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Habitat Conditions in a Continuously Grazed Wildlife Sanctuary in Kenya

Lynn J. Kipkosgei[1*] John W. Kiringe[2] Shem M. Mwasi[1]
1.Department of Environmental Biology & Health, University of Eldoret, P.O Box 1125-30100, Eldoret, Kenya
2.School For Field Studies, Centre for Wildlife Management Studies, P.O Box 27743-00506, Nairobi, Kenya

Abstract
Changes in structure and composition of herbaceous vegetation in rangelands often result from effects of continuous grazing by large herbivores. The structure and composition of herbaceous vegetation were assessed in various vegetation types in Kimana Wildlife Sanctuary. Data were collected using Stratified sampling method, Line transect method, Quadrat method, Disc Pasture Meter method and Descending Step Point method. The study recorded a total of eight grass species belonging to three ecological categories, namely; decreaser, increaser I and increaser II. Frequency distribution of the ecological categories of grasses differed significantly across the vegetation types, with the exception of *Sporobolus fimbriatus* grassland and *Acacia xanthophloea* woodland, which were exclusively dominated by *S. fimbriatus* Nees ex Trin grass. Increaser II species; *Cynodon dactylon* L., *S. fimbriatus* Nees ex Trin and *Harpachne schimperi* Hoschst dominated in all the vegetation types, except for wooded grassland, which was dominated by *Pennisetum stramineum* Peter, an increaser I species. *Cenchrus ciliaris* L. occurred at low frequencies (< 50%) in wooded grassland and *C. ciliaris* grassland. Grass standing crop, grass basal cover, grass height and inter-tuft distance between grass swards also varied across the vegetation types. All the vegetation types, except wooded grassland indicated conditions of over-utilization. Wooded grassland indicated conditions of under-utilization. We suggested restoration of vegetation types dominated by increaser species through reseeding using increaser species such as *Cenchrus ciliaris* L., *Themada triandra* and *Penicum maximum*. We also suggested monitoring of occurrences and distribution of *Cenchrus ciliaris* L. species and other native decreaser species in Amboseli ecosystem and in similar ecosystems in Kenya.
Keywords: Continuous grazing, Grass species, Ecological categories, Vegetation types, Kenya

Introduction

Changes in structure and composition of native vegetation in savanna ecosystems often results from effects of climate, topography, soils, fire, herbivory and human activities (Sankaran et al., 2008; Gandiwa et al., 2011; van der Waal et al., 2011; Gandiwa et al., 2013; Zisanza-Gandiwa et al., 2013). In rangelands, continuous grazing by large herbivores have been shown to cause changes in structure and composition of herbaceous vegetation (Kioko et al., 2012; Zarekia et al., 2013; Mureithi et al., 2014;). Studies on livestock grazing systems have shown that continuous grazing can result to encroachment of woody vegetation, local extinction of some plant species, dominance of unpalatable, annual grasses and non-native grass species and decrease in palatable, perennial and native grass species, grass height, grass cover, grass re-growth, grass biomass, forage resources and fuel resources (Rutherford & Powrie, 2009; Kioko et al., 2012; Kgosikoma et al., 2013; Rutherford & Powrie 2013; Zarekia et al., 2013; Muthoni et al., 2014; Rutherford et al., 2014). Continuously grazed areas are also characterized by loss of vegetation, increase in bare ground, low species richness and low species diversity (Kioko et al., 2012; Zarekia et al., 2013).

Other than their impact on vegetation, continuous grazing can influence the physical, chemical and biological properties of soil resources (Young-Zhong et al., 2005; Kioko et al., 2012; Zarekia et al., 2013). Calcium and nitrogen decreases, sodium increases and soils become acidic (Young-Zhong et al., 2005; Kioko et al., 2012; Rutherford et al., 2014; Zarekia et al., 2013). Soil erosion increases and soil biological properties decreases due to decrease in vegetation cover (Young-Zhong et al., 2005). The impacts caused by continuous grazing on herbaceous vegetation and soil constitutes the most common biological and edaphic indicators of land degradation, a condition that has threatened biological diversity and sustained functions of health rangelands worldwide (Young-Zhong et al., 2005; Oluwole & Sikhalazo, 2008; Kioko et al., 2012; Zarekia et al., 2013). However, restoration of degraded areas have been suggested to be achieved through livestock exclusion, rotational grazing system, appropriate grazing capacity and reseeding using native grass species (Young-Zhong et al., 2005; Kioko et al., 2012; Zarekia et al., 2013; Mganga et al., 2015). Area exclosures, for example, has been shown to improve vegetation and soil conditions in several degraded rangelands (Young-Zhong et al., 2005; Kioko et al., 2012; Zarekia et al., 2013).

