Influence of Rainfall Fluctuations on Population Trends of Eleven Wild Herbivores in Soysambu Conservancy, Kenya

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ABSTRACT

Recent studies have shown that about 70% of wildlife populations are found outside the protected areas in Kenya. In a bid to cater for this large portion of wildlife many conservancies have been established in Kenya. Soysambu is one of the private conservancies that has experienced consistent decline in rainfall during the dry seasons. This may cause decline in wildlife populations in this conservancy as their declines have been shown to be directly correlated with decreases in rainfall unlike in other private conservancies. This study was carried out to determine the population trends of eleven wild herbivores, the effect of temporal variation in rainfall on wild herbivore populations and establish the relationship between wild herbivore populations in Soysambu conservancy. Data for twentyone years (1993-2013) on rainfall and wild herbivore populations were obtained from the conservancy records and the Kenya meteorology service. Regression and correlation analyses were used to assess population trends, relationship between rainfall parameters (wet season, dry season, mean annual, and 5-year cumulative rainfalls) and herbivore populations, and correlation among herbivore populations. Results showed a significant increase in the population of impala ($r^2 = 0.267$, $P = 0.004$), buffalo ($r^2 = 0.511$, $P < 0.001$), zebra ($r^2 = 0.745$, $P < 0.001$), giraffe ($r^2 = 0.786$, $P < 0.001$), herbivore browsers ($r^2 = 0.5641$, $P < 0.001$) and grazers ($r^2 = 0.748$, $P < 0.001$), but a significant decrease in the population of Thomson's gazelle ($r^2 = 0.387$, $P = 0.007$). The significant increase in the populations of zebra, giraffe and all grazers were attributed to the increase in mean annual rainfall and decrease in dry season rainfall. Also, the significant decrease in the population of Thomson's gazelle was attributed to the significant decrease in dry season rainfall ($r^2 = 0.321$, $P = 0.022$) and the increase in the populations of zebra ($r = -0.654$, $n = 21$, $p = 0.040$) and giraffe ($r = -0.654$, $n = 21$, $P = 0.001$). The increase in the other herbivore populations could not be explained by rainfall variability. Pearson correlation showed that there was a significant positive correlation between browsers and grazers ($r = 0.745$, $n = 21$, $P < 0.001$) and significant correlations ($P < 0.05$) among 10 wild herbivore species. For sustainable conservation of diverse wild herbivores in Soysambu conservancy there is need to (i) provide artificial water supply to species that are water-dependent and significantly decreasing to counter the adverse effects of drought, (ii) regulate the populations that are significantly increasing at the expensive of others and (iii) carry out further research to understand habitat requirements of the various herbivore species and identify resource inadequacies before they threaten population viability.

Keywords: Population trends; Rainfall fluctuations; Soysambu conservancy; Wild herbivores.

INTRODUCTION

Monitoring and predicting wildlife population changes have become increasingly important management strategies for species with decreasing populations (Mawdsley *et al.*, 2009). It is estimated that between 1970 and 2010, the abundance of African large mammals in protected areas has decreased to half (Craigie *et al.*, 2010). In Tarangire-Manyara ecosystem in Tanzania and Maasai Mara National Reserve in Kenya, ungulate species such as Cape buffalo, giraffe,

impala, eland, lesser kudu and warthog have all declined since the 1980s (Loftis, 2015). Wildlife population declines appear to be directly correlated with decreases in precipitation (Craigie *et al.,* 2010; Ogutu & Owen-Smith, 2005), management regime of the area, competition with other wildlife and changes in habitats. In Kruger National Park in South Africa, species such as greater kudu, waterbuck, and eland have experienced large population declines, likely due to rainfall fluctuations (Ogutu and Owen-Smith, 2003). Contrastingly, well managed private conservancies in Kenya such as Ol Pejeta and Lewa have experienced increase in wild herbivore abundance in the recent years. A study in Ruma National park in Kenya by Kimanzi *et al*. (2016) showed that some antelopes increased at the expense of other antelopes due to interspecific competition whereas the population dynamics of other antelopes were influenced by habitat changes.

