2021 BIODIVERSITY MONITORING REPORT – FORM GHANA'S AKUMADAN TEAK PLANTATION

2021 BIODIVERSITY MONITORING REPORT OF FORM GHANA'S AKUMADAN TEAK PLANTATION

Report Produced for

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April, 2021

REPORT AT A GLANCE

Main survey periods

15th to 25th March 2021

Major Results

Form Ghana's Akumadan Teak Plantation provides habitat for about 63 plant species, 60 bird species and 17 species of small and large terrestrial mammals (Table 1).

Table 1: Summary of species of conservation interest recorded in the study area

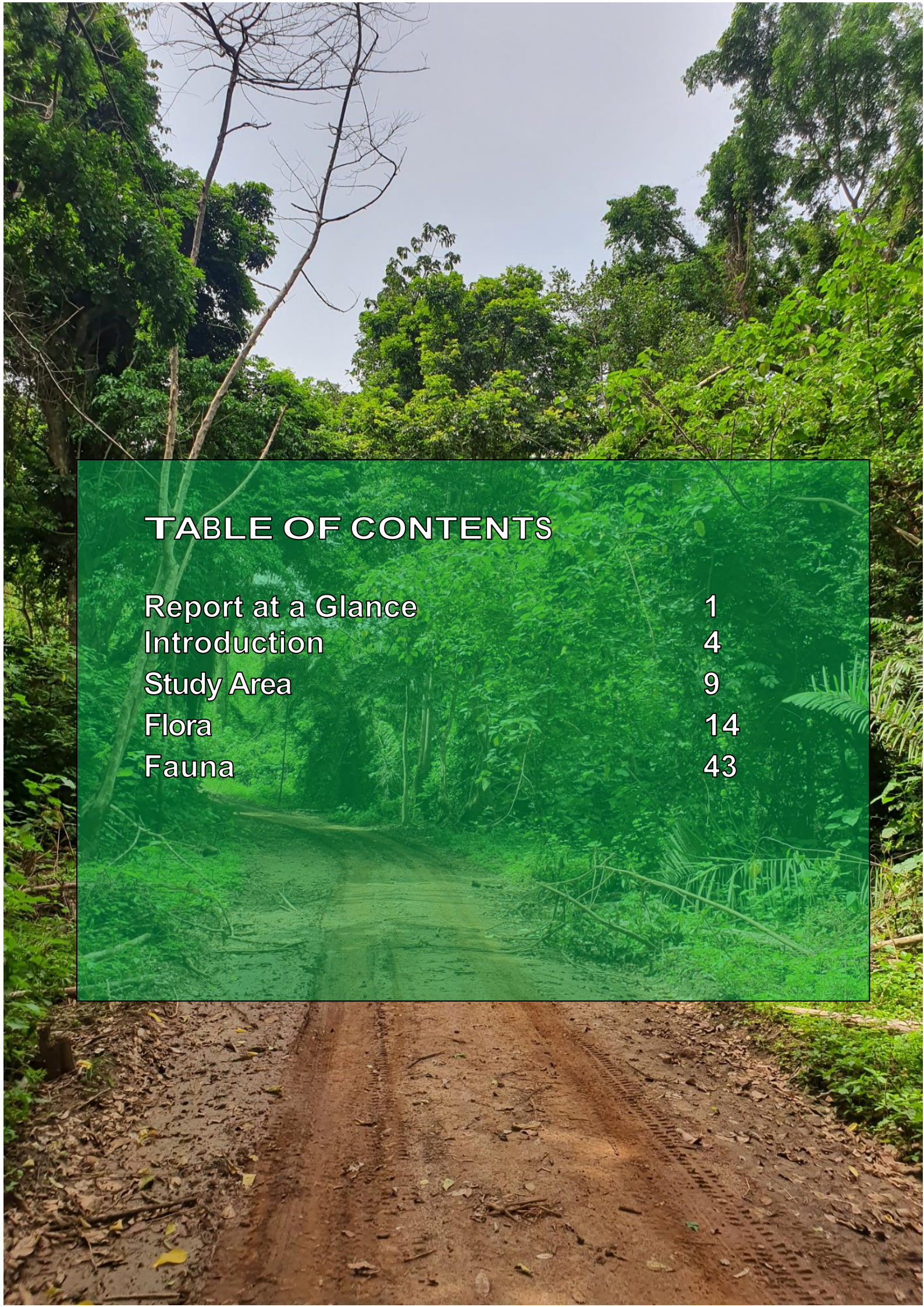
IUCN Status	Flora	Mammals	Birds	Reptiles	Total
Critically Endangered (CR)	-	-	-	-	-
Endangered (EN)	-	Tree Pangolin; *Phataginus tricuspis*	-	-	1
Vulnerable (VU)	*Pseudospondias microcarpa; Cedrela odorata; Khaya anthotheca; K. ivorensis; K. senegalensis; Entandrophragma cylindricum*	Lowe's Mona Monkey; *Cercopithercus lowei*	-	Dwarf Crocodile; *Osteolaemus tetraspis*	8
Near Threatened (NT)	*Hallea ledermannii Milicia excelsa*	-	-	-	2
Least Concern (LC)	44	15	60	-	118
Data Deficient (DD)	-	-	-	-	-
Not Evaluated (NE)	12	-	-	-	12
Total Species	**63**	**17**	**60**	**1**	**141**

Two main land cover types were recorded in the study area. These included teak and indigenous forest. Highest biodiversity were recorded in the indigenous forest areas

compared to within the teak plantation. Thus the indigenous forest accounted for a large proportion of flora and fauna abundance and diversity.

Summary Conservation Recommendations

Two tree species, *Hallea ledermannii* and *Milicia excelsa* are classified as Near Threatened while six other species are classified as 'Vulnerable' on the IUCN Red List 2021. None of the species are listed on any of the CITES Schedules. Locally, five (5) Scarlet Star, five (5) Red Star, four (4) Pink Star and 63 Green Star species (Hawthorne and Abu-Juan, 1995) were recorded. Recorded mammalian species of conservation interest include one carnivore (Tree Pangolin; *Phataginus tricuspis*; Endangered) and one primate (Mona Monkey; *Cercopithercus mona*; Near Threatened). Both species are also listed in Appendix II of CITES (species that are not necessarily threatened with extinction but may become so unless trade is closely controlled). Locally, all primates and the tree pangolin are of special conservation importance in Ghana and are listed in Schedule 1 of the Ghana Wildlife Conservation Regulations (1995). Members of the Family Accipitridae (birds of prey) and Falconidae (falcons) are also listed as Schedule 1 in Ghana. The African civet, common genet, cusimanse mongoose, bushbuck, Maxwell's duiker and members of the Family Columbidae (pigeons and doves) are of some conservation importance locally in Ghana and are listed as Schedule II species (Ghana Wildlife Conservation Regulations of 1995). Compared to previous surveys, there seems to be a significant increase in the number of mammalian species confirmed in the area. Nevertheless, straw-coloured fruit bats (*Eidolon helvum*), which were recorded in 2017 were not observed. This species is known to migrate to other areas when availability of food resources shift and might have migrated during the survey period. Since these bats are frugivorous and use the plantation as suitable habitat, they will return when local fruit resources become abundant. Thus, Form Ghana should continue to enhance the indigenous forest through enrichment planting with preferred fruit bearing plants, provide watering points where possible and create corridors that could link neighbouring indigenous forests to ensure that the ecosystem remains healthy. More research is needed to determine the precise period of bat occupancy in the plantation and their ecological role in the area including their significance as fruit dispersal agents.



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INTRODUCTION

1.0 BACKGROUND

1.1 Introduction

This study is designed to monitor the impact of reforestation activities on biodiversity in Form Ghana's Akumadan Teak Plantation

Globally, forest plantations play a significant role in wood production, ecosystem services and climate change mitigation. As of the year 2000, there was an estimated 187 million hectares of plantation worldwide (Carle et. al., 2002). Forest plantations are grown to supply raw material for industry and for other uses, such as fuelwood and their potential to partially meet demand for wood and fiber for industrial uses is increasing. Forest plantations also provide additional non-wood forest products and benefits that contribute to environmental, social, and economic sustainability.

The expansion of plantations, and gains in forest productivity, will help reduce pressure on natural forests; this is already the focus of the forest policies adopted by several countries. In many countries, particularly in Africa traditional forest owners, such as forest industry companies or governments are known to be interested in managing forest lands. Governments which were previously involved in the establishment of forest plantations are now promoting private sector involvement to manage forest lands and invest in wood processing capacity (ITTO, 2009).

Form Ghana Ltd. is a forest plantation management company based in central Ghana that is aimed at reclaiming degraded forests by providing services in the field of reforestation and plantation management. The company was established in 2007 and is an affiliate company of Sustainable Forestry Investments B.V. in the Netherlands. Currently, the company has two concessions (Akumadan and Berekum) in Ghana where they are engaged in reforestation activities. The Asubima and Afrensu Brohuma forest reserves in Akumadan area have been in operation for over 10 years now. Over the period of operation, conscious efforts have been made to conserve biodiversity. The company among

other best forest management practices, reforests degraded forest lands, restores indigenous forest areas, and controls hunting and bushfires. To measure the effect of these activities on the prevalence of flora and fauna, monitoring is carried out periodically.

The biological survey are therefore conducted as part of the monitoring activities of the company. The survey seeks to provide information on the abundance and distribution of flora and fauna species in the area and determine the impact of the project on biodiversity restoration and conservation. The results of this study will be incorporated in the management documentation. The contractor's previous reports in Akumadan will form important scientific basis in monitoring and evaluation to identify problems and perhaps their causes; establish solutions to these problems; and inform future projects.

1.2 Scope of Services Required for this Assignment

Carry out a flora and fauna survey of Form Ghana's Teak Plantation, near Akumadan in the Ashanti Region of Ghana. Scope of work includes developing survey tools and methodologies in consultation with Form Ghana, carrying out biological (flora and fauna) surveys of vegetation, terrestrial large and small mammals and avifauna of the plantation. For this assignment, it is required to submit field survey data and a comprehensive flora and fauna survey report.

As such, the survey had the following objectives:

- Determine the status of flora (vegetation) and fauna (terrestrial large and small mammals and avifauna) species diversity and distribution in the plantations.
- Investigate the presence or absence of threatened flora and fauna species as defined by the IUCN Red List 2021 and Ghana Wildlife Conservation Regulation Schedules.
- Identify any land use variations in fauna in the plantation.
- Establish impact of plantation development activities towards local biodiversity conservation.

Field surveys were carried out in March, 2021, which fell in the dry season. Transects were walked in the morning to mid-afternoon (07:00 – 17:00). The field data obtained from the survey were used to identify the different biological HCVs along the road.

1.3 Specific tasks for this assignment include:

1.3.1 Desk-based study included but was not limited to:

Scientific literature and project reports on fauna surveys conducted in the Ashanti Region of Ghana as well as other related literatures on wildlife activities were examined and relevant information extracted. Furthermore, papers produced under Form Ghana's operational areas were consulted more especially those dealing with Asubima and Afrenso Brohuma Forest Reserves.

1.3.2 Species and habitat data:

Review of ecological literature, online data sources and published reference materials on ecosystems, habitats and protected areas within and around the concession (e.g. the existence and status of habitats, forest types and vegetation communities) and the fauna, with a special focus on species of national, regional and global conservation significance.

1.3.3 Field assessment

- ***Inventory of birds:*** Using rapid assessment and other appropriate sampling methodology, undertake a bird survey in order to verify species of birds of conservation significance in the concession area including migratory species.
- ***Inventory of mammals:*** Undertake survey of both small and large mammals using a combination of methods including but not limited to transect searches to verify species of conservation importance and their habitats in the concessions.

1.3.4 Outputs

The expected outputs of this assignment are:

- A comprehensive report detailing observed species in the plantation, their habitats and relative abundance.
- A listing of all the species identified and their conservation significance using the IUCN's Red List of Protected Species 2017 and the relevant national list of protected species.
- Recommendations for the maintenance and the protection of biodiversity in the plantation. This will also include management recommendations.

STUDY AREA

2.0 STUDY AREA

Wildlife numbers in the study area have declined rapidly in the past decade because of expanding human activities

2.1 Site Description

Form Ghana operates in two degraded forest reserves in Ghana's Ashanti Region: Asubima and Afrensu Brohuma (Figure 2). Both are situated in the dry semi-deciduous forest zone. Both forest reserves fall under the authority of the Forestry Commission in Offinso District. Asubima FR and Afrensu Brohuma FR share a common boundary over 4,800m of which 1,600m is part of the Form Ghana concessions.

2.1.1 Climate

Asubima and Afrensu Brohuma Forest Reserves lie at the northern fringes of the semi-deciduous forest zone of Ghana. The zone has a tropical monsoon climate with alternating wet and dry seasons (Figure 3). The long rainy season (March to July) is followed by a short dry period (July/August) and a short rainy period (September/October) before the long dry season starts (November to March).

Temperatures are generally high and uniform throughout the year (Figure 3). Mean annual temperature is 26°C. February and March are the warmest months. The total average annual rainfall is 1227 mm. More detailed climatic data can be found in the report "Detailed soil survey and suitability assessment of a pilot site for teak development in the Asubima Forest Reserve".

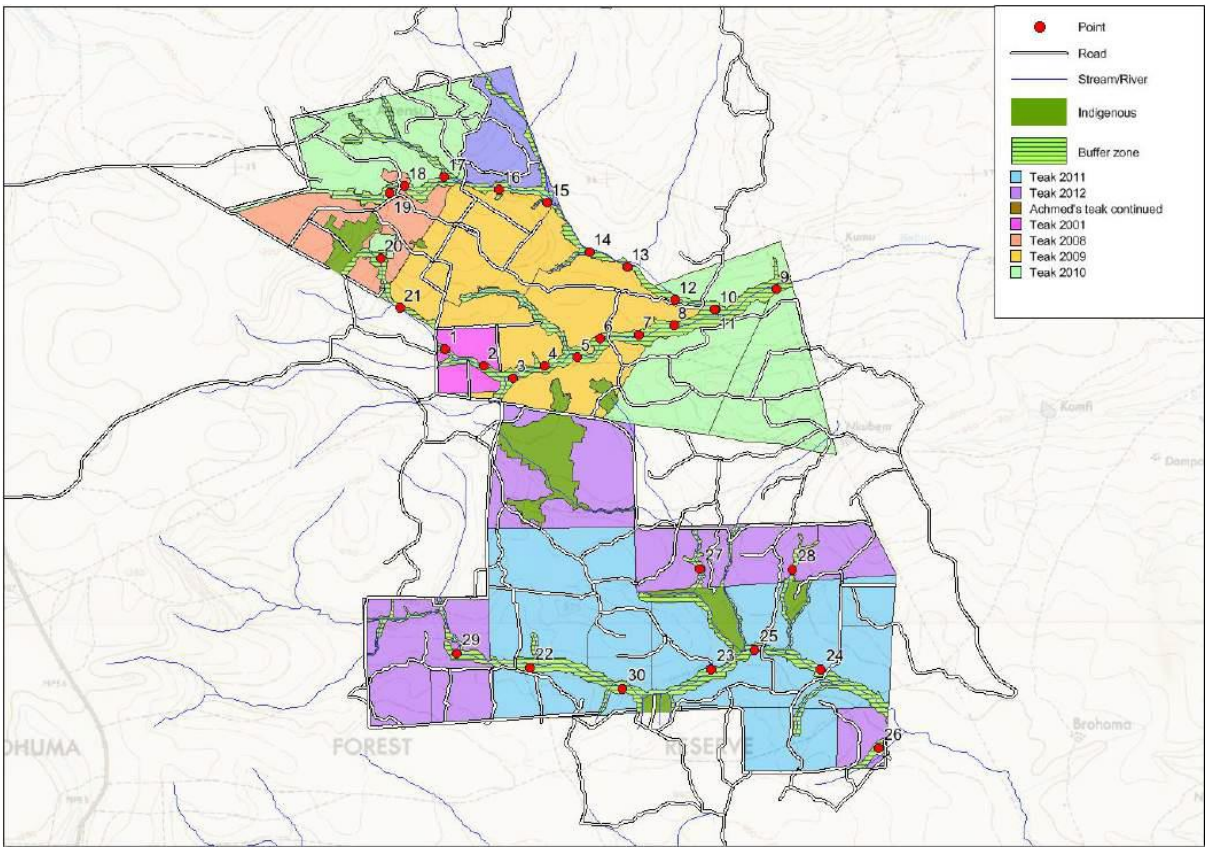

Figure 2.1: Map of Form Ghana's Akumadan Teak Plantation showing management zones.

For teak, a mean annual temperature of 22-27°C and an annual precipitation of 1200-2000 mm/y are optimal (Keogh and Pentsil, 2001). Both temperatures (24-27°C) and rainfall (1227mm) in Asubima and Afrensu Brohuma FR fall well within this range

2.1.3 Abiotic Environment

The geology of the area is important for the growth of the planted forest. Form Ghana takes into account the nature of the terrain as much as possible both in plantation establishment and maintenance. The terrain is undulating with a large ridge running from the east to the west, topped with a nearly horizontal layer of sandstone. Slopes are moderate, between 5-10% in steepness, and the hills have flat tops. Rock outcrops occur in several places in the survey area, but generally cover only small areas. For detailed report on the geology of the area, follow this link:

https://45e820a8-44d1-43ad-b00c-ead94d942715.filesusr.com/ugd/312552_4ac057f376c34cd5b6c450920011b303.pdf

Both forest reserves have a small network of streams, some of which originate in the reserves. The severe forest degradation affected the existing water bodies. Analyses of samples of the water bodies in both forest reserves show severe deterioration of quality parameters such as pH, turbidity, dissolved oxygen (DO), conductivity and nitrate content. Water volume/level was reduced due to siltation and evaporation. More information on water quality measurements can be found in the hydrological report for Asubima Forest Reserve, Social and Environmental Impact Assessments and High Conservation Value studies for Asubima and Afrensu Brohuma Forest Reserves.

The soils in the area have developed in weathered sandstone and generally have a sandy loam to sandy clay loam texture. Deeper horizons have a clay loam to clay texture due to illuviation of clay particles. The detailed inventories of the soils in Asubima and Afrensu Brohuma Forest Reserves are presented in the reconnaissance soil survey reports by H. Scholten in 2012. The reconnaissance soil survey reports can be accessed by contacting Form Ghana management.

2.1.4 Flora and Fauna

Inventories of the area before Form Ghana started planting the indigenous areas showed that virtually no stretch of land within the project area was covered with natural forest due to intensive farming and reported annual fires (Abeney et al., 2008). Weeds and grasses (e.g. *Chromolaena odorata* (Akyeampong) and *Pennisetum purpureum* (Elephant grass) and *Broussonetia papyrifera* (York), introduced for fibre production, had replaced the original high forest, hampering native forest restoration. A single Kokrodua tree (*Pericopsis elata*) was observed in the field by Form Ghana staff members in 2009. Kokrodua is a species listed as endangered on the IUCN Red List and also listed on Appendix II of CITES (IUCN, 2011). Seeds from this tree were collected and cultivated in the nursery for reforestation purposes.

As part of the Social and Environmental Impact Assessment (SEIA), a flora and fauna inventory was conducted in the indigenous forests (riparian zones) of Asubima and Afrensu Brohuma Forest Reserves in 2012. The results of the flora inventory showed a vegetation cover typical for highly degraded areas, with many light-demanding grass and herb species. For the fauna

inventory, birds, mammals, birds, reptiles and butterflies were recorded. Most species of birds and small mammals were common in the area and typical for savannah vegetation. Some rare species of snakes and mammals were recorded, and even a dwarf crocodile, a CITES red-list species, was sighted in Afrensu Brohuma Forest Reserve. The detailed inventories can be found in the SEIA reports (2012). A number of scarlet star-rated species were also found in both forest reserves (Table 2.1). Most of these species were planted by Form Ghana.

Table 2.1: Scarlet star-rated species found in Asubima and Afrensu Brohuma FR (SEIA, 2012).

Local/Common Name	Scientific Name	Akumadan	Berekum
Awiemfosamina	Albizia ferruginea	x	x
Edinam	Entandrophragma angolense	x	
Sapele/Efoborodidwo	Entandrophragma cylindricum	x	
Utile	Entandrophragma utile	x	
Krumben	Khaya anthotheca	x	x
Dubin	Khaya ivorensis	x	
Odum	Milicia excelsa	x	x
Kusia	Nauclea diderrichii	x	
Kokrodua	Pericopsis elata	x	
Wawa	Triplochiton scleroxylon	x	x

Scarlet start rating is explained in detail in page 39.

2.1.4 Socio-economic Environment

Extensive social assessments have been done in Asubima and Afrensu Brohuma Forest Reserves, in 2008 and 2012 respectively. The main conclusions of the last SEIA are included below. More detailed information can be found in the SEIA reports for both forest reserves. An annual social survey is undertaken by Form Ghana to maintain consultations with surrounding communities and individual farmers. These results are included in the annual monitoring reports.


FLORA
SURVEY

3.0 FLORA SURVEY

Six tree species are classified as Vulnerable while two species are Near-Threatened on the IUCN Redlist

3.1 Summary

As part of Form Ghana's commitment to environmental sustainability, the development of the indigenous forest vegetation is monitored every five years. Two indicators have been developed to measure biodiversity in the plantation: (a) Increase of indigenous forest woody biomass stocks up to 350 m^3/ha with at least 2m^3/ha/y and (b) Tree species richness of the project area will remain equal or increase compared to the baseline situation.

In order to verify these indicators, flora in indigenous forest was measured by a KNUST flora team and assisted by the Form Ghana monitoring team. The data was incorporated in the management plan and will be used in management decisions and implementation. Indigenous forest monitoring was done once before, in Asubima Forest Reserve (ASU FR), in 2010, by Noor de Laat, an intern for Form international. A second monitoring was conducted by the Form Ghana monitoring team in 2015, assisted by a botanist (Jonathan Dabo) and trained by Form international (Marthe Tollenaar). The 2021 monitoring was performed by a KNUST field team, assisted by Form Ghana monitoring team. The Form Ghana monitoring team assisted with location of plots and transects lines within the plantation.

Two tree species, *Hallea ledermannii* and *Milicia excelsa* are classified as Near Threatened while six other species are classified as 'Vulnerable' on the IUCN Red List 2021. Both *Hallea ledermannii* and *Milicia excelsa* were also recorded in 2015 by the Form Ghana Team but not by Noor in 2010. None of the species was listed on any CITES Schedule. Locally, five (5) Scarlet Star, five (5) Red Star, four (4) Pink Star and 63 Green Star species (Hawthorne and Abu-Juan, 1995) were recorded.

3.2 Methodology

In order to compare the current state of the indigenous forests (riparian zones) of Asubima FR to the state in 2010 and 2016, data collection was kept largely the same as the method developed by Noor de Laat. Difference in season 2010 and 2021 (may influence census technique and thus confound comparison). Afrensu Brohuma FR was included in the monitoring, thus a number of PSPs were established in Afrensu Brohuma FR (Figure 3.1).

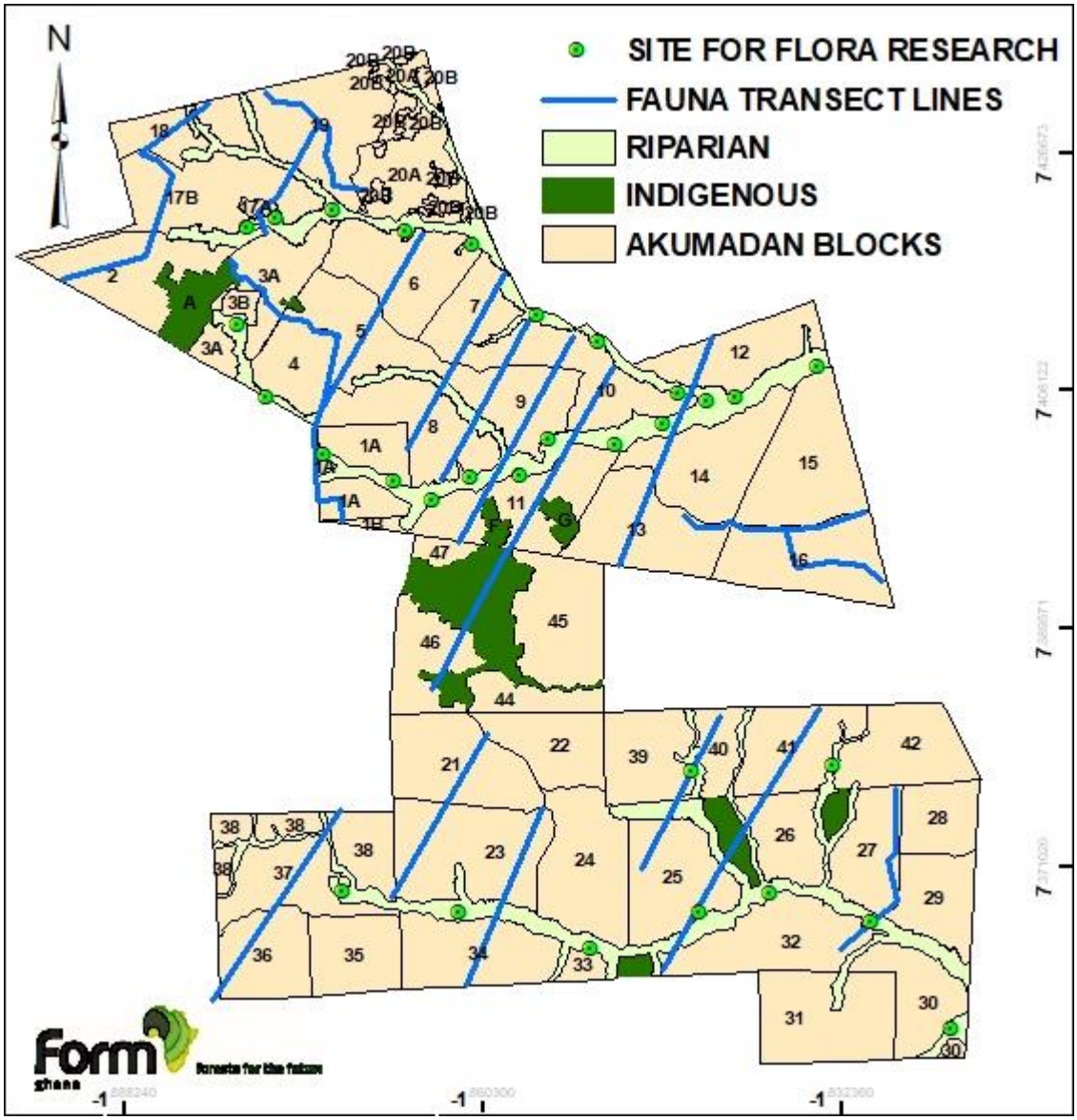

Figure 3.1: Map of study area showing sites for flora research in the plantation.
Source: Boadi Manu Mercy Ama, 2020

3.2.1 Sample Plot Selection and Data Collection

Noor de Laat created 21 Permanent Sample Plots (PSPs) in the indigenous forests of Asubima FR in 2010. The plots were marked with a wooden pole in the centre, which had largely disappeared in 2015 due to termites and other pests. The plots were therefore remarked with metal poles, like the ones used for the teak PSPs, and mounted in the ground with cement. Nine (9) new PSPs were created in the indigenous forest areas of Afrensu Brohuma FR. These plots were marked with the same metal poles. Thus altogether, 30 PSPs (Figure 3.1) were sampled in the current survey.

Each PSP consists of a main plot of 200m^2 (radius: 7.98m), with five nested subplots of 1 x 1m sub-plots (Figure 3.2).

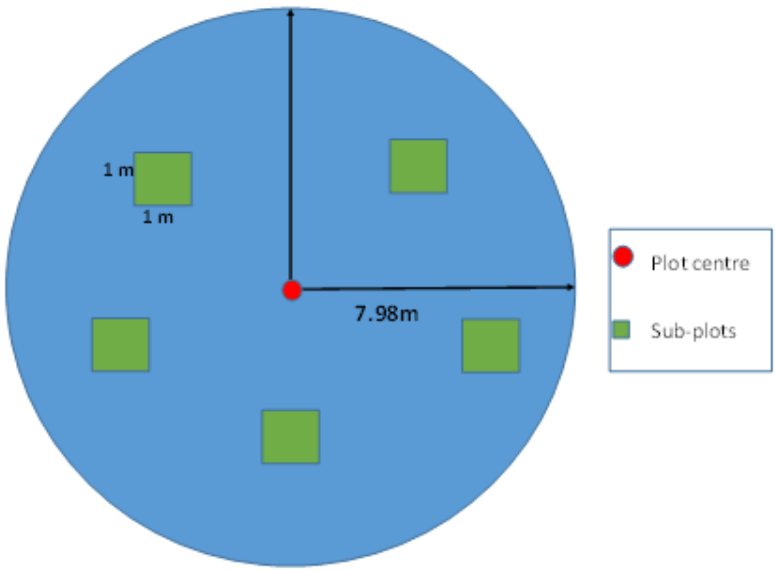

Figure 3.2: Outline of a PSP indigenous forest monitoring plot. Pegs are placed temporarily at the plot boundaries to demarcate the plot. The red dot is the permanent pole, indicating the location of the plot. The squares are the subplots.

The main plots are created in the same way as the PSP monitoring of the teak plantation, with temporary pegs demarcating the outer plots boundaries. The 3x3m subplots were indicated temporarily with 4 pegs on the outer corners. The 1x1m plot was outlined by a 1x1m metal

square. To reach a plot, a cutlass was used to clear a path. Damage to the indigenous forest was kept to a minimum. Inside the plot, no cutlasses were used.

3.2.2 Monitoring parameters

In the main plot (200m^2), trees were measured with Diamter at Breast Height (DBH) > 5cm. DBH is the standard height (1.3m) at which diameter of trees are measured.

The following parameters were recorded:

- ✓ Tree species (scientific/local name)
- ✓ DBH (calliper)
- ✓ Height (estimates by botanist, using Raffia pole as reference)
- ✓ Distance to the middle of the plot (tape measure)
- ✓ Angle from the middle of the plot (compass indicating North (N), South (S), West (W) and East (E), 8 bearings: N/S/E/W/NE/SE/NW/SW).

In the small subplot (1x1m), all shrubs, herbs, grasses and juveniles were measured. The following parameters were recorded:

- Species
- Height (estimate or tape measure)
- Cover in % per species (estimate, only if >15% of the subplot is covered with a certain species)

A qualified botanist was hired to identify the species. If a plant or tree could not be identified, a sample was bagged for determination at the site. In case of herbs and grasses, a full plant was bagged, including stem, leaves and, if possible, flowers/seeds. In case of trees or shrubs, part of a branch was selected that shows leaf composition and, if possible, flowers/seeds. Species were identified with the assistance of field guides (Hawthorne and Gyakari, 2006; Jonking and Hawthorne, 2006).

3.2.2.1 Equipment

The following equipment was used for the field work:

- ✓ Calliper
- ✓ Clinometer

- ✓ Tape measure (10m or more)
- ✓ GPS and Compass
- ✓ Camera
- ✓ 1x1m square to indicate subplots

Plate 3.1: Plot measurments in an indigenous forest in the study area

3.2.2.2 GPS Readings

The plot positions are indicated in Table 3.1.

Table 3.1: GPS readings of center points of plots

Plot	Altitude	GPS Coordinates	
		Longitude (W)	Latitude (N)
Asubima FR			
1	290	1.87274	7.40306
2	288	1.86703	7.40110
3	291	1.86425	7.39957
4	290	1.86118	7.40138
5	285	1.85679	7.40159
6	282	1.85508	7.40431
7	290	1.87274	7.40306
8	268	1.84623	7.40562
9	279	1.83426	7.40986
10	292	1.84059	7.40761
11	266	1.84270	7.40733
12	274	1.84497	7.40793
13	266	1.85115	7.41205
14	273	1.85594	7.414403
15	290	1.86100	7.41944
16	324	1.86631	7.42050
17	342	1.87185	7.42212
18	340	1.87274	7.42158
19	360	1.87849	7.42077
20	318	1.87274	7.41320
21	305	1.87717	7.40759
Afrensu Brohuma FR			
22	270	1.86207	7.36709
23	258	1.84338	7.36717
24	255	1.83002	7.40306
25	252	1.83782	7.36900
26	246	1.87274	7.35839
27	290	1.84394	7.37852
28	259	1.83306	7.37897
29	281	1.87120	7.36900
30	260	1.85199	7.36481

3.2.3 Data Analysis

A software; PAST 2.17c (Hammer et al., 2001) was used to determine species diversity and richness in the various landuse types. Differences in the number of flora per land use and between survey periods were compared using Kruskal Wallis nonparametric analyses. Where appropriate, simple descriptive statistics was used and results presented in the form of graphs, tables and charts for easy observation and understanding.

Plate 3.2: Dbh measurement in an indigenous forest in the study area

3.2.4 Conservation status

Flora conservation status were assessed using the rankings of the International Union for the Conservation of Nature (IUCN, 2021), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)] and National Star Rating System.

International Union for Conservation of Nature and Natural Resources

The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (2021) provides taxonomic, conservation status and distribution information on taxa that have been evaluated using the IUCN Red List Categories and Criteria (Appendix 1a). The main purpose of the IUCN Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on taxa that are categorized as Extinct or Extinct in the Wild; and taxa that cannot be evaluated because of insufficient information (Data Deficient).

Convention on International Trade in Endangered Species of Wild Fauna and Flora

Roughly 5,000 species of animals and 29,000 species of plants are protected by CITES against over-exploitation through international trade. Each protected species or population is included in one of three lists, called Appendices (explained below). The Appendix that lists a species or population reflects the extent of the threat to it and the controls that apply to the trade. Appendix I includes species that are threatened with extinction and are or may be affected by trade. Appendix II includes species that are not necessarily threatened with extinction but may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with the survival of the species in the wild. Appendix III includes species that are not threatened with extinction globally.

Star Rating System

The importance of flora species based on their individual threat from over-exploitation and forest degradation were rated based on the Star Rating System developed by Hawthorne and Abu-Juan (1995)

3.3 Results and Discussion

3.3.1 Description of land use types

Flora were estimated from two major landuse types: Teak plantation and indigenous forest areas. The land use type within each landuse type is described in Table 2. Riparian vegetation constituted parts of the indigenous forest areas and were generally considered as areas of high conservation value because of the potential sensitive biota associated with them.

Table 3.2: Description of management zones surveyed in the study area

#	Management Zone	Land-use Description
1	Teak Plantation	• Monocultures of teak at various stages of growth.
2	Indigenous Forest	• Disturbed forest fragments at various stages of growth including riparian forests along water bodies and undisturbed natural areas

3.3.2 Composition and abundance of plants across the two landuse types

A total of 1067 plants, belonging to 25 families and 77 species were identified and recorded in 30 Permanent Sample Plots. A full list of plant species identified in the PSPs of Asubima and Afrensu Brohuma FRs in 2021 is presented in Table 3.3. *Broussonetia papyrifera* (*n* = 251), was the most abundant tree species and represented 23.52% of the total individuals recorded. They were widely distributed in all landuse types. *Albizia lebbeck* was the second most abundant tree species (*n* = 48, 4.50%) followed by *Albizia zygia* (*n* = 42, 3.94%), *Ceiba pentandra* (*n* = 33, 3.09%) and *Cola gigantea* (*n* = 28, 2.62%). Seven tree species constituted singletons and include: *Xylopia evansii, Dialum guineense, Entandrophragma cylindricum*, *Panda oleosa*, *Morinda lucida*, *Celtis mildbraedii* and *Musanga cecropioides.*

Table 3.3: Checklist of tree species abundances per plot and conservation status

Family	Species	Life form	Asubima FR	Afrensu Brohuma FR	Total	Rel Den (%)	IUCN	Star rating
Anacardiaceae	*Pseudospondias microcarpa*	Tree	7	0	7	0.66	VU	Green
Annonaceae	*Cleistofolis patterns*	Tree	2	0	2	0.19	NE	Green
Annonaceae	*Monodora tenuifolia*	Tree	0	3	3	0.28	LC	Green
Annonaceae	*Xylopia evansii*	Tree	0	1	1	0.09	NE	Green
Apocynaceae	*Funtumia elastica*	Tree	19	18	37	3.47	LC	Green
Apocynaceae	*Rauvolfia vomitoria*	Shrub	4	2	6	0.56	LC	Green
Apocynaceae	*Tabernaemontana africana*	Shrub	2	0	2	0.19	LC	Green
Apocynaceae	*Holarrhena floribunda*	Tree	10	7	17	1.59	LC	Green
Arecaceae	*Raphia hookeri*	Tree	3	2	5	0.47	LC	Green
Arecaceae	*Elaeis guineensis*	Tree	4	2	6	0.56	LC	Green
Asteraceae	*Chromolaena odorata*	Herb	48	9	57	5.34	NE	Green
Bignoniaceae	*Spathodea campanulata*	Tree	2	0	2	0.19	LC	Green
Bignoniaceae	*Newbouldia laevis*	Shrub	2	2	4	0.37	NE	Green
Combretaceae	*Terminalia superba*	Tree	2	0	2	0.19	NE	Red
Combretaceae	*Cumberetum zenkeri*	Liana	5	1	6	0.56	NE	Green
Convolvulaceae	*Ipomoea spp*	Crop	1	0	1	0.09	NE	Green
Ebenaceae	*Diospyros monbuttensis*	Shrub	10	0	10	0.94	NE	Green
Euphorbiaceae	*Ricinodendron heudelotii*	Tree	3	7	10	0.94	LC	Green
Euphorbiaceae	*Macaranga heudolotii*	Shrub	0	1	1	0.09	LC	Green
Euphorbiaceae	*Macaranga barteri*	Shrub	0	6	6	0.56	LC	Green
Euphorbiaceae	*Alchornea cordata*	Shrub	8	0	8	0.75	LC	Green
Euphorbiaceae	*Mallotus oppositifolius*	Shrub	16	17	33	3.09	LC	Green
Fabaceae	*Dialium guineense*	Tree	1	0	1	0.09	NE	Green
Fabaceae	*Centrosema pubescens*	Crop	41	30	71	6.65	LC	Green
Fabaceae	*Abrus precatorius*	Crop	2	0	2	0.19	LC	Green
Fabaceae	*Tetrapleura tetraptera*	Tree	4	0	4	0.37	LC	Green

Fabaceae (Caesalpiniaceae)	*Griffonia simplicifolia*	Shrub	27	13	40	3.75	NE	Green
Fabaceae (Caesalpinioideae)	*Hymenostegia afzelii*	Shrub	0	6	6	0.56	NE	Green
Fabaceae (Caesalpinioideae)	*Leucaena leucocephala*	Shrub	5	0	5	0.47	LC	Green
Fabaceae (Mimosoideae)	*Albizia adianthifolia*	Tree	5	12	17	1.59	LC	Green
Fabaceae (Mimosoideae)	*Albizia lebbeck*	Tree	36	12	48	4.50	LC	Green
Fabaceae (Mimosoideae)	*Albizia zygia*	Tree	25	17	42	3.94	LC	Pink
Fabaceae (Papilionoideae)	*Amphimas pterocarpoides*	Tree	1	2	3	0.28	LC	Red
Fabaceae (Papilionoideae)	*Baphia nitida*	Shrub	13	6	19	1.78	LC	Green
Fabaceae (Papilionoideae)	*Baphia pubescens*	Shrub	2	0	2	0.19	LC	Green
Fabaceae (Papilionoideae)	*Millettia zechiana*	Shrub	22	0	22	2.06	LC	Green
Gentianaceae	*Anthocleista djalonensis*	Tree	2	0	2	0.19	LC	Green
Lamiaceae	*Tectona grandis*	Tree	9	1	10	0.94	LC	Green
Lamiaceae	*Vitex micrantha*	Tree	5	3	8	0.75	LC	Green
Malvaceae	*Pterygota bequaertii*	Tree	0	2	2	0.19	LC	Green
Malvaceae	*Triplochiton scleroxylon*	Tree	5	0	5	0.47	LC	Scarlet
Malvaceae (Bombacaceae)	*Bombax buonopozense*	Tree	3	0	3	0.28	LC	Green
Malvaceae (Bombacaceae)	*Ceiba pentandra*	Tree	6	27	33	3.09	LC	Red
Malvaceae (Sterculiaceae)	*Cola gigantia*	Tree	23	5	28	2.62	LC	Green
Malvaceae (Sterculiaceae)	*Cola millenii*	Shrub	2	3	5	0.47	NA	Green
Malvaceae (Sterculiaceae)	*Sterculia oblonga*	Tree	6	2	8	0.75	LC	Pink
Malvaceae (Sterculiaceae)	*Sterculia tragacantha*	Tree	2	1	3	0.28	LC	Pink
Marantaceae	*Marantochloa purpurea*	Herb	5	0	5	0.47	LC	Green
Meliaceae	*Carapa procera*	Shrub	4	0	4	0.37	LC	Green
Meliaceae	*Cedrela odorata*	Tree	1	1	2	0.19	VU	Green
Meliaceae	*Entadrophragma cylindricum*	Tree	1	0	1	0.09	VU	Scarlet
Meliaceae	*Khaya anthotheca*	Tree	2	0	2	0.19	VU	Scarlet
Meliaceae	*Khaya ivorensis*	Tree	7	2	9	0.84	VU	Scarlet
Meliaceae	*Khaya senegalensis*	Tree	2	0	2	0.19	VU	Green
Meliaceae	*Trichilia monadelfa*	Shrub	10	1	11	1.03	LC	Green
Moraceae	*Antiaris toxicaria*	Tree	3	11	14	1.31	LC	Red

Moraceae	*Broussonetia paperyfera*	Tree	205	46	251	23.52	LC	Green
Moraceae	*Ficus exasperata*	Shrub	0	1	1	0.09	LC	Green
Moraceae	*Ficus variifolia*	Shrub	8	1	9	0.84	LC	Green
Moraceae	*Ficus vogeliana*	Shrub	7	1	8	0.75	LC	Green
Moraceae	*Milicia excelsa*	Tree	1	0	1	0.09	NT	Scarlet
Moraceae	*Morus mesozygia*	Tree	2	0	2	0.19	LC	Green
Moraceae	*Myrianthus arboreus*	Shrub	1	1	2	0.19	LC	Green
Moraceae	*Trilepsium madagascariense*	Tree	0	2	2	0.19	NA	Green
Pandaceae	*Microdesmis pruberula*	Shrub	2	3	5	0.47	LC	Green
Pandaceae	*Panda oleosa*	Tree	1	0	1	0.09	LC	Green
Poaceae	*Penisetum peperum*	Grass	3	2	5	0.47	LC	Green
Rubiaceae	*Hellea ledermannii*	Tree	5	0	5	0.47	NT	Red
Rubiaceae	*Morinda lucida*	Tree	1	0	1	0.09	LC	Green
Sapindaceae	*Blighia unijugata*	Tree	2	0	2	0.19	LC	Green
Sapindaceae	*Lecaniodiscus cupanoides*	Shrub	3	4	7	0.66	LC	Green
Sapindaceae	*Paulina pinata*	Crop	74	7	81	7.59	LC	Green
Sapotaceae	*Pouteria alnifolia*	Tree	1	4	5	0.47	LC	Green
Smilacaceae	Smilax krausiana	Crop	3	0	3	0.28	LC	Green
Talinaceae	*Talinum triangulare*	Herb	1	0	1	0.09	LC	Green
Ulmaceae	*Celtis mildbraedii*	Tree	0	1	1	0.09	LC	Pink
Ulmaceae	*Musanga cercropioides*	Tree	0	1	1	0.09	LC	Green
	Unknown 4	Shrub	3	0	3	0.28		
	Unknown 5	Tree	1	4	5	0.47		
	Total individuals		754	313	1067			
	Total species		69	48	79			

LC Least Concern, NT Near Threatened, VU Vulnerable, NE Not Evaluated

3.3.3 Tree abundance and species diversity across the two forest types

The Asubima FR (69 species) was identified to significantly harbour more tree species (H = 11.200, p = 0.001) than the Afrensu Brohuma FR (48 species). However Afrensu Brohuma FR was the most species diverse forest when various diversity indices were applied to the data (Table 3.4). This results seem strange but the reason for the higher species diversity indices in Afrenso Brohuma FR could be mainly attributed to the presence of extra pioneer and opportunistic species due to its relatively more disturbed vegetation.

Table 3.4: Tree species richness and diversity indices generated by PAST 2.17c

Richness and Diversity Indices	Asubima FR	Afrensu Brohuma FR
Taxa_S	53	38
Individuals	349	139
Dominance_D	0.2103	0.1158
Simpson_1-D	0.7897	0.8842
Shannon_H	2.589	2.922
Evenness_e^H/S	0.2512	0.4889
Brillouin	2.383	2.576
Menhinick	2.837	3.223
Margalef	8.881	7.498
Equitability_J	0.652	0.8033
Fisher_alpha	17.39	17.24
Berger-Parker	0.4384	0.3022
Chao-1	70.5	46.27

From the overall 1067 plants identified in 2021, 754 individuals (71%) were recorded in the Asubima FR while 313 plants (29%) were confirmed in the Afrensua Brohuma FR (Table 3.3, Figure 3.3). This is a significant increase in plant abundance compared to the total of 729 flora comprising of 517 signs (71%) in Asubima FR and 212 flora (29%) in the Afrensu Brohuma FR recorded in the previous 2015 survey. It is expected that as the forest fragments gradually recover from its previous disturbances over time, more new species will begin to gradually appear to represent the true forest conditions.

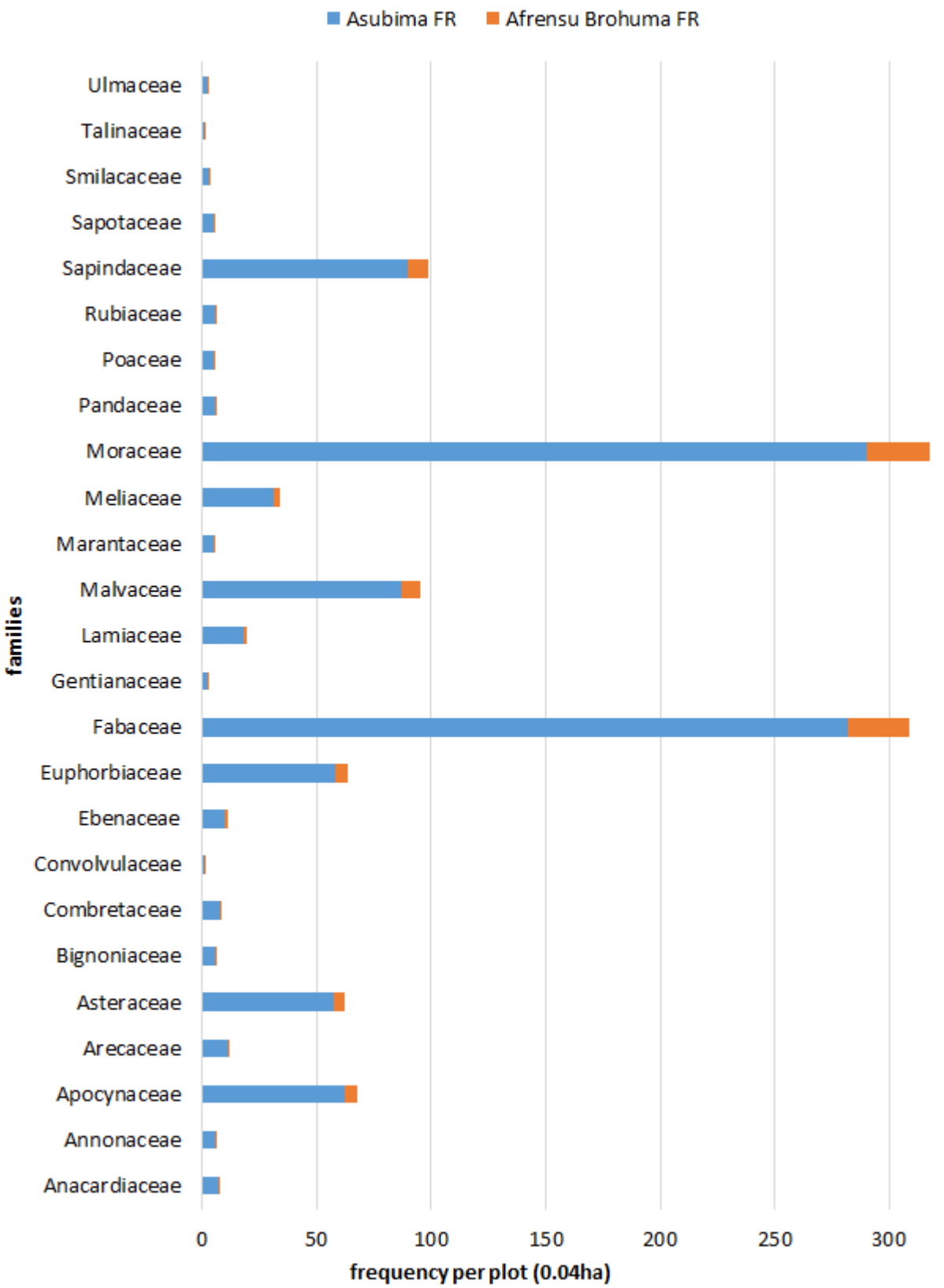

Figure 3.3: Abundance of trees recorded in the study area

Majority of the species were from the families, Moraceae (27%) and Fabaceae (26%) and were most widespread in Asubima and Afrensu Brohuma FR (Figure 3.4).

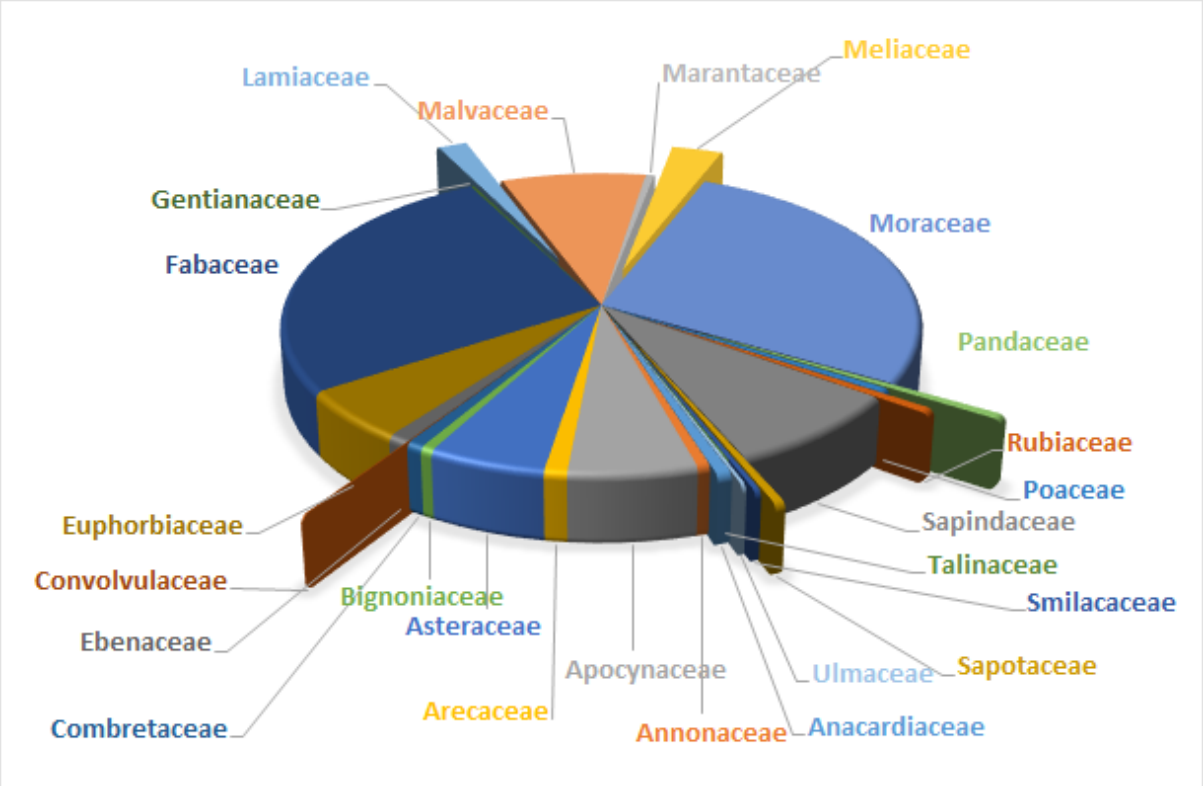

Figure 3.4: Distribution of tree families recorded in the study area

3.3.4 Tree species comparison between survey periods 2010, 2015 and 2021

3.3.4.1 DBH Size Trends

Generally, trees recorded in Asubima FR had larger DBHs in 2021 (16.92m) compared to 2015 (15.6cm) and 2010 (13.7cm). Similarly there were taller trees in in 2021 (11.15m) than in 2015 (9.20m) and 2010 (3.50m), and (Table 1). The trees in Afrensu Brohuma FR showed similar trends (Kruskal-Wallis Test, H = 2.315, p = 0.128) in terms of height and DBH size classes.

Table 3.5: Average DBH/Height of trees in Asubima and Afrensu Brohuma in 2010 and 2015

	Asubima FR			Afrensu Brohuma FR		
	2010	2015	2021	2010	2015	2021
Average DBH (cm)	13.7	15.6	16.92	-	16.3	13.93
Average Height (m)	3.5	9.2	11.15	-	6.9	9.45

This is an indication that the previously degraded forests within the indigenous forests of both Asubima FR and Afrensu Brohuma FR are gradually developing the characteristics of true forest-like vegetation. York (*Broussonetia paperyfera*) was excluded from subsequent analyses in order to make a fair comparison between the monitoring results in 2010, 2015 and 2021. Reasons were: 1) York was not consistently recorded in 2010, and 2) York is an invasive species that does not qualify as a native tree species for the subsequent analysis.

Figure 3.5 below shows the relative DBH size class trends analysis for Asubima FR and Afrensu Brohuma FR for 2021. Trees in Afrensu Brohuma generally had lower average DBHs than in Asubima FR (Figure 8).

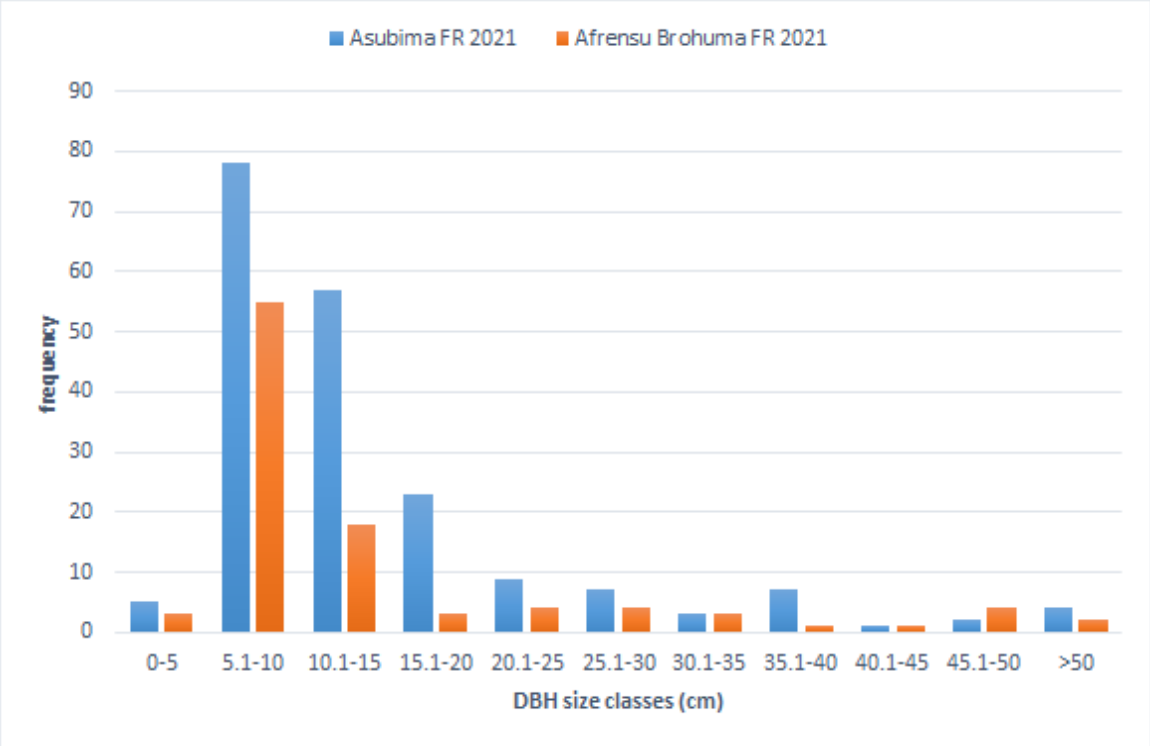

Figure 3.5: Relative DBH distribution in Asubima FR and Afrensu Brohuma FR in 2021

Nevertheless, the DBH size class distributions were very similar, all peaking in the DBH size class (5-15cm). Previuosly in 2010 and 2015, the peaks were within lower DBH size classes of between 0-10cm. Given the very disturbed nature of the original forest, this may suggest a slight mean increase from small plants with small stems in the previous years to bigger plants in 2021. Even so, the current DBH distribution profile still suggests a composition of a relatively young forest with a few number of very big trees.

Figure 3.6 below shows the relative DBH size class trends analysis for Asubima FR for 2010, 2015 and 2021. There were significant difference (Friedman Test, x^2 = 6.65, P = 0.0388) between the DBH size class distributions for 2010, 2015 and 2021. These differences can be shown from the gradual but clear shift in the mean peak frequencies of DBH size classes from 2010, 2015 to 2021 towards bigger size classes.

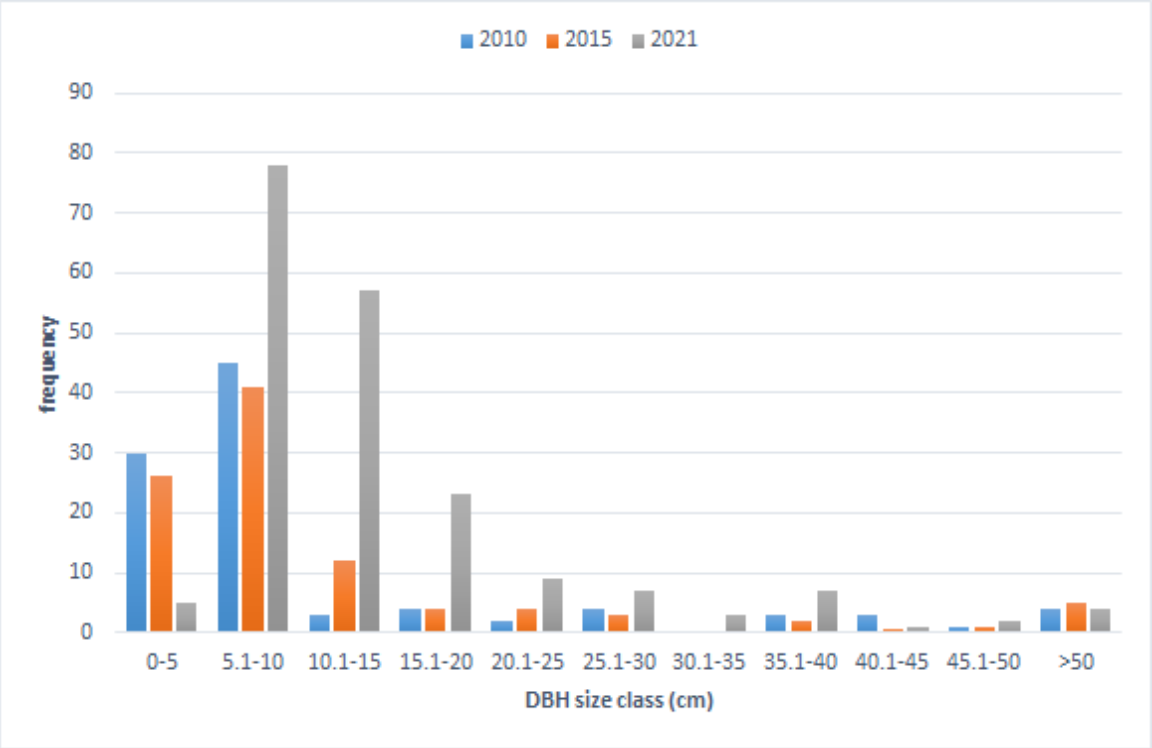

Figure 3.6: Relative DBH distribution in Asubima FR in 2010, 2015 and 2021.

These are evident in the reverse J-shape distribution exhibited in 2010 and 2015 which is typical of very disturbed forests with many young individuals changing to the more uniform bell-shaped distribution exbited in 2021 which is typical of maturing young forests.

Figure 3.7 below shows the relative DBH size class trends analysis for Afrensu Brohuma FR for 2015 and 2021. There were no significant differences (Kruskal-Wallis Test, H = 0.357, P = 0.5501) between the DBH size class distributions for 2015 and 2021. Nevertheless, there seem to be a shift in the mean peak frequencies of DBH size classes from 2015 to 2021 towards bigger size classes.

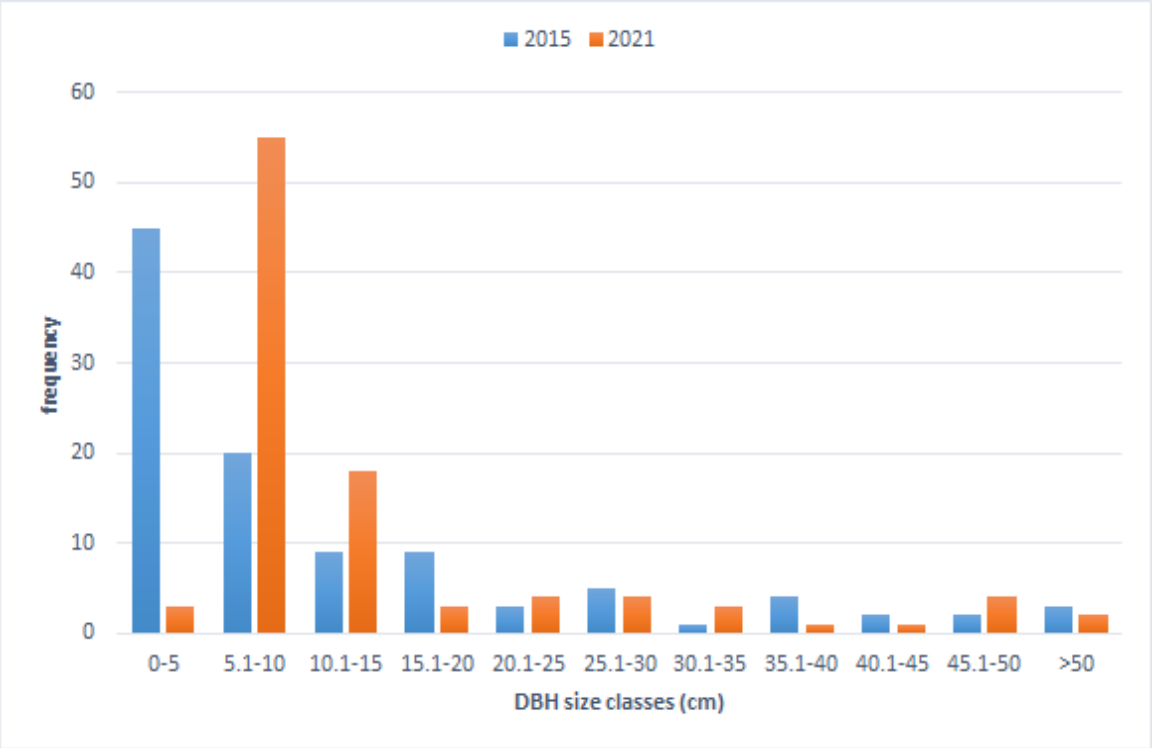

Figure 3.7: Relative DBH distribution in Afrensu Brohuma FR in 2015 and 2021.

Similar to Asubima FR, this can be seen in the change from a reverse J-shape distribution in 2015 to a more uniform bell-shaped distribution in 2021. This suggests a general increase in the mean DBH size class distributions from 2015 to 2021 which is indicative of growth.

3.3.4.2 Height Trends

Distribution over height classes was similar in Asubima and Afrensu Brohuma FR (Figure 3.8). Although trees in Afrensu Brohuma were generally shorter than in Asubima FR, there was no significant difference (Kruskal-Wallis Test, H = 1.168, P = 0.2798) in the height class distribution between both forests in 2021.

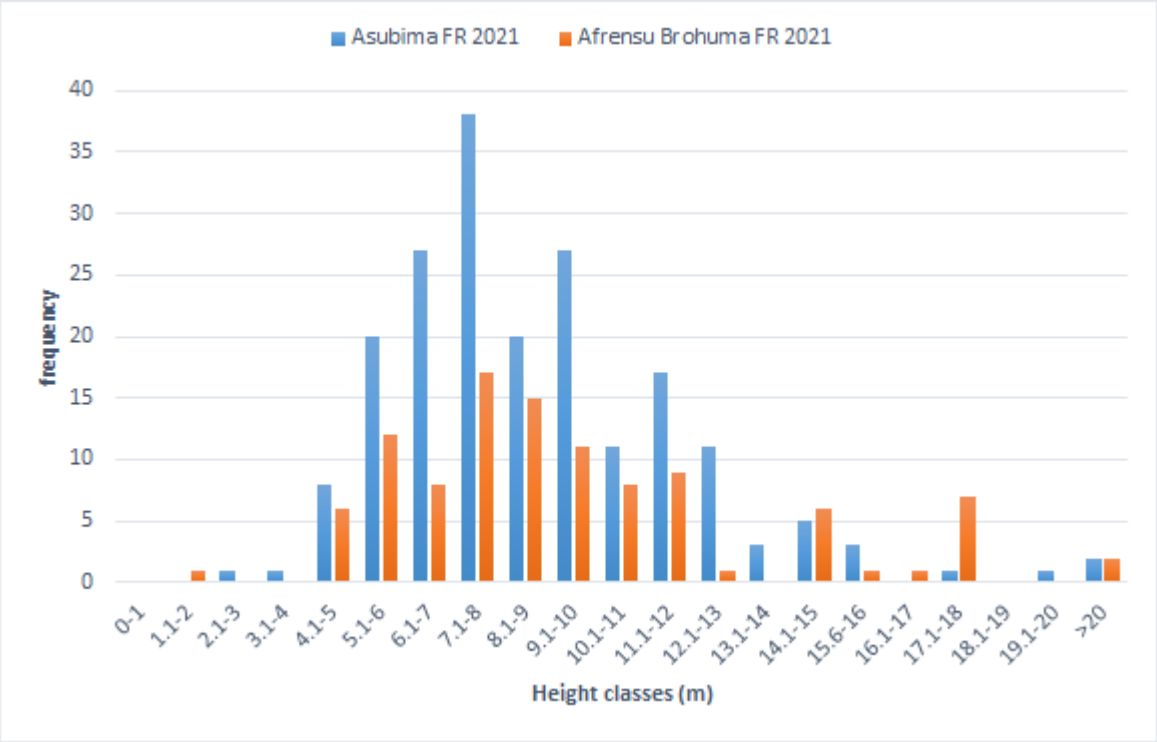

Figure 3.8: Relative height distribution in Asubima and Afrensu Brohuma FR in 2021.

The distribution in Afrensu Brohuma FR however seem to indicate two peaks in height classes; the main one at the height class of between 7-9m, and a smaller one at height classes 17-18m, while in Asubima FR there is only one major peak, at height class 7-8m (Figure 3.8). The two peaks in Afrensu Brohuma could be caused by a rejuvenation of the forest that has a number of high trees still standing, but has room for young trees to establish and develop.

Figure 3.9 below shows the relative height class trends analysis for Asubima FR for 2010, 2015 and 2021. There were significant differences (Friedman Test, $x^2 = 7.93$, P = 0.0189) between the height class distributions for 2010, 2015 and 2021. These differences can be shown from the gradual but clear shift in the mean peak frequencies of height classes from 2010, 2015 to 2021 towards higher size classes.

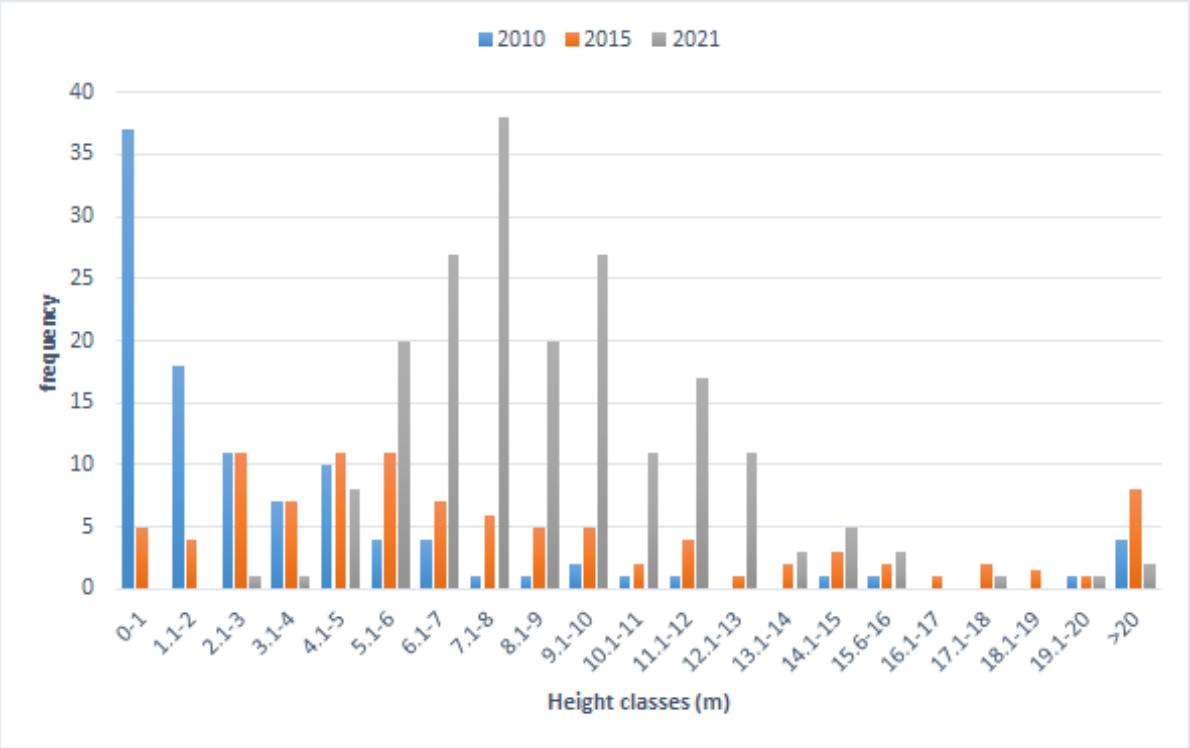

Figure 3.9: Relative height distribution in Asubima FR in 2010, 2015 and 2021.

The height distribution has shifted from a peak in the lower classes (1 and 3) in 2010 to the more equally spread distributions in 2015 ad 2021. These are evident in the reverse J-shape distribution exhibited in particularly in 2010 which is typical of very disturbed forests with many young individuals changing to the more uniform bell-shaped distribution exhibited in 2015 but especially in 2021 which is typical of maturing young forests. This could indicate the maturing of trees in the the indigenous forest areas, facilitated by reduced disturbance.

Figure 3.10 below shows the relative height class trends analysis for Afrensu Brohuma FR for 2015 and 2021. There were no significant differences (Kruskal-Wallis Test, H = 0.388, P = 0.5336) between the height class distributions for 2015 and 2021. Nevertheless, there seem to be a shift in the mean peak frequencies of height classes from 2015 to 2021 towards bigger size classes.

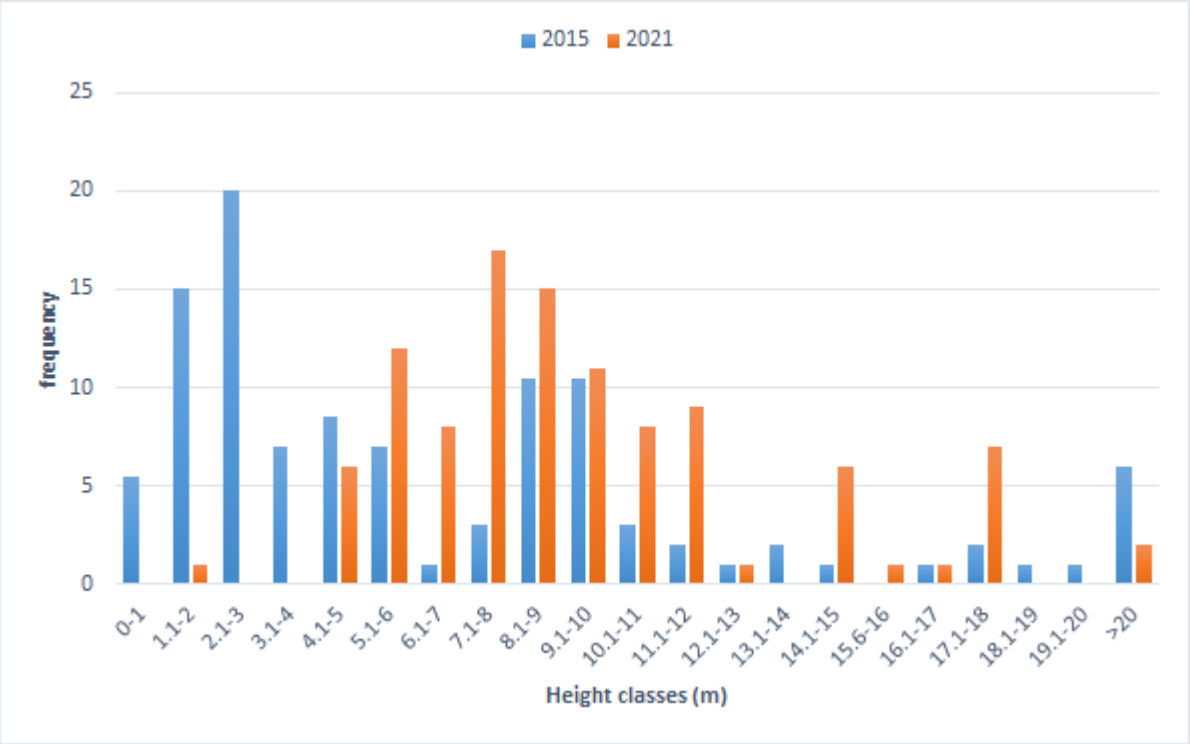

Figure 3.10: Relative height distribution in Afrensu Brohuma FR in 2015 and 2021.

Similar to Asubima FR, this can be seen in the change from a reverse J-shape distribution in 2015 to a more uniform bell-shaped distribution in 2021. This suggests a general increase in the mean height class distributions from 2015 to 2021 which is indicative of growth.

3.3.4.3 Tree Density

The total number of trees (DBH > 5cm) in Asubima FR has increased by 72% from 94 in 2010 to 162 in 2015. Furthermore, there was a 67% increase from 162 in 2015 to 349 in 2021 (excluding York) (Table 3.6). The average tree density in Asubima now has increased from 426 trees/ha in 2015 to 533 in 2021. This is a strong indication for the recovery of the indigenous forests.

Total number of tree species has also increased in Afrensu Brohuma FR, from 45 in 2010 to 57 in 2015 (18% increase) and from 57 in 2015 to 139 in 2021 (82% increase).

Table 3.6: Tree density and total number of species (exl York) in ASU.

	Asubima FR			Afrensu Brohuma FR		
	2010	2015	2021	2010	2015	2021
Total tree number	94	162	349	45	57	139
Trees/ha	247	426	533	-	-	269
Tree species	45	53	52	-	-	38

3.3.4.4 Tree basal area

The accuracy of wood volume assessments is difficult to optimize, hence basal area was used as a best parameter to compare forest cover over the years. Basal area is used to determine more than just forest stand density; it is also linked with timber stand volume and growth. Therefore, it is often the basis for making important forest management decisions such as estimating forest regeneration needs and wildlife habitat requirements. The manipulation of stand basal area to achieve forest management goals can be as important as the use of prescribed fire or other vegetation treatments.

The tree basal area per hectare increased by 80% between 2010 (10.6m2 /ha) and 2015 (19.0m^2 /ha) and by 72% between 2015 (19.0m^2 /ha) and 2021 (24.33m^2 /ha) (Table 3.7). This shows the development of forest cover in the respective indigenous forest areas.

Table 3.7: Basal area

	Asubima FR			Afrensu Brohuma FR		
	2010	2015	2021	2010	2015	2021
Basal area	4.0	7.2	7.53	-	2.4	3.28
Basal area/ha	10.6	19.0	24.33	-	13.4	15.62

3.3.4.5 Biodiversity Index

Adopting the Shannon-Wiener Index to estimate for biodiversity presents a high overall biodiversity rating (3.8), for all plots measured in 2021. The index usually ranges from 1.5 to 3.5, so this is a very high rating of the biodiversity in the indigenous forests of Asubima and Afrensu Brohuma FRs. The 2021 rating (3.8) is higher than the 3.7 rating presented in 2015. This also gives indication that forest condition has improved since 2015.

3.4 Conservation Status

3.4.1 IUCN, CITES and Star Rating

Two tree species, *Hallea ledermannii* and *Milicia excelsa* are classified as Near Threatened while six other species are classified as 'Vulnerable' on the IUCN Red List 2021 (Table 3.8). Both *Hallea ledermannii* and *Milicia excelsa* were also recorded in 2015 by the Form Ghana Team but not by Noor in 2010. None of the species was listed on any CITES Schedule.

Table 3.8: List of tree species of conservation concern on the IUCN Red List 2021

Family	Species	Asubima FR	Afrenso Brohuma FR	IUCN	Star rating
Rubiaceae	*Hallea ledermannii*	5	0	NT	Red
Moraceae	*Milicia excelsa*	1	0	NT	Scarlet
Anacardiaceae	*Pseudospondias microcarpa*	7	0	VU	Green
Meliaceae	*Cedrela odorata*	1	1	VU	Green
Meliaceae	*Khaya anthotheca*	2	0	VU	Scarlet
Meliaceae	*Khaya ivorensis*	7	2	VU	Scarlet
Meliaceae	*Khaya senegalensis*	1	0	VU	Green
Miliaceae	*Entandrophragma cylindricum*	1	0	VU	Scarlet
	Total	25	3		
	Number of Species	8	2		

All the species identified to be of conservation interest are forest species. Major threats in Ghana include over-exploitation and habitat loss. Thus efforts by Form Ghana to protect these species and restore these areas to natural forest in the plantation is very commendable.

3.4.1 Genetic Heat Index/STAR rating

In Ghana, a special system has been developed to assess conservation priority of tree species. Each species has been assigned to a Star category based on its rarity in Ghana and internationally, with subsidiary consideration of the ecology and taxonomy of the species (Hawthorne & Abu-Juam, 1995). Table 3.9 presents the Star rated species identified in Asubima and Afrensu Brohuma FR in 2021.

Out of a total of 14 species, 13 species were identified in Asubima FR that were rated in the Pink Category or above, and 8 in Afrensu Brohuma FR. Overall, there were five (5) Scarlet Star, five (5) Red Star, four (4) Pink Star and 63 Green Star species.

Table 3.9: Observations of STAR-rated species in Asubima and Afrensu Brohuma FRs in 2021

Star	Comment	Species	AFR	ABFR
Black	Urgent attention to conservation of populations needed. Rare internationally, and at least uncommon in Ghana. Ghana must take particular care of these species		-	-
Gold	Fairly rare internationally and/or locally. Ghana has some inescapable responsibility for maintaining these species.		-	-
Blue	Widespread internationally but rare in Ghana, or vice versa. It may be in Ghana‟s interests to pay attention to protecting some of these species.		-	-
Scarlet	Common, but under serious pressure from heavy exploitation. Exploitation needs to be curtailed if usage is to be sustainable. Protection on all scales vital.	*Triplochiton scleroxylon* *Milicia excelsa* *Entandrophragma cylindricum* *Khaya anthotheca* *Khaya ivorensis*	5 1 1 2 7	0 0 0 0 2
Red	Common, but under pressure from exploitation. Need careful control and some tree by tree and area protection.	*Terminalia superba* *Amphimas pterocarpoides* *Ceiba pentandra* *Antiaris toxicaria* *Hallea ledermannii*	2 1 6 3 5	0 2 27 11 0
Pink	Common and moderately exploited. Also nonabundant species of high potential value.	*Albizia zygia* *Sterculia oblonga* *Sterculia tragacantha* *Celtis mildbraedii*	25 6 2 0	17 2 1 1

Each Star category has been assigned a ‘weight’ that indicates the relative value of each category in building up a standard spot conservation score. This score is referred to as the Genetic Heat Index (GHI) and calculated for Asubima and Afrensu Brohuma FR based on collected monitoring data of 2010, 2015 and 2021 (Table 3.10).

The GHI has increased in Asubima FR; from 48 in 2010 to 68 in 2015 and to 82 in 2021. Note that this index indicates relevance for conservation purposes only. There was also an increase in Afrensu Brohuma FR from 41 in 2015 to 53 in 2021. The number of species found that are of no particular conservation concern decrease the GHI value.

Table 3.10: Genetic Heat Index calculated for Asubima and Afrensu Brohuma FRs in 2010, 2015 and 2021. Only main plots (Plot code: 0) were included in the analyses.

	Asubima FR			Afrensu Brohuma FR		
	2010	2015	2021	2010	2015	2021
Genetic Heat Index	48	68	82	-	41	53

All values are within the 'Slightly Warm' range classified by Hawthorne and Abu-Juam (1995) (Table 3.11). Asubima FR is at the higher end of the slightly warm range while Afrenso Brohuma FR is at the lower end.

Table 3.11: Genetic Heat Index categories and ranges.

GHI Category	GHI Range
Cool	0-24
Tepid	25-49
Slightly warm	50-99
Very warm	100-149
Fairly hot	150-199
Very Hot	200+

3.5 Conclusions and Recommendations

3.5.1 Conclusions

- The indigenous forests of Asubima and Afrensu Brohuma FR have shown positive development over the past 10 years from a much degraded state gradually rejuvenating towards a more mature forest, with larger average DBH and taller heights.
- Eight tree species of conservation interest were identified in the indigenous forests. These included *Hallea ledermannii* (NT), Milicia excelsa (NT), *Pseudospondias microcarpa* (VU), *Cedrela odorata* (VU), *Khaya anthotheca* (VU), *Khaya ivorensis* (VU), *Khaya senegalensis* (VU) and *Entandrophragma cylindricum* (VU). Based on the Star Rating System (Hawthorne and Abu-Juan, 1995), five (5) Scarlet Star, five (5) Red Star, four (4) Pink Star and 63 Green Star species were recorded.
- The Genetic Heat Index of Asubima and Afrensu Brohuma FRs have increased over the years, emphasizing the need for further conservation of the indigenous forests.

3.5.2 Recommendations

- We recommend maintaining the current plot design to facilitate easy comparison with future datasets.
- For consistency, we would recommend maintaining the KNUST team in all subsequent monitoring exercise. Maintaining same botanists in the identification will ensure consistencies in the data collection and monitoring data over the years.

FAUNA SURVEY

4.0 FAUNA SURVEY

Indigenous forest had the most diverse fauna abundance and harboured the greatest number of forest – dependent species

4.1 Summary

Four mammal taxonomic groups (primates, carnivores, ungulates and rodents), representing 14 Families, 17 Genera, and 17 Species were confirmed in the Akumadan plantation. More mammals were recorded in the current survey than the previous 2017 survey. Indigenous forests were species richest and most diverse in terms of mammals. Recorded mammals of global conservation interest included one carnivore (Tree Pangolin; *Phataginus tricuspis*; Endangered) and one primate (Lowe's Mona Monkey; *Cercopithercus lowei*; Vulnerable). Both species are also listed in Appendix II of CITES (species that are not necessarily threatened with extinction but may become so unless trade is closely controlled). The African Civet (*Civettictis civetta*) is also listed in Appendix III of CITES (trade in these species is only permitted with an appropriate export permit and a certificate of origin from the member country). Locally, all primates and the tree pangolin are of special conservation importance in Ghana and are listed in Schedule 1 of the Ghana Wildlife Conservation Regulations (1995). All these species were largely restricted to the indigenous forests, making forest fragments an important hotspot for mammal conservation. High priority must be given in order to ensure continuous prevention of illegal human activities within the plantation so that biodiversity can recover. If this is not done, all efforts to conserve fauna populations in the plantation are likely to be unsuccessful.

4.2 Methodology

4.2.1 Transect Selection:

Stratified sampling method (Stohlgren et al. 1997, Hirzel and Guisan, 2002, Grabherr et al. 2003), using trasects, was used to assess plant species in the various landuse types (Figure 4.1).

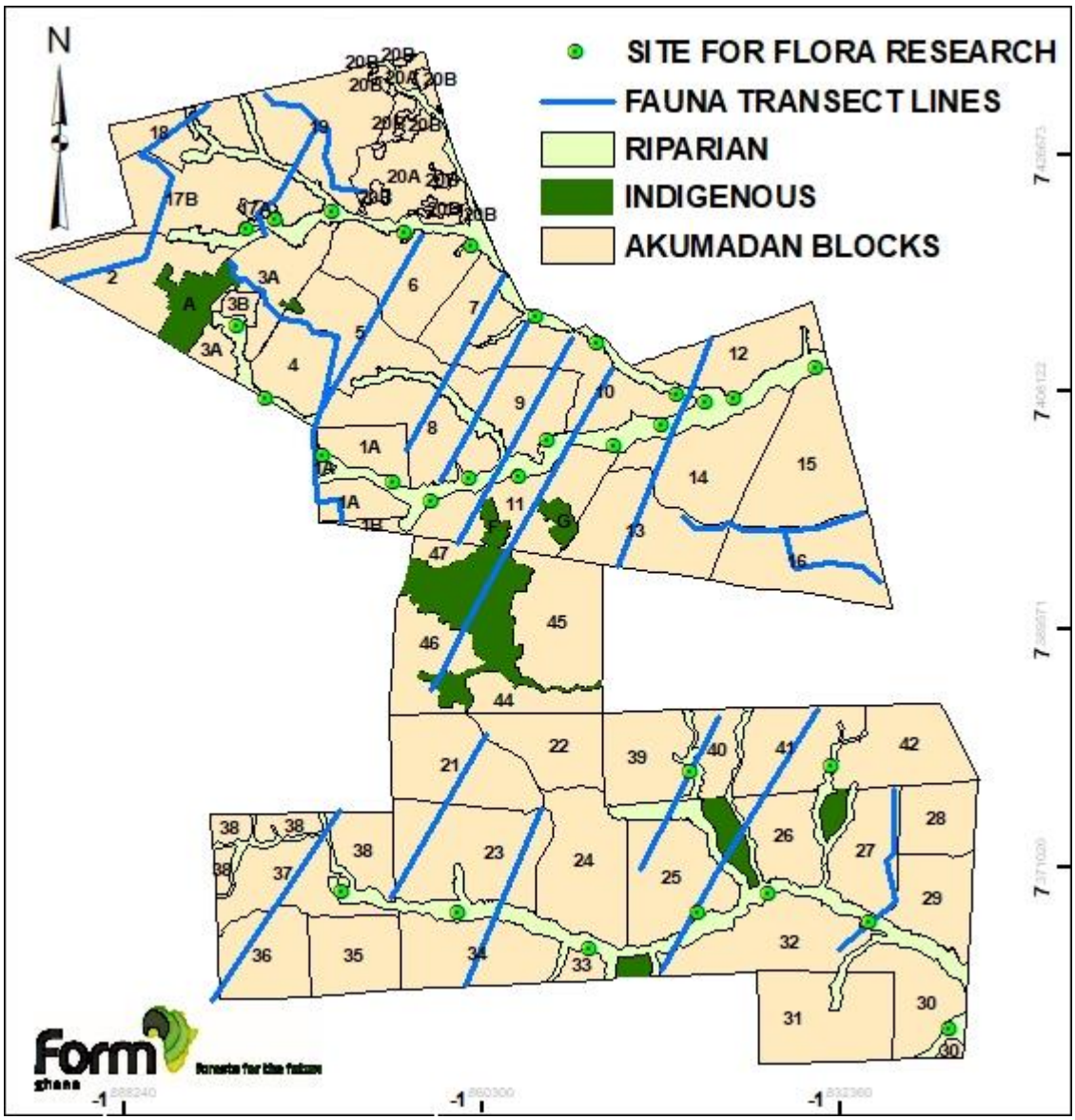

Figure 4.1: Map of study area showing fauna transect lines in the plantation
Source: Boadi Manu Mercy Ama, 2021

4.2.2 Data collection

Monitoring data for all the fauna (birds and mammals) species was collected from existing 17 transects used by De Laat, 2010; Manu, 2011 and Quansah 2011 (Figure 1, Table 1). Field work was undertaken from 15th to 25th March, 2021.

Field guides were used to help in the identification of mammals (Stuart and Stuart, 2006; Happold, 1990) and birds (Barrow and Demey, 2008). All captured and identified specimens were released as soon as possible at the point of capture.

4.2.2.1 Medium to Large Mammals

Medium to large mammal survey was conducted based on direct counts and record of their signs, using the line transect method (Burnham et al., 1980; Buckland et al., 1993, 2001). All the seventeen (17) transects of approximately 2km each used in previous monitoring exercises were followed for data collection. One survey team of three persons and led by a compass man (team leader) was maintained throughout the counts to ensure consistency in data collection procedures. GPS coordinates were recorded each time visual observations of a species or sign of their presence (tracks, walking trails, droppings, feeding signs burrows and nests) was observed.

4.2.2.2 Small mammals

Small mammal survey was conducted to determine species of small mammals in a specific area. The recommended procedures are a combination of live trapping and pitfall trapping with systematic sampling along index trap lines (transects) that are randomly placed within stratified sites. However, due to the extremely high litter density on the forest floor only live trapping using Sherman's live trap was done. Live trapping was also considered the standard as it captures all mammal species or age classes equally and does not remove significant proportion of biotic community as compared to snare or snap trapping. To compliment the trapping method for data collection opportunistic sightings were also made to detect some arboreal species including bat roosts that could not captured by the traps.

Five one-kilometer index trap lines (transects) were systematically selected from the previous monitoring transects taking into consideration the various microhabitats in the area. Two Sherman's live traps were placed at approximately 200m intervals from every trap station on each of the index trap lines. In order to standardize baiting, peanut butter mixed with corn dough was used as bait. The baited traps were inspected every morning and rebaited for six continuous days. Trapped specimens were collected, identified to the species level based on their morphological appearances and by the help of Jonathan Kingdon's field guide.

4.2.2.3 Birds

Several techniques can be used in biodiversity assessment and monitoring programs but the choice of technique depends on several factors. Vegetation cover, temperature, season, humidity, topography, type of bird, time of day survey is conducted are all factors that affect the results obtained in bird survey (there are a lot more factors). In order to identify bird species in this project, we followed existing transects or quadrant lines. We walked transects when birds were most active, around sunrise and sunset. This way they are more easily seen or heard. Birds' counts began not less than 20 minutes after sunrise and ended 3-4 hours later and about 2 hours to sunset. During these periods, birds are known to be very active. Counts were done at random intervals but not less than 200m apart to minimize the possibility of double counting. A pair of binoculars was used to observe the birds for identification. Birds were also identified by their calls. Identified bird species were recorded on a data sheet. Birds' nomenclature followed Borrow and Demey, 2010.

4.2.2.4 GPS Readings

The transect positions are indicated in Table 4.1.

Table 4.1: GPS readings of start and end points of line transects (Afrenso Brohuma FR portion)

Transects	**GPS Coordinates**	
	Longitude (W)	**Latitude (N)**
A1 start	1°52′ 50.2″	7° 21′ 38.7″
A1 end	1°52′ 23.7″	7° 22′ 28.7″
A2 start	1°52′ 02.2″	7° 22′ 02.5″
A2 end	1°51′ 49.5″	7° 51′ 38.2″
A3 start	1°51′ 19.6″	7° 22′ 32.3″
A3 end	1°51′ 50.7″	7° 22′ 29.4″
A4 start	1°50′ 50.6″	7° 22′ 15.4″
A4 end	1°50′ 27.8″	7° 22′ 29.4″
A5 start	1°50′ 46.0″	7° 21′ 47.2″
A5 end	1°50′ 01.2″	7° 22′ 59.2″
A6 start	1°49′ 39,9″	7° 22′ 35,3″
A6 end	1°49′ 56.9″	7° 21′ 52.7″

Table 4.2: GPS readings of start and end points of line transects (Asubima FR portion)

Transects	**GPS Coordinates**	
	Longitude (W)	**Latitude (N)**
B1 start	1° 52′ 18.2″	7° 24′ 27.4″
B1 end	1°52′ 03.0″	7°24′ 47.3″
B2 start	1°51′ 42.3″	7°24′ 40.1″
B2 end	1°51′ 58,8″	7°24′ 15.5″
B3 start	1°51′ 20.9″	7°24′ 47.7″
B3 end	1°51′ 38.4″	7°24′ 23.6″
B4 start	1°51′ 11.6″	7°24′ 39.6″
B4 end	1°51′ 26.9″	7°24′ 17.3″
B5 start	1°50′ 57.9″	7°24′ 35.2″
B5 end	1°51′ 30.0″	7°23′ 45.0″
B6 start	1°50′ 58.8″	7°23′ 44.2″
B6 end	1°50′ 48.4″	7°24′ 16.8″
B7 start	1°49′ 55.8″	7°23′ 54.3″
B7 end	1°50′ 33.4″	7°23′ 51.7″
B8 start	1°49′ 44.5″	7°23′ 35.6″
B8 end	1°50′11,7 ″	7°23′ 50.4 ″
B9 start	1°52′ 28.9″	7°25′ 02.6″
B9 end	1°52′ 43.8″	7°24′ 41.49″
B10 start	1°53′ 34.5″	7°24′ 59.4″
B10 end	1°53′ 07.8″	7°25′ 34.7″
B11 start	1°52′ 33.3″	7°25′ 52.1″
B11 end	1°52′ 38.2″	7°25′ 16.6″

4.2.3 Data Analysis

An indirect technique such as an index count, which produces relative numbers based on encounter rates, was used to estimate species densities.

Fauna sign density = [number of signs / total distance walked----equation 1

Index counts relate animal numbers to an index of animal signs detected along line transects (Buckland *et al*., 2001; Barnes *et al*., 1997).

A software; PAST 2.17c (Hammer et al., 2001) was used to determine species diversity and richness in the various landuse types. Differences in the number of fauna signs per land use and between survey periods were compared using Kruskal Wallis nonparametric analyses. Where appropriate, simple descriptive statistics was used and results presented in the form of graphs, tables and charts for easy observation and understanding.

4.2.4 Conservation status

Fauna conservation status were assessed using the rankings of the International Union for the Conservation of Nature (IUCN, 2021), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)] and National (Ghana Wildlife Laws) Criteria.

4.2.4.1 International Union for Conservation of Nature and Natural Resources

The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (2021) provides taxonomic, conservation status and distribution information on taxa that have been evaluated using the IUCN Red List Categories and Criteria (Appendix 1a). The main purpose of the IUCN Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on taxa that are categorized as Extinct or Extinct in the Wild; and taxa that cannot be evaluated because of insufficient information (Data Deficient).

4.2.4.2 Convention on International Trade in Endangered Species of Wild Fauna and Flora

Roughly 5,000 species of animals and 29,000 species of plants are protected by CITES against over-exploitation through international trade. Each protected species or population is included in one of three lists, called Appendices. The Appendix that lists a species or population reflects the extent of the threat to it and the controls that apply to the trade. Appendix I includes species that are threatened with extinction and are or may be affected by trade. Appendix II includes species that are not necessarily threatened with extinction but may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with the survival of the species in the wild. Appendix III includes species that are not threatened with extinction globally.

4.2.4.3 National Criteria

Ghana's wildlife laws (Ghana Wildlife Conservation Regulations, 1995) also categorize animal species into two main schedules based on the level of protection required for the particular species. The complete list is also provided in Appendix 1b.

4.3 Results

4.3.1 Mammals

4.3.1.1 Mammal species abundances and diversity

Four mammal taxonomic groups (primates, carnivores, ungulates and rodents), representing 14 Families, 17 Genera, and 17 Species were confirmed in the study area during the survey (Figure 4.5, Table 4.3).

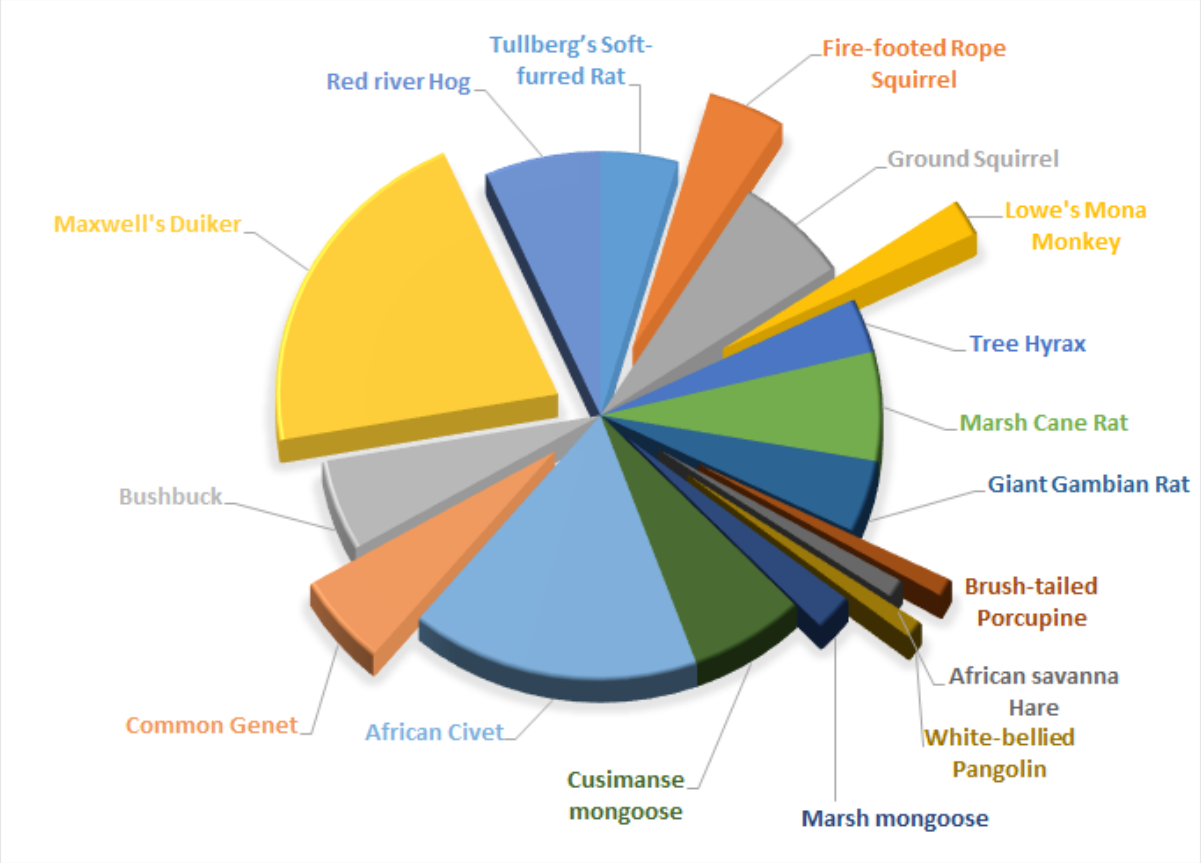

Figure 4.2: Distribution of mammal species recorded in the study area

Ninety (90) terrestrial mammal signs were recorded: 62 signs (69%) in the indigenous forest areas and 28 signs (31%) in teak plantation. This is an important increase in mammal abundance compared to the 32 mammal signs comprising 18 signs (53%) in indigenous forest areas and 16 signs (47%) in the teak plantation recorded in the previous 2017 survey. The Maxwell's Duiker was the most abundant and widespread species in both surveys (Figure 4.3).

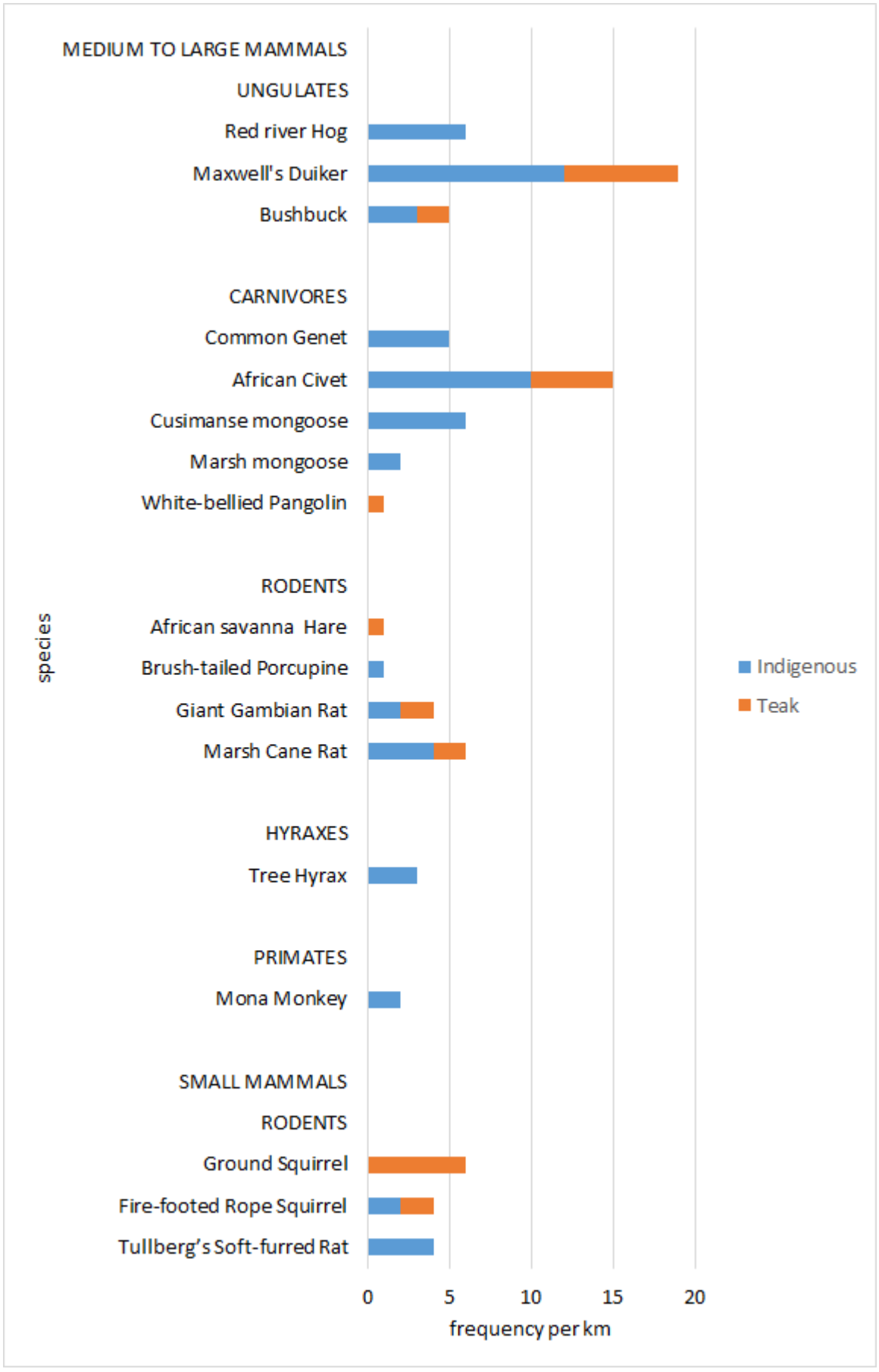

Figure 4.3: Abundance of mammal signs recorded in the study area

The indigenous forests were identffied to significantly harbour more species than the teak plantation (H = 4.156, p = 0.0415) and were the most biodiverse when various richness and diversity indices were applied to the data (Table 4.4).

Table 4.4: Mammal species richness and diversity indices generated by PAST 2.17c

Richness and Diversity Indices	Indigenous forests	Teak
Taxa_S	14	9
Individuals	62	28
Dominance_D	0.1061	0.1633
Simpson_1-D	0.8939	0.8367
Shannon_H	2.424	1.976
Evenness_e^H/S	0.8062	0.8018
Brillouin	2.115	1.615
Menhinick	1.778	1.701
Margalef	3.15	2.401
Equitability_J	0.9184	0.8995
Fisher_alpha	5.633	4.593
Berger-Parker	0.1935	0.25
Chao-1	14	9.2

4.3.1.2 Mammal species comparism between survey periods

Mammal density was significantly higher (H = 4.330, p = 0.0374) in the current 2021 survey than the previous 2017. Therefore it can be noted that overall mammal density had improved appreciably since the last survey in 2017 (Figure 4).

Similarly, eight new species (red river hog (*Potamochoerus porcus*), marsh mongoose (*Atilax paludinosus*), white-bellied pangolin (*Phataginus tricuspis*), savannah hare (*Lepus victoriae*), brush-tailed porcupine (*Atherurus africanus*), tree hyrax (*Dendrohyrax arboreus*), ground squirrel (*Xerus erythropus*) and one primate species (*Cercopithercus lowei*)] which were not recorded in 2017 were confirmed in the current survey (Figure 4.4). Nevertheless, there was no record of chiropterans (bats) in the current survey, even though they were identified in 2017.

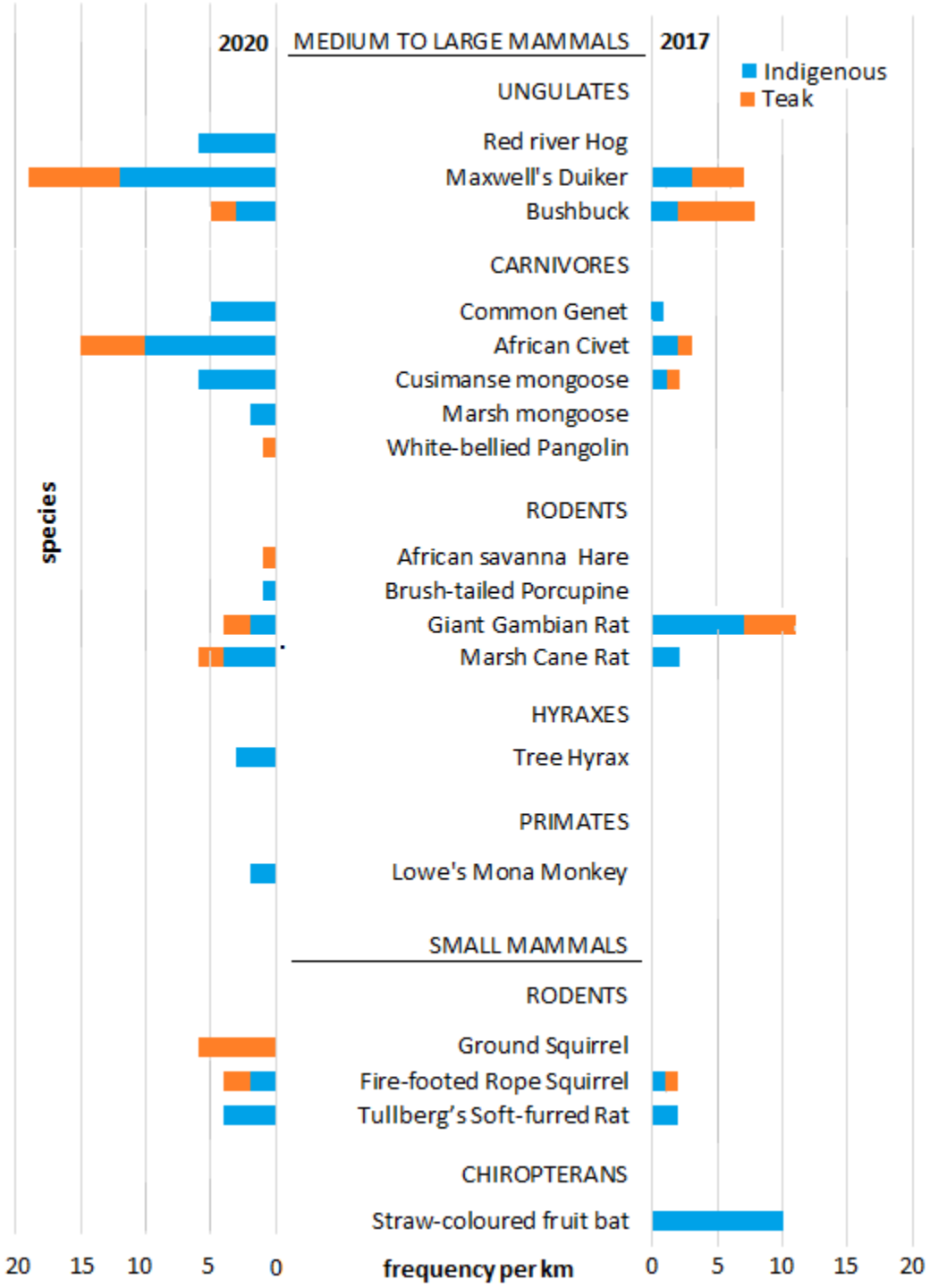

Figure 4.4: Comparison of mammal abundances for the 2017 and current 2021 survey

4.3.1.3 Species of conservation interest

Recorded mammalian species of conservation interest on the IUCN Red List of Threatened Species (2021) include one carnivore (Tree Pangolin; *Phataginus tricuspis*; Endangered) and one primate (Lowe's Mona Monkey; *Cercopithercus lowei*; Vulnerable). Both species are also listed in Appendix II of CITES (species that are not necessarily threatened with extinction but may become so unless trade is closely controlled). The African Civet (*Civettictis civetta*) is also listed in Appendix III of CITES (trade in these species is only permitted with an appropriate export permit and a certificate of origin from the member country). Locally, all primates and the tree pangolin are of special conservation importance in Ghana and are listed in Schedule 1 of the Ghana Wildlife Conservation Regulations (1995) (Appendix 1b).

Table 4.5: Checklist of mammal species abundances per transect and conservation status

Common Name	Scientific Name	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	Total	Rel Den (%)	IUCN Status	WD
PRIMATES																						
Monkeys	**Cercopithecidae**																					
Lowe's Mona Monkey	*Cercopithercus lowei*	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	2.22	NT	1
UNGULATES																						
Bovids	**Bovidae**																					
Bushbuck	*Tragelaphus scriptus*	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	5	5.56	LC	2
Antelopes	**Antelopinae**																					
Maxwell's Duiker	*Cephalophus maxwelli*	2	1	1	1	1	0	1	1	1	2	4	2	0	0	2	0	0	19	21.11	LC	2
RODENTS	***RODENTIA***																					
Cane-rats	**Thryonomyidae**																					
Marsh Cane Rat	*Thryonomys swinderianus*	1	0	0	1	0	0	0	0	0	0	2	0	1	0	1	0	0	6	6.67	LC	3
Pouched Rats	**Cricetomyinae**																					
Giant Gambian Rat	*Cricetomys gambianus*	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	4	4.44	LC	3
Porcupines	**Hystricidae**																					
B-tailed Porcupine	*Atherurus africanus*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1.11	LC	3
Murid Rats	**Muridae**																					
Tullberg's Rat	*Praomys tullbergi*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	4	4.44	LC	3
Squirrels	**Sciuridae**																					
Rope Squirrel	*Funisciurus pyrropus*	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	4	4.44	LC	3
Ground Squirrel	*Xerus erythropus*	0	0	0	0	0		0	0	0	0	0	6	0	0	0	0	0	6	6.67	LC	3

CARNIVORES	***CARNIVORA***																					
Mongooses	**Herpestidae**																					
Marsh mongoose	*Atilax paludinosus*	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	2.22	LC	2
Cusimanse	*Crossarchus obscurus*	0	2	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	6	6.67	LC	2
Genets and Civets	**Viverridae**																					
African Civet	*Civettictis civetta*	1	0	3	0	0	0	1	1	1	2	1	1	2	1	0	0	1	15	16.67	LC	2
Common Genet	*Genetta genetta*	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	5	5.56	LC	2
Pangolins	**Manidae**																					
W-bellied Pangolin	*Phataginus tricuspis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1.11	EN	1
Hyraxes	**Procaviidae**																					
Tree Hyrax	*Dendrohyrax arboreus*	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	3.33	LC	2
Hogs	**Suidae**																					
Red river Hog	*Potamochoerus porcus*	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6	6.67	LC	2
Hares	**Leporidae**																					
Afr Savanna Hare	*Lepus victoriae*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1.11	LC	3
Number of signs		7	5	4	2	3	1	3	4	5	5	24	13	8	2	3	0	1	90			
Number of species		6	4	2	2	3	1	3	4	5	3	12	6	7	2	2	0	1	17			

4.3.2 Birds

4.3.2.1 Bird species abundances and diversity

Sixty (60) Species, belonging to 28 Families were confirmed in the study area during the survey (Figure 4.5, Table 4.7). Sixty-three percent (63%) of the species recorded belong to the Families Pycnonotidae, Columbidae, Bucerotidae, Cisticolidae, Monarchidae, Nectariniidae and Cuculidae. The Common Bulbul, *Pycnonotus barbatus* (relative abundance of 9.7%) and Red-eyed Dove, *Streptophelia semitorquata* (7.64%) were the most recorded and widespread bird species in the study area.

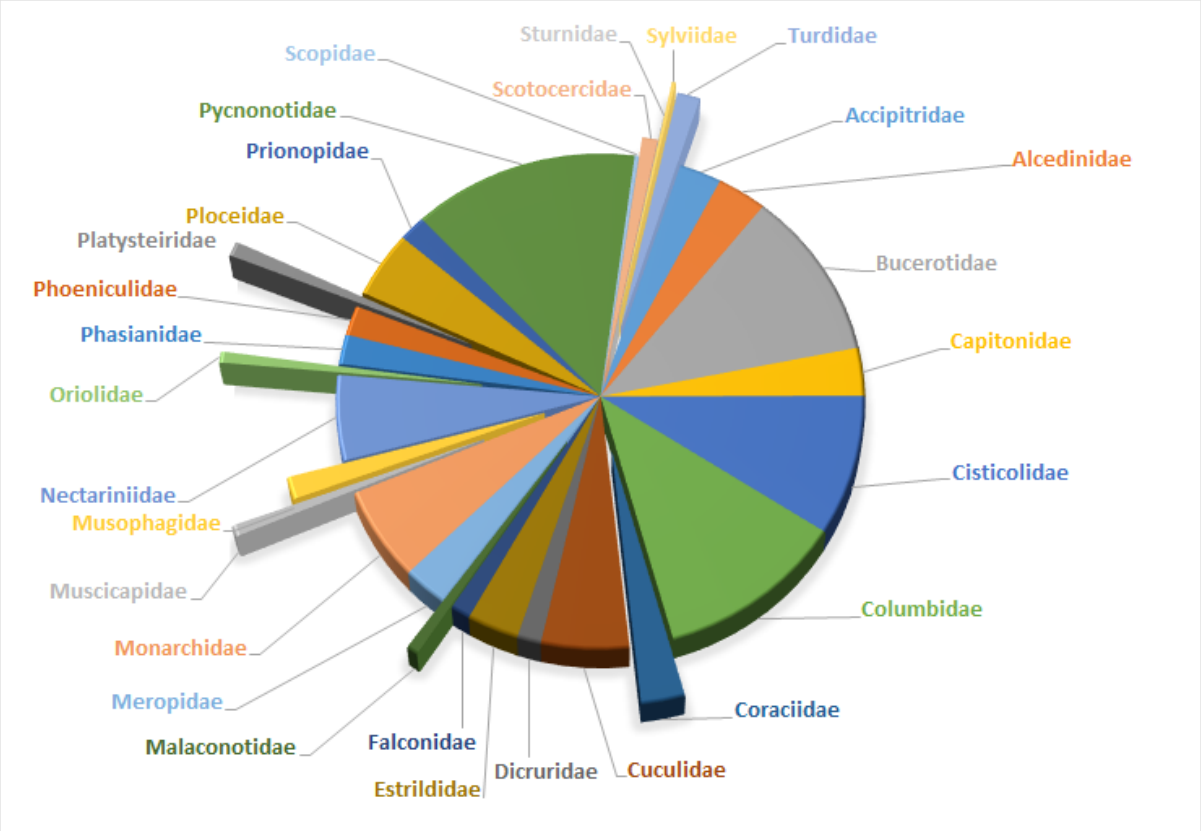

Figure 4.5: Distribution of bird families recorded in the study area

A total of 419 bird records were made: 252 signs (60%) in the forests and 167 signs (40%) in the teak plantation. This is only a slight increase compared to the total of 408 bird signs comprising of 205 signs (50%) in forests and 203 signs (50%) in the teak plantation recorded in the previous 2017 survey. The Families Pycnonotidae, Columbidae and Bucerotidae were the most abundant and widespread species in both surveys (Figure 4.6).

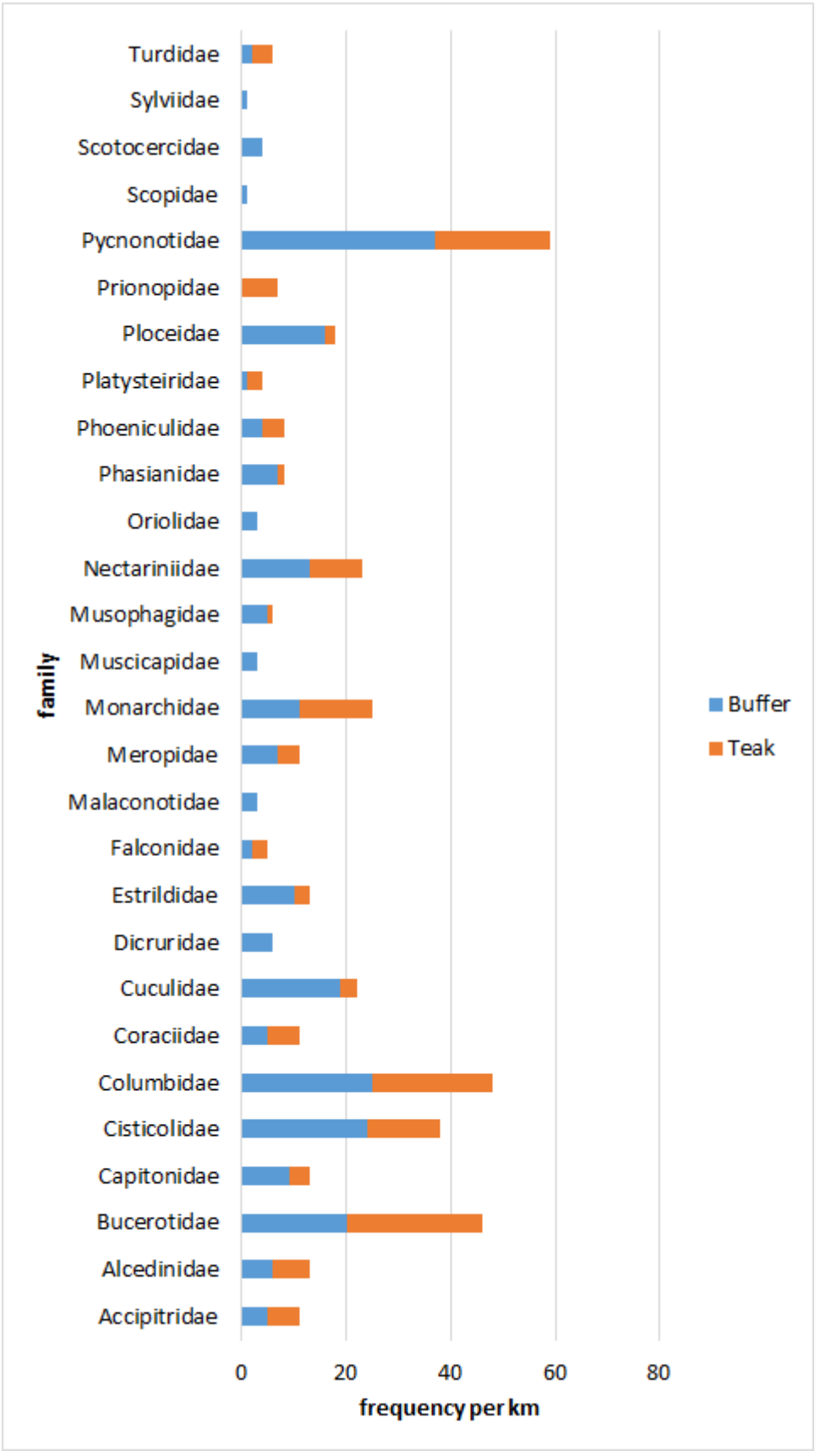

Figure 4.6: Abundance of bird family signs recorded in the study area

Although there seem to be slightly higher bird species diversity and richness in forests than within the teak plantations (Table 4.6), there was no significant difference (H = 2.795, p = 0.0946) in bird abundances between the two land use types.

Table 4.6: Birds species richness and diversity indices generated by PAST 2.17c

Taxa_S	Indigenous forests	Teak
Individuals	454	370
Dominance_D	0.08225	0.1218
Simpson_1-D	0.9177	0.8782
Shannon_H	2.827	2.444
Evenness_e^H/S	0.6034	0.5484
Brillouin	2.71	2.34
Menhinick	1.314	1.092
Margalef	4.413	3.382
Equitability_J	0.8484	0.8027
Fisher_alpha	6.594	4.825
Berger-Parker	0.1784	0.2216
Chao-1	28.33	21.5

4.3.2.2 Bird species comparism between survey periods

Similarly, there was no significant difference (H = 3.824, p = 0.0505) in bird densities in the current 2021 survey and the previous 2017. Therefore it can be noted that overall bird density had only appreciated marginly since the last survey in 2017 (Figure 4.7).

Only one individual each from the Families Malaconotidae (Black-crowned Tchagra; *Tchagra senegalus*) and Muscicapidae (Dusky-blue Flycatcher; *Muscicapa comitata*) were identified as new species in the current survey (Figure 4.7).

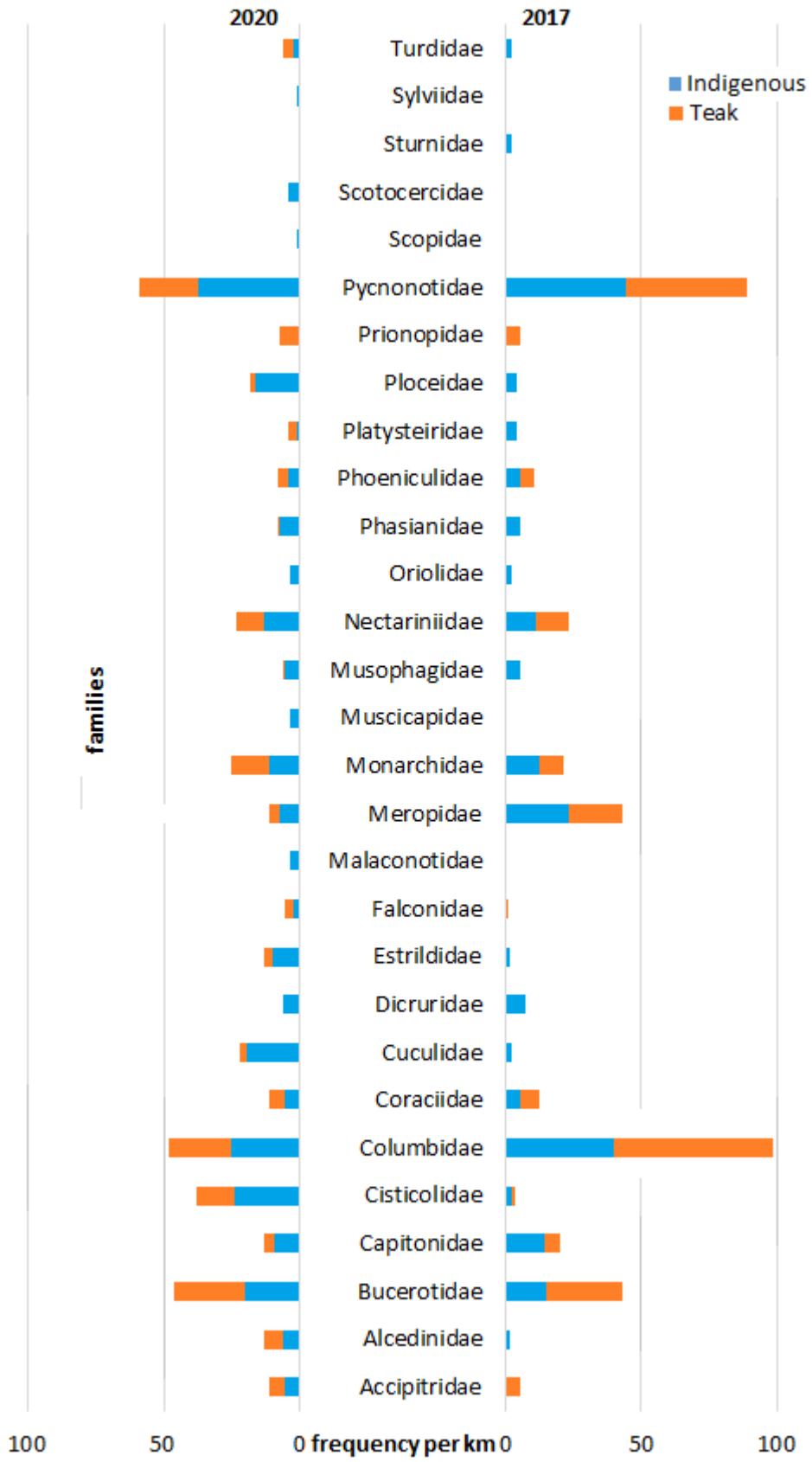

Figure 4.7: Comparison of bird family abundances for the 2017 and current 2021 survey

4.3.2.3 Species of conservation interest

Most of the birds recorded were either forest fringe species or birds of degraded forests. None of the recorded birds are of special conservation importance on the IUCN List of Threatened Species 2021 or CITES schedules. However, generally members of the Family Accipitridae (birds of prey) and Falconidae (falcons) are of special conservation importance in Ghana and are listed in Schedule 1 of the Ghana Wildlife Conservation Regulations (1995). The hunting, capturing or destroying of any species listed in Schedule I is absolutely prohibited. Also, members of the Family Columbidae (pigeons and doves) are of lower conservation importance locally in Ghana and are listed as Schedule II species (Ghana Wildlife Conservation Regulations of 1995).

Table 4.7: Checklist of bird species abundances per plot and conservation status

Common Name	Scientific Name	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	Total	Rel Den (%)	IUCN Status	WD
Birds of Prey	***Accipitridae***																					
Lizard Buzzard	*Kaupifalco monogrammicus*	2	1	1	0	0	0	0	0	2	0	1	1	0	0	0	0	1	**5**	2.15	LC	1
Palm-nut Vulture	*Gypohierax angolensis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.24	LC	1
Black-shouldered Kite	*Elanus caeruleus*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	0.24	LC	1
Falcons	***Falconidae***																					
Grey Kestrel	*Falco alopex*	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	1	0	**3**	1.19	LC	1
Pigeons and Doves	***Columbidae***																					
African Green Pigeon	*Treron calvus*	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	**2**	0.72	LC	2
Red-eyed Dove	*Streptopelia semitorquata*	2	3	4	1	2	6	2	0	2	2	2	2	0	0	2	0	2	**14**	7.64	LC	2
Tambourine Dove	*Turtur tympanistria*	1	0		0	1	1	0	0	0	0	0	0	0	0	0	0	1	**1**	0.95	LC	2
Blue-spot Wood Dove	*Turtur afer*	2	0	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	**3**	2.15	LC	2
Hornbills	***Bucerotidae***																					
African Grey Hornbill	*Tockus nasutus*	2	1	2	1	2	3	2	3	1	2	2	0	0	0	0	2	0	**12**	5.49	LC	3
African-pied Hornbill	*Tockus fasciatus*	0	2	3	5	2	4	0	0	2	3	1	0	0	0	0	1	0	**7**	5.49	LC	3
Bulbuls/Greenbuls	***Pycnonotidae***																					
Common Bulbul	*Pycnonotus barbatus*	3	3	2	1	2	3	2	1	3	2	6	4	4	0	1	0	1	**24**	9.07	LC	3
Swamp Palm Bulbul	*Thescelocichla leucopleura*	0	0	0	0	1	3	0	0	0	0	1	0	0	0	0	0	0	**1**	1.19	LC	3
Little Greenbul	*Andropadus virens*	0	1	0	0	1	0	0	0	0	1	3	1	0	0	0	0	0	**5**	1.67	LC	3
Yellow-W Greenbul	*Andropadus latirostris*	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	**1**	1.19	LC	3
Grey headed bristlebill	*Bleda canicapillus*	0	0	0	1	4	0	0	0	0	0	1	0	0	0	0	0	0	**1**	1.43	LC	3

Barbets/Tinkerbirds	***Capitonidae***																						
Yellow-R Tinkerbird	*Pogoniulus bilineatus*	0	0	0	0	2	1	0	0	0	0	1	0	0	0	1	0	0	**2**	1.19	LC	3
Red-rump Tinkerbird	*Pogoniulus atroflavus*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.24	LC	3
Naked-faced Barbet	*Gymnobucco calvus*	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	**2**	1.19	LC	3
Double-tooth Barbet	*Lybius bidentatus*	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**	0.48	LC	3
																				0.00		
Sunbirds	***Nectariniidae***																			0.00		
Collared sunbird	*Hedydipna collaris*	1	0	1	1	0	2	0	1	0	0	0	0	0	0	0	0	0	**1**	1.43	LC	3
Copper Sunbird	*Cinnyris cupreus*	1	0	0	0	1	0	0	0	1	1	0	0	1	0	2	0	0	**5**	1.67	LC	3
Green-headed sunbird	*Cyanomitra verticalis*	0	1	0	1	1	0	0	0	0	0	2	0	0	0	1	0	0	**3**	1.43	LC	3
Olive-bellied Sunbird	*Cinnyris chloropygius*	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	**2**	0.95	LC	3
Orioles	***Oriolidae***																					
Black-winged Oriole	*Oriolus nigripennis*	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	**1**	0.72	LC	3
Francolins	***Phasianidae***																					
Ahanta Francolin	*Francolinus ahantensis*	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	**1**	0.72	LC	3
D-spurred Francoline	*Francolinus bicalcaratus*	0	0	1	2	0	0	0	0	0	1	0	0	0	1	0	0	0	**2**	1.19	LC	3
Wood-hoopoes	***Phoeniculidae***																					
Black Scimitarbill	*Rhinