A comparative assessment of biodiversity changes in Echuya Central Forest Reserve following anthropogenic activities between 2015 and 2021

By

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IV. Acknowledgements

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V. Executive Summary

Biodiversity is one of the fundamental properties of nature and source of immense potential for economic use and yet the ecological functions performed by the biological diversity are still less understood. Tropical forests are arguably the most biologically diverse places on planet with many endemic and rare species within. Unfortunately an estimated 154 million ha of these tropical forest are cleared each year by human activities for mainly cattle ranching and agriculture. Deforestation of the tropical forests comes in many forms that include wild fires, clear-cutting, unsustainable logging for timber and degradation due to climate change all caused by humans.

The Echuya Central Forest Reserve (ECFR) is not as very rich in biodiversity like the other forests of Bwindi and Mgahinga but is considered of high conservation importance because of its endemic, rare and globally threatened flora, and fauna. Some of the species found in ECFR include the African Golden Cat (Caracal aurata), Rodents (*Lophuromys woosnami*, *Delanymys brooksi*, *Ruwenzorisorex suncoides*), and Birds - Grauer's Swamp Warbler (*Bradypterus grauer*i) and the Abyssinian Ground-Thrush (*Geokichla piaggiae).* Unfortunately, these unique and rare species (including overall biodiversity) in ECFR is under serious threat from anthropogenic activities. In June 2018, the biodiversity threats to ECFR were further exacerbated, when the National Forest Authority (NFA) carried out massive bamboo forest understory clearance/weeding by cutting and removing all tree saplings, vines, shrubs, and lianas under the bamboo forest. This study therefore assessed the impact of the different anthropogenic activities (illegal activities and the forest understory clearance) on the biodiversity of ECFR.

Three taxa; vegetation (trees, shrubs, lianas, vines, and herbs), terrestrial vertebrates (small mammals) and birds were used as surrogate indicator species for the assessment of the status of total biodiversity of ECFR. Furthermore, the study used the biodiversity assessment done in 2015 as baseline to compare the changes in biodiversity currently (2021). Human activities in ECFR of 2021 were also recorded and compared with those previously done in 2015 (baseline). After analyzing the field data collected in 2015 and 2021 using R open-source statistical software version 3.2.2, the study came out with the following results.

A total of 27 tree species were recorded in ECFR for 2015 and 2021 study period. Of these, *Macaranga capensis, Psychotria mahonnii*, *Xymalos monospora, Neoboutonia macrocalyx, Maesa lanceolata* and *Nuxia congesta* were the most dominant tree species in descending order. A comparison of the most dominant tree species between 2015 and 2021 shows that *Macaranga capensis* constituted over 64% of the tree species in ECFR in 2015 but reduced to 34% in 2021 giving way to other tree species. There was no significant difference in the abundance of tree stems (expressed per unit hectare) recorded in 2015 and 2021. However, tree species evenness (abundance) and richness (diversity) were higher in the year 2021 (twice) than 2015.

A total of 60 shrubs and lianas were recorded in ECFR for 2015 and 2021 study period. Of these, the most dominant shrub and liana species in descending order were *Mimulopsis Solmsii*, *Triumfetta cordifolia, Phillipia denguelinsis*, *Dracaena laxissima*, *Urera hypselodendron*, *Piper capense*, and *Rhamnus prinoides*. The abundance of the shrubs and lianas (expressed per unit hectare) were not significantly differently between 2015 and 2021. In terms of species evenness and richness (diversity), the year 2015 recorded higher values than 2021, with the implication that since 2015, ECFR could have lost some shrub and liana species perhaps from the forest understory clearing carried out in 2018.

A total of 92 vines and herbs were recorded in ECFR for 2015 and 2021 study period. Of these, the most dominant vine and herb species in descending order *Alchemilla johnstonii, Drognetia iners, Asplenium spp, Panicum adenophorum, Acalypha pinata* and *Panicium spp*. The relative abundance of the vines and herbs (expressed per unit hectare) were not significantly different in 2015 and 2021. Species evenness and richness of the vines and herbs was higher in 2015 than in 2021, with the implication that since 2015, ECFR could have lost some vines and herb species perhaps from the forest understory clearing carried out in 2018.

A total of 15 rodent species were recorded in ECFR for 2015 and 2021 study period. Of these, the most dominant rodent species in descending order were *Myomys Funatus, Mastomys natalensis, Laphuromys spp., Dasmys incomptu*s and *Lophuromys flavopunctatus*. The relative abundance of the rodents (expressed per unit hectare) was not significantly different between 2015 and 2021. Furthermore, the rodents' species evenness and richness in 2015 and 2021 were similar.

A total of 103 bird species were recorded in ECFR with 72 species in 2015 and 82 species in 2021 study periods. The avifauna of Echuya showed some changes between 2015 and 2021 related to increased level human disturbances in the CFR. There is still a high number of forest birds but a large proportion of the bird community are the forest generalists or forest edge species (F-species) that are of low conservation significance since they are widely distributed. There was also an increase in species density. However, the increase was due to the invasion of non-forest species exploiting new habitats. Further disturbance is likely to lead to loss of more forest species like the forage gleaners that depend on dead trees that are harvested for fuelwood and the ground feeders that depend on bamboo litter which will dry with the removal of more bamboo poles, climbers, and forest understory. The forage gleaners and ground feeders have a highly specialized diet or foraging behavior and are physiologically intolerant of microclimatic changes of a disturbed forest. The increase in the species density of mixed feeders and f-species in some parts of the forest is an indicator of loss of quality of the forest. This study considers only short-term results. However, the responses of any species to disturbance are potentially varied and difficult to predict. There is a need to generate more information on the long-term effects of disturbance on forest bird species that will help management in designing mitigation strategies to reduce the deleterious impacts of human activities on biodiversity.

The forest area that was cleared of forest understory (climbers and other forest understory plants) by NFA in 2018 was calculated to be about 3.6Km^2 and is 11% of the entire ECFR area coverage. The most prevalent human activities recorded in ECFR for both 2015 and 2021 in descending order were fresh human trails, pole cutting, livestock grazing, firewood collection and bamboo stem harvesting. The number of human activity signs recorded in ECFR increased from 61 in 2015 to 227 in 2021 and was statistically significant. The human activities in ECFR have been increasing with increased demand of forest resources from the surrounding communities.

The anthropogenic activities within the ECFR have more than tripled since 2015 and these are most likely going to increase in the near future. It would therefore be plausible to conclude that the increased anthropogenic activities in ECFR together with the clearing and cutting of the bamboo forest understory in 2018 have exacerbated the loss in some biodiversity for the ECFR and this is more expressed by the shrubs, lianas, vines, and herbs.

Furthermore, because of anthropogenic habitat manipulations in ECFR, some opportunistic tree species seem to have taken the advantage of less competition by increasing in abundance (individuals). Several recommendations have been suggested by this study that include enhanced law enforcement, regulation, and strict enforcements of forest resource harvest quotas for ECFR and proactively increased agroforestry activities in the local communities around ECFR.

1.0 Introduction

Globally, biodiversity in forestlands has become one of the major concerns of forest management (Kutnar et al., 2019). Biodiversity is one of the fundamental properties of nature and source of immense potential for economic use and yet the ecological functions performed by the biological diversity are still less understood (Kanieski et al., 2018). The major global biodiversity habitat areas include the polar, tundra, oceans, grasslands, temperate, deserts, and tropical forests (Smith, 1996). Of these habitats, the tropical forests are arguably the most biologically diverse places on planet with many endemic and rare species (Ghazoul & Sheil, 2010; Smith, 1996). The tropical forests provide habitat for vast array of plants and animals, many of which are still undiscovered. Furthermore, these forests are essential for life on earth and about 1.6 billion people depend on them for their livelihood including the protection of watersheds and carbon sequestration (Ghazoul & Sheil, 2010; Odum & Barrett, 2005).

Unfortunately an estimated 154 million ha of these tropical forest are cleared each year by human activities for mainly cattle ranching and agriculture (Bruna & Ribeiro, 2005). Deforestation of these forests comes in many forms that include wild fires, clear-cutting, unsustainable logging for timber and degradation due to climate change all caused by humans (Bruna & Ribeiro, 2005; Ghazoul & Sheil, 2010). Unlike treefall gaps and other ‘naturally’ disturbed areas, the regeneration of secondary forests on anthropogenically disturbed forest does not always follow a predictable pathway. Instead, the type and intensity of post-clearing land use has major implications for the trajectory along which succession proceeds (Bruna & Ribeiro, 2005). Deforestation and habitat loss are widely expected to precipitate an extinction crisis among tropical forest species. Humans cause deforestation, and humans living in rural settings have the greatest impact on extant forest area in the tropics(Wright & Muller-Landau, 2006).

At the extreme corner of southwestern Uganda, lies the Echuya Central Forest Reserve (ECFR) juxtaposed between Mgahinga Gorilla and Bwindi Impenetrable National Parks. The ECFR like the two national parks of Bwindi and Mgahinga, is a unique Afromontane tropical forest with high species endemism and rare species (Plumptre et al., 2007). The

ECFR is not very rich in biodiversity like the other forests in the region (Bwindi and Mgahinga) but is considered of high conservation importance because of its endemic, rare and globally threatened flora, and fauna. These species include the African Golden Cat (Caracal aurata), rodents (*Lophuromys woosnami*, *Delanymys brooksi*, *Ruwenzorisorex suncoides*), and birds - Grauer's Swamp Warbler (*Bradypterus grauer*i) and the Abyssinian Ground-Thrush (*Geokichla piaggiae*) (Plumptre et al., 2007). The vegetation in ECFR is dominated by the montaine bamboo (*Arudinaria alpina*) to the south and southeast. The bamboos are scanty particularly the north and western parts of ECFR, woody and herbaceous plants *of Hagenia abyssinica, Macaranga kilimandscharica, Myrica sadicifolia, Syzygium guineense, Rubaus apelatus, Crotalaria spp*. and *Faurea saligna* dominate. (Banana & Tweheyo, 2001; Bitariho & McNeilage, 2008). The forest has a permanent high attitude swamp at 2300m a.s.l with vegetation dominated by sedges (*Carex* specie*s*), tussock vegetation and Giant lobelias.

The montane bamboo found in ECFR and other forests alike in the region has been variously described under different taxa (e.g. *Arundinaria alpina* and *Sinarundinaria alpina*) and has been recently described as *Yushania alpina* K. Schumann. The montane bamboo is a very important plant ecologically, socially and economically. It provides a habitat and food for the few remaining primates (baboons and blue monkeys) in ECFR and other small mammals (rodents) and birds; it is as well important for its other ecological functions such as water catchments and prevention of soil erosion. Socially and economically the bamboo in ECFR is harvested and used for making household items such as granaries, baskets, and building poles as well as fuel wood (Bitariho & McNeilage, 2008). It is one single most important plant that plays an important component in the livelihoods and rural economies of households around ECFR. The young bamboo shoots are important food component for blue monkeys (*Cercopithecus mitis*) and baboons (*Papio anubis)* during the rains in ECFR (Bitariho & McNeilage, 2008).

2.0 Study Justification

In 2015, Bitariho et al., (2015), assessed the status of biodiversity in ECFR but prior to that, Plumptre et al., (2007) had compiled the known species' information for the different flora and fauna of ECFR. In all the two ECFR biodiversity reports, it is clearly stated that the biodiversity of ECFR is under serious threat from anthropogenic activities and most especially from illegal resource extractions, timber cutting, cattle grazing and agricultural encroachments. In June 2018, the biodiversity threats to ECFR were further exacerbated, when the National Forest Authority (NFA) carried out massive bamboo forest understory clearance/weeding by cutting and removing all tree saplings, vines, shrubs, and lianas under the bamboo forest. This was done ostensibly to stimulate increased growth of the bamboo forest that was observed to be reducing in area. The NFA cleared and weeded an area of about 50 hectares of the mixed bamboo forest. Specifically in 2015, Bitariho et al., (2015) highlighted that despite the numerous development interventions in ECFR, the illegal activities in ECFR were a threat to the biodiversity therein. Nature Uganda has been implementing several community-based conservation initiatives since 1998 to curb illegal activities, promote sustainable use of natural resources and enhance biodiversity recovery in ECFR. There was therefore a need to assess the impact of the different anthropogenic activities (illegal activities and the forest understory clearance) on the biodiversity of ECFR more especially since 2015. This was the reason why this study was carried out. Using the baseline data from Bitariho *et al* (2015), the status of ECFR biodiversity in 2015 and 2021 was compared. The study compared fauna and flora species richness/abundance and distribution in 2015 and currently (2021). As we highlight in the results section below, the comparison of the status of the biodiversity using surrogate indicators highlights the magnitude of the anthropogenic perturbations on the biodiversity in ECFR.

3.0 Study Objectives

The study was based on the following objectives. We;

i. Compared the surrogate fauna and flora species richness, abundance, and distribution in 2015 and 2021.
ii. Determined the number and types of human activities observed in ECFR
iii. Determined the current and updated status of biodiversity in ECFR following various human activities

iv. Made appropriate management, research and monitoring recommendations for subsequent follow up actions

4.0 Methods

4.1 Study site

ECFR is an Afromontane Central Forest Reserve located between latitude 1°14’ to 1°21’ south and longitude 29°47’-29°52’ east in southwestern Uganda. It is located 15 km west of Kabale town, and 11 km east of Kisoro town and is surrounded by eight local administrative parishes (Figure 1). The ECFR covers an area of 34 km^2 with an elevational range between 2,270-2,570 meters above sea level (Bitariho & McNeilage, 2008). The area immediately surrounding the forest is densely populated, with a density of between 150-499 people km^{2}. Majority of the people live below the poverty line, with over 74% of the local population depending heavily on forest resources (Bitariho et al., 2016). The major vegetation types of ECFR include broad leaved trees (*Macaranga capensis, Neobotania macrocalyx and Nuxia congesta*), Mixed bamboo, Pines, pure bamboo, and the swamp sedges (Figure 2). More half of the forest is now covered with broad leaved tree species as Figure 2 shows.