In Kenya, Arid and Semi-Arid Lands (ASALs) occupy over 80% of the country's total land surface (Musyoki et al., 2012) and its natural resources including vegetation support about 25% of the nation's human population, mostly the pastoral and agro-pastoral communities, over 75% of the country's livestock and wildlife resources (Kiringe & Okello, 2005; Musyoki et al., 2012; Okello et al., 2015). Nevertheless, ASALs are experiencing rapid human population growth, expansion of human settlements, land use and land cover changes, land fragmentation, land subdivision and intensification of land uses (Kioko & Okello, 2010; Symbua, 2013; Bhola et al., 2012; Ogutu et al., 2014). As a result, conservation areas, wildlife dispersal areas and migratory corridors have been blocked and seasonal dispersal of wildlife into communal lands reduced (Okello, 2009; Okello & Kioko, 2010; Okello, 2012; Mose et al., 2012). These have caused concentration of wildlife, particularly, large wild herbivores in conservation areas in all seasons, a condition that could result to continuous grazing. Continuous grazing can impact negatively on vegetation and soils in conservation areas (Zarekia et al., 2013). However, there is few data available concerning the impacts of continuous grazing on habitat conditions in wildlife grazing areas. This study, therefore, aimed at understanding habitat conditions in Kimana Wildlife Sanctuary, a significant conservation area in Amboseli ecosystem.

Materials and Methods

Study Area

Kimana Wildlife Sanctuary is found within Amboseli ecosystem in Oloitokitoki Sub-County, Kajiado County, southeastern part of Kenya (Figure 1). It covers an area of about 22.5km^2 (Okello et al., 2011). The climate of Amboseli ecosystem is typical of ASALs of Kenya under Agro-Ecological Zone V1 (Pratt and Gwynne, 1977). Precipitation is low and is partly influenced by relief conditions of Mount Kilimanjaro (Okello et al., 2011). Rainfall occurs in two seasons, with the short season occurring around October to November and the long season occurring around March to early June (Altmann et al., 2002). Mean annual rainfall varies from 150mm to 200mm per year, but it may be relatively high during the two seasons (Altmann et al., 2002). Temperatures are continuously warm to hot and varies within seasons (Altmann et al., 2002). The geology is characterized by undulating uplands and plains and soils are highly variable depending on parent material and landforms (Gachimbi, 2002). The soils have moderate fertility but in cultivated areas organic carbons and phosphorus are generally low (Gachimbi, 2002). Vegetation is diverse in terms of structure and composition (Lekoyiet, 2006; Okello et al., 2011; Kioko et al., 2012). Large herbivores, primates and predators are the common wildlife animals (Okello, 2005). The present land uses in the ecosystem are agriculture and agro-pastoralism (Okello & D'Amour, 2008; Okello, et al., 2011).

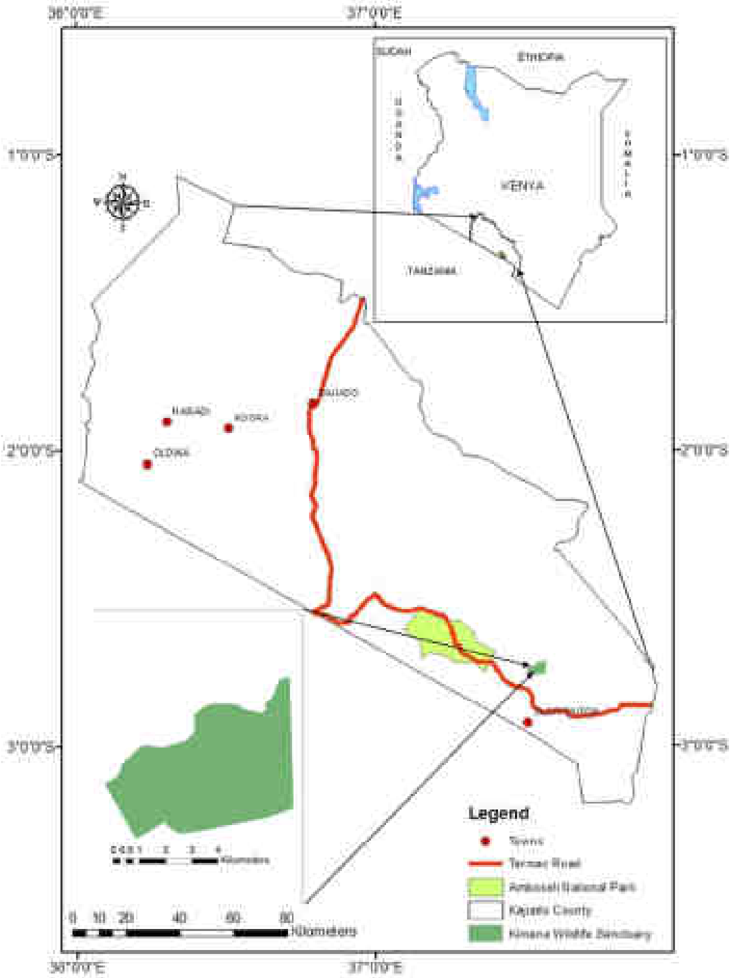

Figure 1: Map of Kenya showing spatial location of Kimana Wildlife Sanctuary

Data Collection

Stratification and Classification of Vegetation

The vegetation of the study area was visually stratified into vertical and horizontal components (Muller-Dombois & Ellenberg, (1974). The vertical component was further stratified into two distinct layers based on plant life forms; the canopy layer, comprised of woody plants (trees & shrubs) and the ground layer, comprised of herbaceous plants (grasses, herbs & forbs). Similarly, the horizontal component was further stratified and classified into six distinct types, based on physiognomic characteristics and dominant species (Pratt & Gwynne, 1977). The stratified and classified vegetation types were taken to represent different sampling strata and habitat types for animal use.

Sampling of Herbaceous Vegetation

Sampling was done during the long rainy season (March-June, 2012) in different vegetation types using stratified sampling technique, line transect method and quadrat method. The line transects varied in number and length depending on the size of the vegetation type. Sampling was done along the line transects at intervals of 200m. Descending Step Point Method (Trollope, 2004; Goqwana & Trollope, 2005) was used to sample herbaceous vegetation and a maximum of 20 steps of approximately 1 m each were walked. From the first sampling point, a metallic pin was dropped perpendicularly to the ground and the following information recorded; the name of the nearest tufted grass species or the name of the nearest forbs/sedge species to the pin and the inter-tuft distance (cm) between the pin and the nearest tufted grass species, which was measured using a tape measure.

Various species of grasses were observed, recorded and grouped into three ecological categories; decreaser, increaser I and increaser II based on their reactions to grazing as defined by Trollope (2004) and Trollope et al., 2011). Disc Pasture Meter method (Ganguli, et al., 2000) was used to estimate the grass standing crop (kg/ha). This method was considered to be faster and to cause minimal disturbance to grass species (Ganguli, et al., 2000). The disc pasture meter consisted of a disc/plate made of acrylic plastic (plexi-glass), with diameter of 45 cm and weight of 1.5 kg and a calibrated metal stick, which was 60 cm long. At every sampling point, the disc was dropped down along the calibrated metal stick and the settling height of the disc was observed and recorded. Aboveground foliage of mixed grasses were harvested from 0.25 m^2 plots using a pair of scissors and packaged in well labeled paper bags. Grass cover was estimated visually in the same plots. Grass samples were taken to botany laboratory at Masinde Muliro University of Science and Technology, Kenya, where they were dried at 70^oC for 48 hours to a constant weight.

Data Analysis

Frequency of each grass species was estimated and frequencies of grass ecological categories were also estimated. Chi-Square Goodness of fit test ($p < 0.05$) was used to test for differences in occurrence of the ecological categories of grasses between vegetation types. Pasture Disc Method was calibrated using the harvest method (Ganguli *et al.*, 2000) and regression analysis was used to developed a linear relationship between grass height (cm) and grass weight (g). Grass standing crop (Kg/ha) was estimated using the developed regression model. Grass standing crop, grass cover and grass height were tested for normality and homogeneity of variance using Shapiro-Wilks test ($p \leq 0.05$) and Levene's test ($p \leq 0.05$) respectively. One-Way Analysis of Variance (ANOVA) at 5% level of significance was used to test for statistical differences among means of grass standing crop, grass cover and grass height. Post hoc analyses for variables with significant differences in their means were carried out using Tukey's Honestly Significant Difference (HSD) ($P < 0.05$). Data were analyzed using Statistical Package for Social Scientists (SPSS) software.

