LAND USE CHANGES AND FLORAL DIVERSITY IN KENYA'S MT. ELGON FOREST ECOSYSTEM †

[CAMBIOS EN EL USO DE LA TIERRA Y DIVERSIDAD FLORAL EN EL ECOSISTEMA FORESTAL DEL MONTE ELGON DE KENIA]

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SUMMARY

Background. Montane forests encompass spectacular landscapes, a wide variety of ecosystems, a great diversity of species, and distinctive human communities. Mountain forests support about one quarter of world's terrestrial biodiversity and include nearly half of the world's biodiversity "hotspots. Understanding of land use change (LUC) in mountain forest ecosystem is crucial for sustainable management of the ecosystem especially in developing countries like Kenya where the majority of the people depend on natural resources for their livelihoods. Changes in land use in this forest ecosystem could lead to a decline in biodiversity and in the livelihoods of the forest adjacent communities. **Objective:** To evaluate the differences in land use changes and floral diversity of Mt. Elgon forest ecosystem. **Methodology:** Differences in land use changes on floral diversity were evaluated using quadrats that were placed in different land uses to measure species diversity and abundance. The Shannon-Weiner diversity index and Whittaker beta diversity index was used to determine changes and similarities in floral diversity, while Kruskal-Wallis test and chi square test was used to determine differences in species abundances. **Result:** This study established that there were differences in floral diversity in relations to land use changes. The Shannon-Weiner diversity index revealed that control (natural forest) site had the highest species diversity (H=2.07331, evenness=0.884), followed by indigenous plantations (H=1.93962; evenness 0.69957), urban settlements (H=1.85081; evenness=0.66754), Nyayo Tea Zone (H=1.5324, evenness=0.56), mixed farming (H=1.43694, evenness=0.43694) and exotic plantation (H=1.28231, evenness=0.61612). Whittaker beta diversity index for control site verses urban settlements was (0.5385), indigenous plantations (0.2222), Nyayo Tea Zone (0.1429) while mixed farming and exotic plantations (0.000). Kruskal-Wallis test revealed a statistically significant differences in total number of plant species in the various study sites (H=8.288; P=0.049). Similarly, the results revealed a significant difference between specific plant communities (trees, shrubs, herbs, ferns, and climbers) in the study area (H=38.116; P=0.000). Chi square test of homogeneity was used to test difference in distribution of species communities in different location and the results revealed that the differences were insignificant. **Implications:** Results of species diversity analyses show differences in floral diversity and similarities in areas under different land uses. **Conclusion**: There are significant differences in floral diversity in areas under different land uses of Mt. Elgon forest ecosystem. Species diversity and similarity of indigenous planted forests and urban settlement closely approach that of the natural forests. Floral diversity play a critical role in provisioning of essential ecosystem services.
Keywords: diversity index; Natural forest; Plantation forest; Plant diversity; Species abundance.

RESUMEN

Antecedentes. Los bosques montanos abarcan paisajes espectaculares, una amplia variedad de ecosistemas, una gran diversidad de especies y comunidades humanas distintivas. Los bosques de montaña apoyan aproximadamente una cuarta parte de la biodiversidad terrestre del mundo e incluyen casi la mitad de los "puntos críticos" de la biodiversidad mundial. La comprensión del cambio de uso de la tierra (LUC) en los ecosistemas forestales de montaña es crucial para la gestión sostenible del ecosistema, especialmente en países en desarrollo como Kenia, donde la mayoría de las personas dependen de los recursos naturales para sus medios de vida. Los cambios en el uso de la tierra en este ecosistema forestal podrían conducir a una disminución de la biodiversidad y de los medios de vida de las comunidades adyacentes a los bosques. **Objetivo:** Evaluar las diferencias en los cambios en el uso de la tierra y la diversidad floral del ecosistema forestal del Monte Elgon. **Metodología**: Las diferencias en los cambios en

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el uso de la tierra en la diversidad floral se evaluaron utilizando cuadriláteros que se colocaron en diferentes usos de la tierra para medir la diversidad y abundancia de especies. El índice de diversidad Shannon-Weiner y el índice de diversidad beta de Whittaker se utilizaron para determinar los cambios y similitudes en la diversidad floral, mientras que la prueba Kruskal-Wallis y la prueba de chi cuadrado se utilizaron para determinar las diferencias en las abundancias de especies. **Resultado**: Este estudio esTableció que había diferencias en la diversidad floral en las relaciones con los cambios en el uso de la tierra. El índice de diversidad Shannon-Weiner reveló que el sitio de control (bosque natural) tenía la mayor diversidad de especies (H=2.07331, evenness=0.884), seguido de las plantaciones indígenas (H=1.93962; evenness 0.69957), asentamientos urbanos (H=1.85081; evenness=0.66754), Nyayo Tea Zone (H=1.5324, evenness=0.56), agricultura mixta (H=1.43694, evenness=0.43694) y plantación exótica (H=1.28231, evenness=0.61612). El índice de diversidad beta de Whittaker para los asentamientos urbanos de versos de sitio de control fue (0,5385), las plantaciones indígenas (0,2222), la Zona del Té de Nyayo (0,1429) mientras que la agricultura mixta y las plantaciones exóticas (0,000). La prueba Kruskal-Wallis reveló diferencias estadísticamente significativas en el número total de especies vegetales en los diversos sitios de estudio (H=8.288; P=0,049). Del mismo modo, los resultados revelaron una diferencia significativa entre comunidades vegetales específicas (árboles, arbustos, hierbas, helechos y escaladores) en el área de estudio (H=38.116; P=0,000). La prueba de homogeneidad de chi cuadrado se utilizó para probar la diferencia en la distribución de las comunidades de especies en diferentes lugares y los resultados revelaron que las diferencias eran insignificantes. **Implicaciones:** Los resultados de los análisis de diversidad de especies muestran diferencias en la diversidad floral y similitudes en áreas bajo diferentes usos de la tierra. **Conclusión**: Hay diferencias significativas en la diversidad floral en áreas bajo diferentes usos de la tierra del ecosistema forestal del Monte Elgon. La diversidad de especies y la similitud de los bosques plantados autóctonos y los asentamientos urbanos se acercan estrechamente a la de los bosques naturales. La diversidad floral desempeña un papel fundamental en el suministro de servicios esenciales de los ecosistemas.

Palabras clave: Índice de diversidad; Bosque natural; Plantación de bosque; Diversidad de plantas; Abundancia de especies.

INTRODUCTION

Biodiversity is the relationship between species and their pattern of richness (Young & Swiacki, 2006). The conservation of biodiversity is an important issue of world conservation strategies. Mt. Elgon forest ecosystem is endowed with rich biodiversity of renowned global importance (Davenport, Howard, & Dickenson, (1996). It harbors a large number of rare and some endemic Afromontane biota (White, 1983). Montane forests encompass spectacular landscapes, a wide variety of ecosystems, a great diversity of species, and distinctive human communities. Mountain forests support about one quarter of world's terrestrial biodiversity and include nearly half of the world's biodiversity "hotspots (Convention on Biological Diversity, 2010). Referred to as the 'water towers of the world', mountain forest ecosystems cover about twenty-seven (27%) of the world's land surface and directly support twenty-two (22%) of the world's population and provide the freshwater needs for more than half of humanity (Convention on Biological Diversity, 2010). Mt. Elgon forest was provisionally ranked amongst the top ten species rich forests and was identified as a priority for the conservation (Davenport *et al*., 1996).

