Chapter 2

Spatial and Temporal Vegetation Dynamics: Opportunities and Constraints behind Wildlife Migration in Eastern Africa Savanna Ecosystem

Ismail S. Selemani and Anthony Z. Sangeda

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.72617

Abstract

The Africa's semi-arid savanna ecosystems are characterized by high spatial and temporal variation in forage resources that influence mobility of wildlife population. Rapid changes in vegetation composition in savanna have been documented. These have notably involved transformation of grasslands into denser bushes and infestation of undesirable weed plants accompanied by diminishing ecological carrying capacity of rangelands. The utilization of different landscape units is strongly correlated with the availability of forage species and their nutritional quality. Foraging animals normally respond to the decline in forage quality and availability by moving to other landscapes with relatively higher quality and abundant forage resources. Although, migration of wildlife outside protected areas is ecologically vital for breeding and survival, it foments human-wildlife conflicts. Limited ecological knowledge and nutritional requirements of wildlife coupled with rapid diminishing quality and availability of forage undermine biodiversity conservation efforts. The understanding of spatial–temporal variability of forage resources along with proper wildlife management practices as well as human-wildlife conflict management are highly needed to realize high productivity in livestock industry and wildlife conservation. This chapter reviews the opportunities and constraints of spatial and temporal variability of forage resources and wildlife mobility in Eastern Africa savanna ecosystem.

Keywords: rangeland degradation, wildlife mobility, vegetation variability, semi-arid savanna ecosystem, climate change

1. Introduction

The Africa's semi-arid savanna ecosystems are characterized by high spatial and temporal variation in forage resources that influence mobility of both wildlife and livestock population [1].

Spatially, vegetation variability occurs ranging from very fine scale (plant level) to regional scale (landscape level), resulting into pronounced patches of quality and availability of forage. On the other hand, vegetation varies in terms of time ranging from few seconds to several years resulting into seasonal fluctuations in forage quality and availability [2]. Although, several factors (such as topography, weather and climate) influence distribution pattern of animals, the vegetation characteristics (quality, quantity, species composition, plant morphology and physiology) are the key determinant of ungulate migration [3]. The vegetation variations caused by changes in land use and climatic variability are major driving forces of wildlife migration. The preference and aversion responses of foraging animals are closely linked with both nutritional composition and nutritional requirements of feeding animals [4].

At landscape level, rangelands consist of pattern of vegetation types clustered in concurrence with climatic condition and geographical features which create mosaic of patchiness [5]. The utilization of different landscape units is strongly correlated with the availability of forage species and their nutritional quality within these patches. Foraging animals normally respond to the decline in forage quality and availability by moving to another landscape with relative higher quality [6]. For example, in Serengeti National Park, ungulate such as wildebeest and zebra have been noted to move progressively in different grazing areas [1]. This grazing succession following feeding preference has great ecological implication through reduction in interspecific competition among grazing animals. On the contrary, wildlife migration has been blamed to cause inter-conflicts between different land uses. For example, Selemani [7] observes that, migration of wildlife to residential areas escalates conflicts between local people and conservationists and, consequently, results into negative attitude towards the protected areas and conservation, in general. Incidences of crop damage are the most common indicators for human-wildlife conflicts across the Sub-Saharan Africa. For example, crop-raiding by elephant in East Africa was reported to exacerbate conflicts by damaging the farmers' livelihood and, consequently, causing retaliatory killing [8].

Limited ecological knowledge and nutritional requirements of wildlife coupled with rapid diminishing of forage quality and availability will continue to be limiting factors for wildlife conservation. Wildlife migration outside the protected areas does not only impede conservation efforts but also fuel human-wildlife conflicts. A better understanding of the drivers for wildlife migration outside protected areas and the knowledge of interactions between native species and human impacts is an important step towards wildlife conservation. It is therefore important to understand both spatial and temporal changes in vegetation. Specifically, it is crucial to know existing potentials and challenges facing wildlife conservation as well as options for management of human-wildlife conflicts.