Results

Vegetation Types

The vegetation of the study area consisted of six distinct types, namely; *Acacia tortilis* woodland, *A. xanthophloea* woodland, wooded grassland, sparse shrubland, *S. fimbriatus* grassland and *C. ciliaris* grassland (Table 1). *A. tortilis* woodland was dominated by *A. tortilis* species, with canopy cover of 22.42% and grass cover of 15%; *A. xanthophloea* woodland was dominated by *A. xanthophloea* species, with canopy cover of 34.38% and grass cover of 70%; Wooded grassland was dominated by *A. tortilis*, with canopy cover of 34.39% and grass cover of 18.5%; Sparse shrubland was dominated by *Balanites glabra* shrub with canopy cover and grass cover of 8.8% and 1.21% respectively; *S. fimbriatus* grassland was dominated by *S. fimbiratus* Nees ex Trin grass with grass cover of 21% and *C. ciliaris* grassland was dominated by *C. ciliaris* L. grass with grass cover of 26.47%.

Table 1: Characterized and classified vegetation types in Kimana Wildlife Sanctuary

Vegetation Type	Dominant Life form	Canopy Cover (%)	Grass Cover (%)
A. tortilis woodland	Trees	22.42	15.00
A. xanthophloea woodland	Trees	34.38	70.00
Wooded grassland	Trees	34.39	18.50
Sparse shrubland	Shrubs	8.80	1.21
S. fimbriatus grassland	Grasses		21.00
C. ciliaris grassland	Grasses		26.47

Composition of Herbaceous Vegetation

A total of eight species of grasses belonging to three ecological categories; decreaser, increaser I and increaser II were recorded in all the vegetation types (Table 2). *Cenchrus ciliaris* L. was the only decreaser species encountered and occurred in wooded grassland and *S. fimbriatus* grassland. Three species of increaser I species occurred in the sanctuary namely; *Pennisetum mezanium* Leeke, *Pennisetum perpureum* Schumach and *Pennisetum stramineum* Peter. Similarly, three species of increaser II species occurred in the sanctuary namely; *Cynodon dactylon* L., *Harpachne schimperi* Hochst and *Eragrotis tenuifolia* (A. Rich.) Steud.

In *A. tortilis* woodland, the proportions of the ecological categories of grass species were 11.81% increaser I and 86.80% increaser II. The increaser II species were significantly more abundant compared with increaser I species (χ^2 = 56.818; df = 1; p = 0.001), where the proportion of increaser II species being 7 times higher, compared with a lower value of 11.81% decreaser I species (Table 2). However, in wooded grassland, the frequencies of the ecological categories were 5.10% decreaser, 28.36% increaser I and 11.43% increaser II and increaser I species were significantly more abundant compared with the other two ecological categories of grasses (χ^2 = 19.409; df = 2; p = 0.001).

In sparse shrubland, the proportions of the ecological categories of grasses were 1.58 % and 12.26% of increaser I and increraser II species respectively and their proportions differed significantly (χ^2 = 7.413; df = 1; p = 0.002), where the proportion of increaser II species being 11 times higher, compared with that of increaser I species. *S. fimbriatus* grassland and *A. xanthophloea* woodland were both dominated by Increaser II species with frequencies of 21.8% and 67.80% respectively. In *C.ciliaris* grassland, proportions of the ecological categories of grasses were 41.05% and 58.94% of decreaser and increaser II species respectively and these differed significantly (χ^2 = 26.95; df = 1; p = 0.001) (Table 2).

Table 2: The composition and frequencies of different ecological categories of grass species across vegetation types in Kimana Wildlife Sanctuary

Grass Species	Ecological Category	ATW (%)	WG (%)	SFG (%)	SSL (%)	AXW (%)	CCG (%)
Cenchrus ciliaris L.	Decreaser	0	5.10	0	0	0	41.05
Decreaser		**0**	**5.10**	**0**	**0**	**0**	**41.05**
Pennisetum mezanium Leeke.	Increaser I	0	2.24	0	0	0	0
Pennisetum perpureum Schumach.	Increaser I	0	3.06	0	0	0	0
Pennisetum stramineum Peter.	Increaser I	11.81	23.06	0	1.58	0	0
Increaser I		**11.81**	**28.36**	**0**	**1.58**	**0**	**0**
Cynodon dactylon L.	Increaser II	86.11	0	0	0.40	0	49.47
Harpachne schimperi Hochst.	Increaser II	0	3.06	0	7.91	0	
Sporobolus fimbriatus Nees ex Trin.	Increaser II	0.69	8.37	21.81	0	67.8	9.47
Eragrotis tenuifolia (A.Rich) Steud.	Increaser II	0	0	0	3.95	0	0
Increaser II		**86.80**	**11.43**	**21.81**	**12.26**	**67.8**	**58.94**
χ^2 – Value		**131.42**	**28.97**	**0.09**	**12.25**	**13.83**	**26.95**
P – Value		**0.000**	**0.000**	**0.768**	**0.002**	**0.000**	**0.000**

ATW, *Acacia tortilis* woodland; WG, Wooded grassland; SFG, *Sporobolus fimbriatus* grassland; SSL, Sparse shrubland; AXW, *Acacia xanthophloea* woodland; CCG, *Cenchrus ciliaris* grassland.

Structure of Herbaceous Vegetation

Results from regression analysis indicated that the measured grass height was a significant (p = 0.001) predictor of grass standing crop with an R^2 value of 0.635 (Figure 2). The regression model that significantly predicted the grass standing crop was Y = 0.054x + 2.5151; where Y was the measured grass standing crop (g/m^2), x was the measured grass height (cm) and R^2 was the coefficient of determination. However, the grass standing crop was estimated at Kg/ha.

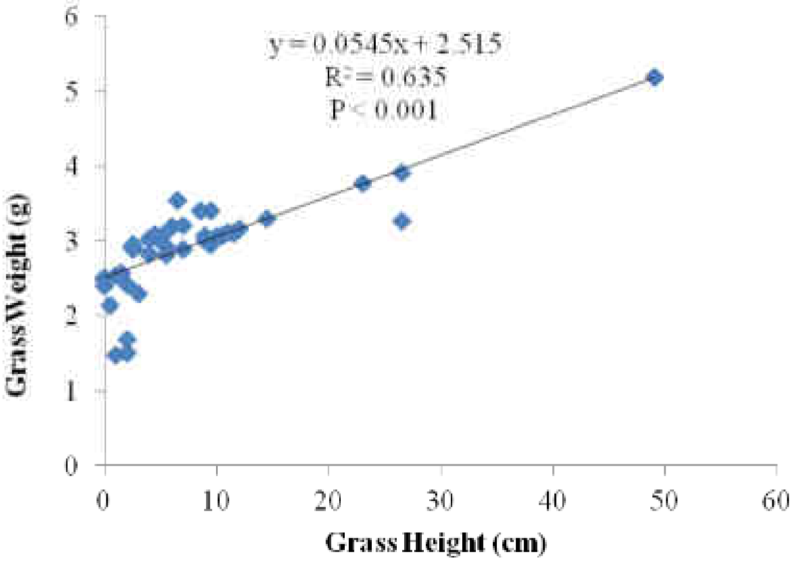

Figure 2: Scatter plots and simple linear regression relationship between grass height (cm) and grass weight (g)

Wooded grassland recorded the highest mean grass standing crop, 3093.10 ± 582.79kg/ha and sparse grassland the lowest, 367.80 ± 46.35kg/ha (Table 3). *Acacia tortilis* woodland recorded the second highest grass standing crop, 1510.30 ± 263.58kg/ha. *Acacia xanthophloea* woodland, *S. fimbriatus* grassland, and *C. ciliaris* grassland had mean values of 2255.20 ± 262.67 kg/ha, 1273.00 ± 242.873 kg/ha and 536.61± 0.84 kg/ha respectively. One-Way ANOVA revealed a significant difference in the mean grass standing crop across the vegetation types ($F = 13.11$; df = 5, 334; $p = 0.007$). Tukey HSD revealed a significantly higher mean grass standing crop in wooded grassland compared with lower values in sparse shrubland, 367.80 ± 46.35kg/ha ($p = 0.018$), *C. ciliaris* grassland, 536.61 ± 0.84kg/ha ($p = 0.004$) and *S. fimbriatus* grassland, 1273.00 ± 242.89kg/ha ($p = 0.032$).