In the last few decades, land use changes in Mt. Elgon forest ecosystem seems to have led to differences in floral diversity of the region. These changes include sprawling of urban centres, enlargement of size of land under mixed and Nyayo Tea Zone (NTZ), introduction of exotic and plantation forests. Nyayo Tea Zone was introduced to create a buffer on the Mt. Elgon forest and thus protect the forest from further encroachment. While Nyayo Tea Zone is believed to increase income of the government and of the local community, little is known about changes in floral diversity and abundance associated with its establishment. Plantations forests cover about 140 million hectares globally, representing about 4 per cent of the global forest area (FAO, 2007). Plantation forests play a critical role in meeting to needs of the society in terms of wood production for domestic and industrial use. To add on this, plantations forests provide several important ecosystem services, including carbon sequestration, clean water production, regulation of the hydrological cycle, and improvement in the connectivity of landscape mosaics for biodiversity conservation and the alleviation of desertification. In Kenya, plantation forest ranges from indigenous to exotic plantations, but little seems to be known changes floral diversity associated with its establishment. Similarly, the level of urban sprawl has that has increased worldwide and particularly in Mt. Elgon could subsequently have led to variations in floral diversity.

The International Congress on Agriculture and Biodiversity (ICAB) opines that more research is needed to establish the link between agriculture, trade, and its effects on biodiversity (UNEP, 2002). Unfortunately, political instability in the Mt. Elgon region has made it difficult for research to be carried out on the Kenyan Mount Elgon region (Masika, 2009). From ecological and conservation point of view, assessment of biodiversity of any habitat or locality has been regarded as one of the vital issue for careful preservation, promotion and management of the variety of life-forms (Alam and Masum, 2005). The objective of this paper is to assess the floral diversity (trees, shrubs, herbs, climbers and ferns) of natural forest, mixed farming site, urban settlements, exotic plantation forests and natural plantation forests of Mt Elgon forest ecosystem.

The findings of this study will ensure adequate measures are taken to protect, conserve and sustainably manage floral diversity in relation to various land use types. Previous research carried out in Mt. Elgon region focused on trans-boundary biodiversity management challenges and the local and stakeholder perceptions of the management policies and conservation of the various protected areas (Pertursson *et al.*, 2011). Little has been reported on land use changes and floral diversity of the Mt. Elgon forest ecosystem. This study therefore fills this gap of knowledge.

METHODS

Study area

Mount Elgon forest is a transboundary ecosystem located in North-western Kenya and Eastern Uganda. In Kenya it is surrounded by the counties of Bungoma to the south and Transnzoia to the east. On the Ugandan side, Mbale district is to the south-eastern part, Sironko district to the west and Kapchorwa district to the north. This study was carried out in Bungoma and Transnzoia counties of Kenya (Figure 1).

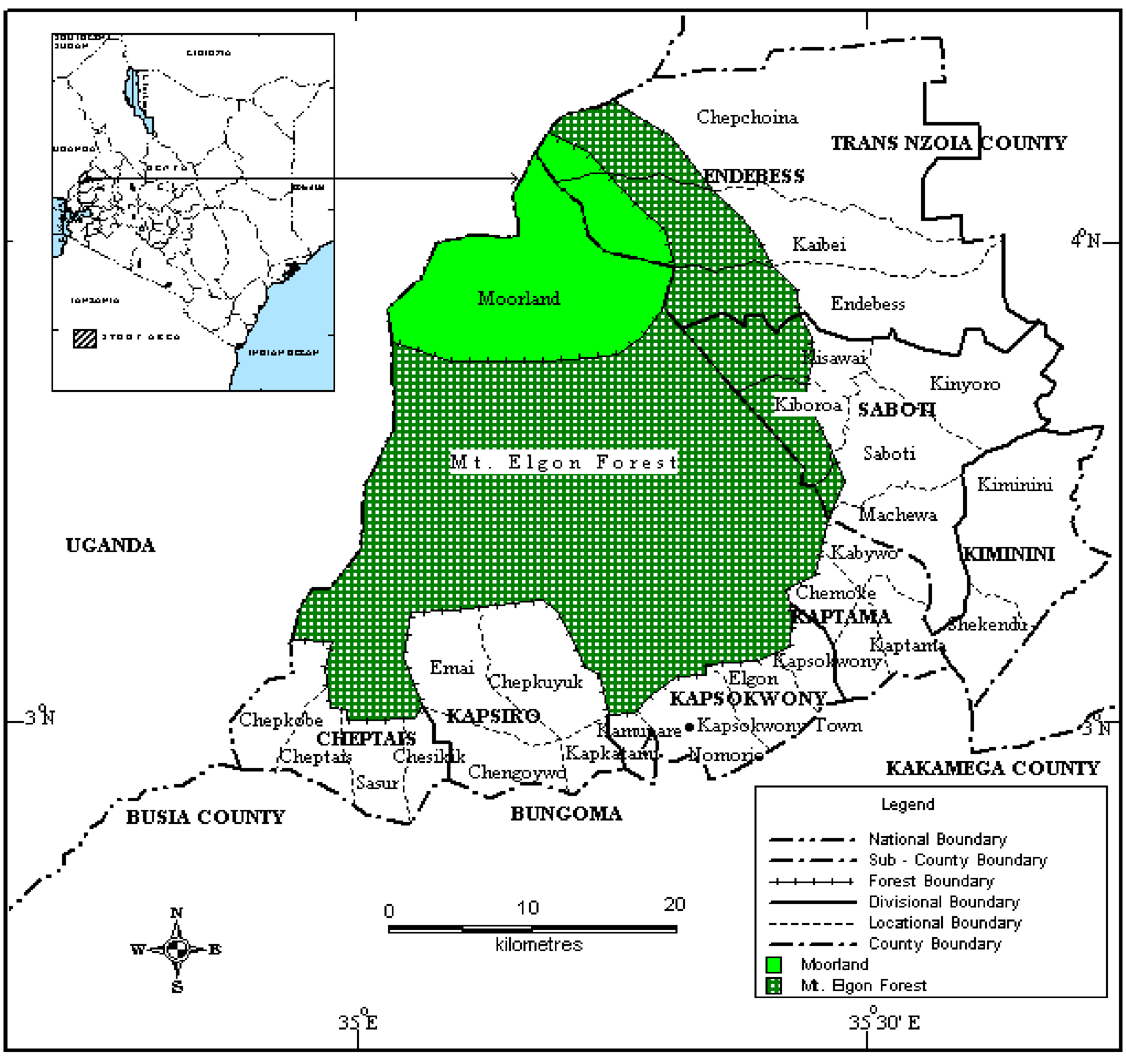

Figure 1. Map of the Mt. Elgon Forest Ecosystem (Source: Author).