2. Factors underpinning wildlife migration

2.1. Anthropogenic activities

Increasing human population has tremendously transformed the previously natural ecosystems used as wildlife habitats. Although natural factors such as drought, wildfire, climate change and

http://dx.doi.org/10.5772/intechopen.72617

unpredictable hazards contribute to modification of wildlife habitats, the key driving force for degradation of forage resources and subsequently migration of wildlife are anthropogenic activities. Wildlife habitats have become more and more fragmented as a result of increasing human activities such as crop production, livestock husbandry, infrastructure development and urbanization. For example, according to Brady [9], agriculture has more profound impact on wildlife conservation than other anthropogenic activities. Cultivated crops adjacent to conservation areas are potential source of forage for wild ungulates such as elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*) and antelopes. Crops like the succulent finger millet and sweet sugarcane are not only highly palatable but contain more protein and minerals compared to the native wild grasses [9]. In addition, during the dry seasons native forage quality normally declines tremendously because natural pastures are characterized by rapidly maturing grasses which attained maturity quickly [10]. Based on Optimal Foraging Theory, which states that animals tend to select high quality diet in the manner that maximizes their nutrient intake [11], it is considered that wildlife migration to adjacent croplands is a coping strategy to survive hash condition escalated by seasonal fluctuations in quality and availability of forage resources [12].

2.2. Increased human population

A growing human population entails the increasing human needs and, consequently, need for expansion of agricultural activities to meet the demand for food and cash. Global population is currently estimated to exceed 7 billion people and is projected to rise to over 9 billion by 2050 [13]. Nearly all of this population increase will occur in developing countries (**Figure 1**). This implies that, the demand for food will increase while competition for land, water resources and energy will intensify. Agricultural production and environmental challenges are inextricably linked; whereas natural environment offers resource base on which agricultural production is completely dependent, while farming itself plays a major role in shaping the environment [13].

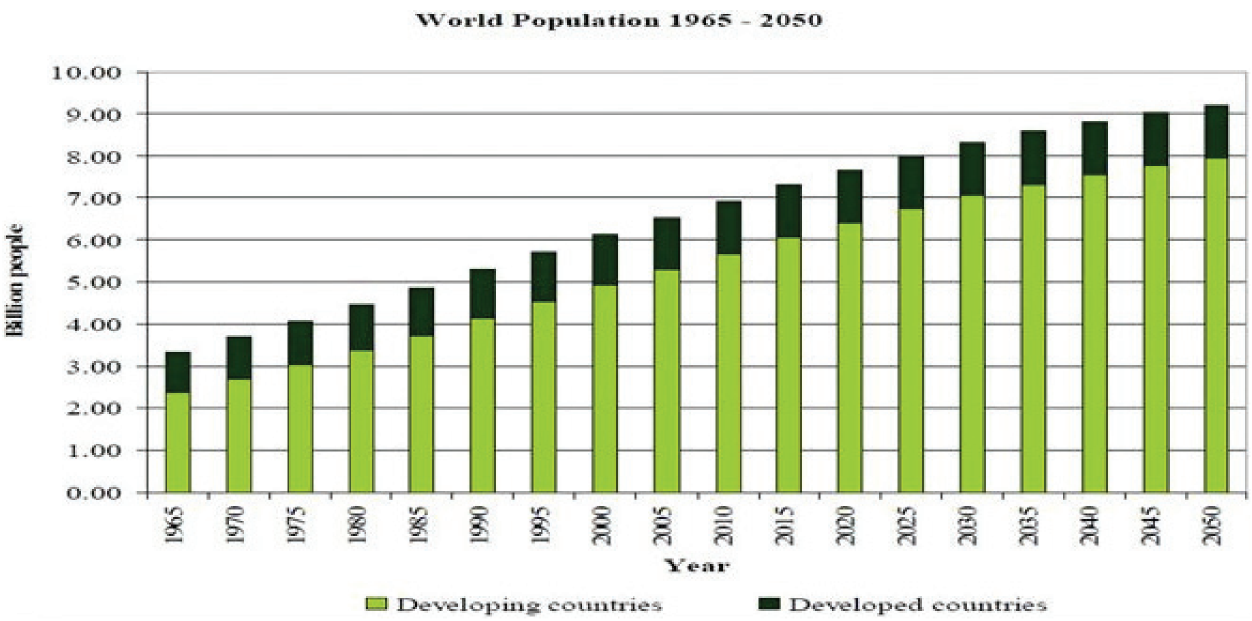

Figure 1. Projected global human population (Source RSPB 2012).

Although wildlife can tolerate agricultural land use intensification, there are thresholds beyond which tolerance is unattainable [14]. These thresholds vary with physiological and nutritional requirement of species and environmental setting. Large ungulates like elephant, zebra, giraffe, wildebeest and buffalo require vast land resources on which forage resources and water are spatially distributed. Shrinking of wildlife habitats due to agricultural expansion causes movement of wildlife to other areas where they can access quality forage resources and water.

