REPUBLIC OF UGANDA

MINISTRY OF WATER AND ENVIRONMENT

WATER MANAGEMENT AND DEVELOPMENT PROJECT

Updating the Ecological Baseline and the Socio-economic Data for Six Central Forest Reserves (Mabira, Namukupa, Nandagi, Kalagala Falls, Namawanyi and Namananga) and Updating the Management Plan for Mabira Central Forest Reserve

ECOLOGICAL BASELINE REPORT FOR MABIRA

PROJECT ID NO. P123204

PROC. REF.: MWE/SRVCS/13-14/00285

AUGUST 2017

FOREWORD

This report is written to update the ecological baseline information for the Mabira ecosystem. Inevitably, the bulk of the ecological baseline data is comprised of biodiversity data. Biodiversity is a word that is now more common than it was at the time of the first Forest Department Biodiversity inventories in the 1990s. It describes the variety of life at all levels of organisation from ecosystems to species/organisms and genes. Whereas the Uganda Forest Department carried out a comprehensive inventory of Uganda's biodiversity in the 1990's, there is a realization that the baseline data generated then, needed to be updated. The reasons may range from improvements in methods of inventory of different taxa to the discovery of additional taxa due to more detailed inventories of critical habitats. In addition, the impact of management activities and humans on the different ecological components of the forest reserves needed to be assessed. These tasks have been achieved and the information is presented this report. It is our belief that the ecological information presented in report will benefit many stakeholders within the Mabira area and beyond.

ACKNOWLEDGEMENTS

We acknowledge the funding for this project from the World Bank funding to the Ministry of Water and Environment for implementing the Water Management and Development Project (ID NO. P123204EU). We also acknowledge the contribution of various people that have contributed in various ways to the success of thia study. The appointed key experts (KE), namely Dr Joseph Bahati (KE – Forest Ecologist), Dr. Gerald Eilu (KE – Taxonomist), Dr. Mary Namaganda (KE – Botanist), and Dr. Robert Kityo (KE – Zoologist). These have been the main personnel in the different components. The field teams are built around these Key Experts.These include mostly field staff of the National Forestry Authority and staff of the Ministry of Water and Environment attached to this work.

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LIST OF ACRONYMS

CFR	Central Forest Reserve
CMG	Consultancy Management Group
CSC	Consultancy Steering Committee
EI	Exploratory Inventory
KOSMP	Kalagala Offset Sustainable Management Plan
NEMA	National Environment Management Authority
NFA	National Forestry Authority
PSP	Permanent Sampling Plots
QAAT	Quality Assurance and Advisory Team
TORs	Terms of Reference
UNCST	Uganda National Council of Science and Technology
UWA	Uganda Wildlife Authority
WIS	Water Information System
WMDP	Water Resources Management and Development Project

CHAPTER ONE

1.0. SUMMARY

Aim and Scope

This report covers the work undertaken by M/S Joseph Bahati and Associates to update, among others, the ecological baseline data of six Central Forest Reserves of the Mabira ecosystem, including Mabira, Namakupa, Nadagi, Kalagala Falls, Namawanyi and Namananga. The findings in this report have subsequently been used in the review of the Management Plan for Mabira Forest Reserves to guide monitoring the effectiveness of implementing the Kalagala Offset Sustainable management plan and the health of the Mabira ecosystem. The objective was to establish the current ecological status of the six Central Forest Reserves.

Following presentation of the Inception Report in January 2016, the data collection tools were finalized and tested in the field. These were used to collect data. Concurrently, there were ongoing reviews of literature and other data sources, to generate an update of the current state of knowledge. The outcome of these reviews and additional data collected during this assignment are presented in this report.

The National Forestry Authority assigned staff to the different components of this work. Participation of assigned staff in the field activities has enabled the realization of the knowledge exchange and capacity building plan. This was aimed at ensuring that the knowledge generated and skills utilized in the accomplishment of this assignment are passed over to relevant stakeholders. Gender Issues have been taken care of in constituting the field teams. The major findings are highlighted in this summary.

Plants

The total number of plant species now known from the Mabira Forest Reserve is 636. The trees, shrubs and climbers (woody plants) contribute 450 species (312 were recorded in the previous Forest Department Biodiversity inventory in the 1990s while 138 are new additions from this work). The herbs contribute 186 species. The rest of the reserves have fewer species: 87 (Namakupa), 92 (Namawanyi), 139 (Nandagi) and 68 (Kalagala), and 68 (Namananga). In the case of Mabira Forest Reserve, the climbers and herbaceous species were previously not included, and also data for the smaller forest reserves are here newly presented in this report. Inclusion of data from the five smaller reserves (Namakupa, Namawanyi, Nandagi, Kalagala and Namananga) gives a total of 732 species recorded from the Mabira ecosystem (this includes 252 species of herbs and 480 woody species). Data on Epiphytes, Mistletoes and Stranglers and other non-vascular taxa such as Bryophytes, Licherns and Fungi are required to enhance the knowledge.

Birds

A total of 154 species was recorded across the whole survey, 97 in Mabira Central Forest Reserve and 100 in the five small reserves. The results show that there were more bird species in the main forest than the five small reserves combined. There was little overlap between the surveyed forest sites, with 54 species unique to the Mabira CFR, 58 species unique to the five small CFRs and 42 species occurring in both forests. Most of the bird species recorded during the surveys are classified as “Least Concern” according to the IUCN redlist criteria. Seven of the species recorded are classified as threatened either at global or regional level. These include the Nahan's Francolin, Grey Parrot, Cinnamon-chested Bee-eater, White headed saw-wing, Toro Olive-Greenbul, White-browed Crombec and Green tailed Bristlebill. There were more forest visitors and other non-forest bird

species recorded in the small CFRs than in the main forest block. Forest related bird species (FF & F) were much more in the main forest than in the small CFRs.

Mammals

The small mammals constitute 22 species (5 shrews and 17 rodents). An additional 9 species are added to these, from records, to make 31 known species. Three closed forest dependent species *Deomys ferrugineus, Malacomys longipes* and *Scutisorex somereni* were recorded albeit in small numbers. A forest dependent species, *Deomys ferugineus* was captured in Namananga and Namakupa forests that have previously been encroached and opened up. In total 12 species of bats were captured with more species captured in Namananga, although historical records available show Mabira CFR to have a higher number of species. A total of 22 medium to large sized mammal species were also recorded for the 6 forests all together. Mabira CFR has the richest number of species compared to the rest.

Amphibians and Reptiles

Up to 42 species of amphibiansi n 13 genera and 9 families were recorded. They belong to the Order Anura. The family Hyperoliidae had the highest number of genera (3) and species (11). The water-confined families of Dicroglossidae, Hemisotidae, Pyxicephalidae and Pipidae were represented by single species. A total of 32 reptile species belonging to 4 orders, 13 families and 23 genera was recorded.

Butterflies

All together 207 species of butterflies were recorded -114 species in Mabira, 64 in Namukupa, 63 in Namananga, 82 Nandagi, 45 in Namawanyi, and 54 in Kalagala. A reasonably high proportion of forest dependent species was found in all the forests although Mabira CFR had the largest number of such species. Kalagala and Namananga had the highest proportion of more open environment species, which would symbolize the heavy level of impact by humans opening up these forests.

Conclusion and recommendation

The data suggest that the small forests (Namukupa, Namananga, Nandagi, Namawanyi, and Kalagala) do support reasonable numbers of species, although the numbers of interior species remain a small subset of those found in the main forest. The relatively high turnover of species across sites implies that a series of such forests could, collectively, hold a significant number of forest species. Hence, their integrity and health must be emphasized in management planning and ecological monitoring.

CHAPTER TWO

2.0. INTRODUCTION

2.1. OVERVIEW OF THE WORK

This work involved collection, analysis and documentation of ecological data and information on the Mabira ecosystem to produce deliverable 2 of the TORs. Six Centra Forest Reserves (CFRs), namely Mabira, Namakupa, Nandagi, Namawanyi, Namananga and Kalagala Falls were covered.

The baseline data updated were derived from the Forest Department Biodiversity Inventories carried out between 1994 and 1996. These included: species data of selected taxa (trees and shrubs, birds, small mammals, and butterflies/as well as moths). Additional to these, data on ground herbs, lianas, primates, other larger forest mammals, reptiles, amphibians and Benthic Macro-Invertebrates were collected to enhance the value of this biodiversity assessment. Data on large mammals have a more direct bearing on human-forest interactions and human-wildlife conflicts. Other taxa of conservation concern especially those on IUCN red list are included on a case-by-case basis. The ecological data include selected environmental variables, specifically on water quality. In addition, secondary data from various literature sources and databases have been checked and incorporated. These data will be stored in an appropriate easy to use database (being developed within this assignment).

It is worh noting that the Forest Department Biodiversity reports mainly presented species data that act as good baselines updated in this report. The ecological components of the Forest Department Biodiversity reports are rather limited, and therefore, this report provides environmental data that should be treated as baseline. The baseline inventory of flora, fauna and other components of the Mabira Forest ecosystem therefore, provide the benchmark against which any future changes will be measured. The current inventory entails detailed descriptions of the surrounding areas to identify unique features and evaluate any potential threats. Future monitoring activities will reveal changes and trends in the ecosystem health.

The following steps were used:
Step 1: Review of information/data that has been collected over the years on the Mabira forest ecosystem. Specifically, we accessed the following datasources:

- Forest Department biodiversity inventory data
- Permanent Sample Plot data

We have accessed other secondary data sources and published/unpublished literature e.g. EIA reports, the Important Bird Area (IBA) data from Nature Uganda (NU) or the National Biodiversity Data Bank (NBDB) at Makerere University. We accessed other datasets on flora and fauna from Makerere University (Herbarium and Museum), as well as other projects such as FOREAIM and BIOTA, among others). These enabled a thorough update of baseline data for the Mabira ecosystem.

Step 2: We conducted field studies to assess the status of taxa targeted by the FD inventories (trees and shrubs, birds, small mammals, and butterflies) as well as other taxa of conservation concern (e.g. red listed species and endemics). Alongside these data, selected environmental variables were assessed.

Step 3: The data generated have been checked for accuracy and will form part of a comprehensive database developed (later linked to the Water Information System (WIS)). Strategies will be put in place to ensure that the database is regularly used and where possible updated.

Step 4: Analyzing the threats to the integrity of the Mabira forest ecosystem has been done mainly through field observations and the socioeconomic surveys (reported elsewhere). Potential sources of threats to flora and fauna from overexploitation, encroachment, invasive alien species, and pollution; and climate change, among others, have been documented.

Step 5: The conservation importance of each forest and the relative conservation value of the different habitats within each forest are highlighted mainly based on disturbance history.

Step 6: Training has been carried out for several field staff to ensure that the client and key stakeholders are able to conduct field surveys for trees and other taxa that are non-traditional for Foresters. The trainees have been re-tooled with some skills to conduct inventories of various taxa, analyze biodiversity data and write up the reports.

Step 7: Recommending Low cost procedures for subsequent monitoring and regular update of the database to ensure usability will be recommended. Relevant staff will, thereafter, be trained to carry out this task.

Step 8: The various elements will be incorporated in the updated Management Plan. The process is ongoing

Technical Approach and Methods

1. Updating the ecological baseline data

Step 1: Reviewing information/data

A review of the existing ecological baseline data was used to define the information gaps; and establish the basis for searching for new information as well as changes in the ecosystem functioning. It also involved examining databases existing in various places that contain relevant information on the CFRs and target taxa.

Step 2: Conducting field studies to assess the status of selected taxa and environmental variables:

We conducted field studies to assess the status of taxa selected (i.e. trees and shrubs, birds, small mammals, and butterflies) and environmental variables. Where possible, the inventories involved participation of members from the local communities and field staff of MWE and NFA. The methods of assessing the different taxa are explained in the following sections.

Sampling design

First, all Permanent Sample Plots (PSPs) located in Mabira Forest Reserve (and the smaller reserves, if any) were assessed. In case they have been assessed recently, the data were accessed and used. Second, additional sampling points were selected by a stratified random approach based on the current management zones where compartments selected within 1-km2 grid squares superimposed on a zone of each disturbance/management category. The whole of the Mabira management plan area (composed of six central forest reserves covering a total area of 31,293 hectares; Mabira (29,974), Namakupa (280) Nandagi (479), Namawanyi (325), Namananga (131) Kalagala falls (104) was covered.

The sites that have undergone different intensities of disturbance (particularly in the case of Mabira Forest Reserve, Figure 1) as well as different sizes of the target reserves) were taken into consideration to achieve a desired intensity of sampling giving a proportionate number of samples. The zones with different disturbance histories are summarized in table 2.1.

Table 2. 1. Disturbance categories to be used as strata for sampling Mabira Forest Reserves

Main Vegetation Type	Description	Site Category (Years since abandonment of disturbance)
A: Encroached	Plots in site less than 3 years after the last encroachment	0-3 years
B: Encroached	Vegetation types in plots abandoned between 3 and 10 years	3-10 years
C: Encroached	Vegetation types in plots abandoned between 10 and 30 years ago	10-30 years
D: Logged	Plots in selectively harvested or mechanically logged (pre and post 1950)	>30 years ago
E: Essentially Undisturbed old growth	Plots that lie in areas that were never harvested or encroached (nature reserve)	Undisturbed

Conservation importance and the relative conservation value of the Forest Reserves

Based on the diversity and distribution of species present as well as the conservation status of those species, assessment of the conservation importance of each forest and the relative conservation value of the different habitats within each forest will be achieved. The population index (i.e. relative numbers) and location of each species will then be usedas baselines for future monitoring.

2.2 USE OF BIOLOGICAL INDICATORS

Maintaining healthy ecosystems in tropical rain forests like Mabira is a prerequisite for conserving biodiversity and involves the use of ecological/biological indicators. These indicators help to detect and track changes in integrity of a community. Ecological indicators are used to communicate information about ecosystems and the impact of human activity on ecosystems. Ecosystems are complex and ecological indicators can help describe them in simpler terms that can be understood and used by non-scientists to make management decisions.

Indicator species are also known as sentinel organisms, the organisms that are ideal for bio-monitoring. An indicator species is any biological species that defines a trait or characteristic of the environment. For example, a species may indicate an environmental condition such as a disease outbreak, pollution, species competition or climate change. Indicator species can be among the most sensitive species in a region, and sometimes act as an early warning to monitoring biologists. The complexity of ecosystems has forced conservation biologists to relay on indicator taxa, which are species or higher taxonomic groups whose parameters, such as density, presence or absence, or infant survivorship, are used as proxy measures of ecosystem conditions.

Previous efforts and current strategy

NatureUgand compiled the accessible biodiversity information on Mabira and produced what at the time were the most comprehensive lists for birds, mammals, amphibians, reptiles and butterfly species for the reserve. Davenport *et al* (1996) whose data formed part of the NatureUganda report conducted systematic surveys in Mabira to document diversity of birds, small mammals, butterflies and large moths. These authors in their report detail the methods used including the effort invested in the

surveys. It is apparent that many parts of the forest were not accessed given the fact that surveys for animal groups rely a lot on trapping techniques that are time intensive methods and were not necessarily possible at that time.

For this report similar approaches to those of Davenport *et al* (1996) have been used including surveying for the same taxa except for the large moths. In addition, for this report we surveyed amphibians, reptiles and medium and large sized mammals that were not done by Davenport *et al* (1996). These additional taxa give a broader view of the richness of Mabira. This aims to increase the objective evaluation of the reserve's worth for conservation. Where the specific field methods have varied from Davenport *et al* (1996), the method used is detailed in the appropriate taxa specific section. The attempt was made to spread the sampling locations throughout the different small forest blocks associated with Mabira CFR. Re-surveying of the same taxa as done by Davenport (1996) has enabled us to make comparisons for species richness at least for Mabira CFR.

2.3 SITE DESCRIPTION

2.3.1 Introduction to the Forest Reserves of the Mabira Ecosystem

Mabira Forest Reserve

The study was conducted in Mabira Central Forest Reserve and five other smaller reserves of the Mabira Ecosystem. Mabira forest islocated in Buikwe District, Uganda (0°24 0°35 N 32°52 33°07 E) and has an area of 306 km^2 (Davenport *et al.*1996), Figure 2.1. Mabira has tropical rain forest communities of medium altitude, described as moist semi-deciduous and moist evergreen. The altitude ranges between 1070 and 1340 m above sea level, with gently undulating plains of numerous flat-topped hills and wide shallow valleys. The mean annual precipitation of the forest is between 725-1474mm while the annual mean minimum and maximum temperatures range from 16 to 17°C and 27 to 29°C, respectively.

The reserve supports a high diversity of biota including mammals, birds, butterflies (Davenport, 1996), and plants, typical of Afro-tropical forest ecosystems. Two main vegetation sub-types are represented in the forest reserve namely; young and colonizing forest covering 2.7% and mature mixed forest which is the largest covering 52% of the forest area. About 312 trees and shrubs exist in Mabira forest of which nine are restricted range species and three Mahogany species listed as globally threatened (Davenport 1996). Forest birds are over 150 species, two species of diurnal forest primates and 218 species of butterflies. The forest has some species of global conservation importance for example *Francolinus nahani* (Nahan's Francolin), found in the list of globally endangered species.

Already by 1996, Davenport *et al* (1996) reported, "Mabira Forest Reserve was subject to extensive encroachment, pitsawing, charcoal burning and hunting formany years. And that in the 1970's and 80's politicians encouraged many people to leave their homes and re-establish inspecially cleared areas of the forest. These immigrants came from many parts of Uganda, in particular from eastof the Nile. This single act caused much disturbance to the forest and it is estimated that 25% of the reserve was cleared to accommodate the settlers. The encroachers were evicted in 1988 after a much-publicized action by the Forest Department.

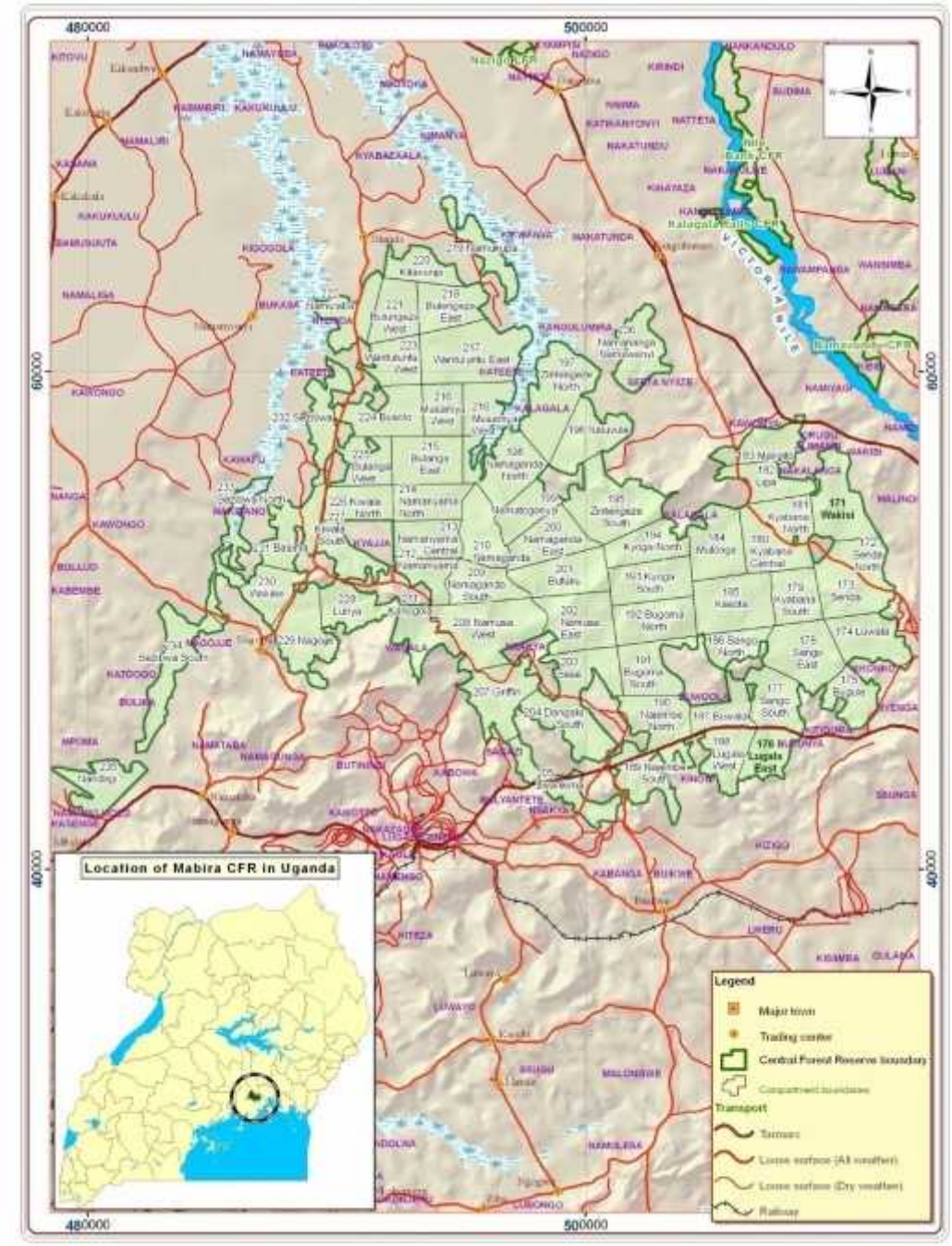

Figure 2.1. Mabira CFR with the other 5 CFRs surveyed for this report

Despite steady recovery from disturbances caused by encroachment of the 1980's, the forest remains heavily degraded mainly at the edges. Enclaves exist in the Mabira Forest Reserve with 27 villages where subsistence farming is the primary economic activity for the 3,506 families within. The secondary economic activities include; charcoal burning, pit sawing, collection of poles for construction, collecting medicinal and other non-timber forest products needed to supplement the incomes of enclave residents. Despite the worrying levels of degradation, the forest remains an important biodiversity reserve and an important tourist destination, receiving more than 62% of all tourists visiting forest reserves in Uganda.

History of Disturbance in Mabira Forest Reserve

A lot of habitat change has been recorded in many areas of the world and Uganda in particular. The extent and quality of forests, woodlands, wetlands and other terrestrial land cover types have been greatly impacted and changed through anthropogenic pressure in the search of resources and land for settlement and agriculture. Large sections of the forests of Mabira, Nandagi, Namananga, Namakupa, Namawanyi and Kalagala over the years experienced massive but varying levels of human incursions on the forest estates and in some cases converting more than 80% (in the case of Nandagi, Namananga, Namakupa, Namawanyi and Kalagala) for cultivation. Large sections of the previously encroached forests have since been reclaimed and some restoration action taken place, although in some section natural regeneration is now observed. While the local sugar works (Sugar Corporation of Uganda Limited) is replanting areas of the forest for their own consumption, they are also responsible for releasing effluent waste into the River Musambya which appears to bepolluting this river that runs into the Reserve".

The Management zones

The Mabira forest was in 1994-1997 divided into Management zones consisting of Strict Nature reserve, Recreation/eco-tourism zone, zone for low impact use and the production zone (Davenport, 1996) these are shown in Figure 2.2.

The Strict Nature Reserve: This is located almost in the centre of the forest and was set aside mainly for species and habitat protection. The only activities allowed in this management zone are education and research with extraction limited to only meet the requirements of these two activities. Studies in this zone were carried out from Wanende 'beat'.

The Recreational/Buffer Zone/eco-tourism: This Management zone surrounds the strict nature reserve and is meant to offer protection from undue human pressure from outside. Allowed in this zone are ecotourism and harvesting of local herbs by inhabitants from surrounding communities. This zone was established within the Forest department as a tourism development project. Studies in this zone were carried out from Najjembe 'beat'.

The low-impact use zone: This zone occurs outside the buffer and on average appears to be the largest. Local inhabitants are allowed to collect firewood and medicine from this zone. Studies in this zone were carried out from Lwankima 'beat'.

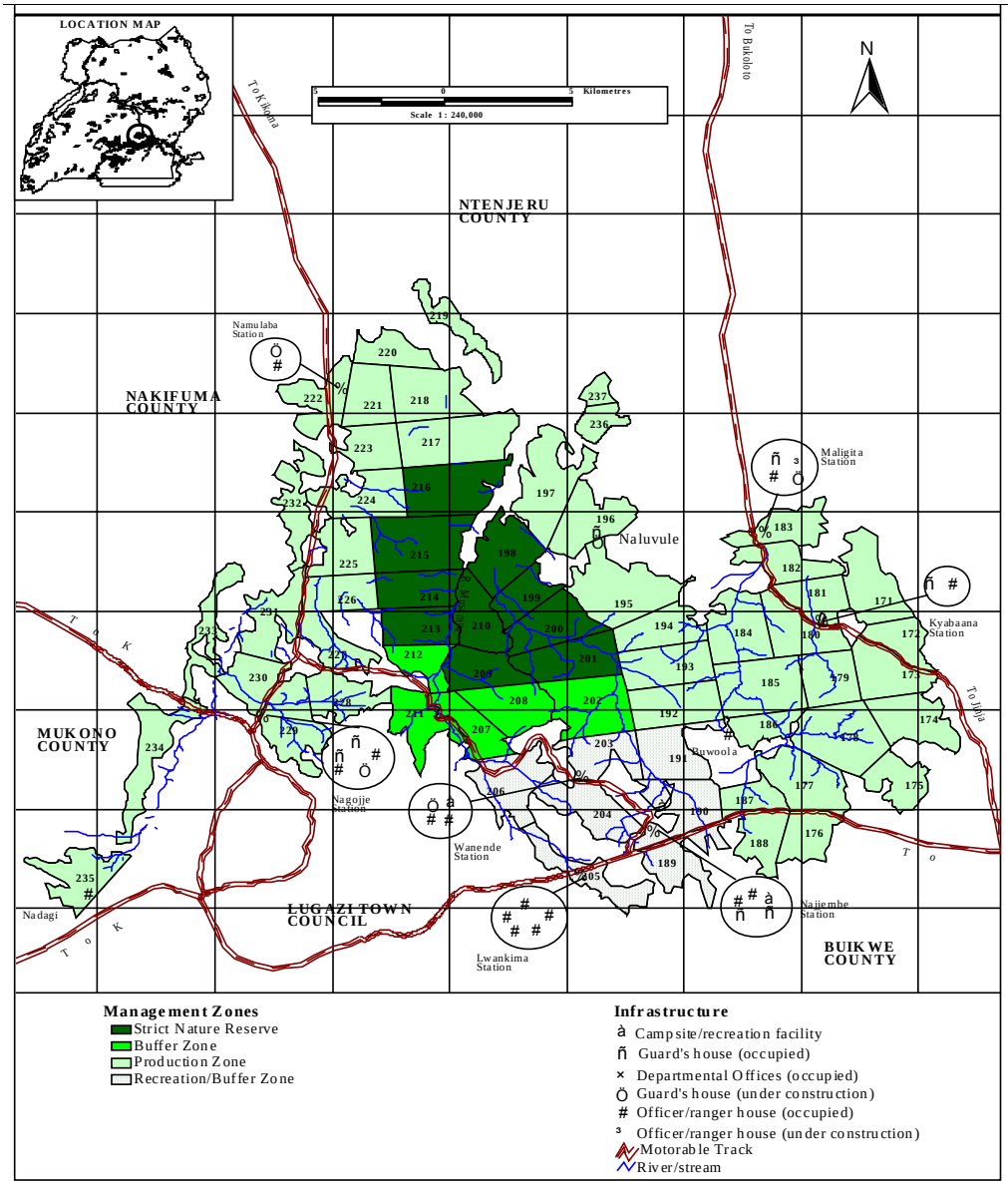

Figure 2.2. Management zoning of Mabira Central Forest Reserve

The production zone: This occurs within the zone of low impact use and is part of the overall forest management programme. Here silvicultural practices are used to enrich stands for extractive use by private companies while other activities include enrichment planting of trees and salvage operations (MWE, 2009; Kizza *et al*, 2013). Studies in this zone were carried out from Nagojje 'beat'.

Namukupa forest reserve

Namukupa forest reserve (Figure 2.3) is located in Namukupa village. Fields of cultivation fringe the forested area with small-scale gardens on the larger side. The other side is fringed by *Learsia hexandra* and *Cyperus papyrus* dominated swamp. The forest still retains her natural vegetation in its centre although the boarders and some sections of the interior are dominated by the invasive *Brousonetia papyrifera*.

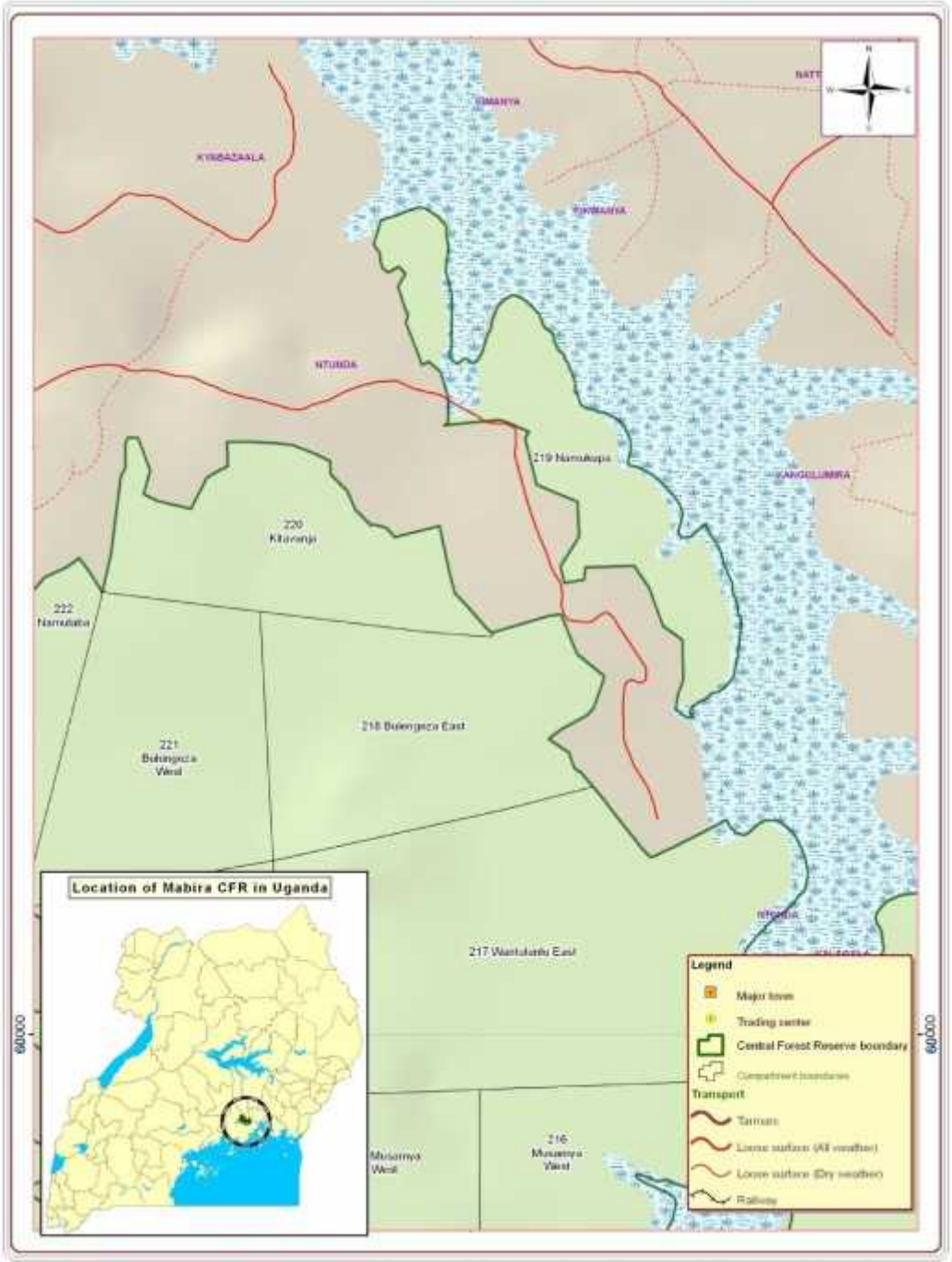

Figure 2.3. Namakupa Forest Reserve which is one of the study sites

Namananga Forest reserve

Namananga Forest reserve (Figure 2.4) is located in Namananga Village. One section of the reserve is in a swamp dominated by *Learsia hexandra* and the forested expanse is dominated by *Brousonetia papyrifera*. Fields of cultivation and areas of human settlement fringe the reserve.

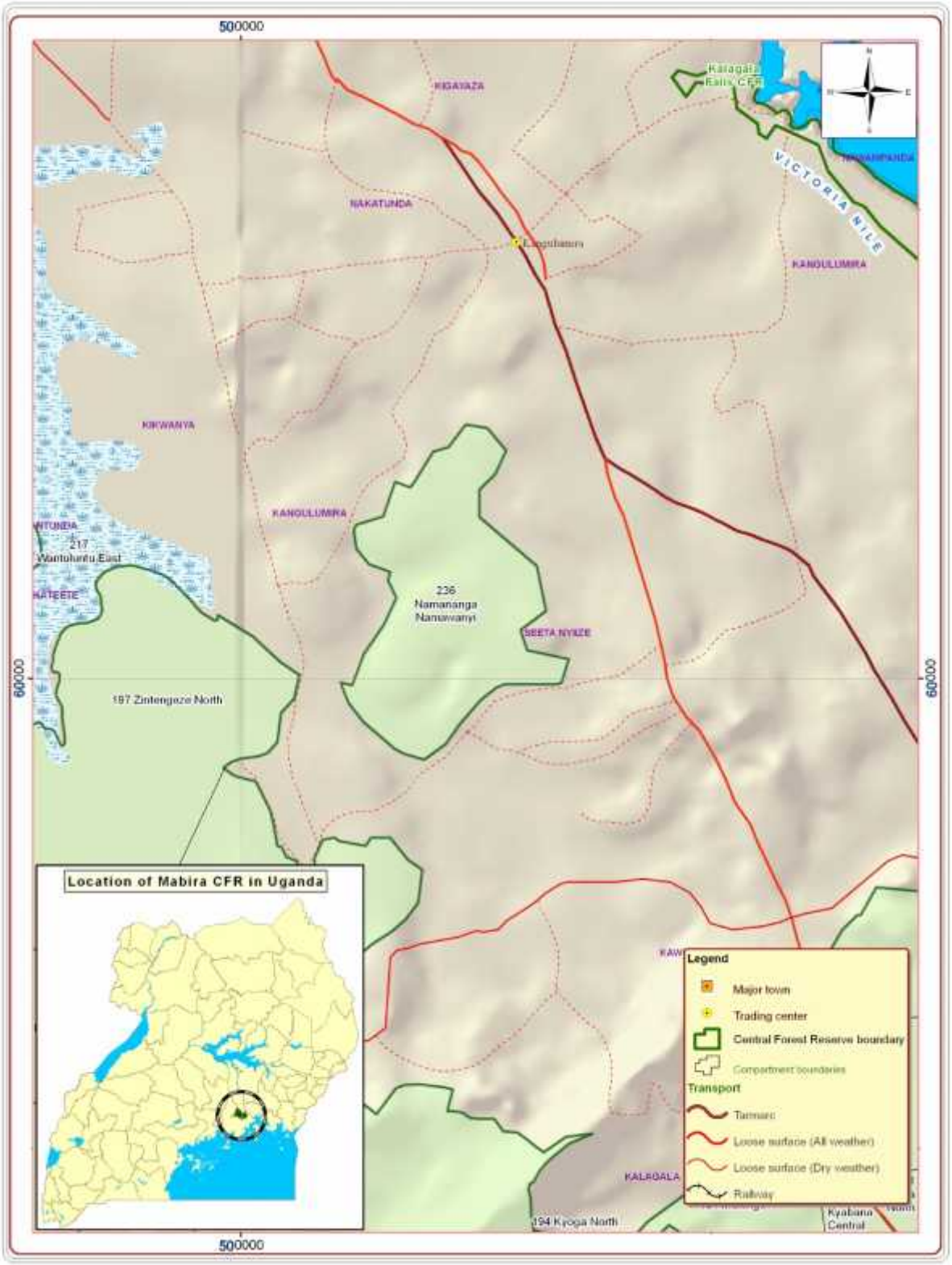

Figure 2.4. Namananga and Namawanyi Forest Reserves

Namawanyi Forest reserve

Namawanyi Forest reserve (Figure 2.4) is located in Namawanyi Village. The reserve is dominated by *Brousonetia papyrifera* with very few indigenous trees and is fringed by fields of cultivation. The forest is contiguous with Namananga and both reserves are regenerating with average tree height below 15m.

Nandagi forest reserve

Nandagi forest reserve is composed of forested expanses, fields of cultivation and fallow lands. The sampling sites outside the Forested part of the reserve are located in Nama 2 village (Figure 2.5) and those inside the forest reserve are located in Nandagi village. Mostof the points in Nama 2 village were within fields of cultivation and fallow lands. Nandagi forest reserve is composed mainly of plantations from trees of *Terminalia* spp, *Eucalyptus* sp. and *Pinus* spp. The reserve is bordered by a long wetland stretch from one end of lower elevation, small-scale agriculture fields from the other and sugar cane plantation from the end of higher elevation.

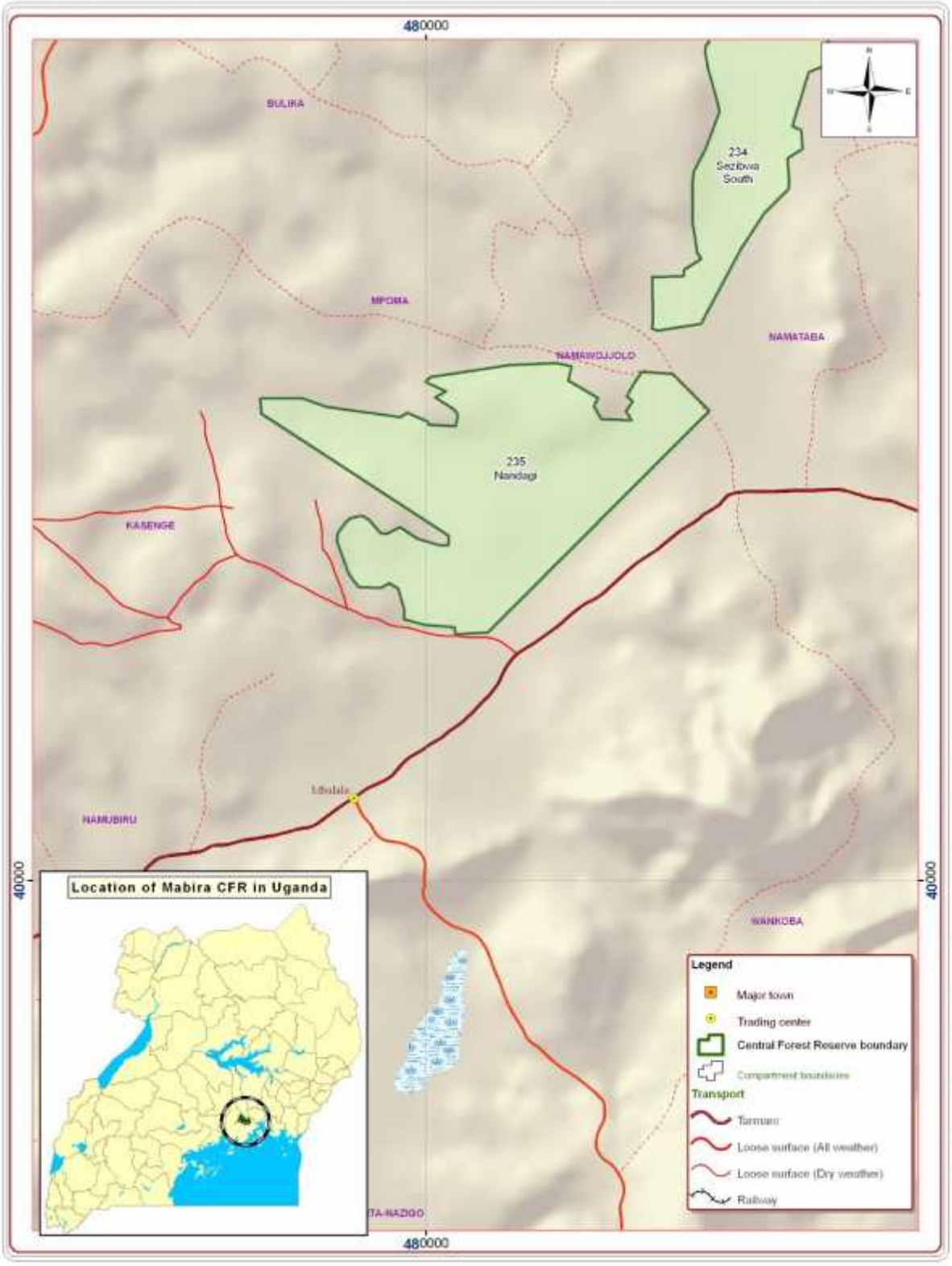

Figure 2.5. Nandagi Forest Reserve which is one of the study sites

Kalagala forest reserve

Kalagala forest reserve (Figure 2.6) is along one section of river Nile in Kalagala village. Parts of the reserve are cultivated with small-scale gardens and tree plantations of *Terminalia* sp. while the natural vegetation forms a stretch of about 3km. On this stretch is a mosaic of bushed thickets and forested patches.

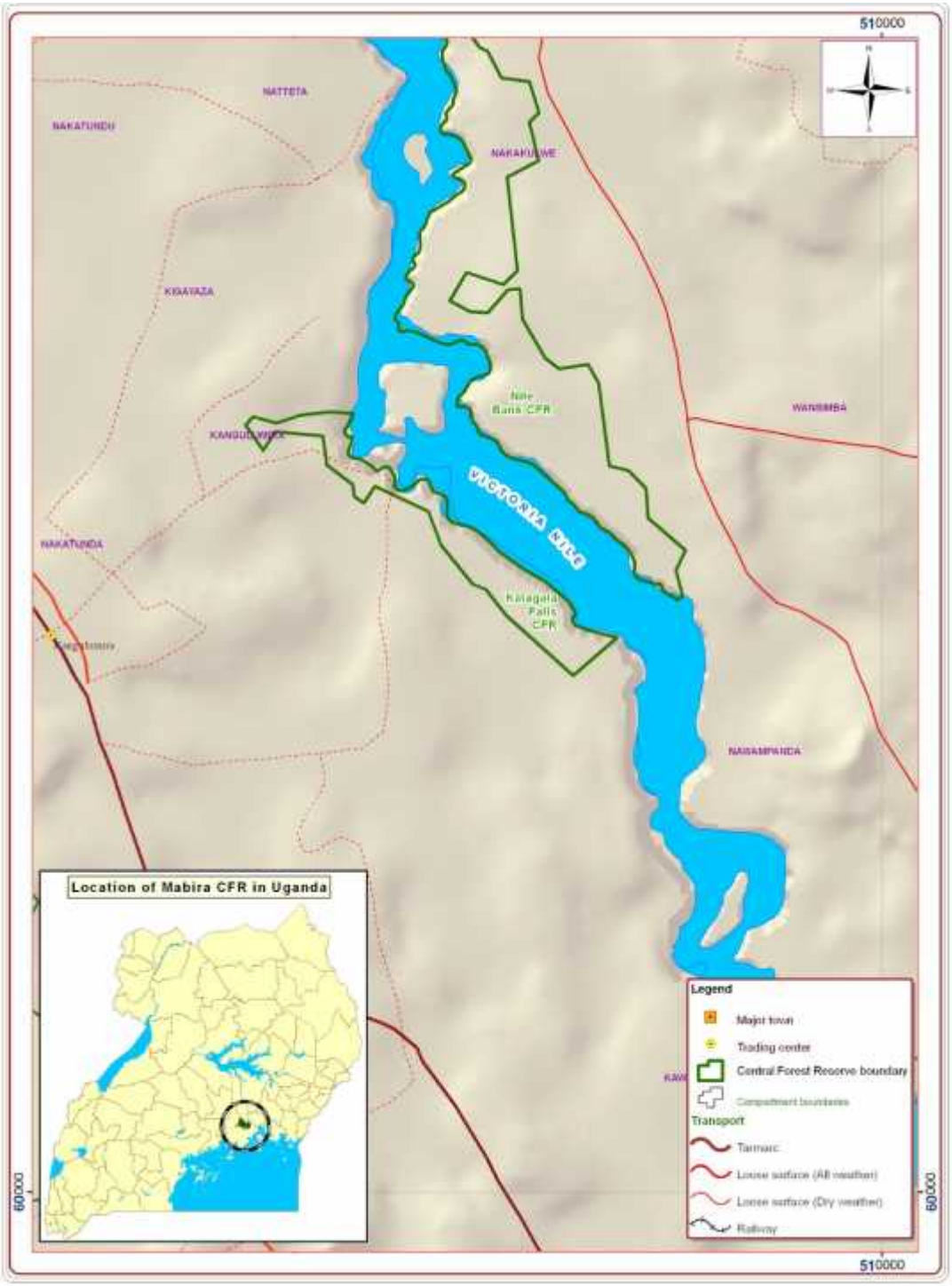

Figure 2.6. Kalagala Falls, one of the study sites within the Mabira Ecosystem

2.4. CONCLUSION

It is therefore evident that the coverage of this task was adequate in recording the key ecological aspects of the Mabira Ecosystem for purposes of updating the baseline data. The findings have been used to develop a database of the ecological data, for management planning and for developing a plan for monitoring the ecosystem health.

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CHAPTER THREE

3.0. FLORA

3.1 SUMMARY

The total number of plant species now known from Mabira Forest Reserve is 636 with the trees, shrubs and climbers contributing 450 species (312 were recorded in the previous Biodiversity inventory and 138 are new additions from this study) and herbs contributing 186 species. The rest of the reserves have fewer species: 87 (Namakupa), 92 (Namawanyi), 139 (Nandagi) and 68 (Kalagala), and 68 (Namananga). In the case of Mabira Forest Reserve, the climbers and herbaceous species were previously not included, and also data for the smaller forest reserves (Namakupa, Namawanyi, Nandagi, Kalagala and Namananga) are here newly presented in this report. In total, we have 732 species recorded for the Mabira ecosystem, including 252 herbs and 480 woody species.

3.2 INTRODUCTION

3.2.1 Aims and rationale

The rationale for the work on flora is that several changes have occurred thereby affecting the plant species. The composition and diversity of plants is crucial for the survival of components such as fauna and for ensuring the ecosystem health. Data from the inventories conducted within this project will be crucial for contributing towards a better understanding of the Mabira flora and implications for the value of the forest including contribution to local livelihoods.

3.2.2 Previous work

Herbaceous species

In the past, data collection in Ugandan forests has not documented the herbaceous plant composition, yet herbs are important constituents of forest vegetation because they can be used to indicate the level of disturbance from human interaction with the forest. Organized forest surveys intended for biomass inventories have focused on documenting only woody species (trees and shrubs). Available information on forest herbs therefore lies scattered in reports (theses) that focused on documenting plant species of ethnobotanical importance to the local communities. Other data occurs as herbarium collections randomly made by various plant collectors. Data for this report was generated from old plant collections housed at the Makerere University Herbarium, from literature and also from fieldwork executed for this purpose.

Data collection

Herbarium data: The Makerere University Herbarium was visited and collections made from Mabira forest were filtered out. The collections have accumulated over years by various collectors, some of which were chance collections or were made during organized surveys. Unfortunately, herbarium data sheets did not give the sampling procedures employed by the different collectors. Statements on the abundance of species have also often neglected by collectors. Most of the collectors probably referred to the whole Mabira forest ecosystem as 'Mabira forest' because searches of collection localities of the smaller forest reserves (Namakupa, Namawanyi, Namananga, Nandagi, and Kalagala) were not successful.

Generation of data from research reports: A PhD research conducted in 2013 and 2014 on the ethnobotanical survey of plants used by communities around Mabira Central Forest Reserve largely contributed to the generated list. For the purpose of this activity, the resourceful parts of this research are those that focused on medicinal, cultural, wild food plants and other products of plants e.g., baskets and crafts. Parts of the plant list are published in Tugume *et al*. 2016, yet others that were kindly provided by the researcher are not yet published. These lists were generated following key informant interviews with renowned traditional healers and resource users (including primary collectors and vendors) in villages lying within 1 – 5 Km from the forest. Field excursions were then conducted with the key informants as guides; following forest trails and collecting voucher specimens of cited plants. The voucher specimens were identified at Makerere University Herbarium.Other published works e.g. Lwanga *et al*. (1998) did not publish their species lists and possibly their specimens were not deposited at the herbarium.

3.3 METHODS

3.3.1 Field methods

All the selected but accessible grids were visited and sampled. The plants were assessed within demarcated plots of 5 x 30 m or 5 x 15 m established randomly within each selected grid. Inventories of trees, shrubs, lianas and herbs were done within the nested plots. The four corners of plots were marked with the ID of the vegetation category. The positions of each plot were marked as accurately as possible on maps of the study sites. For each plot the following data were obtained: i) GPS reading and Altitude at the centre of the plot; ii) Slope: measured by a clinometer.

Plot size considered the history of disturbance. In previously encroached areas the plots of 5 x 30 m were used. In mechanically logged sites and in essentially undisturbed mature forest the plot size will be 10 x 30 m (twice the plot size in the encroached areas). Concentric Circular Plots that are mostly used by the NFA may be considered if appropriate in some cases.

Each plot of 5 x 30 m will be divided it into six sub-plots of 5 x 5 m; plots of 10 x 30 m will be similarly divided into 10 sub-plots of 5 x 5 m. Each 5 x 5 m sub-plot will be divided further into 1 x 1 m quadrats located at the centre.

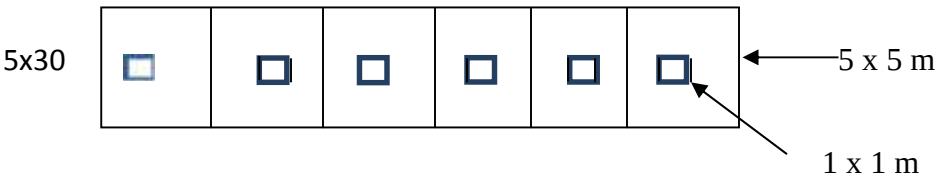

Figure 3.1: Design and outline of inventory plots to be used in all sites

The teams of botanists walked within and assessed the plots. They took records of previously un-recorded as well as recorded species to determine abundance. All individuals with more than half the base rooted in the plot were included.

i. **Large trees**>10 cm DBH: All trees >10 cm DBH were enumerated by species and size in the 5 x 30 m and 10 x 30 m plots.
ii. **Saplings:** Saplings are considered to be trees with diameter between 0.1 mm –10 cm. Saplings were enumerated in 1 x 5 m sub-plots. We shall have three 1 x 5 m sub-plots in the 5 x 30 m plot and six 1 x 5 m sub-plots in the 10 x 30 m plot.

iii. **Lianas and Shrubs:** The lianas (woody climbers) and shrubs (woody plants with multiple branching below 1.3m high) were enumerated within the 5 x 5 subplots. Their diameters were measured at the base or ground level.

iv. **Seedlings:** These are young trees ≤1.3 m tall. They were enumerated in all 1 x 1 m quadrats (i.e. six seedlings plots in 5 x 30 m plot and 12 in 10 x 30 m plot).

v. **Herbaceous species:** These are annual or perennial, and do not produce woody stems. Data were collected in the same plots used for woody species. At the center of each 5 × 5 m quadrat (used for sampling saplings and shrubs), a smaller quadrat of 1 × 1 m was nested for the enumeration of herbaceous species (and seedlings of woody species). All the herbs found in these quadrats were recorded and the percent cover value for each species was visually estimated. Where possible, counts of individual plants were made to estimate species' abundance. In the case of creeping plants, cover was estimated. Species found outside the sampled quadrats were recorded as present although no estimates of abundance or cover were made for them.

3.3.2 Specimen collection and identification

Those plants that could not be named in the field were collected and identified at Makerere University Herbarium. Identification was aided by the use of identification books such as the Forest Trees of Uganda (by Hamilton A.C.), Indigenous Trees of Uganda (By Eggeling, W.J.) and the Flora of Tropical East Africa (various authors). If a plant could not be identified to the species level during surveys, specimens were preserved and identified at the herbarium in Makerere University. The classification system used is that of the Angiosperm Phylogeny Group III (APG III).

3.3.3 Personnel, dates and areas sampled

The appointed key experts (KE), namely Dr Joseph Bahati (KE – Forest Ecologist), Dr. Gerald Eilu (KE – Taxonomist), Dr. Mary Namaganda (KE – Botanist), and Dr. Robert Kityo (KE – Zoologist). These have been the main personnel in the different components. The field teams are built around these Key Experts.

3.3.4 Data analysis

Species richness and diversity

The data have been used to calculate Species richness and diversity. Diversity is based on the Shannon-Wiener diversity index and Fisher's Alpha index within the SDR computer programme. Similarity is also calculated and dendrograms displayed within the Community Analysis Package (CAP).

3.4 RESULTS

3.4.1.Plant Species Richness

The total number of plant species now known from Mabira Forest Reserve is 636 (Table 3.1) with the trees, shrubs and climbers contributing 450 species (312 were recorded in the previous Biodiversity inventory and 138 are new additions from this study) and herbs contributing 186 species. ≈ Red listed woody plant are listed in table 3.2

Table 3.1. Numbers of plant species recorded in Central Forest Reserves of the Mabira Ecosystem

Plant form	Mabira	Kalagala	Namakupa	Namananga	Namawanyi	Nandagi
Woody species	450	31	60	38	61	85
Herbaceous species	186	37	27	30	31	54

Totals	**636**	**68**	**87**	**68**	**92**	**139**

The rest of the reserves have fewer species: 87 (Namakupa), 92 (Namawanyi), 139 (Nandagi) and 68 (Kalagala), and 68 (Namananga). In the case of Mabira Forest Reserve, the climbers and herbaceous species were previously not included, and also data for the smaller forest reserves (Namakupa, Namawanyi, Nandagi, Kalagala and Namananga) are here newly presented in this report. In total, we have 732 species recorded for the Mabira ecosystem, including 252 herbs and 480 woody species.

3.4.2. Herbaceous Plants

A total of 186 herbaceous species was recorded for Mabira Central Forest Reserve (Table 3.3). Most of these were grasses (Poaceae; 13.2 %) and members of the Asteraceae (10.5 %). Two of the grasses are uncommon species in Uganda; *Isachne mauritianum*, a species of forest clearings known only from four other forests namely, Kashyoha-Kitomi, Bwindi Impenetrable, Rwenzori and Mpanga. The wild species of rice, *Oryza eichingeri*, is also uncommon in Uganda and is known from four other forests namely, Zoka, Semuliki, Maramagambo and Budongo. It was last collected from Bugoma forest in 1942 and efforts to trace it in 2014 were futile because all possible habitats had been opened and drained as much of the forest was highly degraded. Wild species of cultivated crops need special protection, especially those in fragile habitats like forests. These species can be possible progenitors of important traits, through breeding experiments, in the development of improved varieties of crops. Two species of ground orchids were recorded; the fairly common *Corymborkis corymbis* and *Zeuxine elongata*. Orchids are a *CITES* protected group of plants. The invasive *Mimosa pudica* has also been recorded for Mabira. This species needs to be observed to monitor if it spreads further into the forest. Factors like forest clearing can hasten the spread of alien invasive species, as they are usually heavy seeders that will quickly colonize disturbed areas. Other potentially invasive species found in Mabira are *Ricinus communis* and *Nicotiana tabaccum*.

In terms of numbers of individuals, the most abundant herbs were *synedrella nodiflora* and *Bidens pilosa*, with relative abundances of 25.5 and 18.4. Species with the highest relative cover values included: *Paspalum conjugatum* (11.4 %), *Panicum* sp. (5.7 %), *Bidens pilosa* (5.7 %), *Synedrella nodiflora* (4.8 %), and *Leptaspis zeylanica* (4.6 %). The cover values appear low because the forest floor has more litter or bare patches than ground plant cover. The annual *Bidens pilosa* and *Synedrella nodiflora* are indicative of areas that have been disturbed, whereas the perennial grasses *Leptaspis zeylanica* and *Paspalum conjugatum* are indicative of stable forest cover that has not been exposed to disturbances in the recent past. The most commonly encountered herbaceous species (present is most quadrats) included, *Leptaspis zeylanica*, *Culcasia falcifolia*, *Aframomum mildbraedii*, *Oplismenus hirtellus* and *Marantochloa leucantha*, with the following relative frequencies; 26.2, 12.9, 8.7, 4.4 and 3.6 respectively. *Leptaspis zeylanica* has high values for relative frequency and cover, implying that it can be used to monitor the quality of the forest over time. It is a species of shade and decline in its occurrence and coverage would imply reduction in the forest cover.

Namananga, a secondary forest dominated by Brussonetia papyrifera tree species has 30 herbaceous species (Table 3.2). Based on number of individuals, Whitfieldia elongata is the most abundant (53.8 relative abundance) and has the highest relative cover (35 %). Its relative frequency is 10, coming second to Oplismenus hirtellus (25), which has a relative cover of 34.2 %. These two species, *Whitfieldia elongata* and Oplismenus hirtellus are shade-loving species, which can be used to monitor changes in the forest cover quality by observing changes in their relative cover values. It would be expected that a reduction in forest cover would result in more light reaching the ground and hence a decline in the coverage of dominating shade loving species.

Namawanyi, another *Brussonetia papyrifera* dominated secondary forest had 31 hebaceous species recorded. Of these, *Whitfieldia elongata* and *Oplismenus hirtellus* are the most common ones, with highest relative frequency (27.6) and relatively high cover values.

Kalagala forest had 37 herbaceous species of which *Justicia flava* was the most common with relative frequency of 12.2 and with the highest relative cover of 32.7 %. The fairly high number of herbs in Kalagala is possibly because this forest is greatly degraded, the low density of trees creating open areas that favour growth of herbs. Only one shade loving species, *Setaria megaphylla*, was recorded. The invasive *Mimosa pudica* also occurs in this forest, hence a need to monitor it.

A few herbaceous species (27) were recorded from Namakupa. The shade loving forest grass *Leptaspis zeylanica* was the most common herb (relative frequency = 41.7). *Dracaena fragrans* was also fairly common (relative frequency = 25). Like Namananga and Namawanyi, Namakupa is also dominated by *Brossonetia papyrifera*, but the dominating herbaceous species differ. This difference could be a result of varying intensities of disturbance between Namakupa and the former two forests.

Nandagi is fairly rich in herbaceous species composition. A total of 54 herbs were recorded. The dominating herbs were *Paspalum conjugatum* and *Marantochloa leucantha* both having a relative frequency of 13, and 21.7 % and 17.1 % relative covers respectively. *Leptaspis zeylanica* was relatively frequent (13) although it had a low relative cover value (2.2). Although *Paspalum conjugatum* and *Marantochloa leucantha* are shade loving species, they can also tolerate conditions with high amounts of light and so cannot be used as indicator species in this forest. Instead, we recommend the less frequent *Leptaspis zeylanica* to be used to monitor the state of Nandagi.

3.4.3. Trees, Shrubs and Climbers

In total, 450 species of woody plants (480 including those recorded from the previous Forest Department Biodiversity inventory of trees, shrubs and climbers were recorded (3.4). The following introduced species are excluded from the list: *Brousonetia payrifera, Lantana camara*, *Senna hirsuta*, *Capiscum frutescens*, *Carica papaya*, *Coffea arabica*, *Musa sapientum*, *Passiflora edulis*, *Solanum mauritianum*, *Terminalia superba*, *Thevetia peruviana* and *Artocarpus heterophyllus*. The first two of these species are invasive in Uganda with *B. papyrifera* dominating the small reserves.

Mabira Forest Reserve, as would be expected from the size and attention given for its protection, has the highest number of species (450). This is followed in order, by Nandagi (85), Namawanyi (61), Namakupa (60), Namananga (38), and Kalagala (31).

Namananga and Namawanyi are the most similar of the forests in terms of their species composition (Figure 3.2). These two, with Namakupa, form a cluster of closely related forests in terms of species composition. This cluster is linked to Nandagi. This leaves out Mabira and Kalagala Falls as the least similar to this cluster. The dominance of *B. papyrifera,* relative to the rest of the species, seems to be the major factor responsible for this pattern.

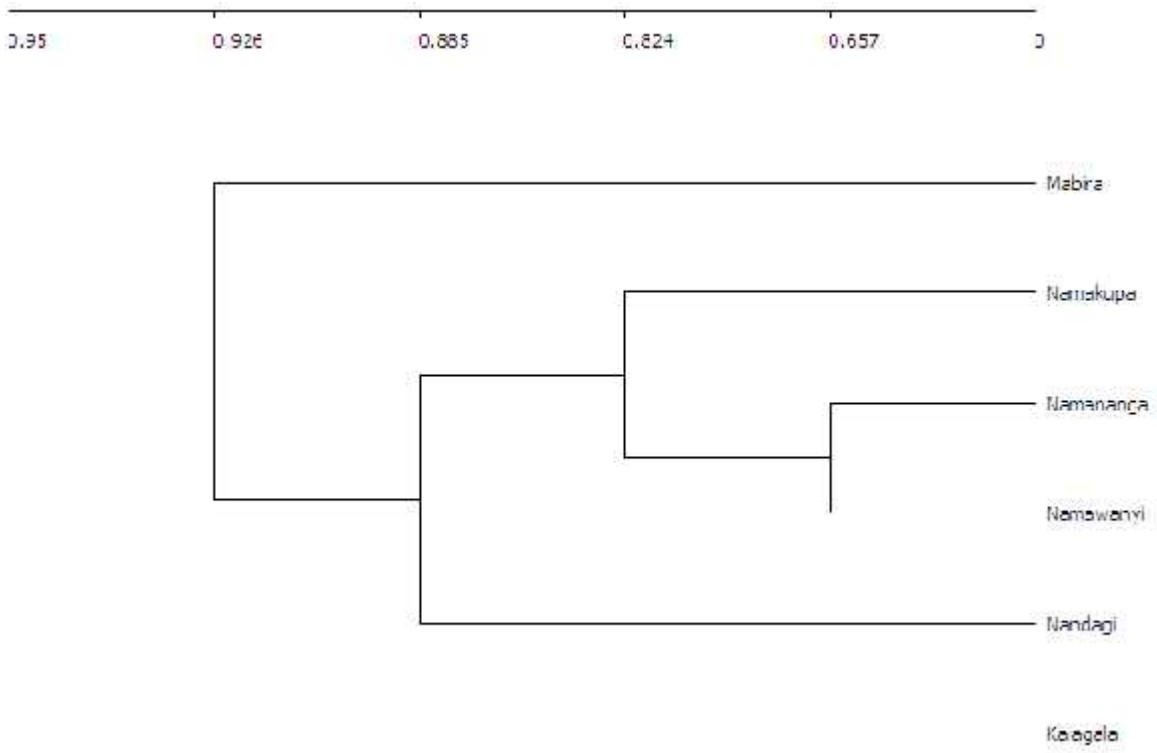

Figure 3.2. Dendrogram showing clustering of forest based on presence-absence matrix

The taxa recorded, include some red listed species such as the Mahoganies (*Entandrophragma angolense, Entandrophragma cylindricum,* and *Entandrophragma utile*. Others include *Prunus africana, Warbugia ugandensis* and *Milicia excelsa*.

3.5. CONCLUSION

The inclusion of 186 herbaceous plant species to the list of Mabira CFR is a major contribution derived from this work. In the case of the smaller reserves, this team has seen no previous lists. The lists for these reserves therefore, are enriched with species.

This work has provided an additional species of woody plants recorded for the Mabira CFR. This is a big contribution towards a proper documentation of the flora of Mabira central Forest Reserve. Considering that there were no species lists of woody plants for the smaller reserves of the Mabira ecosystem, the present work has yielded the following numbers of species that can now be used as baseline.

The key herbaceous species that could be used to monitor the status of the forests are *Leptaspis zeylanica*, *Oplismenus hirtellus* and *Whitfieldia elongata*. Occurrence of the invasive herb, *Mimosa pudica*, should be noted for future monitoring against further spread. The Red Listed Species as well as the invasive species should be monitored to keep track of trends in their status.

Occurrence of the invasive herb, *Mimosa pudica*, should be noted for future monitoring against further spread. The Red Listed Species as well as the invasive species should be monitored to keep track of trends in their status.

The current surveys have added new records of woody species for Mabira CFR, notable of which is the invasive *Broussonetia papyrifera,* but these were probably introduced after the biomass surveys. Not all the 198 new records are new species to the forest. Differences in species richness and diversity from surveys are often dependent on sampling intensity and sample location. In addition, the current survey included woody climbers in the definition of woody species and was not limited to trees and shrubs like the 1996 Forest Department surveys. However, the epiphytes, mistleoes and stranglers are not included. Hence, a complete list of the plants of the Mabira Forest Reserves is still far from complete.

The Mabira ecosystem should be regarded as being of high conservation value because of the presence of several threatened plant species. Twenty-one of the woody species are of conservation concern and are distributed in the different forests in the ecosystem as shown in Table 3.2. None of the herbs is IUCN Redlisted.

Table 3.2. IUCN Redlisted woody plant species in the Mabira Forest Reserves

Species	National threat status	Global threat status	Mbr	Ndg	Kgl	Nmg	Nwy	Nkp
Entandrophragma angolense	EN	VU	1	1				
E. cylindrica	EN	VU	1					
E. utile	EN	VU	1					
Lovoa swynnertonii	EN	NT	1					
L. trichilioides	EN	VU	1					
Beilschmiedia ugandensis	VU	VU	1					
Calamus deeratus	VU	NE	1					
Cordia millenii	EN	LC	1					
Milicia excelsa	EN	NT	1		1	1		
Warburgia ugandensis	VU	NE	1					
Albizia ferruginea	EN	VU	1					
Chrysophyllum albidum	VU	NE	1					1
C. muerense	VU	NE	1					
C. perpulchrum	VU	NE	1					
Erythrophleum suaveolens	VU	NE	1					
Mondia whytei	VU	NE	1			1	1	
Prunus africana	VU	VU	1	1				
Citropsis articulata	VU	NE	1			1	1	
Fagaropsis angolensis	VU	NE	1			1		
Olea welwitschii	VU	NE	1				1	
Khaya anthotheca	EN	VU	1					

Mbr = Mabira, Ndg = Nandagi, Kgl = Kalagala, Nmg = Namananga, Nwy = Namawanyi, Nkp = Namakupa
EN = Endangered, VU = Vulnerable, NT = Near Threatened, NE = Not Evaluated

All the threatened 21 species occur in Mabira, followed by Namananga and Namawanyi respectively with 4 and 3 species of conservation concern. Although Nandagi, Kalagala and Namakupa have a few threatened species (respectively 2, 1 and 1), the value of these forests should not be overlooked. They need to be given equal priority for conservation like the rest of the forests in the landscape, restocked with the native species and the dominating invasive *Broussonetia papyrifera* controlled.

TABLES

Table 3.3. Herbaceous species recorded in the 1996 and 2016 surveys of the Mabira Reserves

Family	Species	Mabira	Namananga	Namawanyi	Kalagala	Namakupa	Nandagi
Acanthaceae	*Asystasia gangetica* (L) T. Anderson	1		1	1		
Acanthaceae	*Barleria brownii* S. Moore	1	1				1
Acanthaceae	*Barleria sp.*	1					
Acanthaceae	*Berleria ventricosa* Hochst. ex Nees				1		
Acanthaceae	*Crossandra sp.*					1	
Acanthaceae	*Dicliptera laxata* C. B. Cl.		1				1
Acanthaceae	*Dyschoriste radicans* Nees	1		1	1	1	
Acanthaceae	*Justicia anseliana* (Nees) T. Anders.	1					
Acanthaceae	*Justicia betonica* L.	1					
Acanthaceae	*Justicia flava* Vahl	1		1	1		
Acanthaceae	*Justicia heterocarpa* T. Anders	1					
Acanthaceae	*Justicia scandens* Vahl			1	1	1	1
Acanthaceae	*Mendoncia sp.*	1					
Acanthaceae	*Nelsonia smithii* Oerst.						1
Acanthaceae	*Thunbergia alata* Sims	1			1		
Acanthaceae	*Whitfieldia elongata* (P. Beauv.) C.B.Cl.	1	1	1			
Adiantaceae	*Adiantum sp.*	1					
Amaranthaceae	*Achyranthes aspera* L.	1	1	1			1
Amaranthaceae	*Aerva lanata* (L.) Schultes	1		1		1	
Amaranthaceae	*Amaranthus dubius* Mart. ex. Thell.	1					
Amaranthaceae	*Amaranthus graecizans* L.	1					
Amaranthaceae	*Amaranthus spinosus* L.	1					
Amaranthaceae	*Celosia trigyna* L.	1					
Amaranthaceae	*Cyathula achyranthoides* (Kunth) Moq.	1					
Amaranthaceae	*Cyathula prostata* (L.) Blume	1			1		1
Amaranthaceae	*Psilotrichum elliotii Bak.*	1					
Amaranthaceae	*Psilotrichum majus* Peter					1	
Amaryllidaceae	*Scadoxus multiflorus* Raf.			1			
Anthericaceae	*Chlorophytum filipendulum* Baker						1
Apiaceae	*Centella asiatica* (L.) Urb.	1			1		1
Apocynaceae	*Gongronema angolense* (N. E. Er.) Bullock	1					
Apocynaceae	*Pergularia daemeri*				1		
Apocynaceae	*Unidentified sp.1*	1					
Araceae	*Amorphophallus abyssinicus* (A. Rich.) N.E.Er.	1					
Araceae	*Arisaema mildbraedii* Engl.	1					
Araceae	*Culcasia falcifolia* Engl.	1					
Araceae	*Culcasia scandens* Beauv.						1
Araceae	*Rhaphidophora africana* N.E. Br.						1
Aristolochiaceae	*Aristolochia elegans* Mast.	1					

Aspleniaceae	*Asplenium emerginatum* P. Beauv.	1					1
Aspleniaceae	*Asplenium monanthes* L.	1					
Aspleniaceae	*Asplenium pocsii* Pichi-Serm.	1					
Asteraceae	*Achyranthes aspera* L.					1	
Asteraceae	*Acmella caulirhiza* Delile	1					
Asteraceae	*Ageratum conyzoides L.*	1		1			1
Asteraceae	*Aspilia africana* C. D Adams		1		1		
Asteraceae	*Bidens pilosa* L.	1	1				
Asteraceae	*Conyza adolfi-fridericii* (Msch.) H. Wild	1					
Asteraceae	*Conyza sumatrensis* (Retz.) E. Walker	1	1				
Asteraceae	*Crassocephalum crepidioides* (Benth) S. Moore	1					
Asteraceae	*Crassocephalum picridifolium* (DC) S. Moore	1					
Asteraceae	*Crassocephalum sarcobasis* (DC.) S. Moore.	1					
Asteraceae	*Dicrocephala integrifolia* (L.F.) Kuntze	1					
Asteraceae	*Erlangea tomentosa* S. Moore	1					
Asteraceae	*Helichrysum sp.*	1					
Asteraceae	*Melanthera scandens* (Schumach & Thonn.) Roberti	1					
Asteraceae	*Mikania cordata* (Burm. f.) B.L. Rob.						1
Asteraceae	*Senecio syringifolius* O. Hoffm.	1					1
Asteraceae	*Sigesbeckia orientalis* L.	1					
Asteraceae	*Sonchus oleraceus* L.	1					
Asteraceae	*Synedrella nodiflora* (L.) Gaertn.	1	1	1	1	1	
Asteraceae	*Tagetes minuta* L.	1					
Asteraceae	*Tridax procumbens* L.	1					
Asteraceae	*Vernonia campanea* S. Moore	1					
Asteraceae	*Vernonia sp.*				1		
Basellaceae	*Basella alba* L.	1					
Brassicaceae	*Cardamine trichocarpa* Hochst. Ex. Rich	1					
Cannabaceae	*Cannabis sativa* L.	1					
Capparaceae	*Cleome gynandra* L.	1					
Capparaceae	*Cleome monophylla* L.	1					
Chenopodiaceae	*Chenopodium ambrosiodes* L.	1					
Chenopodiaceae	*Chenopodium opulifolium* Koch & Ziz	1					
Chenopodiaceae	*Chenopodium procerum* Moq.	1					
Commelinaceae	*Aneilema benieniense* (P.Beauv.) Kunth.						1
Commelinaceae	*Aneilema sp.*	1	1				
Commelinaceae	*Buforestia imperforata* C.B. Cl.					1	1
Commelinaceae	*Coleotrype laurentii* K.Schum.	1					
Commelinaceae	*Commelia foliosa* Chiov.			1			
Commelinaceae	*Commelina africana* L.	1			1		
Commelinaceae	*Commelina benghalensis* L.	1	1				
Commelinaceae	*Commelina diffusa* Burm.f.	1		1			
Commelinaceae	*Commelina foliosa* Chiov.	1					1
Commelinaceae	*Commelina latifolia* A. Rich.	1		1			
Commelinaceae	*Palisota barteri* Hook.f.						1

Commelinaceae	*Palisota mannii* C.B. Clarke	1					1
Commelinaceae	*Polia condesata* C. B. Cl.	1				1	1
Commelinaceae	*Polyspatha paniculata* Benth.	1					
Commelinaceae	*Stanfieldiella imperforata* (C.B.Clarke) Brenan	1				1	1
Convolvulaceae	*Hewittia sp.*	1					
Convolvulaceae	*Hewittia sublobata* L. O Katze	1					
Convolvulaceae	*Ipomoea cairica* (L.) Sweet				1		
Costaceae	*Costus afer* Ker Gawl.						1
Costaceae	*Costus lucanusianus* J. Braun	1					
Crassulaceae	*Kalanchoe crenata* (Andrews). Haw	1					
Crassulaceae	*Kalanchoe glaucescens* Planch. ex. benth	1					
Cucurbitaceae	*Kedrostis foetidissima* (Jacq.) Cogn.	1					
Cucurbitaceae	*Momordica foetida* Schumach	1				1	
Cucurbitaceae	*Zehneria minutiflora* (Coga.) C. Jeffrey	1					
Cyperaceae	*Cyperus cyperoides* (L.) Kuntze				1		
Cyperaceae	*Cyperus sp.*			1			
Cyperaceae	*Kyllinga elatior* Kunth		1				
Cyperaceae	*Kyllinga sp.*	1					
Dioscoreaceae	*Dioscorea bulbifera* L.	1					
Dioscoreaceae	*Dioscorea sp.*					1	
Dracaenaceae	*Dracaena fragrans* (L.) Ker Gawl.		1		1	1	1
Dracaenaceae	*Dracaena laxissima* Engl.	1					
Dryopteridacaeae	*Dryopteris sp.*	1					
Dryopteridaceae	*Dryopteris kirkii* (Hook.) Alston					1	1
Euphorbiaceae	*Acalypha brachystachya* Hornem.	1					
Euphorbiaceae	*Acalypha ornata* Hochst. ex A. Rich.	1					
Euphorbiaceae	*Euphorbia hirta* L.	1					
Euphorbiaceae	*Micrococca mercurialis* (L.) Benth.	1					
Euphorbiaceae	*Phyllanthus amarus* Schum. & Thonn.	1					
Euphorbiaceae	*Ricinus communis* L.	1					
Euphorbiaceae	*Tragia benthamii* Baker	1					
Fabaceae	*Adenodolichos paniculatus* Hutch. & Dalz.			1			
Fabaceae	*Crotalaria spinosa* Hochst. ex. Benth	1					
Fabaceae	*Desmodium adscendens* (SW.) DC	1			1		
Fabaceae	*Desmodium drageanum* Kunth.	1			1		1
Fabaceae	*Desmodium giganteum*(L.) DC.			1		1	1
Fabaceae	*Desmodium repandum* (Vahl) DC.	1					
Fabaceae	*Desmodium sp.*		1				
Fabaceae	*Desmodium tortuosum* (Sw.) DC				1		
Fabaceae	*Desmodium triflorum* (L.) DC				1		
Fabaceae	*Desmodium uncinatum* (Jacq.) DC.						1
Fabaceae	*Indigofera congesta* Welw.ex. Bak. F	1					
Fabaceae	*Indigofera drepanocarpa* Taub.	1					
Fabaceae	*Indigofera emarginella* A. Rich.	1					
Fabaceae	*Indigofera spicata* Forssk	1			1		

Fabaceae	*Mimosa pudica L.*	1			1		
Fabaceae	*Tephrosia sp.*				1		
Fabaceae	*Teramnus labialis* (L. f.) Spreng.			1			
Fabaceae	*Teramnus uncinatus* (L.) Sw.			1			1
Fabaceae	*Vigna parkeri* Baker				1		
Fabaceae	*Vigna unguiculata* L	1					
Lamiaceae	*Coleus latifolius Hochst.* Ex. Benth.	1					
Lamiaceae	*Hoslundia opposita* Vahl		1				
Lamiaceae	*Leonotis nepetifolia* (L) R. Br.	1					
Lamiaceae	*Leucas martinicensis* (Jacq.) R. Br.	1					
Lamiaceae	*Mentha Sp.*	1					
Lamiaceae	*Ocimum basilicum* L.	1					
Lamiaceae	*Ocimum gratissum* L	1					
Lamiaceae	*Oenanthe palustris* (Chiov.) Norman	1					
Lamiaceae	*Plectranthus barbartus* Andr.	1					
Lycopodiaceae	*Lycopodium sp.*	1					
Malvaceae	*Sida acuta* Burm. f.		1				
Malvaceae	*Sida alba L.*	1					
Malvaceae	*Sida cuneifolia* Roxb.	1		1			
Malvaceae	*Sida rhombifolia* L.	1					1
Malvaceae	*Triumfetta rhomboidea* Jacq.				1		
Malvaceae	*Urena lobata* L.				1		
Marantaceae	*Marantochloa leucantha* (K.Schum.) Milne-Redh.	1		1		1	1
Marantaceae	*Marantochloa purpurea* (Ridl.) Milne-Redh.	1					
Melastomataceae	*Tristemma maritianum* A. Juss.	1					
Menispermaceae	*Cissampelos mucronata* A. Rich	1					
Moraceae	*Dorstenia hildebrandtii* Engl.	1					
Nephrolepidaceae	*Nephrolepis biserrata* (Sw.) Schott						1
Nyctaginaceae	*Boerhavia diffusa* L.		1				
Nyctaginaceae	*Commicarpus sp.*	1					
Orchidaceae	*Corymborkis corymbis* Thouars	1				1	
Orchidaceae	*Zeuxine elongata* Rolfe.	1					
Oxalidaceae	*Oxalis corniculata* L.	1					
Phyllanthaceae	*Cleistanthus sp.*			1			
Phyllanthaceae	*Phyllanthus amarus* Schum. & Thonn.				1		
Phyllanthaceae	*Phyllanthus pseudoniruli* Müll. Arg.				1		
Phytolaccaceae	*Hilleria latifolia* L.	1		1			1
Phytolaccaceae	*Phytolaca dodecandra* L'Hér.	1					
Phytolaccaceae	*Rivina humilis* L.	1					
Piperaceae	*Peperomia molleri* C. DC.	1					
Piperaceae	*Piper guineense* Schumach. & Thonn.	1					
Piperaceae	*Piper umbellatum* L.		1			1	1
Piperaceae	*Pothomorphe umbellata* (L.) Miq.	1					
Plantagonaceae	*Plantago palmata* Hook.f.	1					
Poaceae	*Andropogon schirensis* A. Rich.	1					
Poaceae	*Brachiaria decumbens* Stapf				1		

Poaceae	*Brachiaria jubata* (Fig. & De Not.) Stapf	1					
Poaceae	*Cynodon dactylon* (L) Pers.	1					1
Poaceae	*Cyrtococcum multinode* (Lam.) Clayton	1				1	1
Poaceae	*Digitaria abysinnica* (A. Rich.) Stapf	1					
Poaceae	*Digitaria velutina* (Forssk.) P. Beauv.	1					
Poaceae	*Eleusine africana* Kenn. O'Byrne		1				
Poaceae	*Eragrostis tenuifolia* (A. Rich.) Steud.				1		
Poaceae	*Hyparrhenia cymbaria* (L.) Stapf	1					
Poaceae	*Imperata cylindrica* (L) P. Beauv	1					
Poaceae	*Isachne mauritianum* Kunth	1					
Poaceae	*Leersia hexandra* Sw.		1				
Poaceae	*Leptaspis zeylanica* Steud.	1		1		1	1
Poaceae	*Melinis minutiflora* P. Beauv.	1					
Poaceae	*Olyra latifolia* L.	1	1				1
Poaceae	*Oplismenus hirtellus* L. P. Beauv.	1	1	1			1
Poaceae	*Oryza eichingeri* Peter	1					
Poaceae	*Panicum brevifolium* L.			1		1	
Poaceae	*Panicum calvum* Stapf	1					
Poaceae	*Panicum maximum* Jacq.		1		1	1	
Poaceae	*Panicum robynsii* A. Camus	1					
Poaceae	*Panicum sp.*	1					
Poaceae	*Panicum trichocladum* K. Schum.	1	1				
Poaceae	*Paspalum conjugatum* Berg.	1	1	1		1	1
Poaceae	*Paspalum scrobiculatum* L.				1		
Poaceae	*Pennisetum purpureum Schumach*	1					
Poaceae	*Pseudechinolaena polystachya* (Kunth) Stapf	1	1	1			1
Poaceae	*Setaria megaphylla* (Steud.) Th. Dur. & Schinz	1			1		1
Poaceae	*Setaria poiretiana* (Schult.) Kunth	1					
Poaceae	*Sorghum arundinaceum* (Desv.) Stapf	1					
Poaceae	*Sporobolus pyramidalis* P. Beauv.		1		1	1	
Polygonaceae	*Oxygonum sinuatum* (Meissn.) Dammer	1					
Polygonaceae	*Polygonum setulosum* A. Rich	1					
Polygonaceae	*Rumex abyssinicus Jacq.*	1					
Portulacaceae	*Portulaca oleracea* L.	1					
Portulacaceae	*Talinium paniculatum* (Jacq.)	1					
Primulaceae	*Primula sieboldii* E. Morren	1					
Pteridaceae	*Pteris burtoni Bak.*	1					
Pteridaceae	*Pteris catoptera* Kunze var. *catoptera*						1
Pteridaceae	*Pteris dentata* Forssk.	1					1
Pteridaceae	*Pteris hamulosa* (Christ.) Christ.						1
Pteridaceae	*Pteris preussii* Hieron.	1					
Rubiaceae	*Chassalia subochreata* (Hiern) Hepper	1					

Rubiaceae	*Geophila hirsuta* Benth.	1	1				
Rubiaceae	*Geophila repens* (L.) I.M.Johnst.	1		1		1	1
Rubiaceae	*Geophilla repens* (L.) I.M.Johnst.		1				
Rubiaceae	*Hymenocoleus hirsutus* (Benth.) Robbr.	1					
Rubiaceae	*Rubia cordifolia* L.	1					
Sapindaceae	*Cardiospermum grandiflorum* Sw.				1		1
Sinopteridaceae	*Pellaea doniana* Hook						1
Solanaceae	*Capsicum frutescens* L.	1		1		1	
Solanaceae	*Datura stramonium* L.	1					
Solanaceae	*Nicotiana tobaccum* L	1					
Solanaceae	*Physalis peruviana L.*	1					
Solanaceae	*Solanum aculeastrum* Dunal	1					
Solanaceae	*Solanum anguivii* Mill	1					
Solanaceae	*Solanum campylacanthum* Hochst. ex A. Rich.	1					
Solanaceae	*Solanum dasyphyllum* Schumach. & Thonn.	1					
Solanaceae	*Solanum micrantha* Schltdl.	1					
Solanaceae	*Solanum nigrum* L.	1					
Tectariaceae	*Arthropteris orientalis* (J.F. Gmel.) Posth.			1			1
Thelypteridaceae	*Christella dentata* (Forssk.) Brownsey & Jermy						1
Thelypteridaceae	*Thelypteris sp.*	1					
Urticaceae	*Pilea sp.*			1			
Verbanaceae	*Priva flabelliformis* (Mold.) R. Fernand	1					
Vitaceae	*Cissus oliveri* (Engl.) Gilg ex Engl.		1				1
Vitaceae	*Cissus petiolata* Hook.f.	1					
Vitaceae	*Cissus sp.*				1		
Vitaceae	*Cissus sp.2*	1					
Vitaceae	*Cyphostemma adenocaule* (Steud. ex A.Rich.) Desc. ex Wild & R.B.Drumm.	1			1		1
Vitaceae	*Cyphostemma cyphopetalum* (Fresen.) Desc. ex Wild & R.B.Drumm.	1					
Zingiberaceae	*Aframomum angustifolium* (Sonn.) K. Schum	1					1
Zingiberaceae	*Aframomum mildbraedii* Loes.	1				1	1
Zingiberaceae	*Aframomum zambesiacum* (Baker) K. Schum.	1	1				
Zingiberaceae	*Renealmia congesta* Maas						1
Zingiberaceae	*Renealmia congolana* De Wild. & T.Durand	1					
Zingiberaceae	*Renealmia speciosus*	1					
Zingiberaceae	*Zingber officinale Roscoe*	1					
Totals		**186**	**30**	**31**	**37**	**27**	**54**

Table 3.3. Woody plants recorded in Forest Reserves of the Mabira Ecosystem in Central Uganda

	Mabira 1996 surveys	Mabira 2016 surveys	Kalagala	Namakupa	Namananga	Namawanyi	Nandagi	Mabira ecosystem 2016 surveys
Abrus canescens		1						1
Abrus precatorius		1						1
Abuitilon africana	1							
Abutilon mauritianum		1						1
Acacia brevispica	1							
Acacia hecatophylla	1							
Acacia hockii	1							
Acacia monticola						1	1	1
Acacia pentagona		1		1	1			1
Acacia polyacantha	1		1					1
Acalypha acrogyna		1		1	1	1		1
Acalypha bipartita	1	1	1			1	1	1
Acalypha neptunica	1	1		1	1	1	1	1
Acalypha ornata	1	1						1
Acalypha racemosa		1		1	1	1	1	1
Acalypha volkensii		1						1
Acanthus arborescens	1							
Adenia abyssinica		1						1
Adenia reticulata		1						1
Adenia schweinfurthii		1						1
Aeglopsis eggelingii	1							
Agelaea hirsuta		1						1
Agelaea pentagyna		1						1
Aidia micrantha	1							
Alafia grandis				1				1
Alafia lucida		1						1
Alafia microstylis		1					1	1
Alafia schumannii							1	1
Alangium chinense	1	1						1
Albizia coriara	1		1					1
Albizia ferruginea	1							
Albizia glaberrima	1	1	1	1	1	1		1
Albizia grandibracteata	1	1	1				1	1
Albizia gummifera	1	1						1
Albizia zygia	1	1	1	1		1	1	1
Alchornea cordifolia	1		1					1
Alchornea floribunda	1							
Alchornea hirtella	1							
Alchornea laxiflora	1	1						1
Allophylus africanus		1						1

Allophylus dummeri	1	1					1	1
Allophylus macrobotrys	1				1	1		1
Alstonia boonei	1	1			1			1
Antiaris toxicaria	1	1	1		1	1		1
Antidesma laciniatum	1							
Antidesma membranaceum	1	1						1
Antrocaryon micraster	1							
Aphania senegalensis	1	1		1				1
Argomuellera macrophylla	1	1		1	1	1	1	1
Aristolochia elegans		1		1	1	1		1
Artabotrys likimensis		1						1
Baikiaea insignis	1	1						1
Balanites wilsoniana	1	1						1
Balsamocitrus dawei	1	1						1
Baphiopsis parviflora	1	1		1				1
Basella alba		1						1
Beilschmiedia ugandensis	1	1						1
Belonophora hypoglauca	1			1				1
Bequaertiodendron oblanceolatum	1	1						1
Bersama abyssinica	1						1	1
Blighia unijugata	1	1	1		1	1		1
Blighia welwitschii	1	1						1
Bombax buonopozense	1							
Bridelia atroviridis		1						1
Bridelia micrantha	1	1				1		1
Bridelia scleroneura	1						1	
Byttneria catalpifolia							1	1
Caesalpina volkensii	1	1						1
Calamus deeratus	1							
Campylostemon angolense		1						1
Campylostemon bequaertii		1				1		1
Canarium schweinfurthii	1	1						1
Canthium schweinfurthii		1						1
Canthium vulgare	1							
Capparis erythrocarpos		1						1
Capparis tomentosa	1							
Cardiospermum grandiflorum		1		1				1

