Natural Resources, 2015, 6, 91-114
Published Online February 2015 in SciRes. http://www.scirp.org/journal/nr
http://dx.doi.org/10.4236/nr.2015.62009

Population Status and Trend of Water Dependent Grazers (Buffalo and Waterbuck) in the Kenya-Tanzania Borderland

Moses Makonjio Okello[1*], Lekishon Kenana[2], Hanori Maliti[3], John Warui Kiringe[1], Erastus Kanga[2], Fiesta Warinwa[4], Samwel Bakari[3], Nathan Gichohi[4], Stephen Ndambuki[2], Hamza Kija[3], Noah Sitati[4], David Kimutai[3], Machoke Mwita[3], Daniel Muteti[2], Philip Muruthi[4]

[1]SFS Center for Wildlife Management, Nairobi, Kenya
[2]Kenya Wildlife Service, Nairobi, Kenya
[3]Tanzania Wildlife Research Institute, Arusha, Tanzania
[4]African Wildlife Foundation, Nairobi, Kenya
Email: [*]mokello@fieldstudies.org, [*]mokello33@gmail.com

Received 12 January 2015; accepted 1 February 2015; published 5 February 2015

Abstract

Even though over many years the IUCN has considered the African buffalo and waterbuck and abundant species in Africa with no conservation concern, the situation is rapidly changing. Using aerial counts in wet and dry season in 2010 and 2013, this study assessed the trend, population status and distribution of the African buffalo and common waterbuck in the Northern Tanzania and Southern Kenya borderland. Both species were rare in the borderland, with the Amboseli region had the highest number of buffalo (241.5 ± 29.9), followed by Magadi/Namanga (58.0 ± 22.0), West Kilimanjaro (38.8 ± 34.9), and lastly Lake Natron (14.5 ± 9.0) areas. In terms of density, Amboseli also led with 0.03 ± 0.00 (buffalo per km^2), but rest had similar densities of 0.01 ± 0.00 buffalo per km^2. In terms of percent changes in buffalo, Amboseli area had a positive increase (+10.59 ± 27.71), but with a negative growth of −17.12 in the dry season. All other changes in all locations had negative (decline) buffalo numbers over time. For waterbuck numbers, Amboseli area also led with 12.3 ± 3.9 waterbuck), followed by Magadi/Namanga (10.3 ± 3.7.0), Lake Natron (3.8 ± 3.4), and lastly West Kilimanjaro (0.5 ± 0.5) areas. In terms of waterbuck density, they were low and less than 0.00 ± 0.00 per km^2. For percent changes in waterbuck numbers, Magadi/Namanga had higher positive change (+458.33 ± 291.67), but all other locations had negative (decline) changes with the worst being West Kilimanjaro and Lake Natron areas. Further, buffalo number was dependent (p = 0.008) on the season, with numbers being higher in the wet season than dry season.

[*]Corresponding author.

How to cite this paper: Okello, M.M., *et al.* (2015) Population Status and Trend of Water Dependent Grazers (Buffalo and Waterbuck) in the Kenya-Tanzania Borderland. *Natural Resources*, **6**, 91-114. http://dx.doi.org/10.4236/nr.2015.62009

For waterbuck, numbers were independent (p = 0.72) of the season, with numbers being similar across seasons. The findings of this study showed that both species were negatively affected by drought. We recommend a constant joint monitoring program between Kenya and Tanzania, and jointly combat poaching, habitat fragmentation and encroachment to build viable populations in the borderland.

Keywords

African Buffalo, Common Waterbuck, Borderland, Kenya, Population Trend and Status, Tanzania

1. Introduction

1.1. African (Cape) Buffalo

As one of the most widespread African ungulates, African buffalo is found throughout most of Africa south of the Sahara [1] [2]. The African buffalo is one of the most successful grazers in Africa. It lives in swamps and floodplains, as well as mopanegrasslands and forests of the major mountains of Africa [3]. The buffalo prefers habitat with dense cover, such as reeds and thickets, but can also be found in open woodland. While not particularly demanding with regard to habitat, they require water daily, so depend on perennial sources of water. Like the plains zebra, the buffalo can live on tall, coarse grasses. They will seek out glades where possible, but can stay out in the open without shade for extended periods of time [1] [2]. Herds of buffalo mow down grasses and make way for more selective grazers. When feeding, the buffalo makes use of its tongue and wide incisor row to eat grass more quickly than most other African herbivores. Preferred grass species include *Cynodon*, *Sporobolus*, *Digitaria*, *Panicum*, *Heteropogon*, and *Cenchrus* species [1]. Buffaloes do not stay on trampled or depleted areas for long. African buffalo inhabits a wide range of habitats across Africa [2] [4].

The African buffalo is active throughout the day, spending 18 hours per day moving and foraging [4]. Grazing occurs as the herds move, although feeding is most frequent in the late afternoon and evening [2]. The grazing and trampling by buffalo stimulate rapid regrowth of vegetation, which in turn encourage repeated foraging [1]. As a result, herds tend to move through their home range on a circuitous route 50 - 105 km long [4]. Drinking usually occurs in the morning and at dusk [5]. During the hottest time of the day (1200 hrs to 1600 hrs), herds will typically rest and ruminate, although they seem to prefer resting in the open rather than in shade [4]. Mud wallows are frequently used and apparently enjoyed by buffalo [5] [6]. The mud serves to cool the animals, as well as forms a protective crust when dried, which discourages insets from biting [1] [2]. In areas with high human disturbance, buffalo will switch from continuous grazing to night-time foraging [1]. African buffalo has a symbiotic relationship with birds like oxpeckers and cattle egrets, which remove biting and sucking insects from their skin [6].

African buffalo lives in large herds containing 50 to 500 animals [5]. Within these herds are a number of smaller social groups made up of several females and their most recent offspring (up to two years of age) [2] [5]. The bond between females is very strong, and all animals will respond to distress calls, especially those made by calves. The core of the herds is made up of related females, and their offspring, in an almost linear dominance hierarchy. The basic herds are surrounded by sub-herds of subordinate males, high-ranking males and females and old or invalid animals. The young males keep their distance from the dominant bull, which is recognizable by the thickness of his horns. During the dry season, males will split from the herd and form bachelor groups. Two types of bachelor herds occur: one made of males aged four to seven years and that of males 12 years or older [2]. During the wet season, the younger bulls rejoin a herd to mate with the females. They stay with them throughout the season to protect the calves. This cohesion also provides protection for weakened individuals, such that blind buffaloes and three-legged individuals are able to survive in a herd setting [1] [5]. Some older bulls cease to rejoin the herd, as they can no longer compete with the younger, more aggressive males. Males have a linear dominance hierarchy based on age and size. Since a buffalo is safer when a herd is larger, dominant bulls may rely on subordinate bulls and sometimes tolerate their copulation [7].

African buffaloes are notable for their apparent altruism. Females appear to exhibit some sort of "voting behavior". During resting time, the females will stand up, shuffle around, and sit back down again. They will sit in the direction they think they should move. After an hour of more shuffling, the females will travel in the direction they decide [1] [2]. This decision is communal and not based on hierarchy or dominance. When chased by predators, a herd will stick close together and make it hard for the predators to pick off one member. Calves are gathered in the middle. A buffalo herd will respond to the distress call of a captured member and try to rescue it. A calf's distress call will get the attention of not only the mother, but also the herd. Buffaloes will engage in mobbing behavior when fighting off predators. They have been recorded killing a lion and chasing lions up a tree and keeping them there for two hours, after the lions have killed a member of their group. Lion cubs can get trampled and killed. With its large size, massive horns, and cohesive social dynamic, the African buffalo is a formidable fighter [4].

Buffaloes mate and give birth only during the rainy seasons. Birth peak takes place early in the season, while mating peaks later. A bull will closely guard a cow that comes into heat, while keeping other bulls at bay. This is difficult, as cows are quite evasive and attract many males to the scene. By the time a cow is in full estrus, only the most dominant bull in the herd/sub-herd is there. Cows first calve at five years of age, after a gestation period of 11.5 months. Newborn calves remain hidden in vegetation for the first few weeks while being nursed occasionally by the mother before joining the main herd. Older calves are held in the center of the herd for safety. The maternal bond between mother and calf lasts longer than in most *bovids* [2] [8]. However, when a new calf is born, the bonding ends and the mother will keep her previous offspring at bay with horn jabs. Nevertheless, the yearling will follow its mother for another year or so. Males leave their mothers when they are two years old and join the bachelor groups. Young calves, unusually for *bovids*, suckle from behind their mothers, pushing their heads between the mothers' legs [1].

The African buffalo is a species of least concern according to the IUCN [10]. It is not listed on any CITES appendix [9] [10]. The total population of African buffalo is approximately 900,000 animals across the continent [9]. But African buffalo is threatened by habitat loss and hunting pressures [1] [10]. The Cape buffalo is also susceptible to many diseases, including bovine tuberculosis, corridor disease, and foot and mouth disease. As with many diseases, these problems will remain dormant within a population as long as the health of the animals is good. The rinderpest disease has proven a major threat to this species in the past; an epidemic in southern Africa during the 1890s virtually eliminated the buffalo population (they have never recovered), while it's spread into east Africa destroyed 90% of the region's buffalo population [1] [2] [11]. The potential for another rinderpest outbreak remains a threat today [10]. Because of their power and disposition, African buffalo is considered the most dangerous game species in Africa [5]. Nonetheless (or perhaps because of their reputation), the buffalo has been heavily hunted for trophies and food [4]. Unlike the Asian water buffalo, domestication attempts with this species have proven unsuccessful [2].

Apart from humans, buffalo is hunted by lions and crocodiles, which typically attack only old solitary animals and young calves [2]. Other than humans, African Cape buffaloes have few predators and are capable of defending themselves against (and killing) lions. Lions do kill and eat buffalo regularly, and in some regions, the buffaloes are the lions' primary prey. It typically takes several lions to bring down a single adult buffalo; however, several incidents have been reported in which lone adult male lions have been able to successfully bring down adult animals. The average rate of travel is 5.4 km per hour, although buffalo can run up to 57 km per hour for short distances [4] [8] [12]. Coupled with the habit of charging en masse, few predators use African buffalo as a regular food source [13]. The Nile crocodile will typically attack only old solitary animals and young calves, though they can kill healthy adults. The cheetah, leopard and spotted hyena are a threat only to newborn calves, though spotted hyenas have been recorded killing full grown bulls on rare occasions.

Being a member of the *big five* game family [14], a term originally used to describe the five most dangerous animals to hunt, the Cape buffalo is a sought-after trophy, with some hunters paying over $10,000 for the opportunity to hunt one [15]. The larger bulls are targeted for their trophy value, although in some areas, buffaloes are still hunted for meat. Known within Africa as one of the "*big five*", "The Black Death" or "widowmaker", the African buffalo is widely regarded as a very dangerous animal, as it gores and kills over 200 people every year. Buffaloes are sometimes reported to kill more people in Africa than any other animal, although the same claim is also made of hippopotamus and crocodiles. Buffaloes are notorious among big game hunters as very dangerous animals, with wounded animals reported to ambush and attack pursuers [15].

1.2. Common Waterbuck

The waterbuck (*Kobus ellipsiprymnus*) is a large antelope found widely in sub-Saharan Africa. It is placed in the genus *Kobus* of the family *Bovidae*. The thirteen subspecies are grouped under two varieties: the common or *ellipsen* waterbuck and the defassa waterbuck [2] [16] [17]. The common waterbuck and the defassa waterbuck are remarkably different in their physical appearances. Measurements indicate greater tail length in the latter, whereas the common waterbuck stand taller than the defassa waterbuck. However, the principal differentiation between the two types is the white ring of hair surrounding the tail on the rump, which is a hollow circle in the common waterbuck but covered with white hair in the defassa waterbuck. A sexually dimorphic antelope, males are taller as well as heavier than females. Females have two nipples but lack the preorbital glands, foot glands and inguinal glands are absent [2] [17]. The coat color varies from brown to grey. The long, spiral horns, present only on males, curve backward, then forward. Males are darker than females. Though apparently thick, the hair is sparse on the coat. The hair on the neck is, however, long and shaggy. The shaggy coat is reddish brown to grey, and becomes progressively darker with age. Waterbuck are slower than other antelopes in terms of the rate of maturity. The waterbuck lives to 18 years in the wild and 30 years in captivity [16] [17].