2.3. Increased animal population

Overexploitation of forage resources in protected areas due to growing wildlife population causes changes of botanical composition and nutritional quality of vegetation. The transformation of open grassland into dense woodland known as bush encroachment is attributed to overgrazing of herbaceous vegetation. According to Walter's two layer hypothesis, decrease in grass layer following overgrazing offers opportunity for woody plants to access soil water that would otherwise be utilized by grasses [15]. Bush encroachment creates sub-habitat which differs from open grassland and thus exert different influence on grazing behavior for wildlife. Increase in woody abundance is normally accompanied by reduction in herbaceous biomass production and shift in botanical composition [16]. Change in botanical composition following overgrazing results into invasion of more unpalatable and undesirable plant species which prevents voluntary intake by foraging animals. Woody plants respond to herbivore attack through a variety of defensive mechanisms ranging from physical barriers to more complex production of secondary metabolites [17].

2.4. Infestation of invasive plant species

Invasion of noxious weeds in conservation areas largely contribute to significance loss of natural biodiversity of both fauna and flora species. Recently, invasion of alien shrubs such as *Chromolaena odorata* and *Parthenium hysterophorus* species have been observed in conserved areas such as Serengeti and Arusha National Parks in Tanzania. However, abundance and distribution of these species are inadequately documented in East Africa [18] (**Table 1**). Most of invasive weed species have been reported to pose serious threat to wildlife and biodiversity conservation with negative impact on productivity of grassland ecosystems [19]. Previous studies have shown that, the rapid spread of alien species depend on combination of reasons ranging from their high reproductive capacity, high growth rate and capacity to inhibit growth of native plants [18–20]. Allelopathy is considered as the main reason for alien species to eliminate and competitively exclude the neighboring plant species [19]. Allelopathic chemicals produced by most invasive weeds have also been reported to affect animal health by causing rhinitis, asthma, bronchitis, dermatitis, and hay fever [18, 19].

Invasive plant species in East Africa have been reported to cause environmental damaging and biodiversity loss in dry land ecosystems. Their disastrous effects include causing the death of animals (both wildlife and livestock), poisoning and destroying animal health, accelerating biodiversity loss via suppression of native plants, and increasing diseases by offering a breeding ground for mosquitoes, tsetse flies and other disease-causing insects [21] like tsetse-flies (**Table 2**). Wild animals normally respond to increasing unpalatable and noxious invasive plant species by moving to other landscapes with relative palatable and high nutritious plant

Location	Density (spp/m^2)	Frequency %	Abundance
Arusha-Kilimanjaro	4.28	96	6.79
Arusha Airport	6.52	72	5.94
Njiro	9.88	96	10.29

Source: Kilewa and Rashidi [18].

Table 1. Distribution of *Parthenium hysterophorus* in Arusha region.

Invasive plant	Occurrence		Disaster effects/impacts
	Tanzania	Kenya	
Lantana camara (Lantana)	x	x	Breeding ground for sleeping sickness & Nagana, lowers biodiversity
Prosopis juliflora (Mesquite)	x	x	Reduces livestock foliage, deep roots enhance drought, thorns poisonous
Prosopis pallida (Mesquite)		x	Reduces livestock foliage, deep roots enhance drought, thorns poisonous
Opuntia ficus indica (Prickly pear cactus)	x	x	Poisonous to wildlife in parks, affecting potential of tourism
Caesalpinia decapetala (Mauritius thorn)	x	x	Shades out grass & shrubs eaten by animals, limits animal movement
Psidium guajava (Guava)	x	x	Outcompetes native plants and lower species Biodiversity
Senna spectabilis	x	x	Suppresses growth of native park trees
Acacia farnesiana (Sweet acacia)	x	x	Suppresses growth of native trees, forms impenetrable thickets that limits access
Acacia mearnsii (Black wattle)	x	x	Outcompetes native plants lowers biodiversity & increased water loss
Acacia polyacantha	x	x	Suppresses native plant species

Source: Adopted from Obiri [21].

Table 2. Occurrence and impact of invasive species in Tanzania and Kenya.

species. The wildlife migration has socio-economic and ecological implications which are discussed in detail under the following section.

3. Ecological and economic benefits of wildlife migration

Although wildlife migration is often implicated with economic losses and degradation of environment, there are numerous potential opportunities associated with this phenomenon.