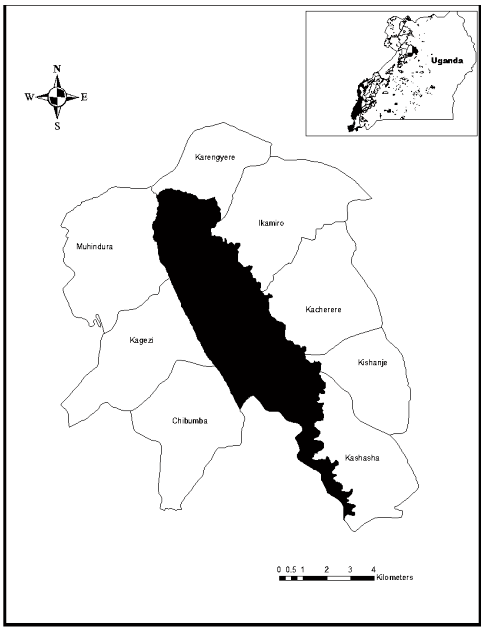


Figure 1 Study area map of ECFR and its surrounding parishes in S.W Uganda

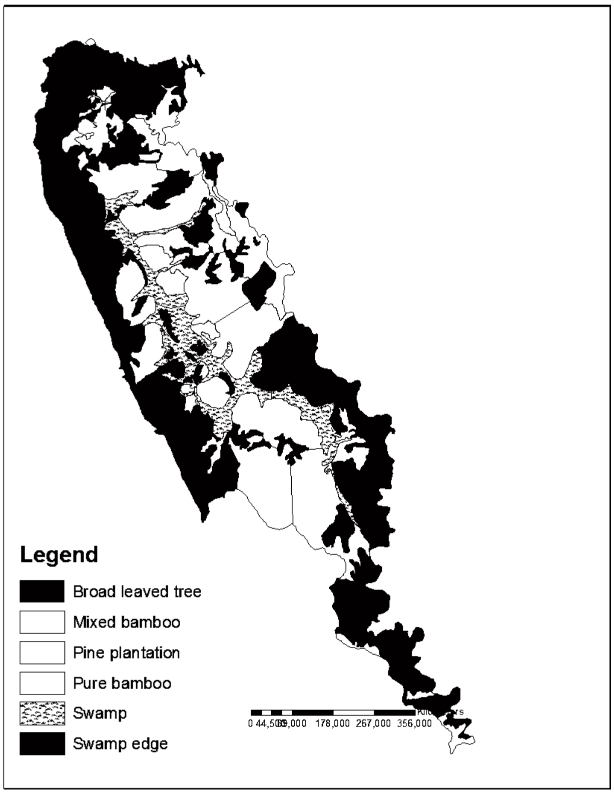


Figure 2 The major vegetation types of ECFR

4.2 Biodiversity surveys

As it is impossible to survey all the possible taxa (Plumptre et al., 2007), three taxa; vegetation, terrestrial vertebrates (only small mammals) and birds were used as surrogate indicator sspecies for the total biodiversity of ECFR. Plumptre et al., (2007) further reports that species richness of mammals, birds and plants could predict well the species richness of other taxa such as reptiles, amphibians, and large mammals. The species richness of small mammals, birds and plants were compared for 2015 (baseline) and 2021.

4.2.1 Assessments of trees, shrubs, lianas, vines, and herbs

Ecologists have devised several ways of assessing vegetation communities (Ghazoul & Sheil, 2010; Sheil, 2001). Transects are particularly quick and allow more productive sampling in dense vegetation (Sutherland, 1996). We therefore used belt transects (10) m wide running from the forest edge into the forest interiors to assess the ECFR plant community (Hall & Bawa, 1993). The location of the transects were determined randomly using random numbers of the eastings/northings of the ECFR map using the ArcGIS mapping software (Figure 3). A total of six transects separated from each other by 1km were established. We then used nested quadrats to assess the different vegetation types of ECFR. Trees (dbh ≥10cm) were enumerated in plots of 10m×10 m, shrubs, lianas in a 5×5m plots and vines/herb in a 2.5×2.5 m plots (Table

1 and Figure 4). The nested quadrats were placed at every 50 m interval along the belt transects following methods of Mwima & McNeilage, (2003): Bitariho & McNeilage, (2008). The plant species were identified to species level, and diameters recorded for only trees in the sample plots.

Furthermore, for each nested quadrat, the following environmental variables were recorded: whether the quadrat was in the site where the bamboo forest understory was cleared/weeded or not, GPS position, altitude, slope position, aspect, canopy cover and any human activity signs identified. We measured the diameter at breast height (DBH) of the tree species only while the rest of the plants (shrubs, vines, herbs and lianas) were recorded for abundance (numbers). The start, sample plot and end of the transect points were marked with biodegradable flagging tape and georeferenced with handheld GPS units.

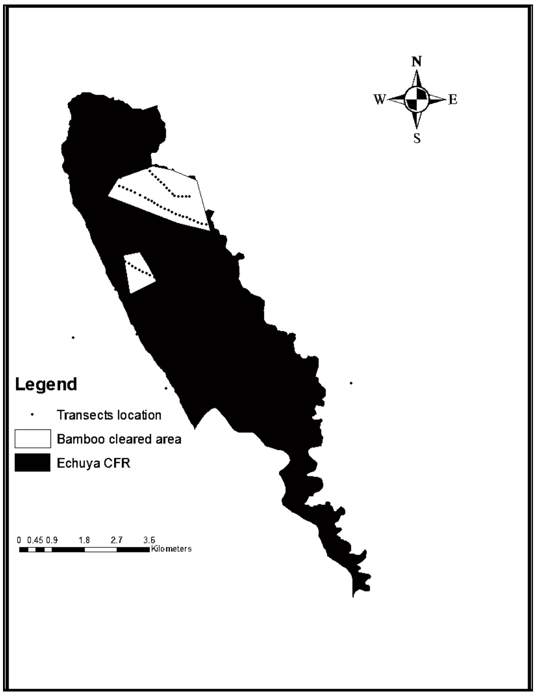
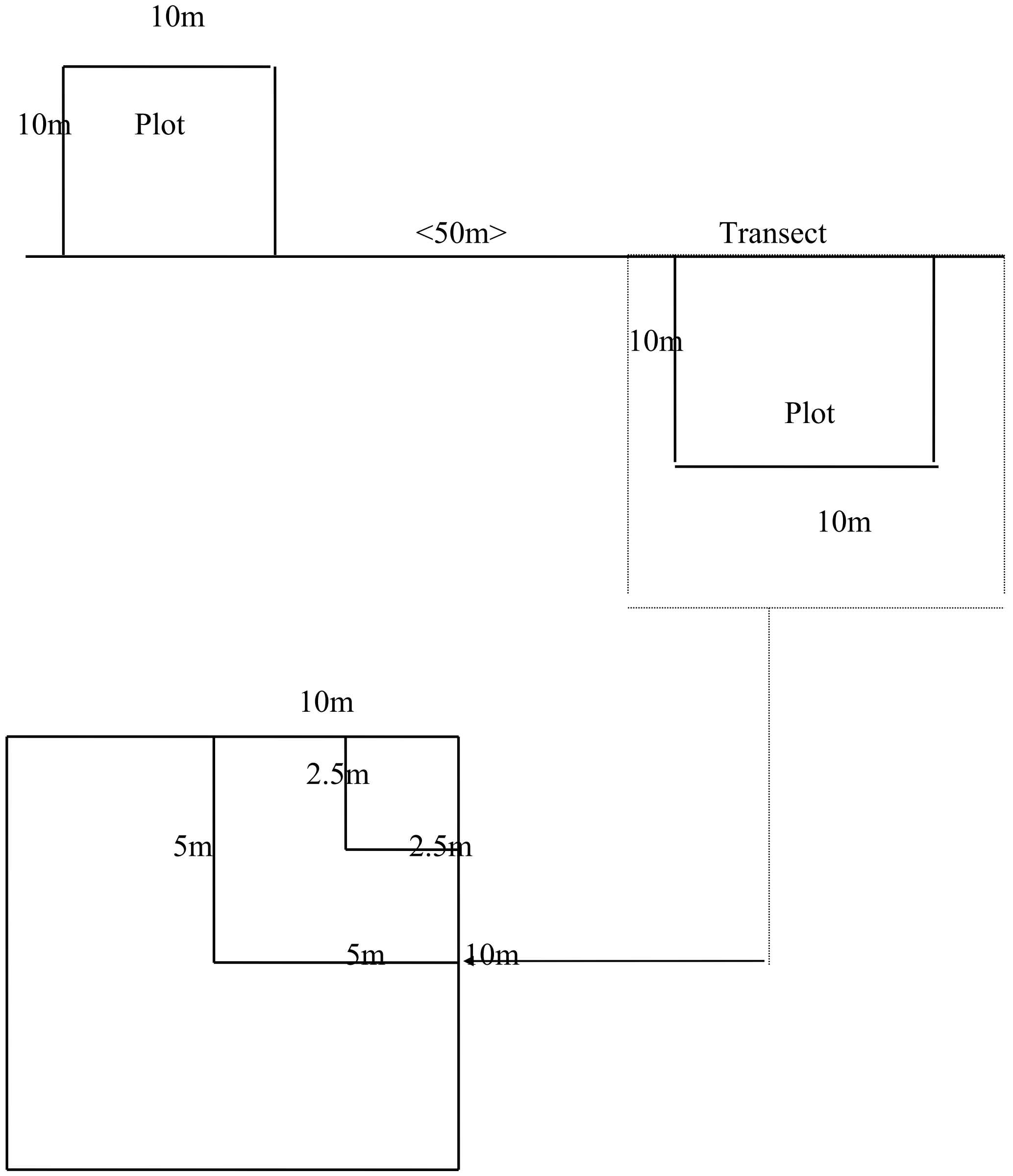


Figure 3 Map of ECFR showing location of the six transects across the forest

Table 1 Quadrat sizes for the various plant life-forms

Quadrat Size (m)	Plant Life-form
2.5 x 2.5	Vines and Herbs
5 x 5	Shrubs and Lianas
10 x 10	Tree species

Figure 4 Nested plot/quadrat layout on the transects



4.2.2 Small mammal (rodents) species diversity and abundance

Small mammals field methods were aimed at obtaining qualitative rather than quantitative data, with emphasis on species richness and relative abundance rather than on population densities. We used two of the six transects set for vegetation sampling and one more transect across the swamp to sample the small mammals. A specific team focusing on small mammals visitd the same points as the vegetation sampling team. Trapping of rodents was done a couple of days after the transects had been set and walked by the botanists and ornithologists to reduce on the possible deleterious effects, any noise and movements made by the botanical team would have on trap success. Sampling was made at 600 m intervals in an area of 10m x 10m and 40 Sherman live traps set in two rows at a 10-m interval. Traps were baited with ground nut butter and over ripened, mashed yellow bananas. The traps were set between 0800 and 0900 hours in the morning and checked between 1630 to 1830 hours in the evening, then reset and checked in the morning of the next day to ensure capture of both diurnal and nocturnal species. Each trapped animal was then weighed, measured, sexed and its reproductive condition assessed. All the external attributes such as fur colour and texture, back colour of fore and hind foot, whisker and other physical features were recorded. The trapped samples were then identified to the species level following (Kingdon, 2015) nomenclature. Small mammal trapping covered both the cleared forest understory sites and uncleared bamboo sites.

Plate 1. Setting up Sherman traps for rodents sampling in the swamp

4.2.3 Bird species richness and diversity

The point-count method was used to assess bird species diversity and richness. Counts of birds were made two days after the transects have been randomly established and walked by the vegetation team to reduce the possible deleterious effects any noise and movements made by the team would have on observations of birds. Point counts were established at 200 m intervals along the transects. On arrival at each point-count site, the team would wait for 2 min before beginning to count to allow the birds to settle down. All birds detected visually and acoustically within a fixed radius of 100 m were recorded during a period of 10 minutes. Birds in flight were not recorded. Bird sampling was conducted between 0700 and 1100 hours in the morning and again between 1600 to 1800 hours in the evening when the weather was calm and dry and the birds most active. Taxonomy and nomenclature follow Stevenson and Fanshawe (2020).

Bird species were grouped using three methods: first, we grouped the species according to their levels of forest dependence following the classification given in Bennun *et al*. (1996): (i) FF-species (*forest specialists*: true forest birds characteristic of the interior of undisturbed forest; occasionally albeit rarely occurring in non-forest habitats and secondary forest if their particular ecological requirements are met, but breeding almost invariably within undisturbed forest); (ii) F-species (*forest generalists*: occur fairly commonly in both undisturbed and secondary forest, forest strips, edges and gaps, but often breed within forest interior); and (iii) f-species (*forest visitors*: birds repeatedly recorded in the forest interior but not dependent on it, being more common in non-forest habitats, where they are likely to breed). Any species not included in the Bennun *et al*. (1996) list was categorized as non-forest (nf). Second, birds were grouped into five categories based on four main feeding habits viz. fly-catching (*flycatcher*), gleaning for insects (*forage gleaner*), fruit eating (*frugivore*) and ground feeders (*ground feeder*), the fifth being a combination of two or more of these (*mixed feeder*) (Githuru and Dejene 2008). We used information in the Birds of Africa series (Vols 1 - 7) for this classification. Last, we singled out the bird species that are globally threatened (Birdlife International 2022) and those endemic to the mountains along the Albertine Rift (Stattersfield et al. 1998).

Due to the low sample sizes for most species, measures of species richness, rather than abundance were analysed. Most species were single individuals, reducing the counts to presence/absence. Therefore, all the data was binary transformed to presence/absence. We then estimated the following basic community indices for each survey period (i.e., 2015 and 2021):

species richness was obtained by use of Margalef's index; species density was estimated as the number of species per count-point; species diversity or heterogeneity was assessed by Shannon diversity index; the degree of similarity in frequency of species occurrences was measured by Simpson evenness index; and the relative importance of dominant species was evaluated using the inverse of Simpson's index (Magurran 1988). We compared the changes in species density in habitat dependency and feeding guilds between 2015 and 2022 using z-tests and changes per major vegetation type (broad-leafed forest, mixed bamboo and herbaceous areas) in relation to habitat categories, feeding guilds using Kruskal-Wallis rank sum test.

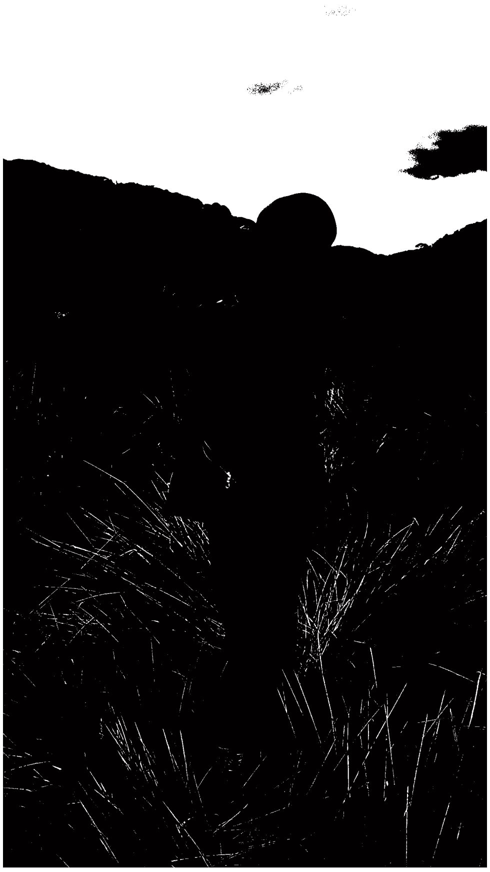


Plate 2 Using a binocular to detect and identify bird species in the Muchuya swamp

We assessed the effects of forest disturbance between 2015 and 2021 on the bird community of Echuya CFR. The following questions were asked: How did the bird community diversity change after five years of intensified forest disturbance? Which species categories were affected, and how?

4.3 Mapping bamboo forest areas whose understory was cleared/weeded

Using a handheld Global Positioning System (GPS) and with the help of NFA officials (Patrol men, forest guards, etc.), we identified and recorded the GPS locations of the ECFR forest areas whose understory were cleared/weeded of tree saplings, lianas, vines, and shrubs by NFA in 2015/6. The boundaries of these cleared bamboo forest patches were walked while taking GPS coordinates at specific physical features e.g., rivers, trails, ridges, etc. The GPS co-ordinates were then be incorporated into the GIS database for ECFR and displayed on the map using ArcGIS 10.5 software.