Studies by Western *et al*., 2009) have shown that about 70% of wildlife populations are found in private and communal lands outside the protected areas (National Parks and National Reserves) in Kenya. In a bid to cater for this large portion of wildlife, many conservancies have been established in Kenya lately. There are 160 Private and Community Conservancies located in 28 counties (KWCA, 2016), which are spread all over the country. Conservancies fall under IUCN category vi, which are natural areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems (IUCN, 1974). These are private or community land registered and managed for purposes of sustainable wildlife conservation and compatible land uses for better livelihoods (KWCA, 2015).

The existing private and communal lands and protected areas are faced with uncertainty in the future due to human-wildlife conflicts, land-subdivision, fencing, land use changes, pollution, agricultural encroachment, farming, poaching, human settlement, habitat loss and destruction, and construction of infrastructure (Kimanzi & Wishitemi 2003; Kimanzi & Wishitemi 2001). The community wildlife conservancy model seeks to mitigate most of these threats. Conservancies enable landowners and communities to sustainably conserve and manage wildlife and their habitat outside formal protected areas for the benefit of the people of Kenya (KWCA, 2015).

This study was carried out in Soysambu conservancy, which has experienced consistent decline in rainfall during the dry seasons for many years (Ogutu and Owen-Smith, 2003). It is not clear whether the prevailing climatic conditions and management regime in Soysambu conservancy promotes wild herbivore population increase or decrease. This study was done to determine the population trends of eleven wild herbivores, the effect of temporal variation in rainfall on populations of these wild herbivores and establish the relationship between the populations of these wild herbivores in Soysambu conservancy.

METHODOLOGY

Study area

Soysambu conservancy is a private conservancy, which was established in 2007. Earlier it was a game ranch covering an area of 190km^2. It is located in Nakuru County about 120km northwest of Nairobi and it is adjacent to Lake Elementaita, which is a Ramsar site as from 2005 (Dwight, 2005). It is among the best-managed conservancies in Kenya besides Lewa and Ol pejeta conservancies.

The main vegetation types in Soysambu Conservancy are grassland and Acacia woodland. The main grass types are *Chloris Gayana, Themeda trianda, Cynodon Dactylon, Pinesetum Nizianum and Pinesetum Catabais*. The Acacia woodland is dominated by *Acacia xanthophloea*. The major wildlife grazers include Burchell's Zebras (*Equus burchelli*) and African Buffalo (*Syncerus caffer*) (Leap, 2019). Some mammal species of conservation concern include the Rothschild's Giraffe (*Giraffa camelopardalis* Rothschildi), Lion (*Panthera leo*), Leopard (*Panthera pardus*), and Colobus monkey (*Guereza guereza*) (Leap, 2019). Other wildlife species include Thomson's Gazelles (*Eudorcas thomsonii*), Spotted hyena (*Crocuta crocuta*), Dik dik (*Madoqua kirkii*), Impala (*Aepyceros melampus*), Grants Gazelle (*Nanger granti*), Warthog (*Phacochoerus africanus*), Waterbuck (*Kobus ellipsiprymnus*), Eland (*Taurotragus oryx*), Bushbuck (*Tragelaphus scriptus)* and Reedbuck (*Redunca redunca*).

Trends in population of wild herbivores

Trends in population of eleven (11) wild herbivores (Impala, Buffalo, Grant's Gazelle, Zebra, Warthog, Giraffe, Waterbuck, Thomson's Gazelle, Eland, Bushbuck and Reedbuck) were determined from secondary data collected through total ground count method in animal counting blocks as described by World Wildlife Fund (2000). This was conducted by dividing the Conservancy into 9 animal counting blocks (Jolai A, Jolai B, Headquarters area, Melia A, Melia B, Congreve, Soysambu, Mbaruk and Lakeside). The blocks were covered by using 4-wheel drive vehicles to enable traversing every part of the block. Data were collected in all the blocks at the same time to avoid double-counting of animals. The ground counting was done early in the morning when wild herbivores are actively feeding and hence easy to sight. Wild herbivore numbers for each belt transect used to collect data in the study area were recorded in specially designed data sheets and their cumulative totals determined. Data from past wild mammal counts in Soysambu conservancy for twenty-one years (1993-2013) were reviewed to determine wild herbivore population trends over time.

Changes in rainfall patterns

Rainfall data for a period of twenty-one years (1993-2013) was acquired from the Soysambu conservancy weather data and Kenya Meteorological Service. Four parameters were derived from the rainfall data: dry season rainfall, wet season rainfall, mean annual rainfall and five-years cumulative rainfall (Cum5Yrs). The dry season rainfall was the total for the driest months in the Soysambu conservancy (December to February), whereas the wet season rainfall was the total for the wettest months (March to June). The mean annual rainfall was averaged from January to December for the 21 years (1993-2013). The five-year cumulative rainfall was calculated using the amount of cumulative rainfall for the past 5 years preceeding the year of collecting herbivore population data via moving averages statistics. The five years were used because past research has shown that the effect of prior rainfall on most wild herbivores (Owen-Smith and Mills, 2006) and antelopes (Kimanzi *et al.*, 2016) is highest about five years prior to the count year.

Data Analysis

Data analysis involved assessing how wild herbivore population trends relate to the various components of rainfall patterns and establishing the relationship between the population numbers of wild herbivores. The wild herbivores were also grouped into three feeding guilds: browsers (giraffe and Bushbuck); grazers (warthog, buffalo, zebra, waterbuck and reedbuck) and mixed feeders (impala, eland, Thomson's gazelle and Grant's gazelle) to assess the population trends of these guilds. Exploratory data analysis was done using graphs while

inferential analysis was carried out using simple and multiple linear regression and correlation analyses.

RESULTS

Population trend of browsers, grazers and mixed feeders of wild herbivore species in Soysambu conservancy

Linear regression was carried out to establish the population trends of wild herbivores in Soysambu conservancy. In general, the results showed that seven wild herbivore species (impala, buffalo, Grant's gazelle, zebra, warthog, giraffe and waterbuck) had an overall population increase (Figure 1) whereas four species (Thomson's gazelle, eland, bushbuck and reedbuck) had an overall population decrease (Figure 2). In particular, there was a significant overall population increase of impala ($R^2 = 0.267$, b = 63.697, P = 0.004), buffalo ($R^2 = 0511$, b = 34.267, P < 0.001), zebra ($R^2 = 0.745$, b = 157.850, P < 0.001) and giraffe ($R^2 = 0.786$, b = 5.695, P< 0.001) whereas warthog ($R^2 = 0.085$, b = 2.578, P = 0.655), grant gazelle ($R^2 = 0.019$, b = 2.501, P = 0.384) and waterbuck ($R^2 = 0.160$, b = 5.206, P = 0.081) showed an insignificant population increase. The results also showed a significant population decrease of Thomson gazelle ($R^2 = 0.387$, b = -115.730, P = 0.007) but an insignificant decrease in the population of eland ($R^2 = 0.125$, b = -12.938, P = 0.164), bushbuck ($R^2 = 0.008$, b = -0.185, P = 0.702) and reed buck ($R^2 = 0.019$, b = -0.064, P = 0.557).

Figure 3 shows the population trend of browsers (giraffe and bushbuck), grazers (buffalo, zebra, waterbuck and reedbuck) and mixed feeders (impala, eland, warthog, Thomson's gazelle and Grant's gazelle). Linear regression showed that there was a significant population increase in browsers ($R^2 = 0.564$, b = 5.024, P < 0.001) and grazers ($R^2 = 0.748$, b = 178.810, P < 0.001) but an insignificant decrease in mixed feeders ($R^2 = 0.019$, b = -39.953, P = 0.555).

Rainfall distribution patterns in Soysambu conservancy from 1993-2013

Trend analysis showed an overall increase in wet season rainfall, mean annual rainfall and 5-year cumulative rainfall but an overall decrease in dry season rainfall from 1993 to 2013 (Figure 4). Simple linear regression analysis showed a significant increase in wet season rainfall ($R^2 = 0.293$, b = 0.386, P = 0.011) and mean annual rainfall ($R^2 = 0.225$, b = 1.422, P = 0.030) but an insignificant increase in the 5-year cumulative rainfall ($R^2 = 0.011$, b = 10.080, P = 0.647) and decrease in dry season rainfall ($R^2 = 0.082$, b = 0.238, P = 0.207).

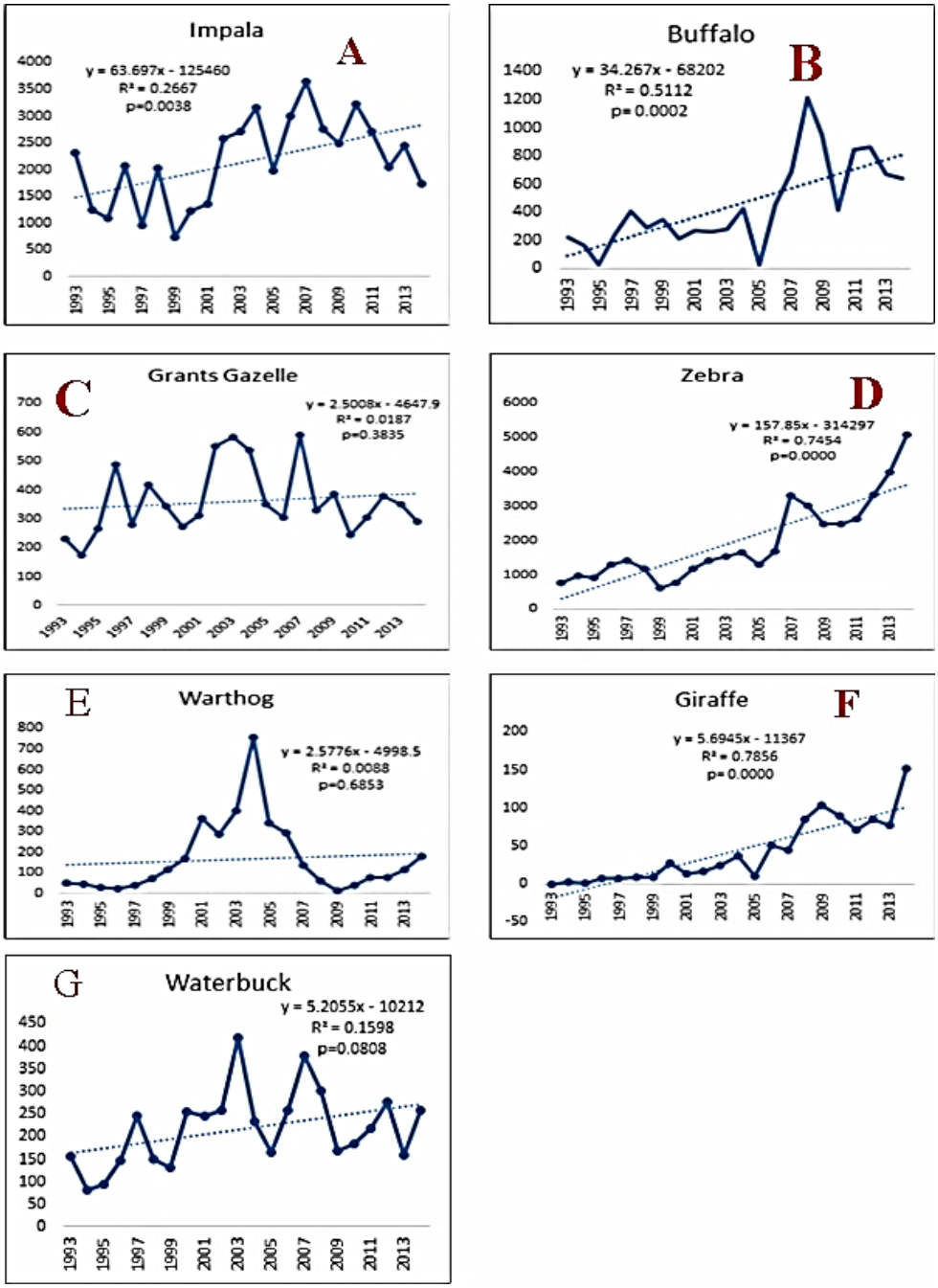

Figure 1: Population trend of wild herbivores that increased between 1993 and 2013 in Soysambu conservancy

