream habitats, inaccessibility or poor timing.



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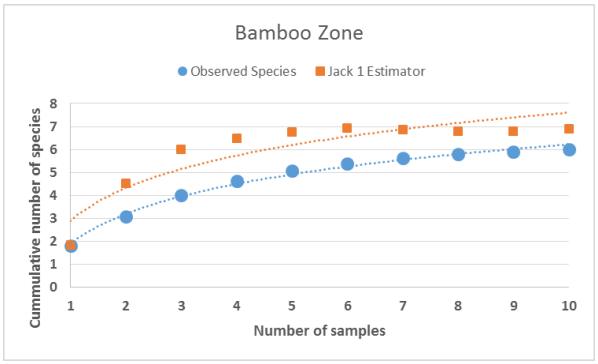

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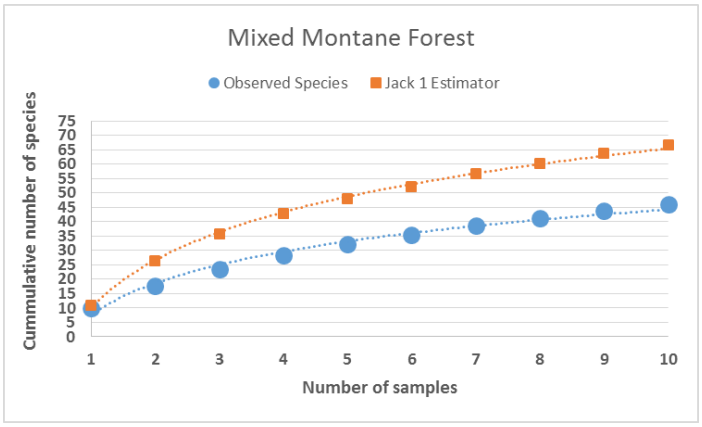

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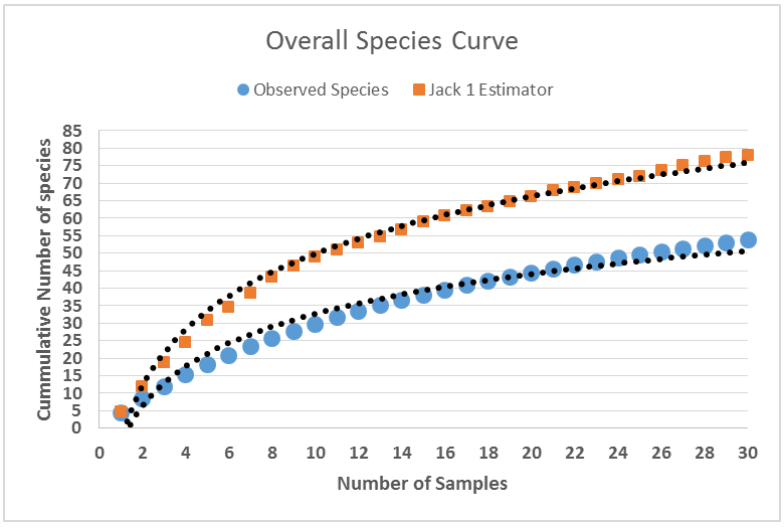


D

Figure 1: Species accumulation curves for reptiles and amphibians for A) Sub-alpine Heath, B) Bamboo zone, C) Mixed montane forest and D) Pooled data for all the three eco-climatic zones in Mt Elgon

Nutt's river frog

Northern clawed frog

Variable skink

Von Hoehnell's chamaeleon

Battersbyi's green snake

White-lipped snake

Figure 2: Some amphibians and reptiles of My Elgon ecosystem

Conclusion and Recommendations

There is indication that an ecological separation of the herpetofaunal assemblages along eco-climatic zones of Mt Elgon exist. The ecosystem generally supports a high diversity of reptiles

and amphibians. However, human encroachment is posing a major threat to key habitats like wetlands and forests which could result in local extintions of some species.

References

Burger, M., Branch, W. R., & Channing, A. (2004). Amphibians and reptiles of Monts Doudou, Gabon: species turnover along an elevational gradient. *Memoirs of the California Academy of Sciences*, 28, 145-186.

Channing, A., & Howell, K. (2006). Amphibians of east Africa. Comstock Pub. Associates/Cornell University Press.

Corn, P.S. 1994. Straight-line drift fences and pitfall traps. In: Heyer, W.R., Donnelly, M.A., Diarmid, M.R.W., Hayek, L.-A.C., Foster, M.S. (Eds.), Measuring and monitoring biological diversity: Standard methods for amphibians. Smithsonian Institution Press, Washington D.C., pp.109-117

Heyer, W.R., Donnelly, M.A., Diarmid, M.R.W., Hayek, L.-A. C., & Foster, M.S. (Eds.) 1994. Measuring and monitoring biological diversity: Standard methods for amphibians. Smithsonian Institution Press, Washington D.C.

Karns, D.R., 1986. Field Herpetology: Methods for the study of amphibians and reptiles in Minnesota, James Ford Bell Museum of Natural History, University of Minnesota, Occasional Paper: No. 18 September.

Lötters, S., Rotich, D., Koester, T.E., Muchai, V., Scheelke, K., Schick, S., Teege, P., Wasonga, D.V. and Veith, M. (2006). What do we know about the amphibians from the Kenyan central and western highlands? A faunistic and taxonomic review. *Salamandra*. 42: 165 – 179.

Loveridge, A. (1935). Scientific results of an expedition to rain forest regions in East Africa. I New reptiles. *Bull. Mus. Comp. Zool*.79:1 19

Loveridge, A. (1942a). Scientific results of a fourth expedition to forested areas in East and Central Africa. IV. Reptiles. *Bull. Mus. Comp. Zool*. 91:231 – 373

Loveridge, A. (1942b). Scientific results of a fourth expedition to forested areas in East and Central Africa. IV. Amphibians. *Bull. Mus. Comp*. Zool. 91: 377 – 436

Loveridge, A. (1957). Checklist of reptiles and Amphibians of East Africa (Uganda, Kenya, Tanzania, Zanzibar) Bull. Mus.Comp. Zool. 117: 153 – 362.

Malonza, P. K. (2015). Patterns of reptile and amphibian species richness along elevational gradients in Mt. Kenya. *Zoological Research*, 36(6), 342.

Malonza, P. K., & Veith, M. (2011). Amphibian community along elevational and habitat disturbance gradients in the Taita Hills, Kenya. *Herpetotropicos*, 7(1).

National Museums of Kenya & Makerere University (2004). Baseline biodiversity assessment of Mt Elgon Regional Conservation Ecosystem (MERECP). Technical Report.

Romdal, T. S., & Rahbek, C. (2009). Elevational zonation of afrotropical forest bird communities along a homogeneous forest gradient. *Journal of Biogeography*, 36(2), 327-336.

S Lotters, P Wagner, BA Bwong, S Schick, PK Malonza, V Muchai, DV Wasonga, & M Veith (2007). A field guide to the amphibians and reptiles of Kakamaga Forest – Kielezo cha amfibia na reptilia wanaopatikana Msitu wa Kakamega - Nairobi and Mainz (National Museums of Kenya and University of Mainz, 112 pp

Spawls, S., Howell, K. Drewes, R. C. & Ashe, J. (2002). Field guide to the reptiles of East Africa. Academic.

Sutherland, W.J. (ED.) 1996. Ecological Census Techniques: A handbook. Cambridge University Press.
Wagner, P., Köhler, J., Schmitz, A., & Böhme, W. (2008). The biogeographical assignment of a west Kenyan rain forest remnant: further evidence from analysis of its reptile fauna. Journal of biogeography, 35(8), 1349-1361.

Appendix 1. List of reptiles and amphibians of Mt. Elgon ecosystem (list includes species from earlier studies)

(a) Tortoises and terrapins

	Common name	**Scientific name**
	Leopard tortoise	*Stigmochelys pardalis*
	Bell's hinged tortoise	*Kinixys belliana*

(b) Lizards

	Common name	**Scientific name**
	Tropical house gecko	*Hemidactylus mabouia*
	Mt Elgon forest gecko	*Cnemaspis elgonensis*
	Elgon forest gecko	*Cnemaspis elgonensis*
	Kenya Dwarf Gecko	*Lygodactylus keniensis*
	Striped skink	*Trachylepis striata*
	Five-lined skink	*Trachylepis quinquetaeniata*
	Alpine meadow skink	*Trachylepis irregularis*
.	Variable skink	*Trachylepis varia*
.	Alpine lizard	*Adolfus masavaensis*
.	Jackson's forest lizard	*Adolfus jacksoni*
.	Peter's writhing skink	*Mochlus afer*
.	Blue-headed tree agama	*Acanthocerus atricollis*
.	Red-headed rock agama	*Agama lionotus*
.	Montane side stripped Chameleon	*Chamaeleo ellioti*
.	Von Höhnel's chameleon	*Chamaeleo hoehnelii*

(c) Snakes

	Common name	**Scientific name**
.	Central African rock python	*Python sebae*
.	Cape file snake	*Ginionotophis capensis*
.	Battersby's green snake	*Philothamnus battersbyi*
.	Jackson's tree snake	*Thrasops jacksoni*
.	South-Eastern Green snake	*Philothamnus hoplogaster*
.	Northern stripe-bellied sand snake	*Psammophis sudanensis*
.	Olive sand snake	*Psammophis mosambicus*
.	White lipped snake	*Crotaphopeltis hotamboea*
.	Boomslang	*Dyspholidus typus*
.	Common house snake	*Boaedon fuliginosus*
.	Common egg eater	*Dasypeltis scabra*
.	Montane egg eater	*Dasypeltis atra*
.	Cape wolf snake	*Lycophidion capense*
.	Forest wolf snake	*Lycophidion ornatum*
.	East African garter snake	*Elapsoidea loveridgei*
.	Forest cobra	*Naja melanoleuca*

.	Black necked spitting cobra	*Naja nigricollis*
.	Black mamba	*Dendaspis polylepis*
.	Puff adder	*Bitis arietans*
.	Large eyed green tree snake	*Rhamnophis aethiopissa*

(d) Amphibians

	Common name	**Scientific name**
.	Kisolo toad	*Sclerophrys kisoloensis*
.	Common toad	*Sclerophrys gutturalis*
.	Kerinyaga toad	*Sclerophrys kerinyagae*
.	Kenya smooth clawed frog	*Xenopus borealis*
.	Lake Victoria clawed frog	*Xenopus victorianus*
.	Common Mascarene ridged frog	*Ptychadena mascareniensis*
.	Anchieta's savanna ridged frog	*Ptychadena anchietae*
.	Small Ridged Frog	*Ptychadena taenioscelis*
.	Nutt’s river frog	*Amietia nutti*
.	De Witte's River Frog	*Amietia wittei*
.	Grauer's western puddle frog	*Phrynobatrachus graueri*
.	Upland puddle frog	*Phrynobatrachus keniensis*
.	Schefler’s puddle frog	*Phrynobatrachus schefleri*
.	Variable spotted green reed frog	*Hyperolius viridiflavus*
.	Lake Kivu reed frog	*Hyperolius kivuensis*
.	Spiny reed frog	*Afrixalus quadrivittatus*
.	Senegal bubbling kassina	*Kassina senegalensis*

CHAPTER FOUR

BIRD SPECIES OF MOUNT ELGON FOREST ECOSYSTEM

By

Leonard Muhanga

Abstract

Most of Kenya's montane forests have received little attention regarding studies on the diversity and abundance of their bird species. We studied the population and abundance of avifauna species of Mount Elgon Forest Ecosystem. Given the preference of different bird species for specific ecological zones, the ecosystem was subdivided into various strata, namely: open montane forest, dense montane forest, bamboo zone, sub-alpine heath and cultivation areas. The study employed the common bird monitoring approach, which comprised use of line transects and point counts within the strata. Birds were identified using the Dale Zimmerman's Bird Guide book and radio call-back using preinstalled voice recognition software, which uses songs and calls of birds. A total of 211 bird species were recorded. Seven of these species require special attention – three are Red List category (per IUCN red data list) while four are Range Restricted, low populations and lack sufficient information at the local and national level. Of the recorded bird species 87 were habitat generalists, while 112 were habitat specialists. A further 9 species rely on the moist moorland vegetation especially for breeding. Specifically, 96 Forest Dependant species (FF) were recorded while 115 are either Forest Generalist (F) or Forest Visitors (f). The dense montane forest had 66 bird species within the national park, which was the highest number in all the four vegetation zones. The dense montane forest had 50 bird species within the forest reserve. The open montane forest, which was located largely in the forest reserve, had 20 species of birds. The bamboo zone had 50 species of birds within the national park and 15 species within the forest reserve. There was no significant difference in the bird population between the forest reserve and the national park within the sub-alpine heath. The Sub-Alpine vegetation zone had 49 bird species. The results suggest that the national park had relatively more bird species than the forest reserve, most of which were habitat specialists. This was perhaps caused by lack of external interference to bird habitats inside the national park. Up to 31 bird species that we expected to record during this study were missing. We suspect that most of these may have emigrated from the forest ecosystem due to forest degradation. Findings of the study suggest that habitat destruction is causing loss bird species in this forest ecosystem.

Key words: *Important Bird Areas, sustainable natural resource management, biodiversity monitoring, conservation interventions, assessment of change*

4.1 Introduction

This is a report of the biodiversity monitoring survey that was conducted in Mt. Elgon forest ecosystem from 4th to 16th May 2017. There are few references in literature about the abundance and population density of birds in Mt. Elgon forest ecosystem. Therefore, very little is known about the quantitative bird populations in this interesting montane forest. This report provides the

first overview of the populations and the composition of bird species. The report introduces the overall region and provides a description of the five subareas that were surveyed. The surveyed subareas represent typical sections of the native forest. They are considered a partial representation of the overall area and are sufficient in making a projection about bird population in the region in general. The only area that was left out was Cheptais due to insecurity concerns.

Mount Elgon Forest Ecosystem

Mount Elgon is located approximately 470 kilometers from Nairobi, 140 km north-east of Lake Victoria and bisected by the Uganda-Kenya border. The Mt. Elgon ecosystem lies between 2,100m and 4,280m above sea level. At 4000km² Mt. Elgon has the largest volcanic base in the world. Located on the Uganda-Kenya border it is also the oldest and largest solitary, volcanic mountain in East Africa. It's vast form (80km in diameter), rises more than 3000m above the surrounding plains. The mountain's cool heights offer respite from the hot plains below, with the higher altitudes providing a refuge for flora and fauna.