4.4 Data analysis

4.4.1 Plants, birds and small mammals' abundance, diversity, and distribution

The fauna and flora species data and environmental variables from all sites was collated in Microsoft Excel spreadsheets. The species data was first coded in an Excel spreadsheet as number of individuals for trees and present/absent for shrubs, lianas, vines, seedlings, small mammals, and birds sampled per unit hectare.The data was then imported into R software package for analysis, graphing and statistical testing (Bitariho et al., 2020). All the data was analysed using R open source statistical software version 3.2.2 (R Core Team., 2018).

Comparisons of the total number and type of species for each taxon in ECFR between 2015 and 2021 was made using boxplots plotted using "ggplot2" in Rstudio 2021 version 1.4.1717 software. Statistical inferences to test for differences in abundance and species diversity for each taxon over the study years (2015 and 2021) was then made using a Kruskal-Wallis Chi-Squared test in RStudio 2021 version 1.4.1717. The Shannon diversity index was used to calculate the diversity index for each taxon and compared for 2015 and 2021 (Kanieski et al., 2018). The higher the Shannon index of two sites compared, the higher diversity of that site. Furthermore, the Shannon Equitability Index was used to calculate species evenness (relative abundance) for the different flora and fauna taxa. When the Shannon Equitability Index is equal to **1** then all the species have same abundance and when it tends towards **0** then the near total of flora is concentrated on only one species (Ifo et al., 2016).

The Shannon index formular used was;

$$\mathbf{H = H = -\sum(n_i/N) \log (n_i/N)}$$

Where $\mathbf{n_i}$ = Importance value for each species,

N=total of importance values

The Shannon Equitability Index formular used was;

$E_H = H / ln(S)$, where:

- ***H*****:** The Shannon Diversity Index
- ***S*****:** The total number of unique species
- ***ln:*** Natural log

This value ranges from 0 to 1 where 1 indicates complete evenness.

Sampling effort for bird species

We analyzed the sampling effort for bird species counts using the species accumulation curve (Figure 5). The slopes of the bird species accumulation curves plotted for successive bird point-counts for each study period (i.e., 2015 and 2021) remained steep (Figure 5), especially for 2015, indicating that more bird species remained unrecorded. However, for 2021, the curve shape showed a steady increase and nearly reached asymptote. This implies that the 2021 survey provided a reliable representation of the bird species of the sampled area. The reason for the difference in curve lengths is that two and half times more points were counted in 2021 than in 2015.

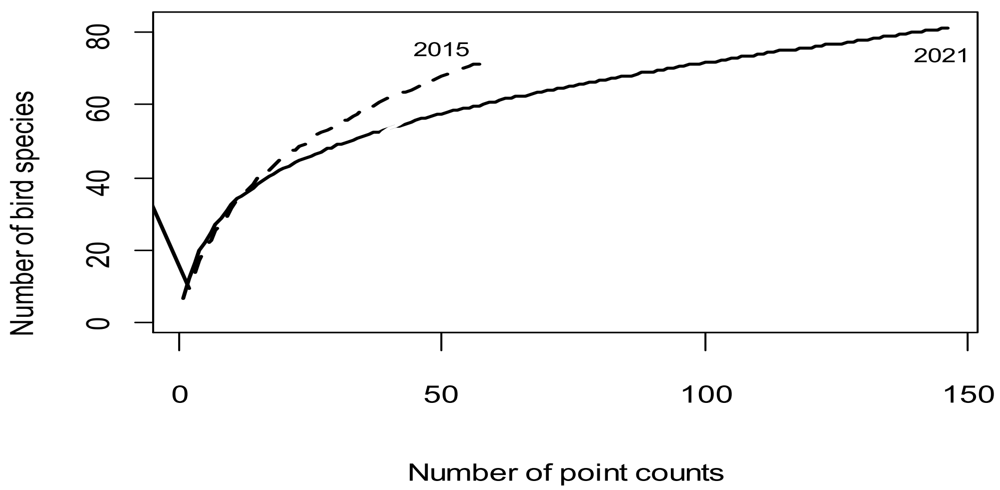


Figure 5 Species-accumulation curves for successive bird counts in 2015 and 2021 in ECFR

4.4.2 Human activities data

The GPS data of the human activity encounters was first entered in Microsoft Excel and then exported (after conversion into txt file type) into RStudio 2021 version 1.4.1717 software. Comparisons of the distribution, number, and types of human activities in ECFR between 2015 and 2021 was made using boxplots plotted using “ggplot2” in Rstudio 2021 version 1.4.1717 software. Statistical inferences to test for differences in human activities between the study years (2015 and 2021) was then made using a Kruskal-Wallis Chi-Squared test in RStudio 2021 version 1.4.1717.

5.0 Results

5.1 Species richness (diversity) and evenness of trees

A total of 27 tree species were recorded in ECFR for 2015 and 2021 study period (See appendix). In 2015, eleven tree species were recorded while in 2021 twenty-one species were recorded (Table 2). Of these tree species, *Macaranga capensis, Psychotria mahonnii*, *Xymalos monospora, Neoboutonia macrocalyx, Maesa lanceolata* and *Nuxia congesta* were the most dominant in descending order (Figure 6). The least dominant tree species in ascending order in ECFR for both 2015 and 2021 were *Podocarpus latifolius, Pittosporum spathicalyx, Mystroxylon aethiopian, Morella salicifolia* and *Lepidotrichillia sp*. (Figure 6). In 2015, a total of 233 tree stems (11 stems per ha) were recorded while in 2021 a total of 591 tree stems (22 stems per ha) were recorded (increased twice fold). However, statistical comparison shows that there was no significant difference in the abundance of the tree stems (expressed per unit hectare) recorded in 2015 and 2021 (Kruskal-Wallis Chi-square == 1.4709, df = 1, **p-value = 0.2252).** Table 2 shows a comparison the relative abundance of the tree species (evenness) and species richness (diversity) in 2015 and 2021. From the Table 2, the species evenness and richness in the year 2021 was twice higher than that of 2015. The tree species evenness in 2015 is low and the species total flora is concentrated only in one species that has more stems (abundance) and this was the *Macaranga capensis* that constituted of over 64% of all the tree stems sampled (Figure 6 & Table 2). In 2021, the tree species relative abundance (evenness) was similar for all the tree species since the evenness tended to 1 (0.71) as shown in Table 2. Table 2 further shows that the tree species diversity in ECFR increased two-fold in 2021. The implication of the tree species evenness and diversity is that 2021 had a higher biological diversity (in terms of trees) than 2015.

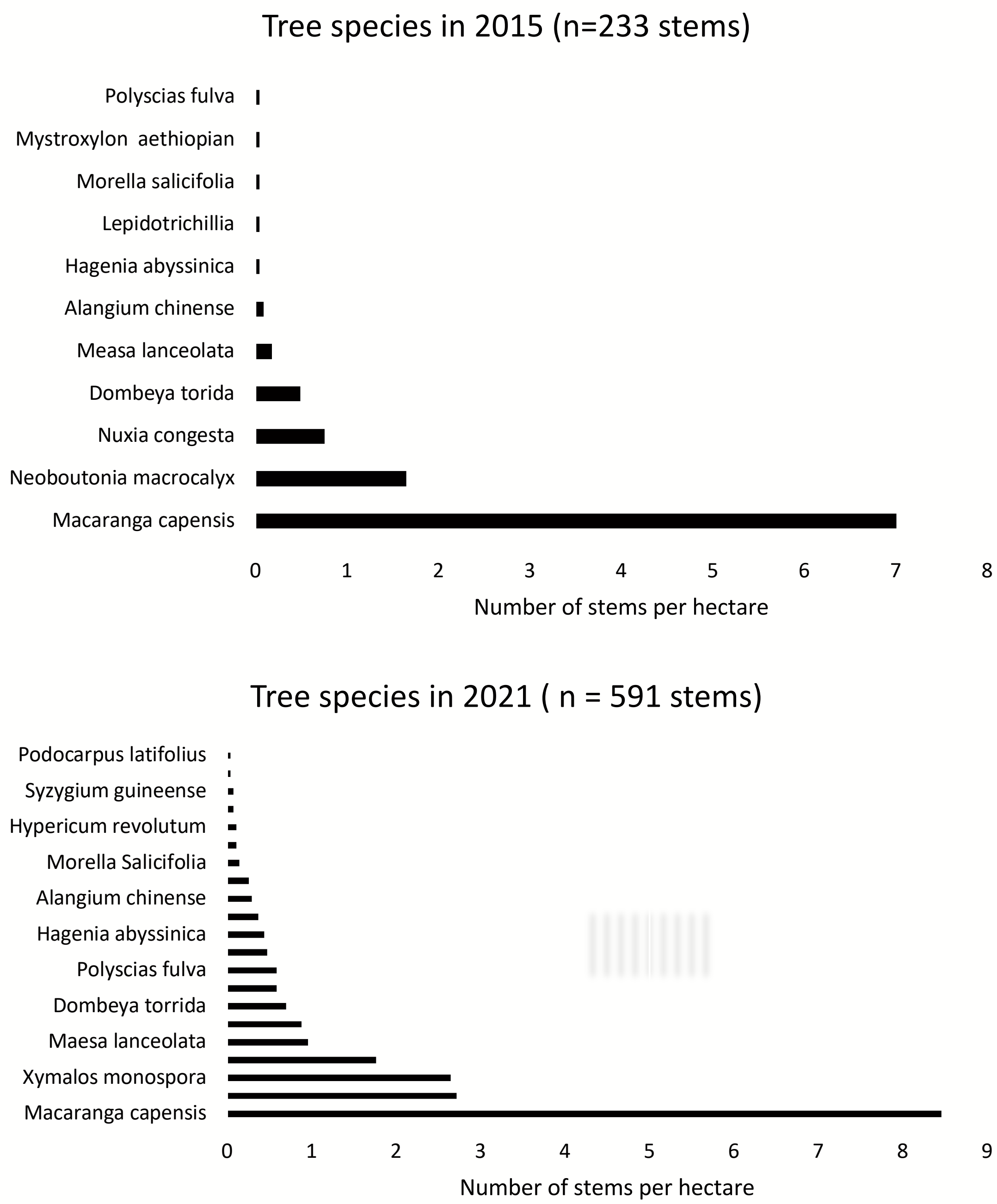


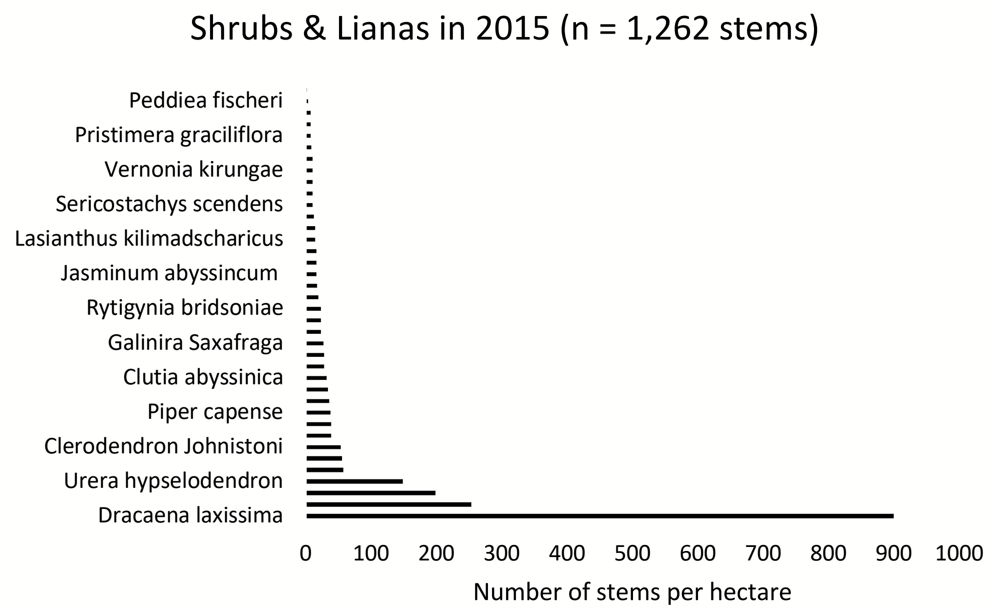
Figure 6 A comparison of tree species relative abundance in 2015 and 2021

Table 2 A comparison of species evenness (relative abundance) and species richness of the different flora and fauna in 2015 and 2021

Species Category	Species abundance per ha		Number of species		Species Diversity		Species Evenness	
	2015	2021	2015	2021	2015	2021	2015	2021
Trees	10	22	11	21	1.12	**2.15**	0.37	**0.71**
Shrubs & Lianas	2,254	9,968	38	40	**2.48**	2.36	**0.79**	0.46
Vines & Herbs	35,907	59,735	48	48	**2.98**	2.86	**0.64**	0.53
Rodents	5	11	11	8	**1.85**	1.81	**1.0**	0.92
Birds	1.8	4.21	76	79	**3.81**	3.49	**1.0**	**1.0**

5.2 Species richness (diversity) and evenness of shrubs and lianas

A total of 60 shrub and liana species were recorded in ECFR for 2015 and 2021 study period (See appendix). In 2015, thirty eight shrub and liana species were recorded while in 2021 forty species of shrubs and lianas were recorded (Table 2). Of these, the most dominant shrubs and lianas in descending order were *Mimulopsis Solmsii*, *Triumfetta cordifolia, Phillipia denguelinsis*, *Dracaena laxissima*, *Urera hypselodendron*, *Piper capense*, and *Rhamnus prinoides* (Figure 7). The least recorded shrubs and lianas in ascending in ECFR for both 2015 and 2021 were *Pcynostachys elliotii, Peddiea fischeri, Keetia queinzii, Hibiscus diversifolius, Connarus longispictatus, Pristimera graciliflora* and *Discopodium pennineviun* (Figure 7). In 2015, a total of 1,262 shrubs/lianas (2,254 stems per ha) were recorded that increased to 6,778 (9,968 stems per ha) in 2021. The total stem abundance of the shrubs and lianas (expressed per unit hectare) was not significantly different between 2015 and 2021 (Kruskal-Wallis Chi-square == 1.4709, df = 1, **p-value = 0.06433**). Table 2 shows a comparison of the relative abundance of the shrub and liana species (evenness) and species richness (diversity) in 2015 and 2021. From the Table 2, the species evenness and richness in the year 2015 was higher than that of 2021. The shrub and lianas species evenness in 2021 was low since the species evenness index tended to 0 (0.4) and the shrubs and lianas evenness is concentrated on majorly one species that has more stems (abundance). This was the *Mimulopsis Solmsii* that constituted of over 31% of all the shrubs and lianas sampled in 2021. In 2015, the shrub and liana species showed similar abundance since the evenness index tended to 1 (0.79) as shown in Table 2. Table 2 further shows that the shrub and lianas species diversity in ECFR slightly decreased in 2021 when compared to 2015. The implication is that since 2015, there has been a slight decrease in biological diversity (in terms of shrubs and lianas) in ECFR with a further implications that ECFR could have lost a few shrubs and lianas species since 2015.