Table 3: Grass standing crop (Kg/ha), Inter-tuft distance (cm), Grass height (cm) and Grass cover (%) attributes (Mean ± SE) between vegetation types in Kimana Wildlife Sanctuary

Vegetation Type	**Grass standing crop (kg/ha)**	**Inter-tuft distance (cm)**	**Grass height (cm)**	**Grass Cover (%)**
WG	3093.10 ± 582.79^{b}	8.65 ± 0.57^{ab}	7.54 ± 1.28^{b}	18.50 ± 10.00^{b}
AXW	2255.20 ± 262.67^{ab}	4.90 ± 0.81^{ab}	7.54 ± 1.87^{b}	70.00 ± 3.66^{bc}
ATW	1510.30 ± 263.58^{a}	10.56 ± 0.75^{b}	3.73 ± 0.56^{b}	15.00 ± 4.01^{b}
SFG	1273.00 ± 242.89^{a}	9.93 ± 1.42^{ab}	4.01 ± 0.69^{ab}	21.00 ± 2.45^{a}
CCG	536.61 ± 0.84^{a}	9.47 ± 0.37^{ab}	10.71 ± 1.46^{a}	26.47 ± 5.37^{c}
SSL	367.80 ± 46.35^{a}	15.81 ± 1.81^{c}	2.70 ± 0.36^{ab}	1.78 ± 1.21^{ab}

Means with different superscript letter within the same column differ significantly (Tukey HSD test $p < 0.05$).
WG, wooded grassland; AXW, *A. xanthophloea* woodland; ATW, *A. tortilis* woodland; SFG, *S. fimbriatus* grassland; CCG, *C. ciliaris* grassland; SSL, sparse shrubland.

Inter-tuft distance between grass swards was highest in sparse shrubland, 15.81 ± 1.81cm and lowest in *A. xanthophloea* woodland 4.90 ± 0.81cm and (Table 3). *Acacia tortilis* woodland, wooded grassland, *S. fimbriatus* grassland and *C. ciliaris* grassland had mean inter-tuft distance of 10.56 ± 0.75cm, 8.65 ± 0.57cm, 9.93 ± 1.42cm, and 9.47 ± 0.37cm respectively. However, the mean inter-tuft distances varied significantly across the vegetation types ($F = 5.699$; df = 5,662; $p = 0.000$). Tukey HSD test found a significantly higher mean inter-tuft distance in shrubland, 15.81 ± 1.81cm, compared with lower values of 4.90 ± 0.81cm in *A. xanthophloea* woodland, ($p = 0.000$), 8.65 ± 0.57cm in wooded grassland, ($p = 0.001$), 9.47 ± 0.37cm in *C. ciliaris* grassland ($p = 0.014$), 9.93 ± 1.42cm in *S. fimbriatus* grassland ($p = 0.033$), and 10.56 ± 0.75cm in *A. tortilis* woodland ($p = 0.047$). Similarly, the mean inter-tuft distance in *A. tortilis* woodland was two times higher compared with a lower values of 4.90 ± 0.8cm in *A. xanthophloea* woodland ($p = 0.009$).

Grass height was highest in *C. ciliaris* grassland, 10.71 ± 1.46cm and lowest in sparse shrubland, 2.70 ± 0.36cm (Table 3). Wooded grassland, *A. xanthophloea* woodland, *A. tortilis* woodland and *S. fimbriatus* grassland had heights of 7.54 ± 1.28, 7.54 ± 1.87, 3.73 ± 0.56 and 4.01 ± 0.69 respectively. The differences in their means was significant across the vegetation types ($f = 10.33$; df = 5, 295; $p = 0.001$). Tukey HSD, revealed a significantly higher mean grass height *in A. tortilis* woodland compared with *S. fimbriatus* grassland ($p = 0.008$), in wooded grassland compared with *S. fimbriatus* grassland ($p = 0.01$), *C. ciliaris* grassland ($p = 0.001$) and sparse shrubland, and in *A. xanthophloea* woodland compared with *S. fimbriatus* grassland ($p = 0.01$), sparse shrubland ($p = 0.002$) and *C. ciliaris* grassland ($p = 0.01$).

Proportion of grass cover was highest in *A. xanthophloea* woodland, 70.00 ± 3.66% and lowest in sparse shrubland, 2.78 ± 1.21% (Table 3). Wooded grassland, *A. tortilis* woodland, *S. fimbriatus* grassland and *C. ciliaris* grassland had grass covers of 18.50 ± 10.00%, 15.00 ± 4.01%, 21.00 ± 2.45% and 26.47 ± 5.37% respectively. The differences in their means was significant across the vegetation types ($f = 12.21$; df = 5, 53; $p = 0.01$). Tukey HSD test revealed a significantly higher mean grass cover in *A. xanthophloea* woodland compared with *A. tortilis* woodland ($p = 0.01$), wooded grassland ($p = 0.01$), *S. fimbriatus* grassland ($p = 0.01$), sparse shrubland ($p = 0.01$) and a higher mean grass cover in wooded grassland compared with sparse shrubland ($p = 0.043$).

Discussion

Results on stratification and classification of vegetation showed that the study area was composed of six different vegetation types, which included; *A. tortilis* woodland, *A. xanthophloea* woodland, wooded grassland, sparse shrubland, *S. fimbriatus* grassland and *C. ciliaris* grassland. This suggested that the vegetation was highly variable, a characteristic that is common to vegetation in savannas and typical of vegetation in ASALs of Kenya (Mutangah, 1989; Lekoiyet, 2006; Okello, 2005; Gandiwa et al., 2011; Kioko et al., 2012; Gandiwa et al., 2013; Zisanza-Gandiwa et al., 2013; Okul, 2014). Previous studies have indicated that variability of vegetation often results from effects of climate, soils and disturbances from fires, herbivores and human activities (Sankaran et al., 2008; Gandiwa et al., 2011; van der Waal et al., 2011; andiwa et al., 2013; Zisanza-Gandiwa et al., 2013). Similar factors, therefore, could have contributed to the observed variability, which are important in promoting biological diversity, ecosystem functioning and diversity of habitats for wildlife use (Ruhlendorf & Engle, 2001; Ritchie et al., 2014).

The study recorded a total of eight grass species belonging to three ecological categories, namely; decreaser species, increaser I species and increaser II species. However, the frequencies of these ecological categories differed significantly across the vegetation types, with the exception of *S. fimbriatus* grassland and *A. xanthophloea* woodland, which were exclusively dominated by *S. fimbriatus* Nees ex Trin species. Increaser II grass species such as *C. dactylon* L, *S. fimbriatus* Nees ex Trin and *H. schimperi* Hochst dominated in all the vegetation types, with the exception of wooded grassland, which was dominated by *P. stramineum* Peter, an increaser I grass species.

The reported variation in the composition of the ecological categories of grasses across the vegetation types and the dominance of increaser species in all the vegetation types could be resulting from selective utilization or over-utilization by herbivores of highly palatable and more preferred decreaser species such as *C. ciliaris* L. as compared with the less palatable and less preferred increaser I and Increaser II species such as *C. dactylon* L., *S. fimbriatus* Nees ex Trin, and *H.* schimperi Hochst (Odadi, 2007; Tefera et al., 2010; Trollope et al., 2011; Angassa et al., 2014). Moreover, the dominance of *P. stramineum* Peter in wooded grassland could indicate conditions of under-utilization or selective utilization (Trollope et al., 2011). This grass species is relatively palatable during the wet season but becomes hard, fibrous and unpalatable during the dry season (Kioko et al., 2012; Mureithi et al., 2014).

Cenchrus ciliaris L. occurred at lower frequency (< 50%) in wooded grassland and *C. ciliaris* grassland, but was absent in the other vegetation types. Its occurrence in the these vegetation types could be due to moderate utilization by wildlife and its ability to resist disturbances including high grazing pressure and droughts due to its strong fibrous root systems that are more than 2m deep, high germination capacity, high drought tolerance, quick responses to rainfall patterns and its allelopathic traits (Marshall et al., 2012; Mganga et al., 2015; Angassa et al., 2014). However, with continuous grazing and increased densities of both grazers and mixed feeders in the study area, this grass species is expected to decrease significantly or to disappear completely from wooded grassland and *C. ciliaris* grassland as was observed in the other vegetation types. Studies that have assessed the ecological impacts of continuous grazing using field experiments have reported that palatable decreaser grasses including *C. ciliaris* decrease under conditions of continuous grazing and increase under conditions of moderate grazing (Trollope et al., 2011; Kioko et al., 2012; Angassa et al., 2014; Mureithi et al., 2014). According to these studies, therefore, wooded grassland and *C. ciliaris* grassland could be under conditions of moderate utilization.