Mobility is one of the important coping strategies for animals grazing in a highly variable ecosystem with unpredictable rainfall. It is recognized that, the quality and availability of forage resources differ between parts of landscape and, therefore, foraging animals move across the landscape units searching for high quality forage [22]. In non-equilibrium condition (such as semi-arid savanna ecosystems), the appropriate management practices recommended is to focus on the process that generate spatial and temporal heterogeneity, including interaction between organisms [23]. Movement of wildlife outside protected areas, offer opportunity for interaction with livestock population (e.g. in WMA) which reduces intraspecific competition and facilitate maximum utilization of available resources distributed in time and space. In East Africa, wildlife and livestock exhibit high degree of spatial overlap or co-existence [1]. Both wildlife and livestock utilize foraging strategies based on mobility (seasonal migration and transhumance) in order to access pasture and water resources occurring in unpredictable environment.

3.1. Ecological benefits

Ecologically, seasonal migration of wildlife offer potential breeding sites to wild ungulates. A well-known example of seasonal wildlife migration in East Africa savanna ecosystem is the annual migration of around 1.3 million wildebeest (*Connochaetes taurinus)*, 0.6 million zebra (*Equus burchelli*) and Thomson gazelles (*Gazella thomsoni*) in Serengeti-Mara ecosystem (i.e. "as in Ref. [24]"). The wildlife migration (between dry and wet season) in Serengeti-Mara ecosystem is ultimately driven by the marked and strongly seasonal rainfall gradient that runs from the southeastern short-grass plains to the tall-grass woodland and savanna habitats in the north, center, and west of the ecosystem (i.e. "in [25]"). The migrant animals leave the plains during dry season and track the spatial and temporarily varying resources across the ecosystem in the wetter northern region. Different explanations have been proposed to explain this movement from the plains, to northern part of ecosystem including higher forage abundance and quality, water nutrient content and avoid risk of predation in the plains especially during breeding (i.e. "as in Ref. (i.e. "in [26]").

In addition to wildlife migration in Serengeti-Mara ecosystem [26], Simanjiro plains have also been reported as important dispersal and breeding areas for wild mammals from adjacent Tarangire National Park. The high density for zebra and wildebeest recorded in Simanjiro plains during rainy season (**Table 3**) was attributed to the seasonal migration behavior from Tarangire National Park for breeding purposes. The population of wildlife has been reported to decline during the dry season as most of wild mammals concentrate close to water points in the Tarangire National Park [27]. Therefore seasonal migration of wild animals has important ecological values; enhance population viability, sustain nutritional requirements of wildlife and preserve animals from risk of predation.

3.2. Economic benefits

Economically, wildlife migration contributes significantly to GDP for East African countries particularly Tanzania and Kenya. For example, migration of wildebeest and zebra across Serengeti-Mara ecosystem is important phenomenon for tourism attraction, resulting in the

http://dx.doi.org/10.5772/intechopen.72617

Species	No. of herd	Head size	Density (km^2)	Abundance (n)
Zebra	105	13.28 ± 1.11	1.48 ± 0.54	11,223 ± 4216
Wildebeest	59	10.20 ± 1.79	0.89 ± 0.43	5199 ± 2670
T. gazelle	25	7.24 ± 1.31	0.34 ± 0.10	1398 ± 491
Impala	21	12.67 ± 2.66	0.63 ± 0.14	4534 ± 1393

Source: Rija and Shombe [26].

Table 3. Distribution and abundance of wild animals in Simanjiro plains.

Serengeti National Park in Tanzania being listed as a World Heritage Site [27]. It was reported that wildlife concentrations outside Serengeti National Park and wildebeest migration across Serengeti-Mara Ecosystem contribute to 30% of tourists' satisfaction [28]. Nevertheless, wildlife migration has indirect vital role in ecosystem function by providing important ecosystem services [29]. Wildlife mobility enhances vegetation diversity through pollination, seed dispersal, germination and growth induced by nutrient recycling. For example, there is direct or indirect influence of plant–animal-mutualism on flowering phenology in tropical region [30].

4. Challenges related to vegetation dynamics and wildlife migration

4.1. Climate change

Rangeland resources worldwide are commonly viewed as overstocked, overgrazed, degraded and unproductive [22]. Increasing human population pressure, encroachment of rangelands for other land uses, bush encroachment and decline in primary productivity contribute to the degradation of rangelands. The heterogeneity nature of semi-arid rangelands coupled with climatic variability, mobility and adaptive management are coping strategies for both wildlife and domestic animals [23]. Ecological evidence demonstrates that rainfall is a key factor determining rangeland productivity in East Africa [1]. The effect of climate change such as rising in temperature and changes in amount and pattern of rainfall in East Africa has affected both ecosystem and biodiversity conservation [29]. Rapid decline in nutritive value of forage species, particularly protein content, during dry season constrain nutritional requirement for wildlife species. For example, green grass intake and protein content both play a key role in determining the movement and distribution patterns of migratory wildebeest in the Serengeti National Park [25]. Quality of forage is better predictor of wildlife migration than the above ground biomass. All these important plant parameters are negatively influenced by climate variability and change.

4.2. Human-wildlife conflicts

Despite the significant importance of wildlife migration, seasonal movement of wild animals has been blamed for everlasting conflicts between different land users [9]. Increasing human population magnifies the competition for scarce grazing land and water resources which in turn increase potential for human-wildlife conflicts. Although humans and wildlife in African rangelands have positively co-existed for many years, currently different forms of human-wildlife interactions are fuelling numerous conflicts. Migration of wild animals from protected areas such as national parks and game reserves to adjacent communal lands inflicts serious damages ranging through crop raiding, livestock depredation, and wildlife-induced accidents to humans. For example, a survey in the villages bordering the Serengeti National Park showed that the wildlife predators caused a loss of livestock equivalent to an average annual financial loss of 19.2% of their cash income [31].

In many parts of Africa, conflicts between human and wildlife are reported as the most serious problem particularly between local people surrounding natural reserves and wildlife managers [32]. Negative conservation attitudes pervade among local people adjacent to protected areas as result of frequent losses caused by wildlife [7]. Lack or inadequate direct benefits that can offset the losses communities experience from wildlife translates into negative attitudes towards conservation and wildlife authorities. For example, people are more likely and willing to support the abolishment of adjacent reserves when the benefits from protected areas are too minimal to outweigh the costs of conservation [32].

4.3. Bush encroachment

Bush encroachment is increasingly becoming a problem in many protected areas of Eastern Africa rangelands thus causing shortage of forage [33] Encroachment of woody plants is normally accompanied by reduced productivity of herbaceous layer (grasses) which are potential source of forage to many wild ungulates. The rapid transformation of grassland ecosystem to denser woodland in most African rangelands has been associated to several factors including heavy grazing pressures and effects of climate changes [15]. The encroached woody plants are normally unpalatable to grazing animals due to impenetrable thickets, suppressing palatable grasses and herbs. Although the causes of bush encroachment is still debatable [34], there is evidence that, effect of poor rangeland management such as overgrazing is the main driver of encroachment of woody species [16]. Overgrazing severely alter natural ecological processes by allowing woody plants to outcompete the grasses for water resources [35]. In addition to heavy grazing, reduction in fire regimes, above average rainfall, and elevation of atmospheric carbon dioxide levels are some of the processes that facilitate the growth and subsequent spread of shrubs and other woody vegetation [36]. Due to differences in their photosynthetic pathways, many woody plant species (i.e., C3 plants) benefit more from elevated atmospheric carbon dioxide due to climate change effects and subsequently grow faster and accumulate more biomass, compared to many grasses (i.e., C4 species) found in semiarid regions [36].

Bush encroachment alter ecosystem characteristic through alteration of vegetation resource and microclimate which subsequently affect wide range of animals including wildlife. Encroaching woody plants change the habitat structure, diversity abundance and composition with different micro-habitat compared to grassland ecosystem. Furthermore, plant and animal diversity is negatively affected through a decrease of vegetation structural diversity leading to an overall loss of ecosystem functioning. In some rangelands, woody plant encroachment is associated with a decline in wildlife grazing capacity up to 80% [35]. The decline in grazing capacity in most protected areas is linked with wildlife mobility to adjacent areas. For example,

http://dx.doi.org/10.5772/intechopen.72617

Research-based literature shows that over 70% of the large native ungulates in the world are found outside the formal protected areas [37].

4.4. Poaching and blockage of wildlife migratory routes

Seasonal mobility of wildlife exposes the wild animals to high risk of poaching. Poaching threatens many migratory mammals and this is intensified by human population growth, particularly around the protected areas. For example, around Serengeti National Park, number of wildebeest consumed per annum ranges from 70,000 to 129,000 [24]. Most of the animals are killed outside the protected areas during the seasonal migration. In Nairobi National Park, the wildlife migratory routes from the park to adjacent areas (**Figure 2**) were found to be more risk areas for migrant species due to poaching incidences and blockage of wildlife corridors [24].

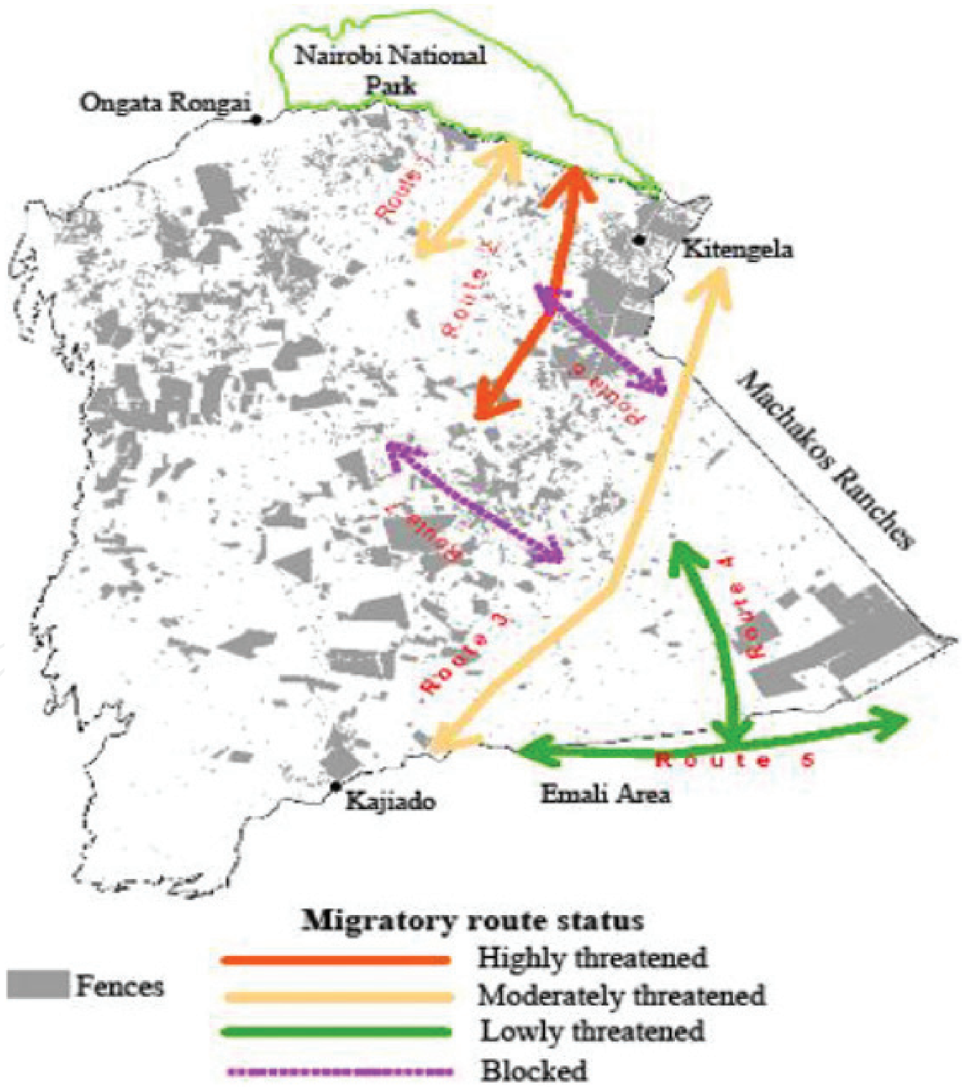

Figure 2. The map showing migratory routes of wild animals from Nairobi National Park. Source: UNEP 2013.

4.5. Diseases

Wildlife migration outside the protected area does not only cause conflicts between park management and surrounding communities, but also expose animal to health risks. The emergence of zoonotic and vector borne diseases pose considerable risks to public health, livestock and migrant wild animals. Migrant wild animals interact with both human and livestock outside the protected areas and, therefore, increase the chances for infections. In general, wild animals are susceptible to infection by the same bacteria, viruses, and parasites that infect livestock and disease transmission can occur in either direction [38]. Approximately 60% of disease causing pathogens illness in human and livestock originates from wild animals [39]. Although there is variation in wild animals and livestock on ability to respond to infections, disease transmission can occur in both directions and, therefore as the phenomenon is a two-way traffic.

