Series 19

THE STATUS OF BIODIVERSITY IN KASYOHA-KITOMI CENTRAL FOREST RESERVE

A Survey Report

National Forestry Authority

Dansk Ornitologisk Forening

NatureUganda

THE STATUS OF BIODIVERSITY IN KASYOHA-KITOMI CENTRAL FOREST RESERVE

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1.0 INTRODUCTION

1.1 GENERAL

The Kasyoha-Kitomi forest is part of a network of Protected Areas (PAs) located in the Albertine Rift region. This region is known for its rare and endemic flora and fauna. The Albertine Rift forest ecosystem is a chain of forest patches (some with interconnected forest corridors) that are a major global center of diversity and endemism and are a focus of most conservation and development agencies. The significant biodiversity values of the Albertine Rift forests have been highlighted in many global and national environmental planning reports. Globally, the Albertine Rift is acknowledged as a major center of diversity and endemism of many taxa. The National Environment Action Plan of Uganda (NEAP) recognizes the global significance of these forests. Some of these forests are cross-border forests and include Bwindi, Echuya, Mgahinga, Rwenzoris and Virungas while others are located within the national Uganda boundaries and include Kasyoha-Kitomi, Bugoma, Budongo and Kalinzu forests. Responsibility for the management of these forests is fragmented with some being managed by the Uganda Wildlife Authority (UWA), National Forest Authority (NFA) as well as respective district local governments. The Kasyoha-Kitomi forest is managed by the NFA and has experienced human disturbance that has led to considerable fragmentation of forest cover, a process that continues today with grave consequences for biodiversity. The degradation arises from high human population density; extreme poverty and heavy dependence on forest resources by neighboring communities that exert immense pressure on the forest reserve. Plumptre (2002) identified the major threats to Kasyoha-Kitomi forest as hunting for bush-meat, illegal harvesting of timber and other plant products, charcoal burning, forest encroachment for agriculture and mining. According to Howard (1991), the reserve is of great conservation importance because:

i. it represents the most extensive tract of relatively undisturbed forest remaining at the altitude of 975 to 2,136 m asl in Uganda;
ii. by virtue of its location close to postulated Pleistocene forest refugia, its great geological and topographical diversity, and the wide range of altitude represented, we should expect to find an exceptionally diverse flora and fauna here;
iii. the more mature forest communities of southwestern KK are amongst the richest in the country; and
iv. the reserve supports at least four species of animals (elephant, chimpanzee, l'hoest's monkey and white-naped pigeon) considered to be globally threatened with extinction, or nearly so.

1.2 WHY CARRY OUT BIODIVERSITY ASSESSMENTS IN KASYOHA-KITOMI?

Few biodiversity status studies have been carried out in Kasyoha-Kitomi Central Forest Reserve (KKCFR. These include those of Howard (1991), Howard and Davenport (1996), Plumptre (2002) and Plumptre ***et al***. (2003). The former two studies were based on actual field surveys while the latter were based on published and unpublished literature sources. Plumptre ***et al***. (2003) does not provide species lists but only the number of species per taxon. Even then, twelve years later, we need to understand the changes in biodiversity that could have taken place as a result of conservation activities and anthropogenic perturbations.

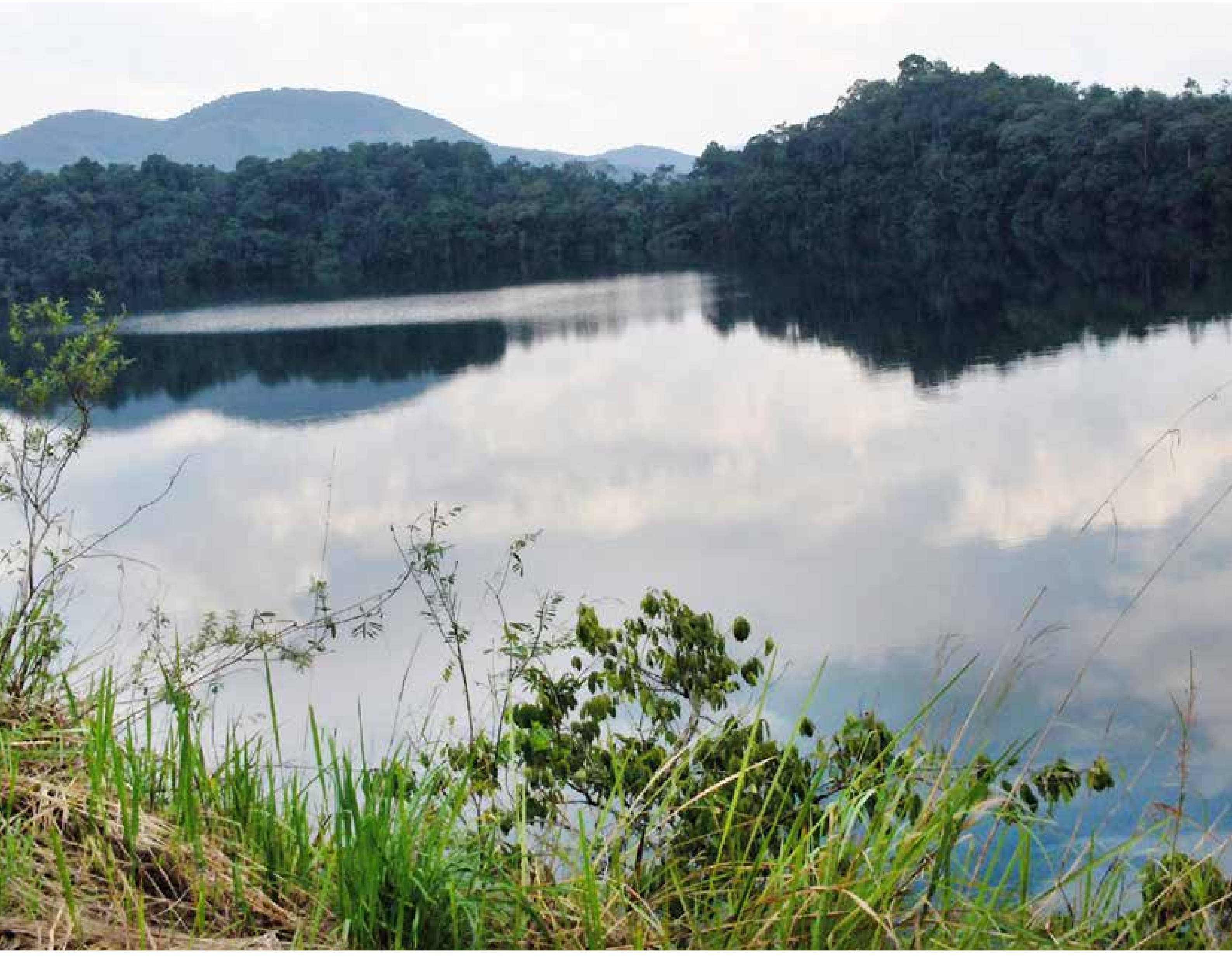
Nature Uganda (NU) implemented a Participatory Environmental Management (PEMA) project in Kasyoha-Kitomi from 2007 to 2011. The project focused on seven parishes that included Ndangaro, Butoha, Mwongyera, Bizenga, Rwajere, Bitooma and Kanywambogo (Figure 1). A number of community based conservation initiatives to curb illegal activities, promote sustainable use of natural resources and enhance biodiversity recovery in Kasyoha-Kitomi were introduced. These included collaborative forest management, livelihoods and income generating projects, illegal activity monitoring and soil conservation measures. These initiatives were introduced by NU to curb the high rate of biodiversity loss and degradation in the forest. However, there has been no assessment of the current status of biodiversity in this forest to determe the impact of the interventions such as those of NU and other development organizations working in the area. Such an assessment is important for better conservation planning for Kasyoha-Kitomi forest and is the basis of this study. The assessment in this study used mammals (medium-to-large and small), birds and some plant forms as surrogates for overall biodiversity.

2.0 STUDY OBJECTIVES

The overall aim of the study was to assess the current status of biodiversity and the effects of anthropogenic related threats on biodiversity in and around KKCFR. The specific study objectives were to:

1. Determine the species richness of plants (trees, shrubs and herbs), terrestrial vertebrates (small sized and, large mammal and birdsin KKCFR;
2. Compare the results of this study with previous biodiversity inventories of the same taxa
3. Determine the forest structure and regeneration status of KKCFR;
4. Assess the species distribution in KKCFR in relation to selected environmental factors, human activity and NU's conservation initiatives; and
5. Identify and map hotspots of anthropogenic related threats to biodiversity of KKCFR.

This information is important in that it can help in zoning of the reserve, identifying the relative importance of sites within the reserve for conservation and as a baseline against which future studies can be compared with.



3.0 MATERIALS AND METHODS

3.1 STUDY SITE DESCRIPTION

Kasyoha-Kitomi Central Forest Reserve (KKCFR) covers nearly 40,000 ha of mid-altitude moist forest in the central part of the Albertine Rift. The reserve lies in the administrative districts of Bushenyi, Rubirizi, Ibanda and Kamwengye (Figure 1). The reserve is one of the few Uganda's remaining medium altitude moist forests. Whereas majority of the large trees have been exploited for timber and fuel wood, recent assessments by international conservation agencies classify the forest as of international importance in terms of global biodiversity values and other ecosystem services. It is a critical forest for migrating large mammals and acts as their refugium during dry seasons. NU initiated conservation interventions through CFM with surrounding communities from 2007 to 2010.

The interventions focused on integrated empowerment of local communities with sustainable management of natural resources and livelihood improvement. For this study, we focused only on portions of the forest bordering the four parishes from Rubirizi District of Butoha, Buzenga, Mwongyera and Ndangaro where Nature Uganda has been running community conservation based projects.

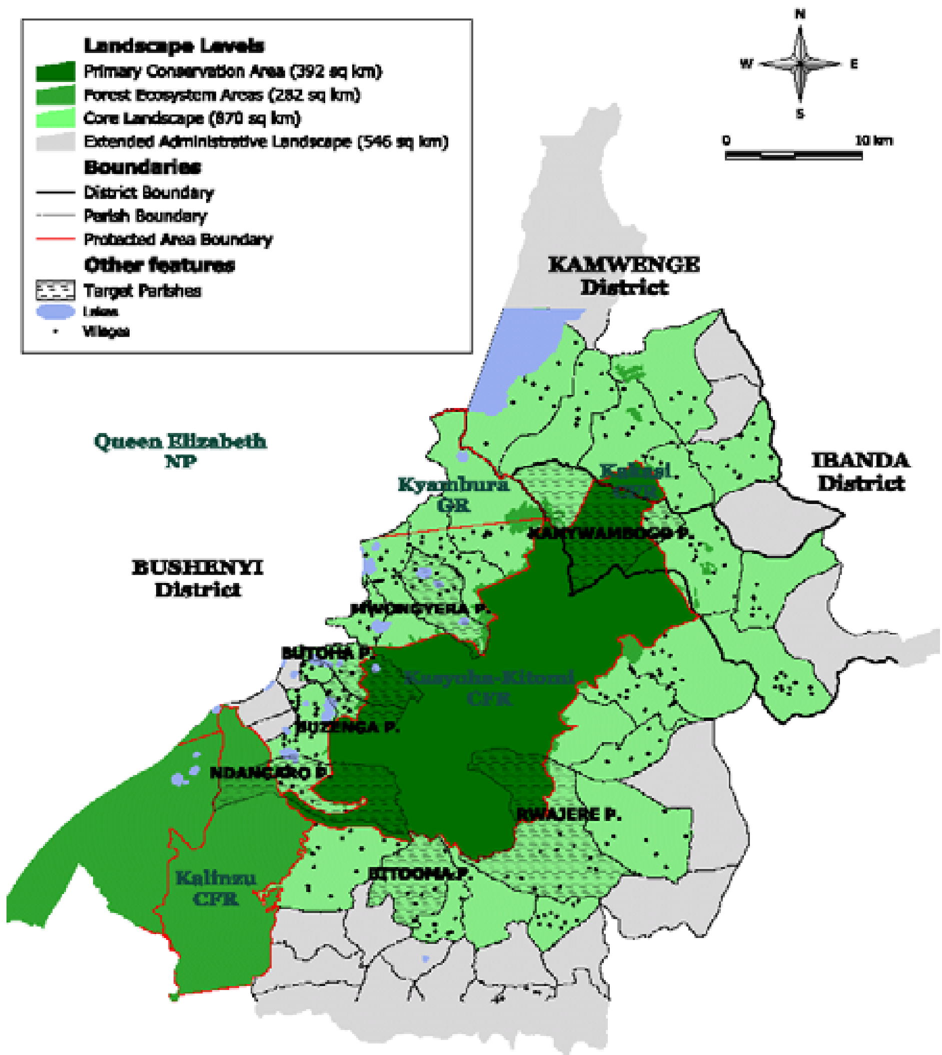


Figure 1 A map of KKCFR, western Uganda and surrounding administrative parishes

3.2 APPROACH TO BIODIVERSITY ASSESSMENTS

3.2.1 Terrestrial large mammals

The methods commonly used for terrestrial mammal inventories include: line transects (Plumptre 2000), direct counts (Silveira, Jácomo & Filho 2003), indirect evidence e.g. nests, tracks and signs (Plumptre & Reynolds 1997), trapping (Kasangaki, Kityo & Kerbis 2003), interviews with local people (Andama 2000) and camera trapping (Tobler *et al.* 2008; Mugerwa *et al.* 2013). Our choice of camera trapping for this study was based on the fact that they provide a non-invasive way of surveying and detecting elusive wildlife that would otherwise be impossible to survey with other methods (Ahumada, O'Brien & Mugerwa 2015). Camera traps have become increasingly popular as technology has improved and costs have decreased (Tobler *et al.* 2008). Camera traps have been used to estimate species richness (O'Brien, Kinnaird & Wibisono 2011; Mugerwa *et al.* 2013), to estimate community structure and diversity (Ahumada *et al.* 2011), and to detect species presence (Sheil & Mugerwa 2013; Mugerwa 2013). Here we used a systematic camera trap survey to assess the terrestrial mammal community and human activity in four parishes immediately surrounding KK.

Camera trapping

A camera trap survey was conducted between December 2015 and January 2016. Camera traps were set at 35 random sites predetermined using regularly spaced points on a 1x1 km grid overlaying a map of KK. The camera traps were thus distributed at a density of 1 camera per km^2 (Fig.1). Specific sites for camera placement were selected using pre-defined GPS-coordinates and *in situ*-assessment of present active animal paths and activity (Mugerwa *et al.* 2013). The camera trap grid covered an elevation of between 1,210 to 1,687 meters above sea level. Camera traps were set along animal trails, attached on trees at a height of 20-50 cm from the ground. This siting was adequate to capture medium to large terrestrial mammals (TEAM Network 2009; Mugerwa *et al.* 2013). We used the DLC white flash camera traps (www.scountingcameras.com) that take color pictures day and night. Camera traps were set with motion sensors on and with a one second interval between consecutive images. The picture quality was set at 5MP. Date and time were also recorded for each image. Mammal identification and taxonomy from camera trap pictures followed Kingdon (1997) and Wilson & Reeder (2005) respectively.

3.2.2 Small mammal, bird and plant diversity and distribution

Four line transects, each 3 km in length, were established from the forest edge into the interior, one in each of the forest areas adjacent to the four parishes of Kasyoha-Kitomi (Butoha, Buzenga, Mwongyera and Ndangaro). The direction of the transects was determined by the terrain of the forest so that the transects cut across the ridges in a straight line so as to capture expected rapid transitions in vegetation types and environmental gradients based on small-scale topographical variation and forest edge to the interior. Sample sites were positioned at 200 m intervals so that there were 16 sample points on each transect. At each site, location coordinates using a Global Positioning System (GPS) and environmental variables – altitude, slope steepness, slope position, slope aspect and canopy openness were recorded. Any form of human activity sign observed within the sample plot was noted. Each site was visited by the three teams (botanical, ornithological, and small mammal teams) in succession.

The botanical team identified, enumerated and measured the dbh of trees (≥10cm) in 20×20 m plots, shrubs and herbs were sampled in a 5×5 m, and in a 2.5×2.5 m plots respectively, nested within the larger 20×20 m plot for trees. All plants were identified to species level.

A team focusing on birds visited the same points as the botanical team. Counts of birds were made one day after the transect was walked by the botanists to reduce the possible deleterious effects any noise and movements made by the other team would have on observations of birds. At each sample site, a point count was undertaken from a fixed location for a period of 10 minutes between 7 and 10 am. On arrival at each point-count site, the team would wait for 3 minutes before beginning to count to allow the birds to settle down. All birds seen, heard or flying over were recorded. The team endeavored to count each individual bird only once at each site. The ornithological team also mist-netted birds on three sites positioned at the beginning, in the middle and end of each of the transects. At each site, six nets of 12–14 m were opened at dawn and closed at dusk and checked every half hour interval while they were open and birds found captured in the nets were identified and released.

A team focusing on small mammals visited eight sites spread evenly along each transect. Trapping of rodents was done one day after bird point counts and mist-netting to reduce the possible deleterious effects any noise and movements made by the ornithological team would have on trap success. At each sample site, 20 Sherman live traps were set. Traps were baited with ground nut butter and mashed fermented yellow bananas. The traps were set between 0800 and 0900 in the morning and checked in the evening between 0500 and 0600 and the traps set between 0500 and 0600 in the evening checked at 0800 and 0900 in the morning of the next day. Each trapped animal was weighed, measured, sexed and the reproductive conditions assessed. All the external attributes such as fur colour and texture, back colour of fore and hind foot, whisker and other physical features were recorded. Trapped rodents were identified to the species level following Delany (1975) nomenclature.

Except for trees, the field methods for all the other taxa surveyed were aimed at obtaining qualitative rather than quantitative data, with emphasis on species richness, rather than on population densities.

3.3 DATA ANALYSIS

3.3.1 Terrestrial large mammals

Species richness estimation

Species data from all camera sites was collated into Microsoft Excel spreadsheets. The data was then imported into the R package "rich" for species richness estimation (Rossi 2011). A rarefaction curve was generated to determine the average number of randomized species richness for our sampling intensity. A thousand (1000) runs were ran for all randomizations. The resultant species accumulation curve was plotted using the package "ggplot2".

Occupancy modeling of human activity and wildlife occurrence in KK

Camera traps that are triggered by motion to take photographs of animals as they pass by allow for non-invasive, unbiased surveys in even the most remote places. We used occupancy modelling that correct for detection probability to determine distribution of wildlife in KK, in relation to tree cover percentage, elevation and human activity.

Several state variables (numerical values which indicate the status of a wildlife population or community) exist. The most common state variable in past biodiversity studies was abundance. Abundance involves quantifying the size of animal populations. However, abundance is a notoriously hard to achieve metric for most biodiversity taxa. This is especially true for rare or elusive species in dense habitats such as those of tropical forests.

A recently developed state variable informative of the state of a wildlife population or community is occupancy. Occupancy is the estimated probability of a species occurrence at a site (MacKenzie ***et al.*** 2006). Occupancy is basically the measure of species range or distribution within an area (Mackenzie & Reardon 2013). While the relationship between abundance and occupancy is not linear (Thompson ***et al.*** 1998), occupancy is often used as a surrogate for abundance (Rovero & Marshall 2009), and does not require individual recognition and identification of animals (Mackenzie ***et al.*** 2002). Occupancy therefore differs from abundance, but can provide information on abundance (MacKenzie ***et al.*** 2005). Furthermore, most tropical forest mammals are very rare, hence, detections generally are too infrequent to adequately estimate abundance; occupancy provides the best obtainable metric for assessing infrequently detected tropical vertebrates because it requires fewer detections than do metrics of abundance (O'Brien ***et al.*** 2010).

In sum, occupancy is increasingly becoming a powerful metric in biodiversity studies because 1) it aids conservation and management of wildlife populations and 2) it is relatively cost-effective to collect the necessary field data. For this study, we use occupancy to investigate the impact of human activity in KK on large mammal species distribution.

Occupancy modelling is based on multiple repeated visits of a species to multiple sites within a habitat. This provides information on where the species of interest was detected. These data can be compiled into a detection history. The proportion of sites that are occupied by the species within a survey period can be computed from the detection history. Specific for this study, the camera trap records of the species were condensed into presence and absence matrices, one for each site, species, and survey day (i.e. sampling occasion). The rows correspond to sampling points and the columns correspond to time periods (days). The species-specific occupancy matrix had a resolution of five days (Rovero ***et al.*** 2015). The cells in these matrices were occupied by a"1" (the species was photographed at site *i* on survey *j*), "0" (the species was not photographed at site *i* on survey *j*) or NA (the site *i* was not actively sampled on survey *j*). A survey day was subscribed as "NA" in case of camera trap failure. We then applied the single occupancy model (MacKenzie ***et al.***, 2006). We conducted occupancy modelling using the unmarked package in R statistical computer program.

Preparing covariates' data

The covariates included; elevation, forest cover and human activity. Data for the environmental covariates was downloaded as raster files from the internet and extracted using selected modules in GRASS (http://grass.osgeo.org/) version 7.1 open source GIS software. The covariates' data downloaded as raster files were the Shuttle Radar Topography Mission (SRTM) (http://glcf.umd.edu/data/srtm/) and Landsat Tree Cover (http://glcf.umd.edu/data/landsatTreecover/). Both the SRTM and Landsat tree cover raster files were downloaded at 90 m resolution. Using specialized modules in GRASS (Table 1), elevation was derived from the SRTM raster file. The human activity occurrence was generated using records of humans and their commensals (dogs, cows and goats) on camera traps to generate their occurrence. Tree cover and elevation were used as predictor variables to generate the human activity occurrence. All covariate data from raster files was extracted using the QGIS plug-in "Point sampling" (QGIS version 2.12-Lyon (www.qgis.org, Development Team, 2015). All covariates were selected based on expert knowledge of resource selection by the species.

Table 1. Summary of predictor variables and GIS methods used for transformation

Covariates	GRASS module	QGIS plug-in
Elevation		Raster analysis, then point sampling
Tree cover (%)		Point sampling
Human activity occurrence		Occupancy modelling, then Zonal statistics

All statistical tests were performed at 5% level of significance in R (R Development Core Team, 2015).

Modeling human activity and wildlife occupancy

A null model (including only the intercepts of occupancy and detection probability) was compared to a global model (including covariates). The null model assumes constant Ψ and p (i.e. Ψ(.), p(.)). The global model, on the other hand, allows p to vary with the covariates. In all models, our hypothesis was that human activity and wildlife occurrence would vary with tree cover and elevation (and human activity in case of wildlife). The covariates were scaled into z-scores prior to the modeling. We included covariates in models either individually or in combination (e.g. global model). We calculated the Akaike Information Criterion (AIC) for all the models to allow model ranking. We selected competing models based on the model selection statistic deltaAICc and Akaike weights (Burnham & Anderson, 2002).

The AIC for the individual covariate models and the global model were closely similar and delta AIC >2. We therefore chose the global model and performed a "Goodness of fit" analysis of its reliability for the modeling process. We tested for over-dispersion in the data by computing a "cHat". A "cHat" value close to one shows no over-dispersion in the data. We then mapped the probability of occupancy of human activity and wildlife in parishes where NU is implementing community conservation programs, by deriving occupancy estimates from covariates computed on a spatial grid with a cell size of 100 m. The final model was imported into the "Raster" package (Hijmans 2015) in R to generate distribution maps of probability of occupancy for human activity and

wildlife, as predicted by elevation and forest cover (for human activity) or human activity (for wildlife).
The covariate raster files were imported into the "Raster" package as tiff files. The raster files were then resampled to the same extent, resolution and coordinate reference system using the "resample" function in the "Raster" package. A "stack" of the covariate raster files was generated to be used to model occupancy for human activity and wildlife. A modeled occupancy was finally plotted.

3.3.2 Plant, bird and small mammal diversity and distribution

Species data were coded in an Excel spreadsheet as number of individuals/stems for trees and present/absent for shrubs, herbs, small mammals and birds observed at each sample site. The data for the environmental variables at each sampling site were entered in a separate Excel spreadsheet. All the data were analyzed using R open source statistical software version 3.2.2 (R Core Team 2015) with add-on packages BiodiversityR (Kindt& Coe 2005), vegan (Oksanen ***et al***. 2015) and labdsv (Roberts 2015).

Species richness

For each taxon, we estimated the species richness for each sampled site. Changes in species richness along each transect running from forest boundary to the interior were plotted on a digital map of KKCFR using ESRI ArcGIS 9.3.

Sampling adequacy

In order to determine whether our sample size was adequate for the subsequent analyses, we used the species rarefaction curves to check the adequacy of our sample size for the surveyed area and for each transect.

Ecological distance

This is a concept that characterizes, on a quantitative scale, how different sample sites are in species composition from each other. It was applied to each taxon species data matrix by calculating the ecological distances between all pairs of sampling sites. We used the Bray-Curtis index. The Bray-Curtis dissimilarity index restricts distances within a range of zero (when two sites are completely similar for every species) to one (when two sites do not share any species). Bray-Curtis distance was used because it is commonly used in analysis of community data since it not influenced differently by outliers and retains high sensitivity in heterogeneous datasets.

Cluster and indicator species analysis

Classification simplifies data by putting sample sites with the same species composition into the same class. The task of describing a high number of sampling sites was simplified to an easier task of describing a low number of classes. We did this by performing a cluster analysis on each taxon's species data matrix. A standard, hierarchical average-linkage clustering algorithm was applied to the data matrix. This algorithm initially assigns each site to a separate group, at each iteration, the clustering routine unites the two groups that have the smallest mean dissimilarity i.e., dissimilarity measured via Bray-Curtis distance between them. The algorithm was complete when all the sample sites are united into one group. The results of this analysis were plotted in a dendrogram. The average-linkage clustering makes no assumptions about underlying structure in the data. We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. Generally, cophenetic correlation values over 0.75 are considered good (McGarigal ***et al.*** 2000). Indicator species analysis was performed on the classes obtained in cluster analysis above to identify the most frequent and constant species within each class. Perfect indicator species are the ones that are exclusive to the class, never occurring in other classes; therefore serve to differentiate among classes derived from cluster analysis.

Ordination

We performed a Non-metric Multidimensional Distance Scaling (NMDS) ordination to plot the sample sites in space using Bray-Curtis as a distance measure. In NMDS, the sample sites are plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. We superimposed the classes defined by cluster analysis on the NMDS ordination plot and then overlaid the external environmental variable information onto NMDS ordination diagram to describe the differences among clusters in ecological terms.

4.0 RESULTS

4.1 TERRESTRIAL LARGE MAMMALS

4.1.1 General results

One and four camera traps operated for 28 and 29 of 30 days respectively. Thirty camera traps operated for the whole survey period of 30 days. The total sampling effort was 1,044 camera days. We recorded fifteen species of mammals (after excluding humans and dogs). The L'Hoest's monkey (Figure 2) was the most recorded species at 30 of 35 sites, hence the highest naïve occupancy value. Dogs and humans were recorded as signs of human presence. Two medium sized carnivore species were recorded - the African golden cat (Figure 3) and the side striped jackal. A summary of species, the number of sites where they were recorded and their respective naïve occupancy is given in Table 2. Naïve occupancy was computed as the number of sites where the species was recorded divided by the total number of sites (N=35). Naïve occupancy is a surrogate of species abundance (Rovero & Marshall 2009; Ahumada ***et al***. 2011).

Figure 2 A L'Hoest's monkey as recorded by the camera trap on 1st January 2016

Figure 3 African golden cat recorded by camera trap on 12th December 2015

Table 2. Recorded species at camera trap sites in KKCFR. The species are listed in order of decreasing number of sites where they were recorded

Animal	Genus	Species	Taxonomic group	No. of sites	Naïve occupancy
L'Hoest's monkey	*Cercopithecus*	*l'hoesti*	Frugivore/Herbivore	30	0.857
Dormouse	Praomys	jacksonii	Frugivore	24	0.686
Congo rope squirrel	*Cricetomys*	*gambianus*	Frugivore	18	0.514
Humans	*Homo*	*sapiens*	Omnivore	15	0.429
Olive baboon	*Papio*	*anubis*	Frugivore/Herbivore	15	0.429
Chimpanzee	*Pan*	*troglodytes*	Frugivore/Herbivore	14	0.4
Black fronted duiker	*Cephalophus*	*nigrifrons*	Herbivore	14	0.4
Giant African pouched rat	*Cricetomys*	*gambianus*	Frugivore	14	0.4
Dog	*Canis*	*lupus*	Carnivore	11	0.314
Servaline genet	*Genetta*	*servalina*	Carnivore	11	0.314
African golden cat	*Caracal*	*aurata*	Carnivore	5	0.143
Side striped jackal	Canis	adustus	Carnivore	5	0.143
African civet	*Civettictis*	*civetta*	Omnivore	5	0.143
Yellow backed duiker	*Cephalophus*	*silvicultor*	Herbivore	5	0.143
Bush buck	*Tragelaphus*	*scriptus*	Herbivore	4	0.114
Black & white colobus monkey	*Colobus*	*guereza*	Frugivore/Herbivore	2	0.057
Blue Monkey	*Cercopithecus*	*mitis*	Frugivore/Herbivore	2	0.057
Red tailed monkey	*Cercopithecus*	*ascanius*	Frugivore/Herbivore	1	0.029
Bush pig	*Potamochoerus*	*larvatus*	Omnivore	1	0.029

4.1.2 Species richness estimation

A cumulative species richness of eighteen species of terrestrial mammals was estimated to occur in the surveyed parishes of KK. A mean value of 5.85 terrestrial mammal species was estimated per site. The rarefaction curve of terrestrial mammal species did not reach an asymptote, indicative that some species may not have been recorded during the survey (Fig. 4).

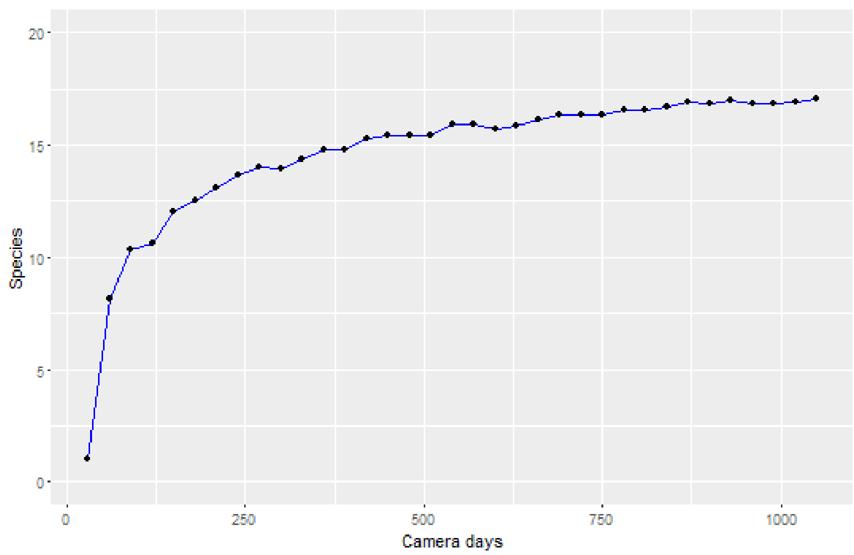


Figure 4. Rarefaction curve showing mammal species accumulation with sampling effort (camera days) for the species detected by camera trapping in KKCFR. The rarefaction curve was close to asymptote

4.1.3 Probability of human activity occurrence

Human activity (humans and/or dogs) was recorded at 16 of the 35 surveyed sites (See also Figure 5). Hence, the naïve occupancy of human activity recorded was 0.429. This means that human activity was recorded in 48% of the surveyed grid cells. Occupancy modeling predicted human activity to occur in 46%± 0.09 of the grids cells in the surveyed area (Table 3).

Figure 5 A fresh pitsawing platform recorded on 16th December 2015

Table 3. Occupancy model coefficients predicting human activity occupancy in the surveyed area of KKCFR, western Uganda

Model	Estimate	Standard Error	[1]nPars	AIC	delta
Null	0.46	0.090	2	385.9	0.0
Elevation	0.42	0.127	3	387.2	1.3
Tree cover	0.57	0.131	3	387.3	1.4
Tree cover + Elevation	0.49	0.117	4	388.9	3.0

Where Null model assumes occupancy and detectability are uniform across the site, [1]the number of parameters per model.

Model comparison showed that the models had closely equal strength to predict human activity occurrence in the surveyed parishes. However, human activity occurrence is likely to be higher in forest areas with high tree cover (Table 3). Since the models had equal explanatory power for human activity occurrence in the surveyed parishes, we used the model that combined tree cover and elevation (global model) as predictor variables. We ran a goodness of fit analysis to ascertain the fit of the global model to our data well. The predicted occupancy of human activity in surveyed parishes of KK is shown in Fig. 6. Human activity is relatively widespread in surveyed parishes. The relationships between human activity occurrence and considered covariates are graphically shown in Fig. 7. The black line is the linear regression fit. Human activity occurrence was significantly negatively correlated with elevation (Estimate= -0.0009, R^2=0.56, $p < 0.05$). Human activity occurrence was significantly positively correlated with tree cover (Estimate=0.05, R^2=0.49, $p<0.05$).

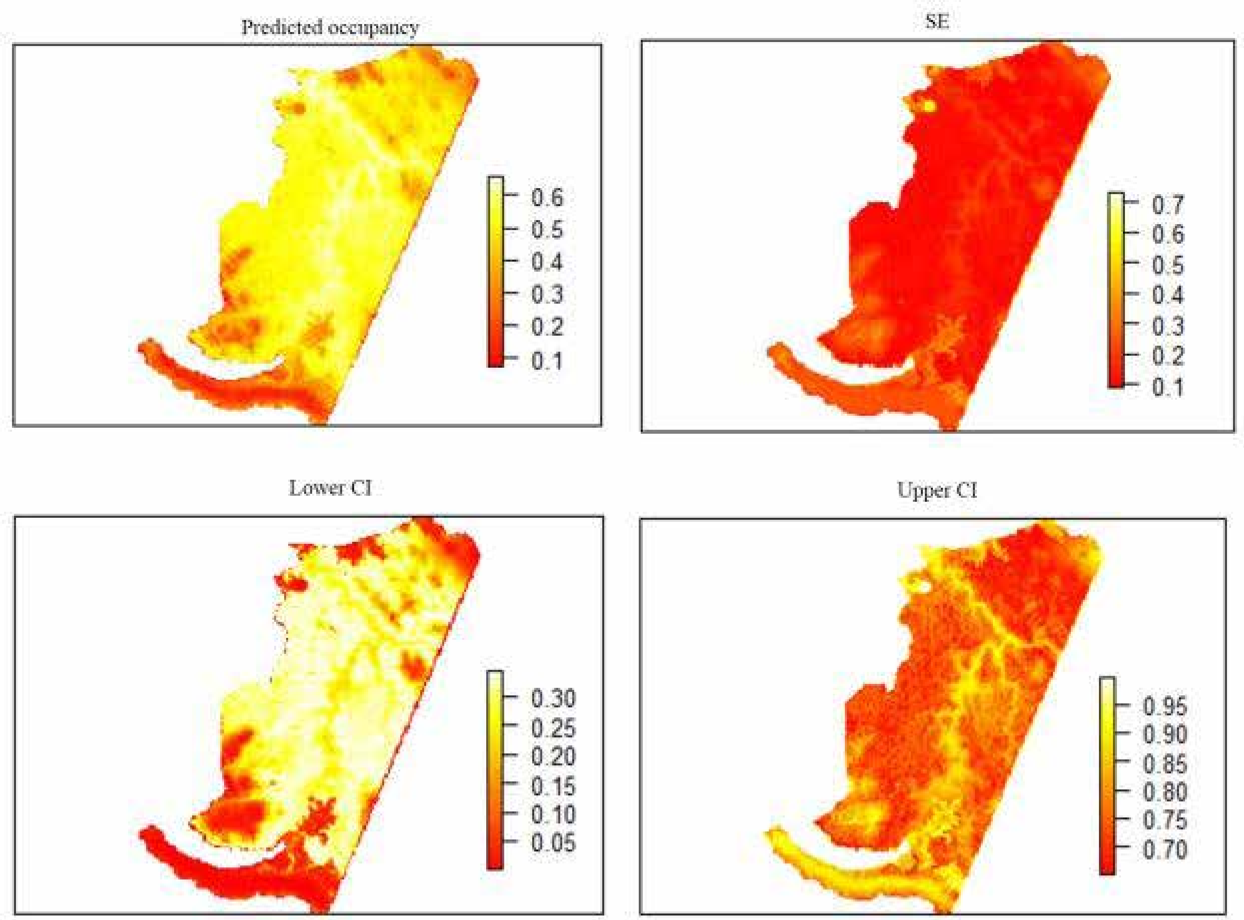


Figure 6. Predicted occupancy of human activity in the surveyed areas of KKCFR, western Uganda. SE is the standard error of prediction. Lower CI and Upper CI are the confidence intervals at 95%

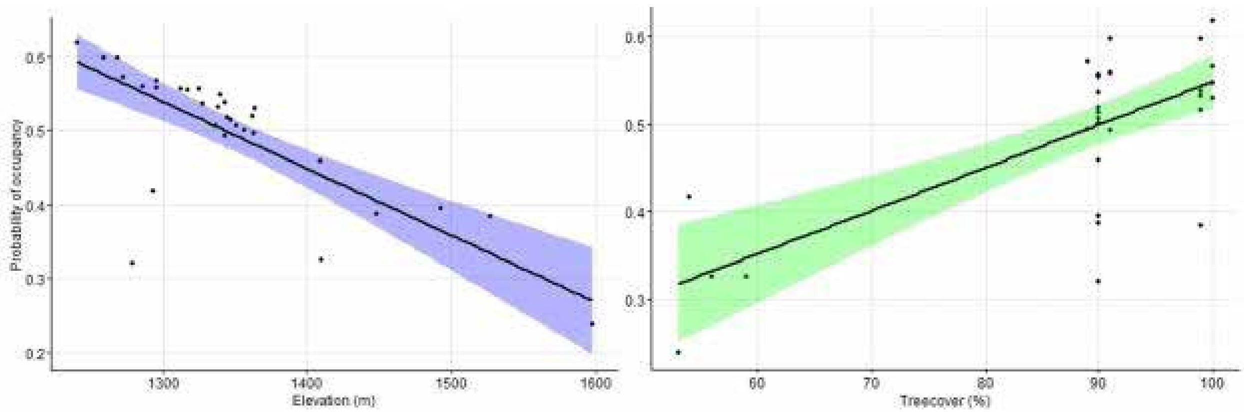


Figure 7. Relationship between human activity occurrence and considered covariates. On the y-axis is the probability of human occurrence and on the x-axis is the covariate (elevation and tree cover). The colored bands are the confidence interval at 95%.

4.1.4 Probability of wildlife occurrence in surveyed parishes of KK

Probability of human occurrence was highly correlated with tree cover ($r=0.56$, $p < 0.05$). For this reason, only human activity was considered in modeling mammal occurrence in the surveyed parishes of KK. The models had closely equal strength in predicting mammal occurrence in the surveyed parishes. For this reason, we used the model that combined human activity and elevation (global model) as predictor variables for mammal occupancy. We ran a goodness of fit analysis to ascertain the fit of the global model to our data well. High occupancy of mammals was recorded in the surveyed parishes of KK. Probability of occupancy of mammals was positively related to elevation and negatively correlated to human activity. The predicted probability of mammal occupancy is shown in Fig. 8, and its relationships with covariates in Fig. 9. The black line is the linear regression fit. Mammal occurrence was significantly negatively correlated with human activity (Estimate= -1.61, R^2=0.84, $p < 0.05$). Mammal occurrence was significantly positively correlated with elevation (Estimate=0.0004, R^2=0.33, $p<0.05$).

Table 4. Occupancy model coefficients for predicting probability of mammal occurrence in the surveyed areas in KKCFR, western Uganda

Model	Estimate	Standard Error	[1]nPars	AIC	delta
Null	0.87	0.079	2	238.3	0.0
Human activity	0.88	0.081	3	239.7	1.5
Elevation	0.89	0.009	3	240.0	1.8
Human activity + Elevation	0.89	0.816	4	241.7	3.4

Where;Null model assumes occupancy and detectability are uniform across the site, 2the number of parameters per model.