Other decreaser grasses that are often considered more palatable and preferred as forage by grazers such as *P. maximum* Jacq. and *T. triandra* Forssk. (Odadi et al., 2007; Treydte et al., 2010; Richie, 2014) and were reported to occur in Amboseli ecosystem, though in low frequencies (0.15%) (Kioko et al., 2012), were completely absent in all the vegetation types in the present study. Their exclusion could be an indication of heavy grazing pressure (Kioko et al., 2012).

Grass standing crop, basal cover, plant height and inter-tuft distance between grass swards were found to vary substantially across the vegetation types. Wooded grassland reported the highest grass standing crop as compared with the other vegetation types. This could be due to accumulation of dead material resulting from excessive self shading of grass species such as *P. strameneum* Peter which dominate this vegetation type and/or accumulation of other moribund grasses with limited re-growth potentials. The high standing crop in wooded grassland could represent important fuel loads for fires that could develop at high intensity, which could be used to remove dead biomass, to control woody encroachment, to stimulate new grass tillers and to increase palatability of grasses for grazers in this vegetation type (Mapiye et al., 2008; Trollope et al., 2011).

Riparian soils are often characterized by a combination of conditions that render them more suitable for growth and survival of vegetation (Richardson et al., 2007). Accordingly, *A. xanthophloea* woodland, which occurred in riparian zone of River Kimana, recorded the lowest inter-tuft distance between grass swards, but the highest grass cover, relatively higher grass standing crop and grass height, hence, its soil is protected from loss by wind erosion (Yong-Zhong et al., 2004). In contrast, sparse shrubland recorded the highest inter-tuft distance but the lowest grass standing crop, grass height and basal cover, a condition that could make it to be more susceptible to wind erosion (Yong-Zhong et al., 2004). According to Yong-Zhong et al., (2005) accelerated wind erosion can result in soil coarseness and loss of soil organic matter.

Studies in rangelands have reported significant decrease in grass biomass, grass height, grass cover and increased inter-tuft distance between grass swards in areas of continuous or heavy grazing (Yong-Zhong et al., 2005; Kioko et al., 2012; Zarekia et al., 2013). Therefore, the observed herbaceous structure in sparse shrubland could be resulting from over utilization and trampling effects of herbivores, particularly domestic large herbivores (cattle & shoats), which have been reported to have a higher selectivity for this vegetation type (Kipkosgei, 2016). However, other factors such as climate and soil conditions could have influenced the structure and composition of herbaceous vegetation across the vegetation types in this study.

Conclusion & Recommendations

Vegetation in Kimana Wildlife Sanctuary was highly variable consisting of six vegetation types, namely; *A. tortilis* woodland, *A. xanthophloea* woodland, wooded grassland, sparse shrubland, *S. fimbriatus* grassland and *C. ciliaris* grassland. It was also evident that herbaceous vegetation varied across the vegetation types on the basis of grass ecological categories, grass standing crop, grass basal cover, grass height and inter-tuft distance between the grass swards. The dominance of increaser species and low grass standing crop, basal cover, plant height and inter-tuft distance between grass swards in most of the vegetation types indicated degradation conditions, while dominance of decreaser grass species and higher grass standing crop, basal cover, plant height and inter-tuft distance between grass swards in wooded grassland indicated conditions of under utilization. Hence, it was recommended that the frequencies of decreaser grasses be increased by reseeding using native grass species with higher palatability and higher resistance to heavy grazing. *Cenchrus ciliaris* L. is an example of such a grass species, and since it occurred in wooded grassland and *C. ciliaris* grassland, though in low frequencies suggests its potential for restoration of all the degraded vegetation types. It was also recommended that the occurrences and distribution of *Cenchrus ciliaris* L. species and other native species be monitored in the study area and similar ecosystems in Kenya. Finally, we recommended studies on soil conditions in all the six vegetation types in the study area.

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