5. Conclusion and recommendations

Foraging resources in Eastern Africa savanna ecosystem vary greatly in space and time. While spatial variations range from very fine scale within plant level to regional scale at landscape levels, the temporal variations range from very few seconds to several years. However, wild animals are constrained by nutritional stress, particularly in protected areas, due to seasonal fluctuations in quality and availability of forage and water resources. These animals normally respond to spatio-temporal variation in foraging resources by selecting high quality forage distributed in space and time. Seasonal migration of wildlife across different landscape units is considered as one of important coping strategies for breeding and survivability of wild ungulates. Economically, seasonal migration of wildlife is of iconic importance for tourism attraction and thus contributes to income generation. Despite the ecological and economic importance of seasonal migration of wildlife, migratory animals are implicated with losses they inflict on communities around protected areas through crop raiding, livestock depredation, accidents to humans. This exacerbates conflicts between local communities and conservationists. As a result of these losses, local communities adjacent to protected areas develop negative attitudes towards conservation efforts. In addition to human-wildlife conflicts, seasonal mobility of wild animals in Eastern Africa savanna ecosystems is also associated with climate changes, poaching, diseases and land use pressures resulting into blockage of migratory routes. It is recommended that, establishment of wildlife habitats should consider ecological and nutritional requirements of stocking animals. Migratory routes (wildlife corridors), breeding sites and dispersal areas should be designed and well protected. Most importantly, appropriate range management practices for improving range health such as bush control, prescribed fire, pasture renovation and distribution of water points are recommended. For sustainable wildlife conservation both within protected and outside protected areas and reduction of human-wildlife conflicts, we propose development of a flexible and adaptive community based conservation system involving a diverse set of stakeholders ranging from community level to region levels.

Author details

Ismail S. Selemani* and Anthony Z. Sangeda

*Address all correspondence to: suma02seleman@yahoo.co.uk

Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture, Chuo Kikuu, Morogoro, Tanzania

References

[1] Nelson F. Natural conservationists? Evaluating the impact of pastoralist land use practices on Tanzania's wildlife economy. Research, Policy and Practice. 2012;**2**(15):1-19. DOI: 10.1186/2041-7136-2-15

[2] Adler PB, Raff DA, Lauenroth WK. The effect of grazing on the spatial heterogeneity of vegetation. Oecologia. 2001;**128**:465-479. DOI: 10.1007/s004420100737

[3] Harris NR, Johnson DE, George MR, McDougald NK. The Effect of Topography, Vegetation, and Weather on Cattle Distribution at the San Joaquin Experimental Range, California. USDA Forest Service General Technical Report. 2002; PSW-GTR-184

[4] Baumont R, Prache S, Meuret M, Morand-Fehr P. How forage characteristics influence behaviour and intake in small ruminants: A review. Livestock Production Science. 2000; **64**:15-28

[5] Hirata M, Kanemaru E, Tobisa M. Patch choice by cattle grazing tropical grass swards: A preliminary study. Applied Animal Behaviour Science. 2006;**97**:134-144

[6] Briske DD, Derner JD, Brown JR, Fuhlendorf SD, Teague WR, Havstad KM, Gillen RL, Ash AJ, Willms WD. Rotational grazing on rangelands: Reconciliation of perception and experimental evidence. Rangeland Ecology and Management. 2008;**61**:3-17

[7] Selemani IS. Communal rangelands management and challenges underpinning pastoral mobility in Tanzania: A review. Livestock Research for Rural Development. 2014;**26**(5). Article no. 78. http://www.lrrd.org/lrrd26/5/sele26078.html.

[8] Karami BR. An Assessment of Perceived Crop Damage in a Tanzanian Village Impacted by Human-Elephant Conflict and an Investigation of Deterrent Properties of African Elephant (Loxodontaafricana) Exudates Using Bioassays. Master Thesis, Georgia Sothern University; 2003

[9] Brady SJ. Effects of cropland conservation practices on fish and wildlife habitat. The Wildlife Society Technical Review. 2007;**7**(1):9-23

[10] Mwilawa AJ, Komwihangilo DM, Kusekwa ML. Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania. African Journal of Ecology. 2008;**46**(1):85-89

[11] Pyke GH. Optimal foraging theory: A critical review. Annual Review of Ecology and Systematics. 1994;**15**:523-575

[12] Nandin R. Wildlife-human conflicts: Old trajectories & new strategies. Current Conservation. 2010;**4**(4):1-11

[13] RSPB. Balancing Agricultural Production and Conservation. Paper to the Oxford Farming Conference; 2012, https://www.rspb.org.uk/Images/oxfordfarmingconference2012_tcm9-301042.pdf

[14] Butt B. Coping with uncertainty and variability: The influence of protected areas on pastoral herding strategies in East Africa. Human Ecology. 2011;**39**(3):289-307

[15] Walter H. Die Verbuschung, eineErscheinung der subtropischenSavanne- ngebiete, und ihreokolohischenUrsachen. Vegetatio. 1954;**5**(6):6-10

