PRE-REINTRODUCTION ASSESSMENT OF DIET SUITABILITY AND POTENTIAL ANTHROPOGENIC THREATS TO THE MOUNTAIN BONGO (*Tragelaphus eurycerus isaaci*) IN MOUNT KENYA FOREST.

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

Signed…………………………………………………

Date…………………………

This thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

To my wife Casty Murugi

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ABSTRACT

The mountain bongo (*Tragelaphus eurycerus isaaci*) is a critically endangered antelope, found only in Kenya. To save the subspecies from extinction, re-introduction of a captive male bongo group from Mount Kenya Wildlife Conservancy (MKWC) to Mount Kenya Forest (MKF) was proposed. The Proposed Bongo Sanctuary (PBS) in the forest and the captive mountain bongo habitat at MKWC were compared for vegetation structure and composition, bongo food availability at the sanctuary was determined and potential anthropogenic threats to a released population assessed. It was hypothesized that habitat quality of the PBS in terms of food availability is similar to that of MKWC; and that there are no human activities within the region which can potentially be detrimental to a re-introduced mountain bongo population. Quadrats were used to assess vegetation composition, food choice was determined using focal animal sampling and anthropogenic threats established using questionnaires. Differences in vegetation composition was analyzed using Students t-test, vegetation similarity was analyzed using Jaccard coefficient of community similarity and Chi square used to analyze anthropogenic data.

In total, 218 plant species were recorded of which 63 (28.9%) species were common to both sites. The mean tree basal area between MKWC (0.15 ± 0.02 m^2/acre) and the PBS (0.23 ± 0.03 m^2/acre) had a significant difference ($t=2.65$, $df=107$, $p<0.05$). The wet season mean herb diversity also varied significantly ($t=7.94$, $df=71$, $p<0.05$) between MKWC ($H'=1.19\pm0.35$) and the PBS ($H'=1.60\pm0.25$). Overall the male mountain bongo diet comprised of 64 plant species of which 67% of them were recorded at the PBS during wet season and 61% during the dry season. Hunting was prevalent in the area (55%) although not significant ($\chi2=3.09$, $df=2$, $p>0.05$) among the three communities sampled. A large proportion of respondents (97%) get firewood, charcoal, fodder and building materials from the forest. Despite male mountain bongos preferred food plants being available at the PBS, these activities remain to be a major threat to a released mountain bongo population. Strengthening conservation awareness campaigns and law enforcement is therefore required with particular emphasis on reducing logging, poaching and encroachment in MKF. Further research on diet selection inclusive of both sexes ought to be conducted prior to reintroduction.

CHAPTER ONE

1.1 Introduction to the study

Bongo antelope belongs to the genus Tragelaphus, which includes the Giant Eland (*Tragelaphus derbianus*), Common Eland (*Tragelaphus oryx*), Sitatunga (*Tragelaphus spekei*), Nyala (*Tragelaphus angasi*), Bushbuck (*Tragelaphus scriptus*), Mountain Nyala (*Tragelaphus buxtoni*), Lesser Kudu (*Tragelaphus imberbis*) and Greater Kudu (*Tragelaphus strepsiceros*). They are the largest forest antelopes with males weighing approximately 220–405 kg while females weigh approximately 150–235 kg. Their large size makes them be the third largest in the Bovidae tribe of Strepsicerotini behind both the common and greater eland (Spinage, 1986). They are found in tropical jungles in lowland equatorial rain forests of West Africa and Congo basin to Southern Sudan and montane forests of East Africa (IUCN, 2008). They have also been managed in captivity in Europe and North America. The captive population in North America is thought to be over 400 individuals and over 250 animals across Europe.

The Bongo (*Tragelaphus eurycerus*) is divided into two subspecies; the mountain bongo (*Tragelaphus eurycerus isaaci* Thomas, 1902 - plate 1) found in montane forests of East Africa and the lowland bongo (*Tragelaphus eurycerus eurycerus* Ogilbyi, 1837) of Central and West Africa's lowland forest zone (Ralls, 1978). Mountain bongo has isolated populations occurring in the montane forests of East Africa, namely Mount Kenya, Aberdare, Eburu and Mau. Kenya hosts the entire population of mountain bongos estimated to be slightly over 100 individuals. Aberdare National Park and Forest Reserve is the stronghold for the subspecies, with an estimated population of 50 individuals. Mau west forest holds an estimated 30 individuals, Mount Kenya forest about 15, and Eburu Forest 10 individuals (Musyoki *et al*, 2012). This low population has been attributed to habitat loss, hunting for meat and trophies, diseases and predation by lions. Inaccessibility of its habitats makes its scientific studies difficult and apart from preliminary surveys to confirm their presence in Mount Kenya, Aberdares, Mau and Eburu (Faria *et al*., 2011), there is scanty ecological data on these populations. Understanding some of the ecological aspects of captive population can provide useful insights to be used for further detailed ecological studies. Mount Kenya Wildlife Conservancy (MKWC) mountain bongo breeding program was therefore useful in understanding dietary composition of the subspecies. The research was undertaken at a time when the Conservancy in collaboration with the Kenya

Wildlife Service (KWS), was planning to re-introduce some of the mountain bongos back into the wild. At the time, the conservancy had a population of 70 individuals (sex ratio of 1:1) which could be a source population in supplementing the existing wild populations. This being a pilot project, the conservancy's management proposed to release males only in the first phase of reintroduction and their survival success to be used in designing future releases comprising of both males and females. The success of such a captive population in the wild is however dependent on mitigation measures undertaken to reduce their interactions between rapid human population growth, increased hunting pressure, habitat loss and epizootic events which are the threats which originally may have led to the population decline (Prettejohn, 2008).

Plate 1: Male Mountain Bongos grazing at the Mount Kenya Wildlife Conservancy

1.2 Literature Review

Bongos (*Tragelaphus eurycerus*) are one of the largest forest-dwelling antelope found in tropical jungles with dense undergrowth up to an altitude of 3,000 meters above sea level (Ralls, 1978). They are generally gregarious with groups comprising of an adult male, adult females, sub-adults and calves. Old bulls are however often solitary and very aggressive. Like other forest ungulates, they are seldom seen in large groups of more than 20 individuals (Kingdon, 1982). They are herbivorous browsers and feed on tree/bush leaves, vines, bark and pith of rotting trees, grasses/herbs, roots, and shrubs. The species thrives on transition vegetation at the forest edge and in new growth areas that occur after disturbance and are perhaps more adaptable than is generally believed (Stuart and Stuart, 2006). They mainly emerge into the open or forest clearings during activity peaks around dawn and dusk to browse (Spinage, 1986).

The species is listed as Near Threatened as it faces ongoing population decline due to habitat loss, hunting pressure, diseases and commercial forestry (IUCN, 2008). It is classified into two subspecies: *Tragelaphus eurycerus eurycerus*, the lowland bongo, and the rare *Tragelaphus eurycerus isaaci*, the mountain bongo. Mountain bongo is larger and heavier, has more vividly-colored coat, with a vibrant chestnut background and striking white stripes than the lowland Bongo ((Stuart and Stuart, 2006). The IUCN Antelope Specialist Group considers the lowland bongo to be at Lower Risk (Near Threatened), and the Mountain bongo to be Critically Endangered (IUCN, 2008).

The lowland bongo inhabits the lowland rain forests of West and Central Africa while small remnant populations of wild mountain bongo can be found in the Aberdares, Mount Kenya, Mau Forest and Eburu Forest. Mountain bongos also once inhabited Cherengani hills, Chepalungu hills and Mount Elgon in Kenya and Uganda where they have been extirpated (Kingdon, 1982). In the four regions where the subspecies is found, populations have diminished and the causes of their decline are uncertain with speculation touching on a number of possibilities.

The most widely held view attributes the decline to illegal hunting with dogs (Estes, 1991; Prettejohn, 2004). Coupled with habitat alteration, it is cited as one of the main cause for the population decline in the Cherangani Hills in the 1950s (Stanley, 1969). Predation by lions introduced into the Aberdares has also been blamed (Cheffings, 1997; Butynski, 1999) as an important contributor to its decline. Another suggestion is that toxicity in *Mimulopsis solmsii* which is sometimes fed on by the bongos may be responsible for the decline (Kingdon, 1982, Glover *et al*., 1966). A more likely cause of the decline is rinderpest, which struck herbivore populations, particularly eland and buffalo in this part of Kenya in the 1980s and 90s (Kock *et al*., 1999).

The dramatic human population increase in Kenya's fertile mountain regions is the root cause of increased habitat destruction which is a major threat to the subspecies survival (Estes, 2006). Grazing of livestock within the forests has increased their contact which can also increase the risk of mountain bongos contracting diseases. Their small numbers, fragmented populations and dependence on a diminishing afromontane forest environment render them less likely to rebound following disease events than are other herbivores (Estes, 2006).

Mountain bongo habitats have also changed over time due to shifts in vegetation communities (Shugart *et al*., 2001). Rapid intensification of land use in Mount Kenya-Aberdares area over the last 50 years has resulted in increased encroachment and natural resources extraction in these protected mountain forest reserves (Imbernon, 1999; Lambrechts, 2003). This is common with most biologically rich montane forests which cover only three percent of Kenya, and are threatened by the fast growing human population and intensive agriculture (Kohler, 1986; Imbernon, 1999). Mountain bongos have concurrently declined throughout their range (Cheffings, 1997), with the 2010 Bongo Surveillance Program's wild population estimates being slightly more than 100 individuals in all the four areas. The subspecies is still declining as their threats continue to escalate and none of the subpopulations in the four areas contain more than 50 mature individuals (IUCN, 2008).

The threat to mountain bongo habitats has long been recognized, and a variety of conservation actions have been taken. Mount Kenya is a designated World Heritage Site whose upper reaches enjoy National Park status, while the lower encircling forests are under forest reserve. Forest custody now falls under the Kenya Forest Service (KFS), which has made impressive strides in minimizing the rampant illegal logging, cultivation, and settlement that took place in the forests towards the end of the 20th century (Gathaara, 1999; Vanleeuwe *et al*., 2003).

Specific conservation efforts of the subspecies and its habitats have recently been set in motion. In Aberdares for example, there has been formation of Bongo Surveillance Program (BSP) under the Rhino Ark. According to Estes (2006), BSP is involved in mountain bongo surveillance within Aberdares National Park, Mount Kenya, Mau forest and Eburu. They have yielded an estimate of up to 50 remaining animals in Aberdares, divided between 5 separate breeding herds, as well as an unknown number of solitary old bulls. Working alongside other interested stakeholders, BSP have also confirmed the presence of small populations in Mount Kenya, Eburu and Mau forests by analyzing DNA extracted from dung (Faria *et al*., 2011). At the same time, in January of 2004, eighteen mountain bongos were repatriated from captive-bred North American populations to MKWC, as the first phase of a long-term project to re-establish a free-ranging population within Mount Kenya Forest (RSCF, 2004).

A large amount of research has also been conducted in Mount Kenya and, to a lesser extent, the Aberdares. The vegetation of both mountain areas has been classified by various authors. The phytosociology of Mount Kenya's forests was described by Bussmann (1994), while Young made in-depth studies of the Afroalpine zone (Young and Peacock, 1992, Mulkey *et al*., 1984). Schmitt (1991) classified both the moorlands and forests of the Aberdares National Park. The Kenya Indigenous Forest Conservation program commissioned several unpublished reports detailing the composition and structure of Mount Kenya and Aberdares forest reserves. The same project also resulted in a mammal survey of Mount Kenya. Mount Kenya's position astride the equator has also been of interest to researchers studying the effects of climate change (Shugart *et al.*, 2001).

Whilst captive breeding program can be viewed as having been successful in ensuring survival of this subspecies, the situation in the wild has been less promising. The wild populations are small, fragmented and vulnerable to extinction. Griffith *et al.* (1989) and Kleiman (1989) noted that the re-introduction of captive-bred species of animals represents a potentially valuable tool in efforts to counter the worldwide loss of biodiversity. Reintroducing the captive bred individuals will be a milestone in saving this critically endangered mountain antelope. However understanding their dietary needs is the basis for a successful reintroduction.

While the lowland bongo has been studied enough to understand its diet selection, habitat associations, and group composition (Elkan, 2003; Hillman and Gwynne, 1987; Klaus-Hugi *et al*., 2000; Turkalo and Klaus-Hugi, 1999), almost nothing is known about the mountain bongo of East Africa. Kingdon's (1982) book on African bovids which draws the subspecies' chapter heavily on the published observations of earlier hunters and explorers (e.g. Stanley, 1969; Glover *et al*., 1966), field records from the Aberdares, and his own findings, offers the most comprehensive reference. Beyond this work, no much detailed ecological studies of the mountain bongo have been published. In fact, few comprehensive studies of forest-dwelling African herbivores exist, particularly of those which reside in Afromontane habitats (Estes, 2006) due to the harsh terrain.

Remote sensing study undertaken by Estes *et al*. (2008) to determine mountain bongo's critical habitat, pinpointed Mawingu area in the Western side of Mount Kenya Forest as a preferred reintroduction site due to its greater abundance of suitable habitat. Understanding their ecology and the habitat managed to their advantage is a milestone in reestablishing them in many parts of their former range (Kingdon, 1982). The existence of a healthy captive population of this subspecies offers the potential for its reintroduction (Estes, 2007). In Kenya, MKWC has proven to be a successful breeding site for the mountain bongo and therefore a future source to the wild sinks.

Successful reintroductions, however, require that a number of species-specific environmental and bio-political criteria be met (Kleiman *et al*., 1994). Whenever there is need to augment the wild population, sufficient founder stock should be available, and extant wild populations should not be jeopardized by the reintroduction (Kleiman *et al*., 1994; Woodford & Rossiter, 1994). The species biology should be well understood, appropriate reintroduction techniques be known, and sufficient resources availed for the program (IUCN, 1998). Prior to reintroduction, there should generally be strong evidence that the threat(s) that caused previous extinction have been identified and removed or sufficiently reduced (IUCN, 2012)

The causes of previous mountain bongo decline have been identified to include habitat fragmentation, poaching, predation pressure, disease and human factors (Emslie *et al*., 2009). All these should be eliminated and/or reduced to a sufficient level to permit survival of the released population. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration program should be initiated before the re-introduction is carried out (IUCN, 1998).

A well executed reintroduction procedure can potentially preserve populations of animals whose habitats are threatened, repopulate areas after local extinctions or with low population densities, and augment genetic diversity in existing gene pools (Konstant and Mittermeier, 1982). The process should conform to legal requirements, be supported by both government and non-government agencies, and have minimal negative impacts on local people (Kleiman *et al*., 1994). Most reintroduction programs, however, are complicated and expensive involving a multi-disciplinary approach to problem solving, long-term financial commitment, active collaboration with a broad range of public and private agencies, and an extended period of post-release follow-up in some cases for many years are critical to their success (Emslie *et al*., 2009).

One criterion that must be satisfied prior to translocation is the availability of suitable habitat which is critical to the survival of reintroduced species (IUCN, 1998). Matching habitat suitability and availability to the needs of candidate species is central to translocation feasibility and design (IUCN, 2012). Some of the species basic needs to be considered in a given habitat prior to translocation include food availability, water availability, cover and space. Comparative studies of the captive habitat to the reintroduction site offers the basis for identifying a suitable habitat if at all the species has successfully survived within their range (Kleiman *et al.*, 1991). Such studies may reveal significant variation even at smaller scales especially in areas with known variation in climatic patterns, altitude, and edaphic factors (Butynski, 1990; Chapman *et al*., 1997). In addition to the vagaries of natural disturbances, tropical forests are modified, fragmented, and eliminated by human activities (Fashing and Gathua, 2004).This may consequently affect species specific habitat requirements.

Generally animal populations that rely on naturally dynamic or anthropogenically altered forest habitats may respond to changes by migrating, shifting home ranges, or altering diet or activity budgets (Kinnaird, 1990; Clarke *et al*., 2002). Mountain bongos can thrive in areas where the forest is regenerating following logging, cultivation or heavy elephant damage (Kingdon, 1982). These are openings in the forest which support dense growth of bushes, herbs, creepers and bamboo shoots (Hillman, 1986) constituting their main diet.

Most studies on mountain bongos denote them to be principally browsers with Hoffman and Stewart (1972) describing bongo as a 'tree and shrub foliage eater' and as 'selectors of juicy, concentrated foliage'. Investigations by Elkan (1996) indicated that bongos feed predominantly on dicotyledonous plants although they do include some grass. They are therefore selective browsers of high protein vegetation; and they use their long, flexible tongue as a feeding tool and the horns are employed to break high branches (Kingdon, 1982). Such food preference among the ungulates is mainly influenced by rainfall patterns, chemical components, shoot phenology, and food availability (Noy-meir, 1973; Owen-Smith and Cooper, 1987; Watson and Owen-Smith, 2002). The model of clever ungulates by Owen-Smith and Novellie (1982), however, states that an optimally foraging ungulate should widen its food acceptance range with declining food availability within its habitat. In so doing, they will be behaving like generalists whose feeding strategies can be summarized as:

i) They eat potentially wide range of food types but at any one-time concentrate on the most familiar and available (Freeland and Janzen, 1974). Diversity in the diet is a response to declining availability of preferred foods.

ii) Food types are eaten according to their relative availability rather than the animal depending on a few critical species in short supply (Clutton–Brock, 1975)

iii) Where there is selection of foods other than according to the relative availability, this ought to be governed by preferential selection firstly of high energy foods (Emlen, 1973) and secondly of plants containing comparatively small amounts of toxic secondary compounds (Freeland and Janzen, 1974).

Foraging theory predicts that animals allocate time to patches depending on their energy returns (Charnov, 1976). A foraging animal wants to obtain the most energy from food intake relative to energy expended in securing and eating the food (Alonso *et al.*, 2005). For an animal to get optimal net returns from the food they utilize, they have to consider the time required to get to those resources, time required to extract the resource and richness of the food resource (Krebs and Cowie, 1976). These are the main factors that determine food preference.

The second most important criterion to be met for a successful translocation aimed at restoring a species in a given ecosystem is the need for a stable, self-sustaining population from which individuals can be drawn for reintroduction purposes (Kleiman, 1994). The population must be sufficiently robust so that removal, and subsequent loss, of *"surplus"* reintroduced individuals over an extended period of time will not severely impact on its genetic integrity (Kleiman *et al*. 1991). In cases where the population is reduced to near extinction levels, it may not be possible to satisfy this criterion. However, MKWC has since early 1980 been breeding mountain bongos in captivity and the population has grown to levels where sustainable removal of individuals will not impact the population negatively. The conservancy has a population of 70 individuals and is expected to grow at a fast rate since the repatriation of 18 individuals from the American zoological parks to the conservancy in 2004.

1.3 Justification

Availability of suitable habitat for a species is a major requirement which should be satisfied prior to any animal re-introduction. Mount Kenya Forest-Mawingu area where the Proposed Bongo Sanctuary (PBS) is located was proposed by Estes *at al.* (2008) to be a good mountain bongo translocation site due to its pristine habitat and its close proximity to KWS rangers post. However, in order to make sound translocation decision, vegetation composition of the source and sink habitats needs to be compared, proper assessment of PBS for food availability conducted and assess if anthropogenic activities within the region could pose any threats the released population. This study was therefore designed to gather such critical information which could enable wildlife managers and other relevant stakeholders in making informed decisions with regard to suitability of Mawingu area as a mountain bongo translocation site.

1.4 Hypotheses

Habitat quality of the PBS in terms of food availability is similar to that of MKWC

There are no human activities within the region which can potentially be detrimental to a re-introduced mountain bongo population

1.5 Objectives of the study

1.5.1 Overall objective

The overall objective of the study was to determine diet suitability and potential anthropogenic threats mountain bongos might encounter once reintroduced within the Proposed Bongo Sanctuary.

1.5.2 Specific objectives

This study was undertaken to:

i) Compare spatial and temporal variation in vegetation composition between the PBS and the captive mountain bongo site in MKWC

ii) Determine seasonal variation in food selection by the captive male mountain bongos at MKWC and food availability at the PBS

iii) Establish anthropogenic threats mountain bongos might encounter once reintroduced within the PBS

CHAPTER TWO

Study area

This study was carried out in Mount Kenya forest reserve around Mawingu area where the proposed bongo sanctuary is located and Mount Kenya Wildlife Conservancy both within Latitude $0^{0}03$'N and Longitude $37^{0}09$'E. They lie at an altitude between 2309m and 2387m above sea level respectively. Mount Kenya forest reserve is managed by Kenya Forest service with most of the land within the reserve under commercial forest plantations. Mount Kenya Wildlife Conservancy on the other hand is a private land, run as a non-profit organization.

Three communities surrounding the two sites i.e. Kwamwea, Kangaita and Kanyoni respectively were sampled for anthropogenic activities. Most of the people in Kwamwea are subsistence farmers owning small parcels of land where they practice small scale subsistence farming. Kanyoni residents are basically squatters while in Kangaita, some people are small scale farmers and others being squatters. The three communities had received extensive conservation education through an outreach program ran by the William Holden Wildlife Education Center, which is a directorate of MKWC

The study site in MKWC was a bongo sanctuary located along River Nanyuki and had been set aside for pre-release conditioning of male mountain bongos earmarked for release. The PBS on the other hand is a small section of MKF reserve around Mawingu area located along Liki River (Figure 1).

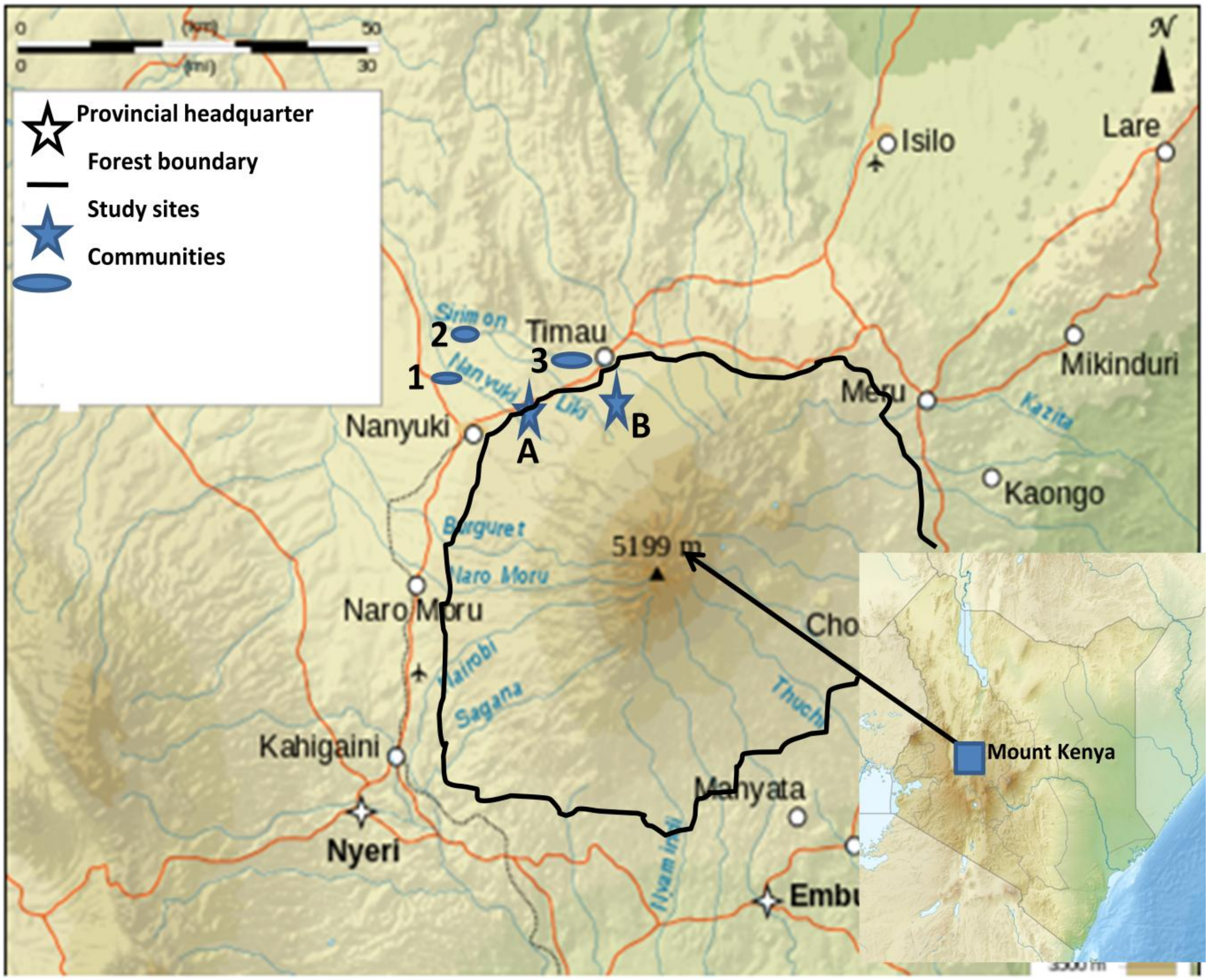

Figure 1: Map of Mount Kenya showing the locations of Nanyuki and Liki Rivers where Mount Kenya Wildlife Conservancy (A) and Proposed Bongo Sanctuary (B) are situated. Numbers 1, 2 and 3 indicating Kanyoni, Kwamwea and Kangaita respectively

2.1 Climate

The climate of Mount Kenya changes considerably over the changing mountain altitude, forming belts of community types. It has a typical equatorial mountain climate which Hedberg (1969) described as 'very cold nights and very hot during the day'. There are two distinct wet seasons around the mountain and two distinct dry seasons with long rains falling from March to June and short rains from October to December. The amount of rainfall ranges from 2,300mm on the south eastern slopes to 900mm in the north (KWS, 1996). The mean annual rainfall from 2002 to 2010 for the region where the study was undertaken was 755mm per annum (Table 1). The temperatures span a wide range, which varies with the changing altitude and season. Diurnal wind circulation is vigorous: down slope winds blow from evening through the night to mid morning, drawing in persistent cloud (Allan, 1991).