Waterbuck inhabit scrub and savanna areas along rivers, lakes and valleys. Due to their requirement for grasslands as well as water, the waterbuck have a sparse ecotone distribution. They are rather sedentary in nature. The waterbuck cannot tolerate dehydration in hot weather, and thus inhabits areas close to sources of water. Predominantly a grazer, the waterbuck is mostly found on grassland [2] [17]. Waterbuck are rather sedentary in nature, though some migration may occur with the onset of wet season. The waterbuck exhibits great dependence on water. It cannot tolerate dehydration in hot weather, and thus inhabits areas close to sources of water. However, it has been observed that unlike the other members of its genus, the waterbuck ranges farther into the woodlands while maintaining its proximity to water. With grasses constituting a substantial 70% to 95% of the diet, the waterbuck is predominantly a grazer frequenting grasslands. Reeds and rushes like *Typha* and *Phragmites* may also be preferred [17].

Though the defassa waterbuck have a much greater requirement for protein than the African buffalo and the Beisa Oryx, the waterbuck spend much lesser time on browsing (eating leaves, small shoots and fruits) in comparison to the other grazers [2] [18]. In the dry season about 32 percent of the 24-hour day was spent in browsing, whereas no time was spent on it during the wet season. The choice of grasses varies with location rather than availability; for instance, in western Uganda, while *Sporobolus pyramidalis* was favored in some places, *Themeda triandra* was the main choice elsewhere [18]. The common waterbuck and the defassa waterbuck in the same area may differ in their choices; it has been observed that while the former preferred *Heteropogon contortus* and *Cynodon dactylon*, the latter showed less preference for these grasses [18].

The IUCN lists the waterbuck as being of Least Concerna ccording to the [19]. More specifically, the common waterbuck is listed as of Least Concern while the defassa waterbuck is Near Threatened [2] [17]. The population trend for both the common and defassa waterbuck is downwards, especially that of the latter, with large populations being eliminated from certain habitats because of hunting and human disturbance [9] [20]. Waterbuck also experience considerable mortality from carnivores. Waterbuck often enter water to escape from predators which include lions, leopards, cheetahs, African wild dogs and Nile crocodiles (leopards and spotted hyenas prey on juveniles). However, it has been observed that the waterbuck does not particularly like being in water. Waterbuck may run into cover when alarmed, and males often attack predators. Waterbuck are also susceptible to ulcers, lungworm infection and kidney stones. Other diseases from which these animals suffer are foot-and-mouth disease, sindbis fever, yellow fever, bluetongue, bovine virus diarrhea, brucellosis and anthrax [21]. The waterbuck is more resistant rinderpest than are other antelopes. They are unaffected by tsetse flies but ticks may introduce parasitic protozoa such as *Theileria parva*, *Anaplasma marginale* and *Baberia bigemina*. Twenty seven species of ixodid tick have been found on waterbuck—a healthy waterbuck may carry a total of over 4000 ticks in their larval or nymphal stages, the most common among them being *Amblyomma cohaerens* and *Rhipicephalu stricuspis*. Internal parasites found in waterbuck include tapeworms, liver flukes, stomach flukes and several helminthes [21] [22].

A gregarious animal, the waterbuck may form herds consisting of six to 30 individuals. The various groups are the nursery herds, bachelor herds and territorial males. Herd size increases in the dry season, whereas groups fragment in the wet months, probably under the influence of food availability. A few females may form spinster herds. Though females are seldom aggressive, minor tension may arise in herds [2] [18]. Breeding takes place throughout the year, but births are at their peak in the rainy season. Young females remain with their mothers in nursery herds, or may also join bachelor herds. When sexually excited, the skin of the waterbuck secretes a greasy substance with the odor of musk, giving it the name “greasy kob”. This secretion also assists in waterproofing the body when the animal dives into water [1].

Males start showing territorial behavior from the age of five years, but are most dominant from the age of six to nine. As soon as young males start developing horns (at around seven to nine months of age), they are chased out of the herd by territorial bulls. These males then form bachelor herds and may roam in female home ranges [2] [17]. There is another social group, that of the satellite males, which are mature bulls as yet without their own territories, who exploit resources, particularly mating opportunities, even in the presence of the dominant bull. The territorial male may allow a few satellite males into his territory, and they may contribute to its defense. However, gradually they may deprive the actual owner of his territory and seize the area for themselves. In a study in the Lake Nakuru National Park, only 7% of the adult males held territories, and only half of the territorial males tolerated one or more satellite males [22]. After the age of ten years, males lose their territorial nature and replaced by a younger bull, following which they recede to a small and unprotected area.

Marking of territories includes no elaborate rituals—dung and urine are occasionally dropped. Territorial males may use several kinds of display. In one type of display, the white patch on the throat and between the eyes is clearly revealed, and other displays can demonstrate the thickness of the neck [17]. These activities frighten trespassers. Lowering of the head and the body depict submission before the territorial male, who stands erect. Fights, which may last up to thirty minutes, involve threat displays typical of *bovids* accompanied by snorting. Fights may even become so violent that one of the opponents meets its death due to severe abdominal or thoracic wounds. A silent animal, the waterbuck makes use of *flehmen* response for visual communication and alarm snorts for vocal communication [2].

While males become sexually mature at the age of six years, females reach maturity within two to three years. Females may conceive by the age of two-and-a-half years, and remain reproductive for another ten years [17]. Breeding takes place throughout the year, and births are at their peak in the rainy season. However, breeding is seasonal in the African savannah, with the mating season lasting four months. The season extends for even longer periods in some areas of southern Africa [2]. Estrus period lasts for a day or less. The gestational period lasts for seven to eight months, followed by the birth of a single calf. Twins are rare. At about three to four weeks, the calf begins following its mother, who signals it to do so by raising her tail. Though bereft of horns, mothers will fiercely defend their offspring from predators. Calves are weaned at eight months, following which time they join groups of calves of their own age.

This study examined the population status, trend and distribution of the African buffalo and common waterbuck populations in the Northern Tanzania and Southern Kenya borderland in the dry and wet season of 2010 and 2013. These findings are important in many ways including but not limited to helping the Kenya and Tanzania governments to formulate collaborative management and conservation of borderland wildlife resources. The dramatic buffalo and waterbuck population declines in the two countries calls for urgent, decisive and comprehensive and remedial interventions to protect the remaining populations and their habitats. In the long-term, this will enhance their population resilience to the intensifying droughts conditions and land use changes whilst contributing to the national economy and sustainable local livelihoods.

2. Objectives

The overall objective of this research was to establish the current status of the African buffalo and common waterbuck population and its recovery after the severe 2007 and 2009 droughts in the Kenya-Tanzania borderland. The specific objectives were to:

Specifically, this study examined the following objectives:

1) Determine the population status and trend of buffalo and waterbuck in the Kenya-Tanzania borderland;

2) Determine the rate of population number and density growth (or decline) in ecosystems along the Kenya-Tanzania borderland;

3) Assess spatial-temporal distribution of buffalo and waterbuck in the Kenya-Tanzania borderland;

4) Make recommendations that will enhance monitoring and conservation of wildlife populations across the Kenya-Tanzania borderland.

3. Study Area and Methodology

3.1. Study Area

The Amboseli-West Kilimanjaro and Magadi-Natron cross-border landscape, as comprises of various ecologically linked areas of Kenya and Tanzania, and is characterized by a high endowment of diverse wildlife species (**Figure 1**). It lies between 10˚37'S and 30˚13'S, South and 350˚49'E and 380˚00'E, East, and on the Tanzanian side, it covers Natron and West Kilimanjaro areas. In Kenyan, it includes; the Amboseli National Park, adjoining Maasai group ranches, private land in the Oloitokitok area along the Kenya-Tanzania border, and the southern part of Kajiado county from Namanga to Magadi and Nguruman The census data reported in this paper were conducted in a landscape covering 25,623 km^2 which included; 9214 km^2 of the Amboseli Ecosystem, 6348 km^2 of the Namanga-Magadi areas in south-western Kenya, 3013 km^2 of the West Kilimanjaro and 7047 km^2 of the Natron areas in north Tanzania.

3.1.1. Amboseli Area

Amboseli region lies in the Southern part of Kenya, along the international border with Tanzania, and occupies an area of nearly 8797 km^2 (**Figure 1**) covering Amboseli National Park, communal Maasai group ranches, private lands on slopes the of Mt. Kilimanjaro [23] [24]. The geology of the area is linked to the formation of Mt. Kilimanjaro, and thus quaternary volcanic soils dominate the northeastern part of Kilimanjaro, and basement rock soils are common on the southeast section [25]. Overall, the region is characterized by an arid to semi-arid

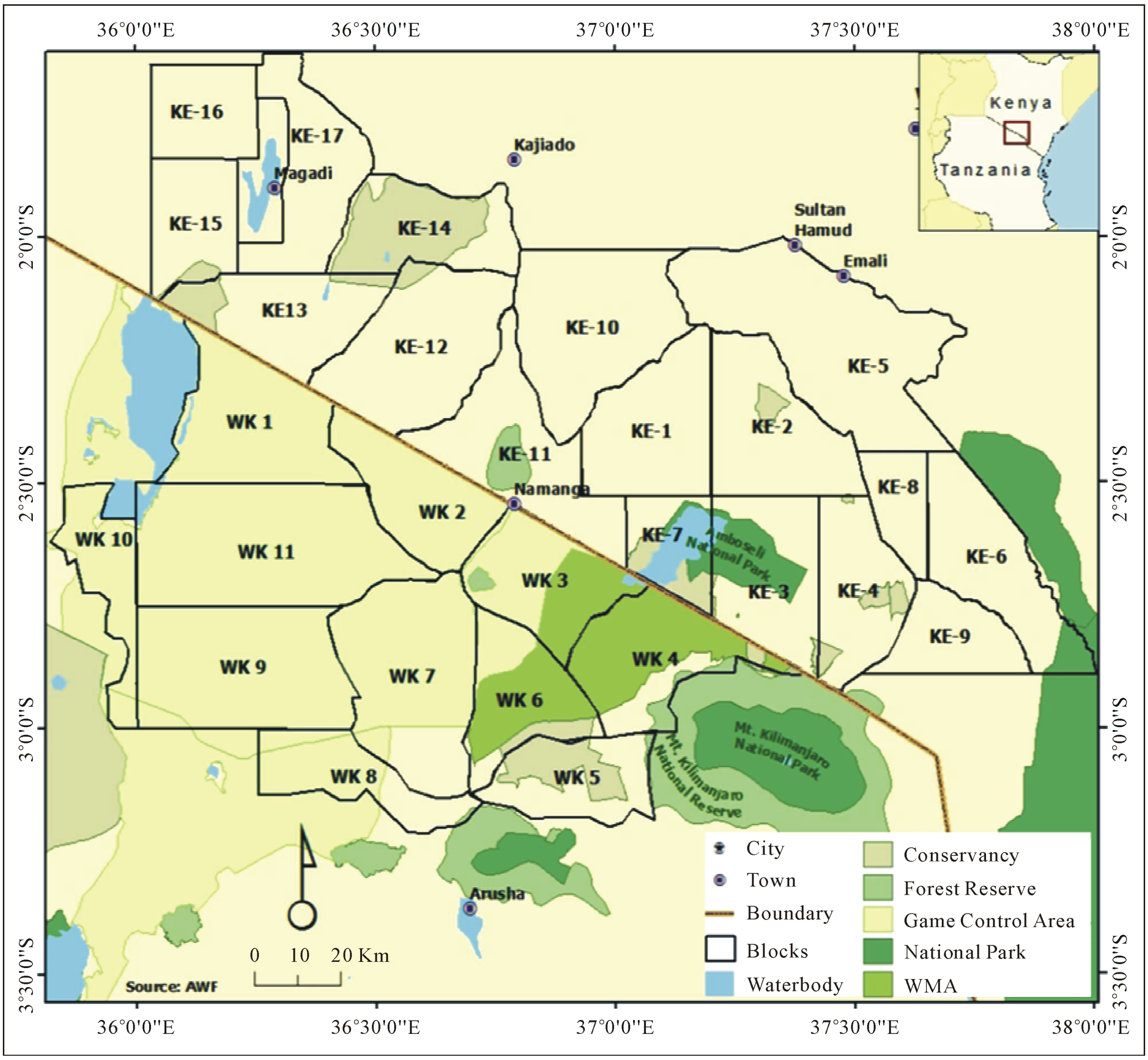

Figure 1. The Amboseli-West Kilimanjaro and Magadi-Natron landscapes along the Kenya-Tanzania borderland. Source: Kenya Wildlife Service and Tanzania Wildlife Research Institute 2013.

environment, with most of it lying in ecological zone VI, making unsuitable for crop farming unless under irrigation [25]. The annual rainfall varies between 400 to 1000 mm [26], and has a bimodal pattern but is largely variable in space and time and unreliable. The short rains usually occur between end of October and mid-December, and the long rains between March and May [23] [27]. Most of the landscape is devoid of permanent water resources, with a few scattered rivers, springs and swamps whose water is supplied through underground hydrological system associated with Mt. Kilimanjaro [23].

Historically, the Amboseli area was predominantly occupied by the Maasai people who depended on pastoralism to meet their livelihood needs [28] [29]. However, in the last century, other Kenya ethnic groups especially the Kikuyu and Kamba have moved into the area, and have introduced farming [23] [27] [30]. Due to due to political, socio-economic and lifestyle changes coupled by decline in pastoralism, most of the Maasai have ventured into crop production, making agro-pastoralism the main land use [23] [26] [27]. This is especially common long the slopes of Mt. Kilimanjaro where soils and rainfall are suitable and in the rangeland where irrigation is possible using water from springs, rivers and swamps. At the same, tremendous changes have occurred in terms of human population, through immigration and a rapidly birth rate among the Maasai people [26].

Typical vegetation in the region is influenced by the ecological conditions which are arid to semi-arid [25]. Some of the key vegetation types include; Acacia dominated bushland southward to the forest belt of Mt. Kilimanjaro, and open grasslands found to in the north and northeast section up to the Chyulu Hills, near Tsavo West National Park.

3.1.2. Namanga-Magadi Area

This landscape comprises of; Meto, Torosei, Mbuko, Elangata Wuas, Olkiramatian, Lorngosua and Shompole ranches, which collectively cover about 5513 km^2 (**Figure 1**). For most parts, the topography of the area is a combination of gently undulating plains and outstanding hilly landscape and the rift valley. The soil is "black clayey" (grumosolic soils) and consist of a range of "black cotton" soils including the calcareous and non-calcareous variants.

Ewaso Ngiro is the only permanent river though there are several other seasonal rivers like the Namanga and Esokota which originate from Namanga and Meto hills. The other main seasonal river is the Ol Kejuado that originates from Ilemelepo hills to the north west of Ibisil town and drains into river Kiboko.

The diverse physical features have led to spatial-temporal variation vegetation communities, but generally, the dominant woody species include a variety of *Acacia* spp., *Commiphora* spp. and *Balanites* spp. Key grasses include; *Chloris roxburgiana*, *Pennisetum stramenium*, *Pennisetum mezianum*, *Digitaria* sp., *Cynodon dactylon* and *Eragrostis* sp. Rainfall is low, bimodal and highly variable, ranging between 400 - 600 mm, making pastoralism by the Maasai the most common land use [27]. However, limited irrigated and rain fed agriculture is practiced in a few areas, mostly along the Maili-Tisa-Namanga road, the main rivers and Ewaso Ngiro.

3.1.3. West Kilimanjaro Area

The West Kilimanjaro covers an of nearly 3014 km^2 within the Longido District of Arusha, Tanzania, and the northern extent of the area is the Tanzania-Kenya border from Namanga southeastward to Irkaswa (**Figure 1**). Its eastern border is defined by the boundary of Kilimanjaro National Park extending southward close to the community of Sanya Juu. The southern part extends west from Sanya Juu to the northeast corner of Arusha National Park, continuing along the northern park border to the Arusha-Nairobi Road that also defines the western extent of the area.

The area comprises of a complex mosaic of diverse communities, extensive grazing lands, and large agricultural fields at lower elevations on Mt. Kilimanjaro. There are traditional, agro-pastoral Maasai communities that graze livestock and raise subsistence crops. The area has several Protected Areas (PAs) in its neighborhoods, mainly; Kilimanjaro N. P (755 km^2) on the eastern boundary, Arusha N. P (137 km^2) to the south, and Amboseli N. P (392 km^2) in southern Kenya, 20 km north of the Tanzania-Kenya border. Other PAs in the West Kilimanjaro include; Longido Game Controlled Area (GCA) (1700 km^2), and Ngasurai Open Area (544 km^2) which provide important habitats for wildlife. Additionally, there are two private conservation areas, West Kilimanjaro Ranch (303 km^2) and Endarakwai Ranch (44 km^2).

Although the area varies in elevation (1230 to 1600 m), the predominant ecological zone is semi-arid savannah interspersed with woodlands. There are extensive agricultural fields along the lower, western flank of Mt.

Kilimanjaro, and lowland forests within the boundary of Kilimanjaro NP. Rainfall is unpredictable, especially at lower elevations, and highly variable from year to year. The average annual rainfall in the semi-arid lower elevations is 341 mm/year [28] [31] and 890 mm/year in agricultural areas at lower elevations on Mt. Kilimanjaro also at Mt. Meru and Monduli in the southern part.

3.1.4. Natron Area

This landscape covers an area of about 7047 km^2, and lies west of the West Kilimanjaro area with its northern extent defined by the Tanzania-Kenya border (**Figure 1**). Its western part is found along the eastern side of Lake Natron to Ngorongoro Conservation Area. The southern boundary extends from the southeast corner of Ngorongoro Conservation Area eastward to the northwest corner of Arusha National Park. The area comprises of a mosaic of diverse vegetation communities and extensive grazing lands. There is a unique Maasai grazing area extending westward from the Kiserian-Mriata Ridge (on the eastern side of the region) extending westward encompassing the grasslands adjacent to Gelai (2942 m ASL) and Ketumbeine (2858 m ASL) mountains. This area is characterized by well-drained savannah grasslands and woodlands where Maasai graze their cattle during the dry season and no permanent human settlements are allowed. It's largely a semiarid savannah interspersed with open acacia woodlands (*Acacia* spp. and *Commiphora* spp.). Like west Kilimanjaro area, rainfall is unpredictable and highly variable from year to year (less than 350 mm). Hunting blocks of Lake Natron GCA and the northern portion of the Monduli GCA are also found within the area.

3.2. Methods and Materials

For a many years since its creation, the Kenya Wildlife Service (KWS) has been undertaking total aerial counts of large herbivores using developed methods [32] [33]. This approach has generated substantial set of total count data from which trends and dynamics of wildlife populations in the country have been understood. Consequently, wet and dry season total elephant counts were carried out in 2010 and 2013 using similar techniques, and systematically covered the entire area of the defined census zone and recorded every individual elephant and herds, including the location on the ground using GPS coordinates.

To improve the quality of data collected on the elephant population, both crew and planes were calibrated to aid in estimation of distance for subsequent calculation of observable strip width. Streamers were mounted on either side of the aircraft wings to create two strip categories, the inner and outer (**Figure 2**). Inner category was defined as the region from the farthest one could see from the belly of the plane to the lower streamer. Likewise the outer category was defined as the region between the lower and the upper streamer (within the streamers).

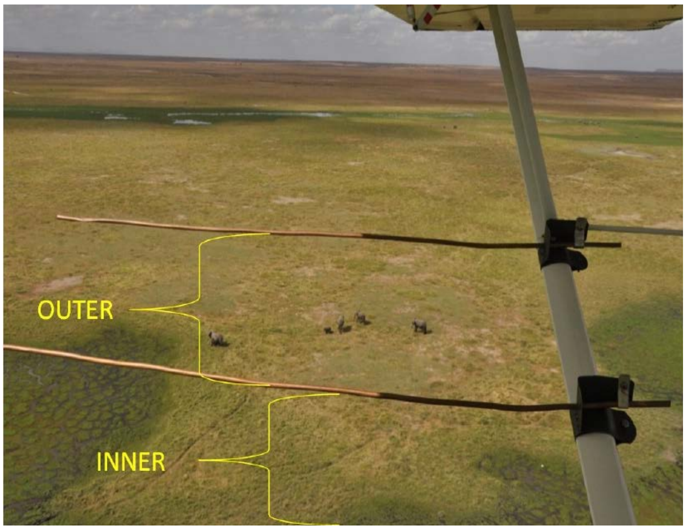

Figure 2. Position of steamers on the wings of an aircraft to help standardize distance of animals from the aircraft during aerial census animal counts. Source: Kenya Wildlife Service and Tanzania Wildlife Research Institute 2013.

Calibration for observers entailed adjusting the angle of view of the streamers to correspond to 500 m and 250 m on the ground for a set altitude of 300 Ft AGL for the upper and lower streamer respectively. This was done by use of clinometers. The Rear Seat Observers (RSO's) were each calibrated and observer specific and plane specific metrics for each calibration recorded according to an individual's physique. The metrics comprised measurements from various reference points on the air craft such as low and high eye mark on the aircraft window, upper and lower streamer mark on wing strut and plane fuselage. In addition, Front Seat Observers (FSO's) and pilots were also calibrated for the purpose of assisting the RSO's to determine whether or not the counted animals are within the strip width.

For each calibration made, test flights were conducted at the set altitude for streamers (300 Ft AGL) to determine how well the streamers fitted to the desired strip width on the ground. This was achieved by creating a flight line at 500 m and 250 m from a very straight and long (5 km) section of a road. When the aircrafts flew on this line, the road was either 500 m or 250 m from the plane and this allowed for evaluation of the streamers. To asses inter observer variability in estimation and enhance species identification, all observers were independently subjected to count a portion of the same block with different species of known numbers in mock flights.

The target landscape was divided into blocks based on visible features from the aircraft like hills, ridges and rivers which helped the pilots to easily navigate during flight (**Figure 3**). To improve counting efficiency, the blocks were delineated into rectangular and square shapes, which also made it easier for the pilots and the front

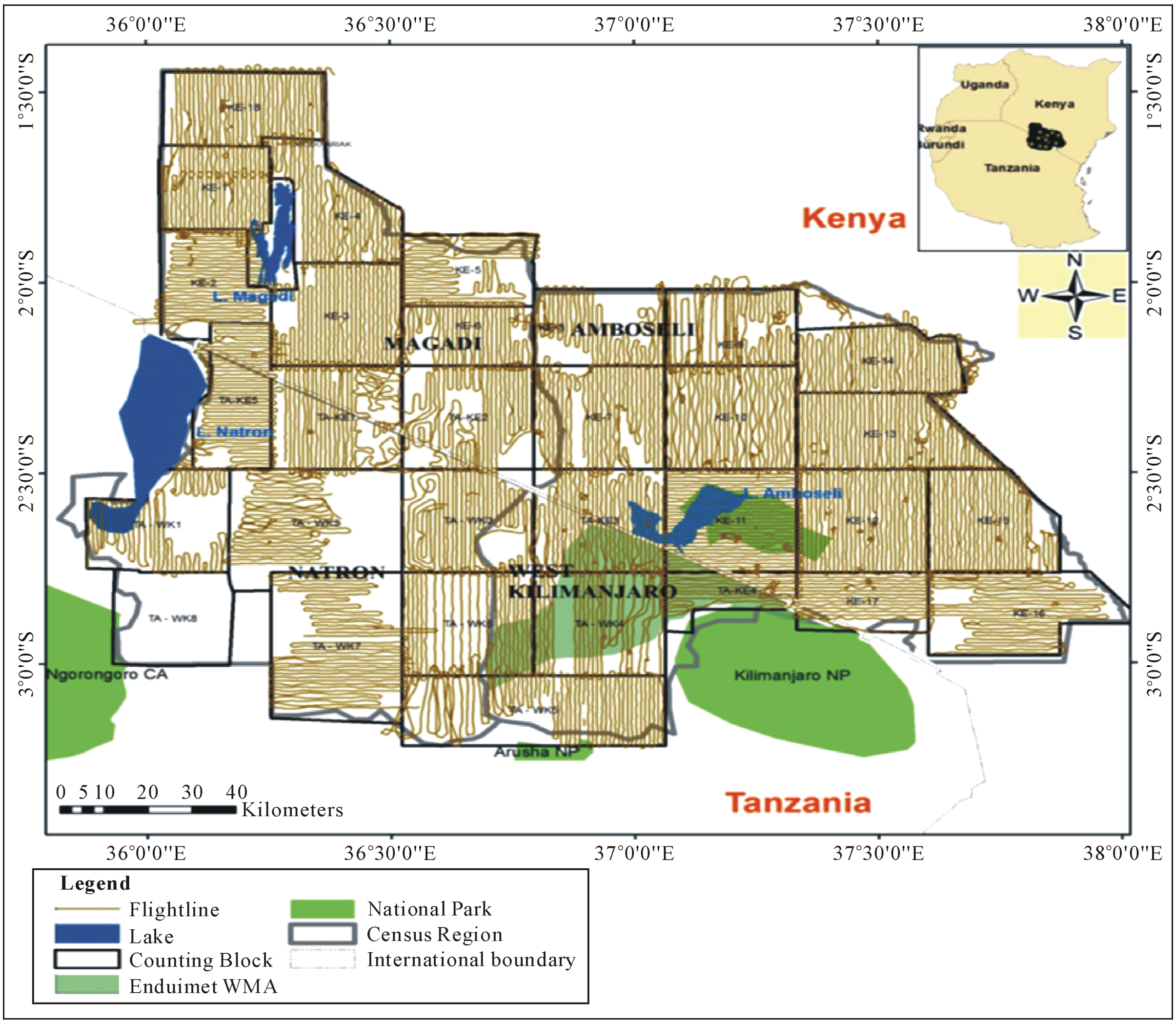

Figure 3. Layout of the census flight paths and flights direction used for the data collection in the study area. Source: Kenya Wildlife Service and Tanzania Wildlife Research Institute 2013.

seat observers (FSOs) to navigate using GPS units. It also gave them ample time to make comprehensive ground observations, and an attempt was made to ensure the blocks were large enough (about 900 km^2 each on average), and could be covered within a maximum duration of six hours per day. The enhance reliability of the data collected, the counting crew were trained on how to conduct aerial counts using mock test flights. Thus, different crews flew at different times but maintaining the same flight orientation so as to evaluate any inter observer variation in their ability to identify, detect, estimate and count wildlife species. They were also trained on use of voice recorders, GPS units and cameras, wildlife species identification, counting, estimation of herd sizes, data processing and handling. As noted by [32], all this preparation was done in recognition of the fact that the accuracy and reliability of such total aerial counts rely heavily on the experience of the flight crew and the pilot.

Counting of large herbivores was done in each block using a light aircraft which flew along East-West and North-South flight transects of 1 - 2 km width depending on the visibility on the ground and nature of the terrain (**Figure 3**). On average, each count began approximately 7:30 am and ended in the afternoon, and the end time was dependent on the size of each block. The crew comprised on a pilot, front and rear seat observers, and in each block the observers systematically searched for any large herbivores on the ground and recorded; the number of individuals, their spatial location using GPS coordinates, the number, and herds of more than ten individuals were photographed so that the actual number could be verified later [32]. Data capture was also done using tape recorders, and on landing, the ground crew downloaded records captured in digital voice recorders, and the data recorded in the GPS units using DNR-Garmin/MapSource software. Once downloaded, the voice records were processed digitally to remove background noises to enable the data to be clearly heard. A team of transcribers listened to these records transcribed the data onto data sheets, and where there were discrepancies; these were verified, corrected and reconciled. All data were then entered into a spread sheet. Double counts especially on flight lines that were overlapping or very near each other were visually searched and eliminated using GIS software. Flight path and way point data were processed using ArcGIS 10.1 software to produce spatial elephant distribution maps.

In addition to elephant data, the flight observers noted and recorded human activities mainly vegetation clearing, livestock grazing, human settlements and infrastructure development. These were considered to represent key changes in the landscape which threatened its ecological integrity and elephant conservation.

3.3. Data Analysis

Only data for the dry period of 2010 and 2013 were used so that comparisons between similar census zones and for wet and dry season could be compared. Tallies, percentages, means and standard errors for the data were calculated using standard mathematical and statistical methods [34]. Population changes were done based on the density of the 2013 and how it varied from 2010 for that particular season.

Chi-square goodness of fit and chi-square cross-tabulations were done to establish differences and the association between ostrich numbers and ecosystem areas; periods after (2010) and post drought (2013); and seasons (wet and dry) using SPSS statistical software. Statistical tests were considered significant if type 1 error (alpha) was less than 5% (0.05) [34].

Since the census areas (for both wet and dry season) for 2010 and 2013 were similar, the total numbers, density and percentages (proportions) of each species of the large mammals seen were reliable measures for comparison.

4. Results

4.1. Cape (African) Buffalo

African (cape) buffalo (*Syncerus caffer*) was well represented in all the landscapes during the 2010 and 2013 censuses. Only within the swamps of Amboseli were the majority seen, and a few more in the Lake Natron and Lake Magadi marshes. Amboseli and its surrounding group ranches had the highest number of African buffalo (**Table 4**) in the borderland (averaging 241.5 ± 29.9 African buffalo), followed by Magadi/Namanga area (58.0 ± 22.0 buffalo), West Kilimanjaro area (38.8 ± 34.9 buffalo), and lastly Lake Natron area (14.5 ± 9.0 buffalo).

In terms of the number composition of buffalo in each area of the borderland (**Figure 4**), similar order was seen (**Table 1**), in which Amboseli and surrounding group ranches led (74.17% ± 9.18%) followed by Magadi/Namanga area (14.25% ± 4.76%), West Kilimanjaro area (7.16% ± 5.97%), and lastly Lake Natron area (4.42%

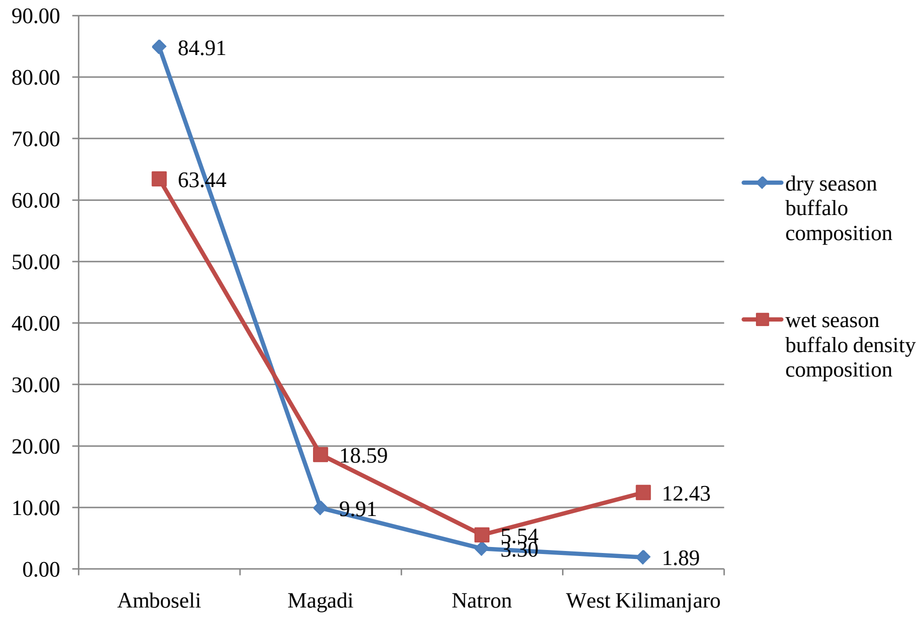

Figure 4. Buffalo composition (%) in the wet and dry season in the Kenya/Tanzania borderland ecosystems.

Table 1. Buffalo numbers and density in the key population hotspots of the Kenya/Tanzania borderland.

Location	Year	Season	Census area (km^2)	Buffalo numbers	Buffalo density (per km^2)	Proportion (%) buffalo numbers in the borderland
Amboseli area	2010	Wet	8797.00	235	0.03	70.36
		Dry	8797.00	222	0.03	69.81
	2013	Wet	9214.44	325	0.04	56.52
		Dry	9214.44	184	0.02	100.00
	Overall (mean ± SE)		-	241.5 ± 29.9	0.03 ± 0.00	74.17 ± 9.18
Magadi/Namanga Area	2010	Wet	5513.00	62	0.01	18.56
		Dry	5513.00	63	0.01	19.81
	2013	Wet	6348.32	107	0.02	18.61
		Dry	63.48.32	0	0.00	0.00
	Overall (mean ± SE)		-	58.0 ± 22.0	0.01 ± 0.00	14.25 ± 4.76
West Kilimanjaro Area	2010	Wet	3014.00	0	0.00	0.00
		Dry	3014.00	12	0.00	3.77
	2013	Wet	3013.18	143	0.05	24.87
		Dry	3013.18	0	0.00	0.00
	Overall (mean ± SE)		-	38.8 ± 34.9	0.01 ± 0.01	7.16 ± 5.97
Lake Natron Area	2010	Wet	7047.00	37	0.01	11.08
		Dry	7047.00	21	0.00	6.60
	2013	Wet	7047.26	0	0.00	0.00
		Dry	7047.26	0	0.00	0.00
	Overall (mean ± SE)		-	14.5 ± 9.0	0.00 ± 0.00	4.42 ± 2.71

± 2.71%). For buffalo density, similar trend was maintained (**Figure 5**) with Amboseli area leading with 0.03 ± 0.00 Buffalo (per km^2), with the rest of the locations having similar densities lead by Magadi/Namanga area (0.01 ± 0.00 buffalo per km^2), West Kilimanjaro area (0.01 ± 0.01 Buffalo per km^2), and lastly Lake Natron area (0.00 ± 0.00 Buffalo per km^2).

Considering (percent) changes in the density in each of the locations of the borderland between 2010 and 2013, Amboseli area had an overall positive buffalo density increase (+5.58 ± 26.45), but with a negative growth of −20.87 in the dry season hence the high variance in overall growth in buffalo density (**Table 2**). All other

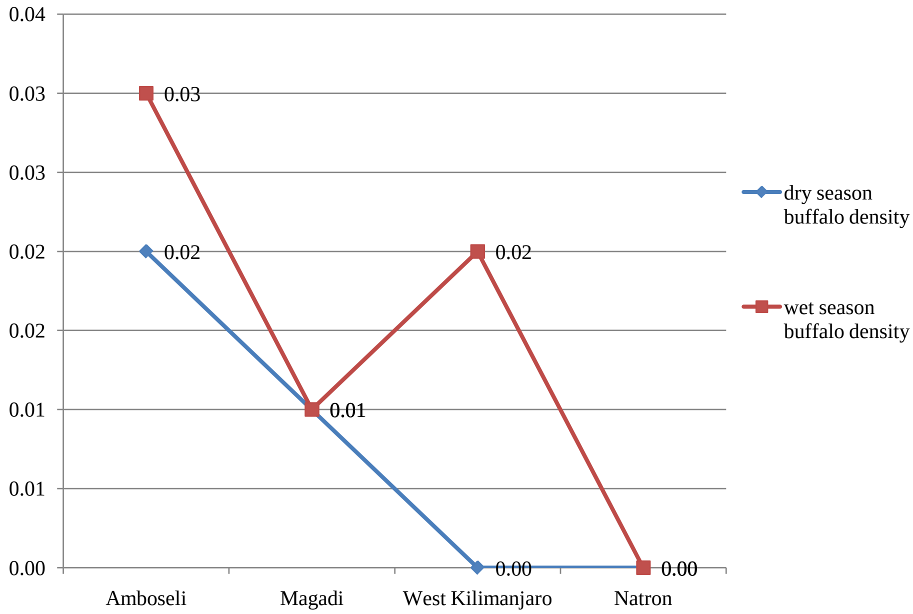

Figure 5. Buffalo densities (per km^2) in the wet and dry season in the Kenya/Tanzania borderland ecosystems.