Bird surveys in Mt. Elgon

What are bird surveys and why do we need them? If we need a reliable estimate or index of the population size of a particular species in a given area, then we must undertake a survey. There may be a number of reasons for wishing to do this. It may simply be that, as the managers or stakeholders of a protected area, we wish to know how many individuals of a particular species of bird are present, or we may need baseline information for an area, or a species, that is poorly known. If repeated at regular intervals, the counts allow us to track changes in bird populations. Alternatively, it may be because a piece of land is being developed (e.g. turned into an industrial area) and we need to undertake an assessment of the likely impact of the development on the nature conservation value of the land.

Frequently, bird survey data are used to assess whether a piece of land should receive legal protection from governments and their agencies; such designations are important to conservation because they are intended to constrain potentially damaging activities. Information on population sizes of individual species can also be used to set priorities, allowing conservation effort to be focused on those species most in need of attention.

In general, smaller population size is associated with greater risk of extinction locally, regionally, or globally. Such information is collected by undertaking surveys over varying geographical areas. The lists of globally threatened bird species (BirdLife International 2000) or of species of conservation concern in individual continents, countries or regions (e.g. Carter et al. 2000; Gregory et al. 2002; www.partnersinflight.org), are based largely on information on population size. In addition, surveys can be used to collect information on where birds are in relation to different habitats, and so assess habitat associations.

4.2 Methods used in the survey

Given the complexity of Mt. Elgon region, we used Common Bird Monitoring (CBM) approach that combines a number of sampling methods and is flexible within and between habitat types. In some cases we made decision on whether to undertake a true census by attempting to count all birds, pairs or nests within the survey boundary, or to count in only a sample of areas within the

survey boundary. Rare birds with restricted ranges were often easier to count using a true census, because sampling might record too few birds to produce a reliable estimate. While carrying out CBM, we had separate datasheets that were used for recording units and behavior of the birds (ages, sexes, nests, singing, calling males, etc). CBM employed the three most common field methods i.e. mapping, line transects and point counts. Birds were identified using Dale Zimmerman's Bird Guide book and radio call-back using preinstalled voice recognition software (for identifying songs and calls of birds)

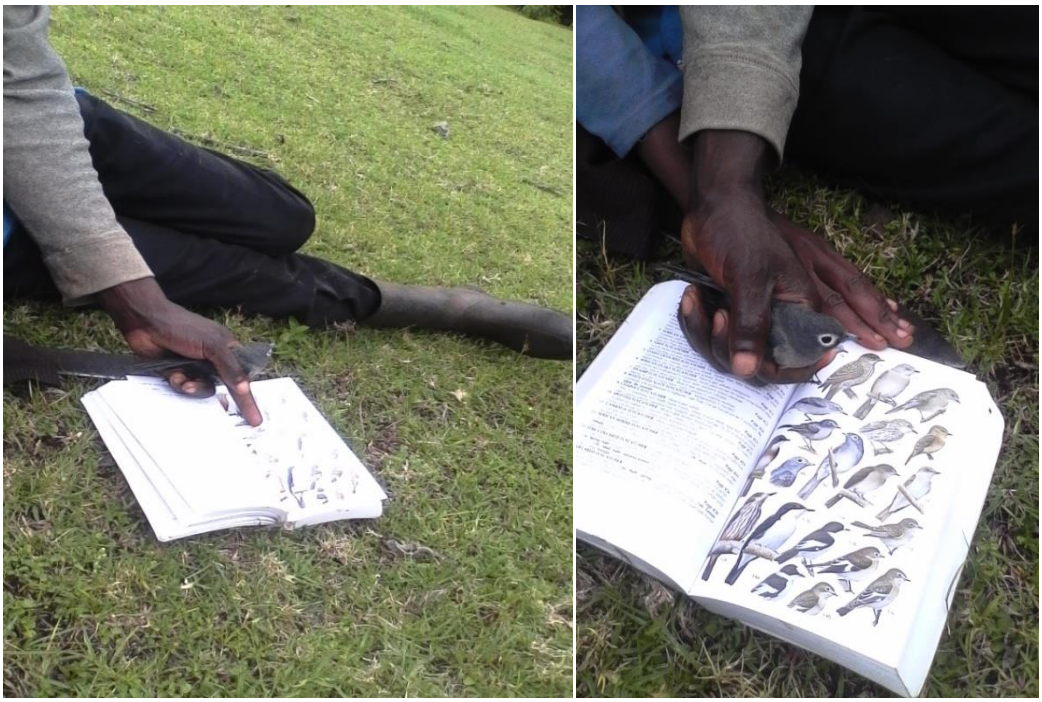


Plate 1: Community members using the Zimmerman's Bird Guide book to identify birds

Choosing the route and starting point.

- We decided to follow the Plants' Team while undertaking our surveys, provided it was within the general area covered by the map.
- Initially, the route needed to be approximately 2km long but based on the terrain, we did approximately 1km although in some few cases it was less than a kilometer.
- We also did not work in a straight line – we followed designated paths and trails to avoid much clearing which would require more labour as well time consuming.
- At each point, we stayed and bird watched in that place for 10 minutes.
- Birds seen or heard during each of the eleven 10-minute bird-watching sessions along our route were recorded in the datasheets.
- Birds encountered while moving from one location to another were recorded as "incidentals" and they form part of the checklist. For an academic project, this is however not allowed.
- Generally, we worked in five subareas based on vegetation types and/or administration. These were:
- Open montane forest

- Dense montane forest
- Bamboo zone
- Sub-alpine heath
- Cultivation areas (Farmlands and forest areas under Plantation Establishment and Livelihood Improvement Scheme - PELIS)

Description of some of the terms used in bird surveys

- Relative numerical status is expressed in the terms "abundant", "common", "fairly common", "uncommon", "scarce" or "rare". However, it is worth noting that a bird may be abundant one season, rare or absent the next; and the numbers may vary greatly between areas. The same term also differs in meaning between groups; a "common" weaver or dove is far more numerous than a "common" buzzard or eagle (Zimmerman et al, 2010).
- A "casual" species is one recorded only 5 – 10 times in a region, but considering its normal range, is one that can be expected to turn up again. "Occasional" species appear every few years, but not regularly. "Accidental" species, also known as "vagrant" birds, have been found once or twice but are not likely to be seen again.
- "Resident" species are those present in the region year-round. "Palearctic migrants" visit East Africa during the northern autumn and winter following breeding in Eurasia. "Intra-African migrants" regularly move into or through our region e.g. the southern race of African Golden Oriole spends April to August with us after breeding in the southern tropics.

4.3 Results and Discussion

A total of 211 bird species was recorded in the Mt. Elgon Forest Ecosystem including 7 species of conservation importance.

Table 1: Bird species of conservation importance

Common English Name	**Scientific Name**	**Special notes**
African crowned eagle	*Stephanoaetus coronatus*	Near Threatened
Sharpe's Longclaw	*Macronyx sharpei*	Globally endangered
Lammergeier (Bearded Vulture)	*Gypaetus barbatus*	Near Threatened
Yellow-billed Shrike	*Corvinella corvina*	Range restricted
White-crested Turaco	*Tauraco leucolophus*	Range restricted
White-breasted Cuckoo-shrike	*Coracina pectoralis*	Range restricted
Splendid Glossy Starling	*Lamprotornis spendidus*	Range restricted

Sharpe's Longclaw is threatened by a very rapid and continuing reduction in the extent and quality of its habitat, such that it now has a very small and highly fragmented range. Similar rates of population decline are likely. This species is therefore classified as Endangered. Importantly, Sharpe's Longclaw depends on tussock grasses. This is the common name for grass species that

grow in clumps or tufts that often thrive in dry habitats. Sharpe's Longclaw depends on them for three key aspects of its survival:

- **Nesting**: the birds form their nests at the base of tussock grasses.
- **Feeding**: Sharpe's Longclaw feeds on insects such as grasshoppers and beetles found at the base of tussocks.
- **Protection from predators**: there is evidence that the bird hides in the tussocks when threatened.

The bearded vulture or the Lammergeier is locally threatened. It naturally occurs at low densities. The bearded vulture is the only known animal whose diet is almost exclusively bone (70-90%). It lives and breeds on crags in high mountains and hills such as Mt. Elgon and Cherengani in Kenya.

The crowned eagle is fairly common in suitable habitat, though at the population level, its numbers have shown a decline in sync with deforestation. Declines appear to be widespread and may be increasing due to the often fevered pace of clear-cutting. This species main habitat is rich, high-canopy forest, which is a major target of timber companies, agriculturists as well as slash and burn farmers.

From previous records submitted to Kenya Birds Atlas monthly, 31 species are documented as having been in the Mt. Elgon forest ecosystem but are now absent. We attribute this to be likely (mainly) due to forest destruction and deforestation.

1	Banded Prinia	17	Square-tailed Drongo
2	Boran Cisticola	18	Velvet-mantled Drongo
3	Olive-green Camaroptera	19	Eastern Nicator
4	Equitorial Akalat	20	Red-shouldered Cuckoo-shrike
5	Grey-chested Illadopsis	21	Pink-footed Puffback
6	Cameroon Sombre Greenbul	22	Sooty Boubou
7	Ansorges Greenbul	23	Mackinon's Shrike
8	Shelley's Greenbul	24	Dusky-crested Flycatcher
9	Toro-olive Greenbul	25	Dusky Tit
10	Honey-guide Greenbul	26	Green Hylia
11	Blue-shouldered Robin-chat	27	Whistling Cisticola
12	White-breasted Negrofinch	28	Brown-eared Woodpecker
13	Eastern Double-collared Sunbird	29	Buff-spotted Woodpecker
14	Green Sunbird	30	Forest Wood-Hoopoe
15	Violet-backed Starling	31	Blue-headed Bee-eater
16	Stuhlmann's Starling		

Our survey did not conduct a night walk due to logistical challenges but some 10 nocturnal species are known to occur in the region. The table below summarizes the nocturnal species known to occur in the Mt. Elgon forest ecosystem:

The following nocturnal species are known to occur in the Mt. Elgon Forest ecosystem:

- Montane Nightjar
- African White-tailed Nighjar
- Dusky Nightjar
- Pennant-winged Nightjar
- Marsh Owl
- Red-chested Owlet
- Verreaux's Eagle-owl
- Cape Eagle-owl
- African Scop's Owl
- African Grass-owl

The table 2 below summarizes the findings from the field surveys but the detailed findings are attached on an Excel datasheet attached to this report in appendices 1 & 2.

Table 2: Summary of species distribution per vegetation types and/or administration

Vegetation type	**No. of Species**
Open montane forest	97
Dense montane forest	104
Bamboo zone	57
Sub-alpine heath	49
Cultivation areas	79

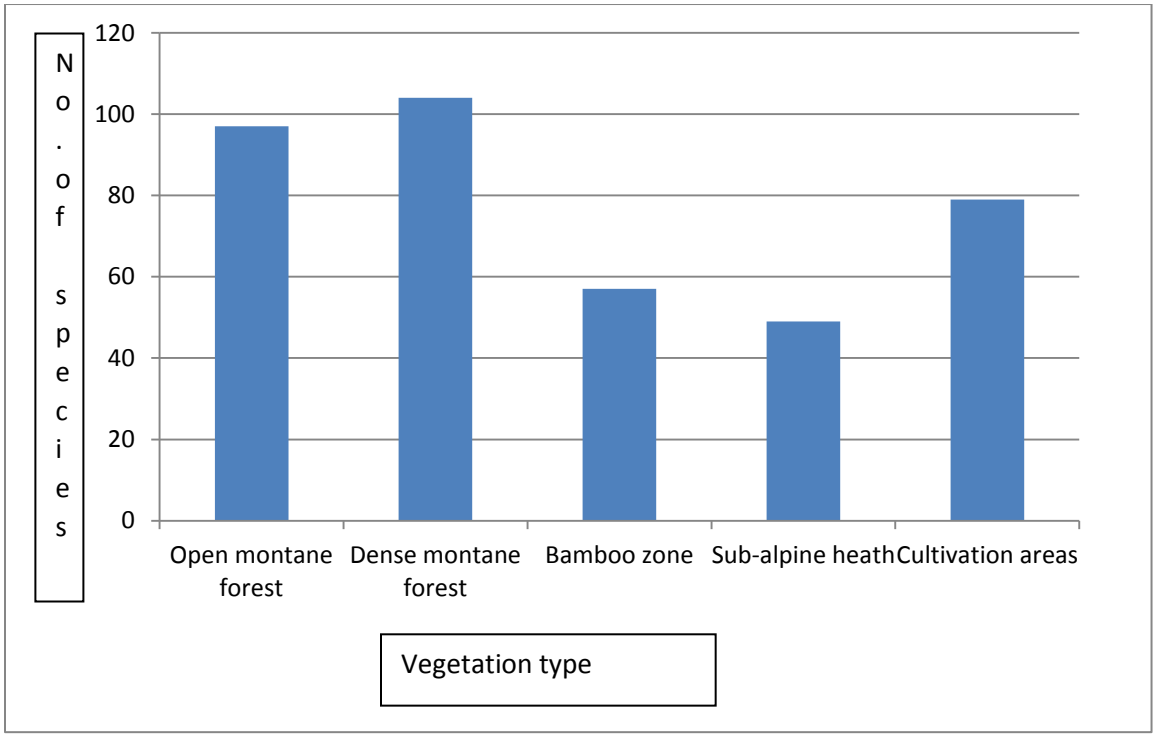


Fig 1: Graphical representation of the number of species seen per region/ area

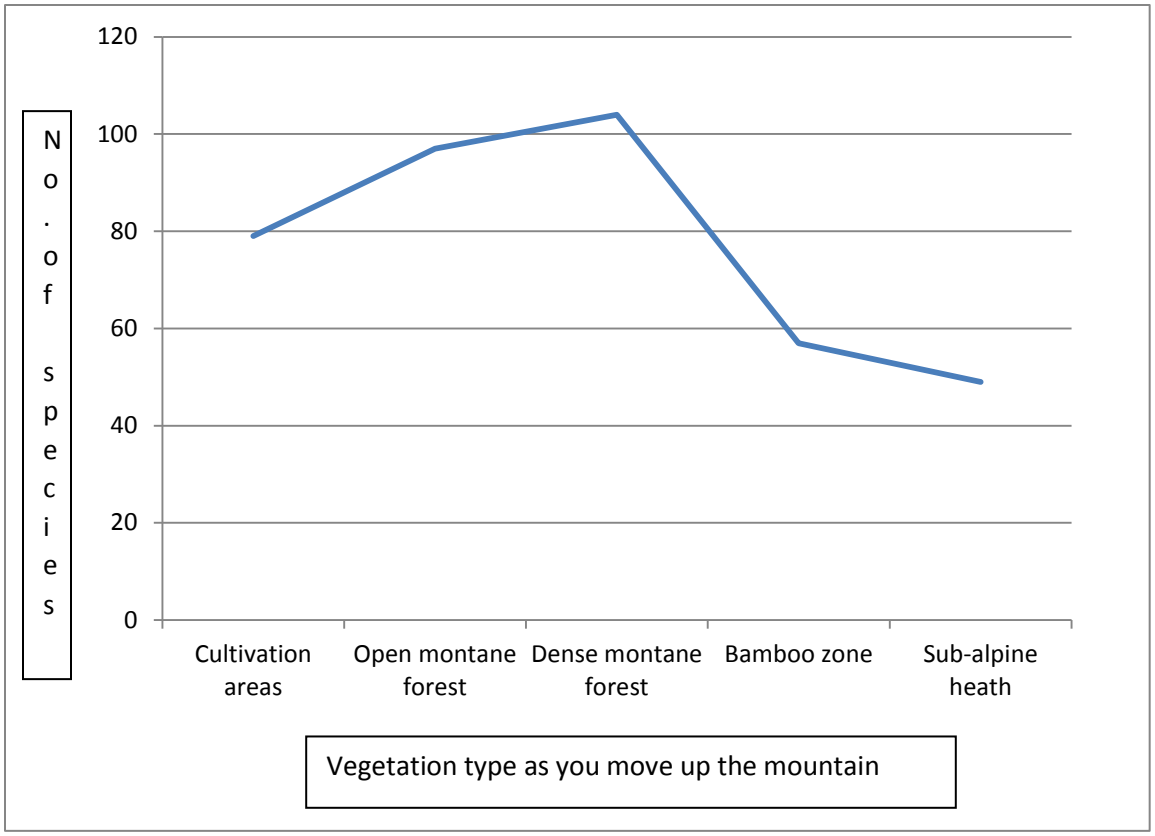


Fig. 2: Linear presentation of species variation along the altitudinal gradient

From Fig. 2 above, the number of species increases gradually from the cultivation area (79) as you move up into the open montane forest (97) and reaches a peak in the dense montane forest (104). There is, however, a sudden reduction in the number of species as you move further to the bamboo zone (57). This can be attributed to the relative low plant diversity in the bamboo zone that also reflects low diversity of micro-habitats due to its uniformity. Generally speaking, nature dislikes uniformity hence the decline in number of bird species in the bamboo zone. The same argument can be employed as you move towards the peak in the sub-alpine zone where the number of species drops further (49). Even though we did not get to the alpine, we project a decline in the number of bird species in this zone.

Recommendations

- Night surveys should be conducted to establish the status of nocturnal birds in the Mt. Elgon forest ecosystem.
- Use of mist-nets is another good method for capturing crepuscular species and we recommend it for future surveys.
- We also advocate for multiple counts to be obtained by counting the same study site repeatedly in the same season, or by counting multiple study sites once. The first option tells us about temporal variation at sites within a season, the second about spatial variation across the sites—both may be important.

Management recommendations:

- The low numbers of Forest specialist species (FF) were thought to be due to the effects of heavy grazing on vegetation, which has been found to alter the species composition of plant communities in Suam and Sosio areas. It is suggested that grazing be reduced in the area, with provision for the needs of local people, and that further research, on a larger scale and including ringing of birds, be carried out before further action is taken in Suam and Sosio areas.
- Clear boundary demarcation and buffer zone should also be established to curb rampant encroachment.
- Promote environmental conservation education for community members to change perception on forest utilization
- Initiate alternative livelihood that is compliant with forest conservation – modern beekeeping, ecotourism (guiding, cultural tourism, traditional accommodation (Bandas), bird watching, quail and guinea-fowl farming), energy-efficient stoves, on-farm woodlots in surrounding communities
- Introduce community based biodiversity monitoring and incorporate protected area managers and target the endangered species
- Curb illegal trade of Parrots and Lovebirds and destruction of nesting sites for endangered species such as Sharpe's Longclaw

References

BirdLife International (2000). Threatened birds of the world. Barcelona and Cambridge, Lynx Edicions and BirdLife International, UK.

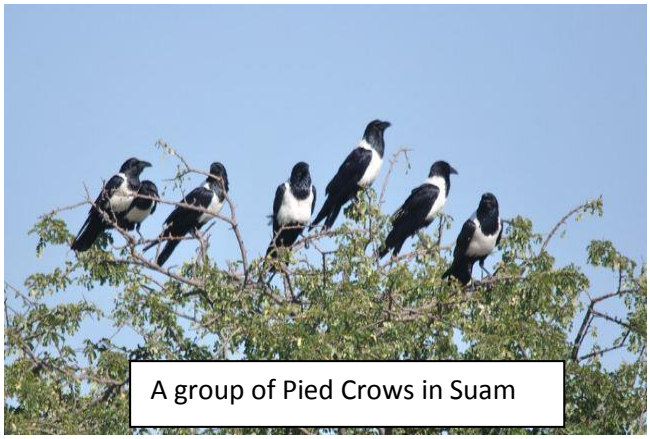
Carter, M.F, Hunter, W.C., Pashley, D.N., and Rosenberg, K.V. (2000). Setting conservation priorities for land birds in the United States: the partners in flight approach. Auk, 117, 541–548.

Gregory, R.D., Noble, D., Field, R., Marchant, J.H, Raven, M., and Gibbons D.W. (2003). Using birds as indicators of biodiversity. Ornis Hungarica (in press).

Zimmerman, D.A, Donald, A.T & Pearson, D.J (2010). Birds of Kenya and Northern Tanzania (Field Guide). A & C Black Publishers Ltd, 36 Soho Square, London W1D 3QY

Appendix 1: Photos of some birds of Mt. Elgon Forest Ecosystem

Forest visitors (f)



A group of Pied Crows in Suam

African Blue Flycatcher

Fan-tailed Ravens in Suam

Juvenile Greater Blue-eared Starling

Forest generalists (F)

Black & White Casqued Hornbill

Grey Crowned Crane

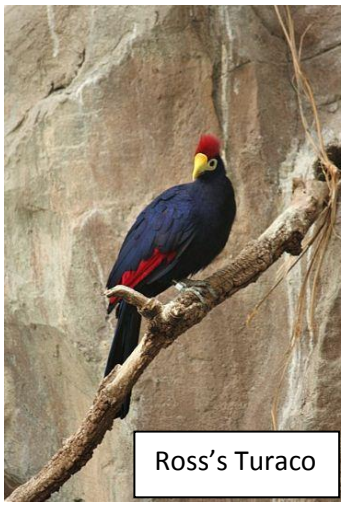
Long-crested Eagle

Great Sparrow-hawk (a) Dark morph, (b) Light morph

Forest Dependent species (FF)

African Golden Oriole

Purple-throated Bush-shrike



Ross's Turaco

Klaas Cuckoo

Appendix 1

Checklist of birds in Mt. Elgon Forest Ecosystem

No.	Common English Name	Scientific Name	Occurance Frequency	Habitat preference	Special notes
1	**Abyssinian Ground Thrush**	*Geokichla piaggiae (formerly Zoothera piaggiae)*	1	FF	
2	**African Black Swift**	*Apus barbatus*	1	f	
3	**African Blue Flycatcher**	*Elminia longicauda*	1	f	
4	**African Citril**	*Crithagra citrinelloides*	3	f	
5	**African Crake**	*Crex egregia*	2	FF, M	Intra-African Migrant
6	**African crowned eagle**	*Stephanoaetus coronatus*	1	FF,NT	Near Threatened
7	**African Dusky Flycatcher**	*Muscicapa adusta*	1	f	
8	**African Emerald Cuckoo**	*Chrysococcyx cupreus*	1	FF	
9	**African Firefinch**	*Lagonosticta rubricata*	1	f	
10	African Golden Oriole	*Oriolus auratus*	1	FF, M	Intra-African Migrant
11	**African Goshawk**	*Accipiter tachiro*	1	FF	
12	**African Grass-owl**	*Tyto capensis*	1	FF	
13	**African Green Pigeon**	*Treron calva*	2	FF	
14	**African Harrier Hawk**	*Polyboroides typus*	1	F	
15	**African Paradise Flycatcher**	*Terpsiphone viridis*	5	F	
16	**African Penduline Tit**	*Anthoscopus caroli*	1	F	
17	**African Pied Wagtail**	*Motacilla aguimp*	2	f	
18	**African Thrush**	*Turdus pelios*	1	FF	
19	**Alpine Swift**	*Apus melba*	2	f	
20	**Angola Swallow**	*Hirundo angolensis*	1	f	
21	**Augur Buzzard**	*Buteo augur*	9	F	
22	**Baglafetched Weaver**	*Ploceus baglafecht*	1	F	
23	**Barn Swallow**	*Hirundo rustica*	1	f,M	Palearctic migrant
24	**Black and white Mannikin**	*Lonchura bicolor*	2	FF	
25	**Black Cuckoo-shrike**	*Campephaga flava*	2	FF	
26	**Black Kite**	*Milvus migrans*	1	f	

27	**Black Saw-wing Swallow**	*Psalidoprocne holomelas*	2	f	
28	**Black-billed Barbet**	*Lybius guifsobalito*	1	FF	
29	**Blackcap**	*Sylvia atricapilla*	1	FF	
30	**Black-collared Apalis**	*Apalis pulchra*	2	FF	
31	**Black-crowned Waxbill**	*Estrida nonnula*	1	FF	
32	**Black-faced Rufous Warbler**	*Bathmocercus rufus*	3	FF	
33	**Black-fronted Bush-shrike**	*Malaconotus nigrifrons*	1	FF	
34	**Black-headed Batis**	*Batis minor*	1	F	
35	**Black-headed Oriole**	*Oriolus larvatus*	1	FF	
36	**Black-headed Village Weaver**	*Ploceus cucullatus*	1	f	
37	**Black-headed Waxbill**	*Estrida atricapilla*	3	FF	
38	**Black-throated Apalis**	*Apalis thoracica*	7	FF	
39	**Black-throated Wattle-eye**	*Platysteira peltata*	7	FF	
40	**Black-winged Red Bishop**	*Euplectes nigroventris*	2	f	
41	**Blue-spotted Wood Dove**	*Turtur afer*	6	f	
42	**Brimstone Canary**	*Serinus sulphhuratus*	1	f	
43	**Broad-billed Roller**	*Eurystomus glaucurus*	1	F	
44	**Broad-tailed Warbler**	*Schoenicola brevirostris*	4	F	
45	**Bronze Mannikin**	*Lonchura cucullata*	7	f	
46	**Bronze Sunbird**	*Nectarinia kilimensis*	2	f	
47	**Brown Parisoma**	*Parisoma lugens*	3	f	
48	**Brown Parrot**	*Poicephalus meyeri*	1	FF	
49	**Brown Woodland Warbler**	*Pylloscopus umbrovirens*	1	FF	
50	**Brown-chested Alethe**	*Alethe poliocephala*	2	FF	
51	**Brown-crowned Tchagra**	*Tchagra australis*	4	FF	
52	**Buff-bellied Warbler**	*Phyllolais pulchella*	1	FF	
53	**Buff-throated Apalis**	*Apalis rufogularis*	1	FF	
54	**Cabanis's Greenbul**	*Phyllastrephus hypochloris*	1	FF	
55	**Cameroon Sombre Greenbul**	*Andropadus curvirostris*	1	FF	
56	**Cardinal Woodpecker**	*Dendropicos fuscescens*	1	FF	
57	**Cattle Egret**	*Bubulcus ibis*	1	f	

58	**Chestnut-throated Apalis**	*Apalis porphyrolaema*	4	FF	
59	**Chin-spot Batis**	*Batis molitor*	1	f	
60	**Chubb's Cisticola**	*Cisticola chubbi*	3	f	
61	**Cinnamon-chested Bee-eater**	*Merops oreobates*	1	F	
62	**Common Bulbul**	*Pycnonotus barbatus*	4	f	
63	**Common Drongo**	*Dicrurus adsimilis*	6	F	
64	**Common Fiscal**	*Lanius collaris*	2	f	
65	**Common Scimitarbill**	*Rhinopomastus cyanomelas*	1	F	
66	**Common Stonechat**	*Saxicola torquata*	6	f	
67	**Common Wattle-eye**	*Platysteira cyanea*	5	FF	
68	**Common Waxbill**	*Estrilda astrild*	2	f	
69	**Crested Guineafowl**	*Guttera pucherani*	2	FF	
70	**Croaking Cisticola**	*Cisticola natalensis*	1	f	
71	**Dark-backed Weaver**	*Ploceus bicolor*	1	FF	
72	**Double-toothed Barbet**	*Lybius bidentatus*	2	FF	
73	**Dusky Tit**	*Parus funereus*	1	FF	
74	**Dusky Turtle-Dove**	*Streptopelia lugens*	1	F	
75	**Eastern Bronze-naped Pigeon**	*Columba delegorguei*	1	FF	
76	**Eastern Grey Plantain-eater**	*Crinifer zonurus*	1	FF	
77	**Emarald Spotted-Dove**	*Turtur chalcospilos*	1	F	
78	**Eurasian Bee-eater**	*Merops apiaster*	1	F, M	Palearctic migrant
79	**Eurasian Hobby**	*Falco subbuteo*	1	F, M	Palearctic migrant
80	**Fan-tailed Raven**	*Corvus rhipidurus*	1	f	
81	**Fan-tailed Widowbird**	*Euplectes axillaris*	1	f	
82	**Fawn-breasted Waxbill**	*Estrilda paludicola*	1	F	
83	**Golden-winged Sunbird**	*Nectarinia reichenowi*	1	F	
84	**Grassland Pipit**	*Anthus cinnamomeus*	1	f	
85	**Great Sparrowhawk**	*Accipiter melanoleucus*	1	F	
86	**Greater Blue-eared Starling**	*Lamprotornis chalybaeus*	1	f	
87	**Greater Honeyguide**	*Indicator indicator*	1	FF	
88	**Green Wood-hoopoe**	*Phoeniculus purpureus*	2	FF	

89	**Green-backed Eremomela**	*Eremomela pusilla*	1	FF	
90	**Green-headed Sunbird**	*Nectarinia verticalis*	1	FF	
91	**Grey Crowned Crane**	*Balearica regulorum*	2	F	
92	**Grey Cuckoo-shrike**	*Coracina caesia*	1	FF	
93	**Grey Kestrel**	*Falco ardosiacus*	1	f	
94	**Grey-backed Camaroptera**	*Camaroptera brachyura*	5	FF	
95	**Grey-backed Fiscal**	*Lanius excubitoroides*	3	f	
96	**Grey-headed Bush-shrike**	*Malaconotus blanchoti*	1	F	
97	**Grey-headed Negrofinch**	*Nigrita canicapila*	2	F	
98	**Grey-headed Sparrow**	*Passer griseus*	3	f	
99	**Grey-rumped Swallow**	*Pseudhirundo griseopyga*	1	f	
100	**Grey-throated Barbet**	*Gymbobucco banapartei*	2	FF	
101	**Grey-winged Robin**	*Sheppardia polioptera*	2	FF	
102	**Hadada Ibis**	*Bostrychia hagedash*	4	f	
103	**Hamerkop**	*Scopus umbretta*	2	f	
104	**Hartlaub's Turaco**	*Tauraco hartlaubi*	2	FF	
105	**Hunter's Cisticola**	*Cisticola hunteri*	1	f	
106	**Joyful Greenbul**	*Chlorocichla laetissima*	4	FF	
107	**Klaas's Cuckoo**	*Chrysococcyx klaas*	2	FF	
108	**Lammergeier (Bearded Vulture)**	*Gypaetus barbatus*	1	f, NT	Near Threatened
109	**Laughing Dove**	*Streptopelia senegalensis*	1	f	
110	**Lesser Honeyguide**	*Indicator exilis*	1	FF	
111	**Lilac-breasted Roller**	*Coracias caudata*	1	f	
112	**Long-crested Eagle**	*Lophaetus occipitalis*	1	F	
113	**Luhder's Bush-shrike**	*Laniarius luehderi*	6	FF	
114	**Malachite Kingfisher**	*Alcedo cristata*	1	F	
115	**Malachite Sunbird**	*Nectarinia famosa*	1	FF	
116	**Marsh Tchagra**	*Tchagra minuta*	1	F	
117	**Montane Oriole**	*Oriolus percivali*	1	FF	
118	**Moorland Francolin**	*Francolinus psilolaemus*	2	FF	
119	**Mountain Buzzard**	*Buteo oreophilus*	2	FF	

120	**Mountain Greenbul**	*Andropadus nigriceps*	1	FF	
121	**Mountain Illadopsis**	*Illadopsis pyrroptera*	2	FF	
122	**Mountain Wagtail**	*Motacilla clara*	1	F	
123	**Moustached Green Tinkerbird**	*Pogoniulus leucomystax*	2	FF	
124	**Northern Black Flycatcher**	*Melaenornis edolioides*	1	F	
125	**Northern Double-collared Sunbird**	*Nectarinia preussi*	2	FF	
126	**Northern Puffback**	*Dryoscopus gambensis*	2	FF	
127	**Olive Sunbird**	*Nectarinia olivacea*	3	F	
128	**Oriole-Finch**	*Linurgus olivaceus*	2	F	
129	**Pale Flycatcher**	*Bradornis pallidus*	3	F	
130	**Pied Crow**	*Corvus albus*	2	f	
131	**Pin-tailed Whydah**	*Vidua macroura*	1	f	
132	**Plain-backed Pipit**	*Anthus leucophrys*	1	F	
133	**Purple Starling**	*Lamprotornis purpureus*	1	F	
134	**Purple-throated Cucoo-shrike**	*Campephaga quisqualina*	1	FF	
135	**Red-billed Firefinch**	*Lagonosticta senegala*	1	f	
136	**Red-billed Oxpecker**	*Buphagus erythrorhynchus*	1	F	
137	**Red-cheeked Cordon-Bleu**	*Uraeginthus bengalus*	1	FF	
138	**Red-chested Cuckoo**	*Cuculus solitarius*	5	FF	
139	**Red-collared Widowbird**	*Euplectes ardens*	1	f	
140	**Red-eyed Dove**	*Streptopelia semitorquata*	2	f	
141	**Red-faced Crombec**	*Sylvietta whytii*	1	f	
142	**Red-fronted Parrot**	*Poicephalus gulielmi*	2	FF	
143	**Red-fronted Tinkerbird**	*Pogoniulus pusillus*	1	FF	
144	**Red-headed Bluebill**	*Spermophaga ruficapilla*	1	FF	
145	**Red-headed Weaver**	*Anaplectes rubriceps*	3	FF	
146	**Red-rumped Swallow**	*Hirundo daurica*	2	f	
147	**Red-tailed Bristlebill**	*Bleda syndactyla*	1	FF	
148	**Red-winged Starling**	*Onychognathus morio*	1	F	
149	**Ring-necked Dove**	*Streptopelia capicola*	1	f	

150	**Rock Martin**	*Hirundo fuligula*	2	f	
151	**Ross's Turaco**	*Musophaga rossae*	3	F	
152	**Sand Martin**	*Riparia riparia*	1	f,M	Palearctic migrant
153	**Scaly Francolin**	*Francolinus squamatus*	1	FF	
154	**Scaly-throated Honeyguide**	*Indicator variegatus*	1	FF	
155	**Semi-collared Flycatcher**	*Ficedula semitorquata*	3	F,M	Palearctic migrant
156	**Senegal Coucal**	*Centropus senegalensis*	2	F	
157	**Sharpe's Longclaw**	*Macronyx sharpei*	1	f, E	Globally endangered
158	**Sifflin Cisticola**	*Cisticola brachypterus*	1	f	
159	**Singing Cisticola**	*Cisticola cantans*	3	f	
160	**Slender-billed Greenbul**	*Andropadus gracilirostris*	2	FF	
161	**Snowy-headed Robin-chat**	*Cossypha niveicapilla*	1	FF	
162	**Spectacled Weaver**	*Ploceus ocularis*	1	FF	
163	**Splendid Glossy Starling**	*Lamprotornis spendidus*	1	F,R	Range restricted
164	**Spot-flanked Barbet**	*Tricholaema lacymosa*	1	FF	
165	**Stout Cisticola**	*Cisticola robustus*	1	f	
166	**Streaky Seedeater**	*Serinus striolatus*	1	f	
167	**Striped Flufftail**	*Saronthrura affinis*	1	FF	
168	**Tacazze Sunbird**	*Nectarinia tecazze*	1	FF	
169	**Tambourine Dove**	*Turtur tympnistra*	2	FF	
170	**Tawny-flanked Prinia**	*Prinia subflava*	4	FF	
171	**Thick-billed Seedeater**	*Serinus burtoni*	1	FF	
172	**Tropical Boubou**	*Laniarius aethiopicus*	10	F	
173	**Uganda Spotted Woodpecker (also called Speckle-breasted Woodpecker)**	*Dendropicos poecilolaemus*	1	FF	
174	**Variable Sunbird**	*Nectarinia venusta*	4	f	
175	**Village Indigobird**	*Vidua chalybeata*	1	f	
176	**Violet-backed Starling**	*Cinnyricinclus leucogaster*	1	FF	
177	**Waller's Starling**	*Onychognathus walleri*	2	FF	

178	**Western Black-headed Oriole**	*Oriolus brachyrhynchus*	1	FF	
179	**White-breasted Cuckoo-shrike**	*Coracina pectoralis*	1	FF,R	Range restricted
180	**White-browed Crombec**	*Sylvietta leucophrys*	1	FF	
181	**White-browed Robinchat**	*Cossypha heuglini*	1	FF	
182	**White-browed Scrub Robin**	*Cercotrichas leucophrys*	2	F	
183	**White-chinned Prinia**	*Prinia leucopogon*	1	FF	
184	**White-crested Helmet-shrike**	*Prionops plumatus*	1	F	
185	**White-crested Turaco**	*Tauraco leucolophus*	2	FF,R	Range restricted
186	**White-eyed Slaty Flycatcher**	*Melaenornis fischeri*	1	f	
187	**White-headed Barbet**	*Lybius leucocephalus*	1	FF	
188	**White-headed Saw-wing**	*Psalidoprocne albiceps*	2	f	
189	**White-headed Wood-Hoopoe**	*Phoeniculus bollei*	1	FF	
190	**White-naped Raven**	*Corvus albicollis*	1	f	
191	**White-rumped Swift**	*Apus caffer*	1	f	
192	**White-spotted Flufftail**	*Saronthrura pulchra*	2	FF	
193	**White-starred Robin**	*Pogonocichla stellata*	1	FF	
194	**White-tailed Crested Flycatcher**	*Trochocercus albonotatus*	1	F	
195	**White-throated Bee-eater**	*Merops albicollis*	1	f	
196	**Wire-tailed Swallow**	*Hirundo smithii*	2	f	
197	**Yellow Bishop**	*Euplectes capensis*	1	f	
198	**Yellow Wagtail**	*Motacilla flava*	1	F	
199	**Yellow White-eye**	*Zosterops senegalensis*	3	F	
200	**Yellow-bellied Hyliota**	*Hyliota flavigaster*	1	F	
201	**Yellow-billed Barbet**	*Trachylaemus purpuratus*	2	F	
202	**Yellow-billed Shrike**	*Corvinella corvina*	2	F	Range restricted
203	**Yellow-breasted Apalis**	*Apalis flavida*	1	F	
204	**Yellow-crested Woodpecker**	*Dendropicos xantholophus*	2	F	
205	**Yellow-crowned Canary**	*Serinus canicollis*	3	f	
206	**Yellow-mantled Widowbird**	*Euplectes macrourus*	1	f	
207	**Yellow-rumped Tinkerbird**	*Pogoniulus bilineatus*	2	FF	

208	**Yellow-spotted Barbet**	*Buccanodon duchaillui*	1	FF	
209	**Yellow-throated Leaf-love**	*Chlorocichla flavicollis*	3	FF	
210	**Yellow-whiskered Greenbul**	*Andropadus latirostris*	3	FF	
211	**Zebra Waxbill**	*Amandava subflava*	1	F	

Appendix 2

Species encountered per zone or administrative region or block

Open natural forest 1	Open natural forest 2	Bamboo zone 1	Bamboo zone 2	Transition zone	Kimothon area	Alpine zone	Cultivation areas	National Park (Chorlim)	Suam area
Yellow-rumped Tinkerbird	Common Wattle-eye	Singing Cisticola	Singing Cisticola	Buff-throated Apalis	Brown Parisoma	Yellow-crowned Canary	Black-winged Red Bishop	Brown-chested Alethe	African Green Pigeon
Common Drongo	Yellow-billed Shrike	Brown Parisoma	Broad-tailed Warbler	Sifflin Cisticola	Pale Flycatcher	Black-headed Waxbill	Grey Crowned Crane	Eastern Bronze-naped Pigeon	Broad-tailed Warbler
Dark-backed Weaver	Moustached Green Tinkerbird	Broad-tailed Warbler	Ross's Turaco	Black-throated Wattle-eye	Common Waxbill	Black and white Mannkin	Singing Cisticola	Snowy-headed Robin-chat	Tambourine Dove
Mountain Buzzard	Grey-throated Barbet	Ross's Turaco	Tawny-flanked Prinia	Black-headed Waxbill	Wire-tailed Swallow	Hunter's Cisticola	African Citril	Moustached Green Tinkerbird	Tawny-flanked Prinia
Grey-backed Camaroptera	Tawny-flanked Prinia	Black-throated Wattle-eye	Grey-backed Camaroptera	Mountain Illadopsis	Augur Buzzard	Alpine Swift	Ring-necked Dove	Double-toothed Barbet	Grey-backed Camaroptera
Yellow-spotted Barbet	Stout Cisticola	Tawny-flanked Prinia	Black-faced Rufous Warbler	Black-collared Apalis	Joyful Greenbul	Angola Swallow	White-browed Scrub Robin	Mountain Illadopsis	Black-faced Rufous Warbler
Bronze Sunbird	Uganda Spotted Woodpecker	Grey-backed Camaroptera	Chestnut-throated Apalis	Common Bulbul	Grey-backed Fiscal	Wire-tailed Swallow	Common Stonechat	Common Bulbul	Chestnut-throated Apalis
Augur Buzzard	Common Bulbul	Black-faced Rufous Warbler	Tropical Boubou	Common Wattle-eye	Black-throated Apalis	African Grass-owl	Red-rumped Swallow	Yellow-crowned Canary	Fan-tailed Raven
Chubb's Cisticola	Black-billed Barbet	Chestnut-throated Apalis	Brown-crowned Tchagra	Grey-rumped Swallow	White-crested Turaco	Grey-backed Camaroptera	Senegal Coucal	Black-throated Apalis	Common Drongo
Common Bulbul	Black-throated Wattle-eye	Semi-collared Flycatcher	Augur Buzzard	Chubb's Cisticola	Brown Parisoma	Chestnut-throated Apalis	White-headed Barbet	Violet-backed Starling	Hamerkop
Yellow-whiskered Greenbul	Dusky Tit	Oriole-Finch	African Paradise Flycatcher	Yellow-whiskered Greenbul	Red-chested Cuckoo	Red-rumped Swallow	Red-eyed Dove	Yellow-bellied Hyliota	Pied crow
Hartlaub's Turaco	Green Wood-hoopoe	African Citril	Black-throated Apalis	Purple-throated Cucoo-shrike	Spot-flanked Barbet	Blackcap	African Pied Wagtail	Slender-billed Greenbul	Common Fiscal
Tropical Boubou	Grey-headed Negrofinch	Black-headed Waxbill	Common Stonechat	Blue-spotted Wood Dove	Semi-collared Flycatcher	Grey-winged Robin-chat	Northern Black Flycatcher	Grey-throated Barbet	Black Cuckoo-shrike

Northern Puffback	Yellow White-eye	Grey-winged Robin	White-browed Scrub Robin	Ross's Turaco	Streaky Seedeater	Sharpe's Longclaw	Yellow-fronted Canary	White-chinned Prinia	Northern Puffback
Yellow-throated Leaf-love	Lesser Honeyguide	African Crake	Dusky Turtle-Dove	Red-winged Starling	Fawn-breasted Waxbill	Red-eyed Dove	Chubb's Cisticola	Montane Oriole	Tropical Boubou
Red-chested Cuckoo	Yellow-rumped Tinkerbird	Alpine Swift		Yellow-throated Leaf-love	Grey-headed Sparrow	Grassland Pipit	Thick-billed Seedeater	White-throated Bee-eater	White-naped Raven
Brown Woodland Warbler	Mountain Greenbul	Black Saw-wing Swallow		Red-fronted Parrot	Variable Sunbird	Yellow-billed Barbet	Village Indigobird	White-browed Robinchat	Grey-headed Bush-shrike
Joyful Greenbul	Emarald Spotted-Dove	Barn Swallow		Hartlaub's Turaco	Purple Starling	Yellow White-eye	Bronze Mannikin	Grey Cuckoo-shrike	Marsh Tchagra
Western Black-headed Oriole	Red-fronted Tinkerbird	Yellow-whiskered Greenbul		Cameroon Sombre Greenbul	Tropical Boubou	White-rumped Swift	Common Waxbill	Oriole-finch	Grey-backed Fiscal
Bronze Mannikin	White-tailed Crested Flycatcher	Augur Buzzard		African Paradise Flycatcher	Bronze Mannikin	Pale Flycatcher	Red-cheeked Cordon-Bleu	Brimstone Canary	Yellow-billed Shrike
	Yellow-billed Barbet	Great Sparrowhawk		Bronze Mannikin	Luhder's Bush-shrike	Black-crowned Waxbill	African Firefinch	African Paradise Flycatcher	White-crested Helmet-shrike
	Common Drongo	Crested Guineafowl		Cabanis's Greenbul	Black-throated Wattle-eye	Sand Martin	Yellow-mantled Widowbird	Pin-tailed Whydah	African Paradise Flycatcher
	Moorland Francolin	African Green Pigeon		Red-billed Firefinch	Common Wattle-eye	Red-headed Weaver	Black-headed Village Weaver	Black and white Mannkin	Black-throated Apalis
	Yellow-breasted Apalis	Rock Martin		Fan-tailed Widowbird	Buff-bellied Warbler	Black Saw-wing	Grey-headed Sparrow	African Citril	Common Stonechat
	Double-toothed Barbet	Tambourine Dove		Variable Sunbird	White-browed Crombec	Malachite Sunbird	Variable Sunbird	Black Cuckoo-shrike	Hadada Ibis
	Crested Guineafowl	Yellow White-eye		Red-headed Weaver	Red-chested Cuckoo	Waller's Starling	African Blue Flycatcher	Zebra Waxbill	Green Wood-Hoopoe
	Tropical Boubou	Joyful Greenbul		Tropical Boubou	Blue-spotted Wood Dove	Bronze Mannikin	Pied Crow	Black-throated Wattle-eye	Lilac-breasted Roller
	Grey Kestrel	White-headed Saw-wing		Luhder's Bush-shrike		Rock Martin	Black Kite	Red-headed Bluebill	Malachite Kingfisher
	Cardinal Woodpecker	Mountain Buzzard		Scaly Francolin		Common Drongo	Yellow Bishop	Splendid Glossy Starling	Red-chested Cuckoo
	Luhder's Bush-shrike	Bronze Mannikin		Brown-crowned Tchagra		Tacaze Sunbird	Common Drongo	Olive Sunbird	Eastern Grey Plantain-eater
	Black-throated Wattle-eye	Hamerkop		African Penduline Tit		Mountain Wagtail	Tropical Boubou	Grey-headed Negrofinch	White-crested Turaco
	Brown Parrot	Northern Double-collared Sunbird		Red-faced Crombec		Tropical Boubou	Pale Flycatcher	Red-collared Widowbird	Blue-spotted Wood Dove
	Eurasian Hobby	Tropical Boubou		Black-throated Apalis		Moorland Francolin	African Goshawk	Spectacled Weaver	Augur Buzzard

Common Scimitarbill	Luhder's Bush-shrike
Blue-spotted Wood Dove	Brown-crowned Tchagra
White-eyed Slaty Flycatcher	Green-backed Eremomela
White-spotted Flufftail	Black-collared Apalis
Hadada Ibis	Common Stonechat
African Crake	Yellow-crested Woodpecker
Klaas's Cuckoo	Red-chested Cuckoo
Green-headed Sunbird	Blue-spotted Wood Dove
Northern Double-collared Sunbird	Augur Buzzard
African Paradise Flycatcher	
Joyful Greenbul	
Yellow-throated Leaf-love	
Red-tailed Bristlebill	
African Harrier Hawk	
Brown-chested Alethe	
Olive Sunbird	
African Emerald Cuckoo	

Croaking Cisticola
White-starred Robin
Slender-billed Greenbul
Greater Honeyguide
Klaas's Cuckoo
Blue-spotted Wood Dove
Augur Buzzard

Black-throated Wattle-eye	Olive Sunbird	Black-fronted Bush-shrike	Cattle Egret
Common Wattle-eye	Luhder's Bush-shrike	Common Stonechat	
Black-throated Apalis	Common Fiscal	Grey-headed Sparrow	
Abyssinian Ground Thrush	Black-throated Apalis	Black-headed Oriole	
Common Stonechat	Broad-tailed Warbler	Golden-winged Sunbird	
Augur Buzzard	Semi-collared Flycatcher	Brown-crowned Tchagra	
White-headed Saw-wing	African Dusky Flycatcher	Chin-spot Batis	
Yellow Wagtail	African Thrush	Red-headed Weaver	
Plain-backed Pipit	Eurasian Bee-eater	Luhder's Bush-shrike	
African Pied Wagtail	Laughing Dove	Brown Parisoma	
Scaly-throated Honeyguide	Augur Buzzard	White-breasted Cuckoo-shrike	
White-headed Wood-Hoopoe	Hadada Ibis	Waller's Starling	
African Black Swift		Black-winged Red Bishop	
Red-chested Cuckoo		Common Drongo	
Striped Flufftail		Bronze Mannikin	
Long-crested Eagle		Variable Sunbird	
		Red-fronted Parrot	
		Grey-backed Fiscal	
		Tropical Boubou	
		Common Wattle-eye	
		Red-billed Oxpecker	
		White-spotted Flufftail	

Greater Blue-eared Starling
African Golden Oriole
Black-headed Batis
Cinnamon-chested Bee-eater
Bronze Sunbird
Yellow-crested Woodpecker
Broad-billed Roller
Baglafetched Weaver
Hadada Ibis

CHAPTER FIVE

SMALL MAMMALS OF MOUNT ELGON FOREST ECOSYSTEM

By

Bernard Agwanda and Griffin Ochieng'

5.1 Introduction

Mt Elgon is one the oldest volcanic mountains in Africa (White 1981; Shuttle Radar Topography Mission 2017) and thus considered to be a major centre of dispersal and speciation of many organisms (Demos, Agwanda and Hickerson 2014). As such White (1981) and Kingdon (1989) described it as one of the "archipelagos" of Africa having flora and fauna different from the surrounding lowlands needing concerted conservation effort (Clausnitzer 2001; White 1981).

Despite many scientific expeditions on this mountain over the last century, comprehensive data on mammals have remained elusive. Significant knowledge gaps have persisted since the first mammal survey by Swedish expedition of 1920. This is partly because of previous studies had either too narrow spatio-temporal scope and group specific mammal surveys such as (Carleton, and Graves 2006; Carleton et al. 2006; Clausnitzer and Hutterer 2003; Clausnitzer and Kityo 2001; Clausnitzer 2001, Kuzmin et al. 2010)) or broad (Demos and Agwanda. 2015, 2014; Moritz et al. 2008; Rowe, Heaney, and Rickart 2015). A relatively more comprehensive study of mammals of Mt Elgon was attempted by NMK and Makerere University in 2004 and 2008 under MERECP programme. Unfortunately in these two efforts the list of mammals was developed more from Museum specimen collections and less brief field surveys. One of the most critical knowledge gaps on Mt Elgon biodiversity is on small mammals.

Small mammal is a name commonly used to refer to rodents, shrews and bats but in practice includes all mammals weighing under 5kgs (Delanys 1979). Small mammals therefore include groups of rodents and bats that play important roles in pollination (Goldingay, Carthew, and Whelan 1991), seed dispersal (Corlett 2017) natural control of insect pest and vectors (Kunz et al. 2011). In many terrestrial and aquatic ecosystems small malls form important prey base of carnivores (Mukherjee et al. 2004), snakes (McCauley et al. 2006) and birds (Avenant, 2005). In sum, knowledge on small mammals is critical in conservation of a whole range of other species and tracking ecological changes (Semere and Slater 2007).

Whereas the value of the small mammals as important component of biodiversity is well acknowledged, few studies have devoted efforts to determine species diversity and habitat affiliation on Mt Elgon. Here we report species diversity in various vegetation bands of the southern slopes of Mt Elgon-Kenya, which has received little research attention amidst extensive anthropogenic manipulations. The aim of this survey therefore was to provide baseline information on species diversity and relative abundance in these eco-climatic zones of the mountain to subsequently anchor the much needed conservation efforts of the entire ecosystem.

5.2 Material and Methods

Study sites

Southern slope of Mt Elgon-Kenya was selected for the study. The selection was purposeful, based on expediency and priority due to lack of data to support restoration on this most degraded part of the mountain. Compared to the eastern and northern part of the Mountain, the Southern is least surveyed yet rapidly cleared for farming by forest dwelling communities. Seven out of the thirteen days was therefore dedicated to the southern slope (bottom to top). Only four days was spent to survey the western part of the mountain. Line transects were established in each of the following ecozones:

Mixed montane forest (Fig 1), the natural habitat lying lowest part of the forest and bordering human settlements and farms typically lying at an altitude of 2400m above sea level (a.s.l) and below

Figure 1: Montane forest at Kaberwa where small mammal transect was set

Bamboo zone: the belt lying immediately above montane forest and consists of pure or near pure stand of bamboo (Fig 2). In this part of the mountain, this belt was apparent at altitude range of about 2400m to 2800m a.s.l.

Figure 2: visual structure of bamboo habitat where small mammal sampling transect was set

Subalpine zone: the zone consist of dwarf trees and patches of tussock grass, a structure that seem to have attracted human habitation and livestock keeping in this patch despite its low temperature. The lowest part of this zone (3100m a.s.l) had appreciable amount dense forest of *Juniperus*, *Podocarpus* and *Hagenia.* In contrast however, the upper part (about 3400m a.s.l) of the zone was open grassland with patches of bushes (Fig 3).

Figure 3: Higher section of subalpine habitat where small mammal transect was established

Figure 4: Visual habitat structure of lower section of sub-alpine habitat where small mammals were sampled

Each of these zones was fitted with a trapping transect for sampling small mammals. Each transect was marked on the ground with a GPS (Table 1).

Table 1: GPS coordinates of sites surveyed

GPS coordinates of transect	Name of Zone/Altitude	Description
37N 0686288;0098357 - 37N 0686428; 0098554	Mixed Montane forest (2163-2204m)	Mix species trees with undergrowth
36N 083408; 0100883	Bamboo (2434m)	Pure stand of bamboo
36N 0680925; 0110285	Transition zone: Hagenia mix groove forest (3119)	Forest of Hagenia and other tree species
36N 0677308; 0115412,	Sub-alpine: Moorland (3401m)	Moorland (tussock grass & bushes

Sampling methods

Species diversity of rodents (Order Rodentia) were studied mainly by capturing in baited standard medium Sherman foldable live traps (LFA-TDG, 7.5x 9x23cm), Fig 5), museum special and Tomahawk for large ones(Porcupine and Gaint pouched rat size rodents).

Figure 5: Sherman live trap for sampling rodents

Shrews (Order Soricomorpha) on the other hand were studied by capturing mainly in pitfall traps, in Sherman and Museum special traps. The pitfalls were made of plastic buckets of dimensions: 40 cm deep and 20 cm diameter wide, sunk in the ground so that the rim of open end is flush with ground surface.

Figure 6: Pitfall traps with drift fence for sampling shrews on forest floor

5.3 Results and discussion

Twenty-eight species from 14 families representing four orders were recorded in the 9 day survey. This includes those recorded in the systematic trapping, observational survey (24 species) and opportunistic sightings (3 species). The recorded species comprise rodents (16 species), bats (7 species), Shrews (4 species), and lagomorphs (1 species). To test if the number of species recorded in this survey were reflective of the ecosystem and effort was exhaustive, a cumulative plot was generated to predict likelihood of recording additional new species (Fig 7).

The curve didn't reach asymptote (Fig 7), strongly indicating there were more species that are likely to be recorded with further sampling(Clausnitzer and Kityo 2001). The survey was too brief especially in the bamboo where only one night trapping was done and alpine where trapping was not done at the centre of the zone but boundary with subalpine moorland.

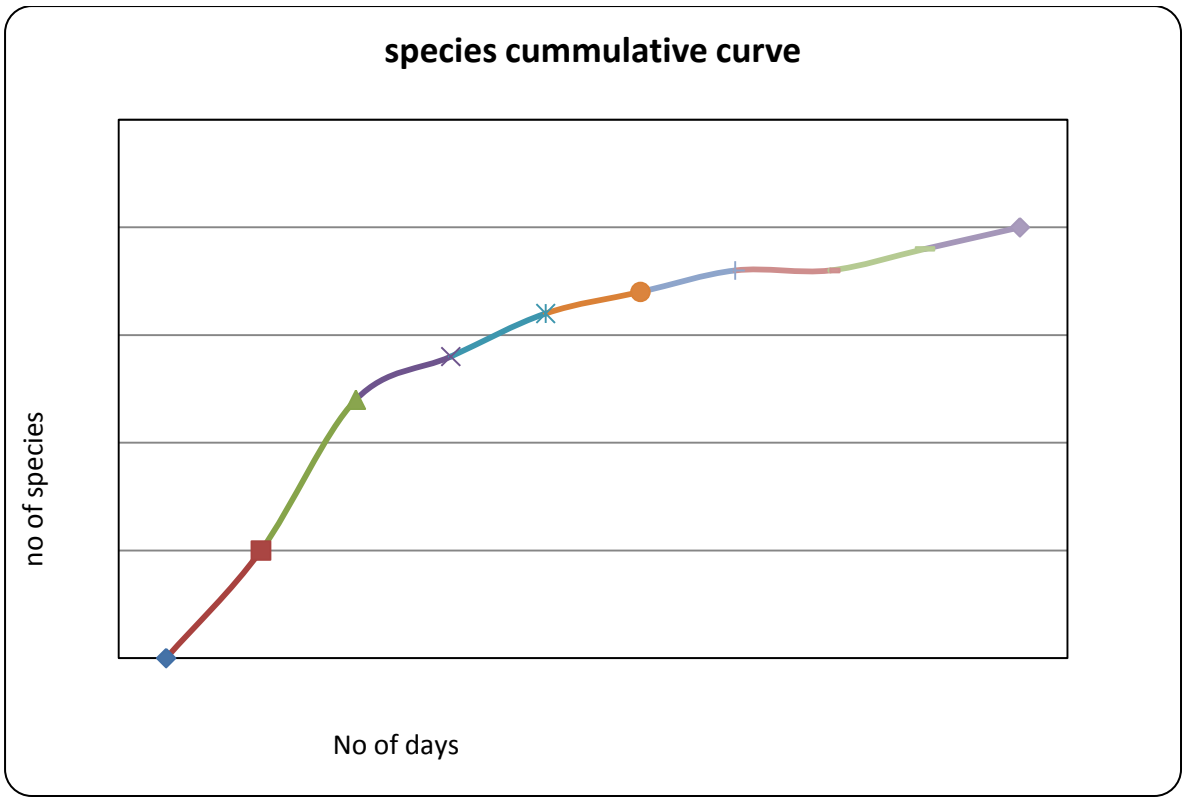


Figure 7: Cumulative curve to predict likelihood of realizing new species for the survey on the southern slope of Mt Elgon-Kenya

We used the number of species recorded in the conventional traps to assess and compare species diversity across the ecozones (Table 2). Taking short-comings of under-sampling into consideration, Species richness varied from highest eight in Montane forest to three in bamboo, using Shannon-Weiner and Brilouin indices (table1), that takes number of species and abundance into account(Magurran 2013). Subalpine forest had second most diverse small mammal species, with fairly even abundance. The moorland though not as poor as bamboo habitat, was less heterogeneous compared to the adjacent habitat (Fig 8 and Table 2). The low small mammal diversity in both bamboo and moorland can be attributed to the apparent habitat configurations. Bamboo has express ecological monotony thereby offering few niches akin to artificial monocrop plantations(Jose, Williams, and Zamora 2006). The moorland has complex ecological structure, the extreme temperature limits species of small mammals that can adapt the habitat hence low diversity.

Table 2: Overall species diversity across all zones of the southern part of Mt Elgon-Kenya

Index	Montane Forest	Bamboo	Transition zone	Subalpine Moorland
No of species	8	3	5	8
Simpson Diversity (1-D)	0.825	0.679	0.879	0.545
Shannon Weiner H'	2.63	1.406	2.611	1.47
Brilluoin H	2.365	1.06	1.94	1.187
Simpson Evenness1/D)	0.662	0.821	0.778	0.418
Modified Nee	0.195	0.464	0.3	0.142

Typically such unique habitats harbor unique species not distributed to common habitats especially for non-volant species such as rodents and shrews.

Diversity and abundance of small mammals in Mixed montane forest zone

At the lower altitude forest (Montane forest), eight species of rodents and shrews; and 5 bats species were recorded in the trapline and acoustic survey respectively. Orange toothed rat, *Tachyoryctes rudii,* Lagomorph, *Lepus saxatilis* and African giant squirrel, *Protoxerus strangeri* were recorded opportunistically in the zone.

Expectedly African soft furred rat, *Praomys jacksoni* was the most dominant (Table 3) followed closely by Brushfurred rat, *Lophuromys zena*. Both species are adapted to and common in wet forests, galleries and secondary growths throughout tropical Africa (Kingdon 2015). Surprisingly, however, typical grass rat, *Lemniscomys striatus* and common mouse, *Mus minutoides* and *Mus triton* were recorded in the same transect in the montane forest (Table 3). These three rodent species are generalists in open woodlands and Savannah(Clausnitzer and Kityo 2001; Granvik 1924; Delany 1972). Their presence in this patch possibly suggests the integrity of this forest as a degraded habitat in the process of selective logging and witnessed livestock grazing.

Table 3: Small mammal species relative abundance in the Montane forest of southern slope of Mt Elgon-Kenya

Species	No of individuals	Relative abundance
1. Praomys jacksoni	19.0	0.3167
2 . Lophuromys zena	11.0	0.1833
3. Mus triton	9.0	0.1500
4. Mus minutoides	7.0	0.1167
5. Lemniscomys striatus	7.0	0.1167
6. Dendromus mesolmelas	3.0	0.0500
7. Crocidura olivieri	3.0	0.0500
8. Crocidura fumosa	1.0	0.0167

Total No. of Individuals = 60.

Diversity and abundance of small mammals in Bamboo

In the bamboo zone, only two species of rodent and one species of hare were recorded (Table 4). One individual African climbing mouse, *Dendromus mesomelas* was trapped in a single night of trapping deep in the bamboo. The rest were directly observed in the same transect. *Tachyoryctes ruddi* and *Lepus saxatilis* were observed in gaps between the bamboo blocks. All

the three species are common in highland and mid elevation forest habitats in Kenya and East and Central Africa (Kingdon 2015, Delany 1972).

Table 4: Species abundance in Bamboo

Species	No of indiv.	R abundance
1. Dendromus mesomelas	1.0	0.1250
2. Tachyoryctes ruddi	3.0	0.3750
3. Lepus saxatilis	4.0	0.5000
Total No. of Individuals =	3.	

Diversity and abundance of Small mammals in Subalpine forest zone

Subalpine zone was nearly similar to the montane forest in terms of small mammal species diversity and abundance, H'=2.61 bits, compared to 2.63 bits for the montane forest. The most abundant in this community new Kenyan near-endemic mouse, *Hylomyscus kerbisperhansi* (Demos and Agwanda et al. 2014) at 28.6% relative abundance. This species has been covered in many studies on this Mountain and elsewhere in east, central and southern Africa with other names hitherto the revision by Demos and Agwanda in 2012 (Carleton et al. 2006; Clausnitzer and Kityo 2001; Clausnitzer 2001; Demos et al. 2014). This species is known to occur in Mau (type locality), Cherengani and Mt Elgon ecosystem. In the 2009, 2010 and 2011 surveys on the NE and Easter slopes of Mt Elgon the species exhibited near dominant presence in the montane forest belt below bamboo (<2400m a.s.l). Its record above bamboo in this side of the mountain is thus uniquely suggesting habitat shift.

The second most abundant (Table 5) in the subalpine forest was Brush-furred rat, *Lophuromys zena*. This species attitudinally widely distributed(Clausnitzer, Churchfield, and Hutterer 2003). It was recorded in the lower altitude of montane forest habitat (c. 2100m a.s.l) and also here (>2900m), but not in the bamboo, according to the results in this study. It would be scientifically curious to confirm if the bamboo belt is a dispersal vicariant, isolating the montane forest and alpine populations. The species is very important prey base for leopard, serval and other cats in the Kenyan mountain ecosystems as evidenced in scat analysis data at the national Museums of Kenya (Agwanda in press). The other species recorded in medium to low abundance are common mountain species.

However, Jackson's African soft-furred rat, *Praomys jacksoni* record at this altitude represent habitat shift and altitudinal rise. Results from previous small mammal surveys in Ugandan side in 2001 (Clausnitzer and Kityo 2001) and more recent studies in Kenyan NE and Eastern section of the mountain in 2009 and 2011 by Agwanda and Demos (Demos et al. 2014), indicates that this species doesn't occur above bamboo belt. This is further corroborated by specimen records held at the National Museums of Kenya. This apparent habitat shift could possibly be due to changes habitat configurations associated with either climate or food resources for this species. A focused study is therefore recommended to determine if this could be due to change in climate factors.

Table 5: diversity and abundance of small mammal species in the subalpine forest zone of Mt Elgon-Kenya

Species	No. of individuals	R. abundance
1. Hylomyscus kerbisperhansi	4.0	0.2857
2. Lophuromys zena	3.0	0.2143
3. Rhabdomys dilectus	2.0	0.1429
4.Graphiurus murinus	2.0	0.1429
5. Praomys jacksoni	1.0	0.0714
6. Otomys typus	1.0	0.0714
7. Crocidura fuscomurina	1.0	0.0714

Total No. of Individuals = 14.

Diversity and abundance of Small mammals in Subalpine forest zone

The sampling transect at this zone was established sub-peak, about 34501m above sea level. The habitat was characteristically and dominantly tussock grass but dotted with shrubs and rocks. There were also widespread signs of recent fire, with sprouting grass and shrubs apparent. This could fundamentally influence the small community structure. It was thus not surprising to note (see Table 6) that highland grass specialist, *Rhabdomys dilectus* dominating by >60% (Table 6). This was distantly followed by mountain ecosystem generalist, *Lophuromys zena*(21.7%). The two Mt Elgon endemic and endangered species of small mammal: *Otomys barbouri* and *Crocidura elgonis* were recorded in this zone. Despite being recorded in low abundance (0.04%) each, their presence presents a glimpse of hope in a gloomy environment where ecological footprint stumped by frequent fire and extensive grazing is threatening to fundamentally wipe native species of both small and large wild fauna.

In previous small mammal surveys in the western slopes(Ugandan side) (Clausnitzer, Churchfield, and Hutterer 2003; Clausnitzer and Kityo 2001; Clausnitzer 2001), Eastern and NE slopes(Demos et al. 2014, 2014; Carleton, Byrne, and Graves 2006), relative abundance of the endangered *Otomys barbouri* is relatively higher than this (2nd highest after *Rhabdomys dilects* (Granvik 1924; Carleton, Byrne, and Graves 2006; Clausnitzer and Kityo 2001; Clausnitzer 2001). As a grass dependent species, frequent fires in this habitat is bound to have far reaching negative effect on the population. The same negative effect is expected on the *Crocidra elgonis* which was recorded in an equally low relative density (0.04%) and is dependent on invertebrates living among the tussock grass

Table 6: small mammal Species diversity and relative abundance in the subalpine Moorland zone of the southern section of Mt Elgon-Kenya

Species.	No. of individuals	R. abundance
Rhabdomys dilectus	15.0	0.6522
Lophuromys zena	5.0	0.2174
Graphiurus murinus	1.0	0.0435
Otomys barbouri	1.0	0.0435
Crocidura elgonis	1.0	0.0435

Total No. of Individuals = 23.

Conclusion and Recommendation

Conclusion

This study provides important results on possible spread of forest generalist species to higher elevation possibly due to change in climatic conditions on the mountain. The study also confirms presence but extremely low abundance of endangered and endemic species of Vlei's rat, *Otomys barbouri and* elgon endemic *Crocidura elgonis.* Another Mt Elgon endemic musk shrew, *Surdisorex schlitteri* was however not recorded in this study.

Recommendation

The most important recommendation is further study to establish viability of population of the endangered and endemic species to Mt. Elgon alpine and subalpine habitats which are under intensive alteration by human induced fire and grazing. The apparent habitat shift by *Praomys jacksoni* possibly due to climate change, also requires research attention. In this could lie the ecological indicator of climate change in a tropical mountain ecosystem.

References

Avenant. 2005 Barn-Owl-Pellets-A-Useful-Tool-for-Monitoring-Small-Mammal-Communities.Pdf." 2017. Accessed July 17. https://www.researchgate.net/profile/N_Avenant/publication/228647076_Barn_owl_pellets_A_useful_tool_for_monitoring_small_mammal_communities/links/0c960536c8b1743fcd000000/Barn-owl-pellets-A-useful-tool-for-monitoring-small-mammal-communities.pdf.

Carleton, Michael D., Ellen Schaefer Byrne, and Gary R. Graves. 2006. "The Status of Otomys Orestes Dollmani Heller, 1912 (Muridae: Otomyinae), a Rodent Described from the Mathews Range, Central Kenya." *Proceedings of the Biological Society of Washington* 119 (4): 477–515. doi:10.2988/0006-324X(2006)119[477:TSOOOD]2.0.CO;2.

Carleton, Michael D., Julian C. Kerbis Peterhans, Julian C. Kerbis Peterhans, William T. Stanley, and Gary R. Graves. 2006. "Review of the Hylomyscus Denniae Group (Rodentia: Muridae) in Eastern Africa, with Comments on the Generic Allocation of Epimys Endorobae Heller." *Proceedings of the Biological Society of Washington* 119 (2): 293–325. doi:10.2988/0006-324X(2006)119[293:ROTHDG]2.0.CO;2.

Clausnitzer, V. 2001. "Rodents of the Afro-Alpine Zone of Mt. Elgon."

Clausnitzer, V., S. Churchfield, and R. Hutterer. 2003. "Habitat Occurrence and Feeding Ecology of Crocidura Montis and Lophuromys Flavopunctatus on Mt. Elgon, Uganda." *African Journal of Ecology* 41 (1): 1–8. doi:10.1046/j.1365-2028.2003.00386.x.

Clausnitzer, V., and R. Kityo. 2001. "Altitudinal Distribution of Rodents (Muridae and Gliridae) on Mt Elgon, Uganda." *Tropical Zoology* 14 (1): 95–118. doi:10.1080/03946975.2001.10531145.

Corlett, Richard T. 2017. "Frugivory and Seed Dispersal by Vertebrates in Tropical and Subtropical Asia: An Update." *Global Ecology and Conservation* 11 (July): 1–22. doi:10.1016/j.gecco.2017.04.007.

Delany, Michael James. 1972. "The Ecology of Small Rodents in Tropical Africa." *Mammal Review* 2 (1): 1–42.

"Demos, Agwanda and Hickerson 2014." 2017. Accessed July 6. https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/jmammal/95/1/10.1644_13-MAMM-A-268/2/95-1-E1.pdf?Expires=1499446597&Signature=ZtcsE2I1q1k~UIVdeiyV55-mKE31zSSZERpnllF~KcWtW~J3ovdKJFVWebck0VYpJvujv4FH70zClVRr33PSg536DZXtZ0tqkzW0HlSt78tTfYBlhifmEi2RwsUrpDhu-Umb4zomZc3sHxhvCo8~PmgnwH4psyDjKJqaavgU3UH7Xo2Rm~et5u8PPSxosyBDOsBSShOlm6ENV-yaTwyYETOMJ0kf-qleqoeDDBDPlrbw22N36ZFBGTx983xNVFoknqsNp2O9Ln09FyxnT0TcEcDf6HoWB

gfDSF1D3Tl~hWXWGHSB8MSBOX9R8X7I3TD6HD2JKqhhEKhrs4u~FnKLDA__&Key-Pair-Id=APKAIUCZBIA4LVPAVW3Q.
Demos, Terrence C., Julian C. Kerbis Peterhans, Bernard Agwanda, and Michael J. Hickerson. 2014. "Uncovering Cryptic Diversity and Refugial Persistence among Small Mammal Lineages across the Eastern Afromontane Biodiversity Hotspot." *Molecular Phylogenetics and Evolution* 71 (February): 41–54. doi:10.1016/j.ympev.2013.10.014.
Goldingay, R. L., S. M. Carthew, and R. J. Whelan. 1991. "The Importance of Non-Flying Mammals in Pollination." *Oikos* 61 (1): 79–87. doi:10.2307/3545409.
Granvik, H. 1924. *On Mammals from the Eastern Slopes of Mount Elgon, Kenya Colony: Mammals Collected by the Swedish Mount Elgon Expedition 1920*. C.W.K. Gleerup. https://books.google.co.ke/books?id=-NP0JQAACAAJ.
Jose, Shibu, Richard Williams, and Diomides Zamora. 2006. "Belowground Ecological Interactions in Mixed-Species Forest Plantations." *Improving Productivity in Mixed-Species Plantations* 233 (2): 231–39. doi:10.1016/j.foreco.2006.05.014.
Kingdon, Jonathan. 2015. *The Kingdon Field Guide to African Mammals*. Bloomsbury Publishing.
Kunz, Thomas H., Elizabeth Braun de Torrez, Dana Bauer, Tatyana Lobova, and Theodore H. Fleming. 2011. "Ecosystem Services Provided by Bats." *Annals of the New York Academy of Sciences* 1223 (1): 1–38. doi:10.1111/j.1749-6632.2011.06004.x.
Kuzmin, Ivan V, Michael Niezgoda, Richard Franka, Bernard Agwanda, Wanda Markotter, Robert F Breiman, Wun-Ju Shieh, Sherif R Zaki, and Charles E Rupprecht. 2010. "Marburg Virus in Fruit Bat, Kenya." *Emerging Infectious Diseases* 16 (2): 352–54. doi:10.3201/eid1602.091269.
Magurran, Anne E. 2013. *Measuring Biological Diversity*. John Wiley & Sons.
McCauley, Douglas J., Felicia Keesing, Truman P. Young, Brian F. Allan, and Robert M. Pringle. 2006. "INDIRECT EFFECTS OF LARGE HERBIVORES ON SNAKES IN AN AFRICAN SAVANNA." *Ecology* 87 (10): 2657–63. doi:10.1890/0012-9658(2006)87[2657:IEOLHO]2.0.CO;2.
Mukherjee, Shomita, S. P. Goyal, A. J. T. Johnsingh, and M. R. P. Leite Pitman. 2004. "The Importance of Rodents in the Diet of Jungle Cat (Felis Chaus), Caracal (Caracal Caracal) and Golden Jackal (Canis Aureus) in Sariska Tiger Reserve, Rajasthan, India." *Journal of Zoology* 262 (4): 405–11. doi:10.1017/S0952836903004783.
Semere, T., and F.M. Slater. 2007. "Ground Flora, Small Mammal and Bird Species Diversity in Miscanthus (Miscanthus×giganteus) and Reed Canary-Grass (Phalaris Arundinacea) Fields." *Biomass and Bioenergy* 31 (1): 20–29. doi:10.1016/j.biombioe.2006.07.001.
"Shuttle Radar Topography Mission." 2017. Accessed July 13. https://www2.jpl.nasa.gov/srtm/africa_radar_images.htm.
Kerbis j, Hutterer and Agwanda B., 2017. Accessed July 13. http://www.iucnredlist.org/details/45954401/0.
WHITE, F. 1981. "The History of the Afromontane Archipelago and the Scientific Need for Its Conservation." *African Journal of Ecology* 19 (1–2): 33–54. doi:10.1111/j.1365-2028.1981.tb00651.x.

CHAPTER SIX

LARGE MAMMALS OF MOUNT ELGON FOREST ECOSYSTEM

By

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ABSTRACT

A direct mammal sighting and signs survey was conducted along roads and line transects in each eco-climatic zone. The surveys were undertaken through foot walk during the day time and vehicle patrols at night. The assessment was aimed at determining large mammal species range, spatial and temporal distribution in the four vegetation zones of Mt Elgon Ecosystem. The study area altitude ranged from 2178 meters to 2825 meters above sea level. The vegetation types covered included scattered mixed broad leave mixed montane forest, bamboo low-canopy forest and the sub-alpine heath.

6.1 Introduction

Mt Elgon forest ecosystem is a priority conservation area with 37 faunal species listed as "globally threatened" (22 mammal, 2 insect and 13 bird species), 9 species of which are endemic to the ecosystem (IUCN, 1995a, 1955b; (http://www.iucn.org/). Large mammals are those weighing at least 15 kg per individual. According to MUIENR and NMK, (2005) mammals seem to be reasonably well studied, with the earliest record dating 1909. Out of 13 Orders of mammals recorded for Africa, Mount Elgon has 12 of them, which is surprisingly high for such a small ecosystem.

Mammals are represented by 120 species belonging to 44 families. The mammals of Mt Elgon represent those groups that are known to be adapted to savannah, open bush land, woodland, forest mosaics, tropical rain forest, montane forest and moorland. Therefore the main objective of this rapid survey was to establish the abundance of large mammals and their distribution within the Mt Elgon ecosystem. More specifically, the study sought to determine the relative abundance of each species, the geo-spatial distribution of large mammals, and the impact of anthropogenic activities on the distribution of large mammals

6.2 Materials and Methods

A mammals' survey was conducted between 4th and 16th May 2017 along roads and line transects according to Kie (1988) and Mohammed (2010) in four eco-climatic zones namely; Mixed Montane forest, Bamboo vegetation and bushy grassy Sub-alpine vegetation.

To determine the presence of species, visual observations of mammals and other signs such as tracks, droppings, dung, feeding signs, walking trails and nests were recorded. A team of 3 to 4 persons were assigned to each transect. The team also noted the evidence of hunting, illegal farming and other activities that impact the conservation of large mammals. The surveys were undertaken through foot walks during the day time and vehicle patrols at night. The assessment was aimed at determining large mammal species range and spatial distribution in the four vegetation zones of Mt Elgon Ecosystem. Data collected was subjected to simple analysis.

6.3 Results

Roads were about 6 meters wide, open cross section from road edge is average 10 meters. Therefore allowing for about 5 meters radius tree crowns, view range was estimated at 6 + 2x10 = 2x5 = 36 meters, though this range increased up the altitude where sites were more open. Counts and densities were based on 36 meters view range from the roads and transects according to habitats.

19 mammal species were recorded, out of which the family of ungulates had the highest number of species at 7 followed by 4 carnivores and 3 primates. The African Elephants were the most abundant species leading at 156, then followed by 141 buffalos and 103 black and white colobus monkey. 4 diurnal species namely Silver backed jackal, starc's hare, Giant forest hog and Aardvark were sighted. The total number of direct sighting is estimated at 597 individuals. Table 1 below shows the mammals recorded, conservation status and preferred habitat.

Table 1: Mammal diversity

No	Family	Species	Common name	IUCN status	Kenya Wildlife Act	Habitat
1.	Artiodactyla –even-toed ungulates	*Kobus ellipsiprymnus*	Defassa waterbuck	Not endangered	Not endangered	Sedentary in woodlands, forests and non forest mosaics where there is permanent water.
2	Carnivores - carnivora	*Civettictis civetta*	African civet	Not endangered	Not endangered	Forested and partly forested mosaics, cultivated and marshy areas
3	Primates – baboons - papio	*Papio anubis*	Olive Baboon	Not endangered	Not endangered	Woodland and forest mosaics
4	Primates – pied colobus	*Colobus guereza*	Black and White Colobus monkey	vulnerable		Rainforest and forest galleries
5	Primates – owl-faced monkey	*Cercopithecus hamlyni*	Blue monkey/ owl faced monkey	vulnerable		Dense montane forests especially bamboo
6	Oxen - Bovini	*Syncerus caffer*	African Buffalo	Not endangered		Grassy glades, watercourses and waterlogged basins
7	Even-toed Ungulates – spiral-horned bovines - tragelaphini	*Tragelaphus scriptus heterochrous*	Bushbuck	Locally vulnerable but Not endangered		Thick cover of thickets, reedbeds and water
8	Proboscids - elephantidae	*Loxodonta africana*	African Elephant	Endangered	Endangered	All vegetation types
9	Even- toed ungulates – pigs-suidae	*Hylochoerus meinertzhageni*	Giant forest hog	rare	Endangered	Mainly forest/grassland mosaics but range from subalpine areas and bamboogroves through montane

						to lowland and swamp forests, wooded savannahs and post-cultivation thickets.
10	Even- toed ungulates – pigs- suidae	*Potamochoerus larvatus*	Bushpig	Not endangered		Forest and woodlands with preference for valley bottoms with dense vegetation and soft soils
11	Odd-toed ungulates – horses - perissodactyla	*Equus quagga*	Burchell's zebra	Not endangered		Grasslands, steppes, savannahs and woodlands.
12	Even- toed ungulates –duikers - cephalophini	*Cephalophus rufilatus*	Red duiker	Not endangered		Swamp forest and marshes at both low and high altitudes up to 3500m
13	Even- toed ungulates –duikers - cephalophini	*Cephalophus niger*	Grey Duiker	Satisfactory		Rainforest, riverine galleries, isolated patches and semi-deciduous forests.
14	Aadvark - tubulidentata	*Orycteropus afer*	Aardvark	Vulnerable		Areas with year-round abundance of ants, termites and beetle larvae.
15	Carnivores – dogs and allies - canidae	*Canis mesomelas*	Silver backed jackal/ side strapped jackal	Not endangered		Various savannah, thickets, forest edges, Montane habitats up to 2700m in disturbed vegetation and cultivation, swamps and moist flood-plains
16	Carnivores – cats	*Felis serval*	Serval cat	Not endangered		Grass savannahs, subalpine and montane mosaics of moorland, forest and glades
17	Carnivores – hyaenids - hyaenidae	*Crocuta crocuta*	Spotted hyena	Not endangered	Vulnerable	Open savannahs, all acacia communities, montane moors, grasslands, dry steppes and plains with abundant

						herbivores
18	Hares - lagomorpha	*Lepus starcki*	Starck's hare	Not endangered		High altitude moorlands (2500-4000m)
19	Rodents – Giant and sun squirrels-protoxerini	*Protoxerus stangeri*	Tree squirrel/ African giant squirrel	Not endangered		In tall swamp forest and at altitude of upto 2000m

Distribution of Large Mammals in Mt. Elgon Ecosystem

The buffalo, bushbuck, grey duiker, Silver backed jackal, serval cat, and spotted hyena were sighted at highest altitude of the alpine vegetation.
The highest number of species were recorded at mixed montane forest (327) followed by bamboo vegetation (156), sub-alpine (75) and alpine (39).
The aardvark was found in bamboo forest. A herd of giant forest hogs was found browsing along Caves road in the mixed montane forest area.

The bushbuck and the buffalos were recorded in the 4 vegetation types while the serval cat and the spotted hyena were recorded in 3 habitats.
The silver-backed jackal and grey duiker were observed in sub-alpine and alpine vegetations only.

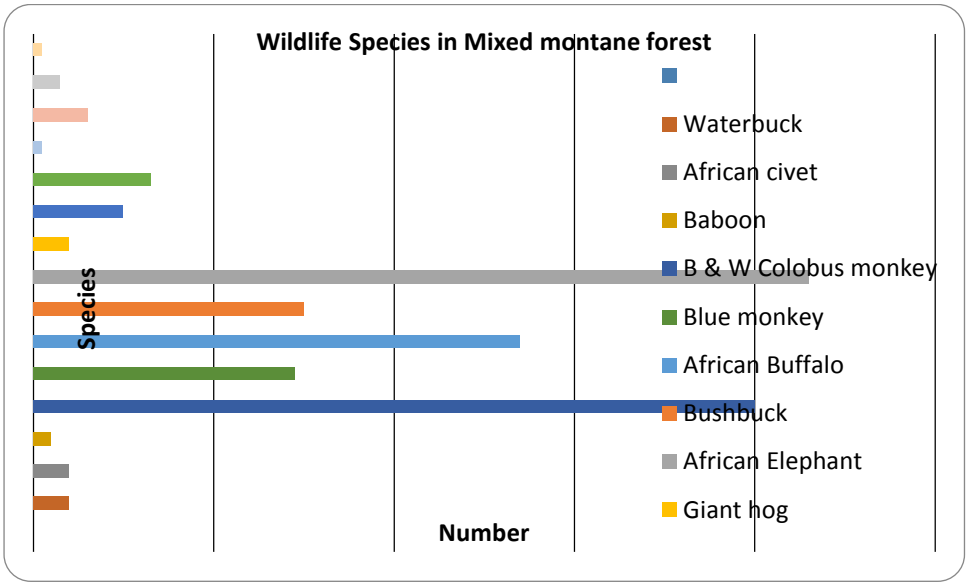
The table below shows the number of mammalian species sighted in various habitats.

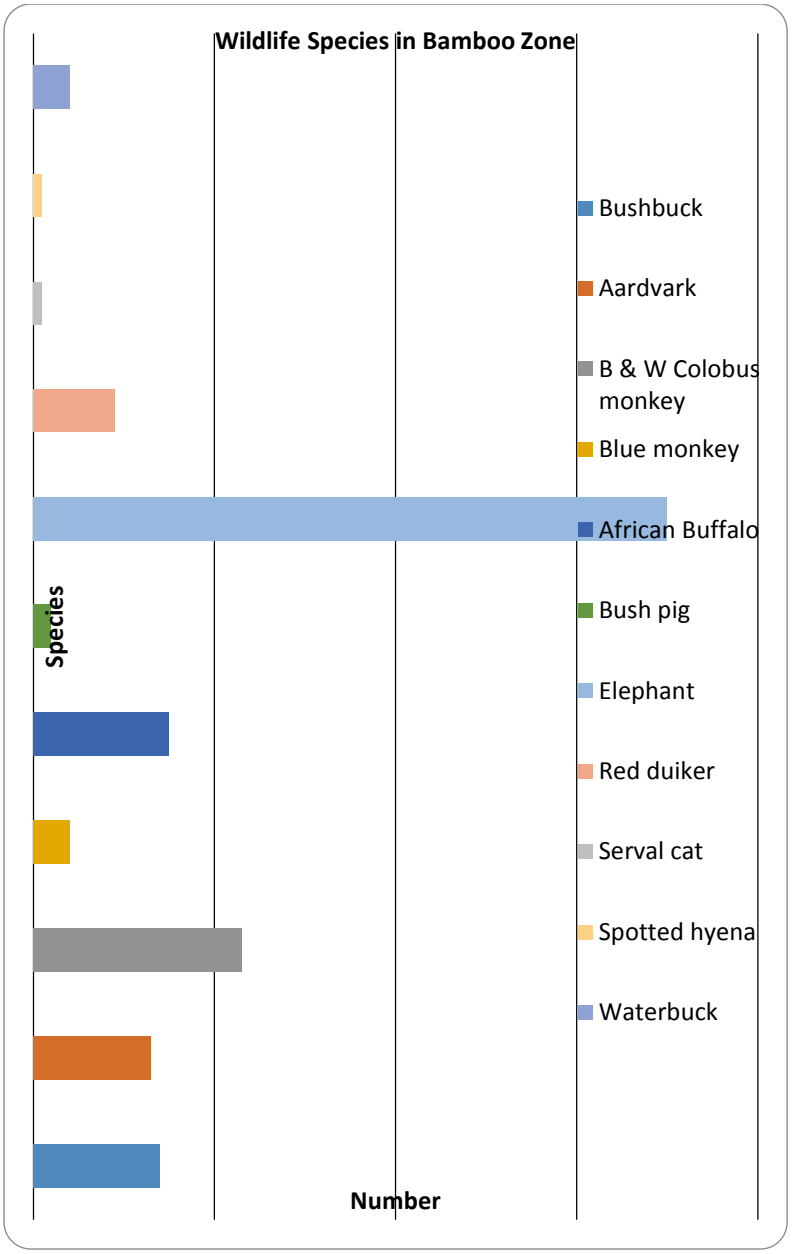
Table 2: Large Mammals distribution

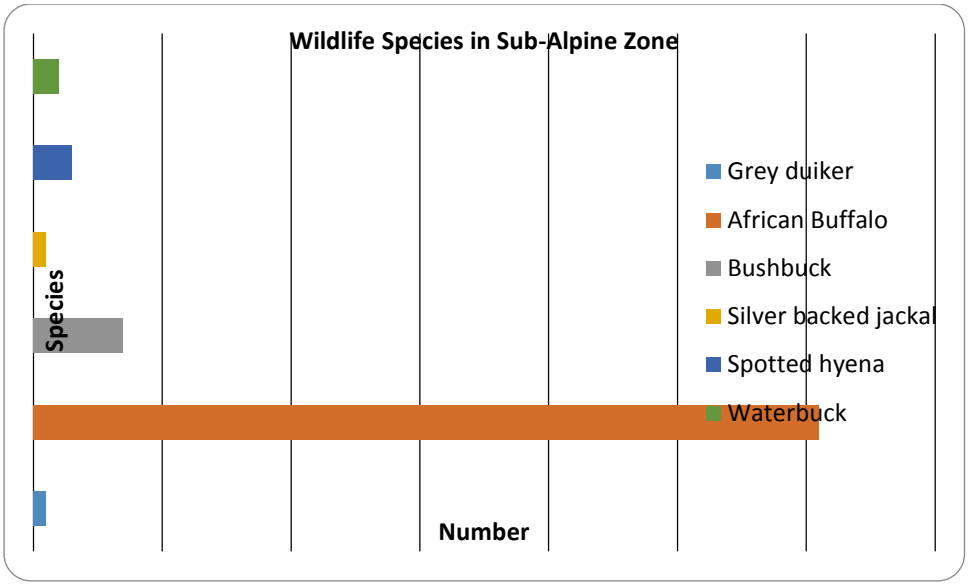
Family	**Common name**	**Mixed Montane Forest**	**Bamboo Vegetation**	**Sub-alpine Vegetation**	**Alpine Vegetation**	**Total**
Artiodactyla –even-toed ungulates	Defassa waterbuck	4	4	2		10
Even-toed Ungulates – spiral-horned bovines - tragelaphini	Bushbuck	30	14	7	7	58
Even-toed ungulates – pigs-suidae	Giant forest hog	4				4
Even-toed ungulates	Bushpig		2			2

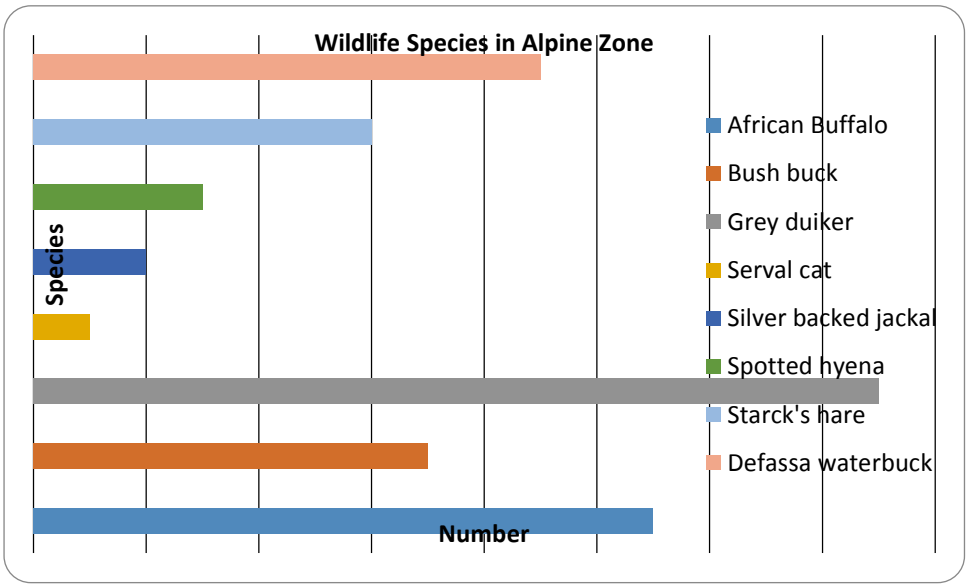
– pigs-suidae						
Odd-toed ungulates – horses - perissodactyla	Burchell’s zebra	10				10
Even-toed ungulates –duikers - cephalophini	Red duiker	13	9			22
Even-toed ungulates –duikers – cephalophini	Grey Duiker			1	15	16
Carnivore	African civet	4				4
Carnivores – dogs and allies - canidae	Silver backed jackal			1	2	3
Carnivores – cats	Serval cat	1	1		1	3
Carnivores – hyaenids - hyaenidae	Spotted hyena	6	1		3	10
Primates	Olive Baboon	2				2
Primates	black and white colobus monkey	80	23			103
primates	Blue monkey	29	4			33
Oxen-Bovini	Buffalo	54	15	61	11	141
Proboscids - elephantidae	African Elephant	86	70			156
Aadvark - tubulidentata	Aardvark		13			13
Hares - lagomorpha	Starck's hare	3		3		6
Rodents – Giant and	Tree squirrel	1				1

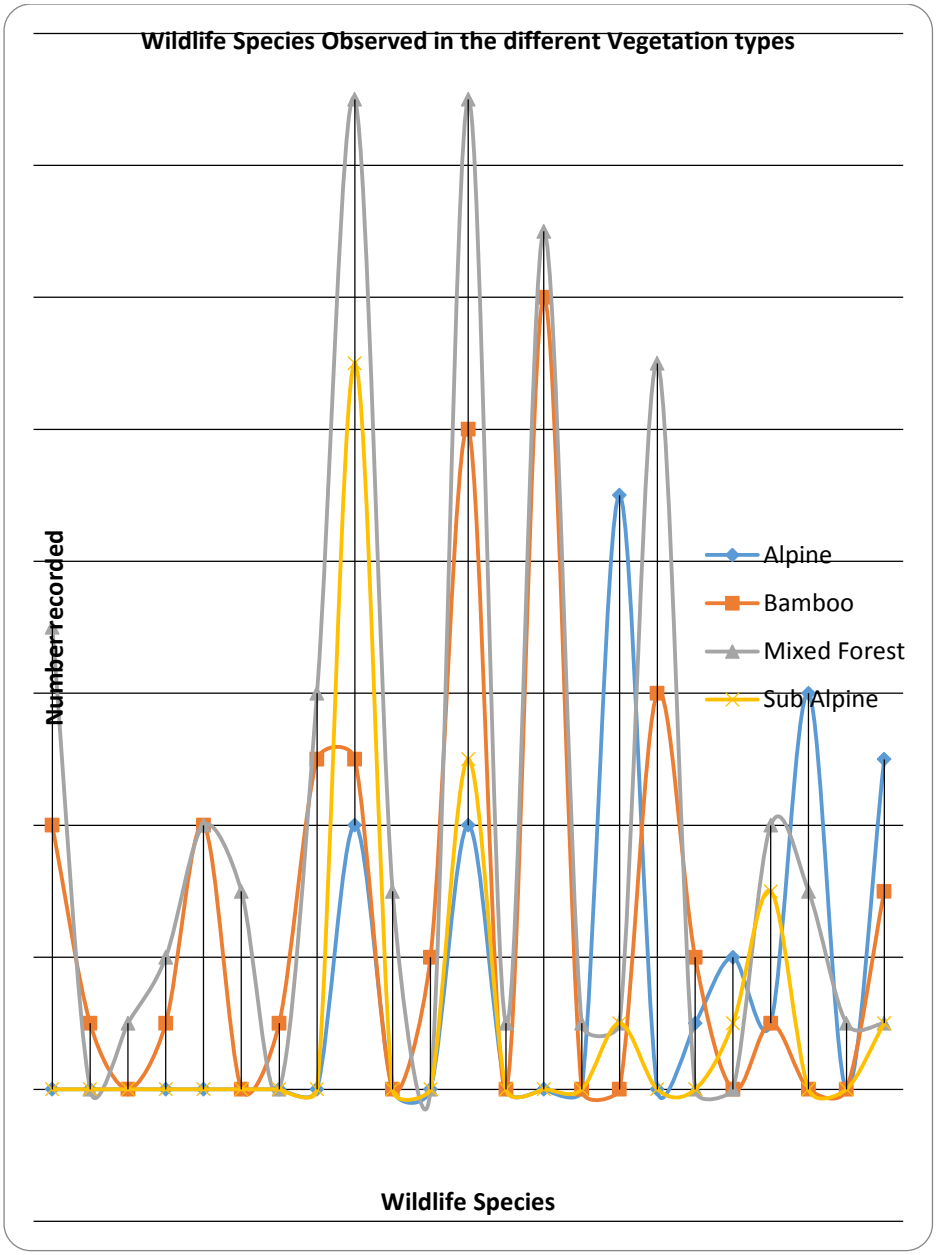
sun squirrels-protoxerini						
	Grand Total	**327**	**156**	**75**	**39**	**597**




Wildlife Species in Bamboo Zone
Bushbuck
Aardvark
B & W Colobus monkey
Blue monkey
African Buffalo
Bush pig
Elephant
Red duiker
Serval cat
Spotted hyena
Waterbuck
Species
Number


Wildlife Species in Sub-Alpine Zone
Species
Number
Grey duiker
African Buffalo
Bushbuck
Silver backed jackal
Spotted hyena
Waterbuck


Wildlife Species in Alpine Zone
Species
Number
African Buffalo
Bush buck
Grey duiker
Serval cat
Silver backed jackal
Spotted hyena
Starck's hare
Defassa waterbuck



6.4 Discussion

The mixed montane forest had the highest diversity of species while the least were sighted at alpine vegetation. The mixed montane forest area has relatively high number of resources available forage, shelter from undergrowth and upper canopy, salt licks from caves, undulating terrain – thus most species preference (Table 2). This is in concurrence with the results of MUIENR & NMK, (2005). Species records were based on both direct and indirect sightings – the latter were easily recorded from open ground. The alpine zone had relatively low ground vegetation and hence inadequate forage resulting to few sightings.

Buffalos and bushbucks were recorded in the four vegetation types. The bushpig was recorded in the bamboo vegetation. The elephants were recorded in the mixed montane forest and bamboo vegetation.

The species of concern according to the IUCN status and Kenya Wildlife Act 2013 are the African elephant that is endangered, Giant forest hog classified as rare and endangered and the

spotted hyena that is becoming vulnerable. The spotted hyena is becoming vulnerable according to Kenya Wildlife Act 2013 due to the growing negative community view that is a livestock predator that they kill whenever they encounter it.

Conclusion

Some native species during this survey were not recorded leading to recommendation of more intensive and extensive study to determine their presence and status. This would be achieved through allocating more than one team per transect and allocating more days per vegetation zone. Based on the results of the direct and indirect sightings there is potential for use of camera traps to gather more mammalian information as well as quarterly monitoring.

Management interventions

List for in-situ conservation
Sub alpine - Leopard
Mixed montane forest, bamboo & alpine - Spotted hyena
Mixed montane forest & bamboo - African Elephant

Acknowledgement
James Matui, Kennedy Chemoywa, Naitei Serut, David Kiberenge & James Malanga

References

1. Jonathan Kingdon 1997: The Kingdon field guide to African Mammals. A&C Black Publishers Ltd, 36 Soho Square, London W1D 3QY

2. Chris & Tilde Stuart 2000: A field Guide to the Tracks and Signs of Southern and East African Wildlife. Random House Struik (Pty) Ltd

3. Njogu J.G, Makenzi Paul, Ingati Paul, Mwaura A., Tokro G.O & Odhiambo C.N. November 2014:Technical Report of the Proposed Mt Elgon Trans-boundary Biosphere Reserve Kenya & Uganda.
4. Kie, G. John 1988 Performance in Wild Ungulates: Agriculture Forest Service Measuring Population Density Pacific Southwest Forest and Range Experiment Station P.O. Box 245, Berkeley, California 94701

5. Makerere University Institute of Environment and Natural Resources (MUIENR) and National Museums of Kenya (NMK) 2005 Mount Elgon Regional Ecosystem Conservation Project (MERECP) Baseline survey of the biodiversity Resources of MT Elgon Ecosystem.

6. Mohammed, I *et al* 2010 Comaprative Analysis of Fauna Numerical Characteristic of Yankari Game Reserve from 1980 – 2008 Environmental Research Journa 4 (2): 177 – 18, 2010. Medwell Journals 2010

Appendix

Plate 1: Burchell's Zebra recorded feeding at the mixed montane forest at the Chorlim forest block in the Mt Elgon National Park