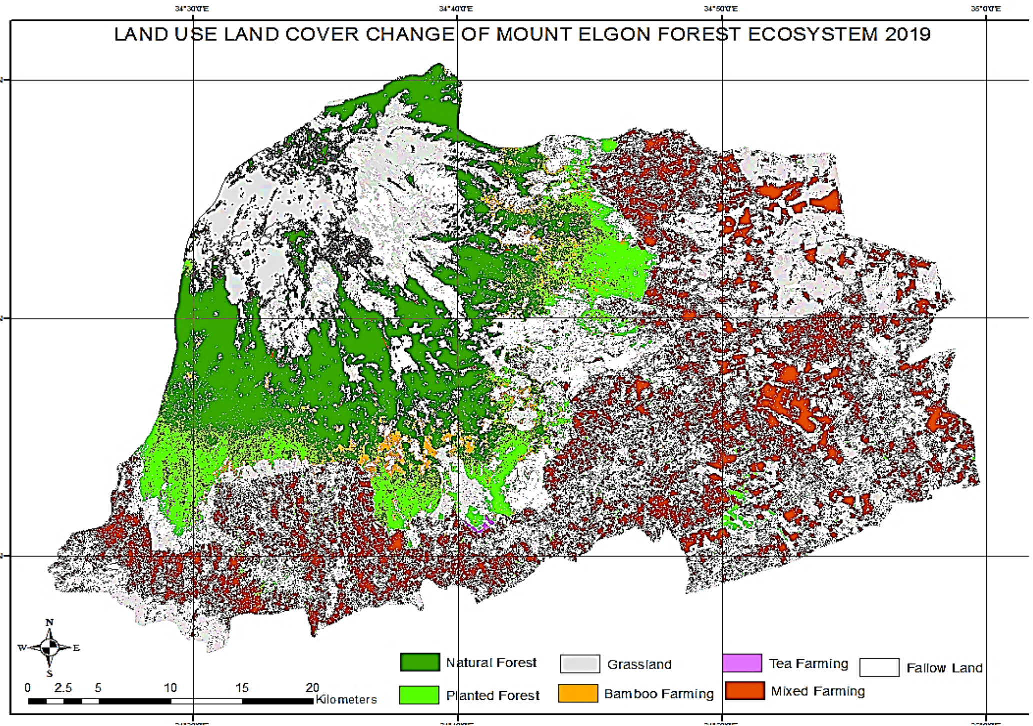

Figure 2. Land Use Land Cover of Mt Elgon Forest Ecosystem (Source: Author).

Data Collection

Field survey and landsat images were used to identify the major land uses in the study area. These land uses captured using landsat images included mixed farming, tea farming, indigenous planted forests and exotic planted forests while field survey established urban settlements as a major land use in the region (Figure 2).

Five duplicate random quadrats 50m x 50m were used for data collection. The first set of quadrats were established in the Nyayo Tea Zone. The second set of quadrats were placed indigenous and exotic plantations at Kaberwa. The third set of quadrats were placed in Chepkitale urban settlements, the fourth quadrats were placed in mixed farming in at Bugaa in Kapsokwony ward while the fifth set were established in the natural forest that served as the control. The control site was located at Labot in Kaptama where the forest exhibited minimum anthropogenic interferences. All species in each quadrat were sampled by counts and types. In quadrats that had trees, the diamenter at breast height (Dbh) of trees above 10cm were measured and their numbers recorded. The location of each land use was mapped using a Global positioning System (GPS).

Observations were made on status of land uses and land cover, and vegetation types both within the forests and areas adjacent in different land uses. Accessible areas of the forest such as Chepkitale and Labot villages were visited and the vegetation cover and plant species diversity recorded. In situations where the numbers of species was too large to be counted, the absolute abundances of some species were estimated by counting the number of species in 1mx1m. The results were calculated and expolated to 50m*50m. This data was captured by use of a 20.1 Mega pixel, Wide 5x zoom Nikon camera.

Data on species diversity was analyzed using Shannon-Weiner Diversity Index and Whittaker beta diversity index while differences in species abundances were analyzed using the Kruskal-Wallis test and chi square test of homogeneity. Kruskal Wallis test was used because the data used failed the normality test based on kolmogrov test for normality. Kruskal-Wallis test was also used to determine the difference in total number of species in various locations and difference in varieties of species (trees, shrubs, herbs, ferns, and climbers) between the different land uses. Chi square test of homogeneity was used to test difference in distribution of species in different location. Variations in species diversity and evenness were computed for species under different land uses. Ranking of species diversity was done to determine the variation in floral diversity in areas under each land use and compared the floral diversity of the control site to assess the variations in plant species in relation to different of land uses. A comparison of the importance of the various species in different locations were also analysed.

RESULTS

There was variations floral diversity with respect to land use types. The variation included changes in species diversity and abundance. Land uses impacted significantly the abundances of trees, herbs shrubs, ferns and climbers. There was a significant decrease in the abundances of trees in majority of the land uses but an increase in herbs and shrubs.

Land uses on floral diversity

Table 1 shows the differences in floral diversity under different land uses in the Mt Elgon ecosystem; Exotic plantation forests had the lowest diversity index in comparison to other land uses. Indigenous forests had a diversity index (H= 1.93962, evenness=0.69957) that was not significantly different from the control (H=2.07331, evenness=0.864). Urban Settlements had a diversity index of H=1.85081, Evenness=0.66754) Nyayo Tea Zone (NTZ) (H=1.5324, Evenness=0.56) and mixed farming H=1.43694, Eveness=0.452114)

Table 1. Floral diversity under different land uses.

Rank	Study Site	Shannon Weiner Diversity Index	Evenness
1	Control Site	2.07331	0.884
2	Indigenous Plantation forest	1.93962	0.69957
3	Urban Settlement	1.85081	0.66754
4	Nyayo Tea Zone	1.5324	0.56
5	Mixed Farming	1.43694	0.452114
6	Exotic Plantation forest	1.28131	0.61612

Results indicated that there was an insignificant difference in the plant species diversity between and indigenous plantation forests (H= 1.93962) and the near natural (control) forest at the Labot site (H=2.07331). Similarly, there was variation in the evenness of plant species in the three study sites.

Within-habitats of various study sites, Whittaker beta diversity index for urban settlements verses control site was overally ranked the highest with β-diversity index of 0.5385. This was followed by indigenous plantations with a β-diversity index of 0.2222. Nyayo Tea Zone had a β-diversity index of 0.1429. The study however revealed that mixed farming and exotic plantations had a β-diversity index of 0 (Table 2).

Table 2. Below shows differences in Beta Diversity index in areas under different land uses in Mt Elgon forest.

Rank	Study Site	Beta Diversity Index
1	Control Site /Urban Settlement	0.5385
2	Control Site/ Indigenous Plantation forest	0.2222
3	Control Site /Nyayo Tea Zone	0.1429
4	Control Site /Mixed Farming	0.000
5	Control Site /Exotic Plantation forest	0.000

These results reveal that species in urban settlements were more similar to those of the control site. This was followed by indigenous plantations and Nyayo Tea Zone (Table 2). On the contrary exotic plantation and mixed farming had species that were completely different from those of the control site. These findings show that the floral diversity of indigenous plantation forest and urban settlements can easily approach that of undisturbed natural forests over a shorter time scale.

Results of Kruskal-Wallis test revealed that there was statistically significant differences in total number of plant species in the various study sites (H=8.288; P=0.049). Similarly, the results revealed a significant difference between specific plant communities (trees, shrubs, herbs, ferns, and climbers) in the various study sites (H=38.116; P=0.000). Chi square test of homogeneity was used to test difference in distribution of species in different location and the results revealed that the differences were insignificant.

Land uses Changes and Species abundances

Species abundances varied with different land uses. Figure 3 shows differences in floral species abundances in different land uses compared to the control. Herbs were the most abundant species in exotic and indigenous plantation forests. In exotic plantation forests, herbs had an abundance of 50% (n=4) while in indigenous plantation forest, this abundance was 43.75% (n=7). This translated to an overall increase of 23% in herbs in exotic plantation forests and a 16.48% increase in indigenous plantation forests as compared to the control site that had a herb abundance of 27.27% (n=3). There were further differences in the abundance of trees with a 17.5% decline in abundance in indigenous plantation forests and a 30% decline in exotic plantation forests as compared to the control site (Figure 3). Shrubs also increased by 3.41% in the indigenous plantation site in comparison to the Labot control site but did not exist in exotic plantations. Climbers were reported both in indigenous and exotic plantations with an abundance of 25% and 6.25% respectively. Climbers were however not present in the control site. Ferns were only reported in the control site.

Figure 4 shows the abundances of floral species in the control and the urban settlements. A comparison of species by species abundance revealed that trees declined by 29.55% in urban settlement site from 54.55% (n=6) to 25% (n=4). One fern species recorded in the control site was absent in urban settlements. There was an increase in herb species in urban settlement site by a 16.48% from 27.27% (n=3) to 43.75% (n=7). Shrubs also increased by 9.66% in the urban settlement site in comparison to the control site while grasses had a 6.25% (n=1) abundance in urban settlement site (Figure 4).

Figure 5 shows a species by species comparison between the control site and the area under tea plantation. Trees and ferns declined by 48.3% and 9% respectively while herbs increased by 33%, climbers 6.67%, and shrubs 4.21% in the Nyayo Tea Zone.

The most abundant species in mixed farms were herbs with 54.55% (n=12) abundance, followed by shrubs with an abundance of 36.36% (n=8) while climbers and trees were the least abundant with each at 9.09% (n=2) dominance (Figure 6).

There was a clear distinct variation in plant species between the control site and mixed farming areas. Tree species declined by 45.46% in mixed farming compared to the control site. Similarly, there was a 9.09% decline in the abundance of ferns. There was, however, a 27.27 % increase in the abundance of shrubs, 27.28% in herbs and 9.09% in mixed farming. Results of Kruskal-Wallis test revealed that there was statistically significant difference in plant communities(trees, herbs, shrubs, ferns and climbers) between the control site and mixed farming site (H=13.113; P=0.011). Figure 7 summarizes the various species recorded in different land uses in Mt Elgon forest ecosystem.

ABUNDANCE AND DIVERSITY OF HERBS

The most abundant herb in Mt Elgon forest ecosystem was *Isoglossa laxa* with a mean abundance of 18.37%. Its highest abundance was recorded in indigenous plantations 66.53% (n=8050). This was a 42.15% increase from the 24.38% (n=1950) abundance in the control site. This herb had an abundance of 14.48% (n=3650) in urban settlements and a 4.8% (n=4875) abundance in Nyayo Tea Zone. *Isoglossa laxa* therefore reported a 10% and 19.58% decline for urban settlements and Nyayo Tea Zone respectively (Table 3).

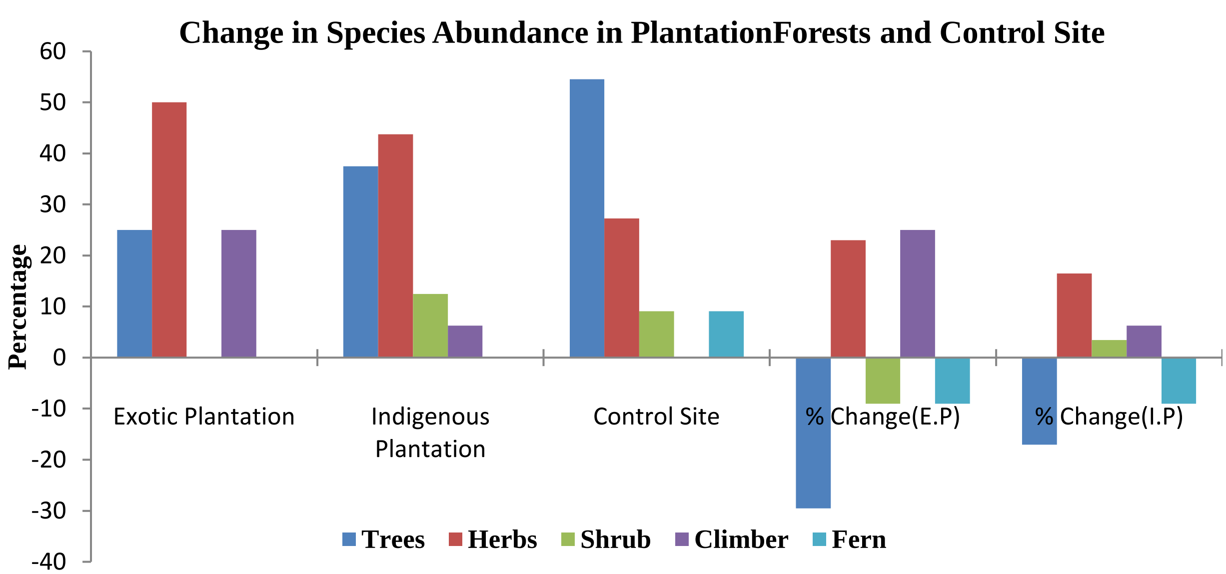

Figure 3. Abundance of species in the control, exotic (EP) and indigenous (IP) forest plantations.

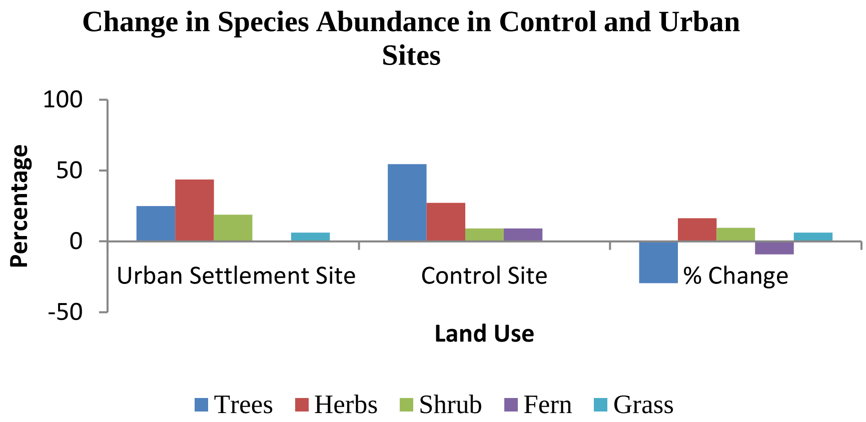

Figure 4. Percentage change in plant species between urban settlements and the control site.

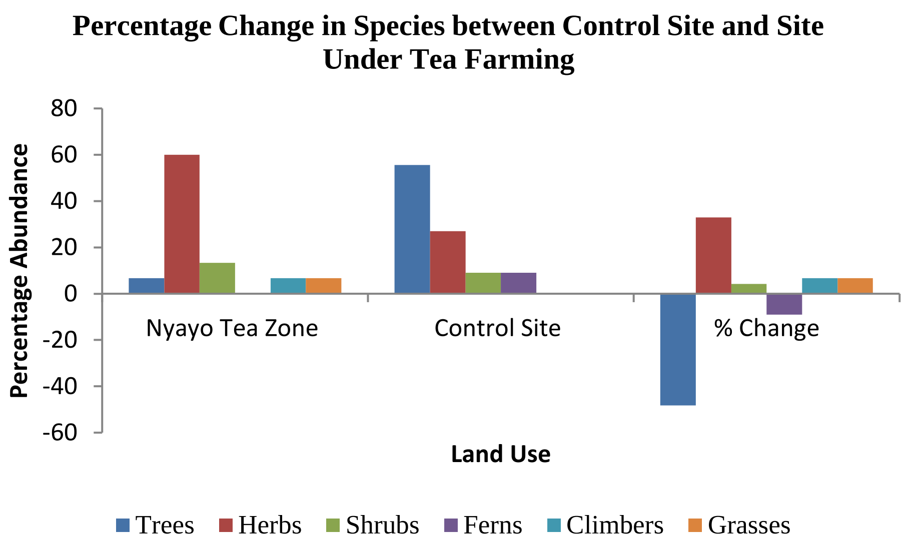

Figure 5. Percentage change in species between the control and Nyayo Tea Zone.