Table 1: Average monthly rainfall amount received at Mount Kenya Wildlife Conservancy from 2002 to 2010. Rainfall data from the William Holden Wildlife Education Center weather station.

Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Mean**
Amount (mm)	380	282	677	1681	1123	302	576	800	566	829	930	920	755

2.2 Vegetation

The vegetation of Mount Kenya is diverse, due to the variation in altitude, rainfall, aspect and temperature. The mountain slopes can be divided into vegetation zones, with each zone having different dominant plant species (Young, 1991). The forest is part of the largest continuous block of indigenous closed canopy forest in Kenya with a total of 882 plant species, subspecies and variants found within the forest (Gathara, 1999).

Within the forest reserve and the conservancy where the study was undertaken, around 40% is closed canopy riverine forest with numerous open grades mainly composed of shrubs, herbs and grass. It is a luxuriant montane forest of red cedar (*Juniperus procera)* growing to over 30 m, podo (*Podocarpus falcatus)* which can grow up to 45m and the olive trees (*Olea africana).* The area is predominated by the *Juniperus procera – Olea africana* forest type on this drier west to northeast slopes up to about 2,300m. The dominant shrubs include *Toddalia asiatica, Rhus natalensis* and *Trichocladus ellipticus.* Herbs composition varies with season although the genus *Hypoestes* is dominant throughout the year. The indigenous-invasive and unpalatable *Brachypodium flexum* is the dominant grass species in the area

2.3 Fauna

Mammals of conservation interest in Mount Kenya ecosystem found within the study areas include the four rare or threatened species; African elephant (*Loxodonta africana*), Leopard

(*Panthera pardus*), Giant forest hog (*Hylochoerus meinertzhageni*) and Black fronted duiker (*Cephalophus nigrifronshooki*). There are eight species of ungulates in the area which include the Cape buffalo (*Syncerus caffer*), duiker (*Neotragus moschatus*), bushbuck (*Tragelaphus scriptus*), deffassa Water Buck (*Kobus ellipsiprymnus*), bush pig (*Potamochoerus larvatus*), the common zebra (*Equus burchelli*), Suni (*Neotragus moschatus*) and the common duiker (*Sylvicapra grimmia altivallis*). Several primates are found in the region, the most common being Mount Kenya guereza (*Colobus guereza kikuyuensis*), Kolb's monkey (*Cercopithecus mitis kolbi*), olive baboon (*Papio anubis*) and the bush baby (*Galago* sp). Large carnivores other than the leopard found within the area include the spotted hyena (*Crocuta crocuta*). Small carnivals include the serval cat (*Felis serval*) and black backed jackal (*Canis mesomelas*) and the genet (*Genetta tigrina*). Mount Kenya forest is an important bird area and home to the threatened and little known Abbott's starling and eight bird species are endemic to Mt. Kenya ecosystem. Some of the bird species found within the study area include, crowned hawk eagle (*Stephanoaetus coronatus*), hartlaub's turaco (*Turaco hartlaubi*), scaly francolin (*Francolinus squamatus*), silvery cheeked-hornbill (*Ceratogymna brevis*), the harmercop (*Scopus umbretta*), olive pigeon (*Colomba arquatrix*), crowned hornbill (*Tockus alboterminatus*) and the giant kingfisher (*Megaceryle maxima*).

2.4 Human Activity

Most of the people in Kwamwea practice small scale subsistence farming while others keep livestock (mainly sheep and goats) for commercial purposes. In Kanyoni and Kangaita however, land is a limiting factor with most people venturing into illegal charcoal burning, hunting and illegal timber sale. The three communities use the forest margins and forest reserve quite heavily for livestock grazing, temporarily cultivated tree plantations (shambas) and farm settlements. Most of the fairly educated youth in the area however work as guides and porters during mountain climbing safaris with perception that tourism can benefit more local people if developed and well promoted in the Park. There is however much unrest over conflicts between farmers and marauding wild animals (KWS, 1996) and especially elephants and baboons.

2.5 Conservation value

Mount Kenya Forest is one of the largest, most ecologically significant and commercially important natural forest areas in Kenya and is considered to be among the highest priority forests for national conservation (Wass, 1995). It provides a stream of goods and services, which generate economic benefits and support economic activities that accrue to the global community, the Kenyan economy and the livelihoods of the people who live around the forest. It is the second highest mountain in Africa after Kilimanjaro and is a vital water catchment on which many people depend. According to Emerton (1997) the total quantified gross benefits of conserving MKF are worth US$ 77 million a year which are composed of local forest utilization; local cultivation of forest land under *shamba* system arrangements and other licensed utilization of timber and non-timber forest products, tourism and recreational values and watershed catchment protection benefits. These economic benefits support a range of employment, income and subsistence opportunities at local, national and international levels. The forest is regarded as a holy mountain by local communities like the Kikuyu, Embu and Meru.

2.6 Management constraints

Human interference in the park is minimal although there is marked over exploitation of natural resources in the gazetted forest reserve where the study was undertaken. According to Gathaara (1999) the forest is heavily impacted by extensive illegal activities leading to serious destruction through logging of indigenous trees. Most of the clear-felled plantations are still open glades having not been replanted with tree seedlings, although these areas were at one time under the 'shamba system'. Encroachment into the fringes of indigenous forests emanating from shamba-system cultivated areas is common in the area. Charcoal production especially at Kanyoni is extensive with charcoal fuel coming from the forest leading to significant destruction of the forest. Illegal logging of indigenous timber trees such as cedar, and podo is common and most people graze their livestock in the forest. Fire is also a major threat to the forest resources and is mainly caused by humans either knowingly or due to recklessness or even natural (lightning) fires during dry seasons.

CHAPTER THREE

Methods

3.1 Spatial and Seasonal variation in vegetation composition and structure

Prior to sampling, I conducted a preliminary survey in September 2010 to understand the topography and vegetation structure of the PBS and the bongo sanctuary at MKWC. Within the conservancy, I systematically established vegetation belt transects running from Nanyuki Riverbank directly outwards to the edge of the bongo sanctuary (i.e. perpendicular to the river channel). The Belt lengths ranged between 350-400m and I settled for a standard length of 300m for all the belts to factor in the edge effect. I used the same belt length at the PBS with belts running perpendicular to Likii Central River. One animal keeper from MKWC was trained in data collection while a botanist from National Museums of Kenya helped in species identification.

3.1.1 Belt transect

Each belt transect was 20m wide, and was placed 20m away from the river and 20m from the fence line. The orientation of the transect allowed for a detection of changes in diversity with the increasing depth of the water table as one moves away from the river channel (Hughes 1990). In each of the two sites 11 belt transects were set up systematically at an interval of 300m. These transects were numbered and four belts were randomly selected for sampling in both sites. Due to high densities of plant species in the two forest sites, further sampling was done in each of the belt transects by subdividing them into subsamples of quadrats measuring 50m by 20m. These quadrats were systematically placed along each transect at intervals of 60m to have three quadrats per belt. These quadrats were grouped in three strata i.e. valley bottom, slope and top valley quadrats. A 50m tape measure was used to demarcate the quadrats with all their locations being georeferenced using a GPS (GPSmap 60CS model). The four corners of the quadrat were marked using marking tags.

3.1.2 Vegetation Data Collection

I collected data for trees with height 10 m and above and diameter at breast height (DBH) of ≥10cm (Sheil *et al.,* 2000) within the 20m by 50m quadrat. A diameter tape was used to measure

DBH taken at 1.3m trunk height from the ground. The species were identified by their botanical names standardized (names) by following the taxonomic scheme of Beentje (1994). Crown diameter was taken considering the long and short crown diameters. Tree height and Percentage canopy cover was estimated by three people and the average was recorded.

I sketched the 20m by 50m quadrat and subdivided into 5m by 5m plots and using table of random numbers, I selected four plots. These plots were laid on the 20m by 50m quadrat and here shrubs were identified by their botanical names and number of stems counted. Their percentage cover within the plot was estimated by three people and their average recorded. In this case, shrubs were taken to be the woody multi stemmed plants more the 1m above the ground and less than 10cm DBH (Nkurungi *et al*., 2004). The locations of these plots were marked using marking tags.

Finally, I selected six 1 m x 1 m subplots randomly thrown within the larger 20m by 50m quadrat. Within each subplot, all the herbs were identified by their botanical names and their numbers recorded. Locations of these subplots were marked using marking tags.

All plant samples were carried to the conservancy offices for identification and where difficulties arose they were pressed and sent to the National Museums of Kenya for identification using herbarium collection.

3.2 Seasonal food selection and preference

A group of 20 captive male mountain bongos which had been earmarked for release to MKF were followed for seven months from October 2010 to April 2011 at MKWC. During the study, the months of October, November and December were raining while the rest of the months were dry. The group was enclosed in a fenced sanctuary located along Nanyuki river riverine forest. Focal animal observation technique was employed (Altman, 1974) with only one individual being followed per sample period.

3.2.1 Focal animal observation

I collected feeding data between October 2010 and April 2011 for five days continuously every month. Each data collection session commenced at 7.00am till 9.30am and again 3.00pm to

6.00pm. This was due change of group's behavior during commercial feed supplementation at 10:30 am and there after resting for the rest of the mid-morning to late afternoon. During the study, vocal animal observation was used with each sample period lasting ten minutes followed by ten minutes of food plant identification and/or collection. Focal individuals were selected on a rotating basis using their identification names. To randomize the individuals, I developed name tags for all the individuals in the group. A tag was randomly picked from a bag and if a tag was picked twice during the study session, it was returned and another one picked so as to ensure all the individuals in the group were sampled.

3.2.2 Feeding data collection

Feeding data was collected continuously for 10 minutes in each focal sample and I recorded 1) the length of time to the nearest second a given plant species was fed on and 2) food species being fed on. Feeding time on a given plant species ended when an individual 1) stopped eating for >10 seconds on a given species, and 2) changed from one feeding site (= individual plant) to another (Irwin, 2008). Feeding was considered to be the time taken by an animal acquiring and ingesting food. The number of times (frequency) an individual visited a food item was recorded.

Plant species fed on by the bongos were identified and standardized using the taxonomic scheme of Beentje (1994). Those plant samples which could not be identified in the field were collected and pressed before transporting to the National Museums of Kenya – herbarium section for identification.

3.3 Potential anthropogenic threats to the released mountain bongo population

Questionnaires were used to achieve this objective with each questionnaire designed to gather information on community awareness towards conservation, benefits derived from MKF, threats to natural resources and bush meat consumption and trade. The questions were designed to be simple and straight forward to avoid respondent biases. Most questions were open ended, but a few were multiple choice.

I selected three communities that represented the different land use types and ownership situations (Gadd, 2005) in the area adjacent MKWC and the PBS. The three communities included Kanyoni where most people are squatters, Kwamwea being mainly small scale farmers and Kangaita with both squatters and small scale farmers.

3.3.1 Interview method

Between May and July 2011, 120 people were interviewed within the three communities living adjacent to MKWC and the PBS. The target population was persons over the age of 10 years who permanently resided at the location. The age 10 was selected because it is the acceptable age group for those students and/or groups visiting William Holden Wildlife Education Center. At each site, an effort was made to obtain relatively equal proportions of gender, education level and age group. Some potential respondents were dismissed if they were from a demographic subset that was already represented. The targeted respondents were grouped according to age with categories of 10-20 years, >20-45 years, >45-60 years and over 60 years.

3.3.2 Questionnaire administration

A total of 40 questionnaires were administered in each of the three communities with each gender getting 20 questionnaires per community. Only one person in every third house along the designated roads and/or paths was permitted to participate in the interview. The purpose of the interview was explained and if the person was willing to participate, the interview proceeded. In cases where there was nobody in the homestead or the person is below 10 years, I moved to the next homestead. Each interview lasted 20-30 minutes and I conducted them and assisted by a locally hired person who had good knowledge of the area. Interviews were conducted in Swahili and Kikuyu depending upon the respondent's preference. Each interview took the form of a conversation, structured around a written questionnaire consisting of general and specific questions.

3.4 Data Analysis

I calculated the relative importance of tree species using the Importance Value Index (IVI) of Curtis & McIntosh (1951). The index is the sum of the relative abundance, relative frequency and relative dominance. I used the stem basal area to estimate the relative dominance (Mueller-Dumbois & Ellenberg, 1974). The relative values were calculated using:

Relative density = Number of individuals/Number of individuals of all species

Relative dominance = Total basal area/Total basal area of all species

Relative frequency = Number of quadrats occurring/Total number of quadrats

Following Kent & Coker (1992) I calculated Shannon-Wiener diversity indices for trees, shrubs and herbs using the formula illustrated below.

$$H' = \sum_{i=1}^{S} - (P_i \times \log_{10} P_i)$$

Where:

H' = Shannon-Wiener diversity index

P_i = the proportional abundance of the i-th species in N individuals

S = total number of all plant species recorded

To compare the vegetation structure, tree heights, canopy cover and basal areas between the two sites, I used Student's t-test. Using the distance from the river channel (slope) as the random factor, I used One Way Analysis of Variance (ANOVA) to assess the spatial changes in plants diversity. On the other hand, Student's t-test was used to test for temporal mean difference in plant diversity between the two sites and the difference between the wet and dry seasons within the site.

A checklist of food plants consumed was produced and preference index or P-index (Zhaoyuan and Rogers 2006) calculated to measure the level of preference for a food item using:

$$\text{P-index} = \frac{\text{Percentage time recorded feeding a food plant}}{\text{Availability index of the food plant}}$$

Where availability index is the ratio of number of quadrats a food plant species is recorded to the total number of quadrats sampled.

The degree of vegetation and food plant species similarity between the conservancy and the forest was assessed using Jaccard coefficient of community similarity (Mueller-Dombois and Ellenberg, 1974) as shown below:

$$CC_J = \frac{C}{S_1 + S_2 - C}$$

Where:

CC_J= Jaccard coefficient (As a percentage)

S_1 and S_2= number of species in communities 1 (MKWC) and 2 (PBS) respectively

C= number of species common to both communities

The overall time spent feeding on the different food items during the entire study period was illustrated using a pie chart. Monthly dietary profiles were constructed using multiple line graphs where percentage feeding time devoted to different food item (i.e. grass, trees, shrubs, herbs and other foods such as mosses and fallen litter) was used. To investigate the differences in time spent feeding the various food items, I analyzed monthly total time spent feeding on the top twenty preferred food items using one way ANOVA, with months as the random factor. Student's t-test was used to test for difference in amount of time spent feeding various food types during wet and dry periods. I used Statistica 6.0 and PAST softwares in the analysis.

To analyze the data on anthropogenic threats, the responses were entered verbatim into Microsoft Excel spreadsheets. Repeated-similar answers were categorized and tallied. To identify correlations in the responses, I used Pearson chi-squared ($\chi 2$) in the analysis using SPSS 16.0 software.

CHAPTER FOUR

Results

4.1 Spatial and Seasonal variation in vegetation composition and structure

Overall, a total of 218 plant species were identified in both sites with a total of 175 species recorded at the PBS and 106 species at MKWC. Sixty three (28.9%) plant species were common to both sites.

4.1.1 Vegetation Structure

The forest structure in MKWC and PBS did not have much variation with tree heights and canopy cover having no significant difference (Table 1) between the two sites. The mean tree basal area between the two sites however had a significant different ($t=2.65$, $df= 107$, $p<0.05$). The conservancy had lower mean basal area per acre, mean tree height and percentage canopy cover than the PBS. The mean stem density was however high at the conservancy (9.26 ±2.86 stems/acre) than at the PBS (6.99 ±1.85 stems/acre).

The canopy layer (height>10 m) within the conservancy was dominated by *Juniperus procera* (IVI=0.25) while the PBS was dominated by *Podocarpus falcatus* (IVI=0.29).

Table 2: Structural data collected from quadrat surveys (12 quadrats per site). The differences in mean tree heights, basal area and cover between MKWC and PBS were analyzed using t-test. Percentage canopy cover data was arcsine-transformed.

Parameter	MKWC	PBS	t value	d.f.	*p*
Mean tree height (m)	15.0±6.5	15.8±5.9	0.87	106	>0.05
Mean canopy cover (%)	56.2±14.6	54.8±12.1	1.75	106	>0.05
Mean Basal area (m^2/acre)	0.15±0.02	0.23±0.03	2.65	107	<0.05
Stem density per acre	9.26 ±2.86	6.99 ±1.85	1.28	12	>0.05

4.1.2 Shrub and herb composition

Within the MKWC, the sub-canopy layer (1-10 m height) was dominated by *Rhus natalensis* with a density of 92.5 plants/ acre whereas *Ocimum lamiifolium* (55.8 plants/acre) was dominant at the PBS. Within the conservancy, two grass species, *Stipa keniensis* and *Brachypodium flexum,* were the dominant and *Hypoestes aristata* was the dominant herb. At the PBS *Hypoestes aristata* (Herb) and *Stipa keniensis* (grass) were the dominant.

The mean Shannon-Wiener diversity index for shrubs was slightly high at the conservancy and did not vary during the wet and dry seasons in both sites (Figure 2). Mean herb diversity was high at the PBS in both wet and dry seasons.

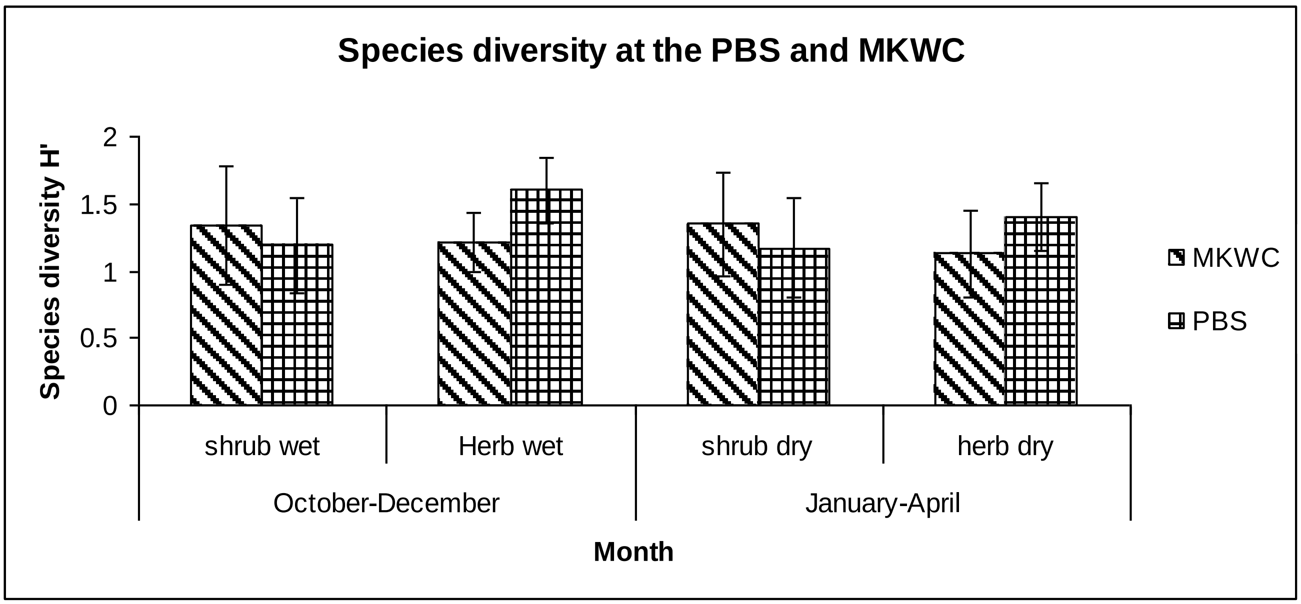

Figure 2: Figure indicating variation in shrub and herb diversity during wet and dry season at the proposed Bongo sanctuary and Mount Kenya Wildlife Conservancy. The error bars indicating standard deviation from the mean.

4.1.3 Spatial and Temporal variation

Comparing the two sites, the mean herb diversity between the conservancy (*H'* =1.19±0.35) and the PBS (*H'* =1.60±0.25) had a significant difference (t=7.94, df=71, $p<0.05$) during the wet season. There was however no significant difference (t=1.72, df=71 $p>0.05$) in mean herb diversity between MKWC (*H'* 1.24±0.47) and the PBS (*H'* =1.40±0.25) during the dry seasons.

The relationship between the change in slope as one moves away from the river channel and species diversity among the three valley strata was analyzed using One way Analysis Of Variance (Table 2). There was no significant difference ($F_{2,\ 9}$=0.07, p>0.05) in tree diversity among the three valley stratas at the PBS. Tree diversity also had no significant difference ($F_{2,9}$=0.93, p>0.05) among the three valley stratas at MKWC. There was a significant difference (p<0.05) in herb diversity among the three slope strata at the PBS during the dry season. Turkey Post Hoc analysis indicated a significant difference (p<0.05) in herb diversity at the valley bottom strata.

Table 3: One Way Analysis of Variance indicating the relationship between the change in slope and shrub and herb diversity at Mount Kenya Wildlife Conservancy and the proposed bongo sanctuary

Season	Site	Plant form	Factor	F	d.f.	*p*
Dry	MKWC	Shrub	Slope	1.99	2,45	p>0.05
		Herb	Slope	1.66	2,69	p>0.05
	PBS	Shrub	Slope	2.23	2,45	p>0.05
		Herb	Slope	4.03	2,69	P<0.05*
Wet	MKWC	Shrub	Slope	1.45	2,45	p>0.05
		Herb	Slope	0.86	2,69	p>0.05
	PBS	Shrub	Slope	2.23	2,45	p>0.05
		Herb	Slope	8.35	2,69	p>0.05

* The mean difference is significant at the 0.05 level analyzed using Turkey Post Hoc test.

d.f. indicate the three slope strata as the random factor and the number of quadrats sampled degrees of freedom respectively

4.2 Seasonal food preference and availability

4.2.1 Seasonal food choice

During the study period, male bongos ate 64 different plant species (60% of all species recorded at MKWC) of 32 families. The families with the greatest number of species in mountain bongo diet were Compositae, Gramineae, Leguminosae, and Acanthaceae; but the family Hamamelidaceae was most consumed during the dry season and Verbenaceae during wet season. There was no major difference in the number of plant species fed on during wet (56 plant species) and dry (58 plant species) periods. Using the time male bongos spent feeding on various food items; green plants (trees, shrub, herbs and grass) comprised 97.6 % of their diet while mosses and leaf litter comprised 2.4% of the diet (figure 3).

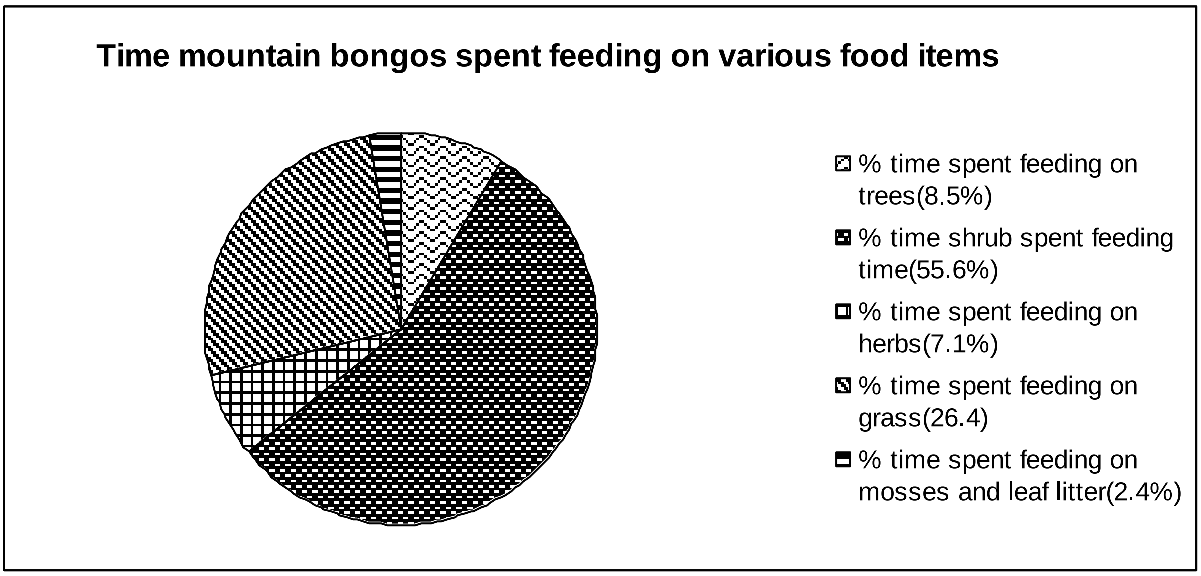

Figure 3: Pie chart showing the percentage time mountain bongos spent feeding the various food items during the seven months of the study.

Even though mountain bongos spent more time feeding on shrubs, figure 4 shows that the time spent feeding on shrubs, mosses and leaf litter increased during the dry season. However, the time spent feeding on grass, herbs and trees reduced during the dry season.

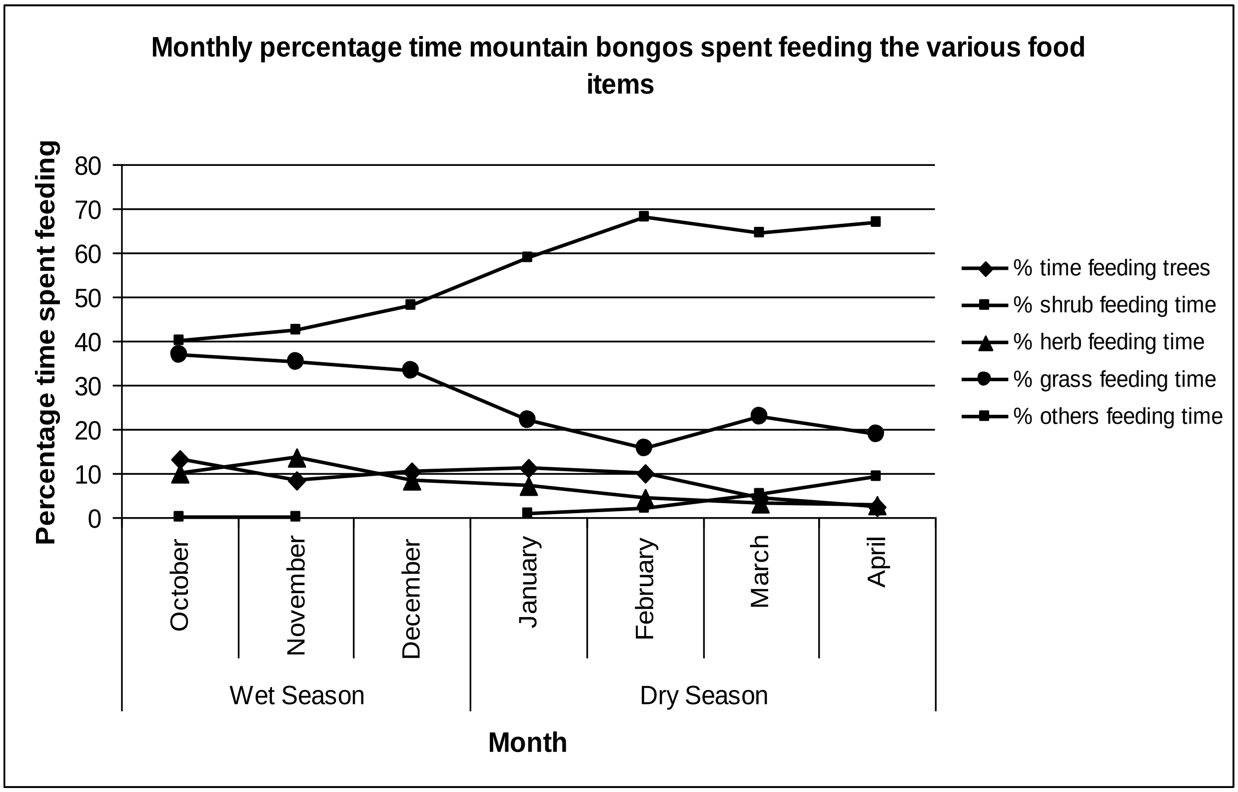

Figure 4: Multiple line graph indicating monthly variation in amount of time male mountain bongos spent feeding on trees, shrub, herbs, grass and leaf litter and mosses (others) during wet and dry seasons.

The male mountain bongo diet comprised of nine grass species, 19 herb species, 27 shrub species and nine tree species during the study period. Within these plant forms, bongos spent a large proportion of time feeding on specific species during the study period; *Stipa keniensis*-grass (13.7 %), *Olea africana*-tree (8.0%), *Toddalia asiatica*-shrub (7.9%) and *Glycine wightii*-herb (1.5%). Using the top twenty plant species male bongos spent more time feeding on, I performed One Way ANOVA to test for relationship in monthly total time spent feeding on these species among the seven months study period. The test had no significant difference ($F_{6,133}=0.14$, $p>0.05$) in time spent feeding specific species per month.

4.2.2 Food preference

The amount of time male mountain bongos allocated to feeding the same plant species during wet and dry periods had no significant difference ($t=0.77$, $df=63$, $p>0.05$). They however exhibited higher preference for particular plant species with food preference indices for the various food plants indicating that *Lantana trifolia* (shrub), *Microglossa parvifolia* (shrub), *Panicum monticola* (grass) and *Glycine wightii* (herb) were more preferred during wet season (Table 3). On the other hand, *Trichocladus ellipticus* (shrub), *Pennisetum clandestinum* (grass), *Carex chlorosaccus* (grass) and *Microglossa parvifolia* (shrub) were more preferred during dry season (Table 4). Hence *Microglossa parvifolia* was more preferred during wet and dry seasons due to its capability of fast sprouting after heavy browsing during the dry season.

Table 4: Male mountain bongos wet season top ten preferred food plants.

Food species	Wet season Availability index	Wet season Preference index
Lantana trifolia L.	0.02	0.96
Microglossa payrifolia (Lam.) O. Kuntze	0.02	0.88
Panicum monticola Hook.f.	0.04	0.78
Glycine wightii (Wight & Arn.) Verdc.	0.06	0.48
Rhus vulgaris Meikle	0.10	0.38
Stipa keniensis (Pilg.) Freitag	0.71	0.27
Senecio hadiensis Forssk	0.13	0.26
Grewia similis K.Schum	0.17	0.24
Clematis brachiata Thunb.	0.04	0.19
Cynodon dactylon (L.) Pers.	0.06	0.19

Table 5: Male mountain bongos dry season top ten preferred food Plants

Food species	Dry season Availability index	Dry season Preference index
Trichocladus ellipticus Eckl. & Zeyh.	0.21	0.57
Pennisetum clandestinum Hochst. ex Chiov.	0.02	0.46
Carex chlorosaccus C.B.Clarke	0.02	0.38
Microglossa payrifolia (Lam.) O. Kuntze	0.02	0.38
Rhamnus prinoides L'Herit	0.23	0.36
Toddalia asiatica (L.) Lam.	0.48	0.26
Clematis brachiata Thunb.	0.01	0.24
Mystroxylon aethiopicum (Thumb.) Loes.	0.19	0.20
Maytenus heterophylla (Eckl. & Zeyh) Robson	0.19	0.19
Dovyalis abyssinica (A.Rich.) Warb.	0.17	0.16

Using Chi-square test, I checked whether the abundance of the top 10 preferred food plants corresponded with the proportion of time mountain bongos spent feeding on them. The expected values for the time spent feeding were calculated as the total number of plant species multiplied by the proportion (%) of time spent feeding (Table 5). There was a significant difference (Table 5) in the expected and observed feeding time in relation to species abundance during the wet and dry seasons.

Table 6: Chi-square test for mountain bongo's top ten preferred plant species. Chi-square values were calculated for the observed and expected values of time spent feeding (%) in relation to species abundance

Species	Abundance	% Time Spent feeding (observed)	Expected	X = |O-E|^2/E
Wet season				
Lantana trifolia L.	1	0.0002	0.0308	0.030401
Microglossa payrifolia (Lam.) O. Kuntze	3	0.00018	0.02772	0.027361
Panicum monticola Hook.f.	37	0.00033	0.05082	0.050162
Glycine wightii (Wight & Arn.) Verdc.	2	0.00027	0.04158	0.041042
Rhus vulgaris Meikle	6	0.00039	0.06006	0.059283
Stipa keniensis (Pilg.) Freitag	82	0.00192	0.29568	0.291852
Senecio hadiensis Forssk	1	0.00033	0.05082	0.050162
Grewia similis K.Schum	12	0.00039	0.06006	0.059283
Clematis brachiata Thunb.	10	0.00008	0.01232	0.012161
	154			χ^2=0.621707
Dry season				
Trichocladus ellipticus Eckl. & Zeyh.	73	0.00208	0.8632	0.859045
Pennisetum clandestinum Hochst. ex Chiov.	3	0.00021	0.08715	0.086731
Carex chlorosaccus C. B. Clarke	147	0.00021	0.08715	0.086731
Microglossa payrifolia (Lam.) O. Kuntze	1	0.00021	0.08715	0.086731
Rhamnus prinoides L'Herit	54	0.00229	0.95035	0.945776
Toddalia asiatica (L.) Lam.	69	0.00479	1.98785	1.978282
Clematis brachiata Thunb.	2	0.00014	0.0581	0.05782
Mystroxylon aethiopicum (Thumb.) Loes.	29	0.00188	0.7802	0.776445
Maytenus heterophylla (Eckl. & Zeyh) Robson	18	0.00188	0.7802	0.776445
Dovyalis abyssinica (A. Rich.) Warb.	19	0.0167	6.9305	6.89714
	415			χ^2=12.55114

N:B. X= (Observed-expected)^2/Expected

Chi square results for the wet season: χ^2=0.62, df=9, p<0.05

Chi square results for the dry season: χ^2=12.55, df=9, P<0.05

4.2.3 Vegetation similarity and Food Availability

Out of the 218 plant species recorded during the vegetation study, eighteen (8%) species were found at MKWC and not detected at the PBS. More species (54 i.e. 25%) out of the total number recorded were however identified at the PBS and were not identified at the conservancy. Vegetation composition between the two sites tested using Jaccard coefficient of community similarity indicated 28% similarity. Seasonal similarity in species composition between the two sites was 33% for dry season and 35% for wet season. Several plant species were among the most abundant at the PBS site, but rare at MKWC (Table 6). Most striking was *Podocarpus falcatus* which was the second most common tree species at the PBS but was represented by only five stems at MKWC. Plant species that were among the fifteen most abundant at PBS and whose abundance was >50% at the conservancy include *Juniperus procera*, *Ocimum lamiifolium*, *Toddalia asiatica*, and *Olea africana*. Some of these species were among the top ten preferred species by the mountain bongos at the conservancy during the wet and dry seasons.

Forty three (67%) plant species out of the 64 species fed on by male mountain bongos at the conservancy, were recorded at the PBS during wet season and 39 (61%) during dry season. Using Jaccard coefficient of community similarity for the top twenty preferred food plants between the conservancy and PBS, there was 72% similarity during the wet season and 80% during the dry season. The mean densities of top 20 preferred food plants within MKWC (17.8±4.9 plants/acre) and the PBS (9.8±3.2 plants/acre) during wet season had no significant difference ($t=1.44$, $df=18$, $p>0.05$) between the two sites. At the same time, the mean densities of top 20 preferred food plants within MKWC (38.3±10.8 plants/acre) and the PBS (27.5±5.1 plants/acre) during dry season had no significant difference ($t=2.09$, $df=19$, $p>0.05$) between the two sites.

There was a significant difference ($t=3.75$, $df=47$, $p<0.05$) in mean shrub cover between MKWC (65.4%±17.3) and the PBS (50.2%±19.5). The wet season herb cover between MKWC (72.1±16.8) and the PBS (88.5±6.0) had a significant difference ($t=6.19$, $df=71$, $p<0.05$). The dry season herb cover between MKWC (53.0%±12.1) and the PBS (73.8±10.3) had a significant difference ($t=6.22$, $df=71$, $p<0.05$).

Table 7: Top five most abundant (total number) trees, shrubs, and herbs (including grass) at the proposed bongo sanctuary identified at Mount Kenya Wildlife Conservancy

Plant form	Species	PBS abundance	MKWC Abundance
Trees	*Chionanthus battiscombei* (Hutch.) Stearn	17	5
	Euclea divinorum Hiern	17	15
	Juniperus procera Endl	54	51
	Olea africana (Mill.) P. Green.	44	37
	Podocarpus falcatus Mirb	49	5
Shrubs	*Scutia myrtina* (Burm. F.) Kurz	21	82
	Rubus pinnatus Willd	21	2
	Ocimum Lamiifolium Benth	67	95
	Toddalia asiatica (L.) Lam.	42	82
	Clutia abyssinica Jaub. & Spach	32	0
Herbs	*Achyranthes aspera* L.	32	1
	Carex chlorosaccus C. B. Clarke	107	16
	Hypoestes aristata (Vahl) Sol. ex Roem. & Schult.	187	62
	Hypoestes forskaolii (Vahl) R.Br	61	5
	Panicum monticola Hook.f.	37	28

4.3 Potential anthropogenic threats to a released mountain bongo population

4.3.1 Awareness

Respondent views on natural resources ownership within MKF had no significant difference (χ^2=0.41, df=2, p>0.05) among the three communities with 41% of those interviewed in Kanyoni believing that natural resources belong to the society and should be protected by the society (67%). In Kwamwea, 55% of the respondents believe that natural resources belong to the society and people should protect them (67%). While in Kangaita 47% of the respondents were for the opinion that natural resources within the area belong to the society and 60% of them believe it is their duty to protect them (Table 7).

A large number of respondents believe that they are the custodians (Table 7) of MKF resources with no significant difference (χ^2=0.94, df=2, p>0.05) in respondents belief regarding natural resources protection among the three communities.

Table 8: Natural resources ownership and protection views in Kanyoni, Kangaita and Kwamwea

		Who owns natural resources in Kenya (%)	Who should protect natural resources in Kenya (%)
Kanyoni	Society	41	67
	Government	56	33
	God	3	0
	Not sure	0	0
Kangaita	Society	48	60
	Government	40	40
	God	12	0
	Not sure	0	0
Kwamwea	Society	55	67
	Government	33	33
	God	9	0
	Not sure	3	0

Respondents awareness regarding ownership of natural resources in Kenya based on their level of education had no significant difference (χ^2=0.73, df=4, p>0.05) among the three communities. Also their view on who is responsible for protecting natural resources based on their level of education had no significant difference (χ^2=4.49, df=4, p>0.05) in all the three communities. A large proportion of women interviewed believe it is the work of the society to protect natural resources (70%) while 30% saying it is the government's duty. Sixty two percent of men interviewed believe that the society should protect natural resources in MKF while 38% believing it is the work of the government.

4.3.2 Community Benefits

In all the three areas sampled, a large number of respondents claimed to be benefiting from MKF with Kangaita 97%, Kwamwea 97% and Kanyoni 100% of the respondents benefiting from the forest. Farming was cited as the main benefit (72%) from the forest (through shamba system) with Kangaita and Kwamwea having more forest farmers (95% each) while Kanyoni had only 37% of the sampled population farming in MKF. Firewood, fodder and building materials extraction were other major products from the forest (Table 8). A higher proportion of the sampled population (14%) in Kanyoni gets their protein diet (meat) from forest animals. Overall, there was a significant difference (χ^2=24.96 df=3, p<0.05) on how each community benefits from various forest resources with no significant difference in the benefits these communities obtain from the forest between men and women (χ^2=3.069, df=5, p>0.05).

Table 9: Percentage of the respondents benefiting from the Mount Kenya Forest and the resource they benefit from in Kanyoni, Kwamwea and Kangaita

	Locality		
Benefit	Kangaita (% population)	Kwamwea (% population)	Kanyoni (% population)
firewood	16	5	9
water	8	0	0
Building material.	3	0	3
Fire wood, building material, fodder	3	57	64
Firewood, fodder	38	0	0
firewood, building material	32	38	23

A large number of those sampled (85%) felt that the release of mountain bongo will benefit the community in terms of attracting tourists in the region (67%), future generations will be able to see the bongo (9%) and meat (9%), with 15% of respondents not sure of the benefits mountain bongo release might bring. Respondents views on the benefits mountain bongo might bring once released had no significant difference (χ^2=0.46, df=2, `p>0.05) among the respondents of the three communities. Level of education did not influence (χ^2=4.39, df=4, p>0.05) the way people view the benefits mountain bongos might bring to the society once released to MKF.

4.3.3 Threats to Wildlife

Hunting is prevalent in the region with 55% of the respondents confirming this. While Kanyoni people practice more hunting (65%) than Kangaita (50%) and Kwamwea (51%), there was no significant difference (χ^2=3.09, df=2, p>0.05) in hunting prevalence among the three communities. Most of the people hunt for subsistence purposes (45%) although a number of them hunt for both subsistence and for sale (42%) to be able to meet other basic needs. Poverty within the three communities was cited to be the main reason (85%) as to why they hunt with commercial hunting contributing to 15%.

Logging, poaching, encroachment and forest fires were other factors believed to endanger natural resources in the area. Most of the people felt that multiple reasons could be threatening natural resources in MKF. Eighty three percent of the sampled population attributed logging to the main loss of natural resources, 68% attributed to poaching, 35% to forest encroachment, 34% to overgrazing, 31% to forest fires, 7% to drought and climate change and only 2% to shamba system. There was no significant difference (χ^2=2.31, df=2, p>0.05) in the way the three communities view these dangers as a threat to natural resources.

In all the respondents interviewed, 83% use firewood and charcoal as the main source of fuel in their homes. Eighty two percent of these get firewood and charcoal from the forest and only 18% of them getting it from their own farms. There was no significant difference (χ^2=1.8, df=3, p>0.05) in the sources of firewood and charcoal among the three communities.

CHAPTER FIVE

Discussion

5.1 Spatial and Seasonal variation in vegetation composition and structure

Comparison of the two sites in Mount Kenya, MKWC and the PBS, which are approximately six kilometers apart, revealed that there are several similarities and differences in their plant communities. Plant species richness was high at the PBS with a total of 175 different plant species being recorded compared to the bongo sanctuary where 106 plant species were identified. The canopy trees community at the current mountain bongo habitat within MKWC is dominated by *Juniperus procera* and *Olea africana* while the undergrowth is dominated by grass species, *Stipa keniensis* and *Brachypodium flexum*. The dominant herb within the conservancy was *Hypoestes aristata*. The proposed bongo sanctuary within MKF is also a riverine forest dominated by *Podocarpus falcatus* and *Olea africana* while *Hypoestes aristata* was the dominant herb and *Stipa keniensis* the dominant grass.

Most of the dominant plant species are shared between the two sites and *Olea africana* and *Stipa keniensis* which comprise a major proportion of mountain bongo diet are dominant within the PBS. The site is therefore more likely to enhance mountain bongo's survival once reintroduced. The similarity in major bongo food plants will also minimize the challenge of finding new food and changing of their food preference once reintroduced.

Much as there were apparent similarities in the species dominance, only 28.9% of the plant species were shared between these two small scale geographically separated habitats. By comparing vegetation composition between the two sites, I was able to demonstrate that there can be substantial vegetation variation even within small spatial separation. Much as the stem density didn't have significant difference between the two sites, it was relatively high at the conservancy which could be attributed to the heavy browsing and grazing of the sub canopy and herbaceous cover by the mountain bongo at the conservancy. The result being minimal competition for sunlight and other resources by tree seedlings hence an increase in an area's tree density (Rocabado *et al*., 2012).

Even with a high stem density, MKWC had a lower mean basal area per acre (an indicator of live standing biomass) than the PBS. The conservancy having been in existence since 1967, the forest could be at the secondary stage contributing to the observed low basal area. Other structural attributes (tree heights, canopy cover and stem density) did not have much difference between the sites, an indication of minimal forest destruction especially from logging within the PBS which is under Kenya Forest Service.

Shrub composition of the two study sites was quite different, with shrub diversity differing substantially between sites. The potential sources of these differences in composition between sites were highlighted by Nchanji and Plumptre (2003) to include small intersite variation in rainfall, soil composition, elevation, and temperature, differences in logging history, and historical differences in the distribution and abundance of large mammals. For example, primates and ungulates do influence the floristic composition of tropical forests via their roles as seed dispersers (Lambert & Garber, 1998).

The high herb and shrub diversity at the PBS during the wet and dry seasons is an indication of a good habitat for a browser and with mountain bongos being predominantly browsers, the high diversity will have positive implications to their survival success once reintroduced. The reintroduced group might experience minimal seasonal variation in shrub and herbs food plants. This is due to the fact that their density was not affected by seasonal variation in rainfall availability. Mountain bongos will therefore experience minimal seasonal food plasticity. The high diversity or herbs and shrub at the PBS will enable them expand their diet range thereby increasing their survival success.

Herb diversity at the PBS varies with increase in distance from the river channel up the slope, with the valley bottom having the highest diversity. This is due to the influence of high moisture contents in the soil during dry seasons. These riparian areas would potentially provide a good habitat to a released mountain bongo population. This subspecies has been known to inhabit valley bottoms and deep gullies (Kingdon, 1982). The area will continuously support the group(s) during the dry season’s fluctuating herbaceous cover.

5.2 Seasonal food preference and availability

Mountain bongos fed on more than half of all plant species recorded at the conservancy. The highest percentage of their food comprised shrubs and grass whose availability was not affected by rainfall and/or water availability. Also their large size and gregariousness could not allow them to be pure selective browsers in a forest habitat (Klaus-Hugi *et al*., 1999). The high shrub abundance during the wet and dry seasons at MKWC resulted to mountain bongos spending the largest proportion of time browsing on shrubs. The large proportion of grass in their diet will enable them survive in a wide range of forest micro-habitats (Klaus-Hugi *et al*., 1999).

Seasonality which affects food availability played a key role in their food choice with the less nutritious mosses and leaf litter being eaten during the dry season. At this time, a large proportion of their diet comprised of shrub spending more time feeding on *Trichocladus ellipticus*. The seasonal variation in food plants (especially herbs) abundance forced mountain bongos to adopt seasonal plasticity in their feeding behaviour qualifying them to be generalist herbivores (Freeland, 1991). This enabled them to cope with the changing food availability by changing their diet to include alternative less nutritious resources. This is an indication of a greater digestive efficiency which coupled with a lower metabolic demand per unit of body mass, enables them survive on foods of lower nutritional value than would small mammals (Belovsky, 1997).

Abundance of a food plant did not direct mountain bongo's food preference throughout the study period. The functional response to availability of food resources (Ricklefs, 1990) only drove them to spending more time feeding on the more abundant *Trichocladus ellipticus* during the dry season. The abundance of the species within the conservancy was advantageous to the mountain bongo by being able to consume this species instead of spending more time and energy searching for more preferred less abundant species (Stephens and Krebs, 1986). The less abundant herbs and grass were however more preferred during the wet season. During this time, food is probably not limiting and palatability may become the dominant selection criterion, which is one plausible explanation to the high preference for *Lantana trifolia.*

This kind of food preference is mainly on the grounds of nutritional qualities to obtain the best mix of nutrients within a fixed total intake (Krivan and Eisner, 2003). Plasticity in food choice enabled them to optimally forage within the confines of the conservancy by switching to the most abundant food when the availability of the preferred one decreases, assuming that food items, favourite and alternative, are homogeneously mixed in the environment (Krivan and Eisner, 2003; Stephens and Krebs, 1986). Such plasticity would enable mountain bongos survive seasonal food availability in their new habitat once reintroduced to the PBS. The survival possibility is supported by the fact that the sink habitat (PBS) is relatively similar to the source habitat (MKWC) with the preferred food plants being available the sink habitat (IUCN, 2012).

The two habitats were comparatively similar in terms of vegetation composition with relatively low herb diversity at MKWC. This could have been caused by the heavy browsing by male mountain bongos within the conservancy. Herb diversity was however high at the PBS during the wet and dry season. With herbs forming the bulk of mountain bongo food, the high diversity at the PBS would enable mountain bongos to easily adapt and survive within the area once reintroduced. The observed similarity will not negatively impact on the mountain bongo's socioecology like it has been reported in other areas where structure and composition differed significantly within the same forest (Fashing and Gathua, 2004). Particularly primates, have been reported to exhibit considerable diet plasticity in response to spatial variation in forest structure and composition (Chapman et al., 2002).

A large proportion of the plant species fed on by mountain bongos were found at the PBS with no marked seasonal differences in the densities of the top twenty preferred food plants. This high similarity in food plants coupled with high plant diversity and a large area of the PBS will enable mountain bongos expand their food choice and change their food preference once released. The new habitat will offer an opportunity for them to sample more food plants and also widen their preference range. The PBS would therefore be a good release site for the mountain bongo due to the high availability of their diet which when combined with other animal basic needs within a given habitat is key to the survival success of a reintroduced species.

Canopy cover which is one of the animal's basic needs did not vary between the two sites. This was due to the fact that the mean stem density and tree heights for the two sites were similar. Shrub cover which mainly provides sleeping and hide outs to many mammals had marked differences between the two sites. It was relatively low at the PBS which could be attributed to the high mean tree basal area with large crowns which curtail undergrowth recruitment. Also with the high herbaceous cover at the PBS, growth of the woody vegetation is minimal and hence the observed low shrub diversity. The high canopy cover will be vital in providing refuge from human disturbances and shelter from thermal extremes (Patton 1992) while the available sub-canopy cover (shrub cover) will be critical for providing hiding and concealment cover.

5.3 Potential anthropogenic threats to the released mountain bongo population

Most of the people living in Kanyoni, Kwamwea and Kangaita appreciated the fact that natural resources belong to them and it is their duty to protect them. Such a perception will enhance conservation of the region's natural resources by not depleting them to levels which might deny access by future generations. In Kanyoni and Kangaita, however, a considerable number of respondents believe that natural resources belong to the government and it is the responsibility of the government to protect them. With most of these area's respondents being squatters, this lack of a sense of responsibility to protecting the forest endangers the same critical ecosystem their livelihood is dependent on.

The level of education did not influence the respondent's opinion regarding ownership of natural resources and their protection in all the three communities. This was not expected owing to the fact that William Holden Wildlife Education Center (WHWEC) had put a lot of effort to sensitize the locals on the importance of bongo reintroduction with schools being their main target. Raising awareness on the importance of reintroduction as a viable conservation option previously enhanced the high-profile reintroductions of a few charismatic vertebrates in the 1970s and 1980s, including the Arabian oryx (*Oryx leucoryx*) in Oman (Stanley Price, 1989). Such awareness programs help garner local support for the reintroduction program boosting the survival success of the reintroduced population.

In an effort to enhance community support for conservation programs in the forest, KFS introduced the 'shamba' system in the area with a large proportion of the respondents from the three communities farming in the forest (Plate 2). In this system people own small parcels of land in the forest where they plant exotic-timber trees within their small farms and ultimately abandon the farm to allow for the rapid growth of trees. Much as the locals understand the impact of farming as a threat to MKF, most people pointed it as a major benefit they derive from the forest. This is a forest management practice which has been controversial though successful where managed well (Mathu, 2011). It however remains to be the biggest threat to tropical forests (Myers, 1987) and has increased the fragmentation of many forests resulting to extinctions of both flora and fauna (Bender *et al*., 1998).

Livestock grazing in the forest and collection of fodder was another benefit respondents cited to be deriving from the forest. This might have negative impacts to the forest structure and diversity (Madhusudan, 2005) by reducing undergrowth diversity causing an increase in tree density hence reducing browser's habitats. Controlled grazing may be essential to the maintenance of biodiversity (Brockington, 2002). This might not be true in the case of high livestock stocking rate and changing climatic conditions due to global warming resulting to overgrazing of limited and water scarce ecosystems. Livestock herds might also pose competition for food and space to the wild herbivores and also transmission of diseases between them might occur.

Plate 2:Aerial photo of the shamba system plantation within Mount Kenya Forest (Photo by Mount Kenya Trust)

Hunting and/or poaching was prevalent in the region with the highest number of respondents from Kanyoni confirming its existence. This is a major threat to wildlife within and outside the forest and in most of the tropical forests (Koppert *et al*., 1993). Most of the people blamed poverty to the persistence hunting in the region and a large proportion of them believed that hunting was for subsistence purposes. Bush meat is therefore a major source of protein in the region because domestic meat is unaffordable (Koppert *et al*., 1993) and is obtained for free. Hunting was actually the main cause for mountain bongo population decline in Kenya and is considered to be a primary reason for biodiversity loss in many tropical forest regions (Fa *et al*., 2003). With its high prevalence within the reintroduction site, it will be a major threat to a reintroduced population. Unless managed to sustainable levels, bush meat hunting coupled with the fast growing human population remains to be a major threat to mountain bongo reintroduction and the general conservation of wildlife in the region.

Most of the respondents cited logging to be another major threat to natural resources in the area. A large number of them attributed logging to access to firewood and charcoal which on the contrary is a benefit they derived from the forest. Logging which mainly involves extraction of construction poles/timber involves rapid, non-sustainable harvesting of particular species (Gentry and Vasquez, 1988) resulting in a progressive degradation of forest structure and biodiversity. It results in conversion of previously continuous forests to landscape mosaics of forest fragments, secondary vegetation, and ultimately agricultural areas (Harris and Silva-Lopez, 1992).

Conservation of MKF is thus one of the greatest challenges to KWS and KFS involving a delicate balance between complex-fragile ecosystem, and impoverished human population. Combined with the rapid population growth within the region, the demand for the primary resources (land, fuel, and protein) available in the forest will steadily increase as their availability per person decreases outside the forest. To minimize this threat, there is need to change the area's economic dynamics by sustainably reducing local dependence on forest resources. Nature based enterprises (including beekeeping, fish farming and local tourism) need to be promoted within the region by financially empowering the locals. Establishing community managed campsites and bandas within the area will market the region as tourist destination.

5.4 Conclusions

The PBS has a high abundance of plant species compared to MKWC and notable was the high herbs and shrub diversity at the PBS. These comprised of the largest proportion of mountain bongo food and their high diversity makes the site suitable for the reintroduction of captive bongo population. This is supported by the fact that their densities were not affected by seasonality and hence the reintroduced population will not experience marked seasonal plasticity in food choice.

Mountain bongos fed on a wide range of plant species and were able to cope with the seasonal variation in food availability by including alternative less nutritious resources in their diet. The observed seasonal plasticity in food choice will enable the reintroduced population to survive seasonal variation in food availability. The bulk of their diet comprised of shrub, grass and herbs and with their high diversity within the PBS, mountain bongos will be able to expand their food choice in the new habitat boosting their survival success. A large proportion of plant species eaten by mountain bongos were also available at the PBS. Canopy cover which is one of the basic habitat requirements did not vary between habitats and with the successful survival of mountain bongos at the conservancy, there is a high chance of the population surviving at the PBS.

Anthropogenic activities in the forest reserve still remain to be a major challenge to conservation. Most of the activities which the local people view as benefits derived from the forest i.e. farming, timber, grazing and firewood collection are actually detrimental to the habitat and are bound to affect the released population. These were the same human induced factors which lend to the initial decline of mountain bongos in Kenya. Hunting was another major cause of mountain bongo decline in their habitats and in some instances total local extinction, still remains to be a major threat to wildlife in the region.

The high hunting prevalence in the region was blamed on the existing high poverty levels in the region. Most of the people were however confident that the release of mountain bongos will attract more tourists in the region hence opening job opportunities for them. This will come a long way in curbing poverty levels in the region which is a major concern of the local people. The Laikipia county government in collaboration with KWS and KFS should also explore other nature based enterprises to enable curb overdependence on forest resources by the communities living adjacent MKF. This will be in support of the Bali's World park congress of 1982, which concluded that "protected areas in developing countries will survive only insofar as they address human concerns" (Western, 1989).

5.5 Recommendations

The diet results are only for male mountain bongos and might not reflect sexual differences in food choice. Also the influence of male-female association on food choice and preference could not be accounted for. I would therefore recommend more research on diet selection including both sexes in the study to ascertain whether both sexes exhibit the same degree of diet plasticity. Also during the study period, the group should not be provisioned to allow for a whole day follow-up.

The group(s) to be followed comprising both males and females should be considered for reintroduction. This is because male bongos are often solitary and releasing a male group might end-up segregating rendering post release monitoring impossible. Also for any given population to be sustainable and have growth potential, it should comprise of both sexes.

Human activities in the region which pose major threats to conservation efforts need to be checked and managed to sustainable levels. The existing forest and wildlife conservation laws need to be enforced and conservation strategies developed incorporating community's needs.

Conservation education and awareness campaigns should be intensified within the region targeting churches, schools, public meetings, youth and women groups and community forest association meetings.

Hunting is still prevalent in the region and more studies on off take levels need to be conducted to ascertain how much is hunted, consumed in the households and sold in the market.

Once released, post-release monitoring of the group(s) will be a vital part of the reintroduction process. This will be one of the most important aspects to help in planning of the future reintroductions. The monitoring team should provide enough information on the group(s) movements, feeding habits, and habitat choice during both the dry and wet seasons

CHAPTER SIX

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APPENDICES

Appendix 1: Questionnaire

Potential anthropogenic threats to a released mountain bongo population

PART ONE

Respondent particulars

1. Sex

   Male [ ] Female [ ]

2. Marital Status

   Married [ ] Single [ ] Divorced [ ] Widowed [ ]

3. Your age bracket

   10 – 20 [ ]

   20 – 45 [ ]

   45 – 60 [ ]

   Over 60 [ ]

4. Your occupation

   ………………………………………………………………………………………

5. Your Education level;

   Primary Level [ ]

   Secondary Level [ ]

   College/ Diploma [ ]

   University [ ]

   None [ ]

6. How many years have you lived here [ ]

PART TWO

Section 1: Awareness

1. Whom do you think owns the natural resources in Kenya?

2. In your own view, whose mandate is it to protect the natural resources in Kenya?

3. a) What wild animals have you seen to-date (list)?

   b) If you have seen the mountain bongo in 3a, where did you see them?
   MKF [ ] MKWC [ ] KWS park [ ] Media (TV/News paper) [ ]
   Others______

   c) i) If haven't seen mountain bongo in 3a, have you heard of them?
   Yes [ ] No [ ]

   ii) If yes where
   Media [ ] Public baraza [ ] Friend/colleague [ ] WHWEC [ ]
   Others

Section 2: Attitude and perception

1. i) Do you/your family benefit from the forest resources?
   Yes [ ] No [ ]

   ii) If yes how?
   Firewood ______ Water ______ Building material________ Honey______
   Fodder _______ Medicinal plants _________

iii) Food: Fruits ______ Wild vegetables ______ Meat_____ fish ________ Others ______

iv) Social/cultural/customary utilization ___________________

2. i) Has living close to Mount Kenya forest been of benefit or a challenge for you?
   Benefit [ ] Challenge [ ]

   ii) If a challenge, which are the challenges?

3. i) Do you think the release of mountain bongo will be of any benefit?
   Yes [ ] No [ ]

   ii) If yes how
   Tourism [ ] Security [ ] Meat [ ] others ____________

Section 3: Threats

1. In your own view, which are the dangers facing natural resources in this area?

2. i) What are the main fuel sources in your home?

   Fire wood [ ] Charcoal [ ] Electricity [ ] Biogas [ ] Kerosene [ ]
   Others_____________

   ii) If fire wood and charcoal, where do you source for them within this area?

3. i) If mountain bongos are to be released today in MKF, do you think they have a chance to survive?

   Yes [ ] No [ ]

   ii) If no in question three above, why do you think they might not survive?

Section 4: Bushmeat

1. What are your main sources of protein?

2. i) Do you think game hunting is prevalent in this area?

   Yes [ ] No [ ]

   ii) If Q2 is yes, why do you think people in this area go for bushmeat?

   Commercial[ ] Subsistence [ ] Others___

3. In your own view, what are the main reasons for hunting within this region

Appendix 2: Dry season food preference index

Food species	% Time Spent feeding Dry season	Dry season Availability index	Dry season Preference index
Trichocladus ellipticus Eckl. & Zeyh.	0.1190	0.208	0.5712
Pennisetum clandestinum Hochst. ex Chiov.	0.0095	0.021	0.4560
Carex chlorosaccus C.B.Clarke	0.0080	0.021	0.3848
Microglossa payrifolia (Lam.) O. Kuntze	0.0079	0.021	0.3795
Rhamnus prinoides L'Herit	0.0835	0.229	0.3645
Toddalia asiatica (L.) Lam.	0.1240	0.479	0.2587
Clematis brachiata Thunb.	0.0034	0.014	0.2421
Mystroxylon aethiopicum (Thumb.) Loes.	0.0368	0.188	0.1964
Maytenus heterophylla (Eckl. & Zeyh) Robson	0.0355	0.188	0.1893
Dovyalis abyssinica (A.Rich.) Warb.	0.0261	0.167	0.1566
Rhus vulgaris Meikle	0.0156	0.104	0.1495
Glycine wightii (Wight & Arn.) Verdc.	0.0062	0.042	0.1492
Stipa keniensis (Pilg.) Freitag	0.0923	0.639	0.1445
Brachypodium flexum Nees	0.0706	0.500	0.1412
Panicum monticola Hook.f.	0.0092	0.069	0.1327
Senecio deltoideus Less.	0.0018	0.014	0.1324
Rhus natalensis Krauss	0.0768	0.646	0.1189
Grewia similis K.Schum	0.0135	0.167	0.0811
Carissa edulis (Forssk.) Vahl	0.0078	0.104	0.0752
Olea africana Mill.	0.0574	0.833	0.0689
Rhamnus staddo A. Rich	0.0118	0.188	0.0628
Albizia gummifera (JF Gmel.) C. A. Sm	0.0046	0.083	0.0556
Rubia cordata Thunb.	0.0084	0.181	0.0465
Senecio nandensis S.Moore	0.0044	0.097	0.0453
Ocimum Lamiifolium Benth	0.0103	0.250	0.0414
Scutia myrtina (Burm. F.) Kurz	0.0186	0.583	0.0320
Olinia rochetiana A. Juss	0.0121	0.417	0.0290

Sporobolus agrostoides Chiov.	0.0028	0.111	0.0248
Euclea divinorum Hiern	0.0096	0.417	0.0231
Commelina benghalensis L.	0.0026	0.111	0.0230
Cynodon dactylon (L.) Pers.	0.0014	0.069	0.0208
Peperomia abyssinica Miq	0.0003	0.014	0.0200
Ficus exasperata Vahl	0.0016	0.083	0.0191
Indigofera swaziensis Bolus	0.0028	0.167	0.0170
Cyphostemma kilimandscharicum (Gilg) Desc. ex Wild & R.B.Drumm.	0.0010	0.069	0.0142
Achyranthes aspera L.	0.0018	0.139	0.0127
Leucas grandis Vatke	0.0019	0.167	0.0112
Prunus africana (Hook.f.) Kalkm.	0.0008	0.083	0.0095
Maerua triphylla Dur. & Schinz	0.0006	0.063	0.0090
Cynanchum alatum Wight & Arn.	0.0005	0.056	0.0090
Solanum aculeastrum Dunal	0.0063	0.750	0.0084
Pennisetum schimperi A.Rich.	0.0004	0.056	0.0074
Thunbergia alata Bojer ex Sims	0.0010	0.167	0.0062
Hypoestes forskaolii (Vahl) R.Br	0.0016	0.472	0.0034
Asparagus falcatus L.	0.0007	0.313	0.0021
Santalum sp	0.0002	0.833	0.0003
Dodonaea angustifolia L.f.	0.0139	0.000	0.0000
Lantana trifolia L.	0.0083	0.000	0.0000
Leucas sp	0.0046	0.000	0.0000
Zehneria scabra Sond.	0.0076	0.000	0.0000
Periploca linearifolia Quart.-Dill. & A.Rich.	0.0027	0.000	0.0000
Dombeya sp	0.0004	0.000	0.0000
Smilax anceps Willd.	0.0011	0.000	0.0000
Hibiscus sp	0.0000	0.021	0.0000
Hibiscus maculatus Lam.	0.0020	0.000	0.0000
Justicia diclipteroides Lindau	0.0000	0.000	0.0000
Helichysum sp	0.0005	0.000	0.0000

Croton microstachys Baill.	0.0000	0.000	0.0000
Juniperus procera Endl	0.0004	0.000	0.0000
Hypoestes aristata (Vahl) Sol. ex Roem. & Schult.	0.0003	0.000	0.0000
Hyparrhenia sp.	0.0000	0.014	0.0000

Appendix 3: Wet season food preference

Food species	**% Time Spent feeding wet season**	**Wet season Availability index**	**Wet season Preference index**
Lantana trifolia L.	0.0200	0.021	0.962
Microglossa pyrifolia (Lam.) O. Kuntze	0.0183	0.021	0.879
Panicum monticola Hook.f.	0.0326	0.042	0.783
Glycine wightii (Wight & Arn.) Verdc.	0.0269	0.056	0.484
Rhus vulgaris Meikle	0.0392	0.104	0.376
Stipa keniensis (Pilg.) Freitag	0.1915	0.708	0.270
Senecio hadiensis Forssk.	0.0330	0.125	0.264
Grewia similis K.Schum	0.0392	0.167	0.235
Clematis brachiata Thunb.	0.0079	0.042	0.190
Cynodon dactylon (L.) Pers.	0.0105	0.056	0.189
Solanum aculeastrum Dunal	0.0035	0.021	0.168
Rhamnus prinoides L'Herit	0.0409	0.250	0.164
Ocimum Lamiifolium Benth	0.0538	0.333	0.161
Trichocladus ellipticus Eckl. & Zeyh.	0.0292	0.188	0.156
Olea africana Mill.	0.1077	0.833	0.129
Maytenus heterophylla (Eckl. & Zeyh) Robson	0.0226	0.188	0.120
Dovyalis abyssinica (A.Rich.) Warb.	0.0199	0.167	0.119
Hibiscus sp	0.0020	0.021	0.096
Thunbergia alata Bojer ex Sims	0.0023	0.028	0.084
Zehneria scabra Sond.	0.0055	0.069	0.079
Mystroxylon aethiopicum (Thumb.) Loes.	0.0140	0.188	0.075
Carissa edulis (Forssk.) Vahl	0.0049	0.069	0.071

Rhus natalensis Krauss	0.0412	0.625	0.066
Commelina benghalensis L.	0.0089	0.153	0.058
Toddalia asiatica (L.) Lam.	0.0240	0.438	0.055
Pennisetum schimperi A.Rich.	0.0042	0.083	0.051
Brachypodium flexum Nees	0.0252	0.500	0.050
Sporobolus agrostoides Chiov.	0.0033	0.097	0.034
Albizia gummifera (JF Gmel.) C. A. Sm	0.0027	0.083	0.032
Indigofera swaziensis Bolus	0.0037	0.167	0.022
Scutia myrtina (Burm. F.) Kurz	0.0137	0.625	0.022
Achyranthes aspera L.	0.0027	0.139	0.019
Euclea divinorum Hiern	0.0064	0.500	0.013
Cynanchum alatum Wight & Arn.	0.0010	0.083	0.012
Rhamnus staddo A. Rich	0.0022	0.188	0.012
Cyphostemma kilimandscharicum (Gilg) Desc. ex Wild & R.B.Drumm.	0.0009	0.083	0.010
Olinia rochetiana A. Juss	0.0034	0.417	0.008
Rubia cordata Thunb.	0.0014	0.181	0.008
Carex chlorosaccus C.B.Clarke	0.0020	0.389	0.005
*Hypoestes forskaoli*i (Vahl) R.Br	0.0012	0.347	0.003
Prunus africana (Hook.f.) Kalkm.	0.0005	0.167	0.003
Leucas grandis Vatke	0.0005	0.188	0.003
Pennisetum clandestinum Hochst. ex Chiov.	0.0676	0.000	0.000
Dodonaea angustifolia L.f.	0.0217	0.000	0.000
Leucas sp	0.0145	0.000	0.000
Periploca linearifolia Quart.-Dill. & A.Rich.	0.0088	0.000	0.000
Ficus exasperata Vahl	0.0021	0.000	0.000
Dombeya sp	0.0020	0.000	0.000
Smilax anceps Willd.	0.0011	0.000	0.000
Hibiscus maculatus Lam.	0.0005	0.000	0.000
Justicia diclipteroides Lindau	0.0018	0.000	0.000
Senecio deltoideus Less.	0.0000	0.139	0.000

Maerua triphylla Dur. & Schinz	0.0000	0.042	0.000
Helichysum sp	0.0005	0.000	0.000
Asparagus falcatus L.	0.0000	0.264	0.000
Croton microstachys Baill.	0.0005	0.000	0.000
Juniperus procera Endl	0.0000	0.833	0.000
Salanum sp	0.0000	0.000	0.000
Hypoestes aristata (Vahl) Sol. ex Roem. & Schult.	0.0000	0.000	0.000
Peperomia abyssinica Miq	0.0000	0.014	0.000
Hyparrhenia sp.	0.0041	0.000	0.000

Appendix 4: List of plant species within the proposed bongo sanctuary

Acalypha volkensii Pax

Achyranthes aspera L.

Achyrospermum schimperi (Briq.) Perkins

Acritochaete volkensii Pilg.

Agrocharis melanantha Hochst.

Albizia gummifera (JF Gmel.) C. A. Sm

Alchemilla killipii Rothm.

Amphicarpa africana (Hook.f.) Harms

Apodytes dimidiata E.Mey. ex Arn.

Asparagus falcatus L.

Asplenium aethiopicum (Burm. f.) Bech.

Asplenium buettneri Hieron. ex Brause

Asplenium prolongatum Hook.

Bothriochloa sp.

Brachypodium flexum Nees

Carex conferta A.Rich.

Carex chlorosaccus C.B.Clarke

Carex vesicaria L

Carissa edulis (Forssk.) Vahl

*Droguetia iners (*Forssk.) Schweinf.

Ehretiasp.

Ekebergia capensis Sparm

Eragrostis sp

Erythrococca bongensis Pax

Erythrococca fischeri Pax

Euclea divinorum Hiern

Euphobia sp

Euphorbia schimperi C.Presl

Galium aparine L.

Galiniera saxifraga (Hochst.) Bridson*a*

Glycine wightii (Wight & Arn.) Verdc.

Grewia similis K.Schum

Halleria Lucida L.

Hibiscus maculatus Lam.

Hibiscus sp.

Hypoestes aristata (Vahl) Sol. ex Roem. & Schult.

Hypoestes forskaolii (Vahl) R.Br

Hypoestes triflora (Forssk.) Roem. & Schult

Cassipourea mollis (R.E.Fr.) Alston
Chionanthus battiscombei (Hutch.) Stearn
Cineraria deltoidea Sond.
Cirsium vulgare (Savi) Ten.
Clematis brachiata Thunb.
Clutia abyssinica Jaub. & Spach
Commelina benghalensis L.
Convolvulus kilimandschari Engl.
Crassocephalum montuosum (S.Moore) Milne-Redh.
Cucumis sp
Cupressus lusitanica Mill.
Cyathula cylindrica Moq.
Cyathula polycephala Baker
Cyanthula sp
cyanthula sp
Cynanchum alatum Wight & Arn.
Cynanchum abyssinicum Decne.
Cynodon dactylon (L.) Pers.
Cyphostemma kilimandscharicum (Gilg) Desc. ex Wild & R.B.Drumm.
Dalbergia lanceolata Zipp. ex Span.
Dichrocephala integrifolia (L.f.) Kuntze
Didymodoxa caffra (Thunb.) Friis & Wilmot-Dear
Dodonaea angustifolia L.f.
Dovyalis abyssinica (A.Rich.) Warb.
Ocimum Lamiifolium Benth
Olea africana Mill.
Olinia rochetiana A. Juss
Panicum monticola Hook.f.
Papero sp
Impatiens meruensis Gilg
Indigofera swaziensis Bolus
Isoglossa gregorii (S.Moore) Lindau
Jasminum fluminense Vell.
Juniperus procera Endl
Justicia striata (Klotzsch) Bullock
Kalanchoe densiflora Rolfe
Lantana trifolia L.
Laportea alatipes Hook. f.
Leonotis ocymifolia (Burm.f.) Iwarsson
Lepidotrichilia volkensii (Gürke) J.-F.Leroy
Leucas grandis Vatke
Maerua triphylla Dur. & Schinz
Maytenus heterophylla (Eckl. & Zeyh) Robson
Maytenus undata (Thumb.) Blakelock
Microglossa densiflora Hook.f.
Microglossa pyrifolia (Lam.) O. Kuntze
Mormid sp
Myrsine africana L.
Mystroxylon aethiopicum (Thumb.) Loes.
Mytenus sp
Nuxia congesta Fresen
Ocimum gratissimum L.
Solanum keniense Standl.
Solanum incunum L.
Solanum mauense Bitter
Solanum nigrescens M. Martens & Galeotti
Solanum sessilistelatum Dunal
solanum sp

Pavetta abyssinica Fres.
Pavonia urens Cav.
Pennisetum clandestinum Hochst. ex Chiov.
Pennisetum schimperi A.Rich.
Pentas lanceolata (Forssk.) Deflers
Pentas zanzibarica (Klotzsch) Vatke
Phylanthus fisheri PAX
Phyllanthu sfluitans Benth. ex Müll.Arg.
Physalis peruviana L.
phytolacca octandra L.
Pilea johnstonii Oliv.
Plectranthus kamerunensis Gürke
Plectranthus laxiflorus Benth.
Podocarpus falcatus Mirb
Polygala spectabilis DC.
Prunus africana (Hook.f.) Kalkm.
*Psychotriafractinervata*E.M.A.Petit
Psydrax schimperiana (A.Rich.) Bridson
Psydrax sp
Pteridium aquilinum (L.) Kuhn
Pteris aquilina L.
Rhamnus prinoides L'Herit
Rhamnus staddo A. Rich
Rhus natalensis Krauss
Rhus vulgaris Meikle
Rubia cordata Thunb.
Rubus keniensis Standl
Rubus pinnatus Willd
Rubus steudineri Schweinf.
Solanum terminale Forssk
Sonchus oleraceus (L.) L.
Spermacoce princeae (K.Schum.) Verdc.
Sporobolus agrostoides Chiov.
Stephania abbysinica (Quart.-Dill. & A.Rich.) Walp.
Sanicula elata D.Don
Sarcostemma viminale (L.) R.Br.
Schoenoplectus rechingeri Kukkonen
Scutia myrtina (Burm. F.) Kurz
Senecio nandensis S.Moore
Senecio deltoideus Less.
Senecio syringifolius O.Hoffm.
Senecio transmarinus S.Moore
Solanecio mannii (Hook.f.) C.Jeffrey
Solanum aculeastrum Dunal
Stipa keniensis (Pilg.) Freitag
Syzgium cumini (L.) Skeels
Toddalia asiatica (L.) Lam.
Trichocladus ellipticus Eckl. & Zeyh.
Urtica massaica Mildbr
Vepris nobilis (Delile) Mziray
Vepris simplicifolia (Engl.) Mziray
Vernonia brachycalyx O. Hoffm
Vernonia galamensis (Cass.) Less.
Vernonia syringifolia O.Hoffm.
Zehneria scabra Sond.
Vernonia syringifolia O.Hoffm.
Zehneria scabra Sond.
Zehneria scabra Sond.
Salvia sp