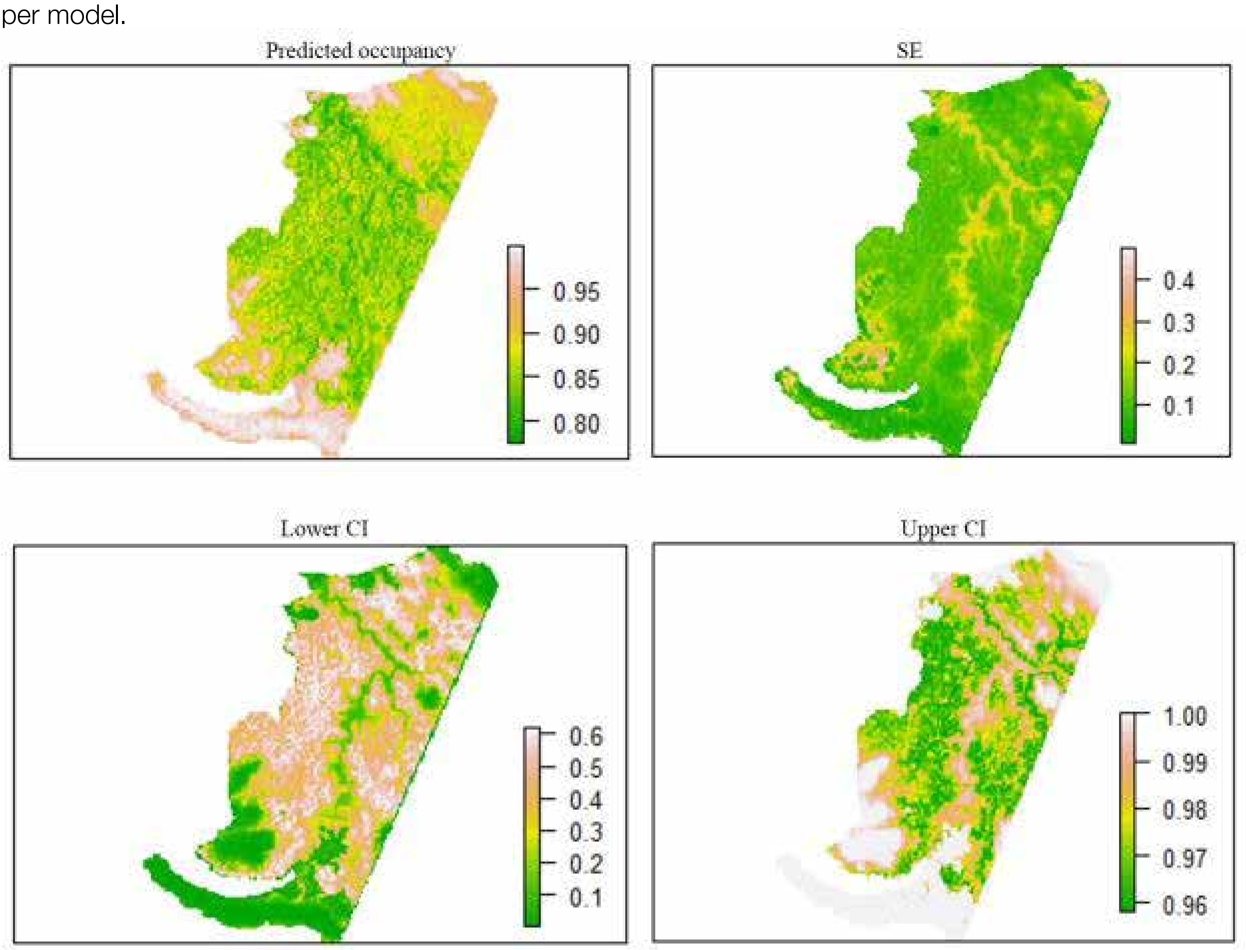


Figure 8. Predicted occupancy of mammals in surveyed areas of KKCFR. SE is the standard error of prediction. Lower CI and Upper CI are the confidence intervals at 95%

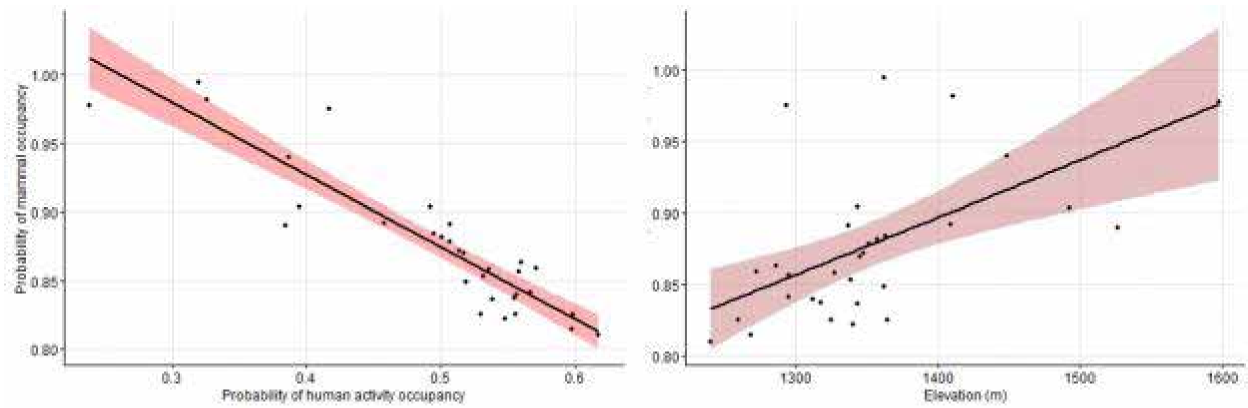


Figure 9. Relationships between predicted mammal occupancy and covariates. On the y-axis is the probability of mammal occupancy and on the x-axis is the predicting variable human activity and elevation. The colored bands are the confidence intervals at 95%

4.2 TREE DIVERSITY AND DISTRIBUTION

4.2.1 Tree species richness across the sites

A total of 64 sites were sampled for trees, 16 sites in each of the forest portion adjacent the four parishes of Mwongyera, Butoha, Buzenga and Ndangaro. However, two sites in the forest adjacent to Ndangaro Parish did not have any tree ≥10cm dbh. A total of 97 tree species were encountered in the surveyed area. Butoha had 41 tree species, 49 in Buzenga, 32 in Mwongyera and 36 in Ndangaro. Site tree species richness ranged from one to 16 species with the modal frequency of four tree species in 20 percent of the sample plots (n=64). There was little variation in tree species richness from forest edge to the interior (Figure 10). The most common tree species were *Funtumia africana* and *Xymalos monospora* which were encountered in 33 and 25 percent, respectively, of all the sites surveyed (n=64).

The curve (Figure11) is a plot of tree species richness as a function of the numberof sites sampled. The slope of the curve remained steep and the asymptote was not reached indicating that more tree species remain unrecorded.

The species accumulation curves allowed comparison of tree species richness of the different study sites at the same sample size (Figure 12). The forest adjacent to Buzenga Parish had more tree species compared to the other three study sites. However, the tree species accumulation curve for each of the study areas remained steep indicating that still more tree species remained unrecorded in each of the four study areas.

Since the species richness accumulation curves did not reach asymptote, we made some predictions, based on the sites sampled, for the expected total species richness using different methods – the first- and second-order Jackknife, Chao and bootstrap formulae. The predictions varied ranging from 113 to 144 expected tree species for the area surveyed.

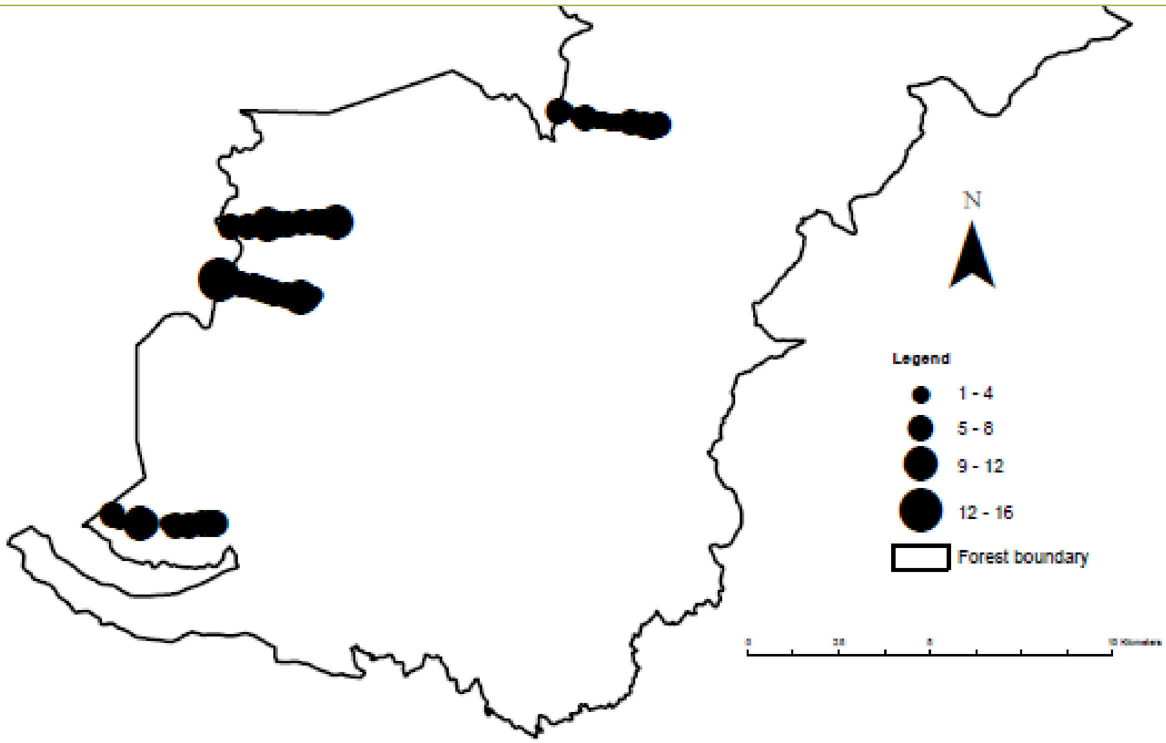


Figure 10. Tree species richness across the sample sites in KKCFR, western Uganda

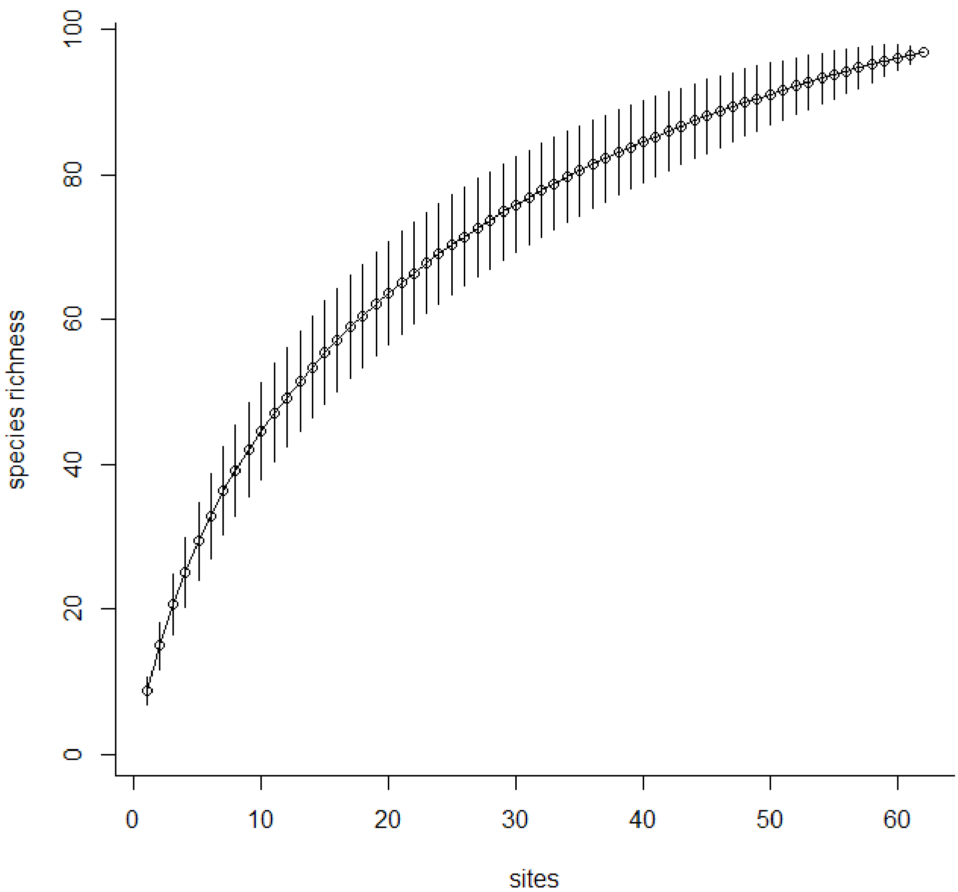


Figure 11. Tree species rarefaction curve for the surveyed area of KKCFR, western Uganda

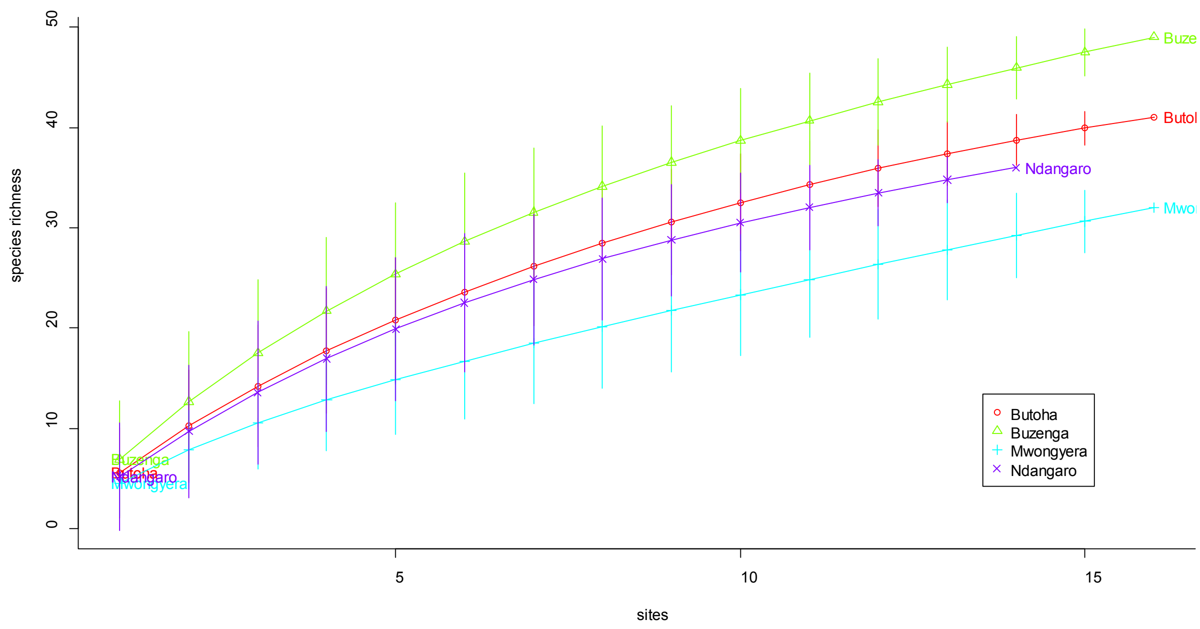


Figure 12. Tree species richness accumulation curve for each area in KKCFR adjacent Butoha, Buzenga, Mwongyera and Ndangaro Parishes, western Uganda

4.2.2 Cluster and indicator species analyses

The sample sites from the surveyed area were arranged into five clusters, with each cluster having sites with similar tree species composition as measured by the Bray-Curtis ecological distance. Sites that were grouped into the same cluster were more similar in tree species composition than sites that were grouped into different clusters. From Figure 13, it can be seen that generally, sample sites from the same study area were grouped together. The first group had sites mainly from Ndagaro, while the second group had sites largely from Mwongyera, third and fourth cluster had sites mostly from Buzenga while the fifth cluster had sites by and large from Butoha. However, more importantly, indicator species analysis showed that the clusters could be distinguished by the ecological characteristics of their indicator tree species (Table 5). The first cluster had trees of mixed ecological characteristics; the second cluster had forest interior tree speciesonly; the third cluster had only forest generalists; the fourth cluster had forest generalists and one forest interior species; while the fifth had mainly forest non-dependent types.

We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. The cophenetic correlation was high (0.77) meaning that the differences portrayed in the dendrogram were a good representation of the differences in species composition between individual sample sites.

4.2.3 Clustering and ordination

Figure 14 is the NMDS bi-plot. The points represent individual sample sites, the ellipses show the five tree cluster analysis classes and the arrows represent significant (p<0.05) quantitative environmental variables. The combined name of the qualitative environmental factors and name of the level (e.g. Positiontop) represent the centroids (averages) of their distribution in the sample sites in relation to the ordination axes.

In NMDS diagram, the sample sites were plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. It can be visualized that sample sites from the same study area were near each other, meaning that they had similar tree species composition, while those from different study areas were far apart indicating that their tree species composition were different.

Altitude, with the longest arrow, was more important in influencing variation in tree species composition than ground cover and distance from forest edge with short arrows. Altitude and ground cover whose arrows are pointing in opposite direction have a correlation of -1.0, while altitude and distance from forest edge whose arrows are close to being at a right angle (90°) are weakly correlated. Ground cover and distance from forest edge arrows at slightly above 90° and are therefore weakly negatively correlated.

The NMDS diagram showed the sample sites clearly with various groupings of similar tree species composition emerging. Sample sites adjacent to Ndangaro and Mwongera Parishes are shown to the right of the plot while those adjacent to Buzenga and Butoha Parishes are located towards the left of the diagram. Much as the transects for Mwongyera and Butoha were closest to each other, the sample sites in the two study areas seem to have the greatest difference in tree species composition.

The sample sites were related to the arrows representing environmental factors and gradients. Sample sites near to or beyond the tip of the arrow are strongly positively correlated with and influenced by the arrow representing an environmental factor. Those at the opposite end are less strongly affected. Tree species composition in the sample sites of Mwongera and Ndangaro were positively correlated with and influenced by altitude, while ground cover and distance from forest edge greatly influenced tree species composition of sample sites in Butoha and Buzenga. Significant qualitative factors such as human activity presence ($p<0.01$) and position of the sample site on the slope ($p<0.001$) are shown as centroids (weighted averages) of their distribution in the sample sites in relation to the ordination axes. The sample sites that are influenced by a particular categorical environmental variable are scattered around the centroid of the categorical environmental variable in the diagram.

African golden cat recorded by camera trap

Table 5. Significant indicator species and their indicator values for the tree cluster analysis classes

Species	Indicator value	*p*-value
CLUSTER 1		
*Macaranga barteri*Fg	0.54	0.00
*Pseudospondias microcarpa*Fn	0.45	0.00
*Funtumia elastica*F	0.37	0.00
CLUSTER 2		
*Strombosia scheffleri*F	0.68	0.00
*Carapa grandiflora*F	0.51	0.00
*Syzygium guineense*F	0.28	0.01
CLUSTER 3		
*Xymalos monospora*Fg	0.85	0.00
*Celtis gomphophylla*Fg	0.40	0.01
*Diospyros abyssinica*Fg	0.28	0.03
CLUSTER 4		
*Funtumia africana*F	0.65	0.00
*Myrianthus holstii*Fg	0.29	0.01
*Trichilia rubescens*Fg	0.27	0.02
CLUSTER 5		
*Macaranga capensis*Fg	0.64	0.00
*Polyscias fulva*Fn	0.52	0.00
*Harungana madagascariensis*F	0.29	0.02
*Pancovia turbinate*Fn	0.29	0.01
*Maesa lanceolata*Fn	0.26	0.01

Key to tree species ecological characteristics: F – Forest interior; Fg – Forest generalists (can occur in forest interior, edge or near rivers); Fn – Forest non-dependent type (occur in forested and open habitats)

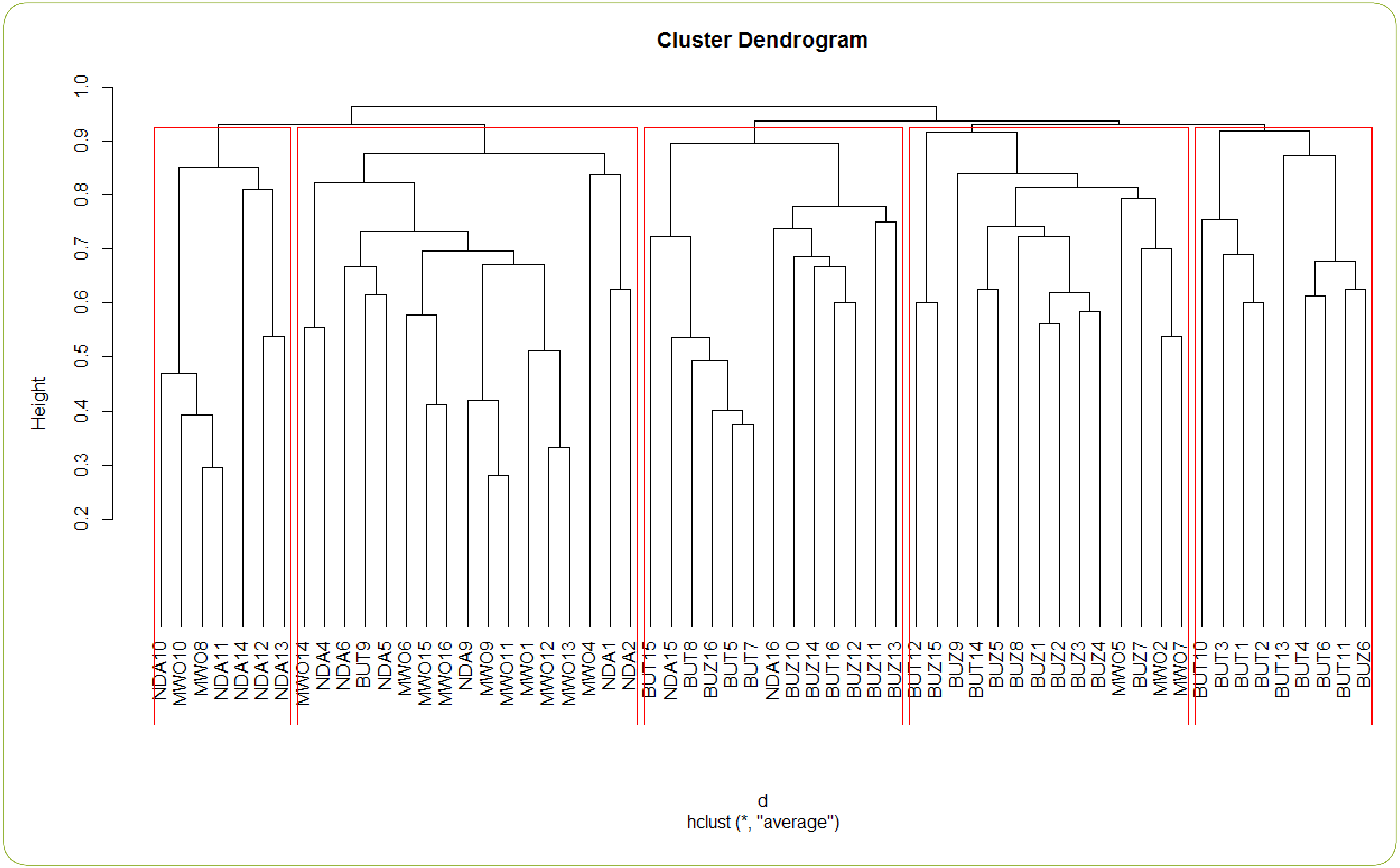


Figure 13. Tree species cluster analysis dendrogram for the surveyed area of KKCFR, western Uganda
Key: NDA – Ndangaro; MWO – Mwongyera; BUT – Butoha; BUZ –Buzenga

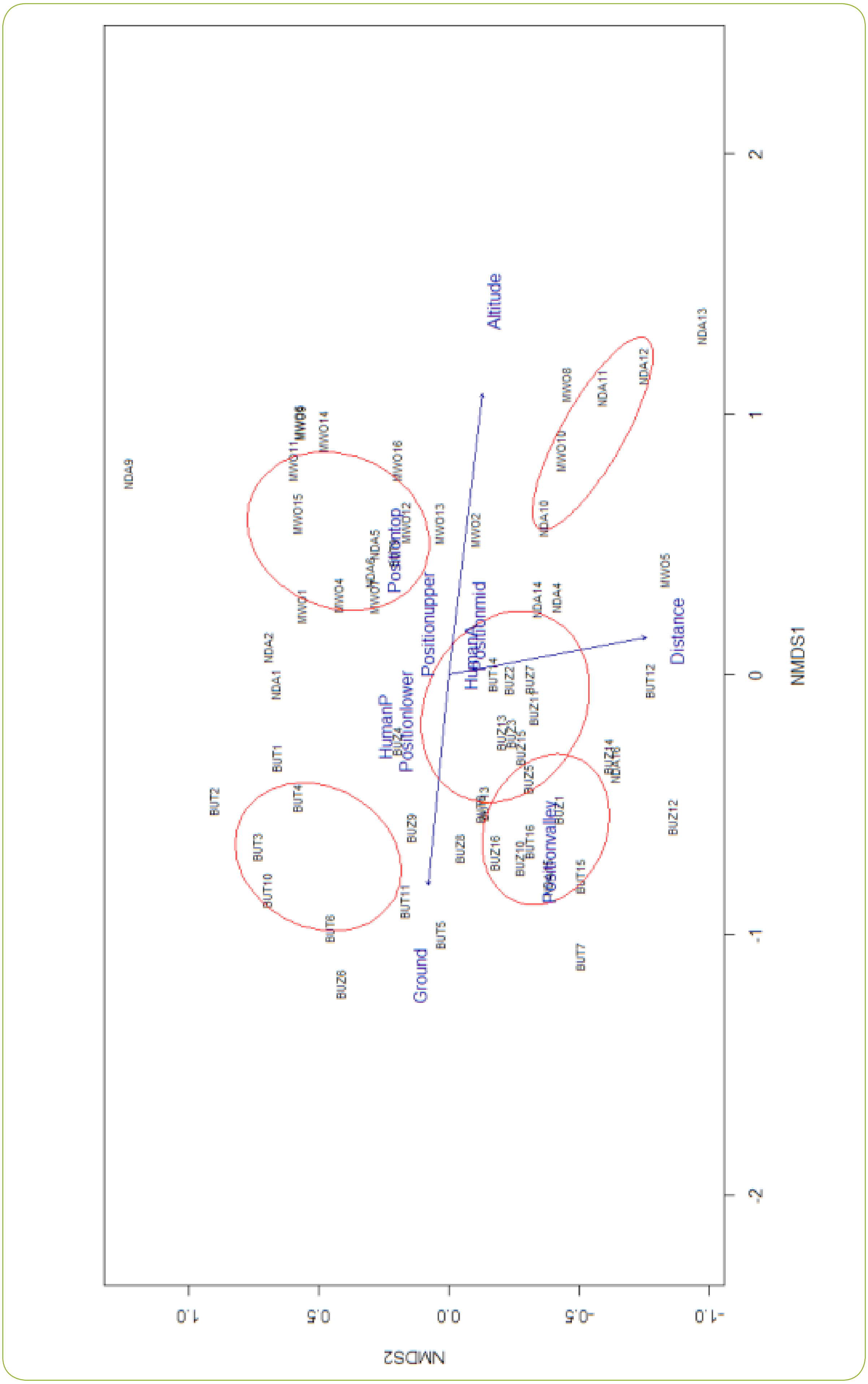


Figure 14. NMDS ordination plot for the tree sample sites in KKCFR, western Uganda

4.2.4 Previous work on tree diversity and distribution

Previous surveys of trees in KKCFR were made by Howard (1991) and Howard *et al.* (1996). A summary of the results of these surveys is presented in Table 6.

Table 6. Previous tree inventory studies in KKCFR, western Uganda

Researcher/study	Extent/sites covered	Methods used/ adapted	No. species recorded
This study	Four transects totaling 12 km length, 64 sample sites, 25 days of sampling	20× 20m sample plot at 200m intervals, trees ≥10 cm dbh	97
Howard *et al.*(1996)	30 transects of unknown lengths, following paths of least resistance, covering all major biological and physical characteristics of the forest, 29 days of sampling	Observation and abundance estimates based on DAFOR	279 (a tree was not defined by minimum dbh therefore this number includes shrubs)
Howard (1991)	Four transects of 4-6 km length, in north east and south west of the forest, five weeks of sampling	20× 20m sample plot at 200m intervals, trees ≥10 cm dbh	204 (includes species recorded before this study)

Differences in the survey methods and extent unfortunately make it difficult to compare the results of this study with the previous ones.

According to Howard (1991) and Howard *et al.* (1996), KKCFR is particularly important for tree diversity and conservation. It contains 37 restricted-range species In addition, the reserve is inhabited by *Ritchiea aprevaliana,* a species whose known distribution in Uganda is limited to this reserve and Budongo only, and *Uvario dendronmagnificum*, a species that is endemic to Uganda.

4.3 SMALL MAMMAL DIVERSITY AND DISTRIBUTION

4.3.1 Small mammal species richness across the sites

A total of 32 sites were sampled for small mammals, 8 sites in each of the forest portions adjacent to the four parishes. A total of 9 small mammal species (6 rodents and 3 shrews) were encountered in the whole survey area (Table 7). The most common species were *Malacomys longipes* and *Praomys jacksoni* which were encountered in 75 and 59 percent, respectively, of all the sample sites (n=32) and were found in all the four study areas.

Figure 15 A rodent being freed after capture by the Sherman trap

Table 7. Small mammal species and their distribution among the study sites KKCFR, western Uganda

Species	Ecological type	Butoha	Buzenga	Mwongyera	Ndangaro
RODENTS					
Dasymys incomtus	AO	■			
Grammomys dolichurus	F	■			
Hybomys univittatus	F		■		
Lophuromys sp	W?	■		■	■
Malacomys longipes	AF	■	■	■	■
Praomys jacksoni	F	■	■	■	■
SHREWS					
Crocidura maurisca	AF		■		
Scutisorex somereni	AF				■
Sylvisorex granti	F	■			■

Key:AF – Swamp forest; AO – Swamp open habitats; F – Closed forest; f – Forest edge; W - Widespread

Site species richness ranged from one to four species. There was little variation in small mammal species richness along each of the four transects except for the northernmost transect in Mwongyera where the species richness increased from forest edge to the interior (Figure 16).

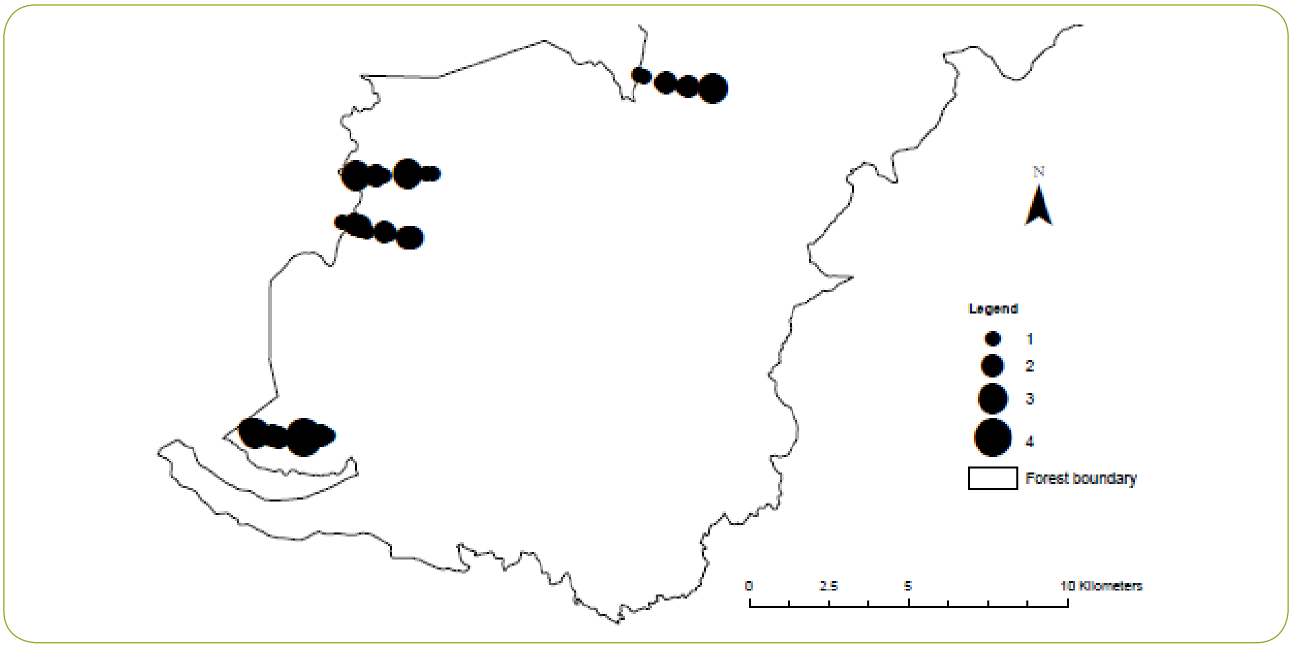


Figure 16. Small mammal species richness across the sample sites in KKCFR, western Uganda

The curve (Figure 17) is a plot of small mammal species richness as a function of the number of sites sampled. The slope of the curve remained steep and the asymptote was not reached indicating that more small mammal species remain unrecorded. Further, the small mammal species accumulation curve for each of the study areas remained steep indicating that still many more small mammal species remained unrecorded in the study areas (Figure 18).

Since the species richness accumulation curves did not reach asymptote, we made some predictions, based on the sites sampled, for the expected total species richness using different methods – the first- and second-order Jackknife, Chao and bootstrap formulae. The predictions varied ranging from 11 to 16 expected small mammal species for the area surveyed.

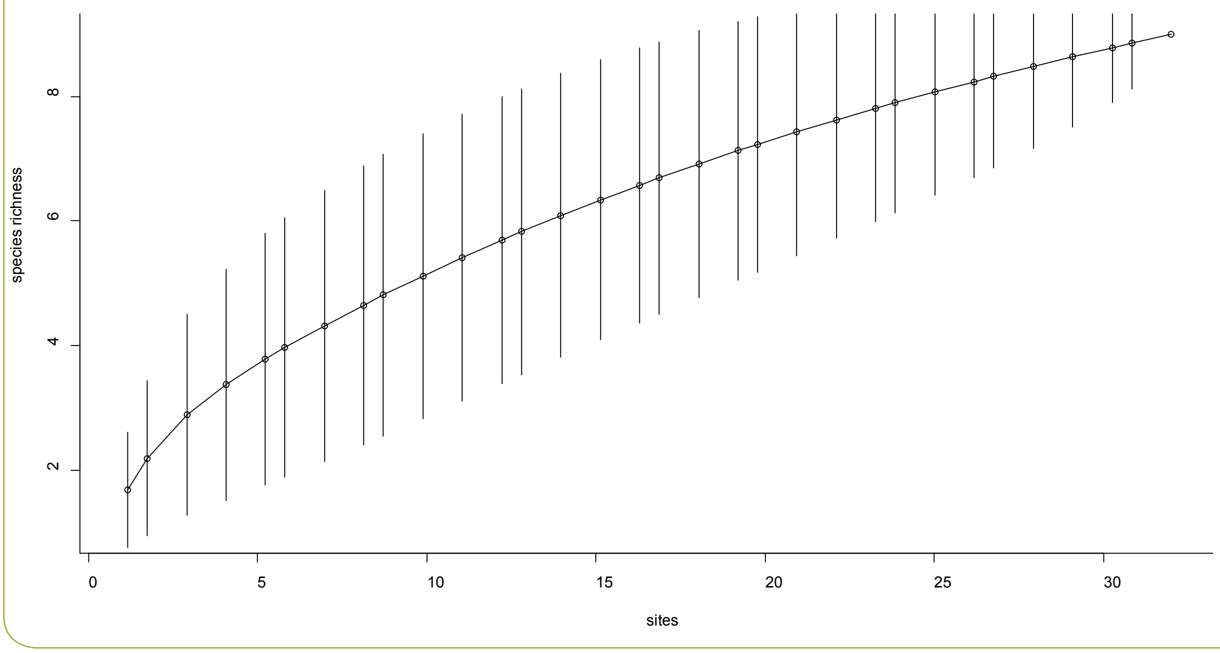


Figure 17. Small mammal species richness accumulation curve for the surveyed area in KKCFR, western Uganda

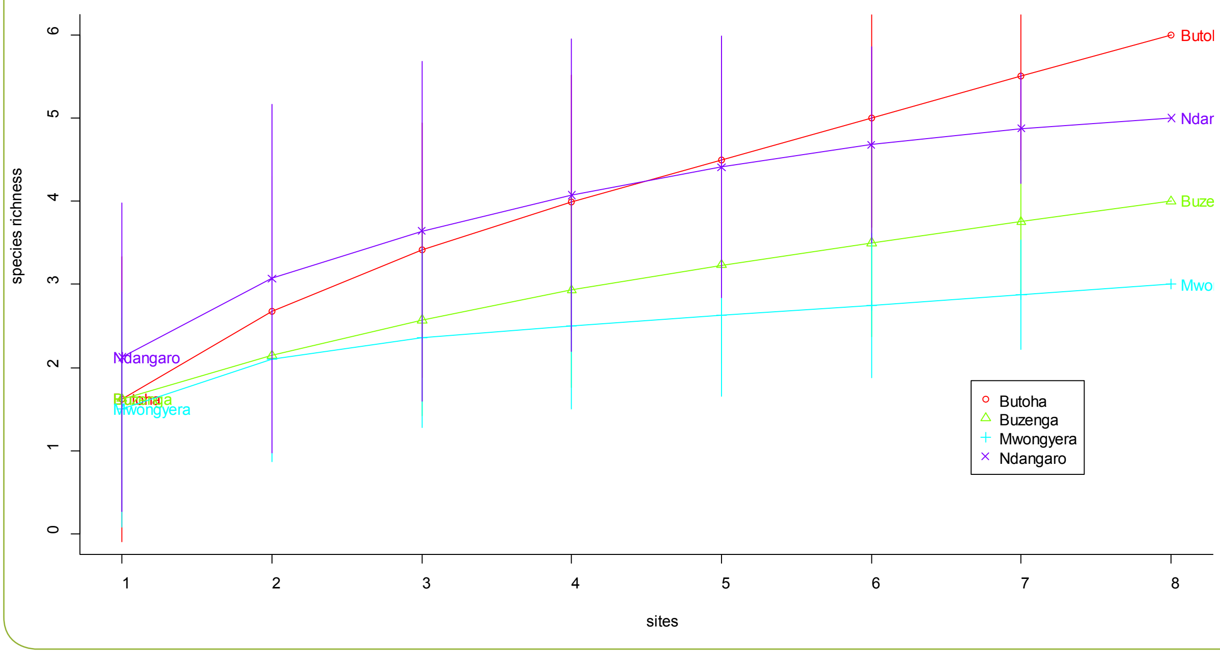


Figure 18. Small mammal species richness accumulation curve for each area of KKCFR adjacent Butoha, Buzenga, Mwongyera and Ndangaro Parishes, western Uganda

4.3.2 Cluster analysis and ordination

The sample sites from the whole study area were arranged into two clusters, with each cluster having sites with similar small mammal species composition as measured by the Bray-Curtis ecological distance. Sites that were grouped into the same cluster were more similar in small mammal species composition than sites that were grouped into different clusters (Figure 19). There was no discernible pattern in terms of the geographical location of the sample sites. We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. The cophenetic correlation was not high enough (0.73) meaning that the distance portrayed in the dendrogram wasa fairly good representation of the species composition between individual sample sites. However, when the environmental variables were superimposed on the NMDS ordination plot, they showed that canopy openness ($p<0.01$) and slope aspect ($p<0.05$) were the most significant factors influencing variation in species composition (Figure 20).

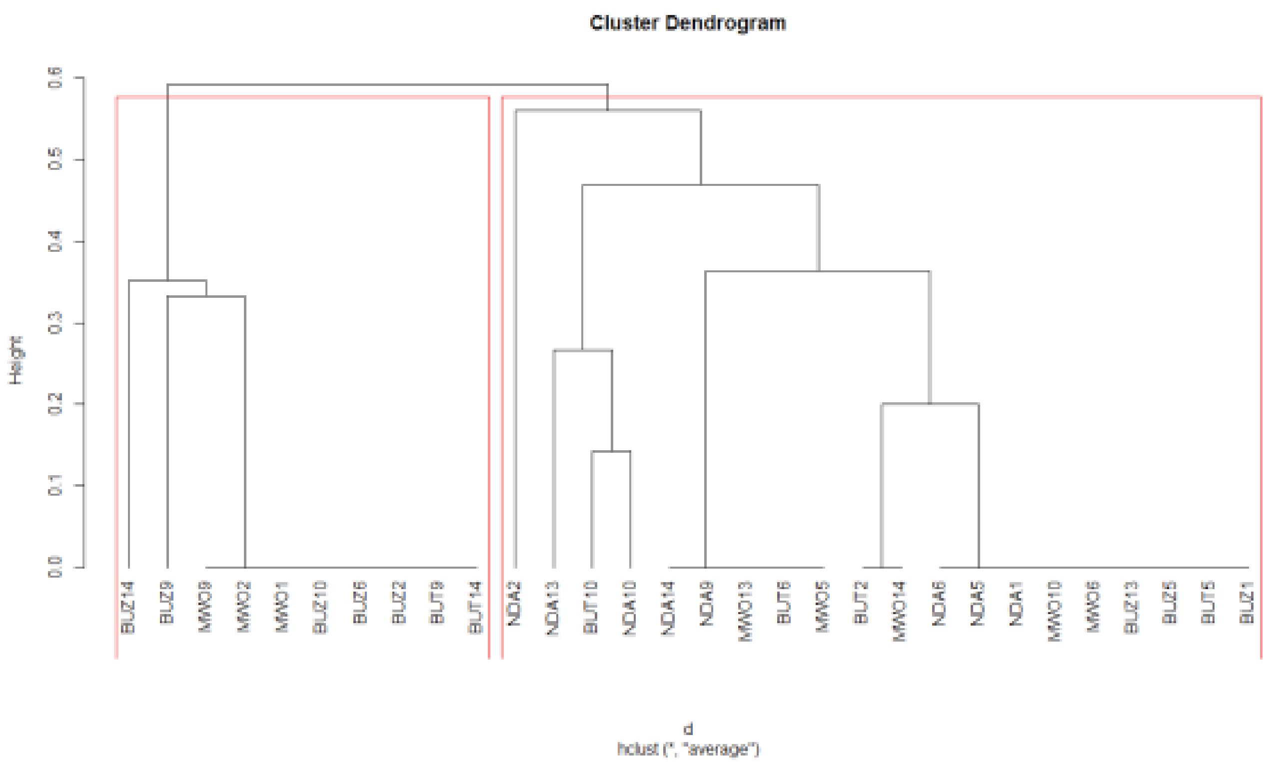


Figure 19. Small mammal species cluster analysis dendrogram for the surveyed area of KKCFR, western Uganda

Key: NDA – Ndangaro; MWO – Mwongyera; BUT – Butoha; BUZ –Buzenga

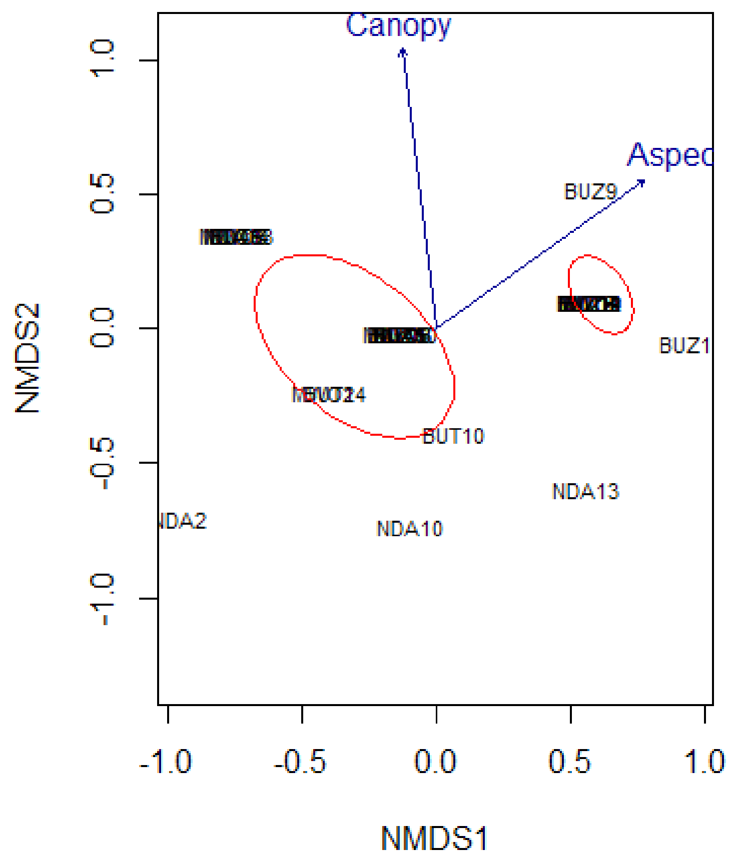


Figure 20. NMDS ordination plot for small mammal species sample sites in KKCFR, western Uganda

4.3.3 Previous work on small mammal diversity and distribution

Previous surveys of small mammals in KKCFR were made by Howard *et al.* (1996). A summary of the results of these surveys is presented in Table 8.

Table 8. Previous small mammal inventory studies in KKCFR, western Uganda

Researcher/study	Extent/sites covered	Methods used/adapted	No. species recorded
This study	Four transects totaling 12 km length, 32 sample sites, 21 days of samplingday and night	Sherman traps set at sample plots at 200m intervals	9 (6 rodents and 3 shrews)
Howard *et al.* (1996)	6 sample sites, distributed around the forest, 42 days of sampling	Combination of traps used: Sherman, Longworth, pitfall and break-back traps in a variety of habitats	23 (12 rodents and 11 shrews)

Differences in the survey methods and extent unfortunately make it difficult to compare the results of this study with the previous one.

According to Howard *et al*. (1996), KKCFR represents one of the richest forest in small mammal species. Of particular interest are three uncommon forest-dependent shrews *Crocidura maurisca* (Northern Swamp Musk Shrew), *C. montis* (Eastern Montane Musk Shrew) and *Scutosorex somereni* (Hero Shrew) and an Albertine Rift endemic *Lophuromys woosnami* (Woosnam's Brush-furred Rat). There are species sensitive to forest disturbance including *Malacomys longipes* (Woosnam's Brush-furred Rat).

4.4 BIRD DIVERSITY AND DISTRIBUTION

4.4.1 Bird species richness across the sites

Point counts

A total of 40 sites were sampled using bird point counts, 10 sites in each of the forest portion adjacent the four parishes of Mwongyera, Butoha, Buzenga and Ndangaro. A total of 118 bird species were encountered in the surveyed area. Butoha had 60 species, 63 in Buzenga, 38 in Mwongyera and 60 in Ndangaro. Site bird species richness ranged from three to 21species. There was variation in bird species richness along each of the four transects (Figure 21). Along northern most transect, species richness tended to increase from forest edge to the interior while on the remaining three transects the trend was a decrease from forest edge to the interior. The most common bird species were Yellow-whiskered Greenbul (*Andropadus latirostris*) and Yellow-rumped Tinkerbird(*Pogoniulus bilineatus*) which were encountered in 88 and 50 percent, respectively, of all the sites surveyed (n=40).

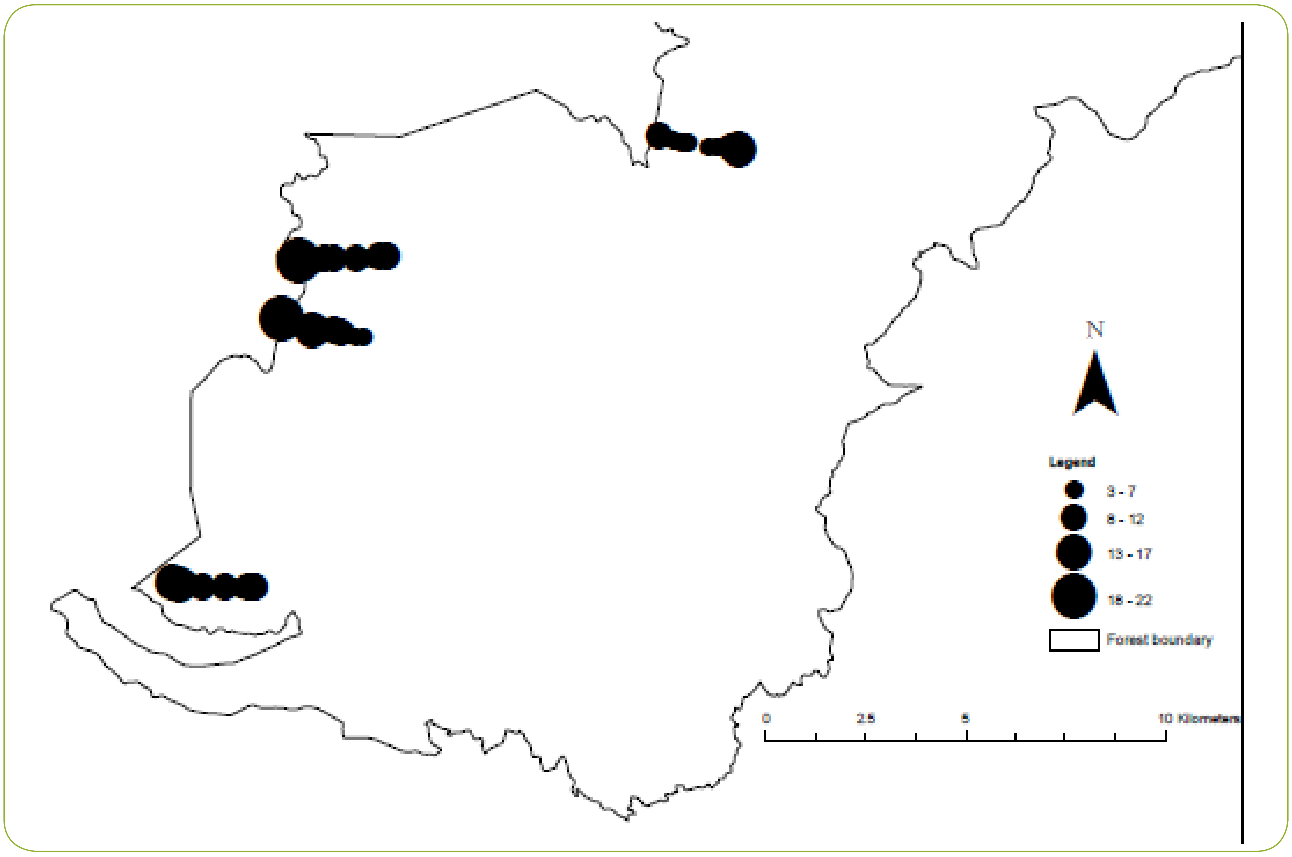


Figure 21. Bird species richness across the sample sites in KKCFR, western Uganda

The curve (Figure 22) is a plot of bird species richness as a function of the number of sites sampled. The slope of the curve remained steep and the asymptote was not reached indicating that more bird species remain unrecorded.

The species accumulation curves allowed comparison of bird species richness of the different study sites at the same sample size (Figure 23). The forest adjacent to Mwongyera Parish had fewer bird species compared to the other three study sites. However, the bird species accumulation curve for each of the study areas remained steep indicating that still more bird species remained unrecorded in each of the four study areas.
Since the species richness accumulation curves did not reach asymptote, we made some predictions, based on the sites sampled, for the expected total species richness using different methods – the first- and second-order Jackknife, Chao and bootstrap formulae The predictions varied ranging from 143 to 201 expected bird species for the area surveyed.

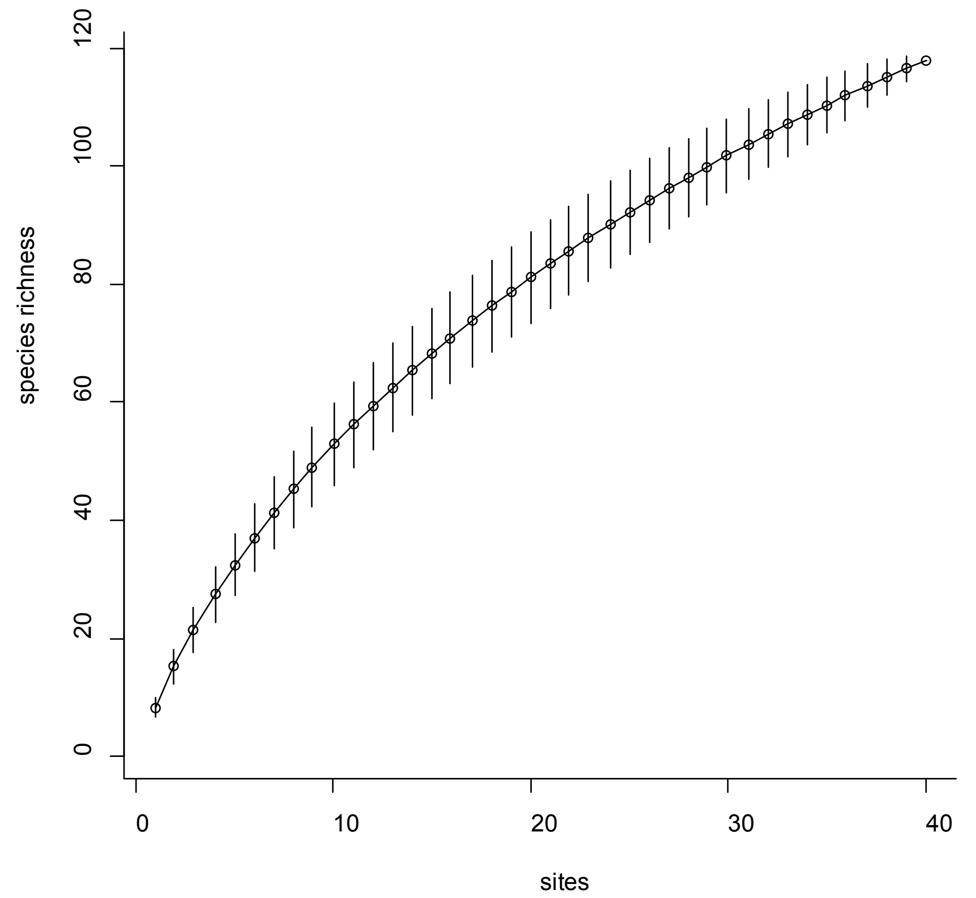


Figure 22. Bird species richness accumulation curve for the surveyed area of KKCFR, western Uganda

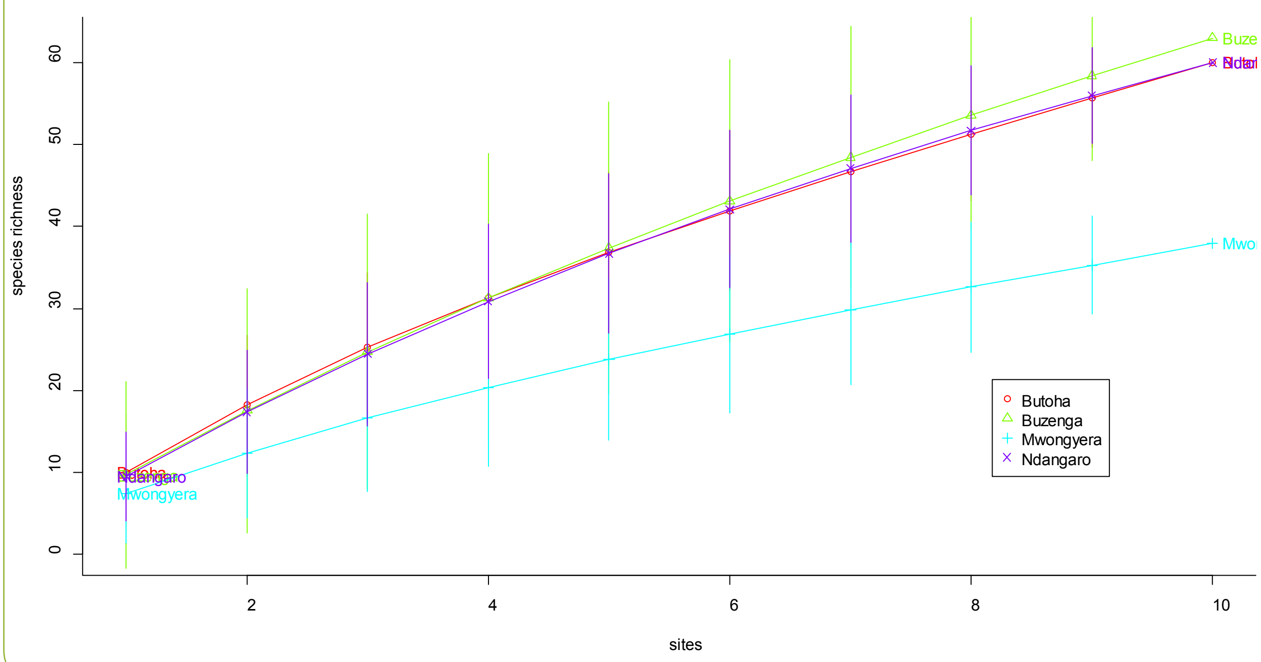


Figure 23. Bird species accumulation curve for each forest area in KKCFR adjacent Butoha, Buzenga, Mwongyera and Ndangaro Parishes, western Uganda

4.4.2 Cluster and indicator species analysis

The sample sites from the whole study area were arranged into five clusters, with each cluster having sites with similar bird species composition as measured by the Bray-Curtis ecological distance. Sites that were grouped into the same cluster were more similar in bird species composition than sites that were grouped into different clusters. From Figure 24, it can be seen that there was no pattern in the sample sites in terms of geographical location.

We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. The cophenetic correlation was moderate (0.66) meaning that the distance portrayed in the dendrogram was a fair representation of the differences in species composition between individual sample sites.

Table 9 shows the indicator species for each of the derived cluster classes. Forest specialist species dominated the bird indicator species in all the cluster classes.

Table 9. Significant indicator species and their indicator values for bird cluster analysis classes

Species	Indicator value	*p*-value
CLUSTER 1		
Blue-headed Coucal A	0.44	0.04
CLUSTER 3		
Black-billed TuracoFF	0.51	0.01
Waller's Chestnut-winged Starling FFH	0.5	0.03
CLUSTER 4		
Lagden'sBush-shrike FFH	1.0	0.00
Luhder's Bush-shrike F	1.0	0.00
Yellow-spotted Barbet FF	0.53	0.04
Red-capped Robin Chat F	0.67	0.02
CLUSTER 5		
Common Bulbul f	0.53	0.02
Yellow-rumpedTinkerbirdF	0.37	0.03

Key: FFH – Highland forest specialist; FF – Forest specialist; F – Forest generalist; f – Forest visitor; A – Aquatic/swamp species;

4.4.2 Clustering and ordination

Figure 25 is the NMDS bi-plot. The points represent individual sample sites, the ellipses show the five bird cluster analysis classes and the arrow represent significant ($p<0.05$) quantitative environmental variables. In NMDS diagram, the sample sites were plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. Canopy closure ($p<0.01$) and altitude ($p<0.05$) were the most important environmental variable influencing variation in bird species composition. The arrows for canopy closure and altitude are at right angles (90°) meaning that the two environmental variables are not correlated.

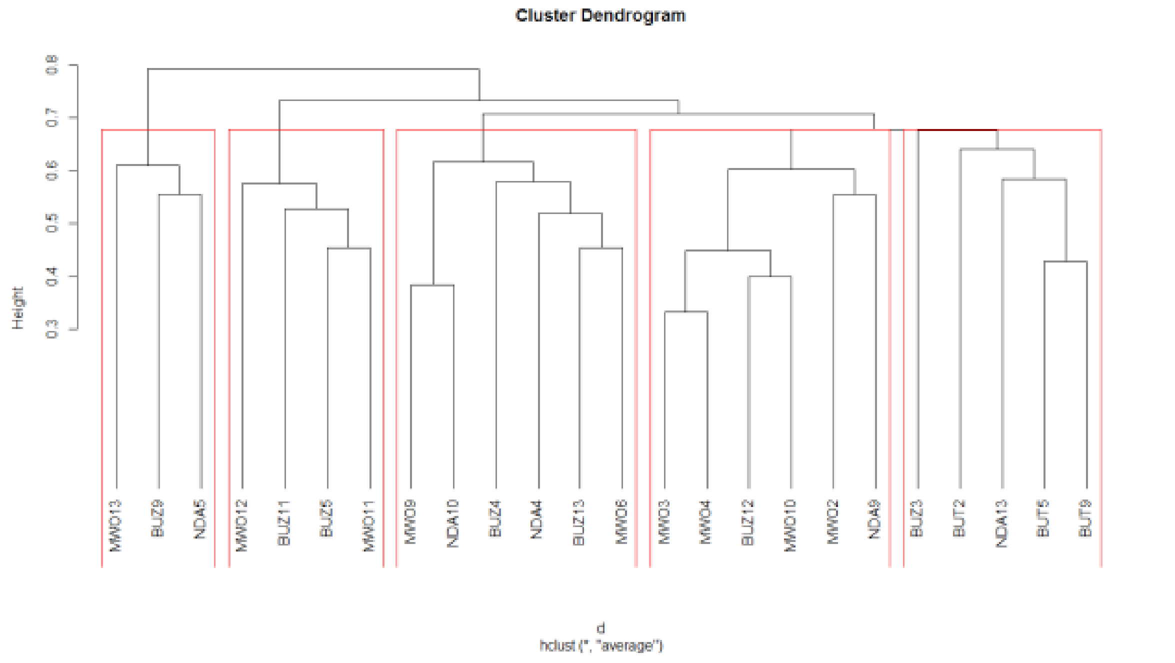


Figure 24. Bird species cluster analysis dendrogram (point count only) for the surveyed area of KKCFR, western Uganda

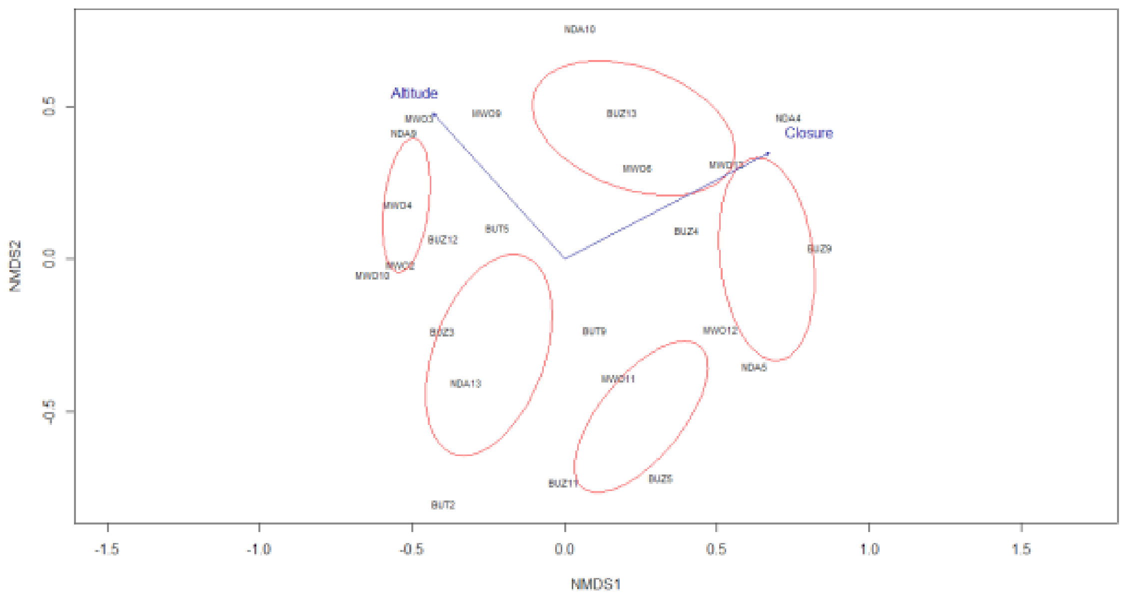


Figure 25. NMDS ordination plot for bird species sample sites (point counts only) in KKCFR, western Uganda

4.4.3 Point counts and mist nets

In addition to point counts, an additional 11 sites were mist netted, three on each of the transects in Butoha, Mwongyera and Ndangaroand two on Buzenga transect, bringing the total sites sampled for birds to 51. The results of the mist nets were combined with those of point counts and data reanalyzed. Six additional species, not observed in point counts, were captured in mist nets making a total of 127 bird species for this study.

4.4.4 Cluster analysis

Cluster analysis for the combined point counts and mist net sample sites were also grouped into five classes of similar bird species composition. From Figure 26, it can be seen that there was no pattern, in terms of geographic location, in the clustering of the combined point count and mist net sample sites. The cophenetic correlation was also low (0.62) meaning that the differences in species composition portrayed in the dendrogram were not a good representation of the differences species composition between individual sample sites.

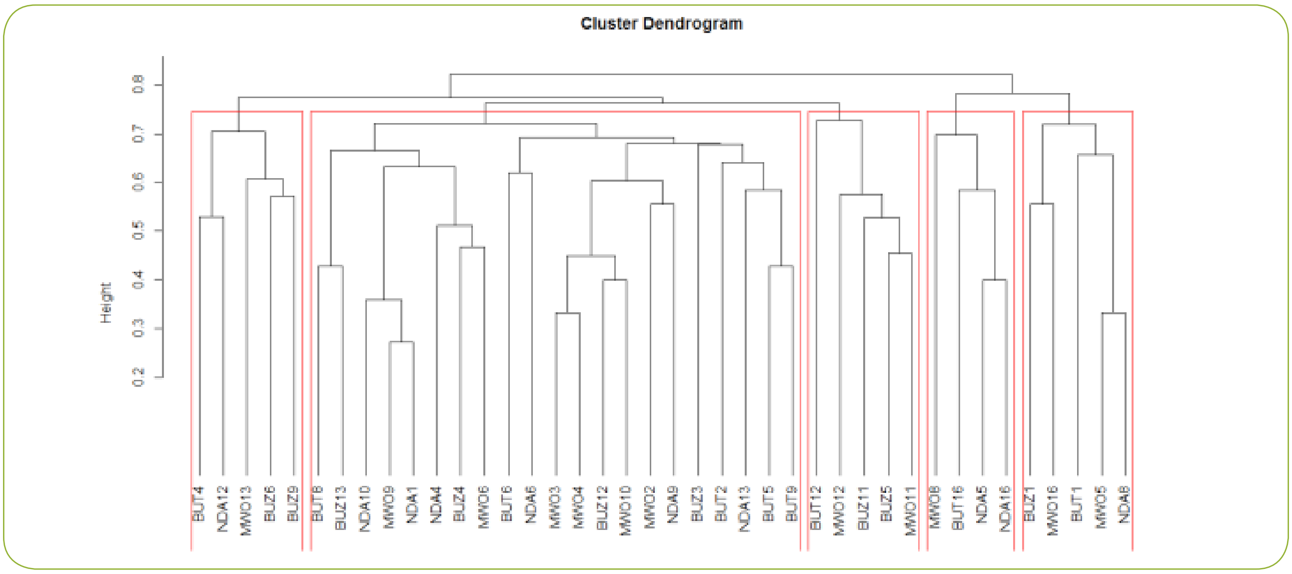


Figure 26. Bird species cluster analysis dendrogram (combined point count and mist net) for the surveyed area of KKCFR, western Uganda

Indicator species analysis shows that the forest specialist bird species dominated the cluster classes except one (Table 10).

Table 10. Significant indicator species and their indicator values for bird cluster analysis classes (combined point counts and mist nets)

Species	Indicator value	*p*-value
CLUSTER 1		
Variable Sunbird f	0.4	0.05
CLUSTER 2		
Tambourine DoveF	0.67	0.00
Black and White Casqued Hornbill F	0.38	0.03
CLUSTER 3		
Narina's Trogon F	0.59	0.00
Yellow-spotted Barbet FF	0.55	0.01
African Green Pigeon F	0.42	0.04
MontaneOrioleFFH	0.41	0.04
Lagden's Bush-shrike FFH	0.4	0.03
Luhder'sBush-shrike F	0.4	0.04
Ross's TuracoF	0.4	0.05
CLUSTER 4		
Black-billed TuracoFF	0.69	0.00
African Paradise Flycatcherf	0.54	0.01
Waller's Chestnut-winged StarlingFFH	0.4	0.01
CLUSTER 5		
Red-capped Robin-chat F	0.63	0.00

Key: FFH – Highland forest specialist; FF – Forest specialist; F – Forest generalist; f – Forest visitor

4.4.5 Clustering and ordination

In NMDS diagram (Figure27), the sample sites were plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. The measured environmental variables had no influence on bird species composition and distribution.

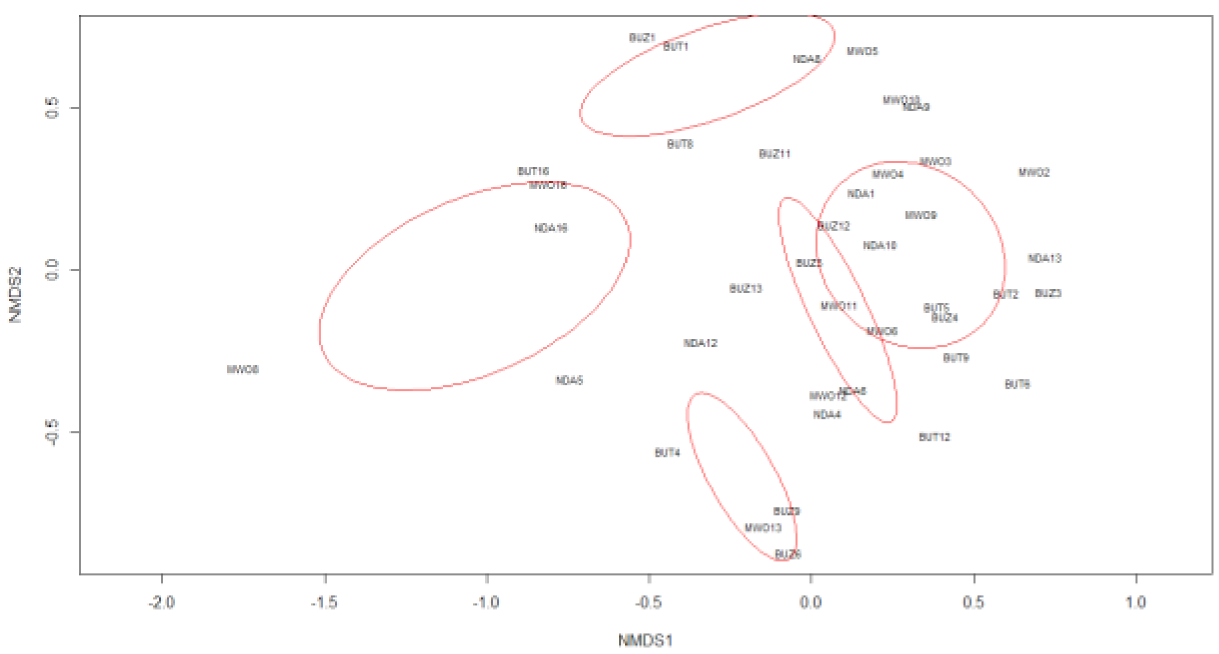


Figure 27. NMDS ordination plot for bird species sample sites (combined point count and mist nets) in KKCFR, western Uganda

4.4.6 Comparison of previous studies and this study

Results of two previous inventories of birds (Howard 1991 and Howard *et al*. 1996) were compared with study (Table 11). However, differences in the survey methods and extent unfortunately make it difficult to compare the results of this study with the previous ones.

Table 11. Previous bird inventory studies in KKCFR, western Uganda

Researcher/ study	Extent/sites covered	Methods used/ adapted	No. species recorded
This study	Four transects totaling 12 km length, 40 sample sites for point counts and 11 for mist netting, 23 days of sampling	Point counts at 200m interval and mist nests at 1,400m intervals per transect	127 species
Howard *et al.* (1996)	Seven blocks (of 3 km^2 each) distributed along the edge of the forest, 57 days of sampling	Observation and mist netting	187 species
Howard 1991	One site in west of the forest mist netted for 20 days	Mist netting	104 species

According to Howard et al. (1996), KKCFR is rich in rare and threatened bird species. The occurrence of White-naped Pigeon, a globally near-threatened species puts a high conservation value on the forest alone as the species has only been recorded elsewhere in Uganda from Kalinzu-Maramagambo Forest Reserves, Kibale and Semliki National Parks. Twenty-one species have been recorded in this forest that are classified as restricted-range. One of these species, Great Crested Grebe (*Podiceps cristatus*) has only been recorded in a few forests. Shelley's Greenbul (*Andropadusmasukuensis)* and the Joyful Greenbul*, (Chloroci chlalaetissima)* are two uncommon greenbuls recorded in this forest. Yellow-bellied Wattleye, (*Platyseira castanea*), although occurring throughout West Africa, is a rare bird in East Africa and has only been recorded in this forest, Kalinzu-Maramagambo and Semliki.

4.5 SHRUB DIVERSITY AND DISTRIBUTION

4.5.1 Shrub species richness across the sites

A total of 64 sites were sampled for shrubs, 16 sites in each of the forest portion adjacent the four parishes of Mwongyera, Butoha, Buzenga and Ndangaro. However, only 48 harbored shrubs. A total of 53shrub species were encountered in the whole study area. Butoha had 14shrub species, 22 in Buzenga, 21 in Mwongyera and 23 in Ndangaro. Site shrub species richness ranged from one to 11 species. There was little variation in shrub species richness along each of the four transects (Figure 28).

The curve (Figure 29) is a plot of shrub species richness as a function of the number of sites sampled. The slope of the curve remained steep and the asymptote was not reached indicating that more shrub species remain unrecorded.

The species accumulation curves allowed comparison of shrub species richness of the different study sites at the same sample size (Figure30). The forest adjacent to Ndangaro Parish had more shrub species compared to the other three study sites. However, the shrub species accumulation curve for each of the study areas remained steep indicating that still more shrub species remained unrecorded in each of the four study areas.

Since the species richness accumulation curves did not reach asymptote, we made some predictions, based on the sites sampled, for the expected total species richness using different methods – the first- and second-order Jackknife, Chao and bootstrap formulae The predictions varied ranging from 64 to 94 expected shrub species for the area surveyed.

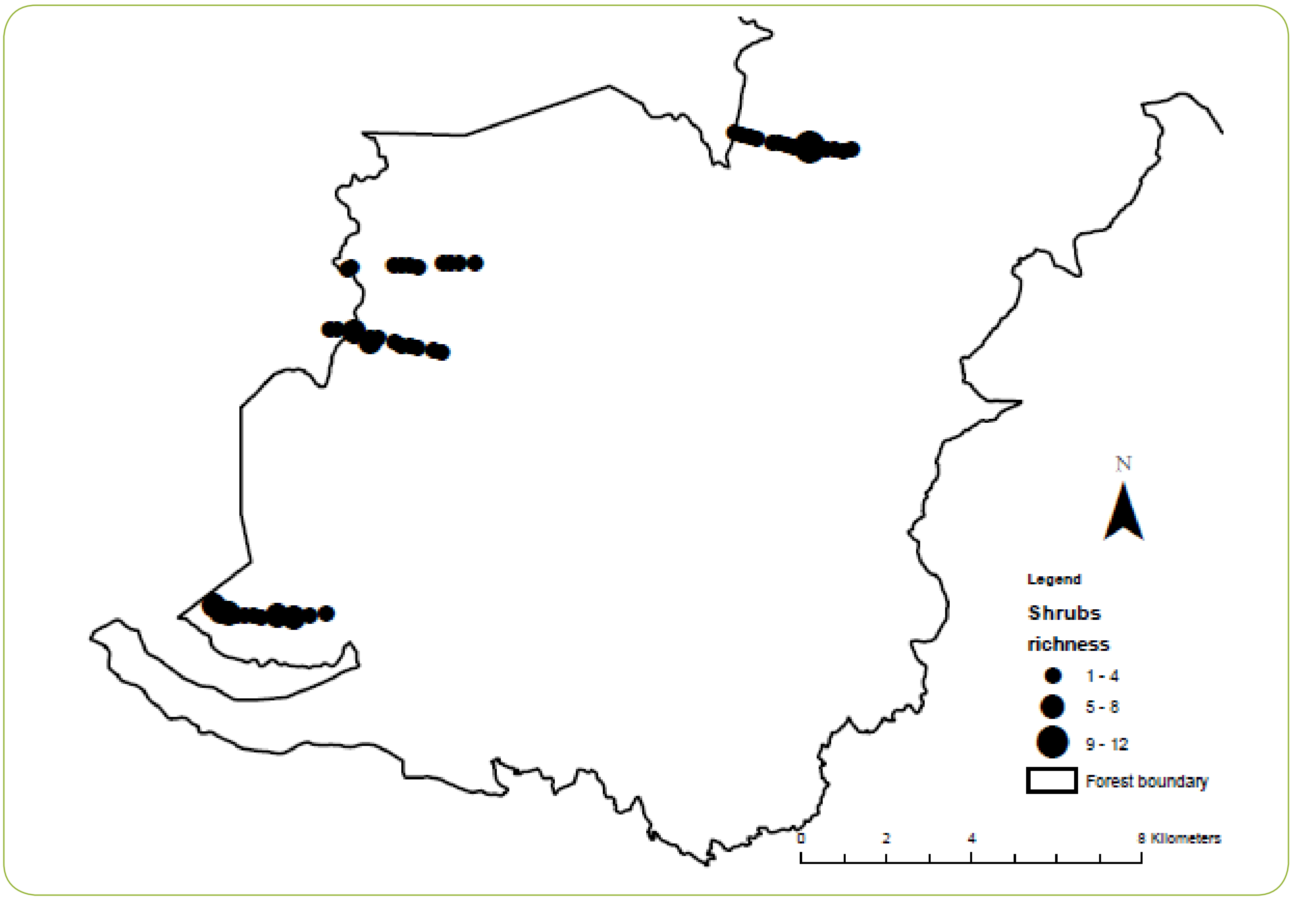


Figure 28. Shrub species richness across the sample sites in KKCFR, western Uganda

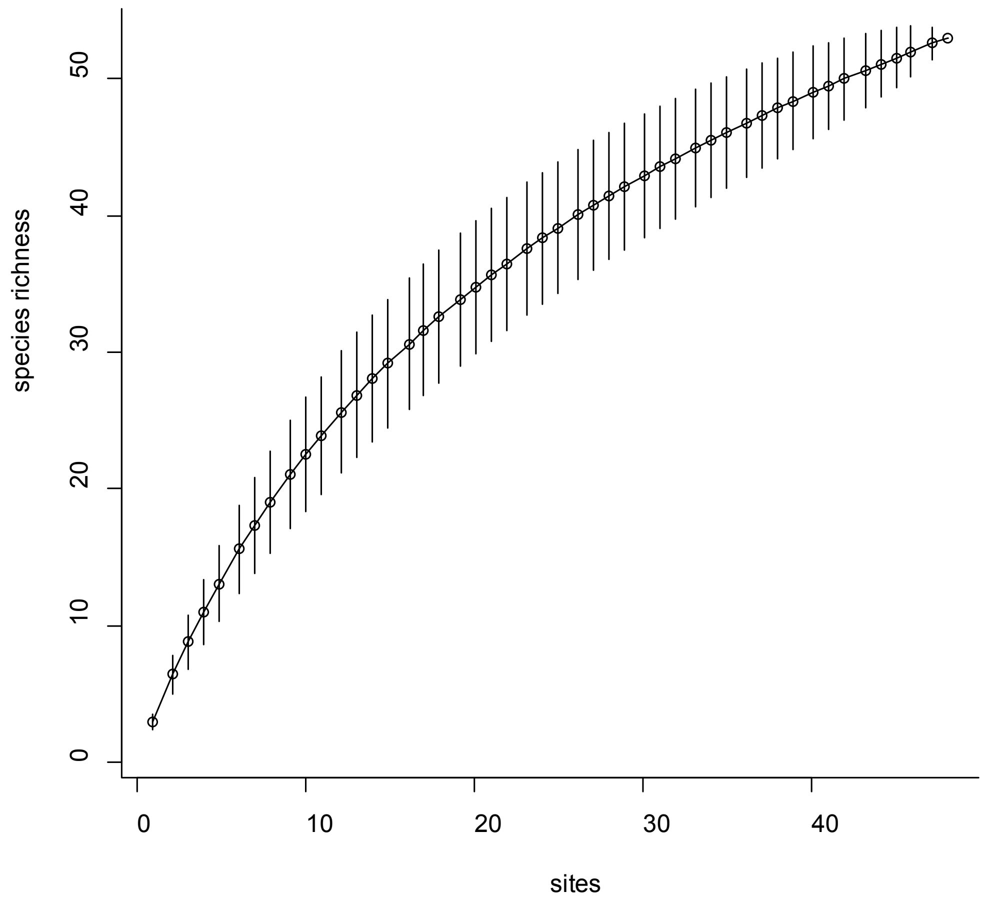


Figure 29. Shrub species richness accumulation curve for the surveyed area of KKCFR, western Uganda

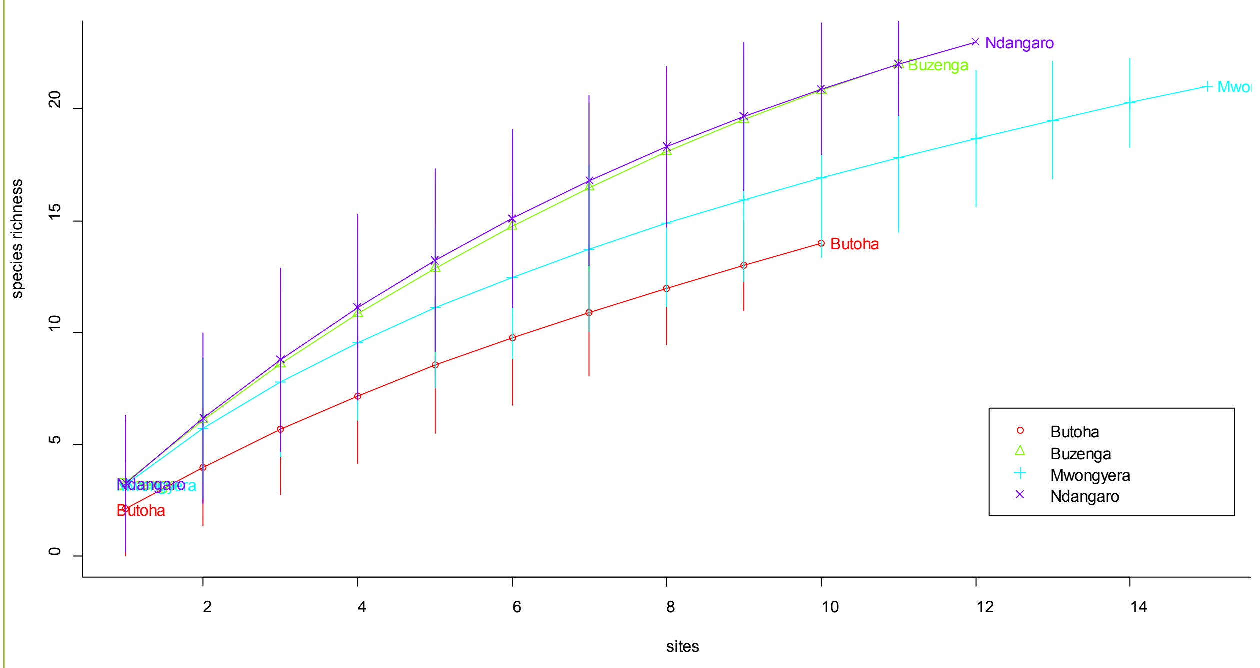


Figure 30. Shrub species richness accumulation curve for each area in KKCFR adjacent to Butoha, Buzenga, Mwongyera and Ndangaro Parishes, western Uganda

4.5.2 Cluster analysis

The sample sites from the whole study area were arranged into six clusters, with each cluster having sites with similar shrub species composition as measured by the Bray-Curtis ecological distance. Sites that were grouped into the same cluster were more similar in shrub species composition than sites that were grouped into different clusters. From Figure 31, it can be seen that there was some pattern in the sample sites with sites from the same geographical location having same species.

We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. The cophenetic correlation was high (0.75) meaning that the distance portrayed in the dendrogram was a good representation of the differences in species composition between individual sample sites.

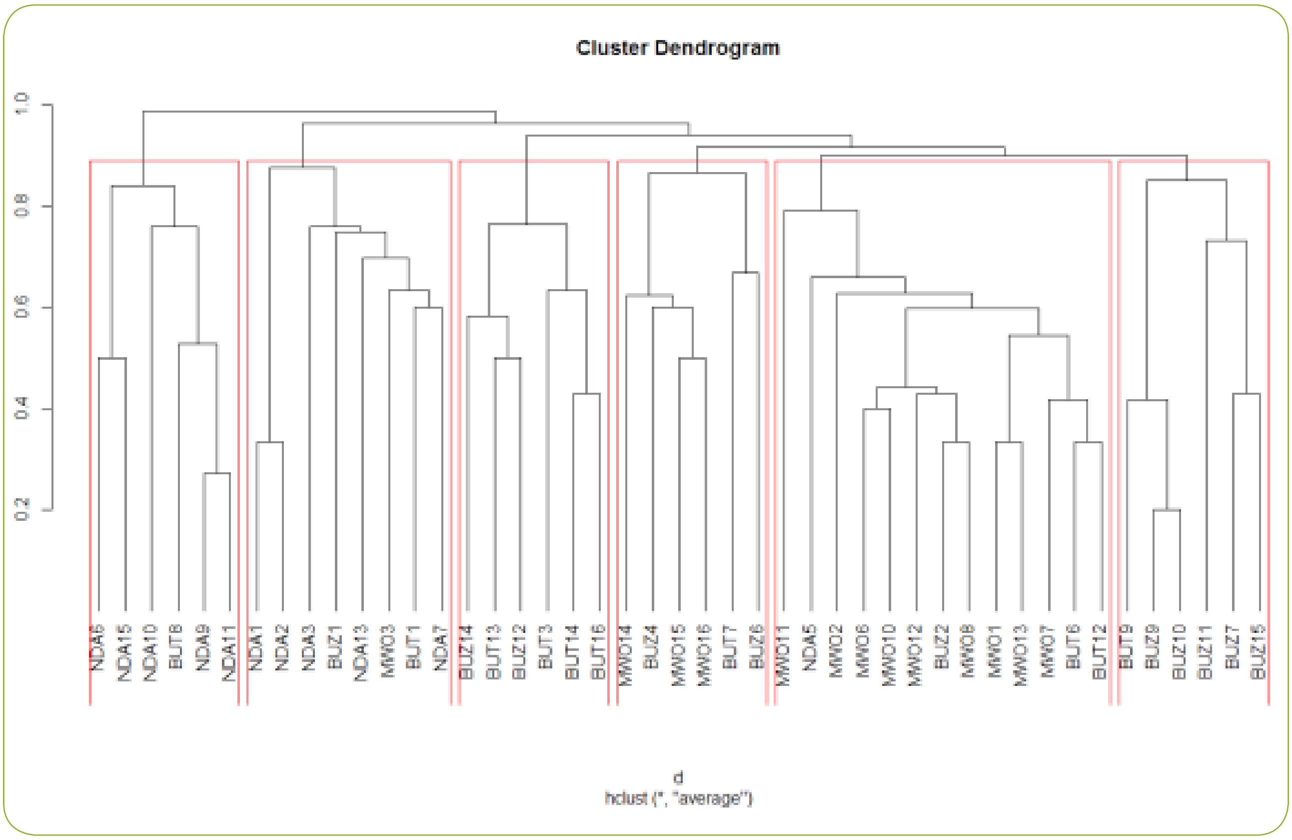


Figure 31. Shrub species cluster analysis dendrogram for the surveyed area of KKCFR, western Uganda

4.5.2 Clustering and ordination

Figure 32 is the NMDS biplot. The points represent individual sample sites, the ellipses show the shrub cluster analysis classes and the arrows represent significant ($p<0.05$) quantitative environmental variables. The sample sites were plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. It can be visualized that sample sites from the same study area were near each other, meaning that they had similar shrub species composition, while those from different study areas were far apart indicating that their shrub species composition were different. Figure 14. NMDS ordination plot for the tree sample sites in KKCFR, western Uganda

Distance from forest boundary, with the longest arrow, was more important in influencing variation in shrub species composition than ground cover and canopy closure with shorter arrows. Distance from forest edge and canopy closure whose arrows are close have a correlation close to +1.0. Distance from forest edge and canopy closure arrows slightly above a right angle (90°) to that of ground cover meaning that distance from forest edge and canopy closure are both weakly correlated to ground cover.

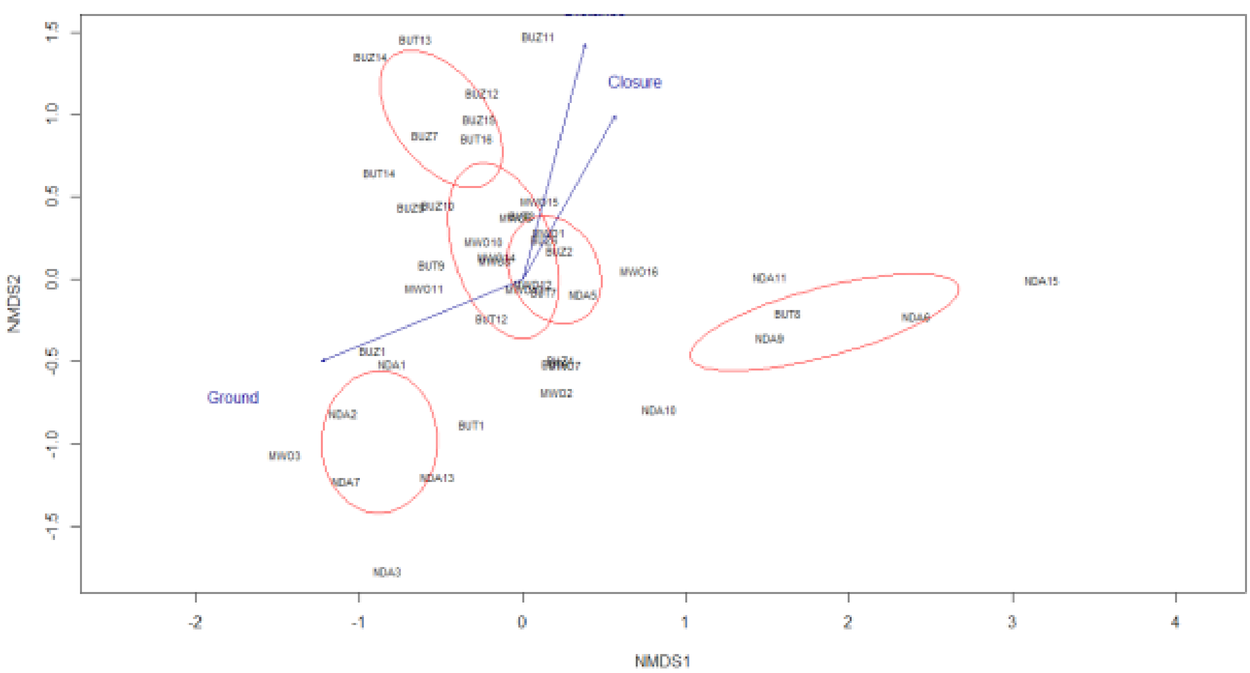


Figure 32. NMDS ordination plot for the shrub species sample sites in KKCFR, western Uganda

4.6 HERB DIVERSITY AND DISTRIBUTION

Out of the 64 sites sampled, 48 had herb species. A total of 53 species were encountered, 14 in Butoha, 22 in Buzenga, 21 in Mwongyera and 23 in Ndangaro. There was little variation in herb species richness along each of the four transects as with shrubs.

The curve (Figure33) is a plot of herb species richness as a function of the number of sites sampled. The slope of the curve remained steep and the asymptote was not reached indicating that more herb species remain unrecorded.

The species accumulation curves allowed comparison of herbspecies richness of the different study sites at the same sample size (Figure 34). The forest adjacent to Ndangaro Parish had more herb species compared to the other three study sites. However, the herb species accumulation curve for each of the study areas remained steep indicating that still more herb species remained unrecorded in each of the four study areas.

Since the species richness accumulation curves did not reach asymptote, we made some predictions, based on the sites sampled, for the expected total species richness using different methods – the first- and second-order Jackknife, Chao and bootstrap formulae The predictions varied ranging from 67 to 94 expected herb species for the area surveyed.

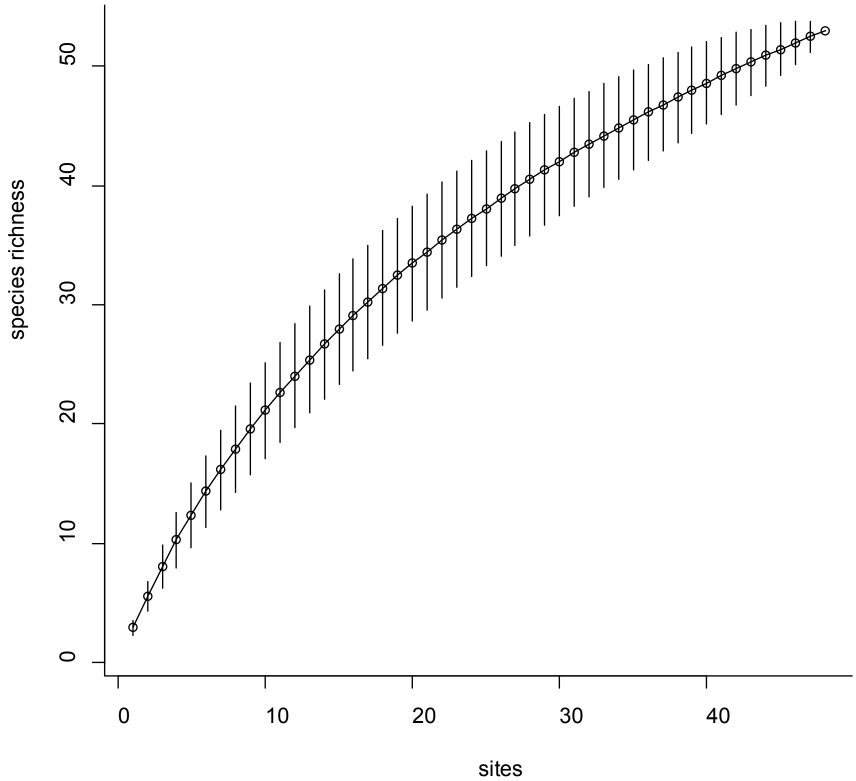


Figure 33. Herb species richness accumulation curve for the surveyed area of KKCFR, western Uganda

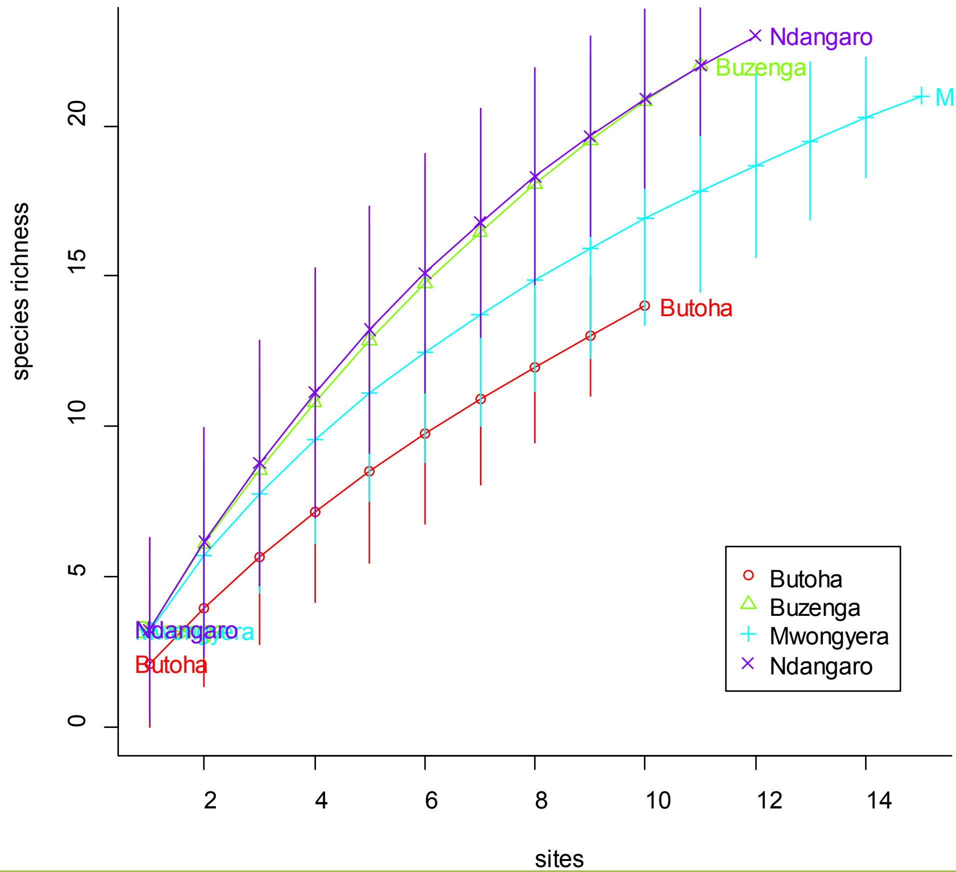


Figure 34. Herb species cluster analysis dendrogram for the surveyed area of KKCFR, western Uganda

4.6.1 Cluster analysis

The sample sites from the whole study area were arranged into six clusters, with each cluster having sites with similar herb species composition as measured by the Bray-Curtis ecological distance. Sites that were grouped into the same cluster were more similar in herb species composition than sites that were grouped into different clusters. From Figure 35, it can be seen that there was some pattern in the sample sites with sites from the same geographical location having same species.

We evaluated how well the differences in species composition among the sample sites were portrayed by the clustering results by calculating the cophenetic correlation. The cophenetic correlation was high (0.77) meaning that the distance portrayed in the dendrogram was a good representation of the differences in species composition between individual sample sites.

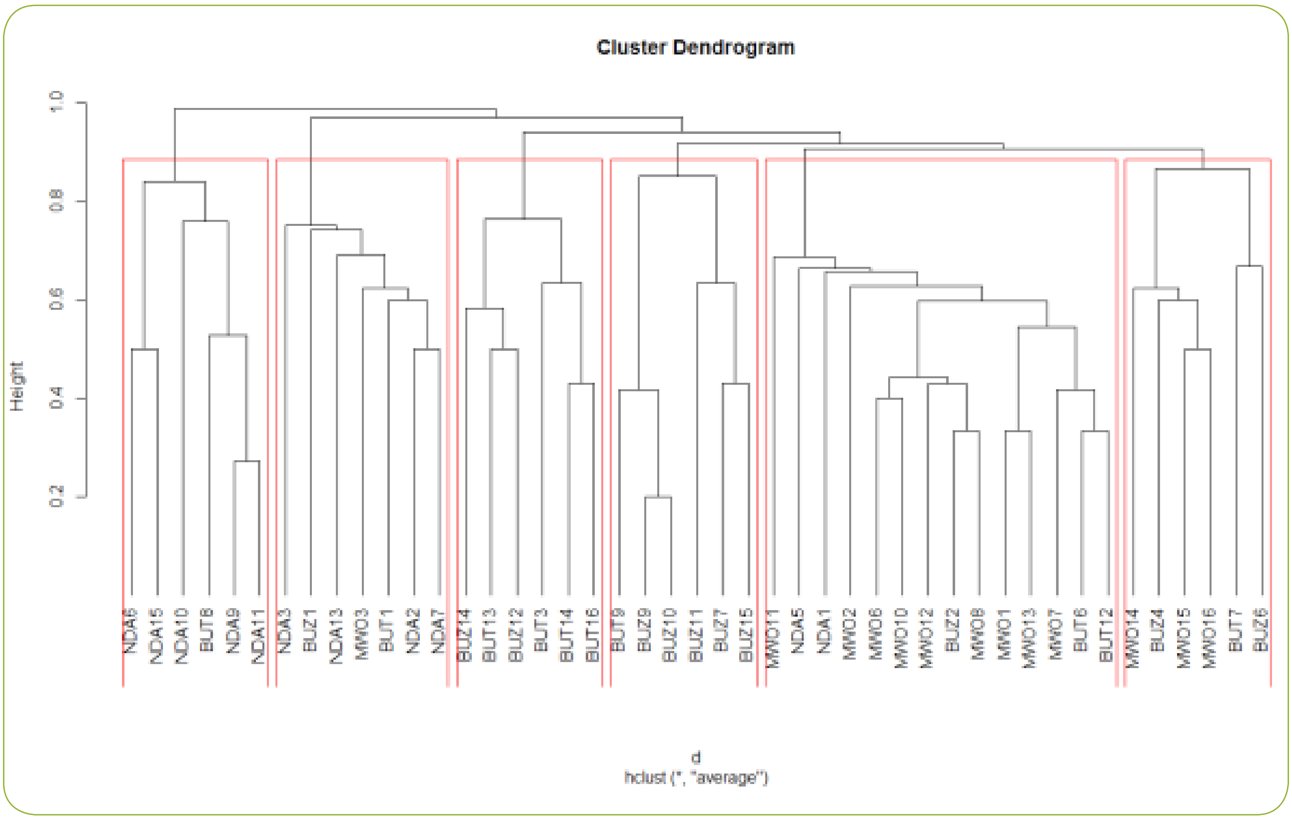


Figure 35. Herb species cluster analysis dendrogram for the surveyed area of KKCFR, western Uganda

4.6.2 Clustering and ordination

Figure 36 is the NMDS biplot. The points represent individual sample sites, the ellipses show the herb cluster analysis classes and the arrows represent significant (p<0.05) quantitative environmental variables. The sample sites were plotted as points in a space comprised of two dimensions, with distance between points in the ordination space representing dissimilarity in species composition between those points. It can be visualized that sample sites from the same study area were near each other, meaning that they had similar herb species composition, while those from different study areas were far apart indicating that their herb species composition were different.

Distance from forest boundary, with the longest arrow, was more important in influencing variation in herb species composition than ground cover and canopy closure with shorter arrows. Distance from forest edge and canopy closure whose arrows are close have a correlation close to +1.0. Distance from forest edge and canopy closure arrows slightly above a right angle (90°) to that of ground cover meaning that distance from forest edge and canopy closure are both weakly correlated to ground cover.