Cardiospermum halicacabum		1						1
Casearia engleri		1						1
Casine buchananii		1						1
Cassipourea congensis	1	1						1
Cassipourea gummiflua	1							
Cassipourea ruwensorensis	1						1	1
Cedrela ordorata							1	1
Celtis adolfi-fridericii	1							
Celtis africana	1	1				1		1
Celtis gomphophylla	1	1						1
Celtis mildbraedii	1	1		1	1	1		1
Celtis philipensis		1		1				1
Celtis wightii	1							
Celtis zenkeri	1	1		1		1		1
Chaetacme aristata	1			1		1	1	1
Chassalia cristata		1			1	1		1
Chassalia subochreata		1						1
Chrysophyllum albidum	1	1		1				1
Chrysophyllum delevoyi	1							
Chrysophyllum gorungosanum	1							
Chrysophyllum muerense	1	1						1
Chrysophyllum perpulchrum	1							
Cissus olivieri					1	1		1
Cissus petiolata		1	1					1
Citropsis articulata	1	1			1		1	1
Clausena anisata	1	1						1
Cleistanthus polystachyus	1	1					1	1
Clematis hirsuta							1	1
Clerodendrum capitatum		1	1		1	1		1
Clerodendrum formicarum		1		1				1
Clerodendrum rotundifolium	1							
Clerodendrum silvanum		1	1					1
Cnestis ugandensis	1							
Coccinea barteri				1		1	1	1
Coccinea grandis							1	1
Coccinia mildbraedii		1						1
Coffea canephora	1	1		1	1			1

Coffea eugenioides	1	1		1				1
Coffea spathicalyx		1					1	1
Cola gigantea	1	1		1				1
Combretum molle	1							
Commelina diffusa		1						1
Connarus longistipitatus	1	1						1
Cordia africana	1							
Cordia millenii	1							
Craibia brownii	1	1						1
Crassocephalum mannii	1							
Craterispermum schweinfurthii	1							
Craterosiphon beniense		1						1
Croton macrostachyus	1	1						1
Croton megalocarpus	1							
Croton sylvaticus	1	1						1
Cryptolepis sanguinolenta		1					1	1
Culcasia falcifolia		1		1				1
Cussonia holstii		1						1
Cyphostemma adenocaule		1					1	1
Cyphostemma cyphopetalum		1						1
Dalbergia lactea	1							
Dasylepis eggelingii		1						1
Desplatsia dewevrei	1							
Dichapetalum angolense		1						1
Dichapetalum ugandense		1		1				1
Dichrostachys cinerea	1		1					1
Dictyandra arborescens	1	1						1
Dioscorea abyssinica		1						1
Dioscorea bulbifera		1						1
Diospyros abyssinica	1	1		1	1	1		1
Dombeya goetzenii	1							
Dombeya kirkii		1						1
Dombeya mukole	1							
Dovyalis macrocalyx	1	1					1	1
Dracaena fragrans	1	1		1	1	1		1
Dracaena laxissima	1	1						1
Dracaena steudneri	1							
Drypetes bipindensis	1							
Drypetes gerrardii	1	1						1

Drypetes ugandensis	1	1						1
Ehretia cymosa	1	1						1
Ekebergia capensis	1	1						1
Elaeis guineensis	1	1					1	1
Elaeophorbia drupifera	1							
Englerophytum oblanceolatum		1						1
Entada abyssininca	1							
Entandrophragma angolense	1	1					1	1
Entandrophragma cylindrica		1						1
Entandrophragma utile	1	1						1
Erythrina abyssinica	1	1						1
Erythrina excelsa	1						1	1
Erythrococca atrovirens		1	1					1
Erythrococca bongensis	1							
Erythrococca mildbraedii		1						1
Erythrococca trichogyne	1							
Erythrophleum suaveolens	1	1						1
Euadenia eminens	1							
Eugenia bukobensis	1							
Fagaropsis angolensis	1	1					1	1
Ficus asperifolia	1	1		1		1		1
Ficus barteri	1							
Ficus conraui	1							
Ficus craterostoma	1							
Ficus cyathistipula	1			1				1
Ficus dicranostyla	1						1	1
Ficus exasperata	1	1			1	1		1
Ficus ingens	1							
Ficus lingua	1	1					1	1
Ficus mucuso	1	1				1		1
Ficus natalensis	1							
Ficus ovata	1							
Ficus polita	1	1						1
Ficus pseudomangifera	1	1						1
Ficus sansibarica	1							
Ficus saussureana	1						1	1
Ficus sur	1	1						1
Ficus thonningii	1							

Ficus trichopoda	1							
Ficus vallis-choudae	1	1						1
Ficus variifolia	1	1						1
Flacourtia indica	1							
Flueggea virosa	1	1	1			1	1	1
Funtumia africana	1	1			1	1	1	1
Funtumia elastica	1	1		1	1			1
Glenniea africana		1					1	1
Glycine whitteri						1		1
Glyphaea brevis	1	1					1	1
Gongronema angolense		1						1
Gouania longispicata		1		1				1
Greenwayodendron suaveolens	1	1						1
Grewia mollis	1							
Grewia pubescens	1	1						1
Grewia trichocarpa	1							
Guarea cedrata	1							
Gymnema sylvestris						1		1
Hallea stipulosa	1							
Harrisonia abyssinica	1	1				1		1
Harungana madagascariensis	1							
Hibiscus calyphyllus		1				1		1
Hibiscus canescens		1						1
Holoptelea grandis	1	1				1		1
Hugonia platysepala	1	1						1
Hymenocardia acida	1						1	1
Illigera pentaphylla		1		1				1
Ipomea schupangensis					1			1
Ipomoea cairica		1						1
Ipomoea obscura		1						1
Ipomoea wightii		1						1
Irvingia gabonensis	1							
Jasminum eminii		1						1
Jasminum fluminense		1					1	1
Jasminum pauciflorum		1				1		1
Keetia purseglovei		1						1
Khaya anthotheca	1							
Kigelia africana	1	1						1
Klainedoxa gabonensis	1							
Landolphia buchananii		1					1	1
Landolphia dawei							1	1
Landolphia landolphioides		1						1

Landolphia owariensis		1						1
Lannea barteri	1							
Lannea welwitschii	1	1	1				1	1
Lantana trifolia	1							
Lasiodiscus mildbraedii	1	1		1				1
Lecaniodiscus fraxinifolius	1	1						1
Lepidotrichilia volkensii	1							
Lepistemon owariensis							1	1
Leptaulus daphnoides	1							
Leptonychia mildbraedii	1	1						1
Lindackeria bukobensis	1	1		1	1	1		1
Lindackeria mildbraedii	1							
Lindackeria schweinfurthii	1							
Linociera johnsonii	1							
Loeseneriella africana		1						1
Loeseneriella apiculata		1						1
Loeseneriella crenata		1						1
Loseneriella clematoides				1				1
Lovoa swynnertonii	1							
Lovoa trichilioides	1	1						1
Lychnodiscus cerospermus	1	1						1
Macaranga barteri	1							
Macaranga monandra	1	1						1
Macaranga schweinfurthii	1							
Macaranga spinosa	1							
Maerua duchesnei	1	1		1	1	1		1
Maesa lanceolata	1	1					1	1
Maesa welwitschii		1					1	1
Maesopsis eminii	1	1	1	1				1
Majidea fosteri	1	1						1
Mallotus oppositifolius	1	1						1
Manilkara dawei	1							
Manilkara multinervis	1							
Manilkara obovata	1							
Margaritaria discoideus	1	1					1	1

Markhamia lutea	1	1	1	1	1	1		1
Masdenia rubicunda						1		1
Maytenus gracilipes				1				1
Maytenus heterophylla			1					1
Maytenus senegalensis	1							
Maytenus serratus	1							
Maytenus undata	1							
Melanodiscus sp.	1	1						1
Memecylon jasminoides	1	1						1
Memecylon myrianthum	1							
Mesoneurum angolense		1						1
Mikania cordata		1						1
Mildbraediodendron excelsum	1	1					1	1
Milicia excelsa	1	1	1		1			1
Mimosa pigra	1							
Mimusops bagshawei	1	1						1
Momordica foetida		1						1
Monanthotaxis angolense		1						1
Monanthotaxis buchananii				1			1	1
Monanthotaxis littoralis		1						1
Monanthotaxis welwiscthii		1					1	1
Mondia whytei		1				1	1	1
Monodora myristica	1	1		1				1
Morinda lucida	1							
Morus mesozygia	1	1		1				1
Motandra guineensis		1		1	1	1		1
Mukia maderaspatana		1						1
Musanga cecropioides	1						1	1
Myrianthus arboreus	1	1						1
Myrianthus holstii	1	1						1
Neoboutonia macrocalyx	1							
Neuropeltis velutina				1				1
Newtonia buchananii		1						1
Ochna afzelii	1							
Ochna bracteosa	1							
Ochna holstii		1						1
Ochna membranacea	1							
Ocimum suave	1							

Olax gambecola	1	1		1		1		1
Olea welwitschii	1					1		1
Oncinotis erlangezi		1						1
Oncinotis glabrata		1						1
Oncinotis tenuiloba		1						1
Oncoba spinosa	1	1				1		1
Oreobambos buchwaldii	1							
Ouratea densiflora	1	1						1
Ouratea hiernii		1						1
Oxyanthus formosus		1					1	1
Oxyanthus speciosus	1	1						1
Oxyanthus unilocularis	1							
Pachystela brevipes	1	1						1
Pancovia turbinata	1	1						1
Pappea capensis	1							
Pararistolochia triactina		1					1	1
Parkia filicoidea	1							
Paropsia guineensis	1						1	1
Paulinia pinnata		1		1				1
Pavetta molundensis	1	1						1
Pavetta oliveriana	1	1						1
Peddiea fischeri	1	1						1
Pergularia daemia							1	1
Periploca nigrescens		1						1
Phoenix reclinata	1			1	1	1		1
Phyllanthus amarus			1				1	1
Phyllanthus ovalifolius	1		1		1	1		1
Phytolacca dodecandra	1	1				1	1	1
Picralima nitida	1							
Piper capensis	1	1					1	1
Piper guineense		1						1
Piptadeniastrum africanum	1	1						1
Pisonia aculeata		1						1
Pittosporum mannii	1							
Pleiocarpa pycnantha	1							
Polyscias fulva	1	1						1
Popowia lucidula		1						1
Popowia sp.		1						1
Pothomorphe umbellata		1					1	1
Pouteria adolfi-friederici	1							
Pouteria altissima	1	1		1				1
Premna angolensis	1	1						1

Pristimera sp.		1						1
Prunus africana	1	1					1	1
Psedrella odorata							1	1
Pseudarthria hoockeri	1							
Pseudograstistachys ugandensis		1						1
Pseudospondias microcarpa	1	1						1
Psilotrichum ellioti		1						1
Psorospernum febrifugum	1						1	1
Psychotria appendicularis					1	1		1
Psychotria kirkii		1	1			1		1
Psychotria parvistipulata		1						1
Psychotria peduncularis		1		1				1
Psydrax parviflora		1	1		1			1
Pterolobium stellatum	1							
Pterygota mildbraedii	1						1	1
Pycnanthus angolensis	1	1						1
Pyrenacantha sylvestris		1						1
Pyrenacantha ugandense		1						1
Raphia farinifera	1							
Rauvolfia oxyphylla	1							
Rauvolfia vomitoria	1							
Rawsonia lucida	1	1						1
Reissantia parviflora		1					1	1
Rhaphidophora africana							1	1
Rhaphiostylis beniniensis		1						1
Rhus natalensis	1		1					1
Rhus ruspolii	1							
Rhus vulgaris	1							
Rhytigynia butanguensis	1							
Ricinodendron heudelotii	1							
Rinorea ardisiiflora				1				1
Rinorea beniensis	1	1						1
Rinorea dentata	1							
Rinorea ilicifolia	1	1						1
Rinorea oblongifolia	1							
Ritchiea albersii	1	1						1
Rothmania whitfieldii		1					1	1

Rothmannia longiflora		1					1	1
Rothmannia urcelliformis	1	1		1			1	1
Rourea thomsonii		1						1
Rubus apetalus	1							
Rutidea orientalis		1						1
Rutidea smithii		1						1
Rytigynia beniensis		1						1
Saba comorensis		1						1
Salacia elegans		1		1		1	1	1
Salacia erecta		1				1		1
Schefflera barteri	1							
Schrebera alata	1							
Schrebera arborea	1	1					1	1
Scolopia rhamniphylla	1	1						1
Scutia myrtina		1		1		1	1	1
Secamone africana		1	1	1	1			1
Secamone punctulata		1					1	1
Securidaca welwistchii		1					1	1
Senna petersiana	1						1	1
Sericostachys scandens		1					1	1
Sesbania sesban	1							
shirakiopsis elliptica	1				1			1
Sida rhombifolia		1	1					1
Solanum incanum	1							
Solanum indicum	1							
Spathodea campanulata	1	1	1					1
Spondianthus preussii	1							
Staudtia kamerunensis	1							
Steganotaenia araliacea	1						1	1
Sterculia dawei	1	1				1		1
Stereospermum kunthianum	1							
Strombosia scheffleri	1	1						1
Strychnos mitis	1	1				1		1
Suregada procera	1							
Symphonia globulifera	1							
Syzygium cuminii						1		1
Syzygium guineense	1						1	1
Tabanaemontana odoratissima		1				1		1
Tabernaemontana holstii	1	1						1

Tabernaemontana usambarensis	1							
Tapura fischeri	1	1		1	1	1		1
Tarenna pavettoides	1	1						1
Teramnus labialis		1						1
Terminalia glaucescens	1						1	1
Tetracera litoralis		1					1	1
Tetracera potatoria		1						1
Tetrapleura tetraptera	1							
Tetrorchidium didymonstemon	1							
Thecacoris lucida	1	1						1
Tiliacora funifera		1						1
Toddalia asiatica	1	1						1
Tragia brevipes		1					1	1
Tragia petiolaris							1	1
Treculia africana	1						1	1
Trema orientalis	1	1						1
Tricalysia bagshawei	1							
Tricalysia niamniamensis			1				1	1
Trichilia dregeana	1	1		1		1		1
Trichilia martineaui	1	1						1
Trichilia prieureana	1				1	1		1
Trichilia rubescens	1	1						1
Trilepisium madagascariensis	1	1						1
Triumfetta diversifolia		1						1
Triumfetta macrophylla	1							
Turraea floribunda	1							
Turraea robusta	1							
Turraea vogelioides	1	1						1
Uncaria africana		1						1
Urera trinervis		1		1				1
Uvaria angolensis	1	1						1
Uvaria welwitschii	1	1						1
Uvariopsis congensis	1	1						1
Vangueria apiculata	1							
Ventilago africana		1		1				1
Ventilago diffusa		1						1
Vepris eggelingii	1	1						1
Vepris grandifolia	1						1	1
Vepris nobilis	1	1	1	1	1			1
Vernonia adoensis	1						1	1
Vernonia amygdalina	1	1	1			1	1	1
Vernonia auriculifera	1							

Vernonia myrianthum					1			1
Vitex amboniensis	1							
Vitex doniana	1							
Voacanga thouarsii	1							
Warburgia ugandensis	1	1						1
Warneckea jasminoides		1						1
Whitfieldia elongata		1		1				1
Xylopia eminii		1						1
Xymalos monospora	1							
Zanha golungensis	1	1				1		1
Zanthoxylum gilletii	1							
Zanthoxylum leprieurii	1							
Zanthoxylum rubescens	1	1						1
Zehneria scarbra		1						1
Totals	**312**	**288**	**31**	**60**	**38**	**61**	**85**	**349**

REFERENCES

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CHAPTER FOUR

4.0. BIRDS

4.1. SUMMARY

A total of 154 species was recorded across the whole survey, 97 in Mabira CFR and 100 in the five small CFRs. The results show that there were more bird species in the main forest than the five small CFRs combined. There was little overlap between the surveyed forest sites, with 54 species unique to the Mabira CFR, 58 species unique to the five small CFRs and 42 species occurring in both forests. Most of the bird species recorded during the surveys are classified as "Least Concern" according to the IUCN criteria. However, seven of the species recorded are classified as threatened either at global or regional level according to the IUCN criteria. These include Nahan's Francolin (*Francolinus nahani*), Grey Parrot (*Psittacus erithacus*), Cinnamon-chested Bee-eater (*Merops oreobates*), White headed saw-wing (*Psalidoprocne albiceps*), Toro Olive-Greenbul (*Phyllastrephus hypochloris*), White-browed Crombec (*Sylvietta leucophrys*) and Green tailed Bristlebill (*Bleda eximius*). The number of bird species in the small CFRs combined was higher than that in the main forest. There were more forest visitors and other non-forest bird species recorded in the small CFRs than in the main forest block. On the other hand, forest related bird species (FF & F) were much higher in the main forest than in the small CFRs.

4.2. INTRODUCTION

4.2.1. Overview

The birds of Mabira Central Forest Reserve are slowly being documented through a number of studies, which means that this taxon is now better known than when Davenport *et al.* (1996) completed the biodiversity The records so far known for Mabira CFR comprise over 300 species of birds of which 109 were recorded during the 1992-1994 Forest Department Biodiversity Inventory (Davenport *et al,* 1996). The bird species record includes three species listed as threatened in the IUCN Red List of Threatened Species. Version 2016-1 - i.e. the Blue swallow (*Hirundo atrocaerulea*), the Papyrus Gonolek (*Laniarius mufumbiri*) and Nahan's Francolin (*Francolinus nahani*).

4.2.2. Aims and rationale

Birds have been described as arguably the best known, most conspicuous and in many ways most easily studied inhabitants of tropical forest, and are therefore well suited to the role of biological indicators (Davenport *et al* 1996). These authors quoting various other sources emphasized facts that make birds a favorable group for study including: -

i. Their well known and stable taxonomy,
ii. Well understood ecology comparatively.
iii. They occur across a broad geographical range and in a large number of habitat types; and some species specialise within narrow habitat bands and are thus sensitive to habitat change.
iv. Birds are readily observed in the field and relatively easy to capture.

Uganda's has an impressively rich avian fauna of 1011 species (Pomeroy, 1993 & Carswell*et al* 2015) that compares quite well with about 1850 species recorded on the African main land's a whole (Brown *et al.,*

1982). This high diversity is, however, countered by low levels of endemism. Only two country endemic species of bird occur, a similarly limited pattern being exhibited in most other vertebrate taxa.

The purpose of sampling the bird fauna (as with other taxa) was to compile species list for Kalagala, Namukupa, Nandagi, Namawanyi and Namananga CFRs and in addition update that of Mabira CFR. Mabira forest reserve (referred to as MFR hereafter) is an important bird area (IBA) comprising about 30% (over 300) species of the total number of birds found in Uganda and is also habitat to globally endagered specie Nahans Francolin (*Francolinus nahani*). More than half of the Guinea-Congo forest biome bird species (74 of 144) that are found in Uganda are present in MFR.

4.2.3. Previous work

More than one researcher has conducted studies on birds of MFR in previous years and records of avian diversity for the reserve can be found in Briton (1980), Hamel (1980), Howard (1991), Davenport *et al* (1996), Byaruhanga *et al* (2001), Carswell *et al.* (2005) and others. Hence the avian diversity of MFR is fairly well known. According to Howard (1991), MFR consisted of 151 species of forest birds, which represented 46% of the country's total. During that time, the threatened or near threatened species were the Nahan's Francolin (*Francolinus nahani*) and Blue Swallow (Hirundo atrocaerulea).

Studies were conducted in Kalagala CFR as part of the wider area of impact for Bujagali dam while for the other 4 CFRs we have not found studies that were conducted within them. The four (Nandagi, Namukupa, Namawanyi and Namananga) are therefore poorly known as no known studies have previously been conducted on the fauna of these reserves.

4.3 METHODS

4.3.1 Field methods

Two survey methods were used: Timed species counts (TSCs) and mistnetting. Both these methods have been deemed suitable for bird surveys in forested landscapes where visibility is normally poor (Nalwanga et al., 2012).

Timed species counts: For all the sites visited, 10 to 20 stations were established at intervals of 100m. Due to access limitations, stations were placed along 1km of existing trails, foot paths or motorable roads. The, transects, used for bird surveys in the main forest are shown in Figure 1 below. For each sampling period, stations were visited within a 3hr period from sunrise and a 3hr period towards sunset. Hence, each station was visited twice. Two trained researchers collected the data. During the surveys, the observers arrived at each station and for 10mins, recorded and counted birds heard or seen within the 100m radius of each station before moving on to the next station. Birds in flight such as raptors were considered as opportunistic observations. Birds were identified according to the bird guide by Stevenson et al. (2005).

Mist-netting. Since there is scanty or no information about the avifauna in the other five CFRs (Kalagala, Nandagi, Namukupa, Namawanyi and Namananga), we conducted mist netting in an attempt to capture the shy, elusive, understory bird species which are normally forest specialists. The same transects/trails used for TSCs were used for mistnetting. Birds captured, were identified and released in the same area. In order to avoid double counting, each site was mistnetted once.

4.3.2. Data analysis

The bird field records were analysed in three ways:

a) Compilation of species lists. This enabled comparison with other forests and provided a basis for highlighting species that are of particular biogeographical or conservation significance.

b) Ecological characteristics. Each species was assigned an ecological (or habitat) type according to Bennun et al. (1996). This is designed to assist in classifying forests, and also to assess the importance of an individual forest to a defined group of bird species with a known habitat requirement. Since the survey was mainly focused on forest birds, the emphasis was placed particularly on forest habitat-type divisions. Hence, birds were divided into the following three categories:

- Forest-dependent species (FF-species) are forest interior birds often uncommon even at the forest edge.
- Forest generalists (F-species) are generalists in their ecology, occasionally occurring outside forests.
- Forest non-dependent species (f-species) are sometimes seen in forests, usually at the edge or in large gaps, but are better thought of as forest visitors.
- Non-forest (open habitat) species. The divisions of species found in non-forest habitats are less fine grained with several habitats being lumped together. For example open woodland, bushland, and grassland are all grouped under the single heading of open habitats (O).
- Birds were further grouped into other categories such as: 1) water specialists or generalists (water birds), i.e. species adapted to aquatic/swamp habitats (Water birds), 2) migratory species (PM) which occur seasonally, or 3) according to their conservation or endemic status. A degree of caution needs to be exercised if including migratory species in analysis as their inclusion on a forest list may depend more on the time of year that the forest was visited than their actual presence or absence.

4.4 RESULTS

4.4.1. Species diversity

A total of 154 species was recorded across the whole survey, 97 in Mabira CFR and 100 in the five small CFRs. Table 4.1 summarises the number of bird species found in each forest, these numbers partly reflect differences in effort, which complicates interpretation, but they clearly show that bird species were higher in the main forest than all the five small CFRs combined.

Table 4.1: Number of bird species recorded in the different forests and survey method used

Forest	Sampling site	Number of species	Sampling method used
Mabira CFR	Ecocentre-Najjembe north	56	TSC
	Buwola Trail	30	TSC
	Nature Reserve	52	TSC
	Nsamya Trail	38	TSC
	Najjembe south	43	TSC
Small CFR	Kalagala	42	TSC and mist-nets
	Namakupa	63	TSC and mist-nets
	Namananga	56	TSC and mist-nets
	Namwanyi	41	TSC and mist-nets
	Nandagi	33	TSC and mist-nets

A full list of species and their occurrence rates across the main forest and the small CFRs survey sites is given in Table 4.2. There was little overlap between the study sites, with 54 species unique to the Mabira CFR, 58 species unique to the five small CFRs and 42 species occurring in both forests.

Overall, the number of bird species in the small CFRs combined was higher than that in the main forest mainly because there were more forest visitors and other non-forest bird species recorded in the small CFRs than in the main forest block. On the other hand, forest related bird species (FF & F) were much higher in the main forest than in the small CFRs. This is an indicator that the small CFRs are highly degraded compared to the main forest because forest dependant species are very sensitive to any forms of anthropogenic disturbance. It is also important to note that within the MFR, bird species richness was highest in the ecotourism regenerating forest and not the nature reserve that is considered an intact forest. This concurs with some of the findings from previous researchers (e.g.Naidoo, 2004).

Bird surveys in the five small CFRs were conducted in April which is a rainy season and when some of migratory bird species are still around. This might partly account for the high number of migratory bird species observed in the small CFRs as opposed to the main forest where no migratory species were recorded because surveys were conducted early June. Nonetheless, there was a higher proportion of forest dependant species in the main forest (Mabira CFR) than in all the small CFRs (Figure 4.1).

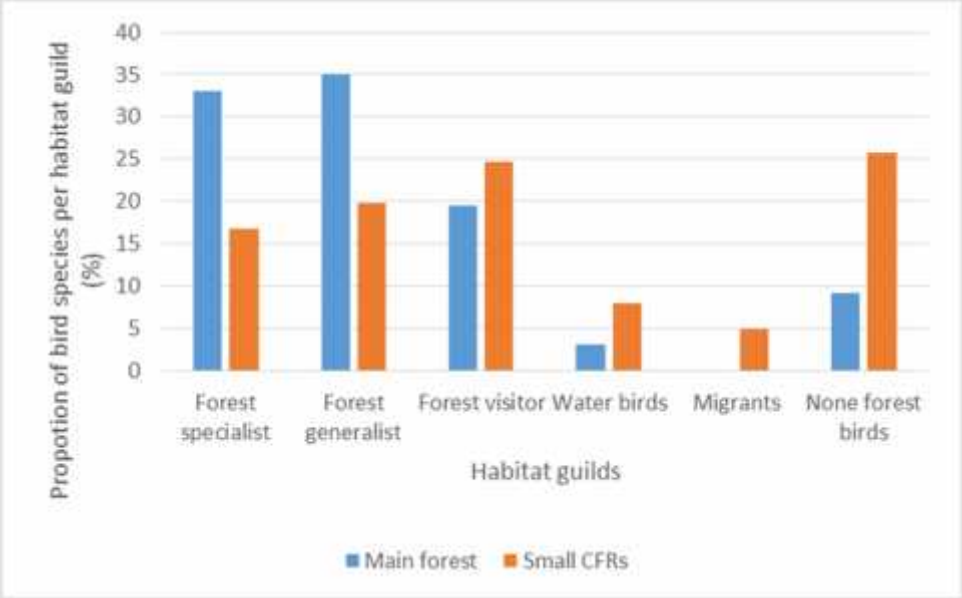

Figure 4.1: Propotion of bird species in the different habitat categories

A total of 37 forest specialist species were recorded from the six forest reserves even after using two sampling methods. There are about 190 FF species in Uganda (Carswell et al., 2005) and 80 in the remaining lakeside forest, Mabira, (Dranzoa, 1990) which is about 300 km^2, hence we recorded 41% of FF species known to exist in Mabira. This is a good representative of existing FF species in Mabira.

The water birds were mainly recorded along water bodies (rivers, swamps or ponds). The non-forest birds recorded are due to the fact that some forests were surrounded by non-forested landscapes (farmlands) and some transects were near the forest edge. For instance, one transects in the main forest reserve traversed a grassland which is found within the forest. Hence most of the bird species recorded in this section were mainly savanna woodland species.

Table 4.2. List of species of birds recorded in each Forest Reserve

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
African crowned Eagle	*Stephanoaetus coronatus*	FF	LC	1	0	0	0	0	0	0	0	0	0
African Dwarf Kingfisher	*Ispidina lecontei*	FF	LC	0	0	0	0	0	1	1	1	1	1
African emerald Cuckoo	*Chrysococcyx cupreus*	F	LC	1	1	1	1	0	0	0	0	0	0
African Fish Eagle	*Haliaeetus vocifer*	W	LC	0	0	0	0	0	0	1	1	0	0
African Harrier Hawk	*Polyboroides typus*	f	LC	1	1	0	1	0	0	0	1	0	1
African Open billed stock	*Anastomus lamelligerus*	W	LC	0	0	0	0	0	1	0	1	1	0
African Paradise-Flycatcher	*Terpsiphone viridis*	f	LC	0	0	0	0	0	1	0	1	1	0
African Pied Hornbill	*Tockus fasciatus*	F	LC	1	0	1	0	1	0	0	0	0	0
African Reed-Warbler	*Acrocephalus baeticatus*	M	LC	0	0	0	0	0	1	0	1	1	0
African Thrush	*Turdus pelios*	f	LC	1	0	0	0	0	0	1	1	0	0
African yellow White-eye	*Zosterops senegalensis*	f	LC	1	0	0	1	1	0	0	1	0	1
Ashy Flycatcher	*Muscicapa caerulescens*	F	LC	0	0	0	1	0	0	0	1	0	0
Augur Buzzard	*Buteo augur*	O	LC	0	0	0	0	0	1	0	1	1	0
Baglafecht Weaver	*Ploceus baglafecht*	f	LC	0	0	0	0	0	0	0	1	0	0
Barn Swallow	*Hirundo rustica*	O	LC	0	0	0	0	0	0	1	1	0	0
Black & white casqued Hornbill	*Ceratogymna subcylindricus*	F	LC	1	0	1	1	0	1	1	1	1	0
Black & white Mannikin	*Spermestes bicolor*	f	LC	0	0	0	0	1	1	1	1	1	1
Black bellied Seed-cracker	*Pyrenestes ostrinus*	F	LC	1	0	0	0	0	0	0	0	0	0
Black billed Turaco	*Tauraco schuetti*	FF	LC	0	0	1	1	0	0	0	0	0	0
Black Bishop	*Euplectes gierowii*	O	LC	0	0	0	0	0	1	0	1	1	1
Black crowned Waxbill	*Estrilda nonnula*	f	LC	0	1	0	0	1	0	1	1	0	0
Black headed Heron	*Ardea melanocephala*	W	LC	0	0	0	0	0	0	0	1	0	0
Black headed Weaver	*Ploceus melanocephalus*	O	LC	0	0	0	0	0	0	1	1	0	0
Black Kite	*Milvus migrans*	O	LC	0	0	0	0	0	0	0	1	0	0

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
Black necked Weaver	*Ploceus nigricollis*	f	LC	1	0	0	1	0	0	0	0	0	0
Black shouldered Kite	*Elanus caeruleus*	O	LC	0	0	0	0	0	1	0	1	1	0
Black throated	*Apalis Apalis jacksoni*	FF	LC	1	0	0	0	0	0	0	0	0	0
Black throated Wattle eye	*Platysteira peltata*	F	LC	0	0	0	0	0	0	1	1	0	0
Blue breasted Kingfisher	*Halcyon malimbica*	F	LC	1	1	1	1	0	0	0	0	0	0
Blue shouldered Robin-chat	*Cossypha cyanocampter*	F	LC	1	0	0	1	0	0	0	0	0	0
Broad billed Roller	*Eurystomus glaucurus*	f	LC	0	0	1	0	0	0	0	0	0	0
Bronze Mannikin	*Lonchura cucullata*	f	LC	0	0	0	0	1	0	0	0	0	0
Brown Illadopsis	*Illadopsis fulvescens*	FF	LC	0	0	0	0	0	1	1	1	1	1
Brown throated Wattle-eye	*Platysteira cyanea*	f	LC	0	0	0	0	0	1	1	1	1	0
Buff spotted Woodpecker	*Campethera nivosa*	FF	LC	1	0	0	0	0	0	0	0	0	0
Buff throated Apalis	*Apalis rufogularis*	FF	LC	1	1	1	0	0	0	0	0	0	0
Cameroon sombre Greenbul	*Andropadus curvirostris*	FF	LC	1	1	0	1	0	0	0	0	0	0
Cardinal woodpecker	*Dendropicos fuscescens*	f	LC	0	0	0	0	0	0	1	1	0	0
Cattle Egret	*Bubulcus ibis*	W	LC	0	0	0	0	0	0	1	1	0	0
Chestnut Wattle-eye	*Platysteira castanea*	FF	LC	1	1	1	1	0	0	0	1	0	1
Cinnamon chested Bee-eater	*Merops oreobates*	F	R-RR	0	0	0	0	0	0	0	1	0	1
Collared Sunbird	*Hedydipna collaris*	F	LC	1	1	1	0	0	0	0	1	0	0
Common Bulbul	*Pycnonotus barbatus*	f	LC	1	1	0	0	1	1	1	1	1	1
Common Cuckoo	*Cuculus canorus*	O	LC	0	0	0	0	0	0	0	1	0	0
Crested Guinefowl	*Guttera pucherani*	F	LC	0	0	0	1	0	0	0	0	0	0
Crowned hornbill	*Tockus alboterminatus*	f	LC	0	0	0	0	0	0	1	1	0	1
Diederik cuckoo	*Chrysococcyx caprius*	f	LC	1	0	0	1	1	0	1	1	0	0
Double toothed Barbet	*Lybius bidentatus*	O	LC	0	0	0	0	0	0	0	1	0	0
Dusky blue Flycatcher	*Muscicapa comitata*	F	LC	0	0	0	0	0	1	0	1	1	0
Dusky long tailed Cuckoo	*Cercococcyx mechowi*	FF	LC	1	1	1	0	1	0	0	0	0	0
Eurasian Reed-Warbler	*Acrocephalus scirpaceus*	M	LC	0	0	0	0	0	1	1	1	1	0

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
Fan tailed Widowbird	*Euplectes axillaris*	O	LC	0	0	0	0	1	0	0	1	0	1
Fire crested Alethe	*Alethe castanea*	FF	LC	0	1	1	1	0	0	0	0	0	0
Forest Robin	*Stiphrornis erythrothorax*	FF	LC	1	1	1	1	0	1	1	1	1	0
Garden Warbler	*Sylvia borin*	f	LC	0	0	0	0	0	0	1	1	0	1
Great blue Turaco	*Corythaeola cristata*	F	LC	1	0	0	1	1	0	1	1	0	1
Great Cormorant	*Phalacrocorax carbo*	W	LC	0	0	0	0	0	0	1	1	0	0
Greater Blue-eared Glossy-chalybaeus	*Starling Lamprotornis*	O	LC	0	0	0	0	0	1	1	1	1	0
Greater Honeyguide	*Indicator indicator*	f	LC	0	0	0	0	0	0	1	1	0	0
Green headed Sunbird	*Cyanomitra verticalis*	F	LC	0	0	0	0	1	0	0	0	0	0
Green Hylia	*Hylia prasina*	F	LC	1	0	1	1	0	1	0	1	1	0
Green sunbird	*Anthreptes rectirostris*	FF	LC	0	0	0	0	0	0	1	1	0	0
Green tailed Bristlebill	*Bleda eximius*	FF	R-NT	1	0	0	0	0	0	0	0	0	0
Grey backed Cameroptera	*Camaroptera brachyura*	f	LC	0	1	1	1	1	1	1	1	1	1
Grey crowned Crane	*Balearica regulorum*	W	LC	0	0	0	0	0	0	1	1	0	0
Grey headed Negro-finch	*Nigrita canicapillus*	F	LC	1	0	0	0	0	0	0	0	0	0
Grey Heron	*Ardea cinerea*	W	LC	0	0	0	0	1	0	0	0	0	0
Grey Parrot	*Psittacus erithacus*	FF	R-NT	1	1	1	1	1	0	0	1	0	0
Grey throated Barbet	*Gymnobucco bonaparte*	F	LC	1	1	1	1	1	0	0	0	0	0
Grey throated Flycatcher	*Myioparus griseigularis*	FF	LC	1	1	1	1	0	0	0	0	0	0
Hadada Ibis	*Bostrychia hagedash*	O	LC	1	0	0	0	1	1	1	1	1	0
Hairy breasted Barbet	*Tricholaema hirsuta*	F	LC	1	0	1	1	0	0	1	1	0	0
Hamerkop	*Scopus umbretta*	W	LC	0	0	0	0	0	0	1	1	0	0
Icterine Warbler	*Hippolais icterina*	M	LC	0	0	0	0	0	0	1	1	0	0
Klaas' Cuckoo	*Chrysococcyx klaas*	f	LC	1	0	0	1	1	0	1	1	0	0
Lead coloured Flycatcher	*Myioparus plumbeus*	f	LC	1	1	1	1	0	0	0	0	0	0
Lesser striped Swallow	*Cecropis abyssinica*	O	LC	0	0	0	0	1	0	0	1	0	0

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
Little Green Sunbird	*Anthreptes seimundi*	F	LC	0	0	0	0	0	1	1	1	1	1
Little Greenbul	*Andropadus virens*	F	LC	1	1	1	1	1	1	1	1	1	1
Little swift	*Apus affinis*	O	LC	0	0	0	0	0	0	1	1	0	0
Little Weaver	*Ploceus luteolus*	O	LC	0	0	0	0	0	0	0	1	0	1
Lizard Buzzard	*Kaupifalco monogrammicus*	f	LC	0	0	0	0	0	1	0	1	1	1
Long-crested Eagle	*Lophaetus occipitalis*	f	LC	0	0	0	0	0	1	0	1	1	1
Nahan's francolin	*Ptilopachus nahani*	FF	G-EN/G-VU	1	0	1	1	0	1	1	1	1	0
Narina Trogon	*Apaloderma narina*	F	LC	0	1	1	1	0	0	0	0	0	0
Northern Black-Flycatcher	*Melaenornis edolioides*	O	LC	0	0	0	0	0	0	0	1	0	1
Olivaceous Warbler	*Hippolais pallida*	M	LC	0	0	0	0	0	0	1	1	0	0
Olive bellied Sunbird	*Cinnyris chloropygia*	F	LC	0	0	0	0	1	1	1	1	1	1
Olive green Cameroptera	*Camaroptera chloronota*	FF	LC	1	1	0	0	0	1	1	1	1	0
Olive Sunbird a	*Cyanomitra olivace*	FF	LC	1	0	1	1	0	0	0	0	0	0
Palmnut Vulture	*Gypohierax angolensis*	W	LC	0	0	0	1	1	0	0	0	0	0
Pin tailed Whydah	*Vidua macroura*	O	LC	0	0	0	1	1	0	1	1	0	1
Plain backed Pipit	*Anthus leucophrys*	O	LC	0	0	0	1	0	0	0	0	0	0
Purple banded Sunbird	*Cinnyris bifasciatus*	f	LC	0	0	0	1	0	0	0	0	0	0
Purple throated Cuckoo-shrike	*Campephaga quiscalina*	FF	LC	1	0	0	0	0	0	0	0	0	0
Pygmy Kingfisher	*Ispidina picta*	f	LC	0	0	0	0	1	0	0	0	0	0
Red bellied Paradise Flycatcher	*Terpsiphone rufiventer*	FF	LC	1	0	1	1	0	0	1	2	0	0
Red capped Robin-chat	*Cossypha natalensis*	F	LC	1	1	1	1	0	1	1	1	1	0
Red cheeked Cordon-blue	*Uraeginthus bengalus*	O	LC	0	0	0	0	0	0	1	1	0	1
Red chested Cuckoo	*Cuculus solitarius*	F	LC	1	1	1	1	1	0	1	1	0	1
Red faced Cisticola	*Cisticola erythrops*	O	LC	0	0	0	0	1	0	0	0	0	0
Red headed Blue-bill	*Spermophaga ruficapilla*	F	LC	1	0	0	0	0	0	0	0	0	0
Red tailed Bristlebill	*Bleda syndactylus*	FF	LC	1	1	1	1	0	0	1	1	0	0
Red tailed Greenbul	*Criniger calurus*	FF	LC	0	1	1	0	0	0	0	0	0	0

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
Red-billed Firefinch	*Lagonosticta senegala*	O	LC	0	0	0	0	0	0	1	1	0	1
Red-chested Sunbird	*Cinnyris erythrocerca*	O	R-RR	0	0	0	0	0	1	1	1	1	1
Red-eyed Dove	*Streptopelia semitorquata*	f	LC	0	0	0	0	0	1	1	1	1	0
Ring-necked Dove	*Streptopelia capicola*	f	LC	0	0	0	0	0	1	1	1	1	0
Ross' Turaco	*Musophaga rossae*	F	LC	0	0	0	0	0	1	1	1	1	0
Rufous Flycatcher-Thrush	*Stizorhina fraseri*	FF	LC	1	1	1	1	0	1	0	1	1	0
Scaly breasted Illadopsis	*Illadopsis albipectus*	FF	LC	1	0	1	1	0	1	1	1	1	0
Senegal Coucal	*Centropus senegalensis*	O	LC	0	0	0	0	0	0	0	1	0	0
Shinning blue Kingfisher	*Alcedo quadribrachys*	FF	LC	0	0	0	0	1	0	0	0	0	0
Singing Cisticola	*Cisticola cantans*	O	LC	0	0	0	0	0	1	1	1	1	1
Slender billed Weaver	*Ploceus pelzelni*	f	LC	0	0	0	0	1	0	0	0	0	0
Snowy capped Robin-chat	*Cossypha niveicapilla*	F	LC	0	0	1	0	0	0	0	1	0	0
Sooty Boubou	*Laniarius leucorhynchus*	FF	LC	0	1	1	0	0	0	0	0	0	0
Speckled Mousebird	*Colius striatus*	O	LC	0	0	0	0	0	0	1	1	0	1
Speckled Tinkerbird	*Pogoniulus scolopaceus*	F	LC	1	1	1	1	1	0	1	1	0	0
Spectacled Weaver	*Ploceus ocularis*	f	LC	0	0	0	0	0	0	0	1	0	0
Splending glossy Starling	*Lamprotornis splendidus*	F	LC	0	0	0	0	1	0	0	0	0	0
Superb Sunbird	*Nectarinia superba*	F	LC	0	0	0	0	1	0	0	0	0	0
Tambourine Dove	*Turtur tympanistria*	F	LC	1	0	1	1	1	0	1	1	0	0
Tawny flanked Prinia	*Prinia subflava*	O	LC	0	0	0	1	1	0	0	0	0	0
Toro Olive Greenbul	*Phyllastrephus hypochloris*	FF	R-VU/RR	1	0	0	0	0	1	1	1	1	0
Velvet mantled Drongo	*Dicrurus modestus*	F	LC	0	0	0	0	1	0	0	0	0	0
Vieillot's Black Weaver	*Ploceus nigerrimus*	O	LC	0	0	0	0	0	0	1	1	0	0
Western black headed Oriole	*Oriolus brachyrhynchus*	F	LC	1	1	1	1	0	0	0	0	0	0
Western Nicator	*Nicator chloris*	F	LC	0	0	0	1	0	0	0	0	0	0
Whinchat	*Saxicola rubetra*	M	LC	0	0	0	0	0	0	0	1	0	0
White breasted Negrofinch	*Nigrita fusconotus*	F	LC	1	0	1	0	0	0	0	0	0	0

Species		Habitat guild	IUCN Status	Ecocentre	Buwola trai	Najjembe South	Namusa	Nsamya River Trail	Kalagala	Namakupa	Namananga	Namwanyi	Nandagi
White browed Coucal	*Centropus superciliosus*	O	LC	0	0	0	0	1	1	0	1	1	0
White browed Crombec	*Sylvietta leucophrys*	FF	R-RR	0	0	0	0	0	0	0	1	0	1
White browed Robin-Chat	*Cossypha heuglini*	f	LC	0	0	0	0	0	1	1	1	1	0
White headed Saw-wing	*Psalidoprocne albiceps*	f	R-RR	0	0	0	1	1	0	1	1	0	0
White rumped Swift	*Apus caffer*	O	LC	0	0	0	0	1	0	0	0	0	0
White spotted Flufftail	*Sarothrura pulchra*	F	LC	1	1	1	0	0	0	0	0	0	0
White throated Bee-eater	*Merops albicollis*	f	LC	0	0	0	1	0	0	0	0	0	0
White throated Greenbul	*Phyllastrephus albigularis*	FF	LC	1	1	1	1	0	1	1	1	1	0
Willow Warbler	*Phylloscopus trochilus*	f	LC	0	0	0	0	0	0	1	1	0	1
Winding Cisticola	*Cisticola galactotes*	f	LC	0	0	0	0	1	0	0	0	0	0
Woodland Kingfisher	*Halcyon senegalensis*	O	LC	0	0	0	0	1	1	0	1	1	1
Yellow Bill	*Pogoniulus bilineatus*	F	LC	1	0	0	1	0	0	0	0	0	0
Yellow billed Barbet	*Trachyphonus purpuratus*	FF	LC	1	0	1	0	0	0	0	0	0	0
Yellow browed Cameroptera	*Camaroptera superciliaris*	FF	LC	1	0	1	1	0	0	0	1	0	0
Yellow crested Woodpecker	*Dendropicos xantholophus*	FF	LC	0	0	0	1	0	0	0	0	0	0
Yellow Longbill	*Macrosphenus flavicans*	FF	LC	0	0	0	1	0	0	0	0	0	0
Yellow rumped Tinkerbird	*Pogoniulus bilineatus*	F	LC	0	0	1	1	0	0	0	0	0	0
Yellow spotted Barbet	*Buccanodon duchaillui*	FF	LC	0	0	1	0	0	0	0	0	0	0
Yellow throated Greenbul	*Chlorocichla flavicollis*	f	LC	0	0	0	0	0	1	1	1	1	0
Yellow throated Tinkerbird	*Pogoniulus subsulphureus*	FF	LC	1	1	1	1	0	1	1	1	1	1
Yellow whiskered Greenbul	*Andropadus latirostris*	F	LC	1	0	0	0	0	1	1	1	0	0
Yellow-throated Longclaw	*Macronyx croceus*	O	LC	0	0	0	0	0	0	0	1	0	0
Zitting Cisticola	*Cisticola juncidis*	O	LC	0	0	0	0	0	0	1	1	0	1

G-EN: Globally endangered, G-VU: Globally Vulnerable, R-VU: Regionally Vulnerable, R-NT: Regionally Near Threatened, R-RR: Regionally restricted

Despite the small area of the small CFRs and the long history of anthropogenic pressures on these five CFRs, they still have a level of importance for conservation of biodiversity at the species level as evidenced by a relatively good number of FF species recorded.

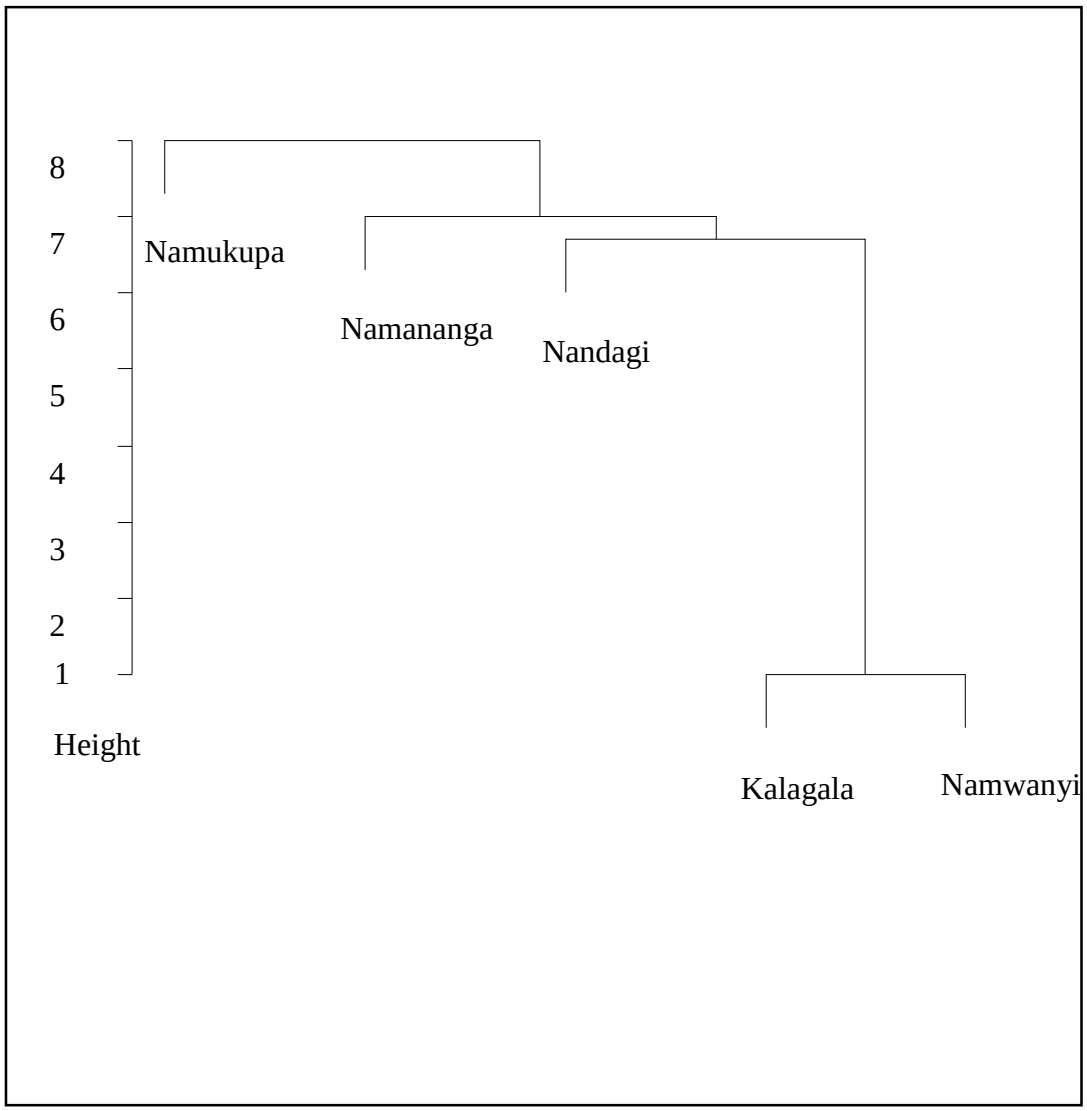

Figure 4.2 Cluster diagram comparing the birds species composition of the five small CFRs

Figure 4.2 plots a comparison of species composition for the five small forest reserves. Not surprisingly they share species but also have elements of the fauna different from one forest to another. The avian fauna in Namukupa CFR was mostly different from that of the other small CFRs while Kalagala and Namawanyi share the most number of species.

Species of conservation concern

Majority of the bird species recorded during the surveys are classified as “Least Concern” according to the IUCN criteria. However, seven of the species recorded are classified as threatened either at global or regional level according to the IUCN criteria (Table 4.3).

Table 4.3. Threatened species of birds recorded in MFR and the five small CFRs

Name	habitat preference	Global/regional threat	Mabira	Kalagala	Nandagi	Namukupa	Namananga	Namwanyi
Nahan's Francolin *Francolinus nahani*	FF	G-EN, R-VU	1	1	0	1	1	1
Grey Parrot *Psittacus erithacus*	FF	R-NT	1	0	0	0	1	0
Cinnamon-chested Bee-eater *Merops oreobates*	F	R-RR	0	0	1	0	0	0
White headed saw-wing *Psalidoprocne albiceps*	F	R-RR	1	0	0	1	1	0
Toro Olive-Greenbul *Phyllastrephus hypochloris*	FF	R-VU/RR	0	1	0	0	0	0
White-browed Crombec *Sylvietta leucophrys*	FF	R-RR	0	0	1	0	0	0
Green tailed *Bristlebill Bleda eximius*		R-NT	1	0	0	0	0	0

The Mottle-throated Spinetail (*Telacanthura ussheri*) that is considered LC and Cassin's Spinetail (*Neafrapus cassini)* that is NT were not encountered during this study. These species are considered Data Deficient. Efforts are required to ascertain their current status.

The records of these species show that threatened/vulnerable species occurred in each of the CFRs. This is a good indicator that the main forest and even the small CFRs are of great ecological importance to some of these endangered species that are normally sensitive to habitat modifications or may have large habitat requirements. The different CFRs have from two to four threatened species of birds, suggesting a moderate level of importance for the conservation of threatened species of birds in the face of alarming deforestation rates in the country.

4.5. CONCLUSION

Bennun *et al* (1996) and Carswell *et al (2005)* reported that Uganda had over 300 species of birds that are forest dependent (FF & F). Owing to the continued loss of forest cover, the conservation of such species is under a lot of pressure.

The data suggest that small forests do support reasonable numbers of forest birds, although the numbers of interior (FF) species remain a small subset of those found in the main forest. The relatively high turnover of species across sites implies that a series of such forests could, collectively, hold a significant number of forest species.

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CHAPTER FIVE

5.0. SMALL MAMMALS

5.1. SUMMARY

The small mammals were sampled using a combination of break back and Sherman traps. Altogether 616 rodents and shrews were captured (449 in Mabira CFR, 15 in Kalagala, 59 in Namananga, 5 in Namawanyi, 15 in Namukupa and 73 in Nandagi). These represent 22 species (5shrews and 17rodents). With an additional 9 species recorded earlier, these make the species richness of the Mabira ecosystem to 31 species. Three closed forest dependent species *Deomys ferugineus, Malacomys longipes* and *Scutisorex somereni* were recorded albeit in small numbers. The surprise in these records was capturing *Deomys ferugineus* in Namananga and Namakupa forests. These reserves have previously been encroached and opened up but are now regenerating. Species accumulation rates were plotted independently for each forest reserve, and neither of them was a asymptotic, indicating that further survey would result in new records.

Surveys for bats were also conducted but these are considered very preliminary. In total 12 species of bats were captured with more species captured in Namananga, although historical records available show Mabira CFR to have an even higher species richness. A total of 22 medium to large sized mammal species were also recorded for the 6 resrves. Mabira CFR has the highest number of species compared to the rest that are much more degraded.

5.2. INTRODUCTION

NatureUganda in 2011 reported a total of 50 large and small mammal species for Mabira Forest Reserve. This been increased through additional research in the main Mabira CFR. Kityo *et al.* (2009), for example, reported a total of 16 species of bats including a new species of bat for Uganda only known from Mabira Forest. These were not previously reported in the NatureUganda (2011). Waswa (2016 unpublished MSc dissertation, Makerere University) found 1 shrew, 1 rodent and 1 bat species that are all new for Mabira CFR. Together these suggest that the mammal fauna of the forest may be far from being completely documented. This report presents biodiversity data on butterflies, dragonflies, amphibians, reptiles, birds and mammals.

Mabira CFR is important for the conservation of mammal species, as it contains a high proportion of forest-dependent species. These include *Deomys ferrugineus* and *Scutisorex somereni* both closed forest-dependent specialists that are highly sensitive indicators of forest disturbance. Of the five primate species reported for Mabira, the Grey Cheeked Mangabey (*Cercocebus albigena*) was subsequently upgraded to an independent species, the Ugandan Crested Mangabey *Lophocebus ugandae* that we recognize for this report. *L. ugandae* is endemic to Uganda that makes Mabira CFR and the four other locations it is known to occur in, very critical for its long-term survival.

The field exercises for this report concentrated on surveying the diversity, distribution and relative numeracy of the different species of mammals surviving in the forests. Small mammals can be safely used to reflect changes in community composition by human habitat modification, due to the fact that they animals are very rarely directly poisoned or hunted by humans so disturbance tends to be through indirect sources.

The surveys for this report aimed at inventorying the mammal biodiversity of the different forest reserves and and to initiate a checklist of species for Nandagi, Namananga, Namukupa, Namwanyi CFRs as well as update the list for Mabira CFR.

The following taxa were assessed: -

i. Rodents and shrews
ii. Bats
iii. Medium and large sized mammals

Before these surveys were commissioned, no mammal surveys had been conducted in Nandagi, Namananga, Namukupa, and Namwanyi. Surveys had been conducted in the Kalagala area for the ESIA as part of the Bujagali Hydro Power Project. Mabira CFR on the other hand was a focus for surveys in the 1990s that resulted into the Biodiversity report for the forest (see Davenport et al 1996). In subsequent years, additional studies have been conducted on small mammals of Mabira by various researchers whose work is however unpublished but still accessed in the unpublished records.

Owing to the immense pressures on the forests in the previous years, it may be safe to assume that l mammal fauna of these reserves has suffered from the intensive disturbances of habitats and modifications including deforestation, agriculture, timber harvesting, charcoal burning, grazing, and movement of livestock.

5.3 METHODS

5.3.1. Field methods

Survey points for small mammal work conducted in Mabira forest are shown in Figure 5.1. The surveys were concentrated in Nagojje, Najembe and Lwankima simply because of accessibility. Results of additional surveys conducted along the route traversed through the forest by the Bujagali transmission line have been assembled and included to give a more comprehensive picture of distribution of mammal species in the forest.

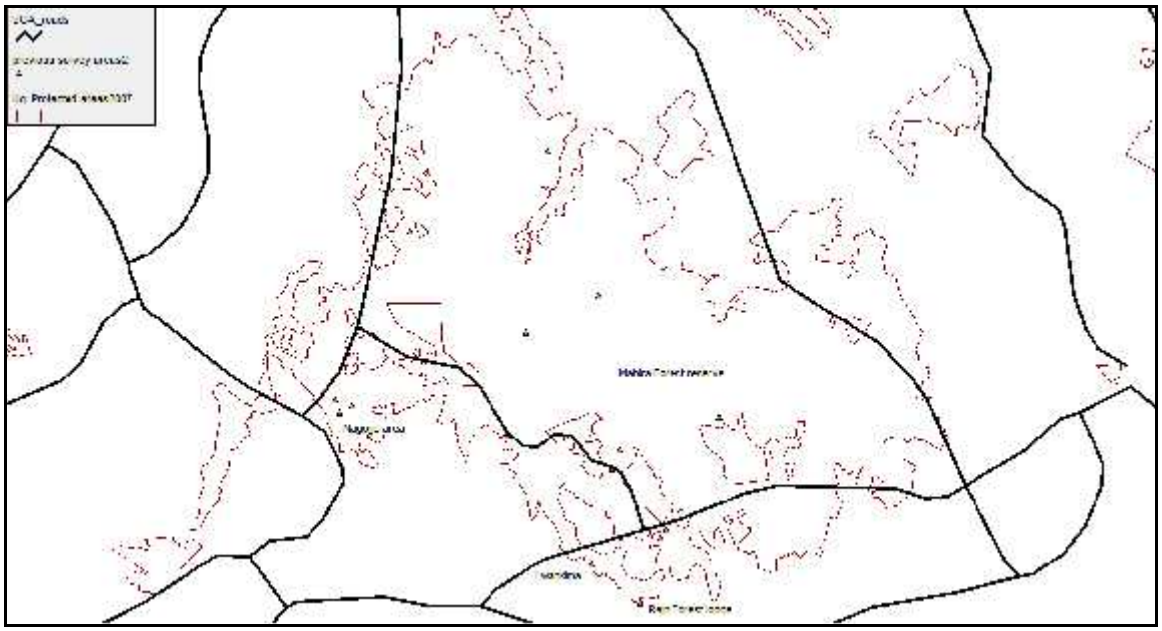

Figure 5.1. Distribution of areas (triangles on map) where surveys for mammals have previously been conducted in Mabira CFR

Data are presented for the six forest reserves (Mabira, Namakupa, Nandagi, Namawanyi, Namananga and Kalagala Falls). The reserves lie in an area of heavy human presence and activity – with the growing of sugarcane and tea being the major large-scale activities. Subsistence farming

and a wide variety of extractive resource use activities such as charcoal making also occur. These have major implications for the mammal diversity.