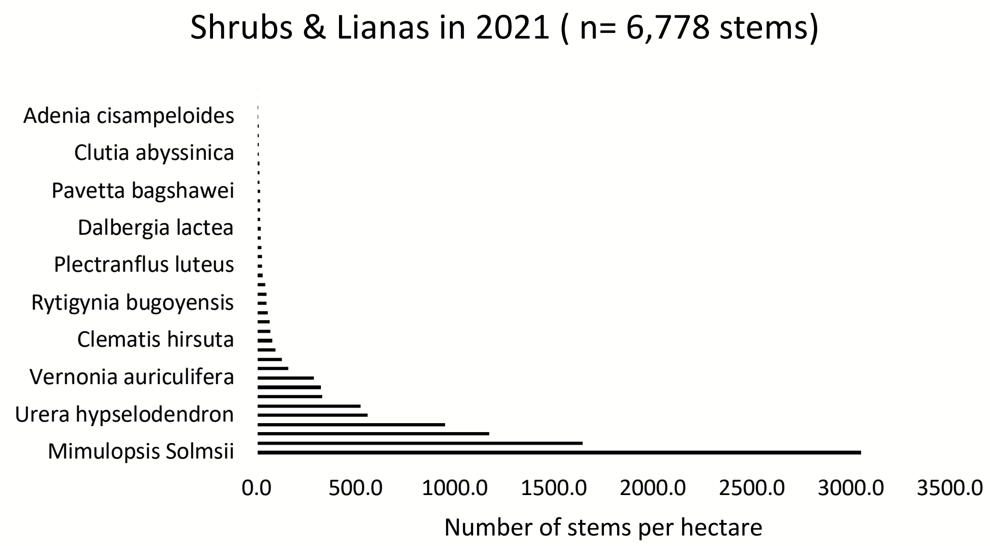


Figure 7 A comparison of the shrubs and lianas' relative abundance in 2015 and 2021

5.3 Species richness (diversity) and evenness of vines and herbs

A total of 92 vines and herbs were recorded in ECFR for 2015 and 2021 study period (see species list in appendix). Forty-eight vine and herb species were recorded in both 2015 and 2021 (Table 2). Of these, the most dominant vine and herb species in descending order *Alchemilla johnstonii, Drognetia iners, Asplenium spp, Panicum adenophorum, Acalypha pinata* and *Panicium spp* (Figure 8). The least vine and herb species recorded in ascending order in ECFR for both 2015 and 2021 were *Afroligusticum aculeolatum, Carpodium glabra, Solanum nigrum, Lobelia manii* and *Afroligusticum runssoricum* (Figure 8). In 2015, a total of 5,027 vines and herbs (35,907 stems per ha) were recorded while in 2021 a total of 10,155 vines and herbs (59,735 stems per ha) were recorded. However, the total stem abundance of the vines and herbs (expressed per unit hectare) were not significantly different between 2015 and 2021 (Kruskal-Wallis Chi-square == 0.97891, df = 1, **p-value = 0.3225).** Table 2 shows a comparison of the relative abundance of the vine and herb species (evenness) and species richness (diversity) between 2015 and 2021. From the Table 2, the species evenness and richness in the year 2015 was slightly higher than that of 2021. The vine and herb species evenness in 2021 was slightly lower than that of 2015 and since the evenness tended to 0 (0.5), the species total flora is concentrated on majorly one species that has more stems (abundance) and this was the *Alchemilla johnstonii* that constituted of over 24% of all the vines and herbs sampled. In 2015, the vine and herb species showed similar relative abundance since the evenness index tended to 1 (0.64) as shown in Table 2. Table 2 further shows that the vine and herb species diversity in ECFR slightly decreased in 2021 when compared to 2015. The implication is that since 2015, there has been a slight decrease in biological diversity (in terms of vines and herbs) in ECFR with a further implications that ECFR could have lost a few vines and herb species since 2015.

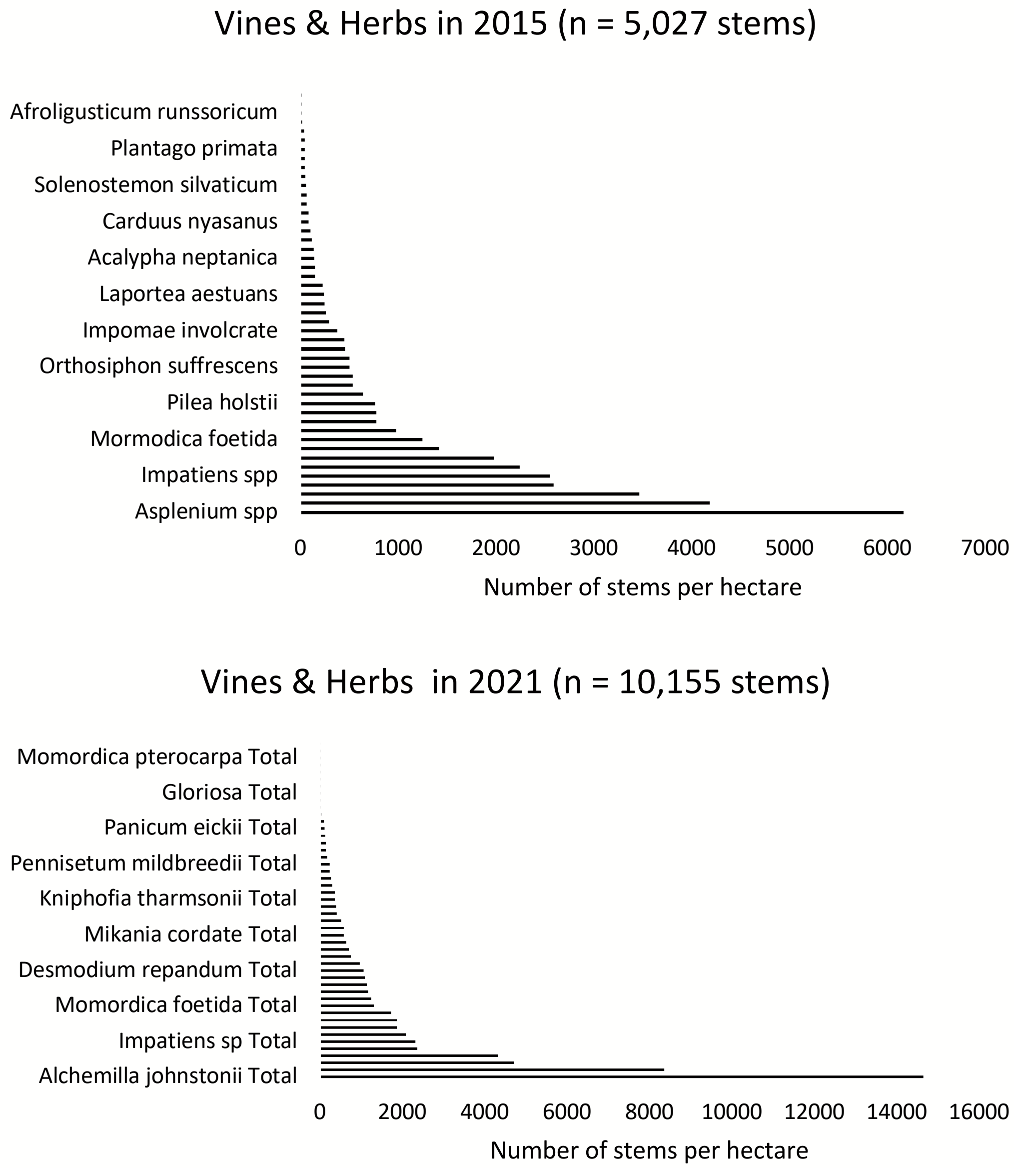


Figure 8 A comparison of vines and herbs; relative abundances in 2015 and 2021

5.4 Species richness (diversity) and evenness of small mammals (rodents)

A total of 15 rodents were recorded in ECFR for 2015 and 2021 study period (see species list in appendix). In 2015, eleven species of rodents were recorded while in 2012, only eight species of rodents were recorded (Table 2). Of these, the most dominant rodent species in descending order were *Myomys Funatus, Mastomys natalensis, Laphuromys spp., Dasmys incomptu*s and *Lophuromys flavopunctatus* (Figure 9). The least recorded rodent species in ECFR for both 2015 and 2021 were *Musgratus spp, Hybomys univittatus, Delanymys brooksi, Ruwenzori sorex* and *Laphuromys funatus* (Figure 9). In 2015, a total of 67 rodents (5 individuals per ha) were trapped/recorded while in 2021 a total of 31 rodents (11 individuals per ha) were trapped/recorded (Figure 9). However, the abundance of the trapped/recorded rodents (expressed per unit hectare) were not significantly different between 2015 and 2021 (Kruskal-Wallis Chi-square == 0.063711, df = 1, **p-value = 0.8007).** Table 2 shows a comparison the relative abundance (evenness) of the rodent species and species richness (diversity) between 2015 and 2021. From the Table 2, the species evenness and richness in the year 2015 was almost similar with that of 2021 (1 and 0.92 respectively). In both 2015, and 2021, the rodent species showed similar relative abundance since the evenness index was 1 and tended to 1 (0.92) for 2015 and 2021 respectively as shown in Table 2. Table 2 further shows that the rodent species diversity in ECFR in 2015 was almost similar with that of 2021 as the diversity index was almost similar (1.85 & 1.81 for 2015 and 2021 respectively). The implication of this is that the rodent species evenness and diversity for 2015 and 2021 was similar with an implication of no significant decrease in biodiversity (in terms of rodents) since 2015.

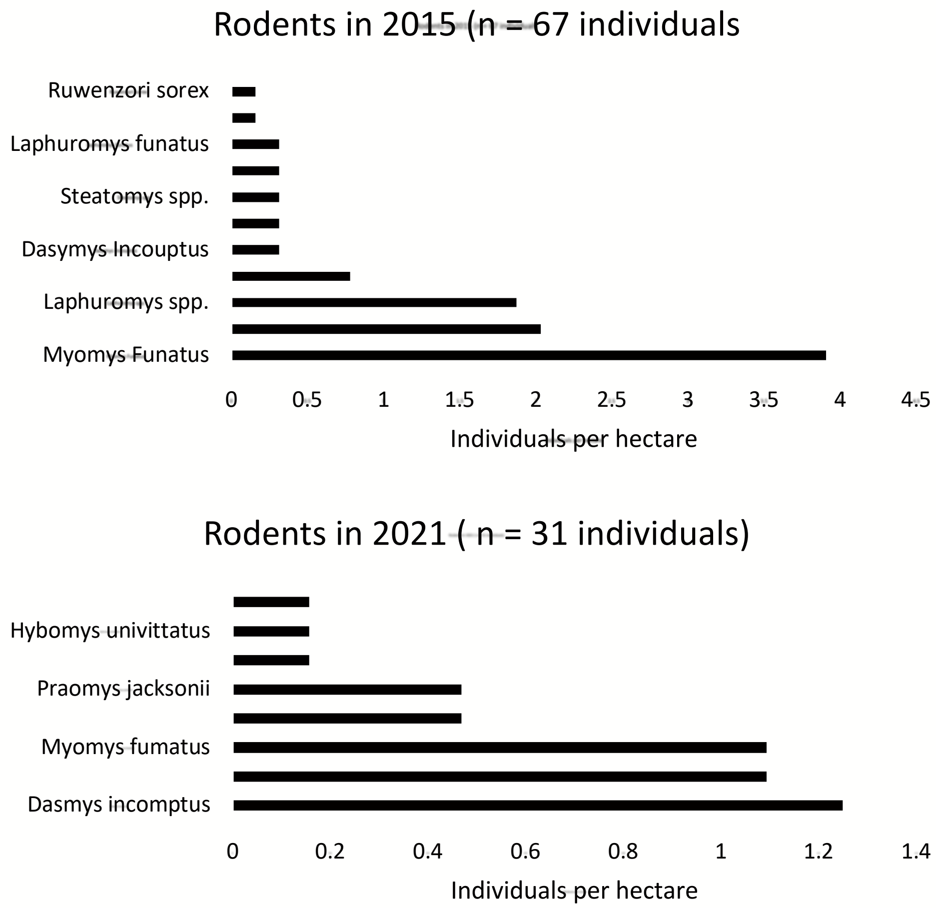


Figure 9 A comparison of rodents' relative abundance in 2015 and 2021

Plate 3. A Delaney's mouse (*Delanymys brooksi*) being Released after capture and identification

5.5 Species richness and diversity of birds

A total of 103 bird species were detected, of which 72 and 81 species were recorded in 2015 and 2021 respectively. There was an overlap of 50 species (48.5% of the total bird species) between the two survey periods, with 22 bird species being detected in 2015 but not in 2021, while 31 species were encountered in 2021 but not 2015 (Appendix 10.4). Of the bird species detected, two are globally threatened - Mountain Buzzard *Buteo oreophilus* (Near Threatened) and Grauer's Swamp Warbler *Bradypterus graueri* (Vulnerable) and 16 are endemic to the mountains along the Albertine Rift (Appendix 10.4). The avian community structure showed particular changes between 2015 and 2021. We recorded a significant higher species density in 2022 than in year 2016 (z-test, $Z=3.81$, $p<0.01$). Also, the dominance was higher in 2021 than 2015 (Table 3). However, the species richness, diversity and evenness declined between 2015 and 2021 (Table 3).

Table 3 Characteristics of avian community in 2015 and 2021 in ECFR

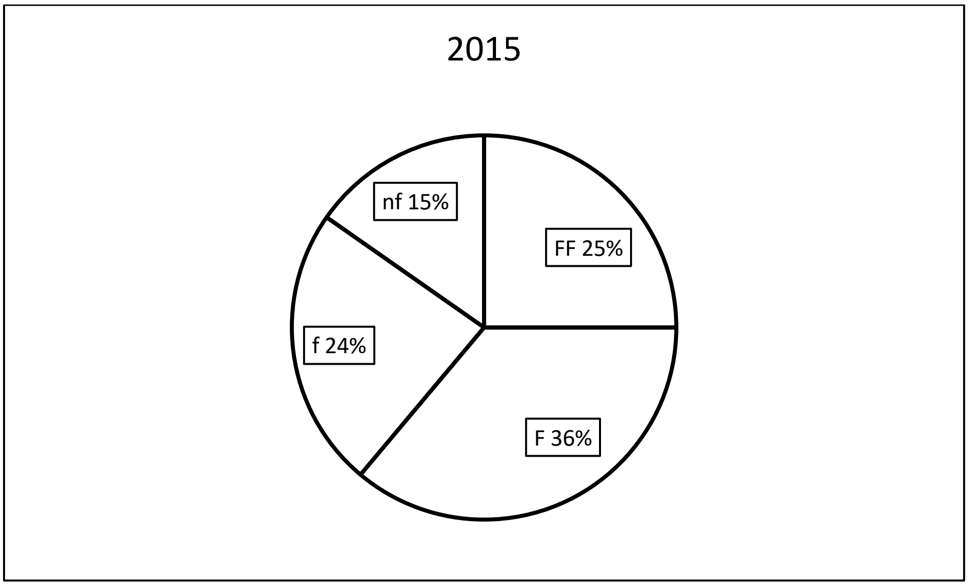
Population characteristic	**2015**	**2021**
Number of count points	58	146
Species recorded	72	81
Species richness	12.24	11.5
Species per count-point (min-max)	5.7 (1-12)	7.2 (2-21)

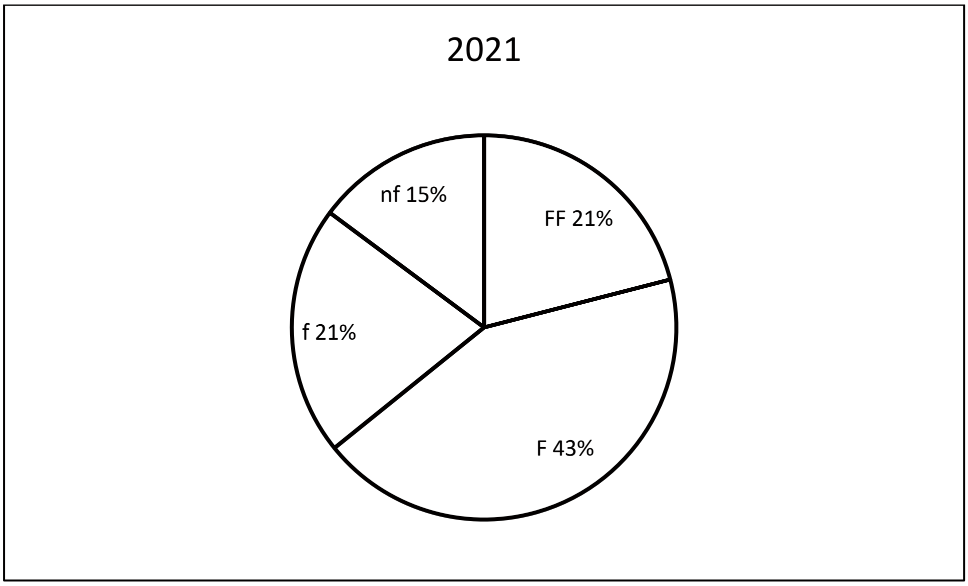
Diversity	3.74	3.67
Evenness	0.44	0.37
Dominance	28.69	29.34

5.5.1 Forest dependency of bird species

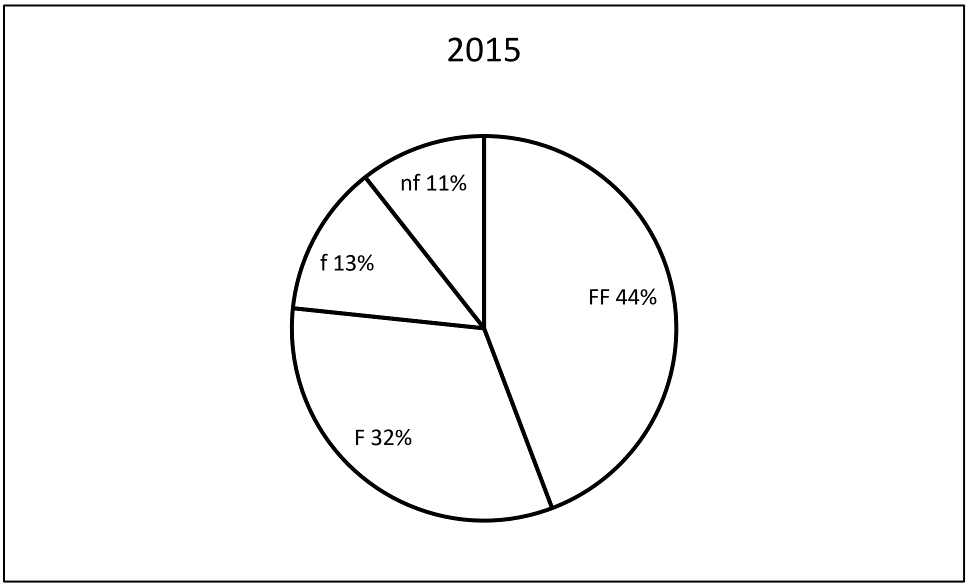
Overall, in both 2015 and 2021, the F-species had the highest percent proportions of the number of species and frequency of species occurrences (Figure 10a and b) and had the largest increase in percent proportion of number of species (by 7%) and in the frequency of species occurrence (by 19%). The increase in F-species occurrence per count-point between 2015 and 2021 was significant (z-test, Z=3.81, p<0.01) and f-species (z-test, Z=2.75, p<0.01). The FF-species declined most in percent proportion of number of species (by 4%) and frequency of species occurrences (by 23%). However, the decline in frequency of species occurrence of FF-species was not significant (z-test, Z=1.68, p>0.05)

a. By number of species





b. By frequency of species occurrence



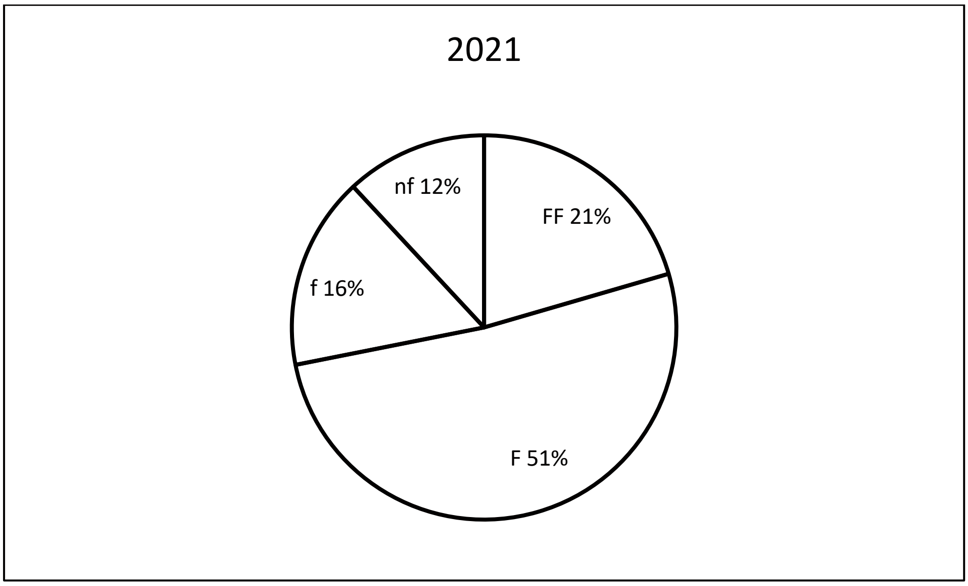


Figure 10 Proportions of birds in different forest-dependency categories in 2015 and 2021 in ECFR (FF: forest interior specialists, F: forest generalists, f: forest visitors, nf: non-forest)

Analysis of forest dependent species categories for each major vegetation type showed that the species density for F-species increased significantly across the three vegetation types and the f-species density increased significantly in broad-leafed forest and nearly significant in mixed bamboo (Table 4).

Table 4 Summary of changes in forest dependent category species density between 2015 and 2021 for the different vegetation types in ECFR

Habitat category	Kruskal-Wallis rank sum tests		
	Broad-leafed forest	Open herbaceous areas	Mixed bamboo forest
Forest interior specialists (FF)	ns	Ns	Ns
Forest generalists (F)	***	*	**
Forest visitors (f)	**	Ns	+
Non-forest (nf)	ns	Ns	Ns

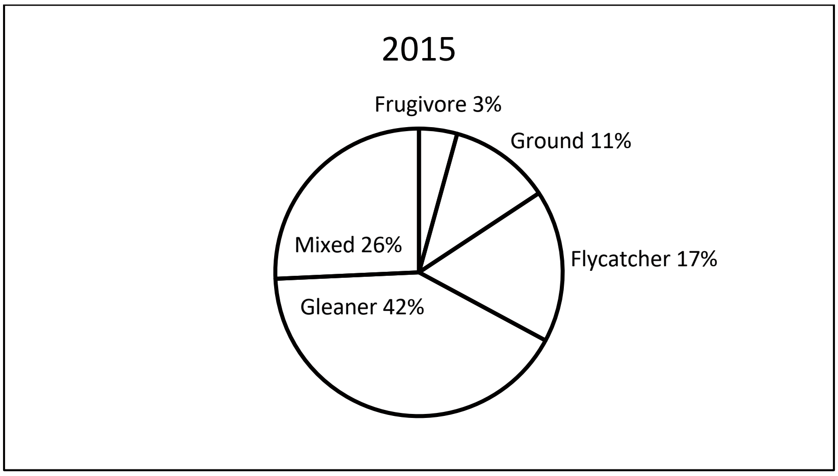
*** = p<0.001; ** = p<0.01; * = p<0.05; + = p=0.06; ns = non-significant

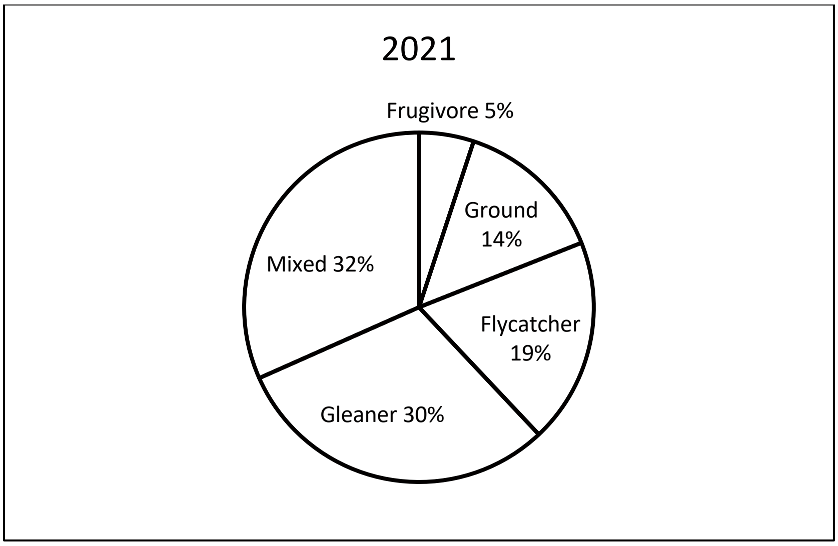
5.5.2 Feeding guilds of bird species

Between 2015 and 2021, the forage gleaners were the only feeding guild that declined in percent proportion of number of species (by 12%), while other feeding guilds marginally increased. As for the percent proportion of frequency of species occurrences, the ground feeders increased most (by 8%), while the frugivores and forage gleaner increased marginally. The frugivores had the lowest percent proportions of the number of species and frequency of species occurrences for both survey time periods (Figure 11a and b).

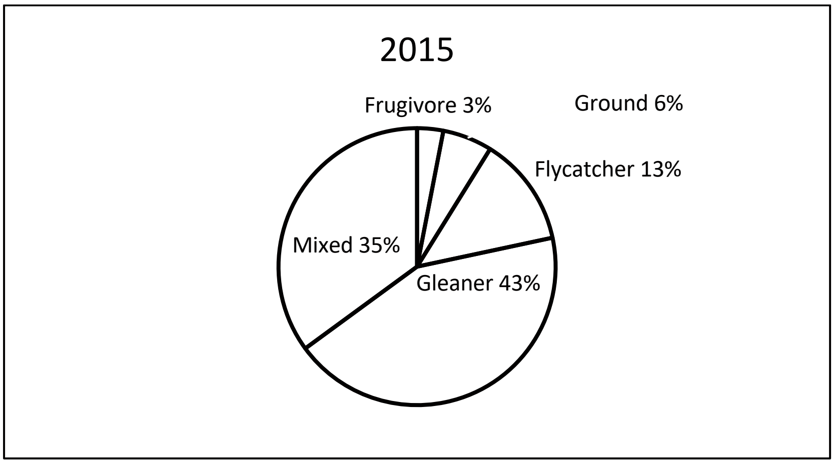
A comparison of the frequency of species occurrences per point-count between 2015 and 2021 indicated a significant increase between 2015 and 2021 for two feeding guilds – ground feeders (z-test, $Z=5.58$, $p<0.01$) and forage gleaners (z-test, $Z=2.96$, $p<0.01$). There was no significant change in species density for the rest of the feeding guilds.

a. By number of species





b. **By frequency of species occurrence**



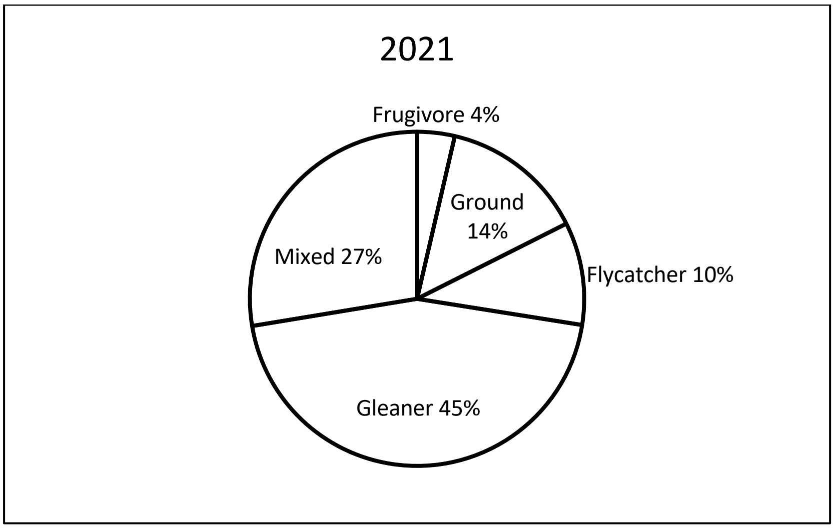


Figure 11 Proportions of birds in different feeding guilds in 2015 and 2021 in ECFR

Analysis of the feeding guilds for each major vegetation type showed that the ground feeders increased significantly in species density between 2015 and 2021 in the mixed bamboo forest, while the forage gleaners increased highly signicantly in broad-leafed forest, and the mixed feeders increased significantly in the mixed bamboo forest (Table 5).

Table 5 Summary of changes in feeding guild species density between 2015 and 2021 for the different vegetation types of ECFR

Feeding guild	Kruskal-Wallis rank sum tests		
	Broad-leafed forest	Open herbaceous areas	Mixed bamboo forest
Frugivores	ns	Ns	Ns
Ground feeders	ns	Ns	**
Flycatchers	ns	Ns	Ns
Gleaners	***	Ns	Ns
Mixed feeders	ns	Ns	*

*** = p<0.001; ** = p<0.01; * = p<0.05; + = p=0.06; ns = non-significant

5.6 Anthropogenic activities in ECFR

Figure 12 is a map of the ECFR showing the area that was cleared of forest understory (climbers and other forest understory plants) by NFA in 2018. The area of ECFR that was cleared of the forest understory by NFA is about $3.6km^2$ and is 11% of the entire ECFR area coverage ($34km^2$). Figure 13 shows the number and types of human activities recorded in ECFR in 2015 and 2021. The number and type of human activities recorded in ECFR were fresh human trails, climber harvests, pole cutting etc. as shown in Figure 13. The most prevalent human activities recorded in ECFR for both 2015 and 2021 in descending order were fresh human trails, pole cutting, livestock grazing, firewood collection and bamboo stem harvesting (Figure 13). The least recorded human activities for in ECFR for both 2015 and 2021 in ascending Climber harvests and beekeeping (Figure 13). The number of human activity signs recorded in ECFR increased from 61 signs in 2015 to 227 in 2021 and this difference was statistically significant (Kruskal-Wallis Chi-square == 2.369, df = 1, **p-value = 0.04238**). Figure 14 is a boxplot showing the differences in human activities recorded in ECFR in 2015 and 2021. The human activities in ECFR have been increasing with increased demand of forest resources from the surrounding communities.

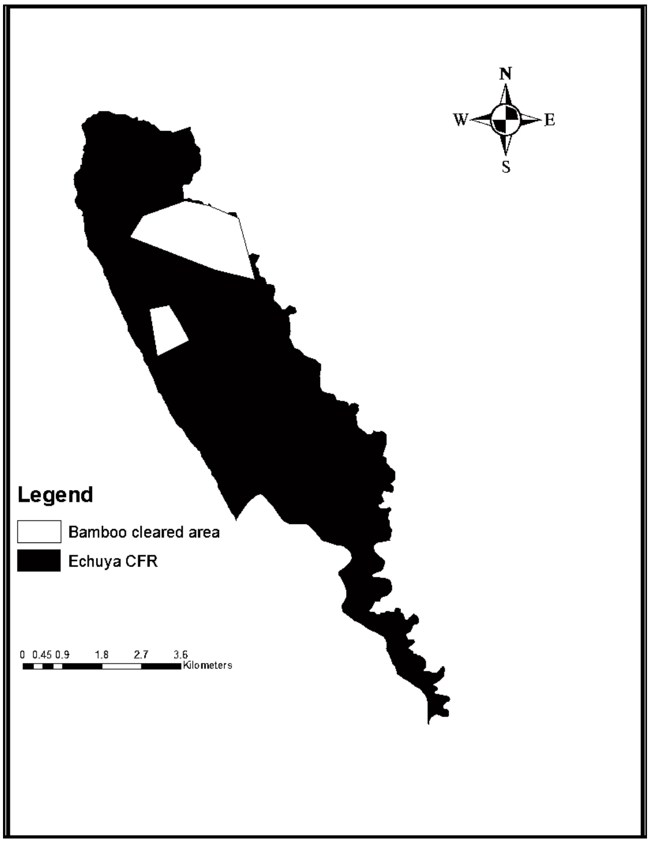
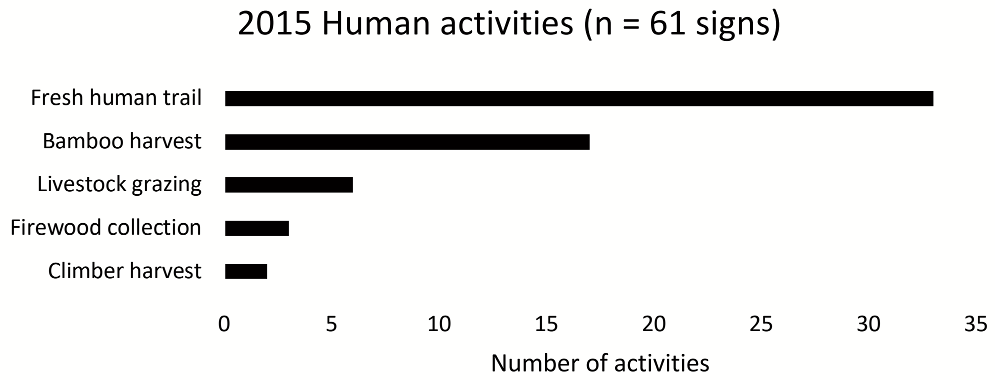


Figure 12 Location and extent of the cleared forest understory of ECFR in 2018


Plate 4. ECFR forest understory clearance in 2018



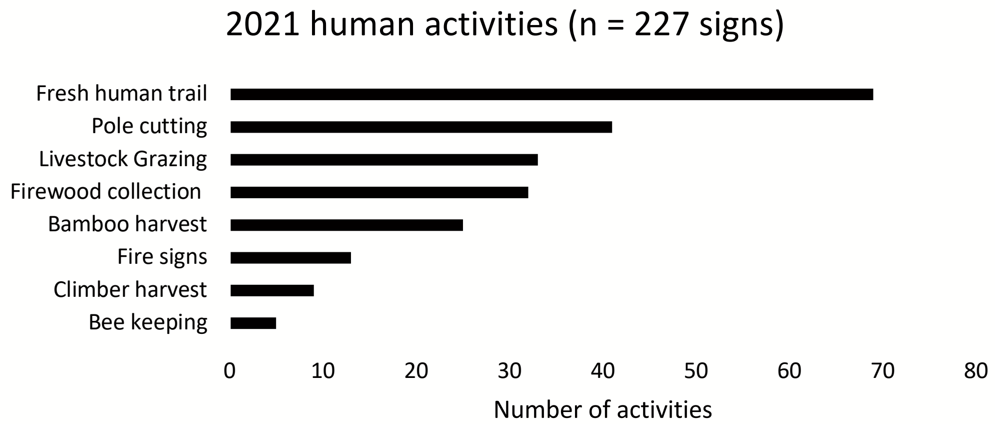


Figure 13 A comparison of types and numbers of human activities recorded in ECFR recorded in 2015 and 2018

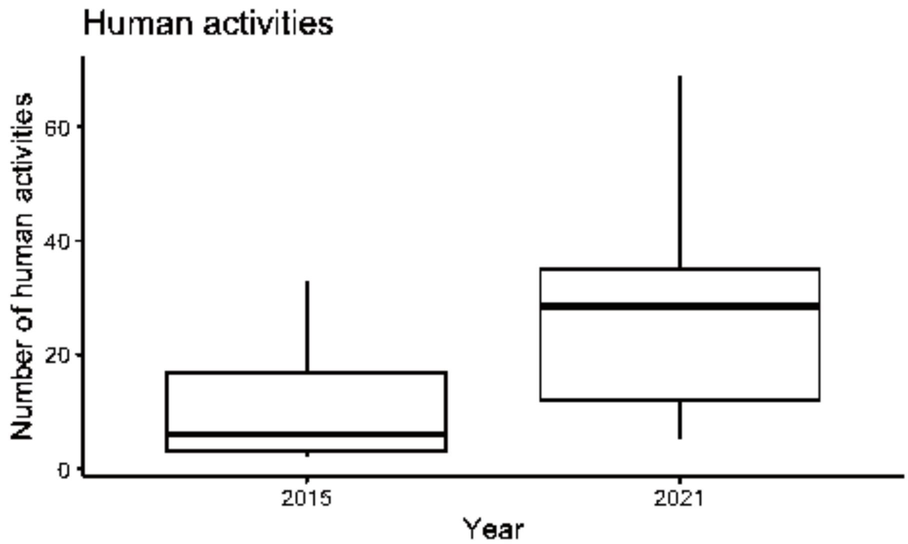


Figure 14 A boxplot showing differences in the number of human activities recorded between 2015 and 2021 in ECFR

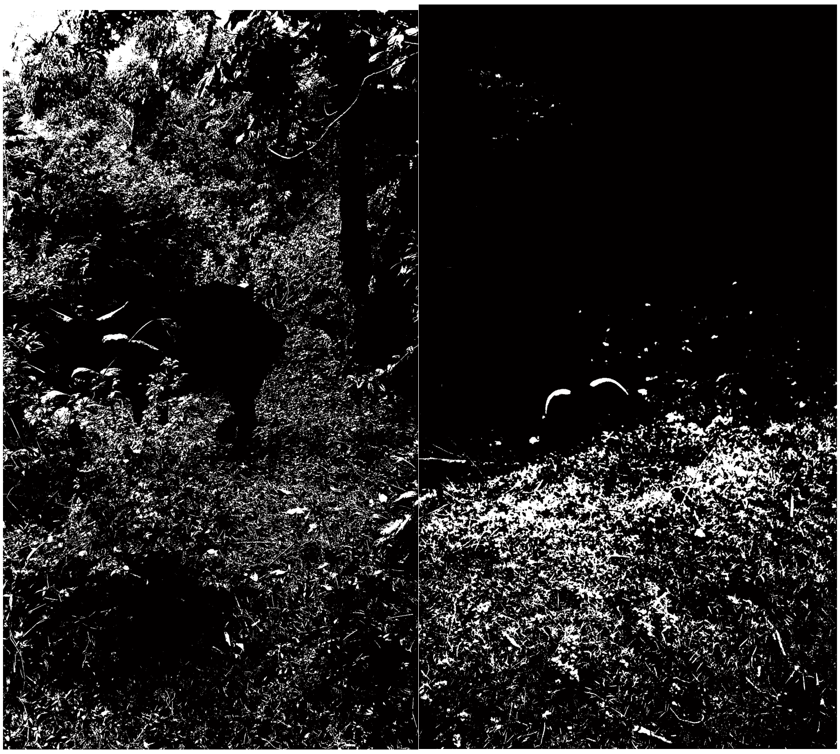


Plate 5. Cattle grazing in ECFR

Plate 6. Firewood collection and Tree pole cutting

6. Discussion

6.1. Abundance and species diversity of the different Flora and Fauna in ECFR

Species abundance is defined as “the measure of the number or frequency of individuals of the same species,” and species diversity demonstrates the “number of species present (species richness) and their abundance (species evenness) in an area or in a community(Odum &

Barrett, 2005). The general relationship between species diversity and abundance can be pictured as a concave or “hollow” curve (Odum & Barrett, 2005). Most natural communities contain a few species with large numbers of individuals (common or dominant species) and many species each represented by a few individuals (Hayek & Buzas, 2010; Odum & Barrett, 2005).

Flora and fauna components of species diversity respond differently to various environmental conditions and most especially habitat changes (Bruna & Ribeiro, 2005). Poor or highly degraded habitats (by humans) posses very little or no diverse flora and fauna. However, the few species that are able to occupy the certain habitats may be abundant in that habitat due to less competition with the other species for resources (Hayek & Buzas, 2010; Odum & Barrett, 2005). This study has shown that; tree species diversity and richness in ECFR was higher in 2021 than 2015, shrubs, furthermore, for the lianas, vines and herbs species diversity and richness was lower in 2021 than 2015 while for rodents and birds species diversity and richness was similar in 2021 and 2015. The implication of these results is that the trees have taken advantage of the absence/reduction of the other species (shrubs, lianas, vines and herbs) to dominate the forest habitat (Hayek & Buzas, 2010; Odum & Barrett, 2005). According to Banana & Tweheyo, (2001); Bitariho & McNeilage, (2008), the ECFR, is slowly being taken over by the secondary forest tree species such as *Macaranga kilimandscharica* and *Neoboutonia macrocalyx* with the bamboo forest dying off in some areas. This is the situation that this study has confirmed with secondary tree species of *M. kilimandscharica, Psychotria mannii etc.* being the most dominant species. Furthermore, as discussed below, human activities such as the clearing of the bamboo understory, could have affected the shrub, liana, vine, and herb species in ECFR. This study has further showed that birds had high Shannon index values (>3) while rodents had low Shannon index values (1.81) compared to the other fauna and flora species. This is an implication that birds had high species richness (more so in 2015), a hallmark of many tropical forests (Ifo et al., 2016). That the rodents had a low species richness is an indication that perhaps the clearing of the forest understory (habitats for rodents) could have affected their diversity and distribution.

6.1.1 Implications of Bird species diversity and forest disturbance in ECFR

Plumptre et al. (2007) compiled a list of 136 bird species for ECFR using all the references detailing bird surveys and inventory work. This was higher than our study bird counts. A number of bird species were therefore missed out during our point-count surveys although many aerial feeders and overflying birds were excluded from our counts. However, we were able to record two threatened species and all the 14 Albertine Rift endemics. The species accumulation curves for both survey periods (i.e., 2015 and 2021) were very steep at the beginning. This is indicative of a disturbed forest as they tend to accumulate species fairly quickly following an initial period of destabilization and loss of many species, though they do not necessarily regain species typical of a primary forest (Johns 1986).

Forest disturbance seems to have altered the bird community with an increase in species density and richness, but a decrease in diversity, evenness, and dominance between 2015 and 2021. An increase in species density and dominance is due to the heterogeneous habitat generated by disturbance being taken up by large numbers of successional or opportunistic species while precluding some primary forest specialists (Johns 1986; Dranzoa 1998). Many understory and canopy species are attracted to the forest floor to exploit new niches created by the reduced canopy cover and the resultant dense undergrowth. The other indices – richness, diversity, and evenness were the opposite of what has been found in other studies (e.g., Thiollay 1992 and Dranzoa 1998). Studies at other sites were done for many years (>10 years) after major forest disturbances, particularly logging, whereas in our study, human disturbances (charcoal burning, pole/wood harvesting, human presence) were taking place during field data collection for both survey time periods (i.e., 2015 and 2021). Differences in the pattern of indices with other studies could be because of the ongoing high human disturbance in our study that made the birds to frequently move between different areas while feeding or breeding (Neuschulz et al. 2013) so that their populations were unstable and transient with a few residents (Johns 1986; Dranzoa 1998). However, the use of single diversity indices to examine the whole species dataset is often discouraged (Karr 1976; Johns 1986; Dranzoa 1998) as a single index masks many changes in species composition, as different subsets of species react to environmental disturbance in varying ways. Therefore, the bird assemblage of ECFR was examined in terms of sets of species (i.e., habitat categories and feeding guilds).

6.1.2 Implications of Forest dependency and forest disturbance on birds

The forest generalists (F-species) were the only forest-dependent group that increased in species density between the study periods. This means that forest disturbance may be followed by the loss of some species, but with the appearance of previously unrecorded species from secondary or edge habitat. The F-species are adapted to exploiting forest edges, tree fall gaps and secondary forest. The species of forest interior (FF-species) showed a slight decline in relative proportion but the decrease was not significant. Dranzoa (2000) found that breeding of some forest specialists takes place in a logged forest of Kibale forest, Uganda, although the breeding populations remained depressed. The broad-leafed and mixed bamboo forests in Echuya have been invaded by the opportunistic species – the forest visitors (f-species) of non-forest and edge habitats. This could mean that although the forest generalists are still predominant, the quality of the broad-leafed and mixed bamboo forests is falling to below the requirements of F-species, so that it has now reached the next stage of invasion. This may account for the rarity of FF-species. Some of the forest-interior species that still persist could be because they probably have small home-range sizes (Abalaka and Manu 2007)

6.1.3 Feeding guilds and forest disturbance

Forest disturbance between 2015 and 2021 affected some feeding guilds of the bird community. The forage gleaners increased between the survey time periods in the broad-leafed forest, probably due to the presence of dead wood that provide forage, roost or nesting sites. However, dead trees are commonly collected for fuelwood and this might pose a threat to those species that are dependent on them. The ground feeders increased in the mixed bamboo possibly due to heavy litter from dead bamboo leaves. This provides them with a rich source of food especially the arthropods. But the bamboo is heavily harvested and in some areas are being cleared of climbers and understory. This leads to relatively harsh conditions (higher light intensity, higher ambient temperature and lower humidity) causing widespread drying of the soil or presence of thick undergrowth under disturbed habitat conditions. This makes individual species to be vulnerable to man-induced disturbances. The mixed feeders increased in the mixed bamboo forest. The mixed bamboo forest had the highest number of human disturbance signs within Echuya. The mixed feeders are resilient to human disturbance as they are able to modify their foraging strategies in response to changes in the resource profile. For example, the frugivore-insectivore or insectivore-nectarivores are able to add or increase a proportion of fruit or nectar in their diet when faced with a shortage of insects (Johns 1986). The frugivores had the fewest number of species. This may due to high altitude that limits the number of fruiting trees in montane forests (Robbins and McNeilage 2003) like Echuya.

The avifauna of Echuya showed some changes between 2015 and 2021 related to increased level human disturbances in the CFR. There is still a high number of forest birds but a large proportion of the bird community are the forest generalists or forest edge species (F-species) that are of low conservation significance since they are widely distributed. There was an increase in species density. However, the increase was due to the invasion of non-forest species exploiting new habitats. Further disturbance is likely to lead to loss of more forest species like the forage gleaners that depend on dead trees that are harvested for fuelwood and the ground feeders that depend on bamboo litter which will dry with the removal of more bamboo poles, climbers, and forest understory. The forage gleaners and ground feeders have a highly specialized diet or foraging behavior and are physiologically intolerant of microclimatic changes of a disturbed forest. The increase in the species density of mixed feeders and f-species in some parts of the forest is an indicator of loss of quality of the forest. This study considers only short-term results. However, the responses of any species to disturbance are potentially varied and difficult to predict. There is a need to generate more information on the long-term effects of disturbance on forest bird species that will help management in designing mitigation strategies to reduce the deleterious impacts of human activities on biodiversity.

6.2. Impact of Human activities on the Flora and Fauna of ECFR

Anthropogenic disturbances in forest ecosystems are important drivers of ecosystem structure, function, and biodiversity. These disturbances can cause abrupt changes in understory light and resource availability and can have a lasting legacy on long-term forest dynamics, both of which influence understory herb communities (Kanieski et al., 2018; Kutnar et al., 2019). Actually populations and species are disappearing due to disturbances in the environment caused by human activities (Bruna & Ribeiro, 2005; Kanieski et al., 2018; Wright & Muller-Landau, 2006) Trends in species richness and evenness may reveal a good deal about both past and present conditions of the habitat (Hayek & Buzas, 2010; Kutnar et al., 2019; Odum & Barrett, 2005). Therefore, the past and present anthropogenic disturbances in ECFR, could have had an impact on the flora and fauna's species richness and evenness as the result show. However, this effect was more felt for the shrubs, lianas, vines, and herbs.

The rodents and birds' species might have slightly been affected by the disturbances in ECFR though. According to Kasangaki et al., (2003), rodents seem more abundant in disturbed sites than undisturbed sites. Furthermore, the dense forest understory in tropical forests provides more food and cover from predators for the rodents as noted by Kasangaki et al., (2003). Therefore, the clearing of the forest understory by NFA officials in 2018 with increased human activities in ECFR, could have affected the diversity of the rodents in ECFR. This is also true for the forest understory birds and other species.

According to Ghazoul & Sheil, (2010), habitat loss in tropical forest is mainly caused by forest clearing combined with selective logging by humans and fires. Species that are local, endemic, or that have specialized habitats are much more vulnerable to extinction when their particular habitat is degraded through anthropogenic activities (Wright & Muller-Landau, 2006). Rodents and birds can be used as management indicators of habitat change by anthropogenic perturbations (Patton, 1987). Moreover, these species often have relatively short generation times, an attribute that makes them more sensitive to the effects of habitat disturbance because juvenile life stages will more often be subjected to environmental changes decreased flora and fauna species diversity or significantly reduced the habitats of these endemic and endangered fauna and flora species since 2015.

7.0 Conclusion

The human activities within the ECFR have more than tripled since 2015 and these are most likely going to increase further in future. It would therefore be plausible to conclude that the increased anthropogenic activities in ECFR together with the clearing and cutting of the bamboo forest understory in 2018 have exacerbated the loss in some biodiversity in the ECFR. This loss is more pronounced with the fact that the flora species diversity has significantly decreased at the expense of increased abundances of some "generalist' species. Of specific concern are the endangered and endemic species in ECFR as these could likely be eliminated with increased human activities. As a result of anthropogenic habitat manipulations in ECFR, some opportunistic flora (trees in this case) seem to have taken the advantage of less competition by increasing in abundance (individuals). More studies need to be carried out to assess the extent of this biodiversity loss particularly focusing on the type of species of concern (e.g., the forest understory species such as rodents and birds).

8.0 Recommendations

The following recommendations need urgent attention by NFA and other ECFR stakeholders.

(i) It is no longer debatable that the human activities within the ECFR have been increasing almost thrice since 2015. If this increase is not stemmed, then the likely repercussions especially detrimental to biodiversity and its loss in ECFR will not be avoided. We recommend that the law enforcement efforts in ECFR are increased and facilitated in terms of manpower and resources (financial and equipment). NFA should recruit more patrol staff and highly motivate them. Supervision by the NFA of these field staff also needs to be upped. We witness that the field supervisors rarely come to ECFR and leave the patrol men all to themselves.

(ii) Access for forest resources (Bamboo, firewood, climbers) from ECFR should be highly regulated (e.g., monitor offtake quotas). If possible, this access should be limited to atleast once a month. Currently the forest access for resources in ECFR seems to be a free for all and unregulated and occurring every day of the week. This is the major reason the human activities in ECFR have more than tripled. Animal grazing (cows and goats) in ECFR should not be permitted at all.

(iii) NFA and the development organizations working around ECFR such as NatureUganda should proactively increase the efforts of on-farm cultivation of some of the forest resources from ECFR e.g., Bamboo and trees used for firewood in the communities adjacent the forest. Although these efforts are already taking place, there is need for increased resource mobilization (funds and manpower) to be channeled in forest resource on-farm substitution. Of specific focus is the bamboo on-farm cultivation in homesteads and gardens. Focus should be on the already highly demanded specie of montane bamboo (*Arundinari alpina*).

(iv) Increased efforts and implementation of agroforestry practices in the homestead gardens should be made by the development organization working in ECFR. Since land scarcity is an issue in communities around ECFR, the agroforestry practice should encourage communities to plant trees and bamboo on garden terraces that would also act as soil erosion prevention mechanism.

(v) The management of the natural forest in ECFR and possibly in all other forest reserves managed by NFA should be distinguished from plantation forests. It is known world over that the management of natural forests whose biodiversity is unique from that of plantation forests should be differentiated and managed differently. The clearing of the forest understory in ECFR by NFA should be discouraged and if needed should have been based on scientific experimental plots that are monitored for the likely biodiversity impacts. The major reasons why the forest understory was cleared was to recover the bamboo forest that is slowly being taken over by other forest species (trees). This is a natural phenomena of bamboo forest especially after intensive human activities exacerbated by other external causes such as climate change. It should be noted that the ECFR does not just contain bamboo but also other important flora and fauna (some were cleared).

(vi) If the forest clearings of the understory was required then it should have been evidenced by scientific studies such as the procedure of setting up experimental plots (or trial plots) in small areas (maximum 1 ha) of the bamboo forest (not large forest areas-11% of ECFR) and a long term study carried out that would compare and monitor the cleared understory bamboo forest with other areas where the bamboo grows with other understory tree species. This should have been the basis of clearing large chunks of the bamboo forest understory.

(vii) It has been suggested by a few studies that the reason the bamboo forest is declining could be due to a decline in starch levels of the bamboo rhizomes underneath (in the ground) as a result of poor soil nutrients. In order to assess this hypothesis, it is recommended that studies that analyse the bamboo rhizome sections be commenced in ECFR. Sections of the bamboo rhizomes could be analysed for starch levels. The bamboo rhizome starch level analysis will help in determining bamboo rhizome vigour. Bamboo rhizomes vigour is essential for survival of the bamboo stems that grow on it. The Starch level analysis can be done at Makerere University’s Botany Department or Food and Science Department Faculty of Natural Sciences and Faculty of Agriculture respectively.

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10. Appendix

10.1 Tree species list of Echuya Central Forest Reserve

Id	Species	Life form
1	*Allophylus Abyssinicus*	Tree
2	*Bersama abyssinica*	Tree
3	*Chrysophyllum albidum*	Tree
4	*Eucalyptus*	Tree
5	*Gymnosporia sp*	Tree
6	*Cyathea maniana*	Tree
7	*Hagenia abyssinica*	Tree
8	*Lepidotrichillia*	Tree
9	*Macaranga capensis*	Tree
10	*Maesa lanceolata*	Tree
11	*Allophyllus macrobotrys*	Tree
12	*Morella Salicifolia*	Tree
13	*Mystroxylon aethiopian*	Tree
14	*Neoboutonia macrocalyx*	Tree
15	*Nuxia congesta*	Tree
16	*Pittosporum spathicalyx*	Tree
17	*Podocarpus latifolius*	Tree
18	*Polyscias fulva*	Tree
19	*Psychotria mahonii*	Tree
20	*Syzygium guineense*	Tree
21	*Xymalos monospora*	Tree
22	*Morella Kandtiana*	Tree
23	*Hypericum revolutum*	Tree
24	*Xymalos monospora*	Tree
25	*Dombeya torida*	Tree
26	*Alangium chineense*	Tree
27	*Blechnum tabulare*	Tree

10.2 Shrub and Liana species list of Echuya Central Forest Reserve

Id	*Species*	Lifeform
1	*Adenia cisampeloides*	Liana
2	*Allophyllus africanus*	Shrub
3	*Brillantaisa citricosa*	Shrub
4	*Bubus apetalus*	Liana
5	*Clematis hirsuta*	Liana
6	*Clerodendron Johnistoni*	Shrub
7	*Clutia abyssinica*	Liana
8	*Connarus longispictatus*	Shrub
9	*Dalbergia lactea*	Shrub
10	*Datura suaveolens*	Shrub
11	*Discopodium penninervium*	Shrub
12	*Dracaena afromontana*	Shrub
13	*Dracaena laxissima*	Shrub
14	*Embilia schimperi*	Shrub
15	*Erythrococca trichogyne*	Shrub
16	Rubus apetalus	Liana
17	*Galiniera saxafraga*	Shrub
18	*Hibscus diversifolius*	Shrub
19	*Jasminum abyssincum*	Liana
20	*Keetia queinzii*	Shrub
21	*Lasianthus kilimadscharicus*	Shrub
22	*Mimulopsis arborescens*	Shrub
23	*Mimulopsis Solmsii*	Liana
24	Stachrys aculeolata	Liana
25	*Pavetta bagshawei*	Shrub
26	*Urella hypsellodendron*	Liana
27	*Pcynostachys elliotii*	Shrub
28	*Peddlea fischeri*	Shrub
29	*Peifas occidenfalis*	Shrub
30	*Pentas bussei*	Shrub
31	*Phillipia denguelensis*	Shrub
32	Rubus pinnatus	Liana
33	*Phytollacca dodecandra*	Liana
34	*Piper capense*	Shrub
35	*Plectranflus luteus*	Shrub
36	Sericostachys scandens	Liana
37	*Pristimera graciliflora*	Liana
38	*Psychotria kirkii*	Shrub
39	*Rhamnus prinoides*	Shrub
40	*Rhytigyinia kigeziensis*	Shrub
41	Rubus stendneri	Liana

42	*Rubus pinnatus*	Liana
43	*Rubus steudreri*	Liana
44	*Rumex usembarensis*	Shrub
45	*Rutidea orientalis*	Shrub
46	*Rutidea smithii*	Shrub
47	*Rytigynia beniensis*	Shrub
48	*Rytigynia bridsoniae*	Shrub
49	*Rytigynia bugoyensis*	Shrub
50	*Senecio maranguasis*	Shrub
51	*Sericostachys scandens*	Liana
52	*Todalia asiatica*	Liana
53	*Triumfetta cordifolia*	Liana
54	*Urera hypselodendron*	Liana
55	*Vernonia auriculifera*	Shrub
56	*Vernonia kirungae*	Shrub
57	*Vernonia lasiopus*	Shrub
58	Triumfetta tomentosa	Liana
59	Cyphostemma bambusetii	Liana
60	Jasminum abyssinicum	Liana

10.3 Vine and Herbs species list of Echuya Central Forest Reserve

Id	Species	Life form
1	Acalypha neptanica	Herb
2	Acalypha ornata	Herb
3	Acalypha spp	Herb
4	Achyranthes aspera	Herb
5	Afroligusticum aculeolatum	Herb
6	Afroligusticum runsoricum	Herb
7	Agrolobium scimperian	Herb
8	Ajuga remota	Herb
9	Alchemilla johnstonii	Herb
10	Asplenium elliotii	Herb
11	Asplenium spp	Herb
12	Asplenum dregeanum	Herb
13	Basella alba	Herb
14	Begonia meyeri	Herb
15	Brillantaisia citricosa	Shrub
16	Cardiospernum gradiflorum	Vine
17	Carduu nyasanus	Herb
18	Carpodium glabra	Vine
19	Clutia abyssinica	Shrub
20	Crassoceplalum montuosum	Herb
21	Crassoceplalum viltellinum	Herb
22	Cymbopogon caesius	Herb
23	Cynoglosum ampeifolium	Herb
24	Cyroglosum sp	Herb
25	Desmodium repandum	Herb
26	Dicliptera laxata	Herb
27	Dovyalis macrocalyx	Shrub
28	Drognetia iners	Herb
29	Drynaria cordata	Herb
30	Epilobium stereophyllum	Herb
31	Eriocaulon schimperi	Herb
32	Galiniera saxafraga	Shrub
33	Galium ruwenzoriense	Herb
34	Galium spp	Herb
35	Geraninium aculealafin	Herb
36	Geranium arabicum	Herb
37	Gloriosa sp	Herb
38	Gynura scandens	Herb
39	Helichrysum nandus	Herb

40	Heliclrysm sp	Herb
41	Impatiens sp	Herb
42	Impomae involcrata	Vine
43	Ipomea sp	Vine
44	Justicia spp	Herb
45	Justicia stiata	Herb
46	Kniphofia tharmsonii	Herb
47	Lantana trifolia	Shrub
48	Laportea aestuans	Herb
49	Laportea ovalifolia	Herb
50	Lobelia wollastonii	Herb
51	Mikanie cordata	Vine
52	Mikaniopsis banbusetii	Vine
53	Mimulopsis arborescens	Shrub
54	Momordica foetida	Herb
55	Momordica pterocarpa	Vine
56	Mormodica foetida	Vine
57	Obetia spp	Herb
58	Oplimenus hirtellus	Herb
59	Orthosiphon montuosum	Herb
60	Orthosiphon suffrescens	Herb
61	Panicium aquilinium	Herb
62	Panicum adenophorum	Herb
63	Panicum eickii	Herb
64	Penisetum tetrachyphyllium	Herb
65	Pennisetum mildbreedii	Herb
66	Phamnus prinoides	Shrub
67	Phyllanthus fischeri	Herb
68	Pilea holstii	Herb
69	Pilea rivalaris	Herb
70	Pilea spp	Herb
71	Piper capensis	Shrub
72	Plantago primata	Herb
73	Plectanthus spp	Herb
74	Plectranthus australis	Herb
75	Plectranthus edulis	Herb
76	Plectranthus laxiflorus	Herb
77	Plectrenthus luteus	Herb
78	Psychotria kirkii	Shrub
79	Pteridum acquilinum	Herb
80	Pteris spp	Herb
81	Rubia cordifolia	Herb
82	Rumex bequaertii	Herb

83	Rytigyinia beniensis	Shrub
84	Senecio spp	Herb
85	Senecio subsessils	Herb
86	Smilax aspera	Vine
87	Solenostemon silvaticum	Herb
88	Stephania abyssinica	Vine
89	Thalictrum sp	Herb
90	Triumfetta cordifolia	Shrub
91	Urtica massaica	Herb
92	Vernonia auriculifera	Shrub

10.3 Rodents species list for Echuya Central Forest Reserve

Id	Species
1	*Dasmys incomptus*
2	*Delanymys brooksi*
3	*Hybomys univitatus*
4	*Laphuromys funatus*
5	*Laphuromys spp.*
6	*Lophuromys flavopunctatus*
7	*Malacomys longipes*
8	*Mastomys natalensis*
9	*Mastomys spp.*
10	*Musgratus*
11	*Myomys fumatus*
12	*Praomys jacksonii*
13	*Ruwenzori sorex*
14	*Steatomys spp.*
15	*Uranomys ruddi*

10.4 Birds species list of Echuya Central Forest Reserve

Bird species (Stevenson and Fanshawe 2020) encountered in Echuya Central Forest Reserve in 2015 and 2021 with their forest dependency categories (Bennun et al. 1996), feeding guilds (Birds of Africa 1982-2004), conservation status (Birdlife International 2022; Stattersfield et al. 1998) and frequency of species occurrence for each study period

#	Common name	Scientific name	Abbreviation of common name	Habitat category	Feeding guild	Conservation status	Frequency of occurrence	
							2015	**2021**
THRESKIORNITHIDAE Ibises and spoonbills								
1	Hadada ibis	*Bostrychia hagedash*	HI	nf	Ground feeder	LC	0	1
ACCIPITRIDAE Hawks, vultures, buzzards and eagles								
2	African Harrier-Hawk	*Polyboroides typus*	AHH	f	Mixed feeder	LC	0	2
3	Augur Buzzard	*Buteo augur*	AB	nf	Raptor	LC	1	1
4	Mountain Buzzard	*Buteo oreophilus*	MB	f	Raptor	**NT**	1	0
5	Long-crested Eagle	*Lophaetus occipitalis*	LCE	f	Raptor	LC	0	1
PHASIANIDAE Quails and francolins								
6	Handsome Spurfowl	*Pternistis nobilis*	HS	FF	Ground feeder	LC, **ARE**	2	3
SCOLOPACIDAE Sandpipers and allies								
7	Common Sandpiper	*Actitis hypoleucos*	CSP	nf	Mixed feeder	LC	0	2
COLUMBIDAE Pigeons and doves								
8	African Olive Pigeon	*Columba arquatrix*	AOP	FF	Frugivore	LC	1	0
9	Tambourine Dove	*Turtur tympanistria*	TD	F	Frugivore	LC	8	32
10	Red-eyed Dove	*Streptopelia semitorquata*	RED	f	Frugivore	LC	0	1
11	Ring-necked Dove	*Streptopelia capicola*	RND	f	Frugivore	LC	0	2
CUCULIDAE Cuckoos, coucals and yellowbills								
12	Chattering Yellowbill	*Ceuthmochares aereus*	CYB	F	Gleaner	LC	1	0
13	Blue-headed Coucal	*Centropus monachus*	BHC	w	Gleaner	LC	5	16
14	Barred Long-tailed Cuckoo	*Cercococcyx montanus*	BLTC	FF	Gleaner	LC	4	7
15	Red-chested Cuckoo	*Cuculus solitarius*	RCC	F	Gleaner	LC	2	6
16	Klaas's Cuckoo	*Chrysococcyx klaas*	KC	f	Gleaner	LC	1	0
STRIGIDAE Typical Owls								
17	African Wood Owl	*Strix woodfordii*	AWO	F	Mixed feeder	LC	0	1

COLIIDAE Mousebirds								
18	Speckled Mousebird	*Colius striatus*	SMB	nf	Frugivore	LC	1	3
TROGONIDAE Trogons								
19	Narina Trogon	*Apaloderma narina*	NT	F	Gleaner	LC	0	1
MEROPIDAE Bee-eaters								
20	Cinnamon-chested Bee-eater	*Merops oreobates*	CCBE	F	Flycatcher	LC	0	5
BUCEROTIDAE Hornbills and ground-hornbills								
21	Crowned Hornbill	*Lophoceros alboterminatus*	CHB	f	Mixed feeder	LC	0	1
LYBIIDAE African barbets and tinkerbirds								
22	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	YRTB	F	Mixed feeder	LC	10	7
23	Double-toothed Barbet	*Pogonornis bidentatus*	DTB	f	Mixed feeder	LC	1	0
INDICATORIDAE Honeyguides								
24	Dwarf Honeyguide	*Indicator pumilio*	DHG	FF	Mixed feeder	LC, **ARE**	0	1
25	Greater Honeyguide	*Indicator indicator*	GHG	f	Mixed feeder	LC	0	2
PICIDAE Woodpeckers, wrynecks and piculets								
26	Olive Woodpecker	*Dendropicos griseocephalus*	OWP	FF	Gleaner	LC	0	1
27	Bearded Woodpecker	*Dendropicos namaquus*	BWP	FF	Gleaner	LC	1	0
HIRUNDINIDAE Swallows and martins								
28	Angola Swallow	*Hirundo angolensis*	AS	nf	Flycatcher	LC	0	2
29	Black Saw-wing	*Psalidoprocne pristoptera*	BSW	f	Flycatcher	LC	1	1
30	White-headed Saw-wing	*Psalidoprocne albiceps*	WHSW	f	Flycatcher	LC	0	1
MOTACILLIDAE Wagtails, pipits and longclaws								
31	African Pipit	*Anthus cinnamomeus*	AP	nf	Mixed feeder	LC	0	1
32	Grey Wagtail	*Motacilla cinerea*	GWT	F	Mixed feeder	LC	0	1
CAMPEPHAGIDAE Cuckooshrikes								
33	Red-shouldered Cuckooshrike	*Campephaga phoenicea*	RSCS	f	Gleaner	LC	0	1
34	Black Cuckooshrike	*Campephaga flava*	BCS	f	Gleaner	LC	1	0
35	Grey Cuckooshrike	*Ceblepyris caesius*	GCS	FF	Gleaner	LC	0	1
PYCNONOTIDAE Bulbuls and greenbuls								
36	Eastern Mountain Greenbul	*Arizelocichla nigriceps*	EMGB	FF	Mixed feeder	LC	7	24
37	Yellow-whiskered Greenbul	*Eurillas latirostris*	YWGB	F	Mixed feeder	LC	31	66

38	Common Bulbul	*Pycnonotus barbatus*	CBB	f	Mixed feeder	LC	10	42
MUSCICAPIDAE Old World robins								
39	Red-throated Alethe	*Chamaetylas poliophrys*	RTA	FF	Mixed feeder	LC, **ARE**	7	31
40	White-starred Robin	*Pogonocichla stellata*	WSR	F	Mixed feeder	LC	18	6
41	Archer's Robin-Chat	*Dessonornis archeri*	ARC	F	Mixed feeder	LC, **ARE**	13	28
TURDIDAE Thrushes								
42	Abyssinian Thrush	*Turdus abyssinicus*	AT	F	Mixed feeder	LC	2	40
43	Abyssinian Ground-Thrush	*Geokichla piaggiae*	AGT	FF	Mixed feeder	LC, **ARE**	0	1
MUSCICAPIDAE Old World chats								
44	African Stonechat	*Saxicola torquatus*	ASC	nf	Flycatcher	LC	1	12
45	White-browed Scrub-Robin	*Cercotrichas leucophrys*	WBSR	nf	Flycatcher	LC	1	0
ACROCEPHALIDAE Reed warblers and allies								
46	Mountain Yellow Warbler	*Iduna similis*	MYW	F	Gleaner	LC	6	1
LOCUSTELLIDAE Grasshopper warblers and allies								
47	Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	CBW	F	Gleaner	LC	19	62
48	Grauer's Swamp Warbler	*Bradypterus graueri*	GSW	nf	Gleaner	**VU, ARE**	3	23
49	Evergreen Forest Warbler	*Bradypterus lopezi*	EGFW	FF	Gleaner	LC	3	0
SYLVIIDAE Old World warblers								
50	Eurasian Blackcap	*Sylvia atricapilla*	EBC	F	Gleaner	LC	2	5
PHYLLOSCOPIDAE Leaf warblers								
51	Red-faced Woodland-Warbler	*Phylloscopus laetus*	RFWW	FF	Gleaner	LC, **ARE**	4	35
MACROSPHENIDAE Crombecs and allies								
52	White-browed Crombec	*Sylvietta leucophrys*	WBC	FF	Gleaner	LC	11	13
CISTICOLIDAE Cisticolas and allies								
53	Chubb's Cisticola	*Cisticola chubbi*	CC	F	Gleaner	LC	17	68
54	Black-faced Apalis	*Apalis personata*	BFA	FF	Gleaner	LC, **ARE**	3	47
55	Chestnut-throated Apalis	*Apalis porphyrolaema*	CTA	F	Gleaner	LC	5	30
56	Rwenzori Apalis	*Oreolais ruwenzorii*	RA	FF	Gleaner	LC, **ARE**	0	1
57	Banded Prinia	*Prinia bairdii*	BP	F	Gleaner	LC	7	19
58	Tawny-flanked Prinia	*Prinia subflava*	TFP	f	Gleaner	LC	0	15
59	White-chinned Prinia	*Schistolais leucopogon*	WCP	F	Gleaner	LC	1	0
60	Grey-backed Camaroptera	*Camaroptera brachyura*	GBC	f	Gleaner	LC	4	2
61	Olive-green Camaroptera	*Camaroptera chloronota*	OGC	FF	Gleaner	LC	1	0

62	Black-throated Apalis	*Apalis jacksoni*	BTA	FF	Gleaner	LC	1	0
MUSCICAPIDAE Old World flycatchers								
63	African Dusky Flycatcher	*Muscicapa adusta*	ADFC	F	Flycatcher	LC	2	6
64	Ashy Flycatcher	*Muscicapa caerulescens*	AFC	F	Flycatcher	LC	0	2
65	Yellow-eyed Black Flycatcher	*Melaenornis ardesiacus*	YEBFC	F	Flycatcher	LC, **ARE**	0	2
66	White-eyed Slaty Flycatcher	*Melaenornis fischeri*	WESFC	F	Flycatcher	LC	1	1
PLATYSTEIRIDAE Batises and wattle-eyes								
67	Rwenzori Batis	*Batis diops*	RB	F	Flycatcher	LC, **ARE**	5	21
68	Chinspot Batis	*Batis molitor*	CHSB	nf	Flycatcher	LC	0	1
69	Brown-throated Wattle-eye	*Platysteira cyanea*	BTWE	f	Flycatcher	LC	1	0
MONARCHIDAE Monarch-flycatchers								
70	African Paradise-flycatcher	*Terpsiphone viridis*	APFC	f	Flycatcher	LC	4	17
STENOSTIRIDAE Fairy-flycatchers and allies								
71	White-tailed Blue-flycatcher	*Elminia albicauda*	WTBFC	F	Flycatcher	LC	0	2
PELLORNEIDAE Ground babblers								
72	African Hill-babbler	*Pseudoalcippe abyssinica*	AHB	FF	Flycatcher	LC	19	24
73	Mountain Illadopsis	*Illadopsis pyrrhoptera*	MI	FF	Flycatcher	LC	4	1
74	Scaly-breasted Illadopsis	*Illadopsis albipectus*	SBI	FF	Flycatcher	LC	1	0
ZOSTEROPIDAE White eyes								
75	African Yellow White-eye	*Zosterops senegalensis*	AYWE	f	Gleaner	LC	5	37
NECTARINIIDAE Sunbirds								
76	Bronze Sunbird	*Nectarinia kilimensis*	BSB	f	Mixed feeder	LC	1	0
77	Regal Sunbird	*Cinnyris regia*	RSB	F	Mixed feeder	LC, **ARE**	7	67
78	Malachite Sunbird	*Nectarinia famosa*	MSB	F	Mixed feeder	LC	1	5
79	Blue-headed Sunbird	*Cyanomitra alinae*	BHSB	FF	Mixed feeder	LC, **ARE**	0	1
80	Collared Sunbird	*Hedydipna collaris*	CSB	F	Mixed feeder	LC	1	1
81	Variable Sunbird	*Cinnyris venustus*	VSB	f	Mixed feeder	LC	2	0
82	Rwenzori Double-collared Sunbird	*Cinnyris stuhlmanni*	RDCSB	F	Mixed feeder	LC, **ARE**	0	1
MALACONOTIDAE Bushshrikes and allies								
83	Tropical Boubou	*Laniarius major*	TB	f	Gleaner	LC	1	0
84	Black-crowned Tchagra	*Tchagra senegalus*	BCT	nf	Gleaner	LC	1	0
85	Doherty's Bushshrike	*Telophorus dohertyi*	DBS	F	Gleaner	LC	2	4

86	Slate-coloured Boubou	*Laniarius funebris*	SCB	nf	Gleaner	LC	18	27
87	Northern Puffback	*Dryoscopus gambensis*	NPB	F	Gleaner	LC	6	18
CORVIDAE Crows and allies								
88	White-necked Raven	*Corvus albicollis*	WNR	nf	Mixed feeder	LC	0	1
ORIOLIDAE Orioles								
89	Montane Oriole	*Oriolus percivali*	MO	FF	Mixed feeder	LC	5	22
STURNIDAE Starlings								
90	Waller's Starling	*Onychognathus walleri*	WS	FF	Mixed feeder	LC	1	0
PLOCEIDAE Weavers and allies								
91	Strange Weaver	*Ploceus alienus*	SW	F	Mixed feeder	LC, **ARE**	2	5
92	Baglafecht Weaver	*Ploceus baglafecht*	BFW	f	Mixed feeder	LC	2	2
93	Yellow Bishop	*Euplectes capensis*	YB	nf	Mixed feeder	LC	1	0
ESTRILDIDAE Waxbills and allies								
94	Grey-headed Nigrita	*Nigrita canicapillus*	GHN	F	Ground feeder	LC	1	0
95	Common Waxbill	*Estrilda astrild*	CWB	nf	Ground feeder	LC	0	30
96	Kandt’s Waxbill	*Estrilda kandti*	KWB	F	Ground feeder	LC	3	8
97	Yellow-bellied Waxbill	*Coccopygia quartinia*	YBWB	f	Ground feeder	LC	1	2
98	Black-and-white Mannikin	*Spermestes bicolor*	BWM	f	Ground feeder	LC	0	1
99	Dusky Crimsonwing	*Cryptospiza jacksoni*	DCW	F	Ground feeder	LC, **ARE**	4	9
VIDUIDAE Whydahs and indigobirds								
100	Pin-tailed Whydah	*Vidua macroura*	PTW	nf	Ground feeder	LC	1	0
FRINGILLIDAE Canaries, seedeaters and allies								
101	Streaky Seedeater	*Crithagra striolata*	SSE	f	Ground feeder	LC	5	41
102	Thick-billed Seedeater	*Crithagra burtoni*	TBSE	FF	Ground feeder	LC	2	2
103	African Citril	*Crithagra citrinelloides*	AC	f	Ground feeder	LC	0	7

KEY:
Habitat category: FF – Forest interior specialists; F - Forest generalist; f – forest visitors; nf – non-forest
Conservation status: VU - Vulnerable; NT – Near Threatened; LC – Least Concern; ARE – Endemic to the mountains along the Albertine Rift