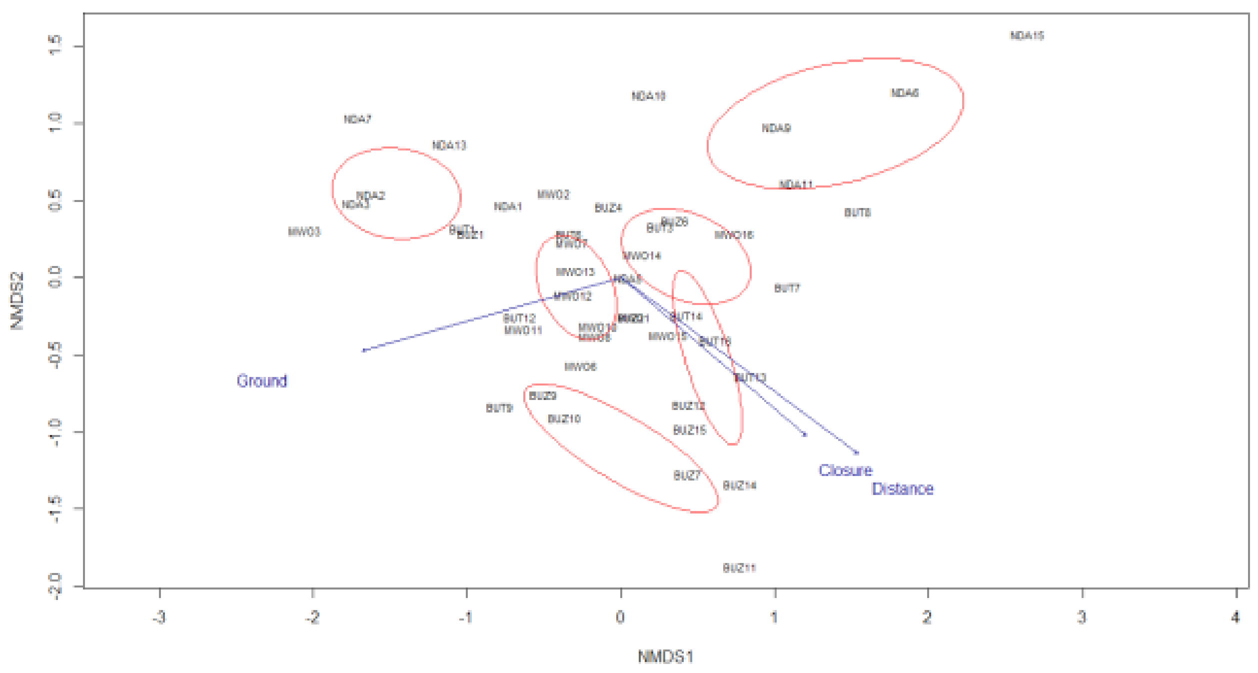


Figure 36. NMDS ordination plot for herb species sample sites in KKCFR, western Uganda

4.7 HUMAN ACTIVITY

Human activity along the four transects was detected in 23 percent out of 64 sites sampled. The most common activity encountered was pit-sawing of large trees for timber (Figure 37). They were also very many trails that were well used by an average of more than one person per day. We also encountered or heard local people, especially children, walking along the trails to collect fuel wood (Figure 38), each day during our field sampling. Many signs of fuel wood collection are subtle since they mainly collect dead wood and trees. We observed fresh signs of charcoal burning (Figure 39) and trees that had been ring barked trees so that they die and are collected for fuel wood at a later date (Figure 40). Only one snare was encountered throughout the sampling period probably because the poaching is done using spears and dogs. Several hunters accompanied by dogs and equipped with spears were captured on the camera traps (Figure 41).

Figure 37 A freshly made Pit sawing platform

Figure 38 A camera trap capture of young man carrying poles from the forest at night

Figure 39 Site of recent charcoal burning

Figure 40 A young tree after having been ring barked for future fuel wood collection

Figure 41 A poacher carrying spears together with his dog on a hunting expedition

L'Hoest's monkey as recorded by the camera trap

Photo by: ICSC

5.0 DISCUSSION

5.1 TERRESTRIAL LARGE MAMMALS

This is the first study to investigate the relationships between human activity and any mammal community in KK. We recorded fifteen mammal species. The rarefaction curve did not reach asymptote, suggesting that some species were not recorded in the study. Human activity occurrence was positively and negatively correlated with tree cover percentage and elevation respectively. Probability of mammal occupancy was negatively correlated with human activity and positively associated with elevation. This latter result suggests potential influence of human activity on both mammal abundance and distribution. Our modeling revealed that human activity is relativelyeven spread in the surveyed parishes. We also show that the mammal community in the surveyed parishes is thriving based on the high predicted probability of occupancy (Fig 5).

5.1.1 Species richness and mammal community composition

Our sampling effort was sufficient to detect a great proportion of species in the mammal community of surveyed parishes, as compared to other previous studies (e.g. Plumptre ***et al.*** 2003). However, these comparisons may be challenged based on the fact that those studies did not use camera traps as in our case and this could be the reason for the observed differences. Therefore, these results may not necessarily depict actual declines or increases in population trends. The difference in species recorded could also be due to the survey seasons. We acknowledge that our camera trap survey clearly missed some species known to occur in KK. Such species could be that they, perhaps, occur in low densities or restricted habitats, which were not covered by our camera trap grid.

Nevertheless, this survey recorded a couple of interesting species, with important ecosystem functions. Notable of these, were the two carnivore species; the African golden cat and the side striped jackal. These two carnivore species are receiving increased conservation attention, as they remain the apex predators in African tropical forests, following the continued extirpation of leopards *Pantherapardus*. Furthermore, the African golden cat is most vulnerable to human driven habitat change, as it is the only forest obligate carnivore species in African tropical forests (Mugerwa ***et al.*** 2013; Bahaa-el-din ***et al***. 2014). There is a need to conduct detailed surveys to understand the population status of these carnivore species, and their response to human disturbance.

Human activity occurrence in the surveyed parishes was recorded at 16 of 35 camera sites and predicted as the results show. This is actually not an alarming result when compared to other tropical forests inhuman dominated landscapes (Plumptre ***et al.*** 2003; Ahumada ***et al.*** 2011; Mugerwa ***et al.*** 2013). Forest cover was an important predictor of human activity in the surveyed parishes, with a positive association between the two. This is particularly an interesting result, as it shows that human activity is most prevalent in good quality intact forests. Human presence in areas of high forest cover could be attributed to the fact that forest resources collected by local people are most abundant in areas with good quality forest cover. Moreover, high forest cover forests naturally have higher species diversity and abundance (Ahumada ***et al***. 2011) for human exploitation. These two factors are likely to be the attractants of people in areas with high forest cover.

5.1.2 Mammal occupancy and distribution

Results have shown that human activity was significantly negatively correlated with mammal occupancy. Negative relationships between forest mammal abundance and distribution and human activity in human dominated landscapes is not uncommon (Mugerwa ***et al.*** 2013; Rovero ***et al***. 2014), and has been suggested as a strategy to avoid human encounters (Olupot 2009; Olupot, Barigyira& Chapman 2009) by mammals. Nevertheless, there was an overlap in the predicted human activity and mammal occupancy. Although wildlife may exhibit behavioral features (such as temporal and fine scale spatial avoidance) that enable them to coexist with humans (Rasmussen & Macdonald 2011; Erb***et al.***2012), this result is of high conservation value. Spatial overlap between wildlife and humans increases the vulnerability of the former to direct encounters with people, direct competition for resources and to lethal remote human activity such as snares (Olupot 2009).

5.2 TREE SPECIES

KKCFR has a high species diversity of trees even when a small portion of the forest was surveyed and we encountered 97 species. Given that none of the study areas had a species accumulation curve reaching asymptote, it means that additional tree species were expected even in areas surveyed. Areas surveyed showed large differences in tree species composition. This is attributed to several factors. In this study, variation in altitude came out as the major factor affecting tree species composition. Other factors that were found to be important in determining variation in tree species composition were ground cover, distance from forest edge, position on the slope and human activity. The human activity could be impacting on tree species composition by selective removal of specific species for timber and fuel wood.

The indicator species showed that the majority of the clusters derived had indicator tree species of secondary forest type – forest generalists and forest non-dependant type. This may be because the sites sampled were near the edge where there was a lot of human disturbance especially fuel wood collection and timber harvesting.

5.3 SMALL MAMMALS

Twenty five species of small are known to occur in KK (Howard ***et al.*** 1996). Six species of rodents and three species of shrews were encountered during this study. Of particular interest were two uncommon forest-dependent shrews ***Crocidura maurisca*** (Northern Swamp Musk Shrew) and ***Scutisorex somerani*** (Hero Shrew). The small mammal species also included a high proportion of a forest-dependent species ***Malacomys longipes*** (Long-footed Rat). The shrew ***Sylvisorex granti*** is restricted to closed forest in Uganda (Howard ***et al***. 1996).

Canopy closure and slope aspect were the most important factors influencing variation in species composition of the small mammals. Majority of the sample sites had open canopy and on slopes facing east direction down slope. These conditions favour luxuriant undergrowth and therefore provide the small mammals with cover from predators and with shade.

5.4 BIRDS

The bird species total for the forest stands at 276 (Howard ***et al.*** 1996). This study recorded 127 species even though only a small portion of the forest was sampled. This shows that the forest is very rich in bird species. However, many more bird species are highly likely to be recorded as the interior of the forest remained unsurveyed by this study and previous surveys.

Indicator species analysis showed that forest specialist bird species dominated the cluster classes. This could indicate that the forest is still in good condition for the forest birds. Point count surveys showed that canopy closure was a very important environmental variable in determining species composition variation among the sites in the forest. Even though the tree species composition indicates that the areas sampled are secondary forest, the canopy is still closed enough to favour forest specialist birds.

5.5 SHRUBS AND HERBS

Shrub and herb species composition and variation among the sampled sites was determined by distance from forest edge, ground cover and canopy closure. More species were found in open canopy areas, near the forest edge and in areas with sparse ground cover. This was expected since shrub and herb species favour areas where light from the sun can reach the ground. These are areas mainly near the forest edge that are disturbed by human activities such fuelwood collection and timber harvesting.

5.6 HUMAN ACTIVITIES

Rules governing forest resource extractionin KK do not permit hunting of wildlife and timber harvesting. Collection of fuel wood from the forest by local people is allowed within 2 km of the reserve boundary and only once a week. Just dead wood, including dead trees, should be collected but felling of dead trees is not allowed. Whereas the impact of dead-wood collection is low, standing dead are ecologically important as they provide important nest sites for barbets and hornbills, and feeding sites for woodpeckers. However, these regulations are not adhered to. Timber harvesting signs were found to increase with distance from the forest edge, probably because that is where the harvestable timber trees can still be located. Fuelwood collection, that is supposed to be done once a week, was taking place everyday and collected beyond the 2km limit distance from forest boundary. Also, instead of collecting only dead dry wood, community members also cut and/or debark live trees. This is because of scarcity of dead wood because of high demand. Hunting of wildlife for game meat seems to be rife. Setting of snares seems to be rare and most of the wildlife poaching appears to be done by men hunting with dogs and spears.

Although the human activities seem to be at a low level compared to other natural forests in the region like Echuya (Bitariho ***et al.*** 2015), they have been going on for a long time so that they may be having severe impacts on forest structure and composition (Howard 1991).Tree species such as *Mahogany*, *Grevelia*, and *Markhamia* were close to extinction before restrictions on logging were imposed (Raben ***et al***. 2007). The elephant (*Loxodonta africana*) and the buffalo (*Syncerus caffer*) once widespread can no longer be found in the reserve (Howard 1991).

6.0 CONSERVATION

Overall, we recorded a greater proportion of mammal species estimated to occur in the surveyed parishes of KK. The recorded and predicted human activity in our study was also surprisingly lower than expected. This is based on our experience in working on mammal communities in tropical forests in human dominated landscape elsewhere. We, however, cannot attribute the high mammal and low human activity occupancy reported for this studyto conservation efforts by NU. This is because we did not replicate the study in other parishes where NU is not implementing conservation programs ("control parishes").

Moreover, mammal populations in tropical forest habitats do exist in isolation, but tend to range in vast areas. Therefore, the intensity of human activity and distribution of mammals reported in this study would have been more informative if the chosen study area (and/or parishes) were representative of the whole forest reserve. For instance, we effectively surveyed 67.3 km^2(calculated as a simple Minimum Convex Polygon around the camera trap sites), which is only 17.5% of the total forest reserve area. Although the predicted occupancy of human activity was low, its strong negative correlation with mammal occupancy should be of concern.

The forest supports a high diversity, particularly forest-dependent species of trees, birds and small mammals. This is due to a combination of altitudinal, geological and topographical diversity and close proximity to the postulated Pleistocene refugium (Howard ***et al***. 1996).
This biodiversity is under threat from human activities such as fuel wood collection, pit sawing and hunting. There is need for a comprehensive rural development programme around the forest if biodiversity is to be conserved.

Chimpanzees are resident in KK forest

7.0 RECOMMENDATIONS FOR IMPROVED CONSERVATION AND MANAGEMENT OF KKCFR

These recommendations are based on this study and previous surveys like Howard (1991) and Howard *et al.* (1996).

Recommendations to National Forestry Authority (NFA)

1. Regulations governing forest produce harvesting and collection should be enforced. Fuel wood collection should be restricted to once a week, within 2 km of the boundary and only fallen dead wood and trees should be collected. No felling of dead or live trees should be permitted.
2. Continued closed access to resources like timber and wildlife where sustained use is not possible, due to either complexity, high demand or slow growth rates, and where the emphasis needs to be placed on providing alternatives outside the reserve;
3. Although there are NFA staff to patrol the forest, they are simply not doing all that they can or are supposed to do, in a way of discouraging the banned timber harvesting and illegal fuel wood collection. For example, the NFA staff we worked with during this study made no attempt whatsoever to catch or stop any people felling or pit-sawing trees for timber that we came across and the people that were collecting fuel wood on a wrong day. The behavior of the NFA staff clearly indicated that they did not consider apprehension of people doing illegal activities in the reserve as part of their duties;
4. Attention should be focused on providing alternative sources of fuel wood outside the reserve, recognizing that dead-wood use from the edge of the forest can only meet a fraction of the local needs and staff capacity to manage this activity is limited. NFA should provide seedlings and help local community members establish tree nursery gardens for sustainable supply of tree seedlings;
5. NFA should enforce provisions of the Wildlife Act of 2000 and apprehend poachers of wildlife. Currently, hunting of wildlife using spears, dogs and snares seems to go on unabated in the areas we surveyed and we believe this could be the case throughout the reserve; and
6. Ecotourism, which as at a very small scale now, should be encouraged and developed further, based on bird watching and physical features like the crater lakes. This could dramatically change the attitudes of the local communities so that they recognize that the reserve has more value than just the collection of forest resources.

For example, the NFA staff we worked with during this study made no attempt whatsoever to catch or stop any people felling or pit-sawing trees for timber that we came across and the people that were collecting fuel wood on a wrong day. The behavior of the NFA staff clearly indicated that they did not consider apprehension of people doing illegal activities in the reserve as part of their duties;

Recommendations to Nature Uganda and other non-governmental conservation organizations

In order to gain a better understanding of population trends and corresponding drivers for mammals in KK, we require continued monitoring using standardized protocols. The Institute of Tropical Forest Conservation (ITFC), the Uganda Wildlife Authority and the Tropical Ecology Assessment and Monitoring Network (TEAM; www.teamnetwork.org) have been (for past 7 years) monitoring terrestrial vertebrates in Bwindi Impenetrable National Park.

The generated data set has not only highlighted important trends for some populations, but also the importance of use of camera trap data for monitoring tropical forest mammal communities (please see http://wpi.teamnetwork.org/wpi/welcome).

Continued monitoring of mammals using standardized methods following this baseline study will be the only way to measure the impacts of NU conservation initiatives on wildlife conservation in KK. Other specific recommendations for other taxa include;

1. Given the short time of the survey and the limited access to a large area of the forest, we recommend that further biodiversity surveys be undertaken, particularly in the interior of the forest to improve on the species lists we have compiled to date and get more information on the factors that influence species distribution and composition;
2. An ethnobotanical survey should be carried out to get information on plant resources that are utilized by the local communities and determine the demand and make a survey of the availability of these resources within the reserve so that sustainable harvest of these resources can be determined;
3. Support NFA in encouraging people to plant trees as an alternative to collection of wood resources in the reserve using the Collaborative Forest Management arrangement strategy;
4. KK is surrounded by a high human population density. Land is becoming scarce and poor agricultural methods are practiced on steep hills. NU could support the local communityby advising on better agricultural methods, value addition and marketing of the agricultural produce. This can help make the people less dependent on the reserve for their livelihood.

An ethnobotanical survey should be carried out to get information on plant resources that are utilized by the local communities and determine the demand and make a survey of the availability of these resources within the reserve so that sustainable harvest of these resources can be determined;

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APPENDICES

APPENDIX I.

Global Positioning System coordinates (WGS_84_36S) of the sample sites for botanical, ornithological and small mammal inventory in KKCFR, western Uganda

Sites	Eastings	Northings
BUT1	182511	9969499
BUT2	182726	9969532
BUT3	182598	9969539
BUT4	183090	9969537
BUT5	183376	9969554
BUT6	183608	9969569
BUT7	183789	9969577
BUT8	183966	9969570
BUT9	184179	9969554
BUT10	184353	9969589
BUT11	184559	9969604
BUT12	184749	9969602
BUT13	184932	9969619
BUT14	185126	9969603
BUT15	185321	9969635
BUT16	185501	9969636
BUZ1	182694	9968002
BUZ2	182281	9968066
BUZ3	182480	9968058
BUZ4	182083	9968090
BUZ5	182872	9967945
BUZ6	183052	9967790
BUZ7	183246	9967853
BUZ8	183419	9967809
BUZ9	183612	9967764
BUZ10	183791	9967712
BUZ11	183977	9967663
BUZ12	184146	9967623
BUZ13	184342	9967584
BUZ14	184522	9967567
BUZ15	184723	9967554
BUZ16	184874	9967622

Sites	Eastings	Northings
MWO1	191598	9972697
MWO2	191766	9972653
MWO3	191956	9972618
MWO4	192112	9972552
MWO5	192315	9972499
MWO6	192487	9972477
MWO7	192637	9972462
MWO8	192814	9972422
MWO9	192985	9972370
MWO10	193177	9972366
MWO11	193373	9972351
MWO12	193571	9972358
MWO13	193747	9972319
MWO14	193939	9972290
MWO15	194144	9972275
MWO16	194339	9972293
NDA1	179374	9961565
NDA2	179560	9961440
NDA3	179737	9961374
NDA4	179905	9961371
NDA5	180107	9961363
NDA6	180300	9961336
NDA7	180495	9961316
NDA8	180692	9961313
NDA9	180886	9961327
NDA10	181091	9961316
NDA11	181265	9961287
NDA12	181454	9961323
NDA13	181633	9961349
NDA14	181834	9961361
NDA15	182013	9961373
NDA16	182183	9961342

APPENDIX II.

Data sheets used in the biodiversity inventory

Environmental characteristics
Site Number:
Vegetation type:
Slope angle:
Aspect:
Ground cover:

Vegetation Sampling
GPS Coordinates:
Altitude:
Slope position:
Canopy closure:
Human activity sign(s):

Tree 20 x 20 metre plot

Genus	Species	dbh (cm)

Shrubs 2.5 x 2.5 metre plot

Genus	Species	No. of individuals

Herbs 1 x 1 metre plot

Genus	Species	No. of individuals

Bird Point Counts

Site	Date	Time	Species	< 20 metres			Flyovers		
				0-3 min	4–5 min	6–10 min	0-3 min	4–5 min	6–10 min

Bird Mist Nets

Site	Date	Net No.	Species	Time captured (within 45 min)	Weather and wind	Time nets open	Time nets closed	Age	Plumage	Breeding status

Small Mammal Inventory Data Sheet

Date	Time	Species	Site	Trap Type	Bait used	BM (g)	Age	Reprd status	ToL (mm)	TL (mm)	HBL (mm)	EL (mm)	HFL (mm)	Remarks

About *Nature* Uganda

NatureUganda, the East Africa Natural History Society (EANHS) in Uganda, is a membership, research and conservation organization established to undertake conservation actions using scientifically proven methods for the benefit of the people and nature. It is the oldest membership organisation in Uganda, having been founded (as EANHS) in 1909 as a scientific organization with the primary aim of documenting the diversity of wildlife in East Africa.

By the mid-1990s, EANHS-Uganda had attracted many members and broadened the scope of activities in scientific research, conservation action, public awareness raising and advocacy. At this point it was realized that a formal registration within Uganda would be necessary as a response to the increasing activities. The Society was therefore registered as a non-profit, independent national organization in 1995 with the operational name of NatureUganda – The East Africa Natural History Society. Her sister in Kenya is NatureKenya – The East Africa Natural History Society.

NatureUganda has been the national Partner of BirdLife International since 1995, and the society's programmes are based on the four well-established pillars of BirdLife global strategy, namely Species, Sites, Habitats and People.

NatureUganda's mission is promoting the understanding, appreciation and conservation of nature. In pursuing its mission NatureUganda strives to:

- Create a nature-friendly public
- Enhance knowledge of Uganda's natural history
- Advocate for policies favorable to the environment
- Take action to conserve priority species, sites and habitats.

NatureUganda has its secretariat in Kampala- Naguru, and services its 2,000 members and supporters though branches in Gulu, Mbale, Busitema and Mbarara.

Inspired by the original purpose of the East African Natural History Society to document natural history of East Africa, NatureUganda's work is hinged on scientific information generated through well laid down research and monitoring programmes. Considering that 90% of Uganda's GDP is derived from Natural Resources (tourism, forestry, fisheries), biodiversity conservation is a priority for the country. NatureUganda supports biodiversity protection and economic development through its research, monitoring and conservation programme, which provides quality scientific information mainly using birds as indicators to support local and national governments to make informed decisions. The support is provided through established partnerships with government agencies including Uganda Wildlife Authority (UWA), National Forestry Authority (NFA), National Environment Management Authority (NEMA), Wetlands Management Department (WMD). This report of "The Status of Biodiversity in Kasyoka-Kitomi Central Forest Reserve" is a culmination of this collaboration effort to document the status of biodiversity in Uganda.

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