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Conservation Studies in the Kilombero Valley, Southern Tanzania: An Interim Report

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Technical report

Becker, S., Ward, L., Wightman, C., Couchman, O., Appleby, T., Saunders-Irving, R., Haigh, C., Steer, M., Belle, E. & Fanning, E. (eds)

Ministry of Natural Resources and
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Kilombero Valley Teak Company (KVTC)
KVTC was set up in 1992 by the Commonwealth Development Corporation (CDC) with the aim of creating a viable hardwood reforestation project with teak plantations arranged in a mosaic between natural forests and other natural vegetation. An area of 28,159 ha was leased by KVTC for this purpose. The company is presently undergoing certification from the Forestry Stewardship Scheme (FSC) and ISO 14001. As part of the criteria for this certification they have been and will continue to contract professionals to undertake scientific surveys of the area.

The University of Dar es Salaam (UDSM)
The University of Dar es Salaam was established in July 1970 as a centre for learning and research in the arts and the physical, natural, earth, marine, medical and human sciences. The University is surveying and mapping the flora and fauna of Tanzania and is conducting research into the maintenance and improvement of the environment and the sustainable exploitation of Tanzania's natural resources.

The Society for Environmental Exploration (SEE)
The Society is a non-profit making company limited by guarantee and was formed in 1989. The Society's objectives are to advance field research into environmental issues and implement practical projects contributing to the conservation of natural resources. Projects organised by The Society are joint initiatives developed in collaboration with national research agencies in co-operating countries.

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The Society for Environmental Exploration and the University of Dar es Salaam have been conducting collaborative research into environmental issues since July 1989 under the title of Frontier Tanzania, of which one component is the Frontier Tanzania Savanna Research Programme (FT SRP). Since July 1998, the FT SRP has been working in the Kilombero Valley undertaking conservation research and development activities including baseline studies of the Kilombero river birds and fisheries, the puku antelope, the biodiversity of miombo areas, land use planning of Itete Ward, facilitation of the establishment of a Community Based Organisation, and the development of an environmental education programme.

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EXECUTIVE SUMMARY

As one of the most fertile regions of Tanzania, the Kilombero Valley is under increasing pressure from an ever-growing human population. Agricultural encroachment, unmanaged burning practises and poaching threaten species that rely upon the habitat of both the Ramsar-protected wetlands and surrounding miombo woodland. This report summarises work carried out by the Frontier Tanzania Savannah Research Programme (FTSRP) in the valley between July and September 2009. The main focus of research was a continuation of the study assessing large mammal movements between the Selous Game Reserve and the Kilombero floodplain. This work was extended to study the specific effects of the newly constructed Kilombero Valley Teak Company (KVTC) sawmill on large mammal movements in the area. The work programme also included intensive biodiversity surveys of scavenger carnivores, herpetiles, birds and aquatic macro-invertebrates. This research was carried out in conjunction with environmental education efforts in two local primary schools.

In total 41 mammal, 162 bird, 24 herpetile and 110 lepidopteran species have now been recorded in the valley by FTSRP. There is general evidence that biodiversity levels are decreasing within the valley, but populations of many large mammals and various large predators are still present. Results have demonstrated a gradual increase in abundance of many large mammal species in the area since the study began, suggesting that disturbance in the surrounding area is forcing the natural range of these species into ever constricting refuges of undisturbed habitat. With low levels of human disturbance recorded across the study site, it is likely that the area surrounding Sayari camp is acting as one such refuge. However, evidence is also presented to suggest that certain species such as baboon (*Papio anubis*) are increasing in the region due to the food source provided by human settlement and agriculture.

Community management plans are required in the Kilombero Valley to ensure that the local ecosystem remains a viable habitat whilst providing local people with the resources they require. As the populations of many species are forced into direct competition with humans and their cattle, it is vital that measures are put in place to neutralize the inevitable increase in human-wildlife conflict that will result. The community work and environmental education component of FTSRPs research programme is essential to ensure the sustainability of conservation efforts in the region.

1. INTRODUCTION

1.1 Area and Camp Overview

All research undertaken by the Frontier-Tanzania Savannah Research Programme (FTSRP) occurs in the Kilombero Valley, Morogoro Region, Tanzania. The Kilombero Valley covers an area of 6,650km² between the Udzungwa Mountains National Park and the Selous Game Reserve and is a site of considerable biological interest (Starkey *et al.*, 2002). It is the largest freshwater wetland in East Africa (East 1998) and was designated as Tanzania's third RAMSAR site in 2002. The valley also supports high densities of large mammals and has been classified as a Game Controlled Area for over 40 years. The Valley is home to one of the largest individual populations of the puku antelope (*Kobus vardoni)*, one of only two populations in Tanzania (Starkey *et al.*, 2002). Fragments of the Eastern Arc forest and extensive areas of miombo woodland fringe the seasonal floodplain on the valley floor. Miombo is the common name given to *Brachystegia* dominated, fire-sustained, sub-climax woodland found throughout the savannah woodland areas of Eastern Africa.

The Kilombero Valley is also widely recognised as one of the most fertile areas in Tanzania and as a result, its conversion to agriculture has been widespread and rapid (Jones *et al.*, 2007). Increased human settlement is putting considerable pressure not just on the floodplain itself, but also on the miombo woodland that borders it (BTC 2005). Human resource use and disturbance is, in fact, one of the biggest influences on the dynamics of the miombo woodland ecosystem, and the majority of miombo in Tanzania is secondary due to the ever-increasing human use (Misana *et al.*, 1996). Apart from large-scale deforestation (largely due to tobacco cultivation for export and teak plantations), miombo woodland supports many aspects of rural communities. Resources removed range from essential necessities such as food and fuel, to plants used in religious and cultural practices. Firewood and construction materials are in highest demand and are generally species specific (Clarke *et al.*, 1996).

In January of 2008 FTSRP established Sayari Camp, situated in pristine miombo woodland between the Ifakara-Mahenge road and the Selous Game Reserve (see table 1 for precise location). The camp is located on Igumbiro village land and lies approximately 8 kilometreskilometres east of this village and 25 kilometres west of the Selous border, a prime location to study the interactions between humans and wildlife in the area. The camp is accessed via a dirt road leading from the village of Mavimba, 13 kilometreskilometres away. The area surrounding Sayari is characterized by relatively pristine rolling hills of open miombo woodland. In low lying areas, marshes dominated by razor grass are common and in areas along river beds some evergreen forest is present. Three kilometres to the east of camp two sharp hills rise above the surrounding vegetation.

Pastoralists and farmers are using the areas to the west and north of camp with increasing frequency. This phase, local villagers cleared several hillsides illegally for farms and constructed permanent houses. Cattle grazing is also increasing in the area. To the south and east there is virtually no human disturbance. However, FTSRP found evidence of two sites of timber poaching in 093. The road passing by camp runs all the way to the border of the Selous, although it is rarely used and is extremely overgrown past the turn off to Sayari Camp. Most research carried out in 093 was within walking distance of camp with the exception of some wetland and bird sites near Mavimba and Lupiro villages.

1.2 History and Rationale of Program

FTSRP has been based in the Kilombero Valley since 1998. Most work prior to 2008 was conducted in conjunction with the Kilombero Valley Teak Company (KVTC) and focused on biodiversity and pre-felling reports. This work was concluded in July 2007 when KVTC completed planting on all the land they currently lease and pre-felling assessments were thus no longer required. We remain in close contact with the company however, and there is potential for future monitoring work. In 073 and 074, FTSRP moved north of the river and focused on documenting the viability of the Ruipa wildlife corridor. This work has led to funding being awarded by the Darwin Initiative to carry out a three year project facilitating cohesive management of the corridor. This work will begin in October 2009.

In the interim, FTSRP has established Sayari Camp south of the river and has based a new research programme there. Work has focused on monitoring large mammal populations in the area as well as carrying out projects on other taxa such as small mammals, butterflies and birds. The area around Sayari is currently relatively untouched by human presence, but this is changing. A road is already present and villagers frequently travel deep into the woodland looking for fuel wood and other forest products. Land between Sayari and local villages is rapidly being converted to farmland and evidence of timber collection, legal and illegal, is clearly evident. Over the course of the last 18 months, FTSRP has found and confiscated 12 large mammal snares and either heard or directly encountered poachers on a number of occasions. KVTC has also built a new sawmill on land close to Mavimba's eastern border and timber processing is due to start in the autumn of 2009. A new road running from the main road through the outskirts of the village to the sawmill is already complete and an electric fence has been established around the 100 hectare site. The new road allows the passage of large vehicles and may have unintended consequences on the ecosystem as it increases access to the woodlands. It is essential that we carry out baseline biodiversity surveys in the area to better understand any changes that take place due to the ever increasing level of human encroachment. FTSRP is ideally located to study the effects of human disturbance on the biodiversity of miombo woodlands, an area that is currently poorly understood.

1.3 Research overview

This report outlines the findings and research progress made between July and September 2009 (also referred to as phase 093). Original plans were for FTSRP to move to an area north of the Kilombero in order to complete the objectives laid out in the Darwin Initiative Grant. After a reconnaissance trip to the area with TZE, it was decided that the proposed area was unlikely to still be a viable corridor and that the area was unsafe for volunteers due to the high density of humans. The location of FTSRP therefore remains at Sayari Camp.

FTSRP's main focus continues to be the monitoring of large mammal populations in the area around Sayari Camp. Large mammal surveys are conducted across a 7 km^2 grid in an area that straddles the border between disturbed and relatively untouched miombo. Movement between the Selous Game Reserve and the Kilombero Valley remains a mystery and FTSRP hopes to begin finding some answers using a series of twenty-four 500 meter transects, repeated every phase. Complementing this long-running project, we also conducted large mammal transects at differing distances to a local village to assess the impact of human encroachment on large mammal abundance and diversity.

In conjunction with the large mammal transects assessing human encroachment effect on large mammals, a new project was undertaken which aims to assess the effect of human encroachment on scavenger carnivores such as genet and civet. An initial round of data was collected this phase and will continue next phase. Human encroachment also entails an increase in fire as farmers burn to clear land and poachers burn to facilitate the ease of hunting large mammals. A second new project began, looking at how burning affects the abundance of reptiles and amphibians in grassland and woodland habitats. Data collection will continue through the 094 phase.

A third project began this phase, which aims to monitor aquatic macroinvertebrate assemblages along a river course near camp. Macroinvertebrates are key indicator species in aquatic habitats, though there is a general lack of information and indices for these species in tropical zones. FTSRP will continue monitoring this river course throughout the year and expand to seasonal wetlands.

Finally, a species-specific study was undertaken to describe the feeding ecology of Retz’s helmet-shrikes *(spp)* and their associated species. This study aims to elucidate the complexities of habitat use by avian species, to provide more detailed information on the effects of human disturbance on these species. FTSRP will continue monitoring these species next phase.

In addition to the biological surveys carried out by FTSRP, community work and environmental education remain an integral part of the programme in the Kilombero Valley. Two primary schools were visited this phase, with lessons focussing on the effects of burning on biodiversity. Environmental education is essential for the sustainability of the conservation efforts of FTSRP in the Kilombero Valley.

1.4 Location of Survey Sites

Table 1: Location of all survey sites in 093.

Work Sites	Dates	GPS Grid Reference
Sayari Camp	ALL PHASE	37 L 0251803 UTM 9072438
Villages	Throughout phase	Igumbiro, Lupiro, Mavimba

▪

2. MONITORING OF LARGE MAMMAL POPULATIONS IN MIOMBO WOODLAND BETWEEN THE SELOUS GAME RESERVE AND THE KILOMBERO FLOODPLAIN

Principal Investigator: Sarah Becker

2.1 Introduction

The Kilombero Valley has long been an important area for large mammal populations and at one time had the largest density of wildlife in Tanzania located outside protected areas (Haule *et al.*, 2002). It is situated between two wildlife rich areas, the Selous-Mikumi ecosystem and the Udzungwas Mountains, and historically animal migration paths across the valley linked the two areas. A resident large mammal population in the valley and a migratory population moving between the two protected areas have been identified and it is essential that this connectivity remains in place to ensure regional animal movements and to maintain gene flow (Jones *et al.,* 2007).

Immigration into the Kilombero Valley has increased significantly in recent years and this change has had a direct impact on large mammal populations in the valley (Jones *et al.,* 2007). In a report on a survey carried out by Conservation International in 2007, Jones *et al.,* identified just two remaining viable corridors between the Selous and the Udzungwas, but the extet to which these corridors are used remain unclear. Previous FTSRP work in one of these, the Ruipa Corridor, has documented decreasing animal use through the route and increasing land use change. Corroborating this evidence, villagers interviewed in FTSRP social surveys in 2007 seem to believe animals no longer cross the Kilombero River. Rather, they believe animals from the Udzungwas come down to the villages and floodplain on the north side of the river and then return to the mountains, while animals from the Selous come to the area south of the river. Many species rely on the floodplain as a dry season refuge and move to the surrounding hills as the floodplain becomes inundated (Jenkins *et al.,* 2002).

In general the mammal movement within and across the Kilombero Valley is not well understood and as the remaining corridors constrict, the miombo woodlands fringing the valley are going to increase in importance as wildlife refuges. These woodlands have long experienced low level disturbance, being utilised by local villagers for resources such as firewood and medicine. However, as the human population in the valley expands, the pressure on the woodland is rapidly increasing. Farmers and pastoralists are pushing further and further into the miombo, clearing land, collecting wood, making charcoal and burning pastures. Human-wildlife conflict is increasingly an issue. This study aims to better understand the change in abundance of large mammals throughout the seasons and monitor the effect of increasing human encroachment.

2.2 Materials and Methods

In January 2008, twenty-four permanent large mammal transects in a 7km^2 grid were set up around Sayari Camp such that all transects could be reached on foot and a thorough survey of the area was achieved (Figure 1). Transects were placed approximately one kilometer apart with half running north to south and half running east to west. Each start and end point was marked using GPS and transects were drawn on a map allowing for repetition each phase. Two of the 24 transects originally established in 081, numbers 5 and 7, have subsequently been removed as they were outliers located to the north east and south of the grid respectively. During 084 two new transects, 25 and 26, were added to the grid ensuring even coverage.

Transects were 500 meters long and all large mammal tracks and signs (tracks, dung, paths, diggings, burrows and feeding sites) within one meter either side of the line are recorded. Each 100 meter transect line was divided into 20 meter sections and within each of these sections signs were only recorded once. Game guards were present to confirm all track identifications.

Vegetation characteristics were recorded every twenty meters using a 5 meter by 5 meter quadrant. The following information was recorded: % canopy cover; canopy height; % grass; % shrubs <1m; % shrubs 1<3m; % bare ground; % dead wood; % leaf litter (as a percentage of bare ground); and % burnt ground.

To monitor human disturbance along each transect, the ratio of cut trees to live trees was recorded. Within each twenty-meter section, the number of live, naturally dead, old cut and new cut poles (diameter 5 -15 cm) and timbers (diameter >15 cm) was counted five meters either side of the transect line.

Large mammal abundance, vegetation characteristics and human disturbance were measured along each transect four times a year (each phase). The first quarter of the year (phase xx1) is generally the end of the short rains and the hottest time of the year. The second quarter (phase xx2) is during the long rainy season (March – June) and is the wettest quarter of the year. The long rains are followed by the long dry season during the third quarter (phase xx3). The dry season generally ends in October or November (midway through the fourth quarter) with the short rainy season. For the purposes of this study, phases xx1 and xx3 will be considered dry season and xx2 and xx4 wet season. Once weather station data are obtained from KVTC, data on large mammal movement through the seasons can be analysed.

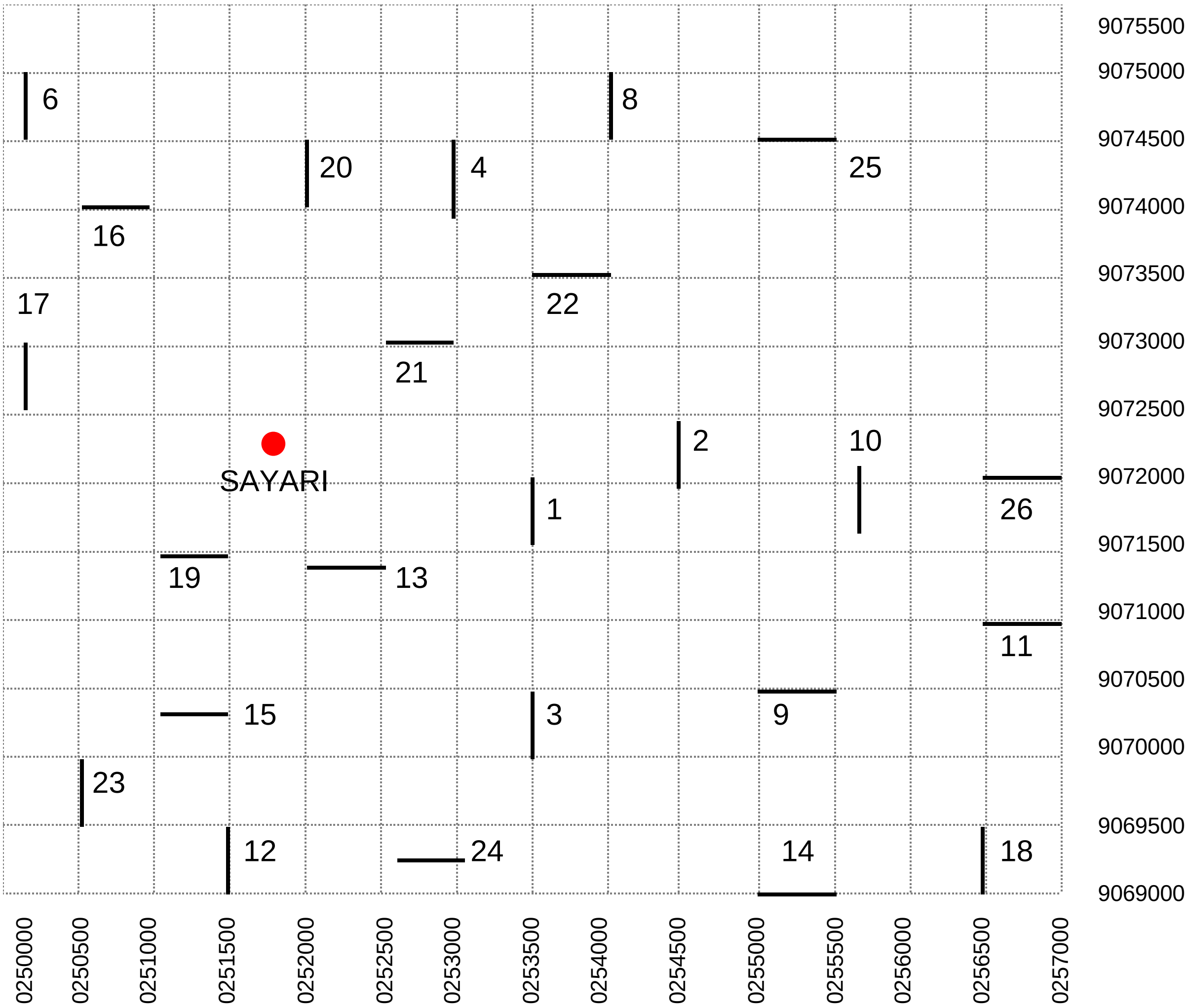

Figure 1: The distribution of LMTs across the 7 km^2 grid surrounding Sayari Camp (coordinates are 37 L/UTM).

2.3 Results

Twenty-one months of large mammal monitoring at Sayari Camp has been undertaken so far. Thirty-one species of large mammal have been recorded, including the domestic dog and cow (Table 4). Both the Bohor reedbuck, *Redunca redunca*, and the Southern reedbuck, *Redunca arundinum*, are referred to as ‘reedbuck’. The ranges of these two species overlap in southern Tanzania and they cannot be distinguished by spoor. Similarly, ‘duiker’ refers to the common or bush duiker, *Sylvicapra grimmia*, the blue duiker, *Cephalophus monticola*, and Harvey’s duiker, *Cephalophus harveyi*, all of which may be present in the study area and cannot be distinguished by spoor. ‘Mongoose’ was used for any mongoose species excluding the water mongoose, *Atilax paludinosus*. “Genet” includes two species: the common, *Genetta genetta*, and the blotched, *Genetta tigrina.*

Table 4: All species recorded on large mammal transects from January 2008 to September 2009, excluding the domestic dog and cow.

Common name	**Scientific name**
Olive baboon	*Papio anubis*
Scrub hare	*Lepus saxatilis*
Spring hare	*Pedetes capensis*
Crested porcupine	*Hystrix cristata*
Cane rat	*Thryonomys swinderianus*
Mongoose	Herpestidae
Water mongoose	*Atilax paludinosus*
Spot necked otter	*Lutra maculicollis*
Spotted hyena	*Crocuta crocuta*
Genet	*Genetta* spp.
African civet	*Civettictis civetta*
Serval	*Felis serval*
Wild cat	*Felis lybica*
Lion	*Panthera leo*
Leopard	*Panthera pardus*
Aardvark	*Orycteropus afer*
Elephant	*Loxodonta africana*
Zebra	*Equus quagga*
Hippopotamus	*Hippopotamus amphibious*
Bush pig	*Potamochoerus larvatus*
Warthog	*Phacochoerus africanus*
Buffalo	*Syncerus caffer*
Bushbuck	*Tragelaphus scriptus*
Eland	*Taurotragus oryx*
Duiker	Cephalophini
Kirk's dik dik	*Madoqua kirkii*
Reedbuck	*Redunca* spp.
Waterbuck	*Kobus ellipsiprymnus*
Hartebeest	*Alselaphus busephalus*
Sable antelope	*Hippotragus niger*

The species richness of large mammals in 093 was 23, which is similar to previous phases. However, the abundance of spoor in 093 was much greater than in previous phases. The abundance of spoor increased steadily since 081, suggesting a greater number of wildlife are using the area (Figure 2). The most common species in 093 were buffalo, elephant, waterbuck, bushpig and duiker (Figure 3). These species follow the overall trend of increasing in abundance since 081 (Figure 4). Their abundance increased steeply between the wet (092) and the dry seasons (093). Bushpig, duiker and waterbuck have similar patterns of abundance across seasons. Elephant and buffalo show similar trends in abundance with elephant generally the most prevalent spoor. Habitat use changes slightly for elephants and buffalo between seasons. Elephants and buffalo prefer closed canopy areas during the dry season (Figure 5).

The abundance of aardvark, baboon, cane rat, mongoose and porcupine do not show an overall increasing trend, although all but aardvark dramatically increased in 093 (Figure 6). Cane rat, mongoose and porcupine have similar patterns of abundance, suggesting that environmental factors affect them similarly. Aardvark abundance is only slightly declining. Baboon abundance is increasing overtime, regardless of season.

Uncommon antelope (all those other than duiker and waterbuck) do not show an overall increasing trend except for hartebeest and reedbuck (Figure 7). Hartebeest abundance increased in the wet seasons (082, 084, 092 and 094), while reedbuck abundance increased in the dry seasons (091 and 093). Bushbuck abundance has decreased to rare.

There was very little human disturbance on the LMTs during 093 (4 incidences of cut trees on all 24 transects). Two transects had burnt ground during 093, although that number has probably greatly increased as the burning season began in earnest at the end of 093.

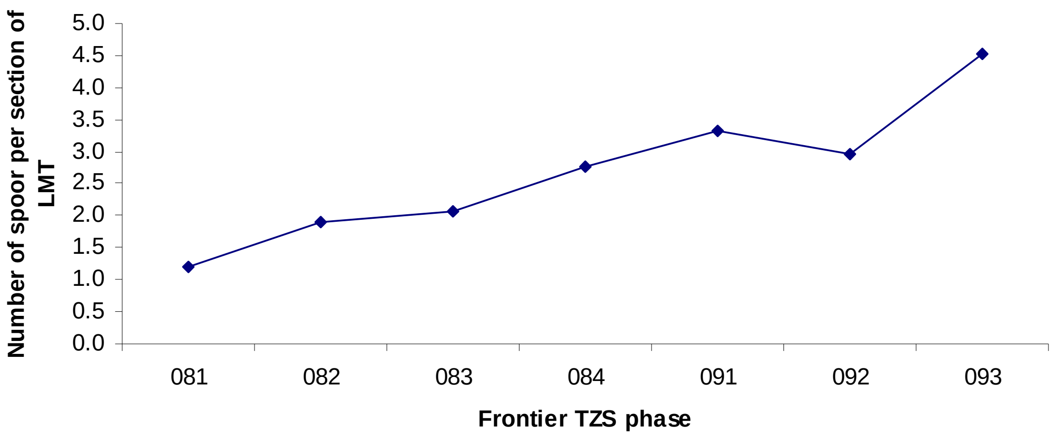

Figure 2: Average number of spoors in a transect section. There were 500 total sections in phases 081 – 084 and 600 total sections in phases 091 – 093.

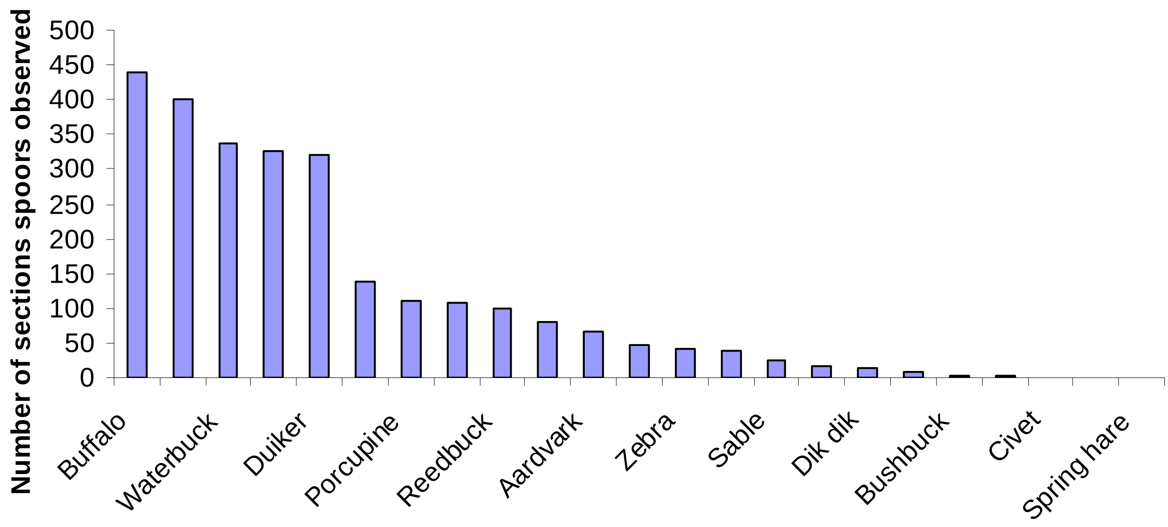

Figure 3: Number of sections with observed spoor for each species in 093.

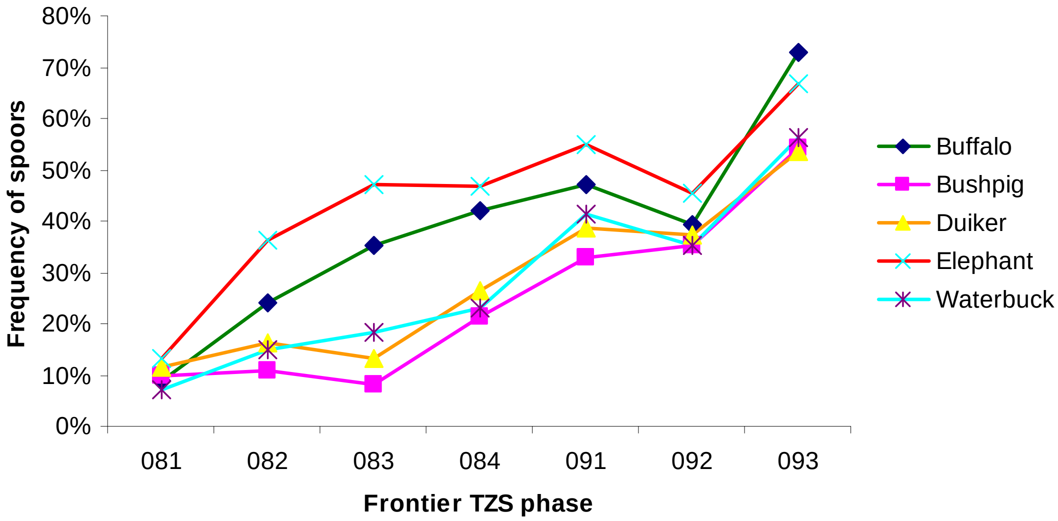

Figure 4: Percentage of sections with spoor of common species through time

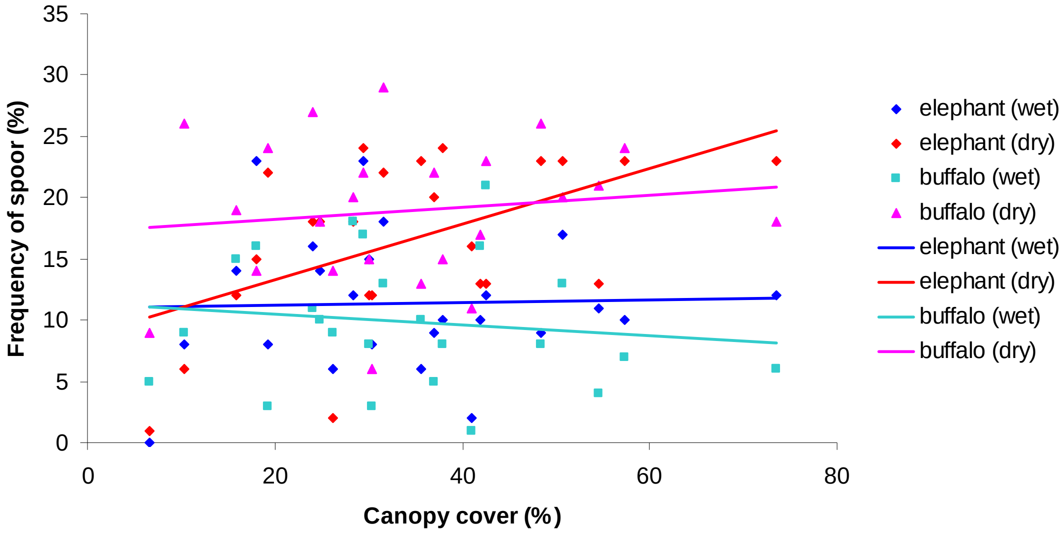

Figure 5: Comparison of habitat use for elephants and buffalo between the 2009 wet season (092) and dry season (093).

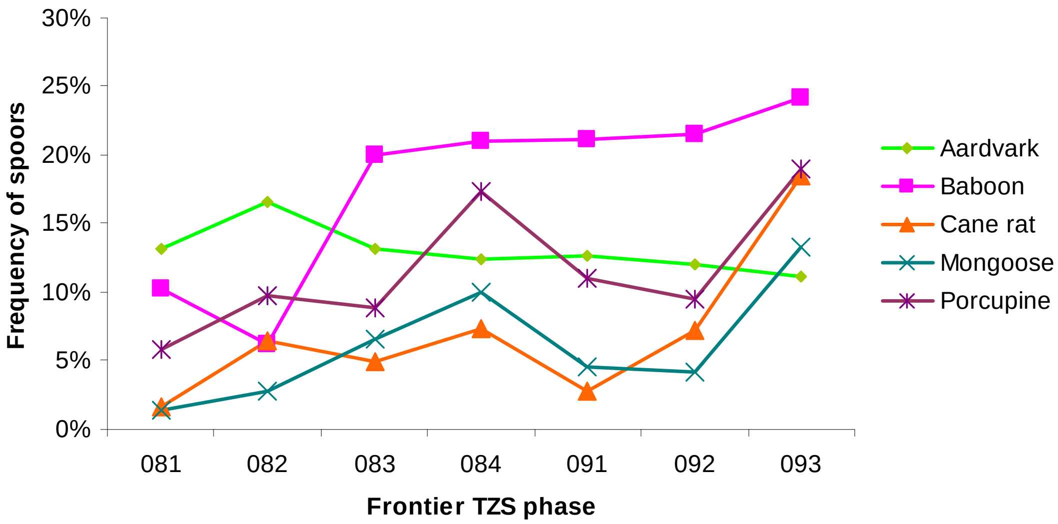

Figure 6: Percentage of sections with spoor of non-grazing species through time

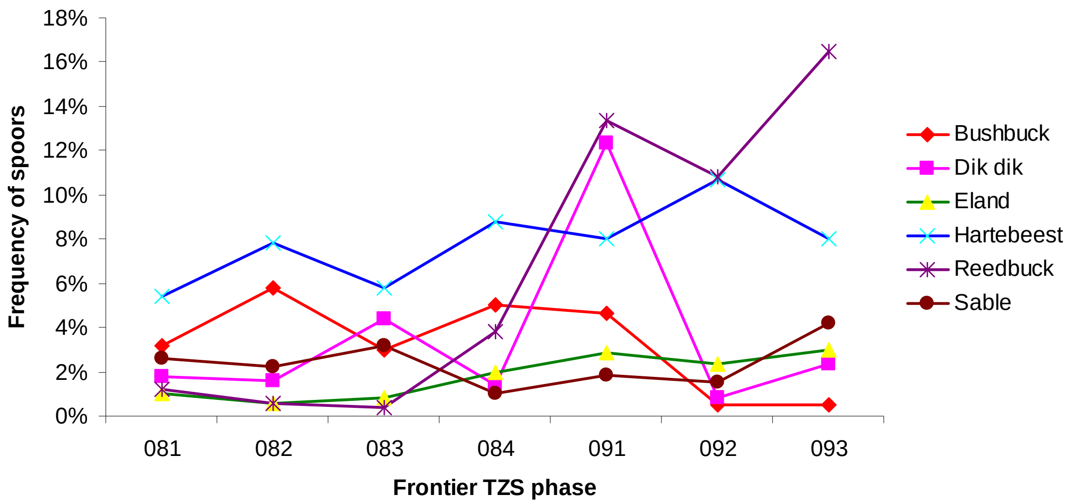

Figure 7: Percentage of sections with spoor of uncommon antelope species through time

2.4 Discussion

The Kilombero Valley is undergoing increasing pressure from humans, agriculture and grazing which is likely impacting wildlife abundance in the valley. TZS has been monitoring large mammal abundance in the valley since 1998 and have been at Sayari Camp since January 2008. Since January 2008, large mammal abundance has been increasing in the area surrounding Sayari Camp regardless of season. The numbers of elephant, buffalo, waterbuck, duiker and bushpig swelled in the latest dry season which augmented the general trend of increasing abundance of these animals. Buffalo and elephant showed a clear preference for forest habitats during the dry season. Uncommon antelope (dik dik, hartebeest, eland, sable, bushbuck and reedbuck) generally showed seasonal patterns or a constant low level of abundance. Non-grazing large mammals (aardvark, baboon, cane rat, mongoose and porcupine) generally showed seasonal patterns and baboon abundance has been gradually increasing in the area.

Large mammal abundance greatly increased in the area surrounding Sayari Camp during the 2009 dry season (phase 093). While the species richness did not increase from the wet season, the abundance of spoor increased by nearly 50%. As human development increases in the Kilombero Valley, wildlife is pushed into smaller areas (Jones *et al*. 2007). The area around Sayari Camp may be one such area because the presence of game guards working for Frontier likely prevents farmers and grazers from encroaching in the area. However, farmers and grazers are moving ever closer to camp and during 093 two permanent human habitations were found just over 2 km west of camp. As more people move into the area, abundance is likely to decrease dramatically as the animals move east into the hunting blocks and the Selous.

The dramatic increase in elephant, buffalo, duiker, bushpig and waterbuck in 093 may be from the presence of permanent water in the area. The wet season was drier this year than in years past (local communication), suggesting that seasonal wetlands dried quickly forcing animals to rely on permanent water sources. The river flowing near camp and its tributaries have several permanent pools that were observed to have a plethora of tracks near them. Animals may be using the area to reach the floodplains of the Kilombero River, located approximately 30 km north of camp. As the dry season continues, animal abundance around camp will likely decrease because of low water levels and most animals have already moved to the Kilombero floodplain. LMTs conducted at the beginning of 094 will test this hypothesis.