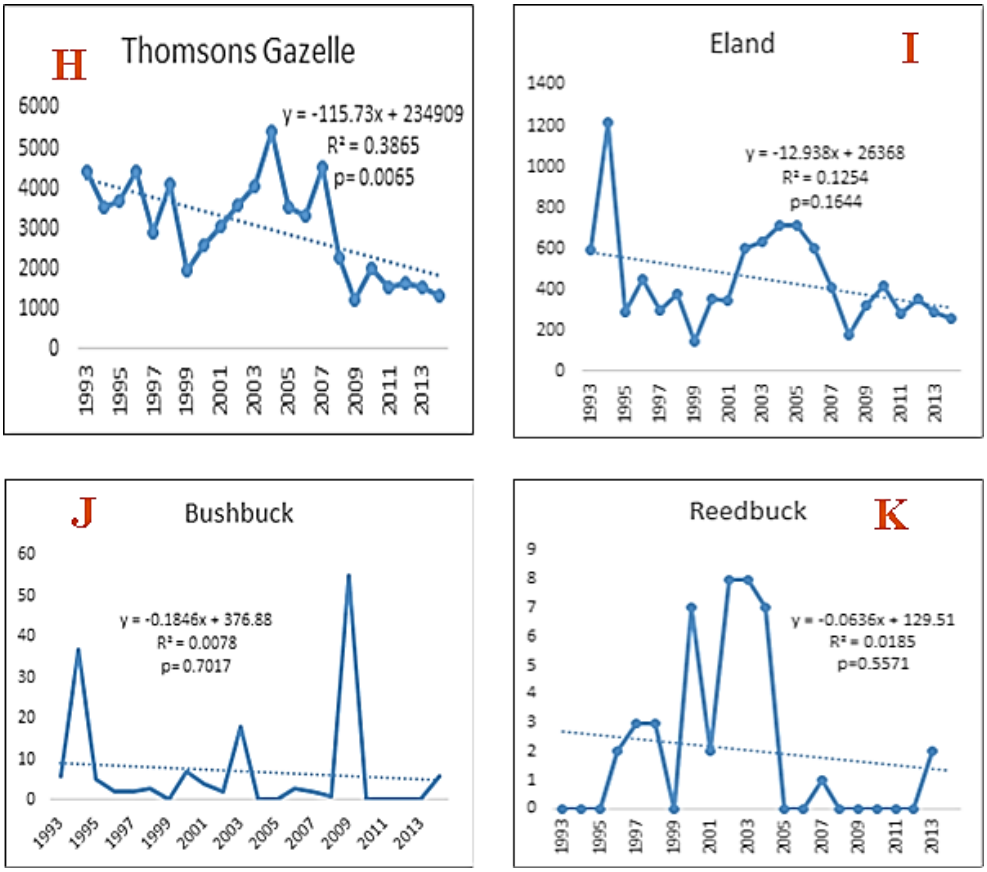

Figure 2: Population trend of wild herbivores that decreased between 1993 and 2013 in Soysambu conservancy

Effects of rainfall parameters on population of browsers, grazers and mixed feeders of wild herbivores in Soysambu conservancy

From the secondary data obtained on population of wild herbivores in Soysambu conservancy, multiple linear regression was performed to establish whether there was any significant effect of rainfall on the population of wild herbivore species. Multiple linear regressions showed that rainfall variability had significant effect on the population change of 5 wild herbivore species but no significant effect on the other 6 wild herbivore species (Table 1). In particular, results showed that the mean annual rainfall had significant positive effect on the population of zebra (R^2 = 11.129, β = 21.255, P = 0.010). Also, dry season rainfall had a significant positive effect on the population of Thomson's gazelle (R^2 = 0.321, β = 9.886, P = 0.022). Finally, the 5-year cumulative rainfall had a significant negative effect on reedbuck (R^2 = 0.213, β = -0.005, P = 0.035).

Multiple linear regression analysis showed that the mean annual rainfall had a significant positive effect on the change of the population of grazers (R^2 = 0.192, β = 0.006, P = 0.047) whereas the dry season rainfall had a significant positive effect on the population of mixed feeders (R^2 = 0.292, β =13.806, P = 0.011) and a significant negative effect on browsers (R^2 = 0.196, β = -0.003, P = 0.044) (Table 2).