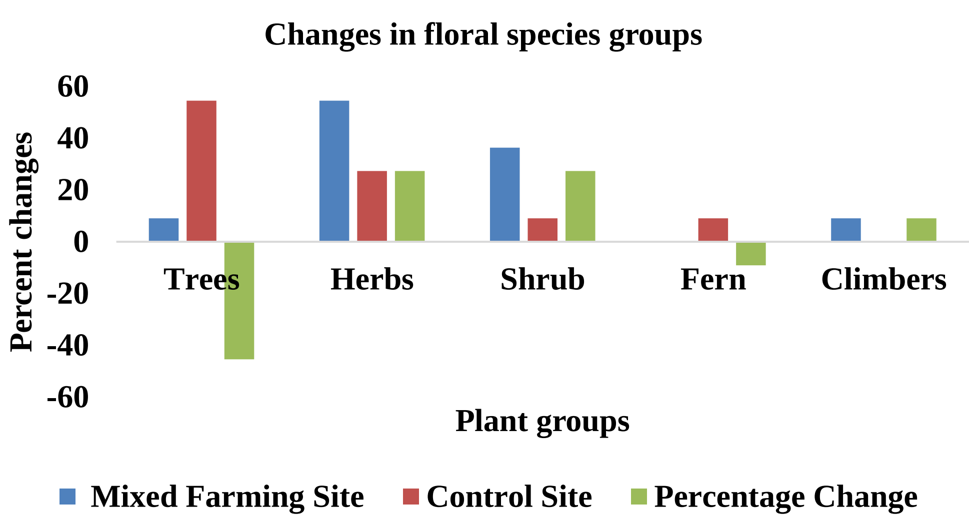

Figure 6. Percentage change in plant species between mixed farming and the control site.

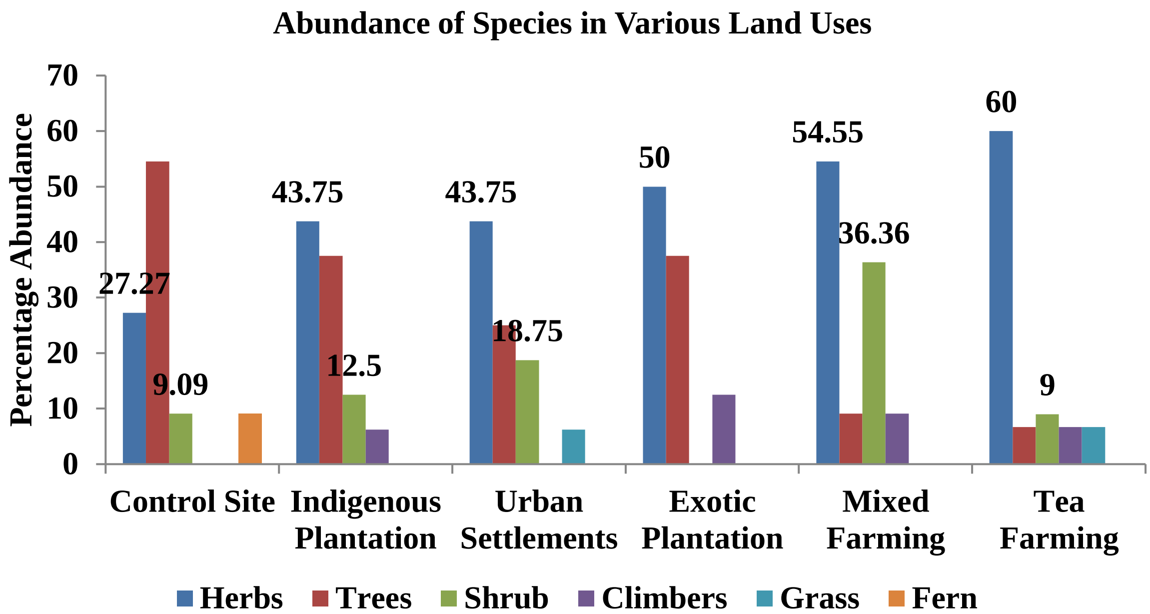

Figure 7. Abundance of species in areas under different Land Use

Oxalis anthelmintica was the second most abundant herb in the region with a mean abundance of 16.75%. It highest ubandance was recorded in urban settlements with an abundance of 57.54% (n=14500). This was a 29.41% increase from 28.13% (n=2250) abundance in the control site. These herb had an abundance of 9.9% (n=10000) and 4.96% (n=600) in Nyayo Tea zone and indigenous plantations respectively (Table 3).

The most abundant herb in the Nyayo Tea Zone was *Urtica massaica* (71.6%; n=72000). These herb had an abundance of 14.09% (n=3550) in urban settlement but was absent in the control site. *Urtica massaica* accounted for the 23.6% of the 33% increase observed in the herbs in the Nyayo Tea Zone (Table 3).

Justicia flava with an abundance of 79.91% (n=23600) was the most abundant and the major contributor to the significant increase in the herbs in mixed farming areas. This herb accounted for some 21.8% of the 27.28% increase in herbs was reported in are under mixed farming. The herb was however absent in all other study sites (Table 3).

Achyrospermum schimperi reported an abundance of 62% (n=11000) in exotic plantations. This herb was absent in all other study sites. Analysis of herbs in the control site, revealed that the most abundant herbs in the control site were *Crepis carbonaria* (47.5%; n=3800). This herb was also reported in urban settlements with an abundance of 9.13% (n=2300) (Table 3)

Galinsonga parviflora with an abundance of 34% (n=6000), *Vernonia auriculifera* 2.8% (n=500) were recorded in the exotic plantation forest but were all absent in the control site. *Vernonia auriculifera* however reported an abundance of 17.32% (n=2100) in indigenous plantations, 3.16% (n=933) in mixed farms and 2.7% (n=2750) in Nyayo Tea Zone (Table 3).

Research established that these herbs played a critical role in provision of herbal medicine to the local community. For instance, the research established that *Conyza bonariensis* is used by the local community in the treatment of head ache. *Plectranthus comosus* is used in the treatment of swollen legs and stomach upsets. *Urtica massaica* is used by the local community in treatment of boils while is used in the management of labour and afterbirth pains. *Urtica massaica* is also used as a wild vegetable species by the local community. *Isoglossa laxa* is a cover crop that protects the soil from soil erosion while the leaves of *Oxalis anthelmintica* was reported to be a medicinal plant that is used by the local community to improve in digestion. These results therefore indicate that the increase in herbaceous species in the study site has played a critical role in the provisioning of essential ecosystem services such as herbal medicines and wild vegetables.

Table 3. Percentage Change in Herbs in the Control Plot and Nyayo Tea Zone (NTZ).

Herb	I.P	E.P	Control Plot	Urban Settlements	NTZ	Mixed Farming	Mean Abundance
Isoglossa laxa	66.53		24.38	14.48	4.8		18.365
Oxalis anthelmintica	4.96		28.13	57.54	9.9		16.755
Urtica massaica				14.09	71.6		14.28167
Justicia flava						79.9	13.31667
Achyrospermum schimperi		62.5					10.41667
Crepis carbonaria			47.5	9.13			9.438333
Galinsonga parviflora		34			0.19	0.56	5.76
Vernonia auriculifera	17.32	2.8			2.7	3.16	3.88
Plectranthus comosus	7.02			2.38		1.58	1.83
Dichondra repens					7.4		1.233333
Plectranthus sylvestris						4.51	0.751667
Ageratum conyzoides						3.39	0.565
Vernonia hymenolepis	3.31						0.551667
Achyranthes aspera						2.93	0.488333
Achyrospermum schimperi					2.1		0.35
Crassocephalum picridifolium						1.81	0.301667
Commelina lugardii				1.19			0.198333
Kalanchoe mitejea				1.19			0.198333
Cymphostemma kilimandscharicum		1			0.15		0.191667
Conyza bonariensis					1		0.166667
Leonotis nepetifolia						0.9	0.15
Phytolaccadodecandra						0.34	0.056667
Conyza foribunda						0.11	0.018333

ABUNDANCE AND DIVERSITY OF TREES

Cuppressus lusitanica was the most abundant tree in the study site with an average abundance of 32%. *Cuppressus lusitanica* was the most dominant tree species in the The Nyayo Tea Zone and site under exotic plantations. There were, however, 18 stumps of indigenous tree species in the NTZ that had been harvested. This probably could explain the reason for the disappearance of the indigenous tree species and an indication that the region has experienced increased anthropogenic activities such as logging and deforestation (Table 4).