The field methods were aimed at obtaining qualitative rather than quantitative data, with emphasis on species richness, rather than on population densities. The numbers of individuals captured are used here as a relative indices of abundance of species. Species that are very numerous will be captured more times than species that are not. A combination of trap types (Sherman and break back traps) was used.

Each forest was surveyed with up to four trap lines each with 40 traps, with the trap lines separated by a distance of approximately 100 m to achieve a wide coverage. Traps were left in place for three consecutive nights before they were moved to a different survey location.

Mist nets and acoustic techniques (with the SM2 bat detector) for recording presence and relative abundance of insectivorous bats) were used. A variety of bait types was used in order to catch the full range of rodent and shrew species, and traps were set in different habitat types and locations.

5.3.2. Specimen collection, identification and taxonomy

Preliminary identification of the rodents and shrews was undertaken in the field, following the taxonomic nomenclature in Delany (1975). Each specimen was identified, where possible, weighed (to the nearest gram), sexed, the state of the vagina or position of the testes noted, and the following measurements taken: head and body length, tail, hind foot, and ear length (to the nearest millimetre). All specimens have been retained at Makerere UniversityZoology Museum for further examination and reference. The detailed measurement data accompany the specimens in the herbarium but are not presented in this report.

5.3.3. Personnel, dates and areas sampled

Robert Kityo headed the field team that included Betty Nalikka, Sadic Waswa and Solomon Sebuliba.

5.4 RODENTS AND SHREWS

5.4.1 General small mammal occurrence

All together 12 species of bats and 21 of rodents and shrews were recorded. Table 5.1 summarizes the species richness and numbers of individuals captured (here interpreted as an index of relative abundance of species captured).

The numbers of the individuals captured altogether suggest that *Praomys jacksoni* is the most abundant species in all forest reserves, with a supra-abundance in Nandagi CFR. *Praomys jacksoni* is a forest species that may also be recorded in dense woodlands. This suggests therefore that it may survive even in heavily degraded forest.

Most of all the other species of rodents and shrews captured are of typically forest habitat affinity. The notable exceptions include *Mastomys natalensis* and *Lemniscomys striatus.* These are typically savanna species of which *Mastomys natalensis* was recorded in Kalagala and Namananga while *Lemniscomys striatus* was recorded in Kalagala CFR albeit in very small numbers. The records in Kalagala should not be very surprising given that rainforest cover is now completely lost. Namananga on the other hand has a relatively much dense cover of regenerating forest. The occurrence of this species in Namananga would suggest a modification of the forest cover habitat, now allowing non-forest small mammal species to range into the area. The very low numbers of this species, which is usually very numerous in savanna habitats, may suggest that the area was not suitable for its occurrence in large numbers.

Table5.1: Relative frequency of small mammal species recorded in different forests

Order	Species	Kalagala	Mabira	Namananga	Namawanyi	Namukupa	Nandagi	Total captured
Megachiroptera *(Fruit bats)*	*Epomophorus labiatus*	4	4	5	1	5	0	19
	Epomophorus wahlbergi	0	1	1	0	0	0	2
	Epomops franqueti	0	7	5	0	0	0	12
	Megaloglossus woermanni	0	1	0	0	0	0	1
	Rousettus angolensis	0	0	1	0	0	0	1
Microchiroptera *(Insect bats)*	*Chaerephon pumilus*	0	0	2	0	0	0	2
	Hipposideros caffer	0	0	0	0	2	0	2
	Nycteris thebaica	0	0	1	2	0	0	3
	Pipistrellus nanus	3	0	0	0	0	0	3
	Pipistrellus tenuipinis	0	1	0	0	0	0	1
	Rhinolophus alcyone	0	0	1	0	0	0	1
	Scotoecus hirundo	0	0	1	0	1	0	2
Insectivora *Shrews*	*Crocidura fuscomurina*	0	0	1	0	0	0	1
	Crocidura hildegardae	0	0	1	0	0	0	1
	Crocidura olivieri	0	2	3	0	0	0	5
	Scutisorex somereni	0	5	0	0	0	0	5
	Crocidura sp	0	10	0	0	0	0	10
Rodentia – mice and rats	*Deomys ferrugineus*	0	10	1	0	1	0	12
	Grammomys dolichurus	1	2	0	0	0	0	3
	Hybomys univitatus	0	13	0	0	1	1	15
	Hylomyscus stella	0	126	0	0	6	0	132
	Lemniscomys striatus	1	0	0	0	0	0	1
	Lophuromys aquilus	1	34	6	1	0	5	47
	Lophuromys sikapusi	1	4	1	0	0	0	6
	Malacomys longipes	0	22	0	0	0	0	22
	Mastomys natalensis	3	0	1	0	0	0	4
	Mus bellus	0	4	13	1	0	1	19
	Mus Mahomet	0	5	6	0	1	3	15
	Mus setulosus	0	3	5	0	0	0	8
	Oenomys hypoxanthus	1	0	0	0	0	0	1
	Praomys jacksoni	7	138	21	3	6	63	238
	Praomys misonnei	0	70	0	0	0	0	70
	Rattus rattus	0	1	0	0	0	0	1
	Total rodent & shrew individuals	**15**	**449**	**59**	**5**	**15**	**73**	**616**
	Number of species of bats	**2**	**5**	**8**	**2**	**3**		
	Number of spp. of rodents/ shrews	**7**	**16**	**11**	**3**	**5**	**5**	

Mabira CFR had a different community composition compared to the other five CFRs (Figure 5.2). The difference is partly due to the larger overall numbers of individuals and species recorded for Mabira CFR. This is really the case since more survey effort was invested in Mabira CFR that is many times larger than the other five CFRs and has much more relatively intact forest. It is expected however that the other 5 CFRs should have a similar community composition to that of Mabira CFR. However perhaps due to the history of disturbance they have faced, the small reserves now represent only subsets of the community known for Mabira.

Namawanyi had the poorest rodent and shrew community with only three species compared to 16 for Mabira. Namananga is comparatively richer with 11 species recorded. In all cases, the numbers of individuals captured in the five forest reserves are small in comparison to those of Mabira. This again, is in part due to the greater survey effort used in Mabira, but there is no reason to believe that a greater survey effort might have produced as large numbers in the small reserves as recorded for Mabira. Human impacts and changes imparted on the forest cover have changed these to a great extent and therefore affected the community structure of the small mammals.

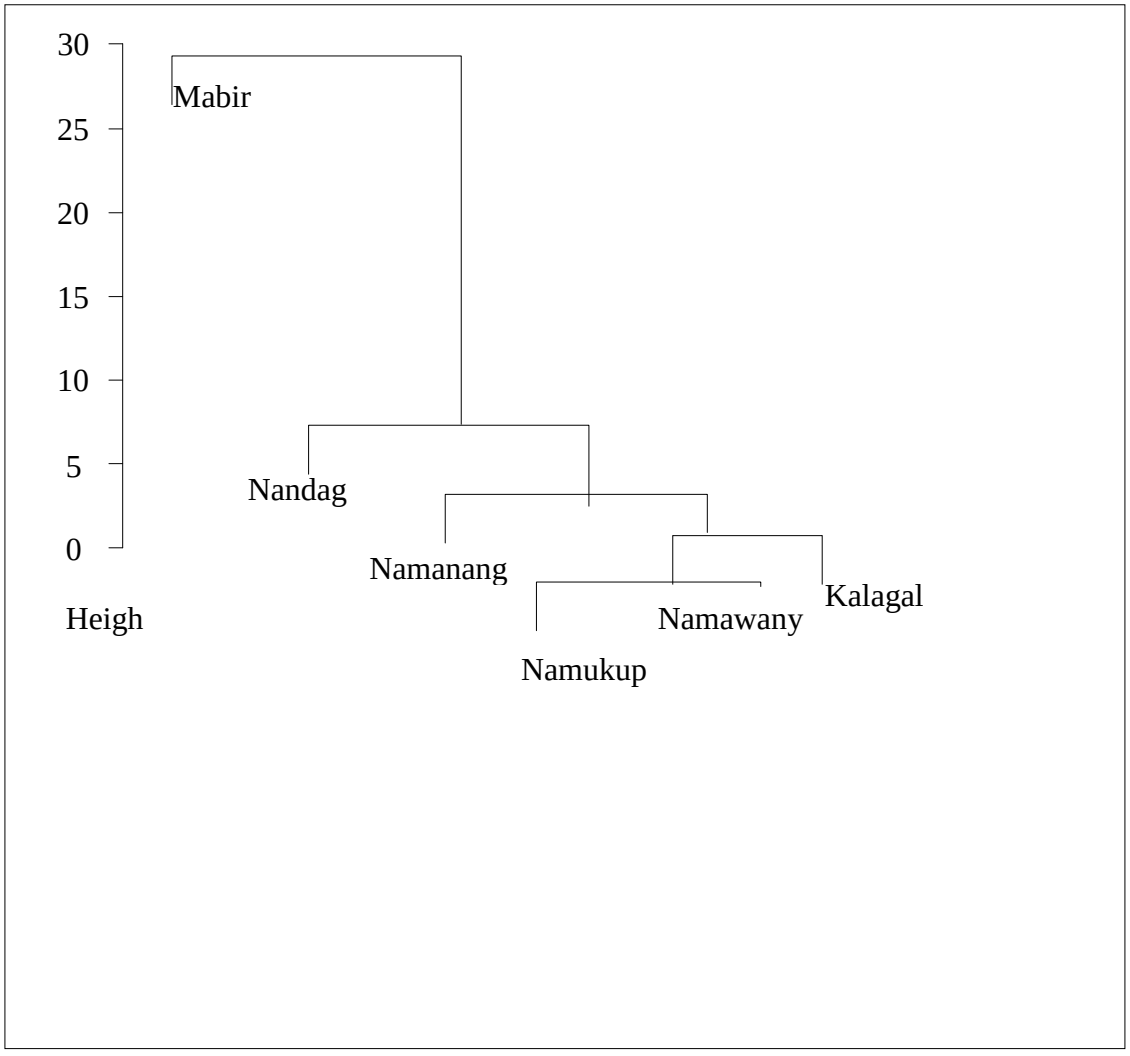

Figure 5.2 Cluster diagram comparing species richness for the six forest CFRs using rodents and shrews

5.4.2. Ecological characteristics

Forest specialist species: A number of species of rodents are usually forest interior species and can therefore only be found in fairly intact forest. Such species can indicate the condition of the forest and hence the relative impact of human pressures on the habitats. Because of the location of the six Mabira Forest Reserves, it ispossible that they werepreviously contiguous and forming a single forest block and that therefore they should have a similar mammalian fauna. It has been noted elsewhere in this report that the smaller forest reserves now have a small subset of the fauna known for Mabira CFR.

In addition, the following four species *Deomys ferrugineus, Hylomyscus stella, Malacomys longipes* and *Praomys misonnei* were captured in Mabira in fairly large numbers but not in the other forests or at worst in very low numbers in the other forests. These four species are forest interior specialists dependent on the presence on an intact forest cover and that would disappear in degraded forest. *Praomys misonnei* is a species only recently reported for Uganda (in Lecompte 2002), it is very similar to *Praomys jacksoni* from which it can only be identified in the field based on details of its palate. It is very likely that the biodiversity surveys reported in Davenport *et al* (1996) also encountered this species but then wrongly identified it as *Praomys jacksoni*. *Praomys misonnei* has only been recorded in Mabira CFR.

5.5 BATS

A total of 12 species of bats (Table 5.2) was recorded. This is most likely not a complete inventory of the bat fauna richness of the six forest reserves. The acoustics data for micro-chiropteran activity are not completely analyzed and are excluded from this report. Previous work (Kityo 2009) reported 19 species.

Table 5.2: Bat species diversity previously reported for Mabira Central Forest Reserve

Family	Species
Pteropodidae	*Casinycteris argynnis*
	Epomophorus labiatus
	Epomops franqueti
	Megaloglossus woermanni
	Myonycteris torquata
	Rousettus angolensis
Nycteridae	*Nycteris argae*
	Nycteris nana
Hiposideridae	*Hipposideros caffer*
	Hipposideros Cyclops
	Hipposideros ruber
Rhinolophidae	*Rhinolophus alcyone*
Verseprtilionidae	*Kerivoula cuprosa*
	Nycticeinops schliefenni
	Pipistrellus capensis
	Pipistrellus nanus
	Scotophilus nux
Molosidae	*Chaerophon pumila*
	Mops major

This survey recorded two additional species of bats *(Epomophorus wahlbergi* and *Pipistrellus tenuipinis*) for Mabira CFR. An additional species *Scotoecus hirundo* is recorded for Namukupa and Namananga. Together these results suggest that the greater Mabira forest system will have at least 22 species.

Threatened Species

Five threatened species (Table 5.3) were recorded. An additional two species are indicated as Data Deficient. These are: *Rhynchocyon cirnei* (Chequered Elephant Shrew) that is recorded as Near Threatened on the IUCN redlist; the other is *Saccolaimus peli* (Pel's Pouched Bat) that is indicated as Least Concern on the IUCN redlisd.

Table 5.3: Threatened Mammal Species

Species Name	Common Name	Iucn Global Status	National Threat Status	Endemic-Uganda
Crocidura selina	Ugandan Forest Musk Shrew, Ugandan Lowland Shrew	DD	EN B2ab(iii)	Endemic
Casinycteris argynnis	Short-palated Fruit Bat	LC	EN B1+2ab(iii,iv)	No
Hipposideros cyclops	Cyclops Leaf-nosed Bat, Cyclops Round-leaf Bat	LC	VU C1	No
Phataginus tricuspis	Tree Pangolin, White-bellied Pangolin	VU	VU A2d	No
Lophocebus ugandai	Uganda Mangabey	LC	VU A2c	Endemic

5.6 CONCLUSION

The results suggest that the small forest reserves associated with Mabira CFR have much more depauperate fauna but that they are still important for the survival of some species. The five small forest reserves except Namananga have a small subset of the diversity in Mabira but several species easily hang on even in degraded forest or that they easily recolonize when the forest is restored. Because we have no baseline on the previous mammalian fauna of the five small forest reserves we are hard placed to say if the community structure we recorded is a recovery or not.

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CHAPTER SIX

6.0. BUTTERFLIES AND DRAGON FLIES

6.1 SUMMARY

Butterflies of Mabira, Namukupa, Namananga, Nandagi, Namawanyi, Kalagala Forest reserves were inventoried using sweep nets. Sampling was conducted at 80 sites in Mabira Central Forest Reserve, 20 sites each in the small forest reserves. Standard baited butterfly traps were also used. All together 207 species of butterflies were recorded -114 species in Mabira, 64 in Namukupa, 63 in Namananga, 82 Nandagi, 45 in Namawanyi, and 54 in Kalagala. A reasonably high proportion of forest dependent species was found in all the forests although Mabira CFR had the largest number of such species. Kalagala and Namananga had the highest proportion of relatively more open environment species, which would symbolize the level of degradation of the forests.

6.2 INTRODUCTION

Biodiversity studies in tropical forest systems are important for understanding patterns of species diversity and community structure. The increasing global habitat destruction (de Vries & Walla, 1999) has made such studies vital. However, due to extra ordinary species richness and complexity of tropical forest ecosystems (de Vries, 1997) very few studies have documented species distributions as would be required in time and space.

Butterflies are probably the best taxonomic group for assessing and monitoring patterns of terrestrial arthropods' diversity (Caldas & Robins, 2003). They have relatively widely studied biology and taxonomy with an estimated 90% species already studied (Midgley, 2002). They derive most of their nutritional and some non-nutritional resources from plants. Tropical butterflies occur in all habitats ranging from pristine to disturbed (Hammer at al, 2003). In the field they are probably the most visually accessible and easily quantifiable representatives of the invertebrate world (Foottit & Adler, 2009).

Butterflies exhibit vertical stratification (into canopy and understorey dwellers) as well as horizontall stratification (with regard to habitat complexity), de Vries (1997). Stratification contributes to tropical diversity among butterflies. The spatial variation in vegetation structure and the butterflies' response to different plant communities is probably the genesis of ecological characteristics, restrictions in range and endemism among butterflies.

Davenport *et al* (1996) have previously carried out the most comprehensive record of lepidopterans (butterlies -199 species and moths – 97 species) for Mabira forest. Like is the case for other fauna, more recent studies have continued to survey the lepidopteran fauna of Mabira.

The aim of this study was to describe butterfly species diversity and community richness in the Mabira Ecosystem forests. Butterflies were recorded from scattered forest reserves that were many years ago part of a single Mabira forest. This report provides data from these surveys.

6.3 METHODS

6.3.1 Sampling sites

The study sampled 80 sites in Mabira Central Forest Reserve, 20 sites in each of the four management zones. The sites were chosen on the basis of their plant community structure evident on ground. Some

samples were also taken within the mixed gardens in the village enclaves. Also sampling was done in Bush lands where the indigenous forest cover was degraded or fallow areas abandoned for a long time or both. Definitely there is overlap in species between these habitats and degraded forest. The relatively intact forest was sampled as well.

6.3.2 Field methods

Standard butterfly traps (35cm diameter with 125cm tubular net) baited with a mixture of mashed and rotting fruits of banana and pineapple (De Vries, 1997; Hill *et al.*, 2001) were used to lure and capture butterflies. Twenty understorey and canopy traps were placed alternately to sample from two vertical levels of stratification. Canopy traps were placed between 10-15m above the ground level while understorey traps were placed 1.5-2 from the ground (Molleman *et al.*, 2006). Traps were suspended on thin nylon ropes running over branches of trees to make them easy to lower and raise. The bait was placed on small plastic plates placed inside each trap. These were replenished with fresh bait each subsequent trapping day for five consecutive trapping days. Trap stations were established at 50m intervals and in different habitats. Species that do not usually get attracted to the traps were sampled using sweep nets. This was done by walking along the 2km long transects through the forest at a slow and even pace of ~1km/h. Each Butterfly seen within a virtual 5 m observation cube projected ahead of the observer was recorded (Pellet, 2007).

6.3.3 Identifications and Taxonomy

Butterflies that could be identified from the field were released after taking a record of their capture and abundance from each trap. Others were collected as voucher specimens and carefully kept in paper envelopes and taken to Makerere University Museum at the department of Zoology for identification. Butterflies were identified to species level with the use of standard guides (Carder et al, 2004; Larsen, 1991).

6.3.4. Data analysis

Species lists were generated from field identifications. For purposes of avoiding confusion and maintaining consistency with previous assessments, Acraeinae, Charaxinae, Danainae, Libytheinae, Nymphalinae, Riodininae and Satyrinae that have been promoted to family level (Davenport, 1996) were retained as sub families was retained.

Ecological characterization: Each butterfly was categorised into one of the ecological types according to Davenport et al (1996) and Kronstad (2009). Forest (“F”) and lowland forest species (“FL”) were combined under forest dependant species (“F”). Other categories are: forest edge species (“f”), Open habitat species (“O”), migratory species (“M”), wide spread species (“W”), species of unknown habitat preference (U), and taxa that were not identified to species level (“U”). Forest dependants (F-species) are those butterfly species that occur only in closed canopy forest habitats. Forest non-dependant species (f-species) are butterflies that may be recorded from closed canopy habitats of the forest but are not dependent upon them. Non-forest butterfly species are those that are either characteristic of open savannah, semi-arid areas, grasslands (O) or swampy/wetland habitats (S). Species described in literarure as widespread were denoted with (W).

Restricted Range species: Restricted range species are species found in 5 or fewer reserves (out of the 64) sampled under the biodiversity survey programme of 1993 (Davenport et al., 1996). Together with forest specialists, restricted range species are of great conservation value (Kronstad, 2009) thus analysis of these species in the sample was done.

Vertical stratification: This was based on field observations as well literature e.g. Fermon (2002). Butterflies were characterised as canopy or understorey species. Understorey species were those captured below 2m heights while Canopy species those captured in traps placed at least 5m high.

6.4 RESULTS

6.4.1. Species Richness

The numbers of species of butterflies recorded, range beween 45 and 114 (Table 6.1). In terms of families, Nymphalidae are the most diverse of the butterflies of Uganda (Table 6.2). The full list of species is presented in Appendix 1.

Table 6.1. Numbers of butterfly species recorded in Central Forest Reserves of the Mabira Ecosystem

	Mabira	**Kalagala**	**Namakupa**	**Namananga**	**Namawanyi**	**Nandagi**
Species	114	54	64	63	45	82
Individuals	1207	162	227	237	176	407
Restricted Range Species	6	2	2	2	1	5

Table 6.2. Number of butterfly species by Family in Forest reserves of the Mabira Ecosystem

Family	**Mabira**	**Kalagala**	**Namakupa**	**Namananga**	**Namawanyi**	**Nandagi**
Nymphalidae	114	31	44	46	34	55.
Hesperiidae		5	6	3	2	8
Pieridae.		9	7	8	6	11
Lycaenidae		6	3	3	1	5
Papilionidae (swallowtails)		3	4	3	2	3

6.4.2. Species of Conservation Concern

Up to 10 butterfly species encountered during the study and others obtained from literature, are included on the IUCN redlist for Mabira Forest (Table 6.3). An additional species *Epitola ceraunia* is indicated on the Ugandan Redlist as Near Endemic but data deficient and Unknown but presumed to occur in Mabira forest. Efforts should be made to search for this species.

Table 6.3: Threatened Butterfly Species recorded in Forest Reserves of the Mabira Ecosystem

Species Name	IUCN Global Status	National Threat Status	Endemic Uganda
Caenides dacena	NE	EN B1+2ab(ii,iii)	NO
Epitola catuna	NE	EN B2ab(iii)	NO
Tanuetheira timon	NE	EN B2ab(ii,iii,iv)	NO
Euryphura albimargo	NE	EN B2ab(ii,iii,iv)	NO
Acraea rogersi	NE	VU B1+2ab(ii,iii,iv,v)	NO
Euryphura chalcis	NE	VU B2ab(ii,iii,iv)	NO
Neptis trigonophora	NE	VU B2ab(iii,iv)	NO
Pseudathyma plutonica	LC	VU B1+2ab(ii,iii,iv)	NO
Belenois victoria	NE	VU B2ab(i,ii,iii,iv)	NO
Pseudopontia paradoxa	NE	VU D2	NO

Based on literature, two Dragonfly species are redlisted for Mabira as Least Concern (Table 6.4). It was not possible to include this taxon in the surveys undertaken.

Table 6.4: Threatened Dragonfly Species in Mabira Forest Reserve

Species Name	Common Name	Iucn Global Status	National Threat Status	Endemic-Uganda
Gynacantha nigeriensis	Yellow-legged Duskhawker	LC	VU B2ab(iii)	NO
Malgassophlebia bispina		LC	VU B2ab(iii)	NO

Each of the reserves had a record of restricted range species. The restricted range species, by forest, are as follows:

- Namakupa: *Amauris hecate* (F) and *Euphaedra rex* (F)
- Namananga: *Amauris hecate* (F) and *Acraea rogersi* (F)
- Namawanyi: *Amauris hecate* (F).
- Kalagala: *Dixeia orbona* (W) and *Amauris hecate* (F)

6.4.3. Ecological characterization

The butterflies in the majority of reserves were dominated by forest specialists ('F'), followed by forest edge/bush dwellers ('f') and then wide spread species ('W'). Swamp specialist ('S') were generally few. All ecotypes were represented (Table 6.5). True understory butterflies recorded are given in Table 6.6. In Namakupa, the forest specialists ('F') were followed by wide spread species ('W') and then forest

edge/bush dwellers ('f'). There were also species of unknown habitat preference. Namananga, Namawanyi, and Nandagi had generally similar patterns.

Kalagala forest reserve was, however, dominated by species of wide spread occurrence ('W') and followed by forest specialists ('F'). Despite the reserve's location on the banks of river Nile, species that prefer swamps (S) were represented by only one species just like those whose preferred habitat is not well known (U).

Table 6.5. Proportionate distribution of butterfly species by their ecological characteristics in the six forest reserves

Ecotype	Mabira		Nandagi		Namananga		Namukupa		Namawanyi		Kalagala	
	No of species	**%**	**No of species**	**%**	**No of species**	**%**	**No of species**	**%**	**No of species**	**%**	**No of species**	**%**
F	21	18	10	12	11	18						
F	58	51	33	40	22	35	30	48	20	44	13	24
M	7	6.1	7	8.5	3	4.8	5	7.9	2	4.4	4	7.4
O	5	4.4	7	8.5	7	11	4	6.3	2	4.4	8	15
S	1	3	2	3.7	1	3.1	1	1.7	1	2.3	1	1.9
U	10	8.8	4	4.9	3	4.8	1	1.7	1	2.3	1	1.9
W	12	11	18	22	15	24	13	21	12	27	19	35

Notes: F Forest dependent. f Forest edge/woodland species, S Swamp species, M Migratory species, U Unknown habitat preference, W Widespread species, O Open habitat species

Vertical Stratification

A total of six species qualified as true canopy species (Table 6.6) and the majority of canopy species were *Charaxes.* There was some true understory species recorded (Table 6.6)

Table 6.6. Relative numbers of true understorey butterflies recorded in three of the forest reserves

Species	Ecotype	Namawanyi	Nandagi	Namananga
Aterica galena	F	6	7	4
Bebearia cocalia	f	3	3	3
Bicyclus sandace	F		2	
Bicyclus vulgaris	W	6	19	8
Elymnias bamakoo	F	3		
Euphaedra medon	F		12	5
Harma theobene	F	2		3

Notes: Ecotype codes are defined below Appendix 1

The true canopy species include *Charaxes cynthia*, *Charaxes eupale*, *Charaxes Lucretius*, *Charaxes pleione*, *Charaxes zingha* and one none Charaxes species *Cymothoe caenis*. Up to 12 Nymphalidae butterflies, qualified as typical understorey species. True understory butterflies include *Aterica galena, Bebearia cocalia, Catuna crithea, Bicyclus sandace, Bicyclus sambulos, Bicyclus vulgaris, Euphaedra harpalyce, Euphaedra medon, Harma theobene, Gnophodes betsimena, Gnophodes chelys*, and

Hypolimnas salmacis. *Bicyclus vulgaris* had the highest number of individuals (62) and *Catuna crithea* followed with 34 individuals.

In Namakupa, one true canopy species *Charaxes etheocles* (F) that had one individual in the total sample was recorded. Three true understorey species *Bebearia cocalia* (f), *Bicyclus vulgaris* (W) and *Euphaedra medon* (F) were represented by 3,4 and 8 individuals in the sample. No true canopy species was registered from Namananga forest reserve while five true understorey species were recorded.

In Nandagi, one individual of the true canopy species *Charaxes etheocles* was captured while five understorey butterflies were recorded. One of these *Bicyclus vulgaris* was encountered much more frequently than the rest although none can be said to have been very numerous. No true canopy species was recorded from Namawanyi forest reserve while five true understorey butterflies were recorded. One true understorey species *Bicyclus vulgaris* (W) with seven individuals in the sample and no true canopy species was recorded from Kalagala forest reserve.

6.5. CONCLUSION

The results presented in this report for the smaller forest reserves associated with Mabira CFR, represent the first scientific documentation of butterfly data. In Mabira forest where only one family of butterflies (Nymphalidae) was recorded, a total of 114 species was recorded, which represents 57% of the (197 species) recorded by Davenport *et al* (1996). The record is however still consistent with a rich butterfly diversity. For the species reported in Davenport *et* al (1996) and that were not recorded, this could be an artefact of season or indeed the spatial context of our sampling strategy. On the basis of the effort we used it is apparent more species would be added to the list through further surveying.

Consistently for all the forest reserves, we recorded more Nymphalids than other species from other families. Therefore, like is the case for Mabira, we can conclude these forests are also important for conservation of Nymphalids.

Based on the species of restricted range or those of particular Conservation Concern occurring in the small er reserves, we emphasize the importance of the different forests for different species of butterflies.

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Appendices

Appendix 1 Species of butterflies recorded in the different forests surveyed

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
HESPERIIDAE	Coeliadinae	*Coeliades forestan*	W				1		
		Eurema desjardinsi	W		1				
	Hesperiinae	*Acleros mackenii*	F		1	1	1	1	
		Borbo fatuellus	W				1		
		Borbo gemella	W		1				
		Caenides dacena	F				1		
		Ceratrichia mabirensis	F				1		
		Metisella midas	S		1		1		
		Monza cretacea	W						1
		Pardaleodes incerta	F		1	1	1	1	1
		Parnara naso	W				1		
	Pyrginae	*Eagris lucetia*	F		1				
		Eretis lugens	W						1
		Sarangesa bouvieri	F						1
		Spialia dromus	W			1			
		Spialia ploetzi	F						1
LYCAENIDAE	Lipteninae	*Pentila pauli*	f				1		1
		Pentila tachyroides	F		1		1		
	Polyommatinae	*Anthene amarah*	O						1
		Anthene ligures	F						1
		Anthene schoutedeni	F			1		1	
		Anthene sp			1	1			
		Cacyreus lingeus	W				1		
		Lampides boeticus	M				1		
		Uranothauma falkensteini	W						1
		Zzula hylax	W						1
	Theclinae	*Axiocerses harpax*	O			1			
		Deudorix	W		1		1		

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		antalus							
		Hypolycaena pachalica	O						1
NYMPHALIDAE	Acraeinae	*Acraea acerata*	O		1		1		1
		Acraea aganice	F	*1*					
		Acraea alicia	W				1		1
		Acraea ancedada	S			1	1	1	1
		Acraea aubyni	F	*1*	1				
		Acraea aurivilli	F	*1*					
		Acraea egina	W	*1*					
		Acraea elgonense	U				1		
		Acraea epaea	F	*1*					
		Acraea eponina	W	*1*		1	1	1	1
		Acraea grosvenori	U	*1*					
		Acraea jodutta	F	*1*		1			
		Acraea leucographa	f			1			
		Acraea lycoa	F	*1*	1		1		
		Acraea macaria	F	*1*					
		Acraea macarista	F	*1*					
		Acraea natalica	W						1
		Acraea orina	F	*1*					
		Acraea peneleos	F	*1*	1				1
		Acraea pharsalus	f			1			1
		Acraea poggei	F		1				
		Acraea pseudegina	W						1
		Acraea quirina	U					1	
		Acraea quirinalis	F	*1*					
		Acraea rogersi	F	*1*		1			
		Acraea servona	F	*1*					
		Acraea sp 1	U	*1*					
		Acraea uvui	f				1		
		Acraea viviana	F	*1*					
		Acraea zetes	W					1	
	Charaxinae	*Charaxes brutus*	F	*1*					
		Charaxes candiope	W	*1*	1	1		1	

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Charaxes Cynthia	F	*1*					
		Charaxes etheocles	F		1		1		
		Charaxes eupale	F	*1*					
		Charaxes fluvescens	F	*1*					
		Charaxes Lucretius	F	*1*					
		Charaxes numenes	F	*1*			1		
		Charaxes pleione	F	*1*					
		Charaxes pollux	F	*1*					
		Charaxes varanes	F	*1*	*1*	*1*	*1*	*1*	*1*
		Charaxes zingha	F	*1*					
		Euxanthe crossleyi	F				1		
	Danainae	*Amauris albimaculata*	F	*1*					
		Amauris hecate	F		1	1	1	1	1
		Amauris niavius	W	*1*	*1*	*1*	*1*		
		Amauris sp 1	U	*1*					
		Amauris tartarea	F	*1*	*1*	*1*			
		Danaus chrysippus	M	*1*	*1*	*1*	*1*	*1*	
		Tirumala formosa	f				1		
	Labytheinae	*Abisara neavei*	F				1	1	
		Labythea labdaca	M	*1*	1				
	Nymphalinae	*Ariadne albifascia*	U		1		1		1
		Ariadne enotrea	F		1	1	1	1	1
		Aterica galena	F	*1*	*1*	*1*	*1*	*1*	
		Bebearia chriemhilda	F	*1*	1		1	1	
		Bebearia cocalia	f		1	1	1	1	
		Bebearia dealbata	F				1		
		Bebearia sp	F	*1*					

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Byblia anvatara	F		1	1	1		1
		Catuna crithea	F	*1*	1				
		Cyrestis camillus	F	*1*					
		Elymnias bamakoo	F						
		Elymnias bammakoo	F	*1*	1				
		Euphaedra eleus	F	*1*					
		Euphaedra harpalyce	F	*1*					
		Euphaedra medon	F	*1*	*1*	*1*	*1*	*1*	
		Euphaedra paradoxa	F			1		1	
		Euphaedra preussi	F	*1*			1		
		Euphaedra rex	F	*1*	1		1		
		Euphaedra sp	U	*1*					
		Eurephene ribensis	F	*1*	1		1		
		Eurytela dryope	W			1	1		1
		Eurytela hiarbas	W			1		1	
		Harma theobene	F	*1*		1		1	
		Hypolimnas anthedon	F	*1*	1			1	
		Hypolimnas dinarcha	F	*1*					
		Hypolimnas misippus	M	*1*	*1*	*1*	*1*		1
		Hypolimnas salmacis	F	*1*					
		Junonia chorimene	O	*1*	*1*	*1*	*1*		*1*
		Junonia oenone	W	*1*	*1*	*1*	*1*	*1*	*1*
		Junonia sophia	W	*1*	*1*	*1*	*1*	*1*	*1*
		Junonia styga	W	*1*			*1*		*1*
		Junonia terea	F	*1*	*1*	*1*	*1*	*1*	*1*
		Junonia westermani	F	*1*					
		Neptidopsis ophione	f		1	1	1	1	1

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Neptis conspicua	F	*1*					
		Neptis melicerta	F	*1*	*1*	*1*	*1*	*1*	*1*
		Neptis metella	F	*1*	*1*			1	
		Neptis nemete	F	*1*					
		Neptis nicomedes	F	*1*	1				
		Neptis saclava	W	1	1	1	1	1	1
		Neptis serena	O	*1*		1	1		1
		Neptis trigonophora	F				1		
		Phalanta eurytis	M				1		1
		Phalanta phalantha	W						1
		Precis archesia	O				1		1
		Pseudoneptis bougandensis	F				1		
		Salamis parhassus	f			1			
		Antanartia deleus	F	*1*					
		Ariadne albifascia	U	*1*					
		Ariadne enotrea	F	*1*					
		Cymothoe caenis	F	*1*					
		Cymothoe herminia	F	*1*					
		Cymothoe sangrias	U	*1*					
		Eurytela hiarbas	F	*1*					
		Lechnoptera anticlia	F	*1*					
		Neptidopsis ophione	F	*1*					
		Phalanta eurytis	M	*1*					
		Pseudacraea boisduvali	F	*1*					
		Pseudacraea sp	U	*1*					
		Pseudogynnis hegemone	F	*1*					
		Pseudoneptis bougandensis	F	*1*					
		Salamis cacti	F	*1*					

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Salamis parhassus	F	*1*					
		Sallya boisduvali	F	*1*					
		Sallya garega	M	*1*					
		Sallya natelensis	M	*1*					
		Sallya occidentalium	M	*1*					
		Vanessula milca	O	*1*					
	Satyrinae	*Bicyclus auricrudus fulgidus*	F	*1*					
		Bicyclus buea	F	*1*	*1*	*1*	*1*	*1*	
		Bicyclus campinus	f	*1*		1		1	
		Bicyclus ena	O	*1*					
		Bicyclus funebris	F	*1*		1		1	
		Bicyclus golo	F	*1*	*1*	*1*	*1*		
		Bicyclus jefferyi	f	*1*		1			1
		Bicyclus kenia	F	*1*		1		1	
		Bicyclus mandanes	F	*1*					
		Bicyclus mesogena	F	*1*		1			
		Bicyclus mollitia	F	1	1		1		
		Bicyclus safitza	W	*1*	*1*	*1*	*1*	*1*	
		Bicyclus sambulos	F	*1*					
		Bicyclus sandace	F	*1*			1		
		Bicyclus sebetus	F	*1*					
		Bicyclus smithii	F	*1*	1				
		Bicyclus sophrosyne	F	*1*					
		Bicyclus sp 1	U	*1*					
		Bicyclus uniformis	U	*1*					
		Bicyclus vulgaris	W	*1*	*1*	*1*	*1*	*1*	*1*
		Gnophodes betsimena	F	*1*					
		Gnophodes chelys	F	*1*					

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Melanitis leda	W	*1*		1			
		Melanitis leda	W						
		Neocoenyra gregorii	W	*1*	*1*	*1*	*1*		
		Ypthima albida	f		1	1	1	1	1
		Ypthima antenatta	O			1		1	
		Ypthima asterope	O	*1*	*1*	*1*	*1*		1
		Ypthima baldus	U				1		
		Ypthimomorpha itonia	O			1	1		
		Ypyhima albida	F	*1*					
PAPILIONIDAE	**Papilioninae**	*Papilio dardanus*	W		1	1	1	1	1
		Papilio demodocus	M		1	1	1	1	1
		Papilio ophidicephalus	F				1		
		Papilio phorcas	F		1	1			
		Papilio zoroastress	f		1				
PIERIDAE	**Coliadinae**	*Catopsilia florella*	M				1		1
		Eurema desjardinsi	U			1	1		
		Eurema hecabe	M		1		1		
		Eurema hepale	O			1			1
		Eurema senegalensis	F		1	1	1	1	1
	Pierinae	*Appias sabina*	F						1
		Belenois calypso	F		1	1			1
		Belenois solilucis	O					1	
		Belenois subeida	f						1
		Dixeia charina	O				1		
		Dixeia orbona	W						1
		Dixeia spilleri	F				1		
		Leptosia hybrida	F					1	
		Leptosia nupta	F		1		1	1	
		Leptosia wigginsi	F		1	1		1	

Family	Sub-family	Species	Ecol type	Mabira	Namukupa	Namanganga	Nandagi	Namawanyi	Kalagala
		Mylothris continua	F				1		1
		Mylothris schumanni	F				1		
		Nepheronia argia	F		1	1	1		
		Nepheronia pharis	F						1
		Nepheronia sp				1			
		Nepheronia thalassina	f		1	1	1	1	
Total number of species				**114**	**64**	**63**	**82**	**45**	**54**

Notes: F Forest dependent. f Forest edge/woodland species, S Swamp species, M Migratory species, U Unknown habitat preference, W Widespread species, O Open habitat species

CHAPTER SEVEN

7.0. AMPHIBIANS AND REPTILES

7.1 SUMMARY

Up to 42 species of amphibiansin 13 genera and 9 families were recorded in the Mabira ecosystem. All of them belong to the Order Anura. The family Hyperoliidae had the highest number of genera (3) and species (11). The water-confined families of Dicroglossidae, Hemisotidae, Pyxicephalidae and Pipidae were represented by single species. A total of 32 reptile species belonging to 4 orders, 13 families and 23 genera were recorded.

7.2 INTRODUCTION

Herpetofauna surveys provide information on habitat requirements and the environmental variables that control their diversity. Being a tropical rain forest, Mabira and its associated forest reserves provide a wide range of habitats that favor the existence of a huge diversity of Herpetofauna. A number of studies on floor-dwelling anurans and reptiles in the Old and New World tropics demonstrate that their species composition and abundance are influenced by a environmental factors, such as vegetation type (Allmon, 1991), elevation (Fauth et al, 1989), and seasonality (Vonesh, 2001a). Human induced factors most especially those related to forest management influence Herpetile distributions (Vonesh, 2001b). Declines in populations, including population crashes and mass localized extinctions, have been noted since the 1980s from tropical rain forests all over the world (McCallum, 2007). These declines are perceived as one of the most critical threats to global biodiversity, and several causes are involved, including disease, habitat destruction and modification, exploitation, pollution, pesticide use, introduced species, and increased ultraviolet-B radiation (Vonesh, 2001a). However, many of the causes of amphibian and reptile declines are still poorly understood, and the topic is currently a subject of much on-going research (McCallum, 2007).

Herpetofauna could provide an early warning system signaling imbalances or degradation in the environment, an ultimate guide to Ecosystem monitoring. However, these organisms can be threatened if they are not prioritized in the management of the forest since they are prone to almost all human activities (Schmuck, 1994). Relative to other vertebrate groups, amphibians and reptiles in East Africa have been poorly studied, and future opportunities may be limited by the threats facing East Africa's forests. The need for baseline herpetological research in tropical Africa has been pointed out by a number of authors (e.g., Lawson, 1993; Drewes & Vindum, 1997). These authors discussed the difficulty in conserving fauna on which we have so little information. The herpetofauna of the East African coastal areas have been reviewed recently by Howell (1993), however, few studies have examined the herpetofauna of the Central African relict forests in East Africa since Loveridge (1935). Such relicts include the Budongo Forest Reserve, Bwamba, Kibale, Bwindi, Mabira, and Mt. Elgon forests in Uganda. Of these forests, only Bwindi-Impenetrable Forest in southwestern Uganda has been inventoried.

A NatureUganda (2011) report has listed in total 15 amphibian and 23 reptile species for Mabira CFR that again as more current evidence suggests does not represent a comprehensive checklist of species. An unpublished Masters dissertation by Isingoma (2016) has for example recorded up to five additional species of amphibians for Mabira. All the five are species that until now were considered Albertine Rift endemics. These findings further emphasize the importance of additional inventories.

Aims, objectives and rationale

The aim of this survey was to determine the Herpetofauna composition of Mabira forest Reserve and its associated 6 forests, with a view of contributing to their conservation.

The specific objectives of the study were to;

i. Determine the diversity and distribution of amphibians within Mabira Central forest Reserve.
ii. Determine the diversity and distribution of Reptiles within Mabira Central forest Reserve.
iii. Establish the conservation status of the target taxa in accordance to IUCN Redlist of species.

Ecological significance of the study

This study provides knowledge on the diversity and distribution of Herpetiles in Mabira forest Reserve and its associated five smaller forests. This information is useful in assessing biodiversity status of this forest ecosystem. Also Mabira Forest Reserve is subjected to a multitude of management practices that could be detrimental to the herpetofauna. Such practices include; the application of chemicals from surrounding plantations especially tea and sugarcanes, charcoal making and logging.

Amphibians are regarded as good ecological indicators. Amphibians are excellent bio-indicators of broader ecosystem health because of their intermediate position in food webs, their permeable skins, and their typically biphasic life (aquatic larvae and terrestrial adults). Beginning in the early 1980s, biologists began to realize that amphibians such as frogs are extremely sensitive to pollution and other environmental stresses. Declines in amphibian numbers and increases in the number of deformed bodies led scientists to investigate the role of habitat loss, increased ultraviolet radiation and chemical pollution in these important changes. Pollutants have varying effects on frogs. Some alter the central nervous system while others cause a disruption in the production and secretion of hormones.

Besides their high degree of sensitivity, either during tadpole stage or adults, which makes them, respond to very slight changes in the environment (Hayes, 2002), the following factors make amphibians' ultimate ecological indicators:

iv. Their population parameters like abundance can easily be assessed
v. Amphibians are very easy to identify due to well established taxonomical knowledge
vi. They occur over wide geographical areas, knowledge can be globally shared
vii. Their life cycle is well documented (Hayes 2002)

Richness of reptile species (rainforest-dependent and mixed-habitat species), varied significantly between site types (Kanowski, et al, 2006). This makes reptiles significant indicator taxa of habitat change.

7.3 METHODS

7.3.1 Field methods

Several methods are applied in these studies and their choice is determined by variety of factors, especially the nature of the habitat and behavior of the target species. However, their effectiveness also depends much on the weather conditions and the time of the day as most success is registered during the nights (at dusk) and early mornings (at dawn).

Terrestrial Sampling methods used

The methods applied in the terrestrials included: Pitfall traps with a drift fence, the Visual Encounter Surveys (VES) and Advertisement calls.

Pitfall traps and drift fence

This method involved making pits to interrupt the movement of target organisms that got trapped. This method was preferred because amphibians are low jumpers, and most reptiles are ground dwellers. However it requires a lot of investment in terms of time and materials (Lunney & Ayres, 2011).

Visual Encounter Survey (VES)

Observers walked through a designated area for a prescribed duration, visually searching (in a systematic way, e.g. along transects), for herpetiles. The number of individuals encountered were noted along with time elapsed during the survey. This method involved a searching the ground in the leaf litter. It was done during the late hours with the aid of the flashlights. This was the most effective method since it coincides with herpetiles' most active period of the day.

Advertisement calls

This was used specifically during amphibian identification. Within the amphibian fauna, each species has a unique call. Some species have adapted to calling at specific hours of the day to avoid competition that comes out of noise of cluster species. With the advertisement call method of assessment, calls were identified in the field while others were recorded for future reference.

7.4 RESULTS

7.4.1 Amphibian species diversity

A total of 42 amphibian species belonging to 13 genera and 9 families was recorded. All recorded species belonged to the Order Anura of class Amphibia. The family Hyperoliidae had the highest number of genera recorded (Table 7.1). The families Ranidae and Arthroleptidae followed this. The water-confined families of Dicroglossidae, Hemisotidae, Pyxicephalidae and Pipidae were represented by single species.

Table 7.1 Amphibian species richness by families and genera for the Mabira ecosystem

Family	Number of genera	Number of species
Dicroglossidae	1	1
Hemisotidae	1	1
Pyxicephalidae	1	1
Pipidae	1	3
Phrynobatrachidea	1	3
Bufonidae	1	4
Arthroleptidae	2	7
Ranidae	2	7
Hyperoliidae	3	11
Total	**13**	**38**

All species recorded were checked against the IUCN list of threatened species, and all are listed as least concern or a few have not been assessed.

There were statistically significant (Global R_{ANOSIM} = -1, p= 0.001) variations in amphibian species composition among the 6 forests sampled, though pairwise comparison of all forests suggests no significant difference (Global R_{ANOSIM} = -1, p= 0.5). However; Mabira had the highest species diversity, followed by Namakupa and Nandagi (Figure 7.1)

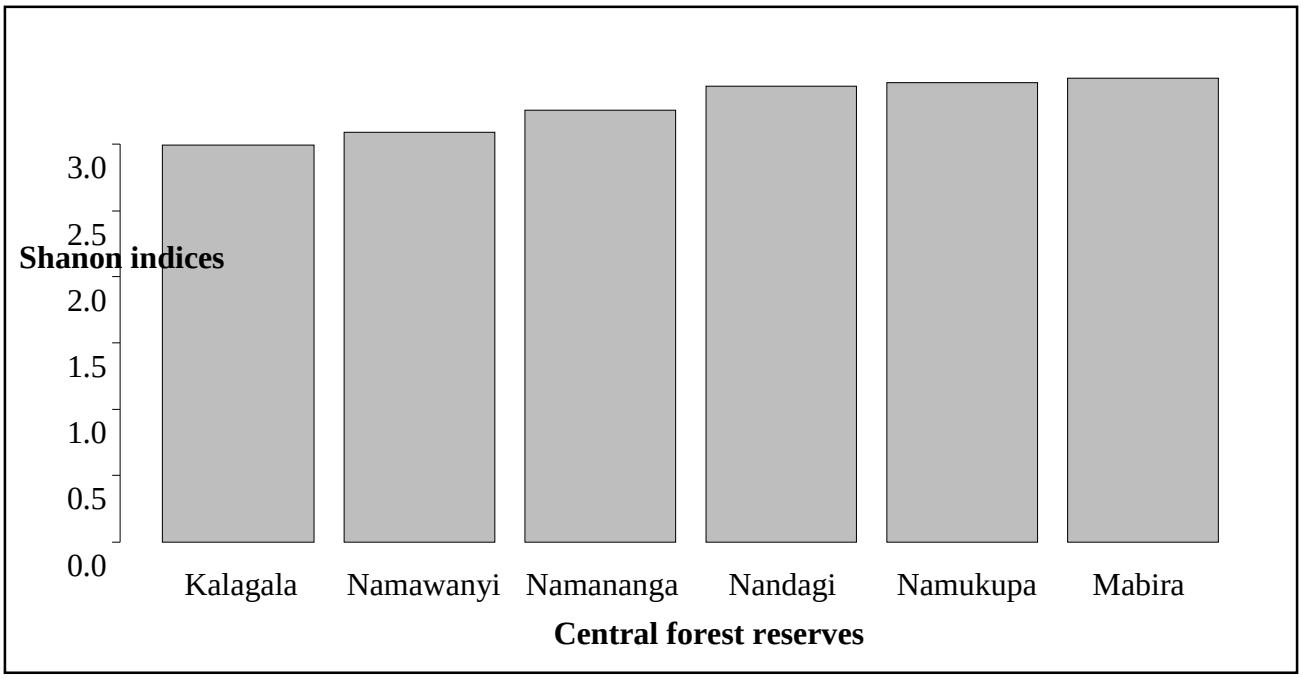

Figure 7.1Comparisons of Shannon indices for amphibian species richness in the six CFRs

Not surprisingly, Kalagala CFR had the lowest and Mabira the highest species diversity. Namukupa CFR is only separated from Mabira CFR by a road, which therefore means that in principal they are the same ecosystem and therefore will share a large number of species.

The individual forest level species richness ranged from 20 to 33, Table 7.2. Based on these results, Mabira CFR has more species than the other 5 CFRs although its species richness compared fairly well with that of Nandagi and Namukupa CFRs. Because amphibians have a very temporal pattern of activity, it is very possible that species could be missed and would therefore the complete inventory list would benefit from much longer-term.

Table 7.2 Species of amphibians recorded in the different CFRs

Family	Species	IUCN status	Kalagala	Namakupa	Namananga	Nandagi	Namawanyi	Mabira
Arthroleptidae	*Arthroleptis* sp 1		0	1	1	1	0	1
	Arthroleptis sp 2		0	1	0	1	0	1
	Arthroleptis sp 3		0	1	1	1	0	1
	Arthroleptis stenodactylus	*LC*	0	1	1	1	1	1
	Leptopelis bocage	*LC*	0	1	0	1	0	1
	Leptopelis christyi		0	0	0	0	1	1
	Leptopelis kivuensis	*LC*	0	1	1	1	0	1
Bufonidae	*Amietophrynus gutturalis*	*LC*	1	1	1	1	0	0
	Amietophrynus maculatus	*LC*	1	1	1	1	1	1
	Amietophrynus regularis	*LC*	1	1	1	1	0	1
	Amietophrynus vittatus	*LC*	1	1	1	1	0	0
Dicroglossidae	*Hoplobatrachus occipitalis*	*LC*	1	1	1	1	1	1
Hemisotidae	*Hemisus* sp.		0	1	0	0	0	0
Hyperoliidae	*Afrixalus cf laevis*		0	1	1	1	1	0
	Afrixalus fulvovittatus	*LC*	1	1	1	1	1	1
	Afrixalus langi	*LC*	0	0	0	1	1	1
	Afrixalus osorioi	*LC*	0	1	1	1	0	1
	Hyperolius acuticeps	*LC*	1	1	1	1	1	1
	Hyperolius cf frontalis		0	0	0	0	0	1
	Hyperolius cinnamomeoventris	*LC*	1	1	1	1	1	1
	Hyperolius kivuensis		0	0	0	0	1	0
	Hyperolius kivuensis	*LC*	0	1	1	1	0	1
	Hyperolius senegalensis		0	0	0	0	1	0
	Hyperolius sp 1		0	1	1	1	1	1
	Hyperolius sp 2		0	1	1	1	1	1
	Hyperolius sp 3		0	1	1	0	0	0
	Hyperolius viridiflavus	*LC*	1	1	1	1	1	1
	Kassina senegallensis	*LC*	0	0	1	0	0	1

Family	Species	IUCN status	Kalagala	Namakupa	Namananga	Nandagi	Namawanyi	Mabira
Phrynobatrachidea	*Phrynobatrachus auritus*		0	1	0	0	0	1
	Phrynobatrachus mababiensis	*LC*	0	1	1	1	1	1
	Phrynobatrachus natalensis	*LC*	0	0	1	1	1	1
Pipidae	*Xenopus muelleri*	*LC*	1	1	0	1	0	1
	Xenopus victorianus	*LC*	1	1	0	0	0	0
	Xenopus sp	*LC*	1	0	0	0	0	1
Pyxicephalidae	*Amietia angolensis*		**1**	0	**0**	**0**	**0**	**1**
Ranidae	*Hylarana albolabris*	*LC*	1	1	1	1	1	1
	Hylarana galamensis	*LC*	1	0	0	0	0	0
	Ptychadena anchietae	*LC*	1	1	0	1	1	1
	Ptychadena chrysogaster	*LC*	1	1	0	1	1	1
	Ptychadena mascareniensis	*LC*	1	1	1	1	1	1
	Ptychadena oxyrhynchus	*LC*	1	1	1	1	1	1
	Ptychadena porosissima	*LC*	1	1	1	1	1	1
Total numbers of species			20	32	26	30	22	33

A few species in Table 7.2 remain incompletely determined, however their taxonomy is continuing to be worked upon to establish their exact identity.

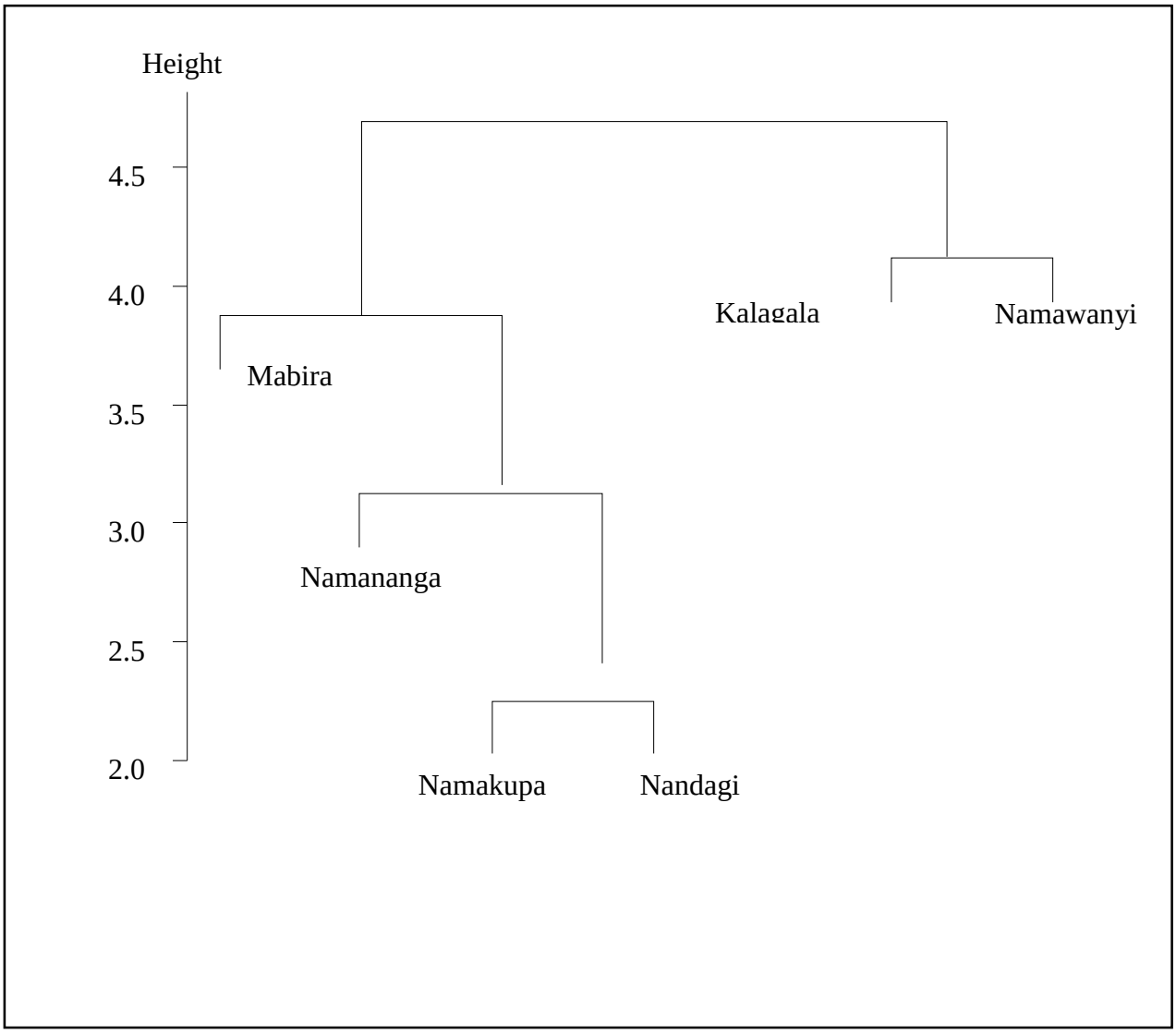

Figure 7.2 Dendrogram comparing the community composition of amphibians in the six CFRs

Kalagala and Namawanyi CFRs have a relatively similar amphibian community that is a little different from that of the four other forest reserves (Figure 7.2). The amphibian community structure of Nandagi, Namukupa and Namananga also closely resembling that of Mabira CFR, each of these forests holds different subsets of species that are found in Mabira CFR.

In Kalagala, a fairly high diversity of amphibian species (Table 7.3) was recorded but mostly within the riverside vegetation. Most of the forest was in previous years heavily encroached and converted to farmlands. Deforestation, as reported elsewhere, alters amphibian species assemblages and reduces species diversity (Jansen & Healey, 2003). Namukupa CFR is fringed by papyrus-wetland that creates a favourable micro-envirnment for the amphibian fauna.

Table 7.3. Numbers of butterfly species recorded in Central Forest Reserves of the Mabira Ecosystem

	Mabira	Kalagala	Namakupa	Namananga	Namawanyi	Nandagi
Species	33	20	32	26	22	31
Genera	12	8	11	10	9	11
Families	8	6	8	6	6	7
Shannon Diversity H'	3.49	2.996	3.466	3.258	2.997	3.465

Namananga CFR is a very much-degraded forest and like the other CFRs, experiences human pressures. The forest was not as rich as the others. Most of **Nandagi CFR** is converted for plantation forestry. At the time of conducting these surveys it was evident that parts of the replanted forests were helping recovery of the forest cover. Hence, Nandagi Forest is relatively less degraded. **Namawanyi forest** has relatively low diversity attributed to human impacts on the forest quality (e.g. frequent and illegal charcoal burning and deforestation). **Mabira CFR** with the highest amphibian diversity is a much larger forest and may therefore present many more opportunities for species of animals to occur. Twelve species of the amphibians recorded were found in one or two of the survey forests while the rest were found in 3 or more of the CFRs. Ten of the species were widely occurring and were recorded in all six CFRs. Some of the species are shown in Figure 7.3.

Figure 7.3: Pictures of some of the amphibian species that were encountered in the Mabira ecosystem


Ptychadena anchietae


Hyperolius osorioi


Hyperolius sp.