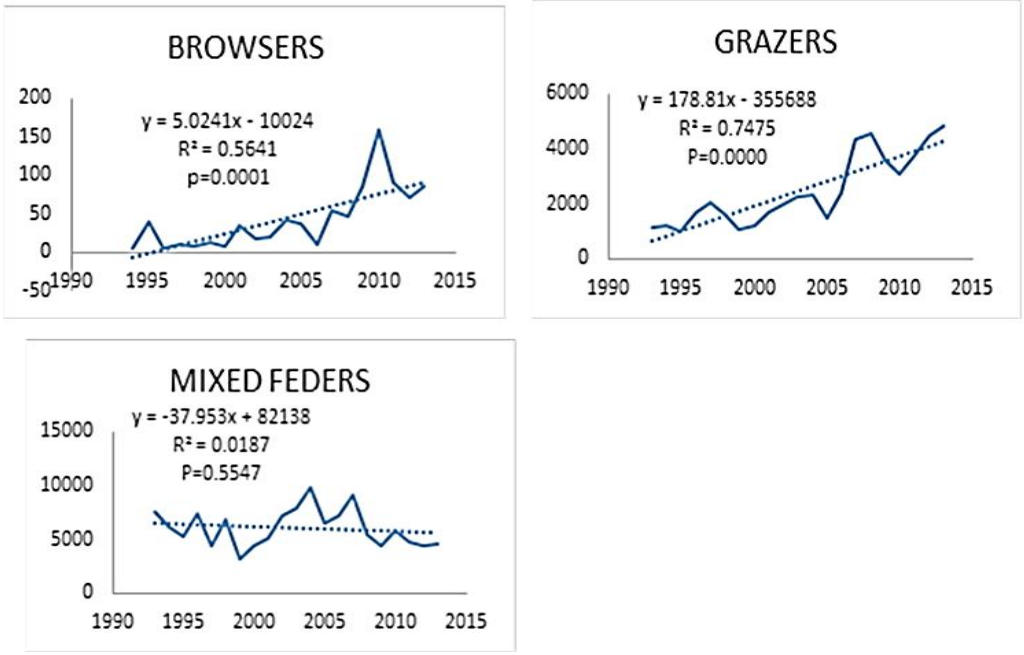

Figure 3: Population trend of browsers, grazers and mixed feeders of wild herbivores in Soysambu conservancy

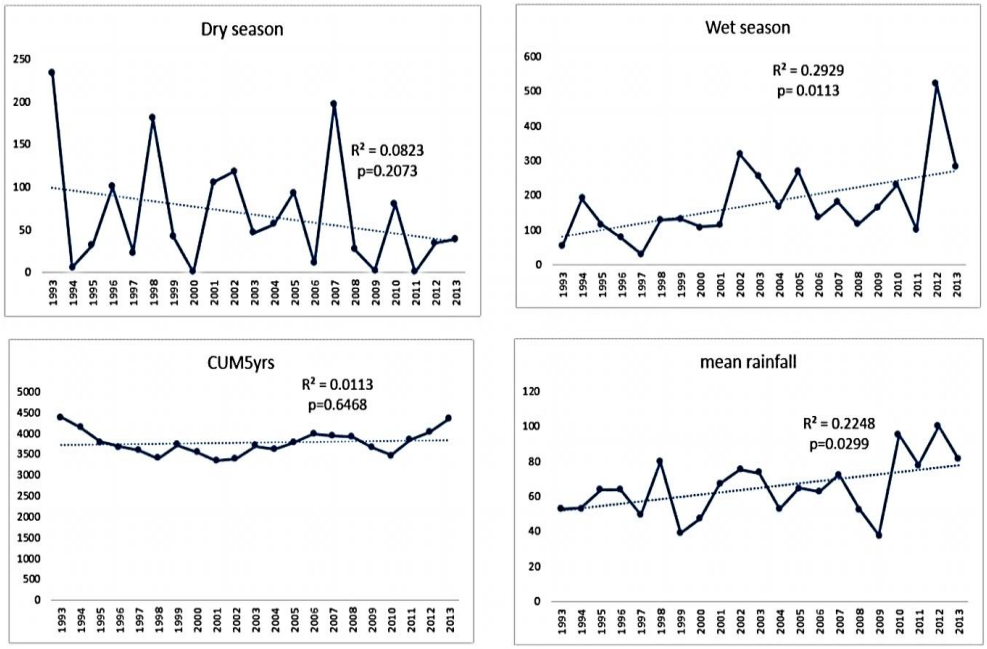

Figure 4: Rainfall distribution patterns in Soysambu conservancy from 1993-2013

Table 1: Multiple linear regression statistics of rainfall parameters with significant effect on the population of wild herbivore species