Olea europea was the most dominant tree species in urban settlements with an abundance of 86.49% (n=32). This abundance was quite high in comparison to its abundance in the control site 11.32% (n=7). This tree species was however absent in other study sites. The dominant tree species in the mixed farms was *Croton macrostachyus (*66.67%; n=67). This tree species was also reported in small numbers in exotic plantations and indigenous plantations (Table 4).

The tree species *Cedrus atlantica*, was the most abundant tree species in the control site with a 47.5% (n=28). It was also reported in urban settlement site with an abundance of 2.7% (n=1). *Zanthoxylum giletti* was the most abundant tree species in indigenous plantation forest with an abundance of 39.47% (n=1500). This tree species was also reported in exotic plantations with an abundance of 6.12% (n=300) (Table 4).

Olea africana was the only tree species that was present in both the indigenous plantation forest and the control though with reduced abundance in the control site. Its abundance in the indigenous plantation site was 34.21% (n=13) while its abundance in the control site was 1.69% (n=1). *Olea africana* had an abundance of *8.11%* (n=3) in urban settlements which was also higher than its abundance in the control site (Table 4).

Table 4. Percentage Abundance of Trees in the Study Area.

Tree Species	Control Plot (%)	E.P (%)	I.P (%)	Urban Settlements	Mixed Farming	NTZ	Mean Abundance
Cuppressus lusitanica		92				100	32
Olea europea	11.86		-	86.49			16.39167
Croton macrostachys	-	2.04	2.63		66.67		11.89
Cedrus atlantica	47.46		-	2.7			8.36
Zanthoxylum giletii	-	6.12	39.47				7.598333
Olea africana	1.69		34.21	8.11			7.335
Ficus lutea					33.33		5.555
Podocarpus latifolia	22.03		-	2.7			4.121667
Erythrina abyssinica	-		*18.4*				3.066667
Rapanea melanophloeos	10.17		-				1.695
Hagenia abbysinica	6.78		-				1.13
Albizia gummifera	-		2.63				0.438333
Acacia lahai	-		2.63				0.438333

Ficus lutea (33.3%; n=33) was only present in mixed farms. The control site, however had a higher abundance of *Podocarpus latifolia 22.03%* (n=13) in comparison to urban settlements 2.7% (n=3). *Erythrina abyssinica* was only present in indigenous plantations while *Rapanea melanophloeo* 10.17% n=6 and *Hagenia abbysinica* 6.78% (n=4) were only present in the control site (Table 4).

These findings indicate on an increase in abundance of exotic tree species and a decline to indigenous tree species. *Cedrus atlantica* was used as herbal medicine for the treatment of skin disease. This tree species is also used in the production of durable wood used in furniture production. The results point to a decline in this plant species in the region and thus a reduction in the essential ecosystem services provided by it. *Podocarpus latifolia* is used by the local community for the cleansing of the womb after birth and in production of timber. The tree is endemic to Mt Elgon forest of western Kenya. This results reveal that this tree species has greatly declined in the region and it is thus among the species that are endangered in the region. *Rapanea melanophloeos* is used as herbal medicine in the treatment of stomach ache. *Olea Africana* is used in the treatment of coughs, TB and difficulty in breathing. *Croton macrostachys and Erythrina abyssinica* were also reported to be used as an ornamental plant by the local community. *Albizia gummifera* was reported to be used in the treatment of malaria, fever, typhoid and Sexually Transmitted Infections. *Acacia lahai* was used in the treatment of skin eruption while *Cuppressus lusitanica* was used in the treatment of breathing difficulties and in building and construction. On the contrary, *Olea europea* is used as an ornamental plant in the region while *Cuppressus lusitanica* is used as an ornamental plant and in the production of timber for construction in the region. The decline in indigenous plant species could endanger the production of hard wood and production of herbal medicine for the community use.

ABUNDANCE AND DIVERSITY OF SHRUBS

Vangueria apiculata ((9.09% n=3) was the only shrub in the control site but was absent in the urban settlements. *Clutia abbysinica* was the most common in urban settlement site with a 65.52% (n=950) dominance followed by *Solanum dasyphyllum* 20.69% (n=300) and *Balanites aegyptiaca* 13.79% (n=200) but were absent in the control site (Table 5).

There was a 4.21% increase in abundance in shrubs in the Nyayo Tea Zone (13.3%; n=2) compared to 9.09% (n=1)) in the control site. *Senna didymobotrya* was the most abundant shrub in the Nyayo Tea Zone site with 97.96% (n=2400) accounting for the increase in shrubs in the Nyayo Tea Zone.

Most shrubs present in mixed farming were absent in the control site. Among the shrubs, *Senescio snowdenii* was the most abundant shrub species in the mixed farming site with a 43.39% (n=1533) abundance (Table 5). *Senescio snowdenii* was a major contributor to the increase in shrubs and accounted for 11.83% of the reported 27.27% increase (Table 5). *Ocimum gratissimum, Acanthus eminens and Sida rhombifolia* each had an abundance of 11.32% (n=400). Two shrubs were noted in the indigenous plantations. They included *Maesa lanceolatum* (21.7%; n=250)) and *Triumfetta rhomboidea* (78.3%:

n=900). These shrubs were however absent in the control site.

The results reveal mixed farming site has the highest number of shrubs followed by urban settlements. *Senna didimobotrya* is used in the treatment of Malaria, fever and typhoid. *Lantana trifolia* is used in the treatment of coughs while *Clutia abbysinica* is used in improving digestion. *Sida rhombifolia* is used in the treatment of sore throat,while *Acanthus eminensis* used in the treatment of spleen, liver and the aklimentary canal. Research further established that *Dombeya torrid* is used to sustain pregnancy and treat sexually transmitted diseases. *Maesa lanceolatum* was reported to treat heart burns while *Vangueriaa piculata* often forms part of concortions used in herbal medicines. Increase in shrubs in the region could point to an increase in herbal medicines in the region.

There was a slight increase climber in mixed farming. *Stephania abyssinica* (94.44%; n=567) and *Cymphostemma cyphopetalum* (5.56%: n=33) were the most abundant (Figure 6). *Stephania abysssinica* was also reported as the only shrub in NTZ and exotic plantations. These climbers were not recorded in the control. *Dichondra repen* was the only climber reported in Indigenous plantations. The fern *Pteris catoptera* was recorded in the control site but absent in urban settlements.

DISCUSSION

This study established that there were differences in plant species adjacent to different land uses. The differences were mainly, changes in species diversity, similarities and abundances. Indigenous plantations had Shannon Weiner diversity indexes that closely approach that of the natural forest (control site). Similarly, the Whittaker beta diversity index results established that there was a small similarity in the type of plant species found in the two sites. Results indicated that exotic plantations had the least species diversity index and that the plant species found in the control site were totally different from those found in the exotic plantations. The findings of this study partly agree with the findings of Norul and Mizarul (2011) who studied the natural and exotic plantations forests of Rema-Kalenga Wildlife Sanctuary in Bangladesh. The study revealed a higher diversity of tree species in the natural forest while that of the exotic plantation forest was less. While exotic plantations supported lower tree diversity, indigenous plantations appeared to support a higher diversity of tree species diversity. Stephens and Wagner (2007) also found that indigenous plantations are generally more similar in habitat structure to natural forests than are exotic plantations.