Table 2. Buffalo numbers and density changes in wet and dry seasons between 2010 and 2013.

Location	Season	Buffalo density (per km^2) (mean ± SE)	Buffalo % numbers in location (mean ± SE)	Change (%) in buffalo density over 3 years	Change (%) in buffalo proportion over the 3 years
Amboseli Area	Wet	0.03 ± 0.00	63.44 ± 6.92	+32.03	+38.30
	Dry	0.02 ± 0.00	84.91 ± 15.09	−20.87	−17.12
	Overall	0.03 ± 0.00	74.17 ± 9.18	+5.58 ± 26.45	+10.59 ± 27
Magadi and Namanga Area	Wet	0.01 ± 0.00	18.59 ± 0.02	+49.87	+72.58
	Dry	0.01 ± 0.01	9.91 ± 9.91	−100.00	−100.00
	Overall	0.01 ± 0.00	14.25 ± 4.76	−25.06 ± 74.94	−13.71 ± 86.29
West Kilimanjaro Area	Wet	0.02 ± 0.02	12.43± 12.43	No animals in wet season 2010 and dry season 2013.	No animals in wet season 2010 and dry season 2013.
	Dry	0.00 ± 0.00	1.89 ± 1.89	−100.00	−100.00
	Overall	0.01 ± 0.01	7.16 ± 5.97	-	-
Lake Natron Area	Wet	0.00 ± 0.00	5.54 ± 5.54	−100.00	−100.00
	Dry	0.02 ± 0.00	3.30 ± 3.30	−100.00	−100.00
	Overall	0.00 ± 0.00	4.42 ± 2.71	−100.00 ± 0.00	−100.00 ± 0.00

changes in buffalo density in all locations in the borderland were negative (decline in buffalo density). The worst off in terms of this decline was Lake Natron area (−100.00 ± 0.00), followed by West Kilimanjaro area (−100.00 in dry season because there were no buffalo in the wet season of 2010 and dry season of 2013), and least decline for Magadi/Namanga area (−25.06 ± 74.94) which experienced a decline of −100.00 in the dry season buffalo density (**Table 2**).

In terms of changes (percent) in the buffalo number composition of the locations in the borderland between 2010 and 2013, similar trend as in (percent) changes buffalo density was observed (**Table 2**). Amboseli area had an overall positive (percent) buffalo numbers increase (+10.59 ± 27.71), but with a negative growth of −17.12 in the dry season hence the high variance in overall growth in buffalo density (**Table 2**). All other changes in buffalo (percent) changes in number in all locations in the borderland were negative (decline in buffalo numbers). The worst off in terms of this number decline was Lake Natron area (−100.00 ± 0.00), followed by West Kilimanjaro area (−100.00 in dry season because there were no buffalo in the wet season of 2010 and dry season of 2013), and least decline for Magadi/Namanga area (−13.71 ± 86.29) which experienced a decline of −100.00 in the dry season buffalo numbers (**Table 2**).

There were higher wet season changes in buffalo density and composition in Amboseli and West Kilimanjaro areas. However, dry season changes in density and composition of buffalo occurred in Lake Natron area only. The highest change differences in both density and composition occurred in Magadi, followed by Lake Natron and then Amboseli area. Decline (negative change) in buffalo density and composition occurred in Lake Natron and West Kilimanjaro areas in all seasons, but negative only in the dry season in Amboseli and Magadi (**Table 2**).

Wet and dry season numbers of buffalo over time varied from with location in the borderland (**Table 3**). For Amboseli area and the surrounding area in 2010, wet season and dry season numbers were similar ($p = 0.54$), with wet season being non-significantly higher. However in 2013, wet season buffalo numbers were higher ($p < 0.001$) than dry season numbers. However, for the set of wet season, buffalo numbers were similar ($p = 0.31$), with non-significant increase in wet season. For the pair of dry season, buffalo numbers were also similar ($p = 0.059$) over time, with a non-significant decline in the dry season over time) in the Amboseli area (**Table 3**). For Magadi area in 2010, wet season and dry season numbers were similar ($p = 0.93$). For 2013, wet season number was higher than dry season number because there were no buffalo seen in dry season. For the set of wet season, buffalo number in 2013 was higher ($p = 0.001$) than for 2010 (*i.e.* buffalo number increased with time for both seasons). This cannot be said for the dry season because there were no buffalo in 2013 meaning a possible decline.

For West Kilimanjaro area in 2010, buffalo were only seen in the dry season and not in the wet season. However, in 2013, buffalo were only seen in the wet season and not in the dry season. For the pair of wet season, buffalo were only seen in 2013 implying an increase with time. But for the dry season, buffalo were seen only seen in the in 2010 implying a possible decline with time (**Table 3**). For Lake Natron area for 2010, the buffalo number in the wet season was higher ($p = 0.036$) than the dry season. However, for 2013, there were no buffalo numbers in both wet and dry season. For both pairs of wet and dry season, buffalo were only seen in 2010 but not 2013, implying a possible decline with time for both seasons for Lake Natron area (**Table 3**).

In terms relationships between Buffalo numbers in different locations (closer or further away from protected areas), influence of seasons on Buffalo numbers varied among the locations in the borderland (**Table 4**). Generally, buffalo numbers in locations was dependent ($p = 0.008$) on the season, with numbers both closer and further away from protected areas being higher in the wet season than dry season. Specifically, in the wet season, buffalo number in locations was dependent ($p < 0.001$) on the year, with numbers in both closer and further from protected areas increasing with time. Further, in the dry season, buffalo number in locations was dependent ($p < 0.001$) on the year, with numbers in both closer and further from protected areas declining with time (**Table 4**).

4.2. Common Waterbuck

The common waterbuck (*Kobus ellipsiprymnus*) was well represented in all the landscapes and ecosystems (protected areas and dispersal areas) along the Kenya-Tanzania borderland during the 2010 and 2013 censuses. Amboseli area had the highest number of common waterbuck (**Table 5**) in the borderland (averaging 12.3 ± 3.9 common waterbuck), followed by Magadi/Namanga area (10.3 ± 3.70 common waterbuck), Lake Natron area (3.8 ± 3.4 common waterbuck), and lastly West Kilimanjaro area (0.5 ± 0.5 common waterbuck).

Table 3. Buffalo number comparisons between seasons and within season in various locations within the Kenya-Tanzania borderland.

Census location	Year	Season census done		Chi-square goodness of fit value	Conclusion
		Wet season	Dry season		
Amboseli	2010	235	222	$X^2 = 0.37$, df = 1, p = 0.54	For 2010, wet season and dry season numbers were similar, with wet season being non-significantly higher.
	2013	325	184	$X^2 = 39.06$, df = 1, p < 0.001	For 2013, wet season number was higher than the dry season number.
	Chi-square value	$X^2 = 14.46$, df = 1, p = 0.31	$X^2 = 3.56$, df = 1, p = 0.059	For the set of wet season, and dry season, buffalo numbers were similar over time (with non-significant increase in wet season, but also non-significant decline in the dry season over time).	
Magadi	2010	62	63	$X^2 = 0.008$, df = 1, p = 0.93	For 2010, wet season and dry season numbers were similar.
	2013	107	0	No statistical test necessary	For 2013, wet season number was higher than dry season number because there were no buffalo seen in dry season.
	Chi-square value	$X^2 = 11.98$, df = 1, p = 0.001	No statistical test necessary.	For both sets of wet season, buffalo number in 2013 was higher than for 2010 (*i.e.* buffalo number increased with time for both seasons). This cannot be said for the dry season because there were no buffalo in 2013 meaning a possible decline.	
West Kilimanjaro	2010	0	12	No statistical test necessary	For 2010, buffalo were only seen in the dry season and not wet season.
	2013	143	0	No statistical test necessary	For 2013, buffalo were only seen in the wet season but not in the dry season.
	Chi-square value	No statistical test necessary.	No statistical test necessary.	For the pair of wet season, buffalo were only seen in 2013 implying an increase with time. But for the dry season, buffalo were seen only in the in 2010 implying a decline with time.	
Natron	2010	37	21	$X^2 = 4.41$, df = 1, p = 0.036	In 2010, the buffalo number in the wet season was higher than the dry season.
	2013	0	0	No statistical test necessary	For 2013, there were no buffalo numbers in both wet and dry season.
	Chi-square value	No statistical test necessary.	No statistical test necessary.	For both pairs of wet and dry season, buffalo were only seen in 2010 but not 2013, implying a possible decline with time for both seasons.	

Table 4. The relationship between Buffalo numbers and census location proximity to existing protected areas (Amboseli and West Kilimanjaro) and away (Magadi and Lake Natron Area) within the borderland.

Season of the year	Year	Location of census area		Chi-square cross tabulation value	Conclusion
		In or around protected areas	Away from protected areas		
Wet season	2010 (after drought)	235	99	$X^2 = 14.67$, df = 1, p < 0.001	In the wet season, buffalo number in locations was dependent of year, with numbers in both closer and further from protected areas increasing with time.
	2013 (post drought)	468	107		
Dry season	2010 (after drought)	234	84	$X^2 = 58.37$, df = 1, p < 0.001	In the dry season, buffalo number in locations was dependent on year, with numbers in both closer and further from protected areas declining with time.
	2013 (post drought)	184	0		
Wet season		703	206	$X^2 = 6.96$, df = 1, p = 0.008	Generally, buffalo numbers in locations was dependent on the season, with numbers both closer and further away from protected areas being higher in the wet season than try season.
Dry season		418	84		

Table 5. Common waterbuck numbers and density in the key population hotspots of the Kenya/Tanzania borderland.

Location	Year	Season	Census area (km^2)	Waterbuck numbers	Waterbuck density (per km^2)	Proportion (%) waterbuck numbers in the borderland
Amboseli and surrounding group ranches	2010	Wet	8797.00	18	0.00	50.00
		Dry	8797.00	17	0.00	73.91
	2013	Wet	9214.44	13	0.00	43.33
		Dry	9214.44	1	0.03	5.56
	Overall (mean ± SE)		-	12.3 ± 3.9	0.00 ± 0.00	43.20 ± 14.16
Magadi/Namanga Areas	2010	Wet	5513.00	2	0.00	5.56
		Dry	5513.00	6	0.00	26.09
	2013	Wet	6348.32	17	0.00	56.67
		Dry	63.48.32	16	0.00	88.89
	Overall (mean ± SE)		-	10.3 ± 3.7	0.06 ± 0.03	44.30 ± 18.20
West Kilimanjaro Area	2010	Wet	3014.00	2	0.00	5.56
		Dry	3014.00	0	0.00	0.00
	2013	Wet	3013.18	0	0.00	0.00
		Dry	3013.18	0	0.00	0.00
	Overall (mean ± SE)		-	0.5 ± 0.5	0.00 ± 0.00	1.39 ± 1.39
Lake Natron Area	2010	Wet	7047.00	14	0.00	38.89
		Dry	7047.00	0	0.00	0.00
	2013	Wet	7047.26	0	0.00	0.00
		Dry	7047.26	1	0.00	5.56
	Overall (mean ± SE)		-	3.8 ± 3.4	0.00 ± 0.00	11.11 ± 9.35

In terms of the composition of common waterbuck in each area of the borderland (**Figure 6**), Magadi/ Namanga area had the waterbuck population (**Table 5**) composition (44.30% ± 18.20%) followed by Amboseli area (43.20% ± 14.16%), Lake Natron area (11.11% ± 9.35%), and lastly West Kilimanjaro area (1.39% ± 1.39%). For common waterbuck density all the areas had the same very low density of less than 0.00 ± 0.00 common waterbuck per km^2.

Considering (percent) changes in the density between 2010 and 2013, Magadi/Namanga area had the highest positive average percent change (increase) in common waterbuck density (+384.87 ± 253.29) compared to other locations in the borderland (**Table 6**). All other changes in the landscape had negative (decline) changes in the waterbuck density in all the seasons. The worst decline in density occurred in the dry season in West Kilimanjaro (−100.00%) and Lake Natron area (−100.00%). Amboseli area had relatively low density, but overall negative decline (−62.72% ± 31.67%) in waterbuck density (**Table 6**). For (percent) waterbuck number changes, Magadi/Namanga area highest positive average percent change (increase) in common waterbuck numbers (+458.33 ± 291.67) compared to other locations in the borderland (**Table 6**). All other changes in the landscape had negative (decline) changes in the waterbuck numbers in all the seasons. The worst decline in numbers occurred in the dry season in West Kilimanjaro (−100.00%) and Lake Natron area (−100.00%). Amboseli area had relatively less, but overall negative decline (−60.95% ± 33.17%) in waterbuck density (**Table 6**).

There were more changes in waterbuck density and composition in the wet season in Magadi/Natron, West Kilimanjaro and Lake Natron areas, but more changes in the dry season in only Amboseli areas. The highest positive change differences in both density and composition were in Magadi/Namanga area. Amboseli, West Kilimanjaro and Lake Natron all had negative change in density and numbers of waterbuck, with more negative (decline) being in West Kilimanjaro and Lake Natron areas especially in the dry season (**Table 6**).

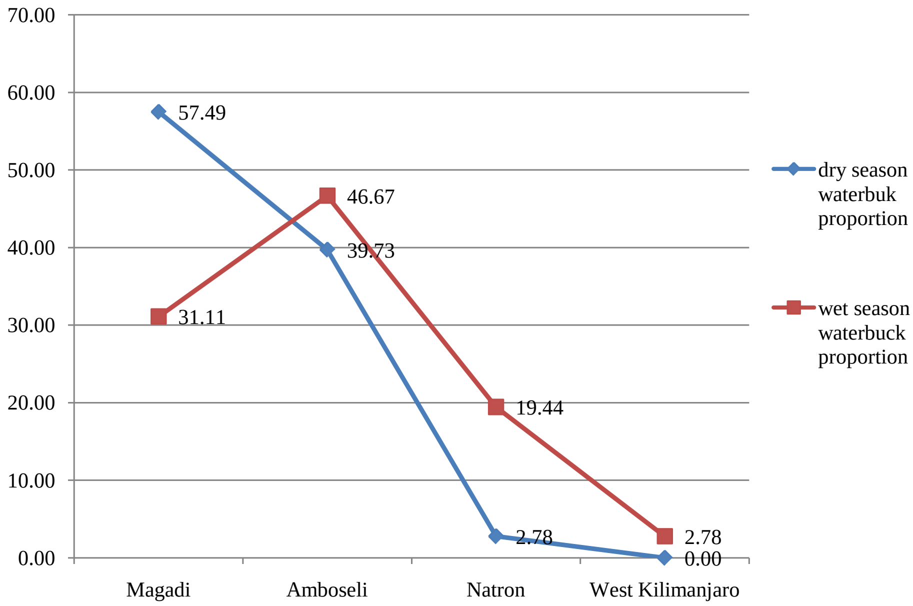

Figure 6. Waterbuck composition (%) in the wet and dry season in the Kenya/Tanzania borderland ecosystem.

Table 6. Common waterbuck numbers and density changes in wet and dry seasons between 2010 and 2013.

Location	Season	Waterbuck density (per km^2) (mean ± SE)	Waterbuck % numbers in location (mean ± SE)	Change (%) in waterbuck density over 3 years	Change (%) in waterbuck proportion over the 3 years
Amboseli Area	Wet	0.00 ± 0.00	46.67 ± 3.33	−31.05	−27.78
	Dry	0.00 ± 0.00	39.73 ± 34.18	−94.38	−94.12
	Overall	0.00 ± 0.00	43.20 ± 14.16	−62.72 ± 31.67	−60.95 ± 33.17
Magadi and Namanga Areas	Wet	0.00 ± 0.00	31.11 ± 25.56	+638.16	+ 750.00
	Dry	0.00 ± 0.00	57.49 ± 31.40	+131.58	+ 166.67
	Overall	0.00 ± 0.00	44.30 ± 18.20	+384.87 ± 253.29	+458.33 ± 291.67
West Kilimanjaro Area	Wet	0.00 ± 0.00	2.78 ± 2.78	−100.00	−100.00
	Dry	0.00 ± 0.00	0.00 ± 0.00	-	-
	Overall	0.00 ± 0.00	1.39 ± 1.39	No waterbuck except 2 ones in wet season 2010.	No waterbuck except 2 ones in wet season 2010.
Lake Natron Area	Wet	0.00 ± 0.00	19.44 ± 19.44	−100.00	−100.00
	Dry	0.00 ± 0.00	2.78 ± 2.78	-	-
	Overall	0.00 ± 0.00	11.11 ± 9.35	No waterbuck in dry season 2010 and wet season 2013.	No waterbuck in dry season 2010 and wet season 2013.

For Amboseli area in 2010, wet season waterbuck number was similar ($p = 87$) to the dry season number. But for 2013, wet season waterbuck number was higher ($p < 0.001$) to the dry season number. For the set of wet season, waterbuck number for 2010 was similar ($p = 0.37$) to that of 2013 (*i.e.* a non-significant decline in number over time in wet season). But for the set of dry season, waterbuck number in 2010 was higher ($p < 0.001$) than for 2013 (*i.e.* waterbuck number was decreasing with time) for the Amboseli area (**Table 7**). For Magadi/ Namanga area in 2010, wet season number was similar ($p = 0.16$) to the dry season number, with non-significant more in the dry season. Similarly for 2013, wet season number was similar ($p = 0.86$) to the dry season number

Table 7. Common waterbuck number comparisons between seasons and within season in various locations within the Kenya-Tanzania borderland.

Census location	Year	Season census done		Chi-square goodness of fit value	Conclusion
		Wet season	Dry season		
Amboseli	2010	18	17	$X^2 = 0.29$, df = 1, p = 0.87	For 2010, wet season was similar to the dry season number.
	2013	13	1	$X^2 = 10.29$, df = 1, p < 0.001	For 2013, wet season number was higher than the dry season number.
	Chi-square value	$X^2 = 0.81$, df = 1, p = 0.37	$X^2 = 14.22$, df = 1, p < 0.001	For the set of wet season, waterbuck number for 2010 was similar to that of 2013 (*i.e.* a non-significant decline in number over time in wet season). But for the set of dry season, waterbuck number in 2010 was higher than for 2013 (*i.e.* waterbuck number was decreasing with time).	
Magadi	2010	2	6	$X^2 = 2.00$, df = 1, p = 0.16	For 2010, wet season number was similar to the dry season number, with non-significant more in the dry season.
	2013	17	16	$X^2 = 0.30$, df = 1, p = 0.86	For 2013, wet season number was similar to dry season number.
	Chi-square value	$X^2 = 11.84$, df = 1, p < 0.001	$X^2 = 4.55$, df = 1, p = 0.033	For the set of wet season, waterbuck numbers in 2010 was higher than for 2010 (*i.e.* waterbuck was increasing with time). Similarly, for the set of dry season, waterbuck number in 2013 was higher than for 2010 (*i.e.* waterbuck was also increasing in the dry season).	
West Kilimanjaro	2010	2	0	No test necessary.	Waterbucks seen only in the wet season of 2010 and not dry season of 2010.
	2013	0	0	No test necessary.	No waterbuck seen in West Kilimanjaro in 2013.
	Chi-square value	No test necessary.	No test necessary.	Waterbuck seen only in the wet season of 2010 and not in other census periods.	
Natron	2010	14	0	No test necessary.	For 2010, waterbuck was seen only in the wet season but not in the dry season.
	2013	0	1	No test necessary.	For 2013, only one waterbuck was seen only in the dry season, but none in the wet season.
	Chi-square value	No test necessary.	No test Necessary.	For the set of wet season, waterbuck was only seen in 2010 and not 2013, implying a decline. But in the set of dry season, only one waterbuck was seen in 2013 and not 2010, implying a re-colonization.	

in the Magadi/Namanga area. For the set of wet season, waterbuck numbers in 2010 was higher ($p < 0.001$) than for 2010 (*i.e.* waterbuck was increasing with time). Similarly, for the set of dry season, waterbuck number in 2013 was higher ($p = 0.033$) than for 2010 (*i.e.* waterbuck was also increasing in the dry season).

For West Kilimanjaro area in 2010, Waterbuck was seen only in the wet season of 2010 and not the dry season of 2010. Further, for the 2013 wet season, no waterbuck seen in West Kilimanjaro in the whole of 2013. For the set of wet and set of dry seasons, comparisons were not possible because only two waterbucks were seen in the wet season of 2010 and not in the dry season, and not in the entire 2013 censuses in West Kilimanjaro area (**Table 7**). For Lake Natron area for 2010, waterbuck was seen only in the wet season and not in the dry season. Similarly for 2013, only one waterbuck was seen and only in the dry season, but none in the wet season. For the set of wet season, waterbuck was only seen in 2010 and not 2013, implying a decline. But in the set of dry season, only one waterbuck was seen in 2013 and not 2010, implying a re-colonization in Lake Natron area (**Table 7**).

In terms relationships between common waterbuck numbers in different locations (closer or further away from protected areas), influence of seasons on common waterbuck numbers varied among the locations in the borderland (**Table 8**). In general, waterbuck numbers in locations near and further away from protected areas

Table 8. The relationship between common waterbuck numbers and census location proximity to existing protected areas (Amboseli and West Kilimanjaro) and away (Magadi and Lake Natron Area) within the borderland.

Season of the year	Year	Location of census area		Chi-square cross tabulation value	Conclusion
		In or around protected areas	Away from protected areas		
Wet season	2010 (after drought)	20	16	$X^2 = 0.10$, df = 1, $p = 0.32$	In the wet season, waterbuck number in locations was independent of year, with numbers in both closer and further from protected areas remaining similar with time.
	2013 (post drought)	13	17		
Dry season	2010 (after drought)	17	6	$X^2 = 19.16$, df = 1, $p < 0.001$	In the dry season, waterbuck number in locations was dependent on year, with numbers near protected areas declining with time while those further away from protected areas increasing with time.
	2013 (post drought)	1	17		
Wet season		33	33	$X^2 = 0.13$, df = 1, $p = 0.72$	Generally, waterbuck numbers in locations was independent on the season, with numbers closer and further away from protected areas being similar across seasons.
Dry season		18	23		

was independent (cross-tabulations, $p = 0.72$) of the season, with numbers in all locations being similar across seasons. In terms of relationship with years, in the wet season, waterbuck number in locations near and further away from protected areas was independent ($p = 0.32$) of year, with numbers in both closer and further from protected areas remaining similar with time. But in the dry season, waterbuck number in locations was dependent ($p < 0.001$) on year, with numbers near protected areas declining with time while those further away from protected areas increasing with time (**Table 6**).

5. Discussions

The African buffalo and common waterbuck were poorly represented both in distribution and numbers in the borderland, and their population size is very low. The buffalo seem to be comparatively less abundant with about a majority of them are Amboseli and very few (less than fifty) in other areas. But common waterbuck were even more less, with most of the numbers less than ten in number in each of the locations. This is worrying because these species are very important grazers and prey in the African savannah ecology and these results highlight their decline. It is also instructive to note that whereas other species may easily be under-estimated in aerial counts because they are relatively small to see from the air (some gazelles, warthogs and most carnivores), and because of habitat cover (baboons and those who prefer thickets and bush), the African buffalo and waterbuck can clearly be seen from the air [32] and therefore their estimates quite reliable for actual size determination. It is therefore important for conservationists and wildlife observers to monitor the population sizes of these so that more studies on why they are declining are elaborated.

For the buffalo, Amboseli had the majority of the few numbers of buffalo (over 74%) and therefore remains the bedrock of viable buffalo populations in the borderland. However, buffalo were also found in all the locations of the borderland. This also highlights the potential and importance of other locations for supporting buffalo populations in the borderland. But more important is when you examine the rate of density and number changes over time and across seasons. Buffalo, only Amboseli had a small positive growth in density and numbers, but still had a decline (negative growth) in wet season. All other locations in the borderland had a negative growth in buffalo populations. This result reinforces the concern that the buffalo may actually be on its constant trend of decline and attention to reasons (drought mortality, retaliatory killings, declining water sources as climate change takes more tall) needs to be elaborated. This species is often sedentary and localized in ranging as buffalo herds maintain specific home ranges, so a decline in numbers cannot be attributed to drastic movements and immigration, but most likely on mortality. When the decline is in all the seasons and all the locations of the borderland, then this implies that buffalo may be becoming a locally threatened and endangered species in the borderland and urgent attention by conservationists need to be undertaken to highlight not only reasons for the decline, but remedial measures.

For both common waterbuck, both Magadi/Namanga area (with 44%) and Amboseli area (with 43%) had similar numbers and therefore both areas seemed to be critical as they contained the majority of the few remaining (about ten individuals each) of the species. This highlights the potential and importance of Magadi/Namanga area for supporting a good population of waterbuck in the borderland. The numbers in West Kilimanjaro and Natron will be wiped off unless there is immigration or rapid population recovery as the numbers are less than four in Lake Natron area and less than one in west Kilimanjaro. The waterbuck population in West Kilimanjaro is already practically locally extinct already. Looking at the changes in numbers and density of waterbuck over time, only Magadi/Namanga had a positive waterbuck population in density and numbers, but all other locations, including Amboseli area had negative (decline) change. This result reinforces the concern that waterbuck is already on its constant trend of decline as the population numbers are likely below viable population thresholds in the entire Kenya/Tanzania borderland. Therefore attention to reasons (drought mortality, retaliatory killings, declining water sources as climate change takes more tolls) needs to be urgently elaborated. Waterbuck are very sedentary and localized in ranging [2], so a decline in numbers cannot be attributed to immigration, but decline is likely to be due to mortality from natural death, predation and lack of livelihood resources. When the decline is this drastic, and especially for such small numbers, then waterbuck as a species is becoming highly endangered locally in the borderland, and any stochastic environmental events (such as droughts, diseases, floods etc) and demographic events (such as genetic drifts and poor mating encounters especially due to low numbers) will quickly wipe off the remaining numbers in the entire borderland.

The African buffalo belongs to the tribe *bovini* with domestic cattle among other bovids ([2]). Ecologically, the buffalo, a good habitat usually comprises dense thickets (for thermal and predation) as well as open woodland and grassland. Buffalo is a bulky grazing species that is able to subsist on grasses too tall and coarse for most ruminants, hence reducing grass height for more selective grazers. It also is more adaptive by doing some selective browsing in the dry season and when grass is of poor quality. When water and grass are plenty, buffalo is more mobile in search of fresh grass, but becomes more sedentary in riverine areas where fresh grass and water are available during drought or dry season. This brings them into conflicts with pastoralists who seek the same habitats for their livestock during drought and dry season [13] [15]. They are therefore water-dependent, bulky feeder on green grass (although it can eat dry one) and whose body condition deteriorates fast when water and fresh forage declines. There social behavior of living in large groups as anti-predation mechanism also increases competition for green grass and water especially in dry season and droughts. They are also vulnerable to *bovine* diseases which they may tolerate in good body condition, but succumb when the body condition declines such as in droughts or dry conditions. Such diseases include bovine tuberculosis, corridor disease, and foot and mouth disease [2], (Badwin *et al.*, 1988). As with many diseases, these problems will remain dormant within a population as long as the health of the animals is good. These diseases do, however, restrict the legal movements of the animals and fencing infected areas from unaffected areas is enforced. That is why possibly buffalo density and numbers often declined especially during and after droughts and why they are more vulnerable to local extinctions.

The Common waterbuck belongs to the tribe *reduncini* with reedbucks among other bovids. Ecologically, the for waterbuck, are the most water-dependent of all herbivores, and have even low tolerance of dehydration compared even to domestic animals. They are selective grazers, and that is why their distribution is limited to grasslands closer to water. Its preferred habitats are therefore grasslands and open woodlands closer to water sources in swamps or riverine areas [17] [18], (Taylor and Spinage, 1969). Even though they prefer dry ground with fresh grass rich in proteins near a water source, they also require thermal and predation cover, as they are prone to predation from main carnivores such as lion and hyena and leopards like any other medium and small-sized antelopes. Despite being a selective grazer that selects fresh grass rich in nutrients, they also can have up to 21% browse (dicots and acacia pods) in their diet composition especially in the dry season when food is either limiting or competed for by with other herbivores [2] [18]. This habitat requirement essentially limits the waterbuck to specific habitats and makes it less flexible in dealing with droughts and dry season, and for this reason, it is likely that they will mostly decline from drought related mortality as they are not adaptive and flexible in terms of diet and ranging. Further, their habitat preferred (near water bodies and where green forage is found) can bring them in direct competition with pastoralists especially outside protected areas and cause them to be forcefully displaced into less suitable habitats in this areas and hence further make them vulnerable to drought-related mortality. This could be part of the explanation of its negative decline in all locations and seasons in the borderland, and it makes population recovery after the 2007 and 2009 difficult for this species.

Results showed that buffalo numbers in locations were dependent of season, and numbers were more in the wet season than dry season in both near and further away from protected areas across the wet and dry season. This is consistent with what is expected. It is expected that generally herbivore numbers will depend on season, and that numbers will increase in the wet than dry season. During the wet season, buffalo numbers are expected increase because more forage and water will be plentiful and competition with other herbivores will be less, as well as predation pressure on them declining due to plentiful other prey species availability [8]. They will spur reproduction and due to their highly gregarious nature, rapid breeding will lead to birth of young by many females and increase the number of buffalo in all the herds. Therefore the dependence of waterbuck numbers on season may be the removal of water and green grass availability imposed by the dry season being lifted when the rains come and the buffalo range gets more water and forage, break into small herd size and reduces competition for these resources within the herd. It also implies that the dry season and droughts impose an ecological limitation to buffalo movements and population increase, thereby causing more mortality during that limiting time.

However, animal numbers will always not thrive in wet season when there is more forage and water. Animal ecology, particularly foraging and habitat requirements may influence how animal numbers respond to wet and dry seasons over time. For Amboseli area showed that even though wet season waterbuck numbers were higher than dry season numbers, generally waterbuck was declining with time. For Amboseli area, buffalo wet season numbers were higher than dry season numbers than in dry season, but numbers were either generally similar or declining with time. In Magadi area, the buffalo numbers were either same or higher in the wet season, but still the buffalo numbers were increasing only in the wet season but declining in the dry seasons over time. In West Kilimanjaro, buffalo was only seen in the wet season of 2013 but not dry season of 2010, implying a decline in the dry season and a possible re-colonization of the area from another location in wet season when herbivores mostly disperse. In the Natron area, there was more buffalo in the wet season than dry season of 2010, and no buffalo seen at all in the area in all seasons in 2013, implying a general decline in buffalo numbers over time, and an indication of impending local extinction of buffalo in Natron area similar to West Kilimanjaro area.

As for common waterbuck, it was also interesting to note that waterbuck its numbers in locations were independent of season, and numbers were similar both near and further away from protected areas across the wet and dry season. This is contrary to what is expected. It is expected that generally herbivore numbers will depend on season, and that numbers will increase in the wet than dry season [18]. During the wet season, waterbuck numbers are expected increase because more forage and water will be plentiful and competition with other herbivores will be less, as well as predation pressure on them declining due to plentiful other prey species availability. Therefore the independence of waterbuck numbers on season may be due to its very dependence on water [35] and on grassland habitats next to the waters such that if the source is the water source is permanent, then its numbers will not be affected by wet or rainy season provided they are not displaced by people or other large livestock seeking the water in droughts or extended dry seasons. If the drought is long and the water source and grass dry up, the waterbuck will experience high mortality because of its inability to endure dehydration and lack of adaptability to utilize other habitats and forage types.

But again animal numbers will always not thrive in wet season when there is more forage and water. Animal ecology, particularly foraging and habitat requirements may influence how animal numbers respond to wet and dry seasons over time. For Amboseli area showed that even though wet season waterbuck numbers were higher than dry season numbers, generally waterbuck was declining with time. In Magadi/Namanga however, even though wet and dry season waterbuck numbers were similar, the general trend was an increasing waterbuck number with time. In West Kilimanjaro area, there were only 2 waterbucks in 2010 and none seen in 2013 implying local extinction was likely in West Kilimanjaro. In Lake Natron area 2010, waterbuck was only seen in wet season and not dry season. Further, only one waterbuck was seen in 2013 (wet season) implying that the number of waterbuck was declining rapidly in Lake Natron area and may be the one seen in 2013 was an immigrant, implying that local extinction of waterbuck in Lake Natron, just as lakeMagadi was also eminent. It therefore seems that waterbuck was also declining with time across locations because of lack of clear increasing population trend in all the locations.

The current status of African Cape buffalo is dependent on the animal's value to both trophy hunters and tourists, paving the way for conservation efforts through anti-poaching patrols, village crop damage payouts, and hunting payback programs to local areas in some countries [15]. Whereas the buffalo is listed as Least Concern by the IUCN [10] as the species remains widespread, with a global population estimated at nearly 900,000 animals, of which more than three-quarters are in protected areas. While some populations (subspecies) are decreasing, others will remain unchanged in the long term if large, healthy populations continue to persist in a substantial number of national parks, equivalent reserves and hunting zones in southern and eastern Africa. They are also, just like cattle and other *bovids*, very vulnerable to droughts because of its dependence of green grass forage and drinking to survive. Reductions in nutritious and green grass exposes them quickly to starvation and therefore high mortality from extend dry seasons and droughts.

Buffalo ranks highly in human-wildlife conflicts because of its high incidences of attack on humans and livestock when they meet or compete for water and pasture [14]. Local extinction of buffalo in the borderland will be a setback for the biodiversity as well as tourism industry as this is a key species in the famed *big five* large mammals highly sort after by tourists. Being a member of the *big five* game family, a term originally used to describe the five most dangerous animals to hunt, the Cape buffalo is a sought-after trophy, with some hunters paying over $10,000 for the opportunity to hunt one. The larger bulls are targeted for their trophy value, although in some areas, buffaloes are still hunted for meat. Known within Africa as one of the “big five”, “The Black Death” or “widowmaker”, the African buffalo is widely regarded as a very dangerous animal, as it gores and kills over 200 people every year [15]. Buffaloes are sometimes reported to kill more people in Africa than any other animal, although the same claim is also made of hippopotamus and crocodiles Buffaloes are notorious among big game hunters as very dangerous animals, with wounded animals reported to ambush and attack pursuers.

The IUCN lists the waterbuck as being of Least Concern [19]. More specifically, the common waterbuck is listed as of Least Concern [19] while the defassa waterbuck is Near Threatened. The population trend for both the common and defassa waterbuck is downwards, especially that of the latter, with large populations being eliminated from certain habitats because of hunting and human disturbance [35]. Waterbuck are also susceptible to ulcers, lungworm infection and kidney stones. Other diseases from which these animals suffer are foot-and-mouth disease, sindbis fever, yellow fever, bluetongue, bovine virus diarrhea, brucellosis and anthrax. The waterbuck is more resistant to rinderpest than are other antelopes. They are unaffected by tsetse flies but ticks may introduce parasitic protozoa such as *Theileria parva*, *Anaplasma marginale* and *Baberia bigemina*. 27 species of ixodid tick have been found on waterbuck—a healthy waterbuck may carry a total of over 4000 ticks in their larval or nymphal stages, the most common among them being *Amblyomma cohaerens* and *Rhipicephalu stricuspis*. Internal parasites found in waterbuck include tapeworms, liver flukes, stomach flukes and several helminthes. Poor forage quality and poor body condition will lead to enhanced waterbuck mortality, and predation especially in the dry season [17].