Species	Predictor	R^2	B	P
Reedbuck	Cumulative five years rainfall	0.213	-0.005	0.035
Thomson's gazelle	Mean dry season	0.321	9.886	0.007
Zebra	Mean annual rainfall	0.247	29.247	0.022

Table 2: Multiple linear regression statistics of rainfall parameters with significant effect on the population of wild herbivore browsers, grazers and mixed feeders

Species	Predictor	R^2	β	P
Browser	Dry season rainfall	0.196	-0.003	0.044
Grazers	Mean annual rainfall	0.192	0.006	0.047
Mixed feeders	Dry season rainfall	0.292	13.806	0.011

Relationship among wild herbivore populations in Soysambu conservancy

Analysis on the relationship among wild herbivore populations in Soysambu conservancy was carried out using Pearson correlation. The correlation analysis showed that ten wild herbivore populations correlated significantly with each other whereas bushbuck did not correlate significantly with any other wild herbivore. The results showed that: (i) buffalo population positively correlated significantly with the populations of impala ($r = 0.455$, $n = 21$, $P = 0.038$), zebra ($r = 0.798$, $n = 21$, $P < 0.001$) and giraffe ($r = 0.846$, $n = 21$, $P < 0.001$) but negatively correlated significantly with the populations of Thomson's gazelle ($r = -0.551$, $n = 21$, $P = 0.010$) and eland ($r = -0.455$, $n = 21$, $P = 0.038$); (ii) Grant's gazelle population positively correlated significantly with the populations of impala ($r = 0.496$, $n = 21$, $p = 0.022$), reedbuck ($r = 0.570$, $n = 21$, $p = 0.007$), warthog ($r = 0.028$, $n = 21$, $p = 0.028$) and waterbuck ($r = 0.574$, $n = 21$, $p = 0.006$); (iii) impala population positively correlated significantly with the populations of giraffe ($r = 0.565$, $n = 21$, $p = 0.008$), zebra ($r = 0.601$, $n = 21$, $p = 0.004$) and waterbuck ($r = 0.494$, $n = 21$, $p = 0.023$); (iv) reedbuck population positively correlated significantly with the populations of warthog ($r = 0.594$, $n = 21$, $p = 0.005$) and waterbuck ($r = 0.445$, $n = 21$, $p = 0.043$); (v) Thomson's gazelle population positively correlated significantly with the populations of warthog ($r = 0.476$, $n = 21$, $p = 0.029$) and eland ($r = 0.507$, $n = 21$, $p = 0.019$) but negatively correlated significantly with the population of zebra ($r = -0.654$, $n=21$, $p=0.040$) and Giraffe ($r = -0.654$, $n = 21$, $p = 0.001$); and finally (vi) zebra population positively correlated significantly with the population of giraffe ($r = 0.830$, $n = 21$, $p < 0.001$).

Also, Pearson correlation showed that there was a significant positive correlation between the populations of wild herbivore browsers and grazers ($r = 0.745$, $n=21$, $P < 0.001$) whereas mixed feeders showed an insignificant negative correlation with browsers ($r = -0.241$, $n=21$, $P = 0.293$) and grazers ($r = -0.070$, $n=21$, $P = 0.763$).

DISCUSSION

From 1993-2013, population trends of wild herbivores in Soysambu conservancy were positive for some species and negative for the others. In particular, there was a significant decrease in Thomson's gazelle and significant increases in four species (impala, buffalo, zebra and giraffe). The other species either decreased insignificantly (eland, bushbuck and reedbuck) or increased insignificantly (Grant's gazelle, warthog and waterbuck). There is need to investigate and address the causes of the population decrease of these four herbivore species.