Table 5. Percentage Abundance of Shrubs in the Study Area.

Shrub	Control Site	Mixed Farming	Urban Settlement	I.P	NTZ	E.P
Vangueriaa piculata	9.09					
Balanites aegyptiaca			13.79			
Clutia abbysinica			65.52			
Solanum dasyphyllum			20.69			
Senescio snowdenii		43.39				
Ocimum gratissimum		11.32				
Acanthus eminens		11.32				
Sida rhombifolia		11.32				
Senna didimobotrya		6.6			97.96	
Lantana trifolium		5.66				
Mussaenda arcuata		5.66				
Rubus niveus		4.7				
Maesa lanceolatum				21.7		
Triumfetta rhomboidea				78.3		
Dombeya torrid					2.04	

The findings of this study therefore differ from those of Norul and Mizarul (2011) who reported high diversity of herb species in the natural forest compared to exotic plantation forests. While many researchers have found low levels of biodiversity in exotic plantations forests (Matthews *et al.,* 2002, Barlow *et al*., 2007, Makino *et al.*, 2007), other studies indicated that plantation forests play an important role in conservation and restoration of forest species. Plantations that utilize indigenous tree species enhance biodiversity outcomes (Pejchar *et al*., 2005).

Results of this study further showed that, there were significant differences in the number of trees, herbs, shrub and climber species in the study area. Results also revealed significant differences in the total number of species found in specific study location. Natural forest was rich in tree species while planted forests had a higher richness of herbs and shrubs. The study further established an increase in herb and shrub abundances in the Mt Elgon forest ecosystem. Despite the general increase in herbs and shrubs in the study area, research further established a decline in the abundance of *Crepis carbonaria* in the region. Similarly, the study established that *Vangueriaa piculata* only existed in the control site and was missing in all other study sites. This findings reveal that *Vangueriaa piculata* plant species is an endangered species in the Mt Elgon region. The decline of *Vangueriaa piculata* could lead to a decline in communities availability of herbal medicine because this plant species forms part of the concortions used in preparing herbal medicine in the area. Gilliam (2007) argued that despite the herbaceous layer having a higher plant species richness than in any other forest stratum, discussions on threats to biodiversity often omit the herb layer. He further asserted that herbaceous species have higher natural extinction rates than plant species in other strata. Gilliam (2007) emphasized that there is a natural tendency to overemphasize trees which are dominant forest species while ignoring herbaceous layer of the forest. Herbaceous layer play a critical role in enhancing the biodiversity of forest ecosystems. Spyreas and Matthews (2006) suggested that herbaceous layer can be used as indicators of biodiversity because of there uniqueness. Kamar (2017) indicated that number of individuals under different floral groups vary depending on the adopted land-use system. Land use change could therefore explain the variation in these plant groups in Mt Elgon ecosystems.

The findings of this study revealed differences in plant species between Nyayo Tea Zone and the control site. Nyayo Tea Zone reported lower species diversity in comparison to the control site. Similarly, there were very little similarities in the plant species found in the control site verses those found in Nyayo Tea Zone. These findings are in agreement with those of Selena *et al*. (2012) who provided evidence of ecological simplification with increased density of tea cultivation. Most tea plantations strictly follow monocultural practices, biodiversity assemblages in such plantations are poor compared to forest ecosystems (Lin *et a/.,* 2012). Kurniawan (2016) reported higher tree species diversity in forested region and jungle rubber than in the region with rubber and oil plantations. Rembold *et al*. (2017) also established highest number of plant species in forested region than any other land-use systems.

Many studies have described the effects of urbanization on species richness and indicated that urbanization can increase or decrease species richness, depending on a number of variables that include: taxonomic group, spatial scale of analysis, and intensity of urbanization. Most of the urban centres in Mt. Elgon region are small and only occupy a small region. Chepkitale is one such urban centre. This could explain the high Shannon weiner diversity index in the plant species of this study site. Similarly, the study revealed the highest similarity in plant species found in control site verses those found in the urban settlement site. Knapp *et al.* (2008) reported similar findings that cities in Germany were hot spots of plant species richness, but included many closely related and functionally similar species, suggesting a decreased capacity in urban areas to respond to environmental challenges. Ramona *et al.* (2018) reported a decrease in plant species diversity with increasing degree of urbanization in Switzerland. Cameron *et al.* (2015) reported similar results for plant species richness, but did not find any effect on plant diversity. In contrast, McKinney (2008) found the highest number of plant species in areas with medium degree of urbanization, whereas Vallet *et al*. (2010) did not detect any difference in total species richness of plants between urban and rural woodlands.

The findings of this study revealed differences in species diversity reported in mixed farms as compared to that of the control site. Mixed farming reported lower species diversity as compared to that of the control site. Similarly, the research revealed that the plant species that were in mixed farming site were totally different from those of the control site. Mixed farming is often believed to reduce environmental impacts of agriculture, but little is known about the differences on plant species found in natural forests as compared to those of the land adjacent to mixed farms. There is little dispute that agriculture is one of the main causes of global biodiversity loss (Kleijn *et al.,* 2008) and that agricultural induced biodiversity decline is accelerated by intensification and expansion of agricultural land use (Clough *et al.,* 2011). After the conversion of natural ecosystems to agriculture, there is often replacement of ecological functions by external inputs such as agrochemicals (Mburu *et al.*, 2016). This changes lead to a reduction in the capacity of agroecosystems to self-regulate and brings in a greater reliance on external inputs and greater vulnerability to environmental changes (Barrios *et al*., 2015). Many studies in Kenya have focused on land use changes and decline in agro biodiversity (Netondo *et al.*, 2011, Ekesa (2009), Masayi and Netondo 2012). This research has unearthed unique information on differences and similarities both in species diversity in areas under different land uses.

CONCLUSION

The study concludes that there are significant differences in floral diversity in areas under different land uses of Mt. Elgon forest ecosystem. Species diversity and similarity of indigenous planted forests and urban settlement closely approach that of the natural forests. Floral diversity of areas under mixed farming, monocultural tea farming and planted forest are lower with exotic plantation forest having the lowest species diversity index. Mixed farming and exotic plantations have plant species that are quite different from those of the natural forests. Results of this study further concludes that, there are significant differences in the number of trees, herbs, shrub and climber species in the study area with natural forest being rich in tree species while planted forests has a higher richness of herbs and shrubs The study also concludes that indigenous plantations can restore floral diversity and abundance in Mt. Elgon forest ecosystem

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Conflict of Interest. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Compliance of Ethical Standards. As part of PhD thesis, the research proposal was approved by the graduate school of Moi University after meeting the post graduate guidelines of the university.

Data Availability. Data are available with Ms Nelly Masayi (Email:nellymasayi05@gmail.com) upon request.

REFERENCES

Alam, M.S. and Masum, K.M., 2005. Status of Homestead Biodiversity in the Offshore Island of Bangladesh. Research Journal Agricultral Biological Sciences. 1(3), pp.246-253

Barlow, J., Gardne, T.A., Araujo, I.S., Avila-Pires, T.C., Bonaldo, A.B., Costa, J.E., Esposito, M.C., Ferreira, L.V., Hawes, J., Hernandez, M,I,M., Hoogmoed, M.S., Leite, R.N., Lo-Man-Hung NF, Malcolm, J.R., Martins, M.B., MestreL, A.M., Miranda-Santos, R., Nunes-Gutjahr, A.L., Overal, W.L., Parry L., Peters S.L., Ribeiro-Junior, M.A., da Silva M.N.F., da Silva Motta, C. and Peres, C.A., 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. Proceedings National Academy Science. 104, pp.18555–18560

Barrios, E., Shepherd, K. and Sinclair, F., 2015. Soil health and agricultural sustainability: the role of soil biota. In: FAO, editor. Agroecology for food security and nutrition. Rome (Italy): Proceedings of the FAO International Symposium, pp. 104–122.