The waterbuck may not be a member of the famed tourism *big five*, but it is interesting and contributes to tourists nevertheless. The common waterbuck is a rare specialized grazer of intense tourism interest. Tourists will tend to value an animal that is easy to view and is also rare. In Amboseli National Park, a study in 2008 [14] showed that in terms of tourism importance based on relative animal numbers as well as tourism animal stoppings, viewing time and vehicle crowding, the common waterbuck was ranked the second most popular species for tourists after only the cheetah (*Acinonyx jubatus*) and followed by the lion (*Panthera leo*), the all-time symbol of African tourism and savannah. So, like most species that are unique but also rare, they contribute to tourism satisfaction, and decline of waterbuck in the borderland will have negative consequences for tourism industry as well.

Re-colonization of buffalo and waterbuck to re-build its seriously reduced numbers that are still continuing to decline during wet season dispersal time will only be possible if less impacts from human encroachment, poaching by bush meat and habitat destruction. Management attention should be focused on all the borderland landscape, but in particular the Lake Natron and West Kilimanjaro because they had lowest numbers and are currently witnessing local extinction of buffalo and waterbuck in the borderland. With increasing of numbers in every wet season, and for every passing year in areas closer and away from protected areas, there is great potential and opportunity to get the numbers of these two species to build up again and become viable populations of the borderland meta-population.

Lastly, the safety of these two species as well as other large mammals in the borderland is critical for allowing for re-colonization of the space where wildlife large mammals in the borderland can again thrive. Increased conflicts with wild herbivores over damages (may be due to crop raiding and in some cases competition for water, pasture and space), and threats (such as bush meat poaching) and habitat destruction will lead to a steady herbivore decline in the borderland [24] [28]. We need to establish what other human-induced mortality has led to a decline of these four species and take remedial action. In this regard, continued cross border collaborative management and population monitoring (between Kenya and Tanzania) is very essential. Further, joint effort in ground population monitoring and undertaking anti-poaching that allow positive population growth and dispersal of large wild mammals in the borderland landscape will enhance the new legal obligations of countries in cross border conservation collaboration in East Africa.

6. Conclusions

The status and distribution of the African buffalo and common waterbuck were very poor both in number and distribution in the mid borderland of Kenya-Tanzania. Most of the buffaloes and waterbucks, however, are found in Amboseli and Lake Natron area, but there is also a good population in Magadi/Namanga area and West Kilimanjaro in Tanzania. The population growth was negative (except in Amboseli wet season and Magadi/Namanga Area). This raises a red flag because it means that the African buffalo and common waterbuck have not recovered from the effects of the 2007 and 2009 droughts and their population is still declining in all the areas of the borderland. These species are very water specific and localized in marshes and swamps where they are able to access water. Small populations and declining numbers mean that they can easily be wiped off by stochastic demographic and environmental parameters and undergo local extinctions. In fact, local extinctions of this species may already have happed in West Kilimanjaro and the Lake Natron Areas. Buffalos kill many people and so they also can be highly persecuted by communities and not tolerated because of their contribution to human-wildlife conflicts. Yet both buffalo and waterbuck are very attractive species to tourists and therefore contribute a lot to the tourism revenue and industry. It therefore needs concerted effort in both Kenya and Tanzania and the borderland communities to avoid poaching, retaliatory killing and insularization of the remaining populations of buffalo and common waterbuck. Further, joint monitoring between Kenya (KWS) and Tanzania (TAWIRI) will enhance science-based management through population monitoring and trend. The buffalo and waterbuck population status and distribution are poor enough in the Kenya-Tanzania borderland to make it a species of conservation concern in the borderland despite what IUCN reports indicate [20].

Acknowledgements

We humbly appreciate the contributions made by the Kenya and Tanzania census teams, and the incredible financial and moral support offered by various organizations and institutions. In particular, funding, personnel and logistical support were provided by AWF, KWS, TAWIRI, WD, TANAPA and ATE. We are equally grateful to the Director KWS, Director ATE, Director of Wildlife in Tanzania, Director General of TANAPA and Mr. Peter Zannetti for provision of aircraft and experienced pilots and observers. The ground crew and support personnel showed a lot of commitment which ultimately went a long way in making this research successful. Finally, we honor all those people who participated in one way or another in this exercise and whose names have not been mentioned. Their input equally contributed to the good work that was accomplished in all the census sessions.

References

[1] Kingdon, J. (1997) The Kingdon Field Guide to African Mammals. Academic Press, London.

[2] Estes, R.D. (2012) The Behavior Guide to African Mammals: Including Hoofed Mammals, Carnivores, Primates. 20th Edition, University of California Press, Berkeley, 107-111.

[3] Beekman, J.H. and Prins, H.H.T. (1989) Feeding Strategies of Sedentary Large Herbivores in East Africa, with Emphasis on the African Buffalo (*Syncerus caffer*). *African Journal of Ecology*, **27**, 129-147.

[4] Nowak, R.M. (1999) Walker's Mammals of the World (Volume 1). 6th Edition, Johns Hopkins University Press, Baltimore, 1166-1170.

[5] Ansell, W.F.H. (1968) Artiodactyla (Excluding the Genus *Gazella*). In: Meester, J.A., Ed., *Preliminary Identification Manual for African Mammals*, Smithsonian Institution, Washington DC.

[6] Buchholtz, C. (1990) Cattle. In: Parker, S.P., Ed., *Grzimek's Encyclopedia of Mammals*, Vol. 5, McGraw-Hill, New York, 360-417.

[7] Butynski, T.M., Schaaf, C.D. and Hearn, G.W. (1997) African Buffalo (*Syncerus caffer*) Extirpated on Bioko Island, Equatorial Guinea. *Journal of African Zoology*, **111**, 57-61.

[8] Mloszewski, M.J. (1983) The Behavior and Ecology of the African Buffalo. Cambridge University Press, Cambridge.

[9] East, R. (1999) African Antelope Database 1998. IUCN/SSC Antelope Specialist Group, Gland, Switzerland and Cam-

bridge, UK.

[10] IUCN Antelope Specialist Group (2008) *Syncerus caffer*. In: IUCN, Ed., *IUCN Red List of Threatened Species*, Version 2010.1, International Union for Conservation of Nature.

[11] Condy, J.B. and Hedger, R.S. (1978) Experiences in the Establishment of a Herd of Foot-and-Mouth Disease Free African Buffalo (*Syncerus caffer*). *South African Journal of Wildlife Research*, **8**, 87-89.

[12] Mahaney, W.C. (1987) Behavior of the African Buffalo on Mount Kenya. *African Journal of Ecology*, **25**, 199-202. http://dx.doi.org/10.1111/j.1365-2028.1987.tb01107.x

[13] Wenink, P.W., Groen, A.F., Roelke-Parker, M.E. and Prins, H.H.T. (1998) African Buffalo Maintain High Genetic Diversity in the Major Histocompatibility Complex in Spite of Historically Known Population Bottlenecks. *Molecular Ecology*, **7**, 1315-1322. http://dx.doi.org/10.1046/j.1365-294x.1998.00463.x

[14] Okello, M.M., Manka, S.G. and D'Amour, D.E. (2008) The Relative Importance of Large Mammal Species for Tourism in Amboseli National Park, Kenya. *Tourism Management*, **29**, 751-760. http://dx.doi.org/10.1016/j.tourman.2007.08.003

[15] Foggin, C.M. and Taylor, R.D. (1996) Management and Utilization of the African Buffalo in Zimbabwe. In: Penzhorn, B.L., Eds., *The African Buffalo as a Game Ranch Animal*, South African Veterinary Association Wildlife Group, Onderstepoort, 144-162.

[16] Huffman, B. (2014) Waterbuck. Ultimate Ungulate. http://www.ultimateungulate.com/Artiodactyla/Kobus_ellipsiprymnus.html

[17] Melton, D.A. (1978) Ecology of Waterbuck *Kobus ellipsiprymnus* (Ogilby, 1833) in the Umfolozi Game Reserve. University of Pretoria, Pretoria.

[18] Spinage, C.A. (1982) A Territorial Antelope: The Uganda Waterbuck. Academic Press, London.

[19] IUCN SSC Antelope Specialist Group (2008) *Kobus ellipsiprymnus*. In: IUCN, Ed., *IUCN Red List of Threatened Species*, Version 2010.4, International Union for Conservation of Nature.

[20] Convention on the International Trade in Endangered Species of Wild Flora and Fauna, CITES (2009) Appendix I, II, and III as Adopted by the Conference of the Parties, Valid from 22 May 2009. Available Online at the CITES Website.

[21] Green, A.A. (1979) Density Estimate of the Larger Mammals of Arli National Park, Upper Volta. *Mammalia*, **43**, 59-70. http://dx.doi.org/10.1515/mamm.1979.43.1.59

[22] Jumba, I.O., Kisia, S.M. and Kock, R. (2006) Animal Health Problems Attributed to Environmental Contamination in Lake Nakuru National Park, Kenya: A Case Study on Heavy Metal Poisoning in the Waterbuck *Kobus ellipsiprymnus defassa* (Ruppel 1835). *Archives of Environmental Contamination and Toxicology*, **52**, 270-281. http://dx.doi.org/10.1007/s00244-005-0241-2

[23] Ntiati, P. (2002) Group Ranches Subdivision Study in Loitokitok Division of Kajiado District. Land Use Change Impacts and Dynamics (LUCID) Working Paper 7, International Livestock Research Institute (ILRI), Nairobi.

[24] Western, D., Groom, R. and Worden, J. (2009) The Impact of Subdivision and Sedentarization of Pastoral Lands on Wildlife in an African Savanna Ecosystem. *Biological Conservation*, **142**, 2538-2546. http://dx.doi.org/10.1016/j.biocon.2009.05.025

[25] Pratt, D.J. and Gwynne, M.D. (1977) Rangeland Management and Ecology in East Africa. Hodder and Stoughton, London.

[26] Reid, R., Gachimbi, L., Worden, J., Wangui, E., Mathai, S., Campbell, D., Maitima, J., Butt, B., Gichohi, H. and Ogol, E. (2004) Linkages between Changes in Land Use, Biodiversity and Land Degradation in the Loitokitok Area of Kenya. Land Use Change Impacts and Dynamics (LUCID) Working Paper Series 49, 1-29.

[27] Okello, M.M. and D'Amour, D.E. (2008) Agricultural Expansion within Kimana Electric Fences and Implications for Natural Resource Conservation around Amboseli National Park, Kenya. *Journal of Arid Environments*, **72**, 2179-2192. http://dx.doi.org/10.1016/j.jaridenv.2008.07.008

[28] Western, D. (1982) Amboseli National Park: Enlisting Landowners to Conserve Migratory Wildlife. *Ambio*, **11**, 302-308.

[29] Berger, D. (1993) Wildlife Extension: Participatory Conservation by the Maasai of Kenya. ACTS Environmental Policy Series No. 4, 5-45.

[30] Kiringe, J.W. and Okello, M.M. (2005) Use and Availability of Tree and Shrub Resources on Maasai Communal Rangelands near Amboseli, Kenya. *African Journal of Range and Forage Science*, **22**, 37-46. http://dx.doi.org/10.2989/10220110509485860

[31] Western, D. (1975) Water Availability and Its Influence on the Structure and Dynamics of a Savannah Large Mammal Community. *East African Wildlife Journal*, **13**, 265-285.

[32] Douglas-Hamilton, I., Gachago, S., Litoroh, M. and Mirangi, J. (1994) Tsavo Elephant Count 1994. Kenya Wildlife Service, Nairobi.

[33] Norton-Griffiths, M. (1978) Counting Animals. Handbook 1, 2nd Edition, African Wildlife Foundation, Nairobi.

[34] Zar, J.H. (1999) Biostatistical Analysis. 4th Edition, Prentice Hall, Inc., Upper Saddle River.

[35] Taylor, C.R., Spinage, C.A. and Lyman, C.P. (1969) Water Relations of the Waterbuck, an East African Antelope. *The American Journal of Physiology*, **217**, 630-634.