The decrease in Thomson's gazelle was attributed to the decrease in dry season rainfall and increase in three large wild herbivore populations (buffalo, zebra and giraffe) in the conservancy. Rainfall variability influences animal abundances causing the differences in rates at which naturally dynamic ungulate populations decline during dry phases, and increase during wet phases. Illius & O'Connor (2000) pointed out that large grazer populations are limited by rainfall and the rates of decline in drought years are typically higher than rates of increase in wet years. Also, Ogutu *et al*. (2014) pointed out that wildlife herbivore trends are affected by rainfall variability among other factors. Also, the population of Thomson's gazelle being a small mixed feeder was suppressed by the population increase in large grazers (buffalo and zebra) and a large browser (giraffe), which limited the available forage for it. These megaherbivores have been shown to suppress the growth and regeneration of plants and therefore consequently impact other smaller herbivores negatively (Parker & Bernard, 2005; Ripple *et al* 2015).

Out of the four wildlife species that increased significantly, only the zebra could be explained by increase in mean annual rainfall whereas the rest could not be explained by changes in the rainfall parameters considered in this study. The high positive correlation in the population of these four increasing species (impala, buffalo, zebra and giraffe) may indicate that the factors influencing their increase are the same. The increase in buffalo population had negative impact on the population of elands and Thomson's gazelle, which showed declining trends. This could be explained by the effect of interspecific competition between buffalo and the other two species. For example, Borner *et al* (1987) demonstrated that Thomson's gazelle decline (1972 – 1985) in Serengeti National Park was partly due to interspecific competition with Wildebeest. Since Soysambu has been experiencing consistent decline in rainfall during the dry seasons for many years (Ogutu and Owen-Smith, 2003), there could be diet overlap between these herbivores in the dry seasons when resources are limiting with the buffalo being more competitive due to its mega size. The increase in population of impala, buffalo and giraffe could be caused by the overall increase in wet and mean rainfall in Soysambu and other factors, not considered in this study. Such factors could include availability of adequate suitable habitat, effective management regime and adequate security offered in Soysambu conservancy, which have been shown to promote high population growth of wild herbivores in Africa (FAO, 2017; Knight, 2017).

Although, the decrease in the population of reedbucks was insignificant, their decrease was caused by their interspecific competitive with the increased populations of waterbuck and warthog as well as the decrease in the cumulative five-year rainfall. As these three species are all grazers the reedbuck could be outcompeted due to its smaller body size. Since the preferred habitat for reedbucks is grasslands or reeds near water bodies (Wildlife Safari, 2016), cumulative decrease in rainfall causes drying of these wetland habitats thus reducing available habitat. A study in Kruger National Park showed that shrinking of these habitats caused subsequent decline in the number of reedbucks (Kruger National Park, 2016). A similar decline of impala population due to decrease in cumulative five-year rainfall was reported by Kimanzi *et al*. (2016) in Ruma National Park.

The overall increase in wildlife grazers was attributed to the significant increase in mean annual rainfall while the increase in wildlife browsers could be attributed to the decrease in the dry season rainfall. This observed increase in wild herbivore populations in Soysambu conservancy is contrary to the general trend of wild large herbivores declining throughout much of the world (Collen *et al*. 2009; Wilkie *et al*. 2011; Ogutu *et al*., 2016), especially in

protected areas. One of the reasons for this could be the effective management regime and adequate security offered in the conservancy. Similar patterns of population increase of wildlife have been recorded in other well managed private conservancies including Lewa (Sampere & Kinuthia) and Ol pejeta (Vigne, 2017).

CONCLUSION

The study investigated the rainfall patterns and associated population trends of wild large herbivore species in Soysambu conservancy. It was established that populations of many wild herbivore species are increasing and a few are decreasing. Four species (impala, buffalo, zebra and giraffe) increased significantly but only one species (Thomson's gazelle) decreased significantly in this conservancy. Therefore, the population change in some wild herbivore species could be explained by the rainfall fluctuations and correlations between their populations whereas others could not.

RECOMMENDATIONS

The study recommends future research to be conducted on the influence of other variables such as anthropogenic factors, habitat management and climate change on the population dynamics of wild herbivores in Soysambu conservancy. Responsible translocation of herbivores that show high trends, sustainable population sizes and competition with endangered species in Soysambu conservancy should be implemented. Follow up monitoring of the herbivores is also crucially needed to identify resource requirements and inadequacies for declining wild herbivores before they threaten population viability.

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