Cameron, G.N., Culley, T.M., Kolbe, S.E., Miller, A.I. and Matter, S.F., 2015. Effects of urbanization on herbaceous forest vegetation: the relative impacts of soil, geography, forest composition, human access, and an invasive shrub. Urban Ecosystems. 18, pp.1051-1069. https://doi.org/10.1007/s11252-015-0472-6M.

Convention on Biological Diversity (CBD), 2010. Mountain Biodiversity United nations decades on biodiversity. Living in harmony with nature. Available online at https://www.cbd.int/undb/media/factsheets/undb-factsheet-mountains-en.pdf [Accessed 20th January 2020]

Davenport, T., Howard, P. and Dickenson, C., 1996. Mount Elgon Biodiversity Report. Republic of Uganda Forest Department, P.O. Box 1752, Kampala, Uganda.

Ekesa, B.N., 2009. Agricultural biodiversity for food and nutrient security: The Kenyan perspective. International Journal of Biodiversity and Conservation 1(7) pp.208-214.

FAO, 2007. Food And Agriculture Organization of the United Nations Rome, State of the Worlds Forest. Available at http://www.fao.org/3/a-a0773e.pdf

Gilliam, F.S., 2007. The Ecological Significance of the Herbaceous Layer in Temperate Forest Ecosystems. BioScience, 57(10) pp. 845–858, https://doi.org/10.1641/B571007

Kleijn, D., Kohler, F., Bata´ry, A., Ba, P., Concepcio´n E. D., Clough, Y., Dı´az, M., Gabriel, D., Holzschuh, A., Knop, E., Kova´cs, A., Marshall, E. J. P., Tscharntke, T, and Verhulst, J., 2008. On the relationship between farmland biodiversity and land-use intensity in Europe. Proceedings Royal Society-B. 276, pp.903–909 doi:10.1098/rspb.2008.1509.

Kamal, R. A., 2017. Effect of land-use change on the diversity of useful plants in Sumatra (Indonesia). Masters thesis at the Faculty of Forest Science and Forest Ecology. Georg-August-Universität Göttingen.

Knapp, S., Kuhn, I., Schweiger, O., Klotz, S., 2008. Challenging urban species diversity: contrasting phylogenetic patterns across plant functional groups in Germany. Ecology Letters. 11(10), pp.1054-1064.

Kurniawan, S., 2016. Conversion of lowland forests to rubber and oil palm plantations changes nutrient leaching and nutrient retention efficiency in highly weathered soils of Sumatra, Indonesia

Lin, N., Nam T.T, and Perera, J., 2012. Response of birds to different management types of tea cultivation in a forest-agriculture landscape, SW China. Proceedings of the Advanced Fieldcourse in Ecology and Conservation—XTBG 2012, Yunnan, China. 12–20.

Makino, S., Goto, H., Hasegawa, M., Okabe, K., Tanaka, H., Inoue, T. and Okochi, I., 2007. Degradation of longicornbeetle (Coleoptera, Cerambycidae, Disteniidae) fauna caused by conversion from broad-leaved to man-made conifer stands of Cryptomeria japonica (Taxodiaceae) in central Japan. Ecological Research. 22, pp.372–381

Masayi, N. and Netondo G.W., 2012. Effects of Sugarcane Farming on Diversity of VegeTable Crops in Mumias Division, Western Kenya. International Journal of Biodiversity and Conservation, 4(13), pp.515-524.

Masika F. M., 2009. Annual reports and Financial Statements. Kenya Red Cross

Matthews, S., O'Connor, R. and Plantinga A.J., 2002. Quantifying the impacts on biodiversity of policies for carbon sequestration in forests. Ecological Economics 40, pp 71–87.

McKinney, M.L., 2008. Effects of urbanization on species richness: a review of plants and animals. Urban Ecosystems, 11(2), pp. 161–176.

Netondo, G. W., Waswa, F., Maina, L.,Naisiko,T., Ngaira, J.K. and Masayi, N., (2010). Agro-biodiversity endangered by sugarcane farming in Mumias and Nzoia Sugar belts of Western Kenya (African Journal of Environmental Science and Technology, 4(7), pp.437-445,

Norul, A.S. and Mizarul, R., 2011. Comparison of Plant Diversity of Natural Forest and Plantations of Rema-Kalenga Wildlife Sanctuary of Bangladesh. Journal of Forest Science. 27(3), pp. 127-134

Pejchar, L., Holl, K.D. and Lockwood, J.L., 2005. Hawaiian honeycreeper home range size varies with habitat: implications for native Acacia koa forestry. Ecological Applications. 15, pp.1053–1061.

Petursson, J.G, Vedeld, P. and Kaboggoza, J. 2011. Transboundary Biodiversity Management: Institutions Local Stakeholders, and Protected Areas: A Case Study From Mt. Elgon, Uganda and Kenya. Society & Natural Resources. An International Journal 24 (12) pp. 1304-1321 Available at https://doi.org/10.1080/08941920.2010.540 3 10

Selena, A., Charles, M.P., Long, C., Rachel, M., Uchenna, U., Amy, L., Edward, K., and John, R. S., 2012. Biodiversity and phytochemical quality in indigenous and state-supported tea management systems of Yunnan, China. Conservation Letters 6, pp. 28–36 Available online at https://doi.org/10.1111/j.1755-263X.2012.00269.x

Ramona, L.M., Brigitte, B., Hans-Peter, R. and Bruno, B., 2018. Diverse effects of degree of urbanization and forest size on species richness and functional diversity of plants, and ground surface-active ants and spiders. University of Basel, Basel, Switzerland.

Rembold, K., Mangopo, H., Tjitrosoedirdjo, S. S. and Kreft, H., 2017. Plant diversity, forest dependency, and alien plant invasions in tropical agricultural landscapes. Biological Conservation, 213, pp.234-242.

Spyreas, G. and Matthews, J.W., 2006. Floristic conservation value, nested under-story floras, and the development of second-growth forest. Ecological Applications 16, pp.1351-1366

Stephens, S.S. and Wagner, M.R., 2007. Forest plantations and biodiversity: A fresh perspective. Journal of Forestry 105, pp.307–313

UNEP, 2002. Global Environmental Outlook 3. London. Available online at <http/ www.unep.org/geo/geo3/> [Accessed 20th January 2021]

Vallet, J., Beaujouan, V., Pithon, J., Roze, Â.F. and Daniel, H.2010. The effects of urban or rural landscape context and distance from the edge on native woodland plant communities. Biodiv. Conserv. 19, pp.3375-3392. https://doi.org/10.1007/s10531-010-9901-2

White, F., 1983. The vegetation of Africa. UNESCO: Paris

Clough, Y., Barkmann, J., Juhrbandt, J. Kessler, M., Cherico, T., Anshary, W.A., Buchori, D., Cicuzza, D., Darras, K., Putra, W.D., Erasmi, S., Pitopang, R., Schmidt, C., Schulze, C.H., Seidel, D., Steffan-Dewenter, I., Stenchly, K., Vidal, S., Weist, M., Wielgoss, A.C, and Tscharntke, T., 2011. Combining high biodiversity with high yields in tropical agroforests. Proceedings of the National Academy of Sciences, 108 (20), pp. 8311-8316; DOI: 10.1073/pnas.1016799108

Young, S. and Swiacki, L.N., 2006. Surveying the Forest Biodiversity of Evansburg State Park: Plant Community Classification and Species Diversity Assessment. International Journal of Botany. 2(3), pp. 293-299.