[16] Tefera S, Snyman HA, Smit GN. Rangeland dynamics of southern Ethiopia: (2). Assessment of woody vegetation structure in relation to land use and distance from water in semi-arid Borana rangelands. Journal of Environmental Management. 2007;**85**:443-452

[17] Rasmann S, Agrawal AA. Plant defense against herbivory: Progress in identifying synergism, redundancy, and antagonism between resistance traits. Plant Biology. 2009;**12**:473-478

[18] Kilewa R, Rashid A. Distribution of invasive weed *Parthenium hysterophorus* in natural and agro-ecosystems in Arusha Tanzania. International Journal of Science and Research. 2012;**3**(12):1724-1727

[19] Hu G, Zhang Z. Allelopathic effects of *Chromolaena odorata* on native and non-native invasive herbs. Journal of Food, Agriculture & Environment. 2013; **11**(1):878-882

[20] Honu YAK, Dang QL. Responses of tree seedlings to the removal of *Chromolaena odorata* Linn. in a degraded forest in Ghana. Forest Ecology and Management. 2000;**137**:75-82

[21] Obiri JF. Invasive plant species and their disaster-effects in dry tropical forests and rangelands of Kenya and Tanzania. Journal of Disaster Risk Studies. 2001;**3**(2):417-428

[22] Vetter S. Rangelands at equilibrium and non-equilibrium: Recent developments in the debate. Journal of Arid Environments. 2005;**62**:321-341

[23] Gillson L. Testing non-equilibrium theories in Savanna: 1400 years of vegetation change in Tsavo National Park, Kenya. Ecological Complexity. 2004;**1**(4):281-298

[24] UNEP. Saving the Great Migrations: Declining Wildebeest in East Africa? UNEP Global Environmental Alert Services; 2013. www.unep.org/geas

[25] Holdo RM, Holt RD, Fryxell JM. Opposing rainfall and plant nutritional gradients best explain the wildebeest migration in the Serengeti. The American Naturalist. 2009;**173**(4):431-445

[26] Rija AA, Shombe NH. Population density estimates of some species of wild ungulates in Simanjiro plains, northern Tanzania. Africa. Journal of Ecology. 2011;**49**(3):1-3

[27] UNESCO, Serengeti National Park. World Heritage List. United Nations Educational, Scientific and Cultural Organization (UNESCO); 2013 2017. http://whc.unesco.org/en/list/156. Accessed 22nd August

[28] Okello MM, Yerian S. Tourist satisfaction in relation to attractions and implications for conservation in the protected areas of the Northern Circuit, Tanzania. Journal of Sustainable Tourism. 2009;**17**(5):605-625

[29] Lovett JC, Midgely GF, Barnard PB. Climate change and ecology in Africa. African Journal of Ecology. 2005;**43**:279-281

[30] Aizen MA. Influences of animal pollination and seed dispersal on winter flowering in temperate mistletoe. Ecology. 2003;**84**:2613-2627

[31] Holmern T, Nyahongo J, Røskaft E. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biological Conservation. 2007;**135**(4):518-526

[32] Newmark WD, Manyanza DN, Gamassa DGM, Sariko HI. The conflict between wildlife and local people living adjacent to protected areas in Tanzania: Human density as a predictor. Conservation Biology. 1994;**8**(1):249-255

[33] Prins HHT, Vander Jeugd HP. Herbivore population crashes and woodland structure in East Africa. Journal of Ecology. 1993;**81**:305-314

[34] Oldeland J, Dorigo W, Wesuls D, Jürgens N. Mapping bush encroaching species by seasonal differences in hyperspectral imagery. Remote Sensing. 2010;**2**:1416-1438

[35] Meik JM, Jeo RM, Mendelson JR, Jenk KE. Effects of bush encroachment on an assemblage of diurnal lizard species in central Namibia. Biological Conservation. 2002;**106**:29-36

[36] Seamster VA. Consequences of woody plant encroachment for mammalian predators. *PhD Thesis*, Department of Environmental Sciences, University of Virginia; 2010

[37] Wiegand K, Saltz D, Ward DA. Patch-dynamics approach to savanna dynamics and woody plant encroachment: Insights from an arid savanna. Perspectives in Plant Ecology, Evolution and Systematics. 2006;**7**:229-242

[38] Fischer JR, Gerhold R. Wildlife as a risk factor in animal health and zoonosis. Conference OIE. 2002:273-280

[39] Soulsbury CD, White PCL. Human-Wildlife Interactions in Urban Areas: A Review of Conflicts, Benefits and Opportunities. Working Paper, Environment Department, University of York, York, 2015; YO10 5DD, UK

IntechOpen