The data suggest elephants and buffalo prefer areas with closed canopy during the dry season. Elephants especially show a distinct trend towards forested areas in the dry season which is corroborated by Kingdon (1997). He suggests that elephants move to forests and swamps during the dry season because they are reliant on shade and water. He further hypothesized that elephants are not adapted to dry environments because they only recently expanded to this habitat. Buffalo also prefer moist habitats and areas where they can wallow (Kingdon 2001).

Most uncommon antelope species had unvarying low levels of abundance throughout time. In 091, the abundance of dik dik was unexplainably high and returned to its low level of abundance in 092. Reedbuck abundance is increasing over time with the greatest rise in 091. Unlike dik dik, reedbuck's abundance remained high. Hartebeest abundance is increasing overall yet there are still seasonal fluctuations. During wet seasons (082, 084 and 092), hartebeest increased in abundance, likely because most of the study area is woodland which hartebeest prefer in the wet season. They follow drainages during the dry season to feed on fresh greens (Kingdon 2001).

Non-grazing large mammals showed three main patterns of abundance throughout the study. The abundance of aardvark showed little change over the seasons, likely because their spoor, a digging, remains visible for long periods. Any changes in abundance would not be immediately apparent. Season did not affect baboon abundance and baboons are gradually increasing in number. The African Convention lists baboons as vermin due to their omnivorous diets and proclivity for crop raiding (Kingdon 2001). Baboons are very adaptable feeders and eat grass, fruit, crops and insects. The increase in baboon abundance around Sayari may be associated with human population growth in the Kilombero Valley which likely increases the amount of available food for baboons.

Cane rat, mongoose and porcupine all showed similar patterns of abundance through time. The pattern is not obviously related to season; the 2008 dry season (083) had generally lower abundance than the preceding wet season (092), but this pattern was not repeated in 2009 when the dry season had a much greater abundance of these animals. Perhaps these animals have a common predator and their abundance fluctuates in response to the predator's abundance.

2.5 Conclusion

The Kilombero Valley is threatened by farmers and grazers who are immigrating there to exploit the fertile floodplains. As the human population increases, large mammal abundance will be negatively impacted in the area around Sayari Camp, similar to what occurred at previous TZS camps (Simba Camp, Shamba Camp). Yet, preventing people from building farms without providing an alternative way of making a living is not ethical. There needs to be reconciliation between the conservation of large mammals and the development of alternative livelihood schemes that increase the standard of living of Tanzanians

3. AN ASSESSMENT OF THE EFFECTS OF HUMAN HABITATION ON CARNIVORES IN THE KILOMBERO VALLEY

Principal Investigator: Christiana Wightman

3.1 Introduction

Human activity is widely recognized as a key factor influencing the dynamics and behaviour of wildlife populations (Jones *et al*. 2007). The introduction of humans to an area can cause significant environmental stress and consequently has an impact on the surrounding wildlife and habitat. The increasing size of human populations triggers the need for increased agricultural production, invariably resulting in land use changes, causing habitat destruction (Haule *et al*. 2002). It has been widely acknowledged that changes to the habitat brought on by human activity, such as cattle grazing, has decreased the quality of the land and thus the use of the land by much of the wildlife that would previously have inhabited the area (Bonnington *et al.* 2007, Jenkins *et al.* 2002). Yet this may not be the case for all wildlife, as scavenger carnivores are know to inhabit areas where there are human settlements.

The Kilombero Valley is situated in southern Tanzania and parts of it act as a wildlife corridor between the Selous Game Reserve and the Udzungwa Mountains National Park. The valley contains some game controlled areas, which prohibits unauthorised hunting, but does not prohibit change to the use of the land (Haule *et al.* 2002). As a result over the last few decades the Kilombero Valley has endured dramatic changes (Jones *et al.* 2007) as a high influx of people move to the region to farm, hunt and graze cattle on the fertile floodplains (Bonnington *et al.* 2007, Jenkins *et al.* 2002, Jones *et al.* 2007). Due to the growing population of Tanzania, it is evident that the area inhabited by humans is increasing and human encroachment is spreading towards the more pristine area of the country (Jones *et al.* 2007).

This increasing rate of development has brought a number of negative effects on wildlife populations and therefore scientists are concerned that the corridor between the Selous and the Udzungwa Mountains maybe gradually closing up (Jones *et al.* 2007). Farms are spreading throughout the migratory corridor, causing habitat degradation and an increased risk of disease and poaching (Bonnington *et al.* 2007).

In the Kilombero Valley, it has been found that human activity has decreased the populations of large mammals (Bonnington *et al.* 2007). Yet in some cases populations of animals may not decrease, but move towards the human settlement to gain from the resources humans provide. Some scavenger carnivores, such as genet and civet, are well adapted to habitat change and cultivation, therefore allowing them to inhabit and utilize areas close to humans (Kingdon 1997).

The objective of this study is to examine the effect human habitation has on scavenger carnivores in the Kilombero Valley. It was hypothesised that the presence of scavenger carnivores will increase with the increasing proximity to human settlements because they will utilise the resources the humans provide. Carnivore stations were used to assess the frequency of carnivores present at different sites of varying levels of human disturbance and a questionnaire survey conducted to assess local villagers' perception of scavenger carnivore abundance in the area.

3.2 Methods

Site Description
The study was conducted in the Kilombero Valley of Tanzania, which lies between the Selous Game reserve and the Udzungwa Mountains National Park. Specifically the study areas were in miombo woodland between the village of Lupiro and the Frontier Sayari camp (37 L 0251815 UTM 9072451), located in Ulanga District. Miombo woodland mainly consists of the *Brachystegia* tree species and contains many species of carnivores ranging from genets to lions. Rural communities use the woodland for firewood collection, water catchment, and grazing areas. Four study sites were selected situated east of Lupiro village with varying degrees of human habitation. Research was conducted during the dry and short rainy season, between July and December 2009.

Carnivore stations
At each site, four carnivore stations were set up, consisting of an area 1m^2 of loosened ground which has been cleared of vegetation, with a pole holding bait (raw meat) in the centre. The carnivore stations were placed 300 m apart along a 900 m transect line crossing the study site from south to north. Researchers checked the stations at each site for tracks and signs and baited once a day for five consecutive nights. Spoor identifications were confirmed by an experienced game guard.

The level of human disturbance was also recorded at each site along a 200 m transect at the beginning of the site (furthest south point) and then again at the end of the site (furthest north point). Measurements of the ratio of cut trees to live trees and also the presence of livestock faeces, tracks and farms were also taken. Within each 20 m section the number of live, naturally dead, old cut and new cut poles (diameter 5-15 cm) and timbers (diameter ~15 cm) were counted in the area 5 m either side of the transect line. Along with this data, the presence of livestock activity and any farms nearby were recorded.

Village Questionnaire
We surveyed local villagers about carnivore sightings in the village, using pictures from a book for reference to the different animals. Villagers were asked how frequently they see them and their perceptions of the change in abundance of these carnivores over time. It was also enquired whether these animals cause conflict to the villagers, such as attacking livestock.

3.3 Preliminary Results

All carnivore stations were sampled five times on consecutive nights, except for stations 4a and 4b which, for logistical reasons were only sampled four times.

Five species of carnivore were recorded in total; African civet (*Civettictus civetta*), Genet (*Genetta spp.*), spotted hyena (*Crocuta crocuta*), bush pig (*Potamochoerus larvatus*) and water mongoose (*Atilax paludinosus*). Genets were only classified to genus level as individual species could not be identified by spores and tracks alone. Civet was the most common species of carnivore, recorded 24 times across the four study sites, followed by genet species which were recorded 15 times. Hyena, bushpig and water mongoose, were only recorded 1, 2 and 6 times respectively (figure 8).

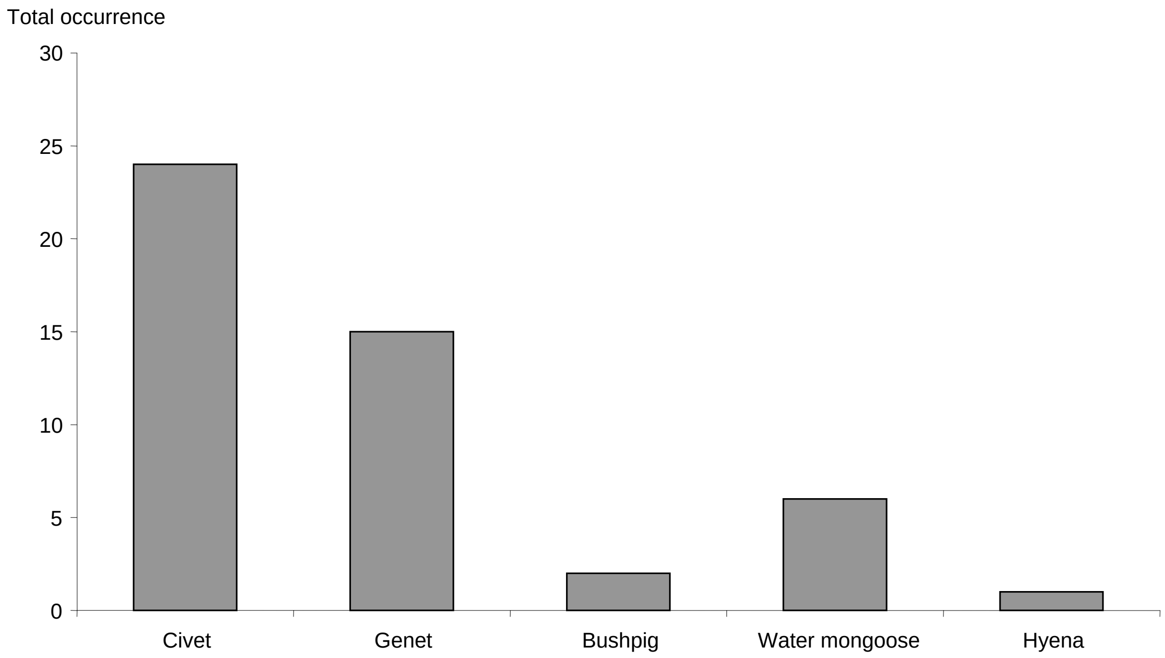

Figure 8. Comparison of total occurrence of five carnivore species across all carnivore stations.

No analysis of carnivore abundance with respect to human disturbance can be carried out until human disturbance data is collected next phase. However, preliminary results suggest that data is only sufficient to compare abundance of civet and genet between sites, due to the low occurrence rate of bushpig, water mongoose and hyena.

There was no significant difference observed in total carnivore abundance between sites (ANOVA, F=0.093, p=0.962) (Figure 9). However, focusing on the most abundant carnivores found, civets showed a significant variation in occurrence between sites (ANOVA, F=3.830, p=0.039). By contrast, genet abundance showed no significant variation (ANOVA, F=1.068, p=0.399) (Figure 10).

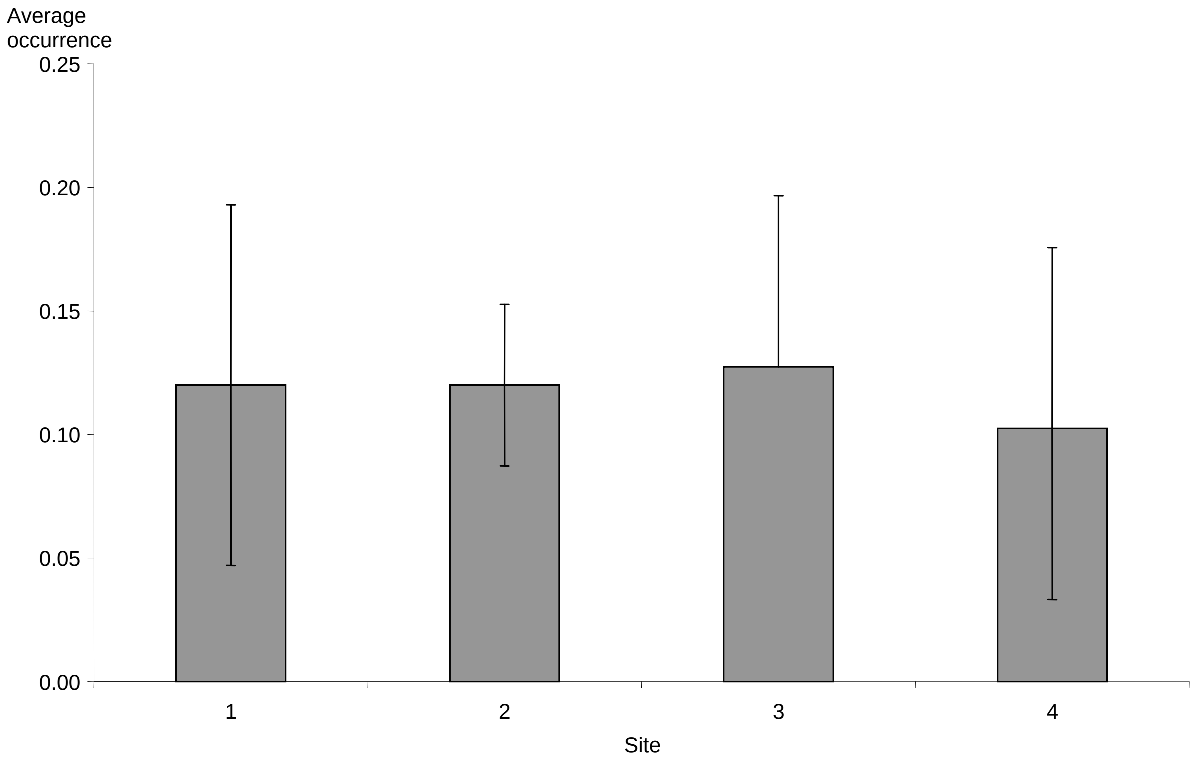

Figure 9. Comparison of total carnivore occurrence across four study sites.

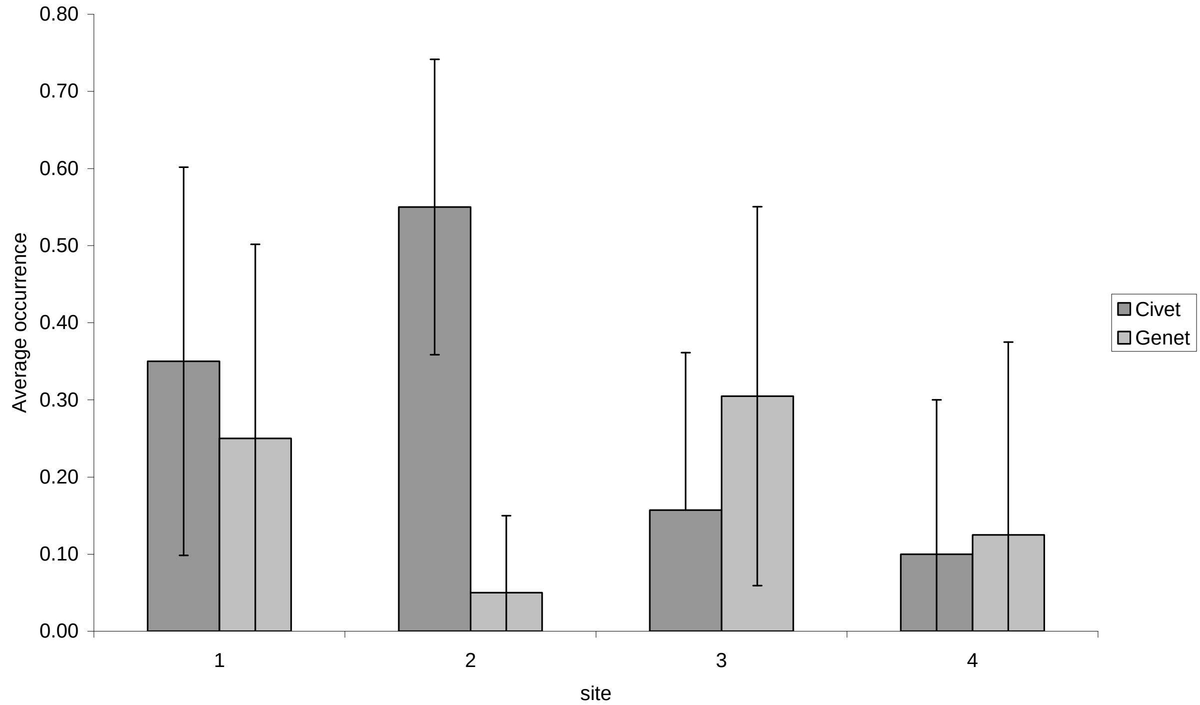

Figure 10. Comparison of average civet and genet abundance across four study sites.

3.4. Preliminary discussion

Preliminary results this phase indicate that the method used is appropriate to the study, providing adequate data to assess carnivore abundance with respect to human disturbance. Human disturbance data collected next phase will elucidate whether the difference in civet abundance correlates with variations in the level of human disturbance between sites two and four. These data will be supported by results of the social surveys carried out on local villagers' experiences of carnivores in the region. These are of particular interests for identifying any exacerbation of human-wildlife conflict which may result if the hypothesised increase in carnivore abundance close to human settlements is found to be true.

Our preliminary results suggest no significant variation in genet abundance between sites. In contrast, similar studies investigating habitat use of genets have highlighted the preference of this species for undisturbed, closed-canopy areas (Zuberogoitia *et al*, 2002; Espirito-Santo *et al*, 2007). The disparity in the results of civet and genet abundance between sites, suggests that if significant variation in human disturbance exists between sites, the two species are differentially affected by this. A previous study carried out in the Ethiopian highlands suggested that scavenger carnivores such as genet and civet are capable of living in close proximity to human settlement and livestock, with both species monopolising the resources provided by refuse sites (Admasu *et al*, 2004). However, this study only presented results based on radio-telemetry of one individual of each species and must be treated with caution. All discussion this phase is largely speculation and work next phase will hopefully provide stronger evidence of the effects of human disturbance upon scavenger carnivore abundance and range.

4. AN INVESTIGATION INTO HOW BURNING PATTERNS AFFECT REPTILE AND AMPHIBIAN COMMUNITIES IN MIOMBO WOODLAND AND GRASSLAND HABITATS

Principal Investigator: Olivia Couchman

4.1 Introduction

Humans have long played a dramatic role shaping the landscapes, through activities such as grazing practices, agriculture and fire (Gichohi *et al*. 1999). In savannah ecosystems, burning has been used for thousands of years as a traditional management strategy by pastoralists to grow nutrient-rich grass for cattle (Gichohi *et al*.1999). As human population increases and the demand for fertile land expands throughout rural areas, the increased burning of land is becoming a great concern to the survival of native flora and fauna (Desanker *et al*. 1997). The savannah landscape harbours a complex mix of invertebrate and vertebrate fauna; many species rely on the canopy, grassland and open and closed miombo habitats for survival (Gichohi *et al*.1999).

In Africa, the miombo woodland savannah zone stretches across seven eastern, central, and southern African countries. The woodlands cover an area of roughly 2.7 million square kilometres and sustain a population of about 40 million people (Desanker *et al*. 1997). Many traditional areas used for agriculture in Tanzania have been greatly degraded, forcing herders to find new fertile land (Jew 2007). The Kilombero Valley in south-east Tanzania has been greatly affected by the movement. The Valley is an attractive alternative with abundant grassland and all year round water supply, ideal for farming practices (Gichohi *et al*. 1999). In the Morogoro region, there has been a great increase in burning due to agriculture, illegal timber extraction, poaching and human settlement (Jew 2007). Often, large tracts of grassland and open and closed Miombo woodland are destroyed, removing vital flora and habitat for native animals (Desanker *et al*. 1997). If burning continues at this rate, there is the risk of habitat destruction which can lead to species diminishing in population (Desanker *et al*. 1997). It is of great importance that we learn more about the implications of burning on animals before irreversible changes to species diversity and population occur.

Amphibians are an important but often overlooked component of most terrestrial systems (Channing and Howell 2006). They are great indicators of a healthy ecosystem in an area since they play an important role in the food chain; frogs, lizards and snakes are an important predator of invertebrates while being preyed on by a wide variety of animals including birds and small mammals (Channing and Howell 2006). Habitat alteration and destruction is the single most important threat to east African amphibians (Channing and Howell 2006). Most amphibians rely heavily on moisture to survive, thus dramatic changes in the environment and habitat, like burning, could have serious consequences on amphibian populations. Reptiles have a dry waterproof skin, enabling them to stay active in dry times and areas where most amphibians will not thrive (Spawls *et al*. 2002). As ectotherms, they need to bathe in the sun to to maintain a regular temperature. Burning will remove canopy cover allowing more sunlight into closed habitats; this may greatly influence lizard thermoregulation, as well as causing changes to food abundance and refuge availability. However, the nutrients of the burnt ground support a high density of insects; this will undoubtedly increase reptile and amphibian populations since it is their major food source (Spawls *et al*. 2002).

The study aims to investigate the impacts of burning on reptile and amphibian communities and the affects of the different habitats of grassland and miombo woodland on species diversity and abundance. A change in food availability, temperature and overall loss of habitat is likely to affect the community structure of the taxa. Insect populations on burnt ground will be evaluated as they form the major food source of the taxa in question. Assessing the impact of vegetation change throughout the dry and wet season will be necessary to collect accurate data. It is hypothesised that reptile and amphibian species adaptable to disturbed areas will flourish on burnt ground due to the increased food source, while more sensitive species will diminish.

4.2 Methods

Study area

The Kilombero Valley is situated in southern central Tanzania, in the Morogoro Region, lying within the Kilombero and Ulanga Districts. The Kilombero Valley floodplain is the largest (796,735 ha) seasonally freshwater lowland floodplain in East Africa and was designated as a Ramsar site in 2002 due to its international, national and regional importance for ecology and biodiversity of wetland birds (Bonnington 2007). The study site for this project is located south of the Kilombero River, near the village of Mavimba. The area is set in a seasonal flooding valley making it extremely fertile land in the dry season. The 100 m x 100 m area was burnt at the end of May 2009, suspected to be by the Wasakuma tribe for agriculture. The land is owned by Igombiro village.

Field methods
The field work began in early August and will be concluded in early December 2009 to cover the dry season and short rainy season in November. Two pitfall lines were placed at the site. One six-bucket line led into Miombo woodland, (37L 0250947 UTM 9072420), while the other led into grassland (37L 0250927 UTM 9072370). The bucket lines were 50 metres apart. A drift fence was dug between the traps to increase capture rate. The fencing was dug 3 cm underground to avoid animals, especially lizards, burrowing underneath. Captured individuals were identified to at least genus level. Reptiles and amphibians will be identified to species level where possible.

Vegetation point transects will be conducted on each site in the dry and wet season. The point transect will be placed 5 metres apart to avoid data collection on disturbed area. The following data will be collected: canopy cover, canopy height, % grass, shrubs, leaf litter, bare ground, burnt ground, dead wood, wind exposure and slope.

4.3 Preliminary results

This study will continue next phase, after which a detailed analysis of all results collected from August to December (encompassing a dry and wet season) will be conducted. However, preliminary results are discussed below.

Trapping success this phase was low, with a total of nine captures across both sites, of which only four were reptiles or amphibians. All herpetofauna captured were identified to at least genus level, and comprised one common squeaker frog (*Arthroleptis stenodactylus*), a Cape Dwarf Gecko (*Lygodactylus capensis*) and two puddle frogs (*Phrynobatrachus spp.*).
It is important to note that this phase lay in the dry season, which has been reported to have been preceded by a wet season which had a lower average rainfall than usual. This may account for the low capture rate for amphibians, many of which depend upon adequate water availability throughout much of their lifecycle. Indeed, the common squeaker is less reliant on water than many other amphibians, laying their eggs in damp leaf litter (Stewart, 1967). However, this theory is contradicted by the capture of the puddle frog, which is described as aquatic in its lifestyle (Stewart, 1967).

With the onset of the wet season in November, it is expected that capture rate will increase in the next phase of research. After this data is collected, a thorough analysis of reptile and amphibian community responses to burning and habitat type will be conducted.

5. FEEDING ECOLOGY OF RETZ'S HELMET-SHRIKE AND THEIR ASSOCIATED SPECIES

Principal Investigator: Thomas Appleby

5.1 Introduction

Itinerant mixed-species flocks of birds have been reported from most parts of the world, achieving great taxonomic and ecological variety in tropical regions. The adaptive value of mixed flocking has usually been attributed to anti-predator effects, aids to foraging, or both (Morse 1970; Krebs 1973; Croxall 1976.)

Retz's helmet-shrike *Prionops retzii,* occurs in small flocks that are widespread but only locally common in a variety of woodland from sea-level to 1900 m. The flocks are mobile and are often part of a larger mixed flock (Stevenson & Fanshawe 2002). Other species often present include common scimitarbill, *Phoeniculus cyanomelas,* fork-tailed drongo, *Dicrurus adsimilis,* African golden oriole *Oriolus auratus,* African black-headed oriole *Oriolus larvatus,* black cuckoo-shrike *Campephaga flava* and white-breasted cuckoo-shrike *Coracina pectoralis* (*pers. obs*.). There is a general paucity of information regarding the flocking behaviour of these species.

The aim of the project is to study the feeding ecology of the Retz's helmet-shrike and establish why certain species regularly associate with them. This will facilitate the production of a one kilometre squared grid illustrating any flock movement patterns and locations of favoured trees. This information may help to illustrate species' habitat preferences on a larger scale. It is hypothesized that Retz's helmet-shrike flocks lead other species of bird in mixed species flocks and that the Retz's helmet-shrike has a preference for certain tree species and perhaps individual trees.

5.2 Methods

5.2.1. Study area

Situated in the Morogoro Region of south-central Tanzania, the Kilombero Valley is between the Udzungwa Mountains (2400 m.a.s.l.) to the north and the Mahenge Mountains to the south. Surrounding the floodplain are transitional wooded grasslands that extend into extensive miombo woodland. Sayari Camp (37L 0251815 UTM 9072451) is situated in the miombo woodland, which is a *Brachystegia* dominated, fire-sustained sub-climax ecosystem found throughout East Africa. This area of pristine open miombo woodland in rolling hills is interspersed with low lying marsh dominated by razor grasses and strips of evergreen forest along numerous watercourses.

5.2.2. Field methods

Surveys will be conducted for up to one hour as and when the Retz's helmet-shrike are present, with or without associated species, and will be located in or around Sayari Camp. A total of four surveyors will be required; each will be assigned a species to study and record certain aspects of their behaviour. All surveyors will be trained on bird identification and distance estimation beforehand. Surveys will be conducted on an opportunistic basis due to the highly mobile nature of the flock. When the flock is sighted, the surveyors will note the time, number of individuals in each species, and the leading and trailing species. The surveyors will also note changes to the general direction from whence the flock came and where they were bound, along with any significant changes in direction and the time of the course alteration.

The tree species in which each bird species is feeding will be noted, together with the zone of feeding; trunk, base of the canopy, mid-canopy or top of the canopy. The canopy is defined as the main foliated section of the tree. To assess the potential influence of termites as a food source, the presence or absence of their mounds up to two metres from the base of the tree in which birds are feeding will be recorded. Evidence of termite activity on the trees will also be noted even if there is no mound up to and including two metres from the base of the tree. Provided the flock will not be disturbed, surveyors will inspect the substrate at the base of the tree if birds are seen feeding on the ground.

Preliminary surveys suggest that the species that most frequently flock together employ different methods to acquire food. Feeding techniques will be categorised as follows; A) sitting on a branch pecking at the bark or leaves, B) hanging or hopping along the branch probing cracks and holes, C) aerial hunting or snatching from a branch or trunk, D) another technique not listed. Any unusual items of food identifiable and the method by which it is acquired and subdued will also be recorded. For subsequent analysis, trees visited by the flock will have their coordinates noted with the aid of a GPS (Global Positioning System).

5.3 Preliminary Results

The species that most frequently associated with Retz's helmet shrike were common scimitarbill, black-headed oriole and fork-tailed drongo. Other species that were often associated with Retz's helmet shrike include cardinal woodpecker (*Dendropicos fuscescens*), black-backed puffback (*Dryoscopus cubla*), grey-headed bush shrike (*Malaconotus blanchoti*), white breasted cuckoo shrike and black cuckoo shrike (*Campephaga flava*).

The Retz's helmet-shrike was always the lead species in the flocks and common scimitarbill was most frequently the trailing species. When foraging, the main techniques employed by the Retz's helmet-shrike were hopping or sitting on the branch and pecking at prey on the bark or aerial hunting from a perch in the canopy. They sat and observed an area closely from a short distance then attacked. The Retz's helmet-shrike would also observe prey, then swoop from a perch and pluck prey from the trunk or underside of a branch whilst hovering briefly. The common scimitarbill hung upside down, underneath or hopped along the branch probing cracks or holes due to its greater agility. This enabled the species to access all areas of the tree and it was frequently observed hanging on the underside of branches probing cavities. The common scimitarbill searched frequently low down on the trunk and vegetation at the base of the tree. Where present, the common scimitarbill probed clusters of leaves and other potential refuges.

Results suggest the mixed flocks including Retz's helmet-shrike visit particular trees repeatedly, mainly within the genus *Brachystegia*. This also applies to the small single-species flocks of Retz's helmet-shrikes. The Retz's helmet-shrikes most frequently foraged in the zone from the base to the top of the canopy. Associated species also fed in the canopy, other zones of the same tree or in vegetation in close proximity. There were particular trees after which the flock changed their direction of foraging.

5.4 Preliminary Discussion

These results suggest that the mixed species flock is led by the Retz's Helmet-shrike. The Common Scimitarbill is able to search a tree or bush in a more thorough fashion owing to its agility and dexterous bill. Due to this ability to access all areas of the tree, the Common Scimitarbill tended to spend longer searching for food in a particular tree and was most often the trailing species.

Brachystegia is a very important source of food for the Retz's Helmet-shrike and its associated species. Individual trees were incorporated into the foraging routes of the Retz's Helmet-shrike repeatedly and every specimen was of the *Brachystegia* genus.

The study will be replicated during the 094 phase. There is a strong possibility that the numbers of Retz's Helmet-shrike and daily movements may decrease and alter during the 094 phase, to be replaced by White-crested Helmet-shrike, *Prionops plumatus* (Ngasamo pers. comms.). If this is true, the 093 study will be replicated with the emphasis on White-crested Helmet-shrikes. The same lines of enquiry will be followed, with further investigation into comparing the feeding ecology of the two closely related species. The GPS coordinates of the trees will be overlaid and compared, within the one kilometre squared grid they visit, to see if there is repetition and if they are the same trees as the Retz's Helmet-shrike visited.

The last week of 093 Retz's Helmet-shrike surveys revealed signs that the flocks of Retz's Helmet-shrike were dispersing. The birds are not sexually dimorphic, but perched birds were seen displaying to other stationary birds. This may indicate the onset of the breeding season and could be a reason for the dispersal of the Retz's Helmet-shrike. Further study of reference material on their behaviour will hopefully assist in adding substance to these suppositions.

6. THE EFFECT OF HUMAN DISTURBANCE ON LARGE MAMMAL ABUNDANCE AND DIVERSITY

Principal investigator: Sarah Becker

6.1 Introduction

As stated in section 3.2, the Kilombero Valley hosts a high floral and faunal biodiversity and supports an elevated abundance of large mammals. Human presence is increasing in the valley due to the fertile soils. Historically, there has been low human population density in the valley. In 092, Holly Chub studied the effect of human encroachment for her BTEC project and FTSRP continued this project in 093. FTSRP has been carrying out research on large mammal populations in the Kilombero Valley for over 11 years and is currently located in pristine miombo woodland close to the border of the Selous Game Reserve. However, areas close to human settlement remain relatively under-studied. This survey looked at an area to the west of FTSRP's main study sites, close to the village of Lupiro. The effect of distance to village was compared to large mammal abundance to determine the effect human disturbance has on various large mammal species.

6.2 Methods

This study began in 092, at which point ten large mammal transects were set up on the east side of Lupiro village (Figure 11). They were placed in two lines 500 m apart all running north to south. Transects were 200 m in length and all large mammal signs (tracks, paths, diggings, faeces, evidence of feeding and burrows) within one metre either side of the transect line were recorded. The transect line was divided into 20 m sections and signs were not recorded more than once in each section. Game guards confirmed all sign identification. Any significant human disturbance or change in habitat was noted.

The study continued in the 093 phase and vegetation and human disturbance data were collected. Vegetation characteristics were recorded every 20 metres using a 5 by 5 metre quadrant. The following information was recorded: % canopy cover; canopy height; % grass; % shrubs <1m; % shrubs 1<3m; % bare ground; % dead wood; % leaf litter (as a percentage of bare ground); and % burnt ground.

To monitor human disturbance along each transect, the ratio of cut trees to live trees was recorded. Within each 20 metre section, the number of live, naturally dead, old cut and new cut poles (diameter 5 -15 cm) and timbers (diameter >15 cm) was counted five metres either side of the transect line.

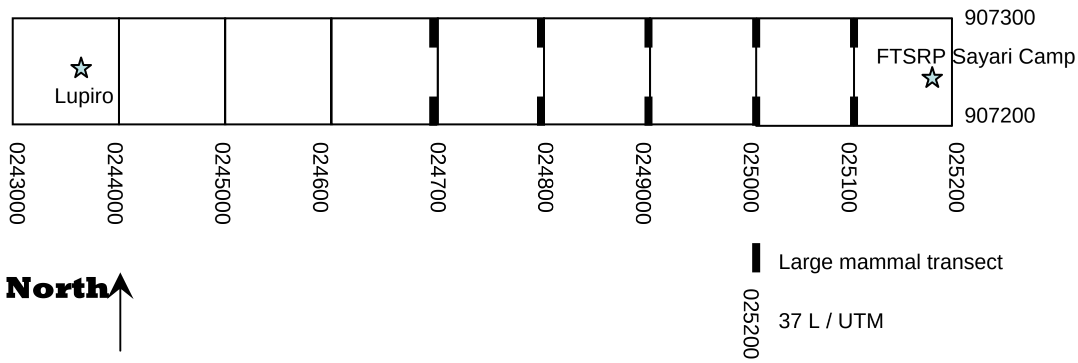

Figure 11. Location of large mammal transects in relation to Lupiro and FTSRP Sayari Camp.

6.3 Results

Twenty-two species of large mammal were recorded over the ten transects including domestic cow, domestic dog and domestic goat. Both the Bohor reedbuck *(Redunca redunca)* and the southern reedbuck *(Redunca arundinium)* are referred to as 'reedbuck'. The ranges of these two species overlap in southern Tanzania and they cannot be distinguished by spoor. Similarly, 'duiker' refers to the common or bush duiker (*Sylvicapra grimmia*), the blue duiker *(Cephalophus manticola)*, and Harvey's duiker *(Cephalphus harvevi),* all of which may be present in the study area and cannot be distinguished by spoor. 'Mongoose' was used for any mongoose species excluding the water mongoose *(Atilax paludinosus)*. "Genet" includes the common, *Genetta genetta*, and blotched, *Genetta tigrina* genet.

Table 5: Species whose spoor was observed on large mammal transects

Aardvark	*Orycteropus afer*
Baboon	*Papio anubis*
Buffalo	*Syncerus caffer*
Bush pig	*Potamochoerus porcus*
Bushbuck	*Tragelaphus scriptus*
Cane rat	*Thryonomys swinderianus*
Dik dik	*Mardoqua*
Duiker	*Sylvicapra* spp.
Elephant	*Loxodonta africana*
Genet	*Genetta sp.*
Scrub hare	*Lepus saxatilis*
Hartebeest	*Alcelaphus buselaphus*
Mongoose	Herpestidae
Crested Porcupine	*Hystrix cristata*
Reedbuck	*Redunca* spp.
Sable	*Hippotrgus niger*
Warthog	*Phacochoerus aethiopicus*
Waterbuck	*Kobus ellipsiprymnus*
Zebra	*Equus grevyi*

In 092, there was no clear relationship between spoor abundance and distance to village. In 093, there was a positive relationship between the abundance of spoor and the distance from the village. We found more spoors of wild animals farther from Lupiro than closer to Lupiro (Figure 12). FTSRP's large mammal monitoring program (Section 3.3.3), suggests that the five most common large mammals are buffalo, bushpig, duiker, elephant and waterbuck. In the monitoring section, all five of these mammals increased in abundance between 092 and 093 (see Section 3.3.3, Figure 4) and the average increase of the five mammals was 0.22 spoors / section between 092 and 093. In the Lupiro LMTs, the abundance of bushpig, duiker and elephant spoor generally increased with increasing distance from the village (Figure 13). Waterbuck and buffalo were not as common close to the village. During 093, there was a negative effect of cattle abundance on buffalo and waterbuck abundance (Figure 14). In 092, only three cattle spoor were observed in the study. The abundance of uncommon antelope species (Bushbuck, dik dik, hartebeest, reedbuck and sable) decreased during the dry season, but the pattern of abundance across distances to the village did not change between seasons (Figure 15).

While walking to and from these LMTs, several new farms and permanent human habitations were observed. Hectares of trees were cut down during the two weeks of data collection to make way for crops and cattle grazing. Villagers constructed at least five permanent houses and had begun planting crops. FTSRP informed an Ulanga district authority on 8 September who promised to investigate this illegal farming.

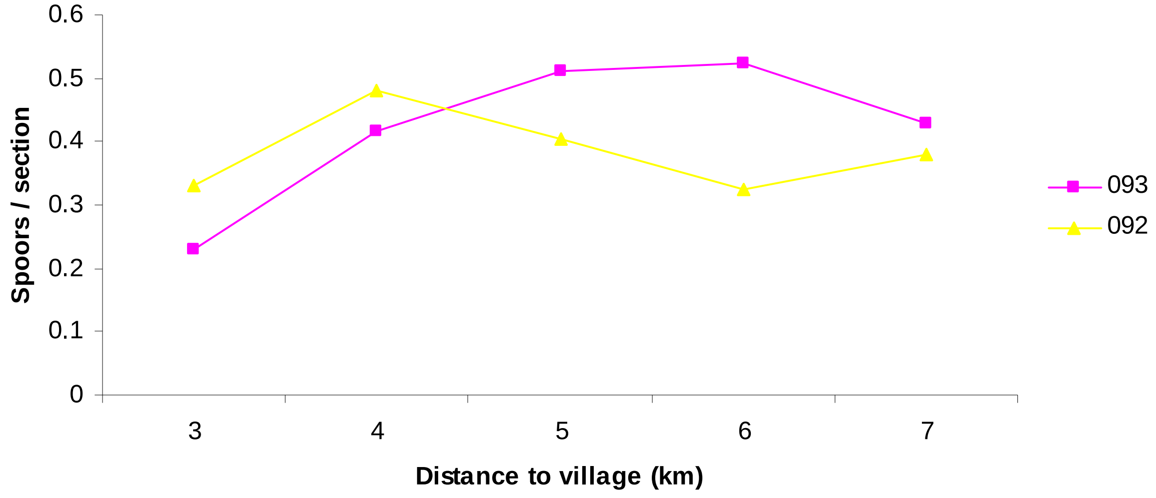

Figure 12: Comparison of the abundance of large mammal spoors between 092 and 093

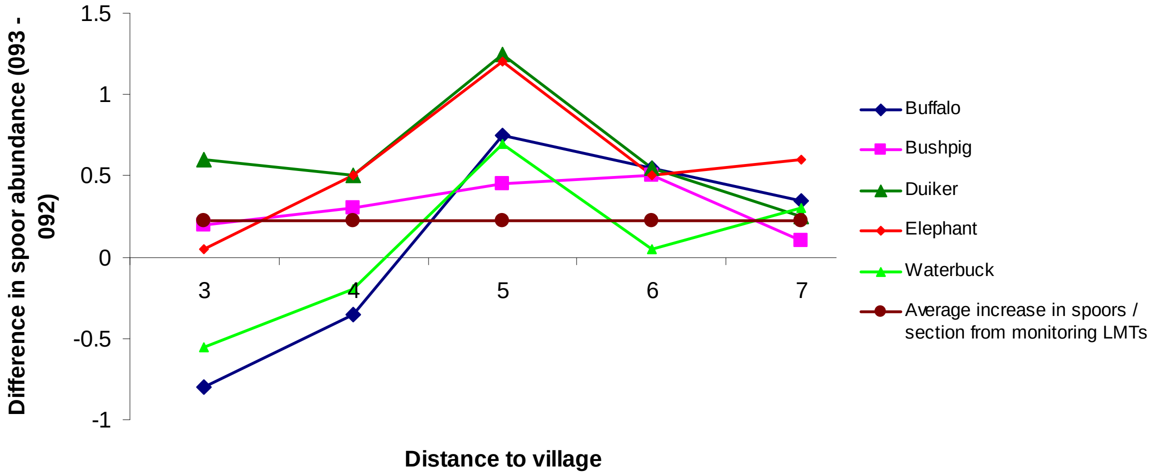

Figure 13: The difference in spoor abundance (093 – 092) of the five most common large mammal species in relation to distance to a village. The brown line represents the average increase from the monitoring LMTs.

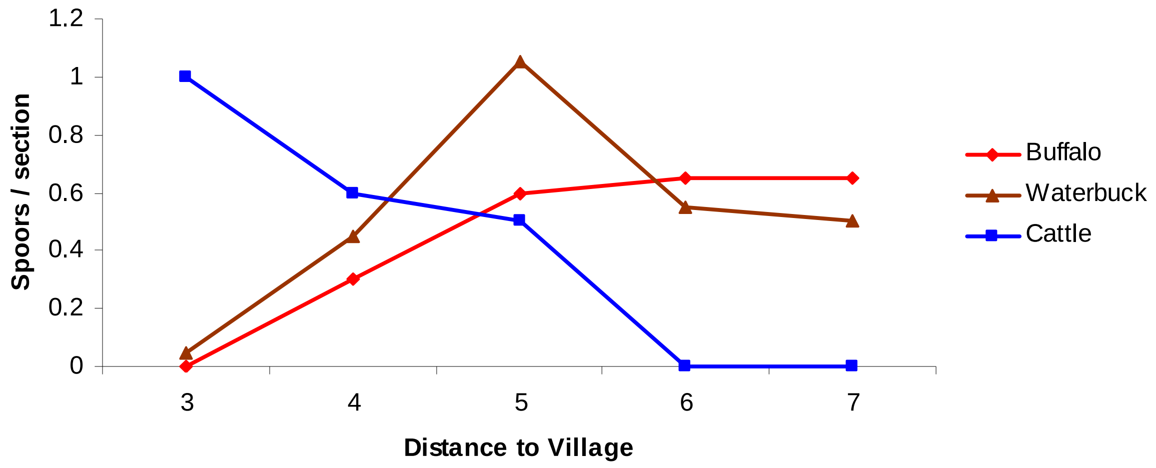

Figure 14: The effect of cattle on buffalo and waterbuck abundance in 093.

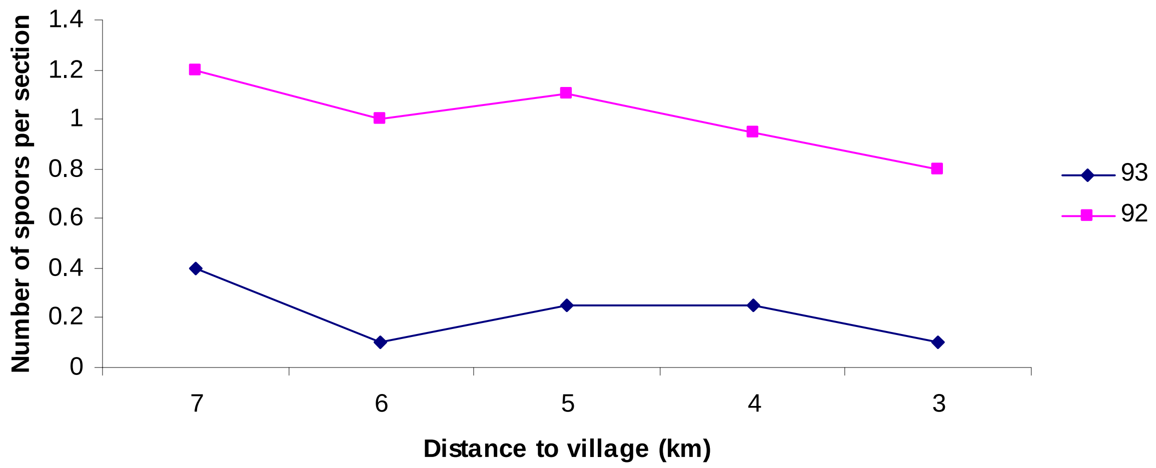

Figure 15: The effect of distance to village on uncommon antelope species (Bushbuck, dik dik, hartebeest, reedbuck and sable).

6.4 Discussion

Increasing human encroachment is threatening large mammal populations in the Kilombero Valley. This study used large mammal transects to assess the effect of village distance on large mammal abundance during the 2009 wet and dry seasons. During the wet season, there was no clear relationship between large mammal abundance and distance to village. However, during the dry season, buffalo and waterbuck abundance decreased on transects closer to a village even though large mammal abundance increased in the pristine woodland surrounding the study site. This pattern may be explained by the dramatic increase in cattle abundance on transects close to the village. Elephant, bushpig and duiker abundance was not affected by distance to village, suggesting these animals are tolerant of cattle presence.

Intense use of an area by cattle may limit the large mammal diversity of an area. After a herd of cattle come through an area, little forage remains and the under story is trampled (pers. obs.). Buffalo and waterbuck both rely on grass and small shrubs for foraging (Kingdon 2001) and hence may be out competed by cattle for sufficient food. The preferred feed of duiker, elephant and bushpig do not overlap with cattle to such an extent. Duiker feed on the leaves and fruits of bushes or trees; elephants browse bushes and trees; bushpigs prefer roots and tubers (Kingdon 2001). Furthermore, local farmers frequently cite bushpig and elephant as crop-raiders (*pers. obs*). The greater tolerance for cattle and the benefits from crop-raiding may explain the continued presence of bushpig, duiker and elephant near villages.

Uncommon antelope species greatly decreased in abundance in 093 compared to 092. Antelopes generally increased in abundance in the project monitoring large mammal abundance in natural woodland (Section 3.2.3, Figure 7). Possibly, these antelope are more sensitive to human presence and avoid areas undergoing conversion to cultivation.

It will be interesting to observe the effect of informing the district office has on illegal grazing and cultivation in the area. If cattle grazing and farming continue, human disturbance will likely push farther east towards the natural woodland surrounding FTSRP base camp. The removal of large mammal habitat is expected to restrict large mammal ranges, forcing species to inhabit smaller areas of undisturbed habitat and bringing increased competition for resources.

7. THE EFFECTS OF THE KVTC SAWMILL SITE ON LARGE MAMMAL MOVEMENT

Principal Investigators: Richard Saunders-Irving, Chloë Haigh and Sarah Becker
This investigation was commissioned by KVTC.

7.1 Introduction

The Kilombero Valley covers an area of 6,650 km^2 and is situated between the Udzungwa Mountains National Park to the north and the Selous Game Reserve to the southeast. It is the largest freshwater wetland in East Africa and is listed as a RAMSAR site. This area contains 70% of the world's remaining puku antelope (*Kobus vardoni*), and supports large populations of large mammals. At the edges of the flood plain, fragments of eastern arc forest and extensive areas of miombo woodland create a mosaic pattern which helps makes the valley an important area for biodiversity, particularly large mammals.

The area is also important for people. It is extremely fertile due to the seasonal flooding of the Kilombero River which allows subsistence farmers to grow many crops. Businesses are also interested in the area; sugar cane plantations are located in the north and Kilombero Valley Teak Company (KVTC) is located in the south. Both subsistence agriculture and commercial growth are causing increases in habitat loss, human-wildlife conflict and land degradation.

KVTC was set up in 1992 by the Commonwealth Development Corporation with the aim of creating an environmentally sustainable hardwood forestry project with teak plantations arranged in a mosaic between natural forests and other natural vegetation. KVTC leased an area of 28,159 ha for this purpose. As of 2009, approximately 30% of the land had been converted into teak plantations. The company is presently undergoing certification from the Forestry Stewardship Scheme. The first stand of teak is now reaching maturity and is ready to be felled, cut and processed into flooring. KVTC built a sawmill and factory near the village of Mavimba (Ulanga District) for this purpose. The sawmill is on a 100 hectare site which consists of factories to cut and process the teak, as well as accommodation and offices for the employees. An electric fence surrounds the site to keep people and animals from entering the site.

Frontier Tanzania Savannah Research Programme (FTSRP) has been carrying out research in the Kilombero Valley since 1998 and a large part of this work has been pre-felling surveys and monitoring of plantations for KVTC. Before the sawmill site was picked by KVTC, an Environmental Impact Assessment was conducted in the area with FTSRP carrying out the large mammal survey. FTSRP is now based 10 km from Mavimba and have been monitoring large mammal populations in the area for the last 18 months. It will be of mutual interest to KVTC and FTSRP to quantify the effect the sawmill site has on large mammals.

The aim of this project is to obtain information on the movement of large mammals around and through the electric fence surrounding the sawmill site. KVTC will use this research as baseline data for continued monitoring purposes around the site and to aid in management plans. It was expected that the only large mammals crossing the fence are those able to fit under or go over the fence. The study was also to find evidence of a large baboon population as KVTC had said baboons were present in and around the site. A greater number of mammals and species were also expected farther from the sawmill site because most large mammals tend to avoid human disturbance.

Transects were laid to achieve the following:

- Assess which large mammal species cross the electric fence, how they cross and what percentage of species turn back or walk along the fence rather than cross it.
- Establish whether the fence deters certain animals from inhabiting the surrounding landscape.
- Determine the closest distance to the fence species of large mammals approach.

7.2 Methods

Twenty-one large mammal transects (LMTs) were completed. These were broken down into six LMTs on the outside of the electric fence surrounding the site, six on the inside of the fence, three within the sawmill site and six in the area surrounding the sawmill site in a relatively pristine area.

For each LMT, all large mammal tracks and signs (tracks, dung, paths, diggings, burrows and feeding sites) were recorded within one metre of the transect. As there exists a two metre wide patch of cleared ground either side of the fence, all tracks and signs in this area were recorded in LMTs along the fence. Game guards confirmed all track identifications. Each transect was divided into 20 metre sections and, for LMTs conducted away from the fence, signs were only recorded once per species within each of these sections. For transects along the fence, species signs were recorded more than once per section if the game guard was confident they were made by different individuals. This was possible due to the ground being cleared and allowed for each individual's reaction to the fence to be recorded.

Vegetation characteristics were recorded every twenty metres using a 5 by 5 metre quadrant. The following information was recorded for each quadrant: percentage canopy cover; canopy height; percent grass; percent shrubs <1m; percent shrubs 1<3m; percent bare ground; percent dead wood; percent leaf litter; and percent burnt ground. A general description of the area was also recorded.

LMTs were conducted along the electric fence to record how the large mammals reacted to the electric fence. These transects were 200 metres long. Six transects on the inside of the fence were distributed alternatively with six on the outside giving even coverage around the fence. On these LMTs, all tracks where classified into one of four categories: the individual walked along the fence, the individual went into the site through the fence, the individual travelled out of the site, or the fence deterred the individual.

Three LMTs were conducted inside the site in the residential area to determine which large mammal species are present inside the sawmill site. These were only 100 metres in length due to the limited amount of untouched vegetation.

Finally, six LMTs were conducted outside the sawmill site on the eastern side to assess what large mammals are present in the area and how close they are coming to the sawmill site. Two transects were 500 metres away from the site, two transects were 1000 metres and two transects were 1500 metres away from the fence. Transects were 200 metres in length and ran north to south. The eastern side is composed predominantly of thicket and miombo habitat. The western side has largely been converted to farmland.

7.3 Results

Large mammal activity around the sawmill site is higher than expected. A total of 15 different species were recorded during this survey. Ten species were found in the thicket surrounding the sawmill site and five species were found within the site. Ten species interacted with the fence by crossing it, moving along it or being deterred by it.

Tracks were not found of any species around the fence that did not cross it, suggesting that all large mammal species recorded encountering the fence can cross the fence (Table 6). Very few individuals turned away from the fence. Rather, the large mammal will search the fence for a suitable place to traverse to either enter or exit the sawmill site. Furthermore, the majority of tracks were found along the fence bordering the thicketed, eastern side of the sawmill site (Figure 16).

Table 6: Number of individuals interacting with the fence and the mode of interaction

Species	Travelling	Crossing the	Crossing the fence	Turning

	along fence	fence and going into site	and going out from the site	away from fence
Yellow baboon *Papio cynocephalus*	8	6	1	0
Bush pig *Potamochoerus larvatus*	21	13	11	2
Bushbuck *Tragelaphus scriptus*	5	0	1	0
Civet *Civettictis civetta*	1	1	0	0
Dik dik *Madoqua kirkii*	9	11	14	1
Duiker *Silvicapra grimmia*	18	17	6	1
Mongoose Herpestidae	3	2	0	0
Vervet monkey *Cercopithecus (a.) p. rufoviridis*	2	4	2	0
Water mongoose *Atilax paludinosus*	0	1	0	0
Warthog *Phacochoerus africanus*	9	7	0	1

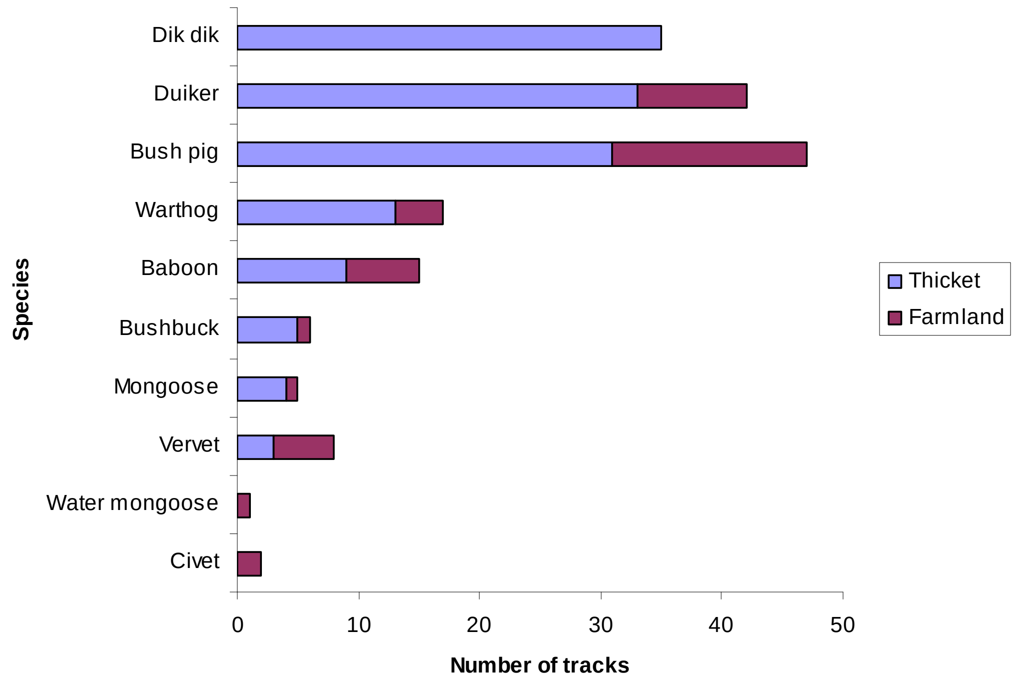

Figure 16: Number of tracks observed along the fence bordering thicket or farmland.

Bush pig, duiker and dik dik were the most abundant tracks found. All three species cross the fence more often than travelling along the fence. Warthog moved along the fence more frequently than crossing it. There was also one individual recorded to move away from the fence. Warthog can and do traverse the fence but due to their size, this is only achieved by force. Baboon also showed a greater movement along the fence than crossing it. However, baboon crossed the fence in high numbers and we found evidence where a troop of baboons burrowed under the fence. However, this site was not within an LMT. Bushbuck was the tallest mammal found to cross the fence, although there is only one individual found to be doing this on the LMTs. However, we found a track inside the fence, not on an LMT. There was no evidence of elephant, reedbuck and waterbuck in the LMTs along the fence.

For each LMT, all large mammal tracks and signs (tracks, dung, paths, diggings, burrows and feeding sites) were recorded within one metre of the transect. As a two metre wide patch of cleared ground was present on either side of the fence, all tracks and signs in this area were recorded in LMTs along the fence. Game guards confirmed all track identifications. Each transect was divided into 20 metre sections and, for LMTs conducted away from the fence, signs were only recorded once per species within each of these sections. For transects along the fence, species signs were recorded more than once per section if the game guard was confident they were made by different individuals. This was possible due to the ground being cleared and allowed for each individual's reaction to the fence to be recorded.

Vegetation characteristics were recorded every 20 metres using a 5 by 5 metre quadrant. The following information was recorded for each quadrant: percent canopy cover; canopy height; percent grass; percent shrubs <1m; percent shrubs 1<3m; percent bare ground; percent dead wood; percent leaf litter; and percent burnt ground. A general description of the area was also recorded.

LMTs were conducted along the electric fence to record how the large mammals reacted to the electric fence. These transects were 200 metres long. Six transects on the inside of the fence were distributed alternatively with six on the outside giving an even coverage around the fence. On these LMTs, all tracks where classified into one of four categories: the individual walked along the fence, the individual went into the site through the fence, the individual travelled out of the site, or the fence deterred the individual.

The electric fence did not deter most species from the area surrounding the sawmill site (table 7). Elephant was the only species which increased in abundance in LMTs farther from the electric fence. Waterbuck and reedbuck use the area surrounding the sawmill site, but do not approach the fence. More mongoose and aardvark tracks were found closer to the electric fence, suggesting that human habitation may attract these species. Alternatively, larger animals and possible predators or competitors of mongoose and aardvark may be excluded, resulting in a relative increase in the abundance of these species near the sawmill site.

Table 7: Numbers of tracks of species in area surrounding sawmill site at various distances. Each distance had two 200m transects.

Species	500 metres away	1000 metres away	1500 metres away

	from fence	from fence	from fence
Aardvark	6	0	0
Baboon	2	0	3
Bush pig	10	17	13
Dik dik	1	4	3
Duiker	14	17	13
Elephant	6	14	10
Mongoose	4	3	1
Porcupine	1	1	0
Reedbuck	0	0	3
Waterbuck	2	1	1

Table 8: Number of tracks of species within the sawmill site (Three 100m transects).

Species	Number of tracks within sawmill site
Baboon	10
Bush pig	10
Dik dik	1
Porcupine	6
Warthog	3

7.4 Discussion

All species found near the fence crossed it either by burrowing under it (baboons), breaking through it (warthog) or by some other means. More tracks were found along the fence bordering the thicketed eastern side, suggesting that the farmlands on the western side support few animals wanting to cross the fence. Finally, the fence does not appear to deter wildlife from the area surrounding the sawmill site.

Most mammal tracks found along the fence were within the area of thicket on the eastern side. Warthog are generally an open-plain specialist and to find them in the thicket is unexpected. Although this area is relatively undisturbed, it is dense thicket, a habitat usually avoided by this species. Baboon and bushpig tracks were still found along the fence bordering the farmland which is not surprising as bushpigs and baboons are both known for crop raiding and have little fear of human activity. We found fewer baboons than expected, which may be explained by their partially arboreal lifestyle.

The results suggest there is a healthy population of elephants using the area and the population has not been affected by the building of the sawmill site. Signs of elephant were found in a high abundance on all LMTs in the surrounding area and elephant faeces were found 50 m from the fence. There were many elephant paths going towards the site which ranged from six months old to two weeks, yet none intersected with the fence, suggesting that elephants recognise the fence perimeter and limitations.

Antelope species differ in their reaction to the fence. Dik dik and duiker cross the fence easily and duiker are common in the thicket surrounding the site. Bushbuck can cross the fence, but are rare in the area. Waterbuck use the thicket surrounding the fence but do not approach the fence. This could be due to the waterbuck being aware that they cannot cross the fence or noise from the sawmill site distressing them. Reedbuck tracks were found on a transect within open grassland 1.5 km away from the fence.

In conclusion, the electric fence appears to be successful in prohibiting elephants and other destructive mammals from entering the sawmill site. Common pest animals such as baboons and bushpig are not deterred by the fence, but extreme means would be necessary to permanently prohibit their movement into an area. Additionally, the fence does not deter large mammals from using the pristine area surrounding the sawmill site.

8. A PILOT STUDY TESTING THE USEFULNESS OF FRESHWATER INVERTEBRATES AS INDICATOR SPECIES IN MIOMBO WETLANDS

Principal investigator: Mikis Bastian

8.1 Introduction

The biological quality of ecosystems can be assessed by a variety of different organisms and has a long history and associated literature (Iliopoulou-Georgudaki *et al.*, 2003). The advantages of biological indicators are manifold: bio-indicators integrate the effects of different environmental stresses and provide a much broader measure of their impact (Iliopoulou-Georgudaki *et al.*, 2003), include information about the environment over time, as opposed to chemical and physical tests, which only give punctual information (Testi *et al.*, 2009), and are reliable and relatively inexpensive.

Benthic macro-invertebrates are one of the best-understood and most commonly used bio-indicators for freshwater ecosystems. They play a major role in aquatic food webs (i.e. grazers, decomposers, prey items), have a long life span and are widely distributed within all major habitats (Ahmad *et al.*, 2002; Picker *et al.*, 2002). Macro-invertebrates are relatively large (visible to the naked eye), easy to identify and changes in the macro-invertebrate community have been shown to mirror human disturbance around the water (Sahlen & Ekestubbe, 2001) and have good correlations with changes in water quality (Ahmad *et al.*, 2002).

The majority of these studies, however, have been conducted in temperate streams of the Northern Hemisphere, and very little information is available for tropical systems (Boyero, 2000). Data deficiency, especially for tropical freshwater ecosystems, has thus excluded the use of many taxa as indicators. Despite the ever increasing pollution and alteration of water bodies due to increases in human populations and farming activities, there are currently no freshwater monitoring networks or biological indicator indices (similar to those available in most temperate zones) in place for most tropical regions.

The aim of this project is to test the usefulness of freshwater invertebrates in assessing the effect of human disturbance on local wetlands. Due to the lack of available data or previous studies in the area, this study provides important baseline data for future studies. Specifically, this study compared macroinvertebrate abundance/diversity and invertebrate community assemblages between relatively pristine and disturbed wetlands along the Lamba River, by carrying out standardised sweeps across all representative microhabitats.

8.2 Methods

The study was conducted in the Kilombero Valley, Morogoro region, Tanzania. Samples of aquatic macroinvertebrates were collected around Sayari Camp (37 L 0251803 UTM 9072438) in wetlands differentially impacted by human disturbances along the Lamba river. The study area is characterised by a mosaic pattern of miombo woodland interspersed with seasonally flooded grasslands and patches of evergreen forest. Miombo is the common name given to *Brachestagia* dominated fire sustained, sub climax woodland, found throughout savannah woodland areas of eastern and southern Africa (Sarkey *et al*, 2002).

The climate of the region is tropical and seasonal with two major wet seasons: a long rainy season from March to May and a much shorter period of rains from November-December. All surveys were conducted from July to October, during the winter dry season, when most streams and rivers stop flowing and are reduced to a series of isolated pools. Macroinvertebrates were sampled along one metre sections of all major microhabitats of the wetlands, using a dip net, covering the entire water column (from surface to substrate). The contents of the dip net were then transferred into large sealable plastic containers and taken back to camp where all samples were preserved in formalin. Invertebrates were then identified to lowest possible level, using Croft (1986) and Picker *et al*. (2002) and invertebrate abundance and diversity calculated per unit area (m^2).

For each wetland sampled, habitat variables, such as extent and structure of the riparian vegetation, substrate composition and average water depth were recorded. The level of human disturbance was estimated by recording all signs of burnings, cuttings, man-made paths/roads, distance to nearest shamba (farm), and signs of livestock grazing and watering. Wetland use by local wildlife was assessed by recording all tracks and signs along the water's edge.

8.3 Results

A total of 959 invertebrates were collected from six sampling sites along the Lamba river. This total comprised 27 different families belonging to 15 orders. This count may be considered conservative as all specimens that could not be identified to family level (i.e. most larvae of Coleoptera and Diptera and water mites) were not included in this count. Table 1 lists all families and their total and relative contribution to the total number of invertebrates collected. Most families belonged to the class of Insecta (16), followed by Gastropoda (3) and Crustacea (2). Of Insecta, the most diverse orders were Hemiptera (7 families) and Coleoptera (3 families). Invertebrate abundance, however, was highly skewed, with most families contributing to less than 5% of the total. The three most abundant families accounted for almost 54% of all invertebrates found; Libellulidae (23.7%), Diptera (19.5%), and Mysidae (10.7%).

As shown in Figure 1, family diversity was highest (19 families) for sampling site 4 (Wet 4) and lowest (6 families) for sampling site 1 (Wet 1). Invertebrate densities (Fig. 18) were relatively low for most sites (average of 130 individuals per m²) but considerably higher for sites 4 and 5 (255 and 258 individuals per m² respectively). Omitting sampling sites 4 and 5, average densities were as low as 66.75 invertebrates per m². The higher densities of these two sites, however, can be attributed to much higher numbers of Libellulidae (for sampling site 4) and Chironomidae (for sampling site 5), rather than an overall increase in densities of all families.

Table 11: Macroinvertebrate families of the Lamba River and their relative contribution to the overall number of invertebrates sampled.

ORDER	Family	Total number of individuals	Overall %
HEMIPTERA	Belostomatidae	1	0.14
	Corixidae	12	1.67
	Gerridae	8	1.12
	Hydrometridae	3	0.42
	Nepidae	2	0.28
	Notonectidae	27	3.76
	Pleidae	9	1.26
DIPTERA	Chironomidae	140	19.52
	Culicidae	7	0.98
EPHEMEROPTERA	Baetidae	29	4.04
	Caenidae	36	5.02
ODONATA	Libellulidae	170	23.71
	Zygoptera (sub-order)	37	5.16
COLEOPTERA	Curculionidae	11	1.53
	Dytiscidae	23	3.2
	Hydrophilidae	38	5.3
	larva (family unknown)	15	2.09
RYNCHOBDELLAE	Glossiphonidae	9	1.26
PULMONATA	Lymnaeidae	4	0.56
	Physidae	26	3.62
PROSOBRANCHIA	Hydrobiidae/Valvatidae	1	0.14
UNIONOIDA	Unionidae	2	0.28
CYRENODONTA	Sphaeriidae	26	3.62
DECAPODA	Grapsidae	1	0.14
MYSIDACEA	Mysidae	77	10.74
ARANEA	Lycosidae	1	0.14
	Salticidae	1	0.14
HYDRACARINA	water mite	1	0.14

Biodiversity, expressed by Shannon-Wiener Index (H), was relatively high and similar for all sites (including the most disturbed site, Wet 9), with the exception of sites 1 and 5, as shown in Figure 20. Sampling site 4, characterized by a high diversity of families (at relatively equal proportions), had the highest biodiversity, while site 1 (with very low family diversity) and site

5 (dominated by Chironomidae and Physidae) had by far the lowest biodiversity, as indicated by their very low Shannon-Wiener index values.

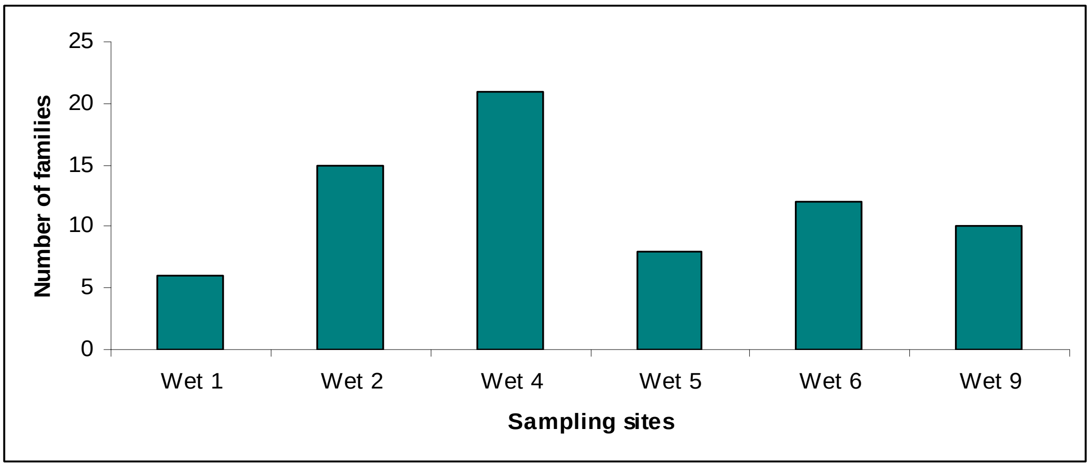

Figure 18: Family diversity of invertebrates along different sites of the Lamba River.

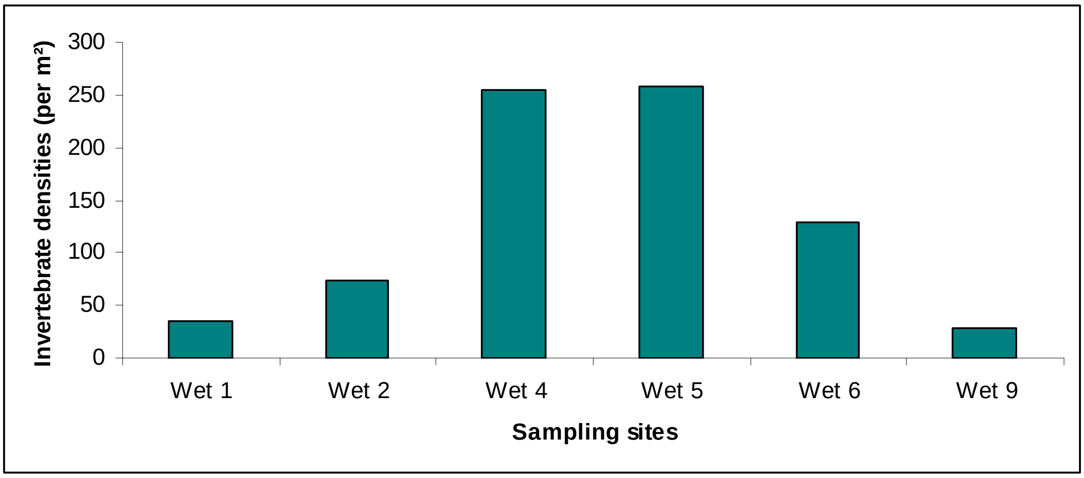

Figure 19: Total invertebrate densities (per m^2) in different sampling sites of the Lamba River.

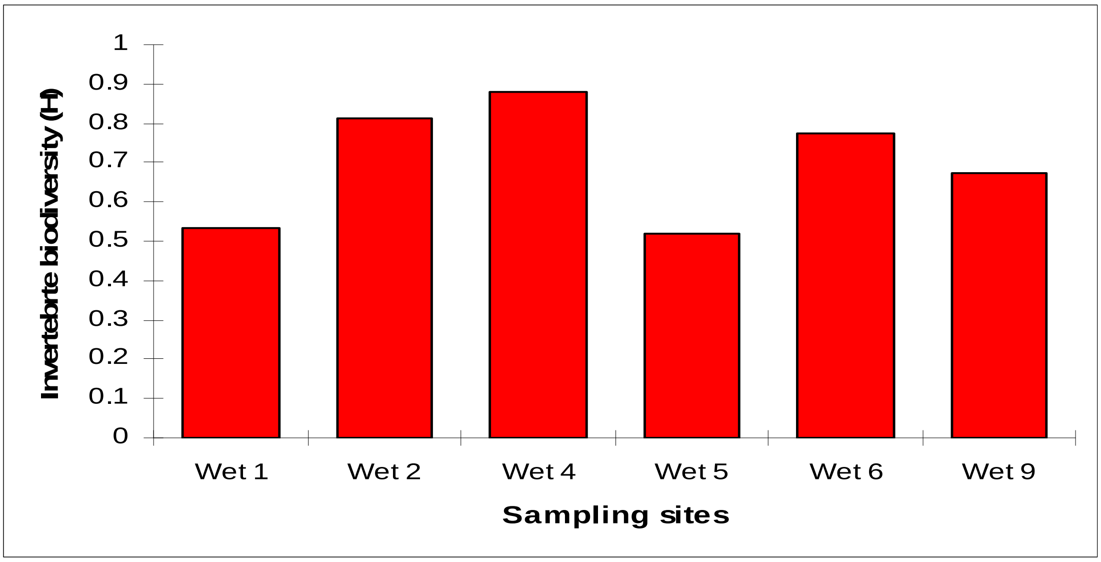

Figure 20: Shannon-Wiener Biodiversity values (H) of invertebrate family diversity for all sampling sites along the Lamba river.

Grouping all invertebrates into feeding guilds (Figure 21) revealed that detritivores were the most abundant group for all sites, followed by the predators. Parasites (all individuals found were in the class Hirudinea - leeches) and filter-feeders (all in the class Bivalvia - mussels) only represented a minor proportion at all sites. All individuals that could not be attributed to one of these groups (i.e. some larva of Coleoptera and Diptera) were grouped together as 'unknown'. The composition of invertebrate communities (based on feeding habits) was very similar for all sites, with predators and detritivores being present at approximately equal proportions. Sites 1 and 5 and the site with human disturbance (Wet 9) however, seemed to show a slight shift towards a more detritivore-dominated community.

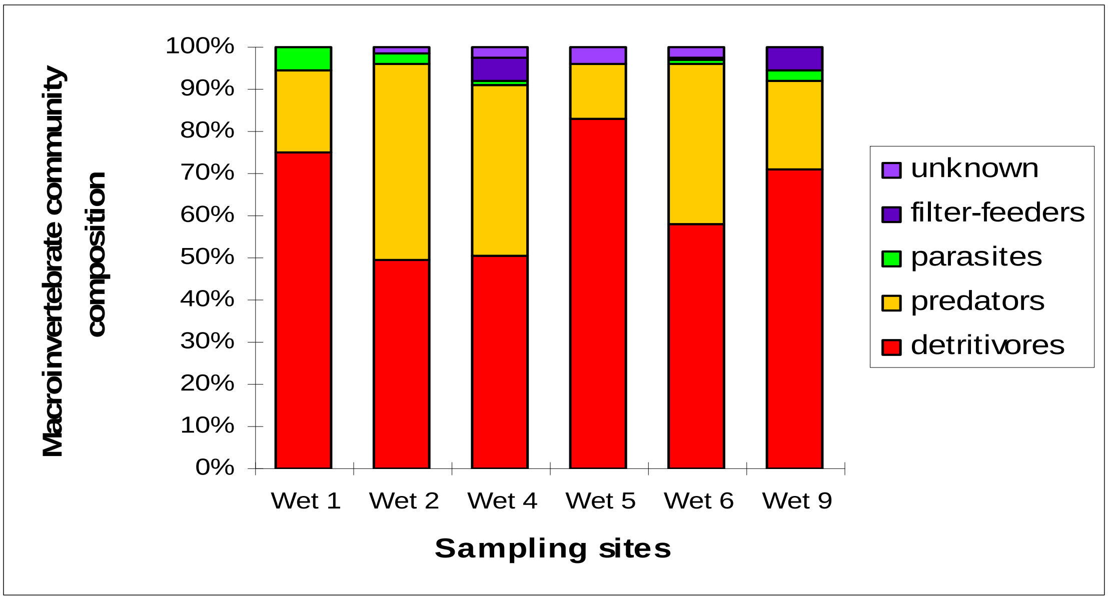

Figure 21: Macroinvertebrate community composition of the Lamba river based on feeding habits.

Furthermore, the predator guild, when analyzed separately (Figure 22), shows that Libellulidae (dragonfly nymphs) are the most common predator (71.3 %) for all undisturbed wetlands. For the disturbed site (Wet 9) however, Libellulidae contributed only 12.5% of the predators, while Notonectidae (backswimmers) - present at relatively low proportions for most other samples - represented the most common predator (87.5%).

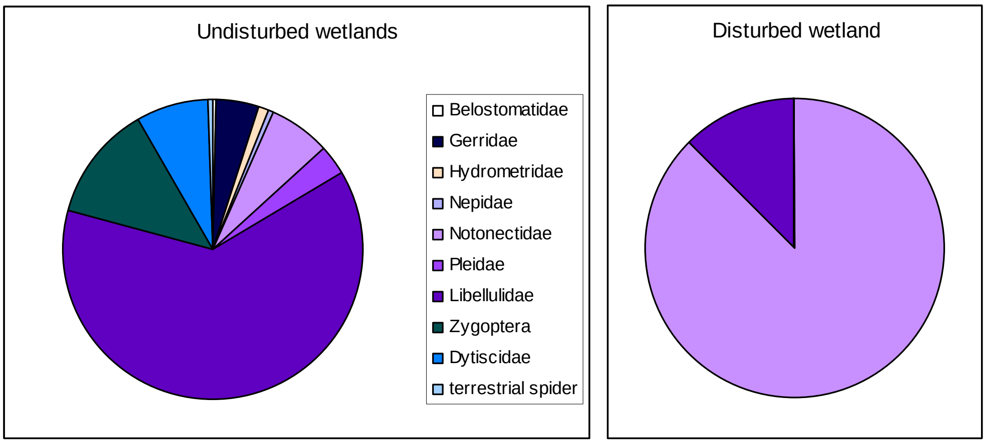

Figure 22: Composition of the predator feeding guild among samples of the Lamba river.

8.4 Discussion

Macroinvertebrate communities for all of the Lamba River were dominated by the detritivore/shredder guild. This is not surprising, considering that the Lamba River is a small-order watercourse, flowing mostly through wooded areas. The trees surrounding the river prevent sunlight from reaching the water, thus limiting the growth of aquatic plants and photosynthetic production. Food webs are therefore dependent on allochthonous sources of energy, such as leaf litter and woody debris.

In addition to the high abundances of detritivores, the majority of sampling sites were also characterised by relatively high proportions of predators. For most undisturbed sites, the proportion of predators was similar to that of detritivores. In most ecosystems, high numbers of predators indicate healthy ecosystems, as all predators rely on sufficient prey items, which in turn can only be supported if environmental conditions are right. For sites 1 and 5, however, and for the disturbed site, predator proportions were much lower, suggesting that these habitats were less healthy. This finding is supported by the generally lower number of invertebrate families and biodiversity indices for these sites.

Both sites 1 and 5 were relatively small, shallow, isolated pools, characterised by a considerable amount of decomposing leaf litter (*pers. observation*). The resulting hypoxic conditions were likely to limit the number of invertebrate taxa that can inhabit these pools. Chironomids, which are well-known for their ability to tolerate very low levels of oxygen and high levels of pollution (Picker *et al.*, 2002), were by far the most dominant family for samples 1 and 5.

Similarly, the disturbed site (Wet 9) was dominated by a single family (Mysidae), with all other invertebrate families being either absent or present at very low numbers. The disturbed site, however, consisted of a relatively large and deep pool and was not characterised by a large amount of decaying leaf litter. The low invertebrate abundance and diversity are most likely to result from the relatively uniform substrate, consisting almost entirely of silt, which is known to support only few invertebrates. The fact that the pool is also extensively used for watering cattle, contributes greatly to increased soil erosion, as indicated by the high levels of suspended silt in the water.

In addition to the generally relatively low proportions of predators, sampling site 9 was also very unusual in terms of the composition of the predator group. For all undisturbed sampling sites along the Lamba River, Libellulidae (dragonflies) was by far the most common family of predators (average 71.26%). For the disturbed site however, Libellulidae contributed to only 12.5% of the predators. According to Sahlem & Ekestubbe (2001), the presence of dragonflies generally indicates a healthy ecosystem, and thus, might be very interesting for future studies using freshwater macroinvertebrates as bio-indicators for water quality and river health.

The fact that macroinvertebrate community composition (at the family level) was relatively similar for all sampling sites of the Lamba River, with no obvious differences in biodiversity and abundance between the disturbed and the undisturbed sites might be as a result of the timing of the study. All sampling was conducted during the dry season, with the Lamba River reduced to nothing more than a series of isolated pools with no flow and low oxygen levels. During this time, invertebrate communities are probably reduced to only the most stress-tolerant taxa, similar to those commonly found in disturbed wetlands and rivers. According to Picker et al. (2002), all invertebrate families found in this study are well adapted to living in stagnant or low-flowing bodies of water such as ponds and pools, with many of them able to tolerate even relatively high levels of pollution. Thus, the fact that all invertebrates of this study were generalists and the lack of taxa restricted to a relatively narrow range of conditions (an important attribute for an indicator species) may have prevented more conclusive results.

It would be interesting to repeat this study and compare macroinvertebrate communities during the wet season, when most rivers have resumed flowing. In addition, the wet season normally coincides with the breeding seasons of most invertebrates and abundances could be expected to be higher than during the dry season. The seasonal flooding of large areas adjacent to most streams and rivers should also provide suitable habitats for many aquatic invertebrates specialised to a much narrower range of conditions, which can be used as indicator taxa for future studies and for the development and implementation of long-term monitoring programs.

9. COMMUNITY WORK AND ENVIRONMENTAL EDUCATION

9.1 Overview

Community work remains an integral part of our programme. We hope that through regular school visits and social surveys we are able to boost the reputation of Frontier in the area and have a significant and lasting impact on local attitudes towards the environment and conservation in the Kilombero Valley. Making local people more aware and more directly involved in our continuing conservation efforts is clearly extremely important if FTSRP is to have any long-term, sustainable effect on wildlife in the area.

9.2 Primary School Visits

Two schools were visited in 093, Igombiro and Mavimba. We chose these two schools because Sayari Camp is located on Igombiro village land and we buy water from Mavimba Village. We taught environmental education lessons to two different classes of grade III and IV students. These lessons were augmented with songs and games. We were assisted by our current Community Liaison Officer (CLO), Sebastian Ngasoma who does an excellent job engaging the students.

The lesson this phase revolved around fire ecology and the effects burning has on large mammals, small animals, birds, the forest and the people. July is the beginning of the burning season when farmers and poachers burn much of the miombo woodland. We wanted to teach the children that although fire is necessary, it can also be harmful to many plants and animals. RAs and children acted out the effects of fire on animals and plants and the lesson finished with a game of 'British bulldog' to demonstrate the effect of increasing fire on animals. As ever, we tried to make the lessons as interactive as possible to engage and entertain the children, thus helping the environmental message sink in.

9.3 Social surveys

An extensive programme of social surveys has been on hold for some time now. We did however conduct several interviews this phase for an RA's thesis research (Katie East). She is currently writing up the results and will share her thesis with TZS once it is completed.

9.4 Conclusion

School visits were, as usual, a highlight of the RAs experience and highly valued by the two schools. This contact with the local community is extremely important as their involvement is critical to the success of conservation efforts in the Kilombero Valley. We hope that in the near future our budget will allow us to extend our environmental education programme and reinstate a significant social survey component.

10. GENERAL CONCLUSION

FTSRP have conducted biological monitoring of the area surrounding Sayari camp since January 2008. The study addresses the vital need for thorough data regarding the impact of an encroaching human population on the biodiversity of the Miombo woodland habitat of the Kilombero Valley. This phase saw an increase in human activity in regions surrounding the study area, with the illegal clearance of a significant amount of land to the north and west of camp for agriculture and housing. Poaching of both timber and mammals was also witnessed, resulting in the confiscation of 12 large mammal snares by FTSRP researchers.

The principal focus of FTSRP at Sayari is the monitoring of large mammal populations in the Miombo woodland between the Selous Game Reserve and Udzungwa Mountains National Park. This phase completed the 21st month of the study, which has confirmed 31 species of large mammal inhabiting the region to date. Although the species richness recorded for this phase was unremarkable (23 species, similar to previous phases), there was a marked increase in spoor abundance indicating a dramatic rise in large mammal density. This corroborates the general trend of the study, which has reported an increase in abundance of a number of species including elephant, buffalo, waterbuck, bushpig, duiker, hartebeest and reedbuck since the survey began. The very low levels of human disturbance recorded across all transects this phase, suggests that this area may be acting as a refuge for large mammals, whose range is constantly constricting as a result of increasing human encroachment.

The dramatic increase in abundance of many species between the 092 and 093 phases may be explained by the clearance of land to the north and west of Sayari, removing vital habitat and forcing populations inhabiting this area further east into the study area. This explanation is supported by the study of large mammal abundance across a gradient of human disturbance, which reported a significant increase in the abundance of many large mammal species with increasing distance from Lupiro. Furthermore, a negative relationship was found to exist between abundance of domestic cattle and that of waterbuck and buffalo, suggesting that cattle are in direct competition with these species. If disturbance continues to increase at the present rate, the restriction of large mammals to smaller regions will bring increased competition and ultimately threaten population numbers. Previous FTSRP research has found a significant relationship between anthropogenic burning of the Miombo habitat and large mammal distribution. For example, selective grazers such as waterbuck and duiker display a preference for extensively burnt regions in order to monopolise the lush, new growth that occurs immediately after (SEE, 2009). With the onset of the main burning season next phase, it is expected that distribution will change in response.

However, the effect of human disturbance on the fauna of the Kilombero valley is not as straightforward as these results suggest. Worldwide, there have been many instances where species have adapted to monopolise resources provided by human settlement. This phase saw a marked increase in baboon abundance, which has been gradually increasing in the area since the study began. In this case, rather than a restriction to range, it is likely that baboons are moving into the area due to the increasing availability of crops which act as a vital source of food. This alteration to their distribution brings with it potential problems, such as an inevitable exacerbation of conflict with humans. Similar results are hypothesised to be seen in the study of human habitation effects on scavenging carnivore species such as civet and genet.

This phase, FTSRP were commissioned to carry out an assessment of the impact of the newly completed KVTC sawmill on large mammal movements within the region. The species richness of the sawmill site and surrounding regions was lower than that recorded in the main large mammal study, suggesting that large mammal distribution is altered by the human disturbance brought by the saw mill. However, it is likely that this is merely due to a lower sampling effort. Large mammal abundance around the saw mill was higher than expected nonetheless, and most species were unrestrained by the fence and traverse the fence if it is encountered. These preliminary results suggest the saw mill, though inevitably impacting upon large mammal distribution, is not having a severely detrimental affect on populations. However, monitoring must continue to ensure any impacts are acknowledged.

Another major focus of FTSRP in the Kilombero Valley is the avian community within the miombo woodland habitat, which has been relatively understudied in the past. This phase saw a more specific focus on the feeding ecology of a common avian species in the region, Retz's Helmet Shrike (*Prionops retzii*). Retz's helmet shrike feeds in mixed-species flocks and is usually the leading species within these flocks, with the Common Schmitarbill often found to be the trailing species. The foraging patterns of these flocks are not stochastic, and results suggest that trees of the *Brachystegia* genus are an important food source for Retz's Helmet Shrike and its associated species. Particular patches are favoured by these flocks, implying that human disturbance to an apparently homogeneous Miombo landscape may affect avian communities in very specific ways according to the specific composition of the patch disturbed. It is important to obtain more specific data on the way in which the woodland is utilised, in order to gain more insight into the impacts of changes to vegetation structure both seasonally and by human and natural disturbance. This work will continue next phase to help elucidate seasonal variations in foraging behaviour.

This phase also saw the start of a new study investigating the use of macro-invertebrates as biological indicators of freshwater wetland health. During the dry season, when this phase data was collected, the watercourses of the Kilombero Valley are reduced to slow-flowing or standing pools of water, that are relatively hypoxic and inhospitable. It is not surprising, therefore, that all families of macro-invertebrate identified are known to be hypoxic specialists. The macro-invertebrate community at all sites was dominated by detritivores, with very little change in composition with the level of human disturbance. However, all undisturbed sites also showed a high proportion of predator species, an indication of good ecosystem health, suggesting that the undisturbed sites are relatively healthy even during the dry season. The lower predator levels in the disturbed site, suggests that human disturbance and soil erosion has caused a general reduction in freshwater health. It will be interesting to see how the community composition changes next phase as the watercourses flow and become more oxygenated. However, the preliminary results of this study suggest that aquatic macro-invertebrates may act as useful indicators of ecosystem health in this wetland environment after further study provides more detailed knowledge of community dynamics within this habitat.

Community work is also a vital part of FTSRPs research in the Kilombero Valley and primary school lessons this phase focussed on fire ecology and the importance of sustainable and managed burning practises. The environmental education of local schoolchildren is crucial if the work of FTSRP is to have a sustainable and lasting effect on conservation in the region.

During 094, data collection for the Darwin grant will begin in earnest, including extensive social surveys on land use and human-wildlife conflict and biodiversity assessments. It will be integral to continue monitoring large mammal movement in the area surrounding Sayari Camp and near the village of Lupiro. Data collection on the abundance of scavenger carnivores near human habitation will also be completed along with the comparison of amphibian and reptile communities in burnt and unburnt grasslands and woodlands. The feeding ecology of Retz's helmet-shrike will also continue to be surveyed. Considering the reports of continued poaching, logging and land clearance this phase, the work of FTSRP in the Kilombero Valley is rendered ever more essential for the conservation of the region. The results of FTSRPs studies will contribute to sustainable management plans for the Kilombero Valley.

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12. Species list

The following is a complete species list for Sayari Camp for phase 093. Bird species listed, however, are those recorded over phases 083-093.

Key to survey/sighting type: LMT = large mammal transect; CS = carnivore station; S = Sherman trap; P = pitfall trap; OS = opportunistic sighting; PC = point count; F = frog survey; BS = butterfly survey.

MAMMALS

Common name	**Scientific name**	**survey/sighting type**
Primates		
Olive baboon	*Papio anubis*	LMT, OS
Greater galago	*Otolemur crassicaudatus*	OS
Vervet monkey	*Cercopithecus aethiops*	OS
Macroscelidea		
Elephant shrew	*Rhynchocyon sp.*	LMT, OS
Lagomorpha		
Scrub hare	*Lepus saxatilis*	LMT, OS
Rodentia		
Crested porcupine	*Hystrix cristata*	LMT, OS
Cane rat	*Thryonomys swinderianus*	LMT, OS
Bush rat	*Aethomys kaiseri*	S, OS
Naked-soled gerbil	*Tatera robusta*	S
Spiny mouse	*Acomys spinissimus*	S
Pygmy mouse	*Mus minutodes*	S
Zebra mouse	*Lemniscomys*	S
Spring hare	*Pedetes capensis*	LMT
Carnivora		
Mongoose	*Herpestidae*	CS, LMT, OS
Water mongoose	*Atilax paludinosus*	CS
Wild cat	*Felis sylvestris*	OS
Spotted hyena	*Crocuta crocuta*	CS, OS
Common genet	*Genetta genetta*	LMT, CS, OS
Blotched genet	*Genetta tigrina*	CS, OS
African civet	*Civettictis civetta*	CS, OS
Lion	*Panthera leo*	OS

Leopard	*Panthera pardus*	CS, LMT, OS
Jackal	*Canis sp.*	OS
Tubulidentata		
Aardvark	*Orycteropus afer*	LMT, OS
Proboscidea		
Elephant	*Loxodonta africana*	LMT, OS
Perissodactyla		
Zebra	*Equus quagga*	LMT, OS
Artiodactyla		
Bush pig	*Potamochoerus larvatus*	LMT, CS, OS
Warthog	*Phacochoerus africanus*	LMT, OS
Buffalo	*Syncerus caffer*	LMT, OS
Bushbuck	*Tragelaphus scriptus*	LMT
Eland	*Taurotragus oryx*	LMT
Duiker	Cephalophini	LMT, OS
Kirk's dik dik	*Madoqua kirkii*	LMT
Reedbuck	*Redunca spp.*	LMT, OS
Waterbuck	*Kobus ellipsiprymnus*	LMT, OS
Hartebeest	*Alselaphus busephalus*	LMT, OS
Sable antelope	*Hippotragus niger*	LMT, OS
Hippopotamus	*Hippopotamus amphibius*	OS

BIRDS

Pelicaniformes		
Great White Pelican	*Pelecanus onocrotalus*	OS
Pink-backed Pelican	*Pelecanus rufescens*	OS
Long-tailed Cormorant	*Phalacrocorax africanus*	OS
African Darter	*Anhinga rufa*	OS
Ciconiiformes		
Cattle Egret	*Bubulcus ibis*	OS
Common Squacco Heron	*Ardeola ralloides*	OS
Striated Heron	*Butorides striatus*	OS
Little Egret	*Egretta garzetta*	OS
Intermediate Egret	*Mesophoyx intermedia*	OS
Great Egret	*Casmerodius albus*	OS
Purple Heron	*Ardea purpurea*	OS
Grey Heron	*Ardea cinerea*	OS
Black-headed Heron	*Ardea melanocephala*	OS

Hamerkop	*Scopus umbretta*	PC, OS
Yellow-billed Stork	*Mycteria ibis*	OS
Woolly-necked Stork	*Ciconia episcopus*	OS
African Open-billed Stork	*Anastomus lamelligerus*	OS
Marabou Stork	*Leptoptilos crumeniferus*	OS
Sacred Ibis	*Threskiornis aethiopicus*	OS
Hadada Ibis	*Bostrychia hagedash*	PC, OC
Anseriformes		
Egyptian Goose	*Alopochen aegyptiqcus*	OS
Spur-winged Goose	*Plectropterus gambensis*	OS
Falconiformes		
Black Kite	*Milvus migrans*	OS
Black-shouldered Kite	*Elanus caeruleus*	OS
African Fish Eagle	*Haliaeetus vocifer*	OS
Palm-nut Vulture	*Gypohierax angolensis*	OS
Osprey	*Pandion haliaetus*	OS
African White-backed Vulture	*Gyps africanus*	OS
Brown Snake-Eagle	*Circaetus cinereus*	OS
Dark Chanting-Goshawk	*Melierax metabates*	OS
Lizard Buzzard	*Kaupifalco monogrammicus*	PC
Little Sparrowhawk	*Accipiter minullus*	PC
African Harrier-Hawk	*Polyboroides typus*	PC
European Honey-Buzzard	*Pernis apivorus*	PC
African Hawk-Eagle	*Hieraaetus spilogaster*	OS
Bateleur	*Terathopius ecaudatus*	OS
Long-crested Eagle	*Lophaetus occipitalis*	OS
Martial Eagle	*Polemaetus bellicosus*	PC, OS
Galliformes		
Helmeted Guineafowl	*Numida meleagris*	PC
Shelley's francolin	*Francolinus shelleyi*	PC
Crested Francolin	*Francolinus sephaena*	PC, OS
Charadriiformes		
African Jacana	*Actophilornis africanus*	OS
Black-bellied Bustard	*Eupodotis melanogaster*	OS
Spotted Thick-knee	*Burhinus capensis*	OS
African Wattled Lapwing	*Vanellus senegallus*	OS
White-crowned Lapwing	*Vanellus albiceps*	OS
Crowned Lapwing	*Vanellus coronatus*	OS
Senegal Lapwing	*Vanellus lugubris*	OS
Common Sandpiper	*Actitis hypoleucos*	OS
Common Greenshank	*Tringa nebularia*	OS
African Skimmer	*Rynchops flavirostris*	OS
Columbiformes		
African Green-Pigeon	*Treron calva*	PC

Feral Pigeon	*Columba livia*	OS
Emerald-spotted Wood-Dove	*Turtur chalcospilos*	PC, OS
Ring-necked Dove	*Streptopelia capicola*	PC, OS
Red-eyed Dove	*Streptopelia semitorquata*	PC
Psittaciformes		
Brown-headed Parrot	*Poicephalus cryptoxanthus*	PC, OS
Brown-necked Parrot	*Poicephalus suahelicus*	PC, OS
Yellow-collared Lovebird	*Agapornis personatus*	PC
Musophagiformes		
Purple-crested Turaco	*Tauraco porphyreolophus*	PC, OS
Cuculiformes		
African Cuckoo	*Cuculus gularis*	OS
Red-chested Cuckoo	*Cuculus solitarius*	PC
White-browed Coucal	*Centropus superciliosus*	PC
Burchell's Coucal	*Centropus burchelli*	PC
Black Coucal	*Centropus grillii*	FP
Strigiformes		
African Wood Owl	*Strix woodfordii*	OS
African Scops-Owl	*Otus senegalensis*	OS
African Barred Owlet	*Glaucidium capense scheffleri*	OS
Caprimulgiformes		
Square-tailed Nightjar	*Caprimulgus fossii*	OS
Firey-necked Nightjar	*Caprimulgus pectoralis*	PC
Apodiformes		
Little Swift	*Apus affinis*	PC
African Palm Swift	*Apus barbatus*	PC
Coliiformes		
Speckled Mousebird	*Cypsiurus parvus*	FP
Trogoniformes		
Narina Trogon	*Apaloderma narina*	PC, OS
Coraciiformes		
Pied Kingfisher	*Ceryle rudis*	OS
Striped Kingfisher	*Halcyon chelicuti*	OS
Grey-headed Kingfisher	*Halcyon leucocephala*	PC
Brown-hooded Kingfisher	*Halcyon albiventris*	PC
Giant Kingfisher	*Megaceryle maxima*	OS
Woodland Kingfisher	*Halcyon senegalensis*	OS
Half-collared Kingfisher	*Alcedo semitorquata*	OS
Malachite Kingfisher	*Alcedo cristata*	OS
Little Bee-eater	*Merops pusillus*	PC, OS
Madagascar Bee-eater	*Merops superciliosus*	OS
White-fronted Bee-eater	*Merops bullockoides*	OS
Broad-billed Roller	*Eurystomus glaucurus*	PC
Lilac-breasted Roller	*Coracias caudata*	OS

Racket-tailed Roller	*Coracias spatulata*	PC, OS
Green Woodhoopoe	*Phoeniculus purpureus*	PC
African Hoopoe	*Upupa africana*	PC
Common Scimitarbill	*Rhinopomastus cyanomelas*	PC
African Grey Hornbill	*Tockus nasutus*	PC
Pale-billed Hornbill	*Tockus pallidirostris*	PC
Crowned Hornbill	*Tockus alboterminatus*	PC, OS
Trumpeter Hornbill	*Bycanistes bucinator*	PC, OS
Southern Ground-hornbill	*Bucorvus leadbeateri*	PC, OS
Piciformes		
Red-fronted Tinkerbird	*Pogoniulus pusillus*	OS
Black-collared Barbet	*Lybius torquatus*	PC
Crested Barbet	*Trachyphonus vaillantii*	PC
Greater Honeyguide	*Indicator indicator*	PC, OS
Lesser Honeyguide	*Indicator minor*	PC, OS
Cardinal Woodpecker	*Dendropicos fuscescens*	PC
Bearded Woodpecker	*Dendropicos namaquus*	PC
Passeriformes		
Flappet Lark	*Mirafra rufocinnamomea*	PC
Common House Martin	*Delichon urbica*	OS
Mosque Swallow	*Hirundo senegalensis*	OS
Lesser Striped Swallow	*Hirundo abyssinica*	PC
Barn Swallow	*Hirundo rustica*	PC
Wire-tailed Swallow	*Hirundo smithii*	OS
Black Saw-wing	*Psalidoprocne holomelas*	PC
African Pied Wagtail	*Motacilla aguimp*	OS
Grassland Pipit	*Anthus cinnamomeus*	OS
Black Cuckoo-shrike	*Campephaga flava*	OS
White-breasted Cuckoo-shrike	*Coracina pectoralis*	PC
Common Bulbul	*Pycnonotus barbatus*	PC
Eastern Nicator	*Nicator gularis*	PC
White-browed Robin-Chat	*Cossypha heuglini*	PC
Kurrichane Thrush	*Turdus libonyanus*	OS
White-headed Black Chat	*Myrmecocichla arnoti*	PC
Yellow-bellied Eremomela	*Eremomela icteropygialis*	PC
Singing Cisticola	*Cisticola cantans*	PC
Rattling Cisticola	*Cisticola chiniana*	PC
Piping Cisticola	*Cisticola fulvicapillus*	PC
Tawny-flanked Prinia	*Prinia subflava*	PC
Grey-backed Camaroptera	*Camaroptera brachyuran*	PC
Yellow-breasted Apalis	*Apalis flavida*	OS
Black-headed Apalis	*Aptalis melanocephala*	PC
African Paradise-flycatcher	*Terpsiphone viridis*	PC
Southern Black Flycatcher	*Melaenornis pammelaina*	PC

Ashy Flycatcher	*Muscicapa caerulescens*	OS
Spotted Flycatcher	*Mucicapa striata*	PC
Pale Batis	*Batis soror*	PC
Arrow-marked Babbler	*Turdoides jardineii*	OS
Variable Sunbird	*Cinnyris venusta*	PC
Amethyst Sunbird	*Chalcomitra amethystine*	PC
Purple-banded Sunbird	*Cinnyris bifasciata*	PC
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	PC
Tropical Boubou	*Laniarius aethiopicus*	PC
Black-backed Puffback	*Dryoscopus cubla*	PC
Black-crowned Tchagra	*Tchagra senegala*	PC
Brown-crowned Tchagra	*Tchagra australis*	PC
Sulphur-breasted Bush-shrike	*Malaconotus sulfureopectus*	PC
Grey-headed Bush-shrike	*Malaconotus blanchoti*	PC
White-crested Helmet-shrike	*Prionops plumatus*	PC, OS
Retz's Helmet-shrike	*Prionops retzii*	PC, OS
Fork-tailed Drongo	*Dicrurus adsimilis*	PC
Square-tailed Drongo	*Dicrurus ludwigii*	PC
House Crow	*Corvus splendens*	OS
Pied Crow	*Corvus albus*	OS
Eurasian Golden Oriole	*Oriolus oriolus*	PC
African Black-headed Oriole	*Oriolus larvatus*	PC, OS
African Golden Oriole	*Oriolus auratus*	PC, OS
Green-headed Oriole	*Oriolus chlorocephalus*	PC
Red-winged Starling	*Onychognathus morio*	OS
Southern Blue-eared Starling	*Lamprotornis elisabeth*	PC
Violet-backed Starling	*Cinnyricinclus leucogaster*	PC
House Sparrow	*Passer domesticus*	OS
Southern Grey-headed Sparrow	*Passer diffusus*	PC
Yellow-throated Petronia	*Petronia supercilliaris*	PC
Black-headed Weaver	*Ploceus cucullatus*	PC
Lesser Masked Weaver	*Ploceus intermedius*	OS
Yellow Weaver	*Ploceus subaureus*	PC
Red-collared Widowbird	*Euplectes ardens*	OS
Yellow Bishop	*Euplectes capensis*	PC
White-winged Widowbird	*Euplectes albonotatus*	OS
Southern Red Bishop	*Euplectes orix*	PC
Northern Red Bishop	*Euplectes franciscanus*	PC
Zanzibar Red Bishop	*Euplectes nigroventris*	OS
Southern Cordon-bleu	*Uraeginthus angolensis*	OS
Red-billed Firefinch	*Lagonosticta senegala*	OS
African Firefinch	*Lagonosticta rubricata*	OS
Common Waxbill	*Estrilda astrild*	PC
Zebra Waxbill	*Amandava subflava*	OS

Bronze Mannikin	*Lonchura cucullata*	PC
Black-and-white Mannikin	*Lonchura bicolor*	PC
Village Indigobird	*Vidua chalybeate*	OS
Yellow-fronted Canary	*Serinus mozambicus*	PC

REPTILES

Chelonians		
Leopard tortoise	*Geochelone pardalis*	OS
Squamata		
Tropical house gecko	*Hemidactylus mabouia*	OS
Tree gecko	*Hemidactylus platycephalus*	OS
Yellow headed dwarf gecko	*Lygodactylus luteopicturatus*	OS
Cape dwarf gecko	*Lygodactylus capensis*	P
Striped skink	*Mabuya striata*	OS
Variable Skink	*Mabuya varia*	OS
Blue headed tree agama	*Acanthocercus atricollis*	OS
Monitor lizard	*Varanus sp.*	OS
Serpentes		
Brown house snake	*Lamprophis fuliginosus*	*OS*
Bark snake	*Hemiohagerrhis nototaenra*	OS
Snouted night adder	*Causus defilippi*	OS
Python	*Python sp.*	OS
Black mamba	*Dendroaspis polylepis*	OS

AMPHIBIANS

Anura		
Flat-backet toad	*Bufo maculatus*	F, OS
Dwarf squeaker	*Schoutedenella xenodactyloides*	F, OS
Common squeaker	*Arthroleptis stenodactylus*	F
Puddle frog	*Phrynobatrachus spp.*	F, OS
Mueller’s clawed frog	*Xenopus muelleri*	F, OS

BUTTERFLIES

Lycaenidae	
Anthene lunalata	BS
Axiocerses harpax ugandana	BS
Axiocerses tjoane	BS

Balichila hildergarda	BS
Cudopois iobates iobates	BS
Delidorix antalus	BS
Euchrysops kabrosae	BS
Euchrysops malanthana	BS
Euchrysops osiris	BS
Euchrysops subpallida	BS
Freyeria trochylus trochylus	BS
Hermiolaus caeculus littoralis	BS
Hypocaena rachauca	BS
Lechnocnema bibulus	BS
Ledochrysops elgonae moyo	BS
Ledochrysops kitale	BS
Ledochrysops lukenia	BS
Ledochrysops parismon parismon	BS
Ledochrysops victoriae victoriae	BS
Leptotes adamsoni	BS
Leptotes pieridaerithous	BS
Psuedacraea sichela sichela	BS
Spendasis apelles	BS
Spendasis homeyeri	BS
Spendasis mozambica	BS
Spendasis neassae	BS
Spendasis tavensis	BS
Teriomima micra	BS
Tuxentius melaena melaena	BS
Zeritis neriene	BS
Zizina anathanossa	BS
Zizula athossa	BS
Zizula hylax	BS
Nymphalidae	
Acraea acrita	BS
Acraea aganue montana	BS
Acraea alicia	BS
Acraea anemosa	BS
Acraea asboloplintha asboloplintha	BS
Acraea caecilla	BS
Acraea caldarena caldarena	BS
Acraea chilo chilo	BS
Acraea encedana	BS
Acraea encedon encedon	BS
Acraea eponina eponina	BS

Acraea equatorialis anaemia	BS
Acraea insignis insignis	BS
Acraea pudorella pudorella	BS
Acraea rahira uasingishuensis	BS
Acraea siykesi	BS
Axiocerses amanga	BS
Bicyclus angulosus angulosus	BS
Bicyclus safitza safitza	BS
Byblia anvatara acheloia	BS
Byblia anvatara anvatara	BS
Byblia Illithyia	BS
Capys rueyi	BS
Catacroptera cloathe cloathe	BS
Charaxes achaemenes achaemenes	BS
Charaxes bohemani	BS
Charaxes castor castor	BS
Charaxes chepalungu	BS
Charaxes cithaeron nairobicus	BS
Charaxes conirarius	BS
Charaxes ethalion kikuygensis	BS
Charaxes fionae	BS
Charaxes guderiana rabiensis	BS
Charaxes hansali baringana	BS
Charaxes kirki kirki	BS
Charaxes lucretia protracta	BS
Charaxes protoclea aloth	BS
Charaxes saturnus	BS
Charaxes varanes vologeses	BS
Charaxes violetta maritimus	BS
Danaus chrysippus chrysippus	BS
Euryphuia aches	BS
Eurytela dryope angulata	BS
Euyanthe wakefieldi	BS
Hamanuminda daedalus	BS
Henotesia phaea phaea	BS
Junonia natalica natalica	BS
Junonia orithya madagascarnesis	BS
Junonia terea elgiva	BS
Neptis deludens echeroids	BS
Neptis kirakoffi	BS
Neptis morosa	BS
Neptis penningtoni	BS
Neptis serena serena	BS
Phalanta phalanta aethopica	BS
Precis antilope	BS
Precis archesia	BS

Pseudacraea acrita expansa	BS
Pseudacraea deludens echeroids	BS
Pseudacraea ludatia protacta	BS
Sallya amulia rosa	BS
Vanessa gardui gardui	BS
Ypthima albida albida	BS
Ypthima asterope asterope	BS
Ypthima granulosa	BS
Pieridae	BS
Belenois aurota aurota	BS
Belenois creona severina	BS
Belenois thysa thysa	BS
Colotis eris eris	BS
Eurema brigatta brigitta	BS
Eurema floricola orientis	BS
Eurema hapale	BS
Eurema hecabe solifera	BS
Eurema regularis regularis	BS