Hyperolius cinnamomeoventris


Afrixalus fulvovittatus


Hylarana albolabris


Hyperolius langi


Phrynobatrachus auritus


Amietophrynus gutturalis


Hyperolius sp. 1


Hylarana galamensis


Amietophrynus regularis

Amietophrynus maculatus

Amietophrynus vittatus

Phrynobatrachus mababiensis

Arthroleptis sp. 1

Ptychadena mascareniensis

Ptychadena chrysogaster

Phrynobatrachus natalensis

Ptychadena porosissima

Arthroleptis sp. 2

Xenopus muelleri

Hyperolius viridiflavus

Afrixalus fulvovittatus

7.4.2 Reptile species diversity

A total of 32 reptiles species belonging to 4 orders, 13 families and 23 genera were recorded altogether from the area surveyed in the six CFRs of the Mabira ecosystem. In total sampled sites of Mabira Forest Ecosystem (Table 7.4 and 7.5). The Order Sauria had the highest number of families recorded (Table 7.4). According to Harold (1992), most lizards have well-developed limbs; the head is normally held high off the ground, and they are agile predators. This increases their colonization success unlike the limbless Serpentes (Savage 1992). With its family Scincidae having the highest number of species; according to (Gerlach, 2005) many Scincidae species are generalists with a wide ecological tolerance, although there are several more specialized species.

The other two orders Chelonii and Crocodylia did not have as many species as suaria and serpents. Table 7.4 summarizes the distribution of species of the Mabira ecosystem in the genera and families recorded. The majority of the species recorded are according to the IUCN Red list of threatened species considered as not evaluated (NE). This reference to a species is usually because there is no sufficient ecological data on the species for it to be meaningfully evaluated.

Table 7.4 Reptile species richness for different Orders and Families recorded

Order		Family	Number of species
SAURIA	1	Agamidae	1
	2	Gekkonidae	3
	3	Lacertidae	1
	4	Scincidae	6
	5	Varanidae	1
	6	Chamaeleonidae	2
CROCODYLIA	7	Crocodylidae	1
CHELONII	8	Pelomedusidae	2
	9	Testudinidae	1
SERPENTES	10	Viperidae	3
	11	Typhlopidae	1
	12	Colubridae	10
	13	Elapidae	1
Total			33

Table 7.5 lists all reptile species recorded in the six CFRs with an indication of the IUCN conservation status. The “p” in the column signifies presence of a record while a blank is for no record. It may well be that additional species could be found for each of the CFRs. The data presented here therefore represents a baseline as no previous studies have been found to form a basis for comparisons.
Several species have therefore been recorded in one or two of the forest reserves while many were found to be widely occurring. At the moment we are hard pressed to conclude that any of the species is restricted to one or the other of the CFRs. Crocodiles which are very linked with a water body may be restricted in or along the river Nile and therefore Kalagala CFR, but they can extend their range into other water course such as those through Mabira and therefore it maybe just a matter of time before they are recorded there.

Table 7.5 Distribution reptiles species recorded in the different forest reserves

Order	Family	Species	IUCN	Namananga	Namawanyi	Mabira	Namakupa	Nandagi	Kalagala
Chelonii	Pelomedusidae	*Pelomedusa subrufa* Marsh terrapin	NE	p		p	p		p
		Pelusios williamsi William's Hinged Terrapin	NE						p
	Testudinidae	*Kinixys erosa* Serrated Hinge-back Tortoise	D D						p
Crocodylia	Crocodylidae	*Crocodylus niloticus* Nile Crocodile	NE						p
Sauria	Agamidae	*Acanthocercus atricollis* Common Tree Agama	LC	p	P	p	p	p	p
	Chamaeleonidae	*Chamaeleo gracilis* Gracile Chameleon	NE					p	p
		Rhampholeon boulengeri Boulengeri Pygmy Chameleon	NE	p		p			
	Gekkonidae	*Hemidactylus brookii* Brook's House Gecko	NE	p	P	p	p	p	p
		Hemidactylus mabouia Tropical House Gecko	NE	p	P	p	p	p	p
		Lygodactylus gutturalis Chevron-throated Dwarf Gecko	NE	p		p	p	p	p
	Lacertidae	*Adolfus africanus* Multi-scaled forest Lizard	NE		p		p		
	Scincidae	*Lygosoma fernandi* Fire skink	NE	p		p		p	
		Trachylepis maculilabris Speckled Lipped Skink	LC	p	P	p	p	p	p
		Trachylepis megalura	LC					p	p
		Trachylepis quinquetaeniata Rainbow Skink	NE						p
		Trachylepis striata Common Striped Skink	LC	p	P	p	p	p	p
		Trachylepis varia Variable Skink	LC	p	P	p	p	p	p
	Varanidae	*Varanus niloticus* Nile Monitor	LC		**P**		p		p
Serpentes	Colubridae	*Boiga blandingii* Blanding's Tree snake	NE					p	
	Colubridae	*Grayia smythii* Smyth's Water Snake	NE				p		p
	Colubridae	*Hapsidophrys smaragdina* Emerald Snake	NE						p
	Colubridae	*Lampropis fuliginosus* Brown House Snake	NE	p	P	p	p	p	p
	Colubridae	*Philothamnus bequaerti* Uganda Green Snake	NE	p	P	p	p	p	p
	Colubridae	*Philothamnus nitidus* Brilliant Green-snake	NE	p		p		p	p
	Colubridae	*Philothamnus semivariegatus* Spotted Bush Snake	NE	p		p			
	Colubridae	*Psammophis sp. 1*	NE					p	
	Colubridae	*Psammorphis mossambicus* Olive sand snake	NE	p		p			p
	Elapidae	*Naja melanoleuca* Forest Cobra	NE	p	P	p	p	p	p
	Typhlopidae	*Typhlops sp.*	NE					p	
	Viperidae	*Atheris nitschei* Great Lakes Bush-viper	NE	p	P	p	p	p	p
	Viperidae	*Bitis arietans* Puff Adder	NE	p		p			p

Order	Family	Species	IUCN	Namananga	Namawanyi	Mabira	Namakupa	Nandagi	Kalagala
	VIPERIDAE	*Bitis sp.*	NE		P				
Total numbers of species				18	13	18	15	18	24

Reptile diversity within the sampled sites

There was no statistically significant (Global R_{ANOSIM} = -1, p= 0.01) differences in Reptile species composition among the 6 forests, However, Kalagala had the highest species diversity (Figure 7.4), that may be attributed to the variety of exposed habitat types including Rocky outcrops, River Nile, Papyrus wetlands, and Farmlands in which it is easier to find reptiles than in closed forest. However the species richness recorde may be an under represention due to habitat modification experienced already in this CFR as is the case with the other small CFRs that form part of the wider Mabira ecosystem. Reptiles have relatively limited dispersal abilities making them susceptible to the effects of habitat fragmentation. They cannot cross-large expanses of unsuitable terrain to move from one patch of habitat to another favourable, but distant, site (Leuteritz *et al*, 2005).

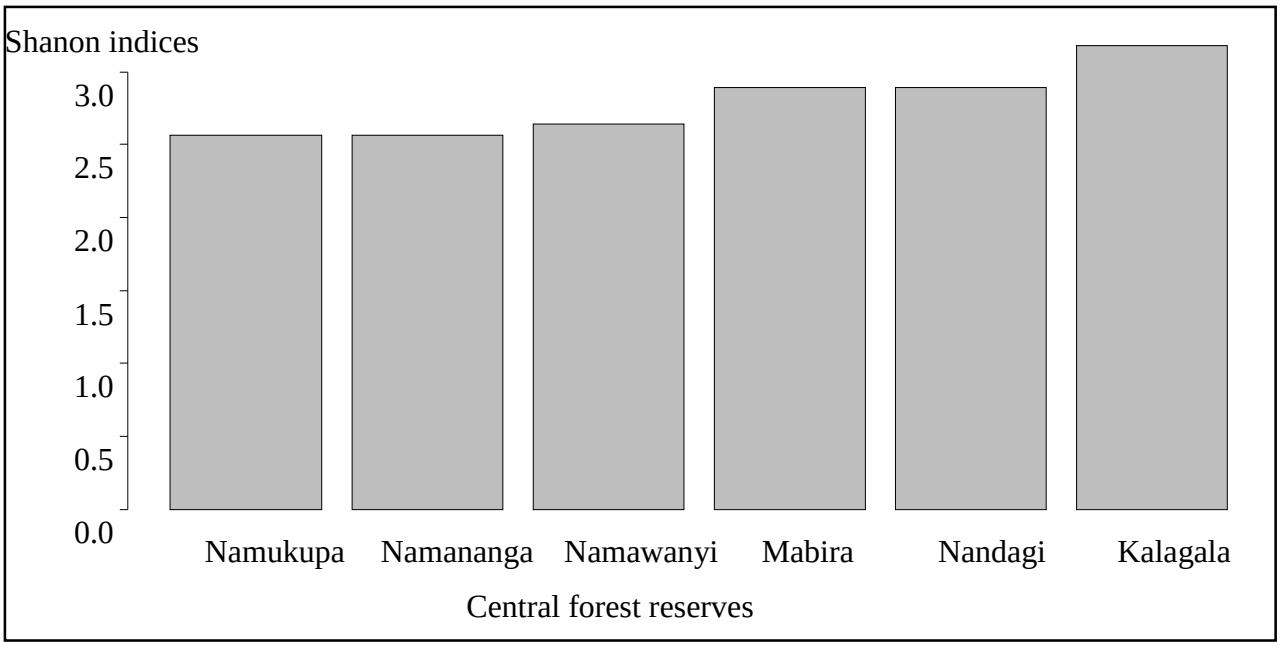

Figure 7.4. Comparisons of Shannon indices for Reptile species richness in the six Central Forest Reserves

Mabira, Namananga and Nandagi have a more similar fauna than the other 3 CFRs that also share a large number of species amongst themselves (Figure 7.5). The richest CFR was Kalagala while the CFR with the least number of species was Namawanyi.A total of 24 reptile species belonging to 10 families and 18 genera were recorded for the Kalagala CFR.

Mabira and Nandagi had the second highest diversity indices, the former although impacted upon by humans, still has a reasonable forest cover and Nandagi CFR has a section of relatively good cover. According to Vitt *et al.* (1998), disturbances that maintain the structural integrity of the habitat may favour species that benefit from lower-intensity disturbances like the forest ecosystem habitats that had a canopy and significant tree structure.

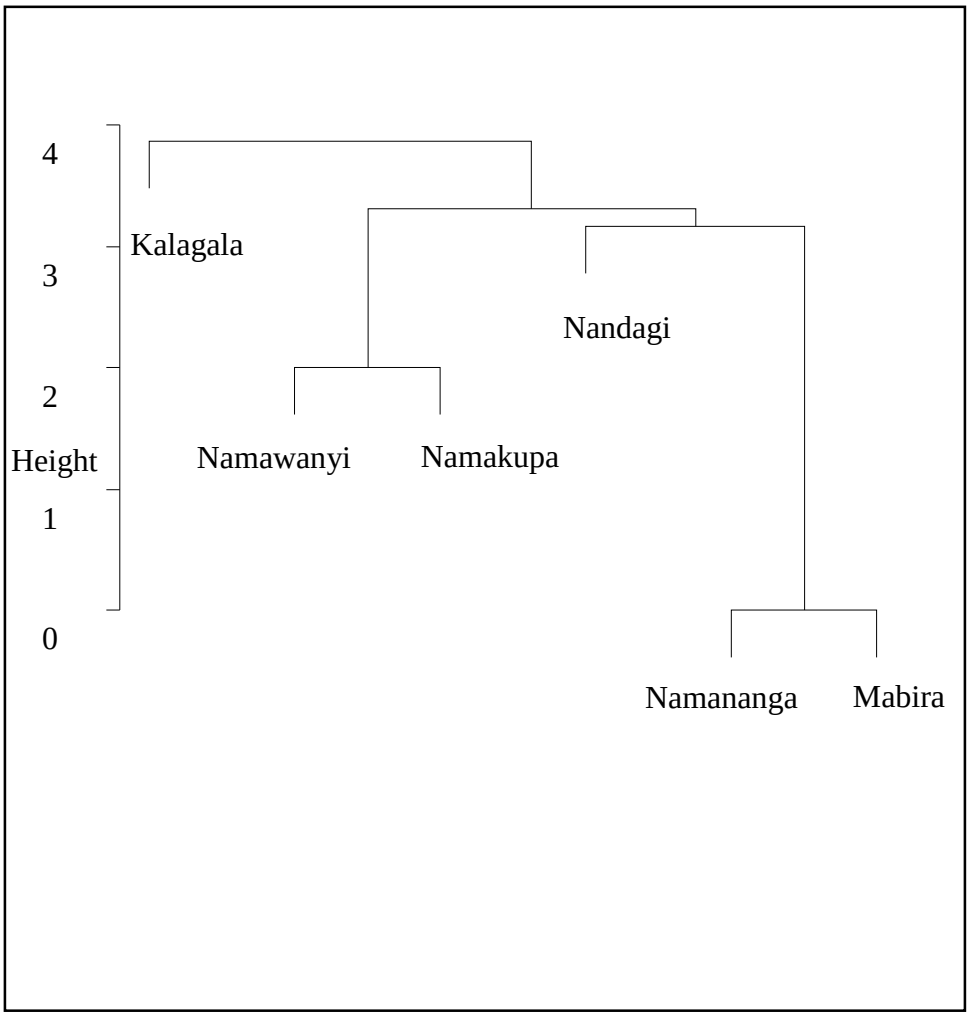

Figure 7.5. Cluster diagram to compare reptile species richness in the six CFRs

We recorded a toal of 15 species of reptiles in Namakupa CFR that also returned a low diversity (*H'*= 2.565). Like most every other of the small CFRs, this forest continues to face anthropogenic pressures including Illegal charcoal burning, logging, farming and cattle grazing. According to Mushinsky (1985), habitat disturbances have the potential to affect reptile species in a variety of manners. High intensity disturbances initially tend to favour reptile species that require characteristics of open, early successional habitats (Greenberg, 2001) and leads to loss of the vulnerable ones.

Namananga CFR is extensively degraded through anthropogenic activities especially charcoal burning leading to regeneration of invasive floral species. The degradation is associated with a reduction in fauna diversity within. This CFR had one of lowest reptile diversity amongst the 6 sampled sites (Shannon W index = 2.565) but a total of only 18 reptiles species were recorded (Table 7.4).

Despite having large parts of Nandagi CFR under plantation forestry, we a firly high shanon diversity index for reptiles (*H'*=2.89). A total of 18 reptile species (Table 7.4) was also recorded in this forest, belonging to 3 Orders, 9 families and 14 genera.

Namawanyi CFR is a highly degraded forest due to frequent charcoal burning and and other human activities that lead to forest cover loss. A total of 13 reptile species, belonging to 2 Orders (Sauria and Serpentes), 8 Families and 9 genera were recorded.

Mabira CFR faces similar anthropogenic pressures like the other 5 CFRs, however it is larger in extent and therefore we have not surveyed it satisfactorily. It is therefore likely that more species remain to be discovered for this reserve. A total of 18 species belonging to 3 Orders, 8 families and 12 genera was recorded for this reserve a figure that we consider to be on the lower side given its extent.

In terms of the conservation status, one Data Deficient Reptile Species (Dipsadoboa weileri - Black-tailed Tree Snake was recorded. On the IUCN Redlist, its status is indicated as Near Threatened (NE), but on the National Status is Data Deficient.

Figure 7.6: Some of the Reptile species that were encountered

Lygosoma fernandi

Hapsidophrys smaragdina

Naja melanoleuca

Philothamnus nitidus

Psammophis mossambicus

Kinixys erosa

7.5. CONCLUSION

The data obtained on theherpetiles in the forests of the Mabira Ecosystem shows that the forests are extremely important for the survival of several species. Whereas the main block (Mabira CFR) is important, the smaller reserves are equally important. Efforts should be made to improve their management and halt further degradation.

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CHAPTER EIGHT

8.0. WATER QUALITY AND BENTHIC MACRO-INVERTEBRATES

8.1 SUMMARY

In terms of water quality of boreholes within and around Mabira Forest Reserve, the pH is relatively lower than the WHO required limits for drinking water. All the other parameters are within the limits for drinking water. In the rivers, the pH of all the sample sites was near neutral except, Mutumbwe as the river flows out of the sugarcane, and Musambya (as it flows into and out of the Sugarcane plantation). Relatively high values of EC, TDS, TSS and TP were observed in Musambya (under Sugarcane plantation), Musamya (under rice cultivation), Mutumbwe (under sugarcane) and Sezibwa (under Tea plantation). Up to 9 benthos families were recorded with the Chironomidae as the most abundant. The findings there demonstrate the impacts of the largescale plantation activities on water quality.

8.2 INTRODUCTION

The objective of water quality assessment is to justify the ecosystem functions and services in terms of water provisioning from the reserves; to track the extent of pollution of water resources from activities inside and outside the reserves;; and to track changes in river flows. The Mabira ecosystem is an important water catchment providing several ecosystem functions and services to aquatic biota and local communities living around the reserves.

Water quality can change frequently over time (years and seasons), necessitating frequent, repeated measurements to adequately characterize variations in quality. For the Mabira catchment where water quality will be assessed after a fairly long period, a monitoring framework is required to be implemented at specific sites within and around reserves.

Temperature and conductivity are true physical properties of water bodies, whereas OD and pH are concentrations, and turbidity is an expression of the optical properties of water (ASTM International, 2003). For the purposes of this report, all of these properties or constituents are analysed from the samples collected from the Mabira catchment.

Benthic macro-invertebrates can be used as bioindicators of watershed condition and water quality in streams and rivers. This is because various taxa have varying tolerances to different types of disturbances. Various variables such as number of taxa and their relative abundances can be used as indicators of water quality.

Aims and rationale

The Mabira Forest Reserve has rivers flowing through it and it is therefore a major water catchment. In order to ensure sufficient flow of water of good quality for the benefit of riparian communities it is necessary to ascertain the water quality of the various rivers and streams. In addition, Mabira Forest Ecosystem is habitat to diverse range of flora and fauna s. It is important to ensure that Mabira Forest Reserve is managed in such a way that it continues to perform its water catchment and ecological functions. The data collected during this assignement will be useful as baseline to monitor pollution of water resources in and around the Mabira ecosystem.

8.3. METHODS

8.3.1. Field methods for water quality assessment

Water quality parameters were determined in surface water within and outside Mabira Forest Reserve (Fig. 8.1). Physical chemical parameters determined included (TN, TP, PO3, NO3, and NH4, pH, DO, turbidity, temperature, electrical conductivity, total dissolve sediment and total suspended solids). These parameters were measured twice in the May 2016.

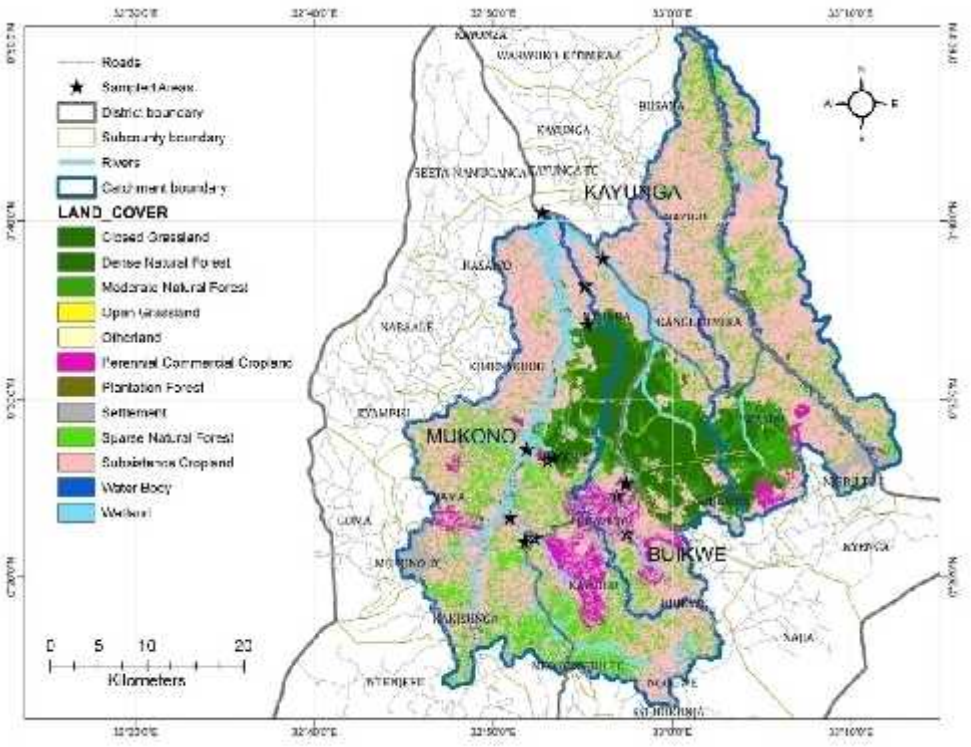

Figure 8.1. Water quality sampling sites within and outside Mabira Forest Reserve

A total of 24 water samples were collected and analysed at Makerere University. In addition water quality information was collected from National Water and Sewage Corporation (NWSC) located in Kayunga.

8.3.2. Assessment Methodsfor Aquatic Benthic Macroinvertebrates

A 100-meter assessment section containing a mixture of habitats (fast and slow riffle/runs, deep and shallow riffle/runs, shaded and exposed riffle/runs) was established as a sampling site along the river and all benthic macroinvertebrate samples was done within the designated reach. A rectangular Dip net was used collect the benthos. The net was positioned on the stream bottom so as to eliminate gaps under the frame with the net opening upstream. The net was held securely while kicking the substrate vigorously for 30 seconds in an area of approximately 0.25 m^2. The bottom substrate was destabilized so that dislodged organisms flow into the net. The net was removed from the water with a quick upstream motion to wash the organisms to the bottom of the net and the emptied the contents of the net into a bucket with water. The process was replicated four times at each sampling section to cover approximately 1 m^2 (4 x 0.25 m^2) of stream substrate. After compositing all four kicks into the bucket, all large objects were removed, inspected for organisms and discarded the residue to reduce laboratory

sorting time and limit the crushing and grinding that damages benthic specimens. The four replicates at each site constituted into one sample.The samples were then preserved using 20% ethanol solution and transferred to the laboratory for analysis.

The characteristics of sites sampled for Benthic Macroinvertebrates are described in the following sections:

Site 1 (River Musamya)

The section of River Musamya studied is approximately 1.8 km below the Griffin forest camp. This section of the River has the following characteristics (Figure 8.2):

- The section has a fast and uniform flow;
- There is a relatively straight 'line' flow of a river;
- Unstable river bank with signs of recent flooding;
- In-stream is artificial, characterised by dark smelly water with waste from Sugar Cooperation Uganda Limited;
- Siltation of the river banks and riverbed;
- The riparian vegetation is dominated by trees; and
- The canopy cover is a mixture of shade, direct light and filtered light.

a) Siltation of the river bank

b) Riverine vegetation

Figure 8.2: River Musamya characteristics

Site 2 (River Sseziwa)

The point along River Sseziwa (Figure 8.2) is located below the bridge along Mukono-Kayunga road. The section of the river has the following characteristics:

- The section had slow and uniform flow;
- There is a straight 'line' flow of a river;
- Unstable river bank, signs of recent bank collapsing and flooding;
- In-stream is natural, characterised by brown water;
- Siltation of the river bed;
- The riparian vegetation is modified on one slide of the bank dominated by grasses; and
- The canopy cover is a mixture of shade, direct light and filtered light.

Unstable bank

Modified riparian vegetation

Figure 8.3: River Sseziwa characteristics

Site 3 (River Mabugwe)

This river section had the following characteristics (Figure 8.4):

- River flow was relatively fast, and uniform;
- The river bed is caracteristiced by a mixture boulders, cobbles, gravel and silt;
- The riparian vegetation is dorminated by trees;
- The river banks were stable;
- The instream conditions were natural characteristed by clear waters; and
- The canopy cover is a mixture of shade and filtered light.

a) Boulders and cobbles

b) Riparian vegetation along River Mabugwe

Figure 8.4. River Mabugwe characteristics

River Waliga

This section of the River Waliga had the following characteristics (Figure 8.5)

- The river flow was relatively fast, straight and unifirm with brown waters;
- In-stream was clear with no accumulation of substrate;
- The riparian vegetation was dorminated by trees;
- The river banks were not stable with recent modification due bank collapse;
- Signs of recent floods (Silt deposition in some parts of the riparian zone);and
- Canopy cover was a mixture of shade, direct light and filtered light.

Unstable banks

Silt deposition in the riparian zone

Figure 8.5. River Waliga characteristics at the sampled site

8.4. RESULTS

8.4.1. Water quality of boreholes

The water quality of boreholes within and around Mabira Forest Reserve is shown in Table 8.1. The pH is relatively lower than the WHO required limits for drinking waters. All the other parameters are within the limit for drinking water. Water pH, TP, PO_{4---}, NO_{3-} and ECwere relatively higher in Kyabazala compared to Nagojje. Both are located in settlement areas with sugarcane plantation around them.

Table 8.1. Waer quality of selected boreholes within and around Mabira Forest Reserve

Sub-county Name	pH	PO4--- (µmol/L)	TSS (g/L)	NO3- (µmol/L)	TN (µmol/L)	Temperature (oC)	EC (µS/cm)	TP (µmol/L)
Kyabazala	6.30	0.13	0.01	1.79	1.82	24.70	268.50	0.20
Nagojje	5.89	0.06	0.01	1.36	2.39	24.00	105.50	0.07

8.4.2. Water quality in River within and around Mabira Forest Reserve

Table 8.2 summarises selected water quality parameters in rivers within and around Mabira Forest Reserve. Generally pH of the all the sites were water samples were collected was near neutral except, Mutumbwe as the river flows out of the sugarcane, Musambya (as it enters the Sugarcane), Musambya as it flows out of the sugarcane. Relatively high values of EC, TDS, TSS and TP were observed in Musambya (under Sugarcane plantation), Musamya (under rice cultivation), Mutumbwe (under sugarcane) and Sezibwa (under Tea plantation).

Table 8.2: Water quality parameters in surface water within and around Mabira Forest Reserve

Name of the River	pH	PO4--- (µmol/L)	TSS (g/L)	NO3- (µmol/L)	TN (µmol/L)	Temperature (oC)	EC (µS/cm)	TP (µmol/L)	TDS (g/l)
Matumbwe	7.04	0.08	0.03	1.16	4.89		99.00	0.13	49.00
Matumbwe (Sugarcane)	7.31	0.13	0.02	1.79	4.10		133.00	0.25	66.00
Musambya (Entry in sugarcane)	7.81	0.11	0.02	1.15	3.52	27.30	61.00	0.17	30.00
Musambya (Sugarcane)	8.81	1.07	0.40	1.16	2.08	27.50	459.00	1.92	230.00
Musamya (Rice cultivation)	6.82	0.36	0.02	1.53	3.45	23.00	194.50	0.72	96.50
Sezibwa (Kayunga outlet)	6.74	0.26	0.01	1.03	3.33	24.70	169.33	0.42	84.00
Sezibwa Forest Nagoje	6.94	0.07	0.01	1.12	3.22	23.30	86.50	0.13	43.00
Sezibwa Namataba (Wetland)	6.81	0.05	0.01	1.13	3.83	23.10	69.00	0.09	34.00
Sezibwa upper (Forest)	7.30	0.07	0.00	1.82	3.35	23.20	43.00	0.07	22.00
Sezibwa Upper (Tea plantation)	7.11	0.08	0.01	1.32	2.28	24.60	126.00	0.09	63.00

8.4.3. Water quality at the outlet of Sezibwa on Kayunga road

Water quality parameters for the two periods sampled are shown in Table 8.3. These values are within WHO limits for drinking water for the studied parameters.

Table 8.3: Water quality at the soutlet of Sezibwa around Kayunga road

Name of the River	pH	PO4--- (µmol/L)	TSS (g/L)	NO3- (µmol/L)	TN (µmol/L)	Temp. (°C)	EC (µS/cm)	TP (µmol/L)	TDS (g/l)
Outlet	6.74	0.26	0.01	1.03	3.33	24.70	169.33	0.42	84.00

8.4.4. Benthic Macroinvertebrates

Preliminary analyses show some of the benthos families collected from four sites in Mabira Forest Reserve. These are summarized in Table 8.4. The most abundant is the Chironomidae. Further analyses will be required to develop a complete documentation of these for future monitoring.

Table 8.4: Benthos Families recorded from Rivers within the Mabira Ecosystem

Family name	Site 1	Site 2	Site 3	Site 4
Chironomidae	214	5	1	
Nematocarcinidae	2	2	2	
Octopodidae			4	6
Potamonautidae			2	1
Elmidae			3	1
Pyralidae			1	3
Muscidae		2		
Libellulidae				1
Gomphidae			1	

8.5. CONCLUSION

The rivers running through the Mabira ecosystem constitute a major source of water for the surrounding communities. There are various industries and domestic water supplies that depend on this catchment. However, the integrity of these ecological functions is being compromised by the non-regulated use of freshwater resources and landuse activities within the catchment. Domestic water supply to the surrounding people must continue to benefit from the Mabira's water catchment functions.

The different water related variables and benthic macroinvertebrates assessed during the present assignment would help management continuously determine status of water resources, evaluate causes of degradation, determine effectiveness of management interventions such as catchment restoration and measure success of management programs. Aquatic insects can, for example, be used because they are easy to sample and identify. Benthic macro-invertebrates, in particular, are recognised as valuable organisms for bio-assessments, due largely to their visibility to the unaided eye, ease of identification, rapid life cycle often based on the seasons and their largely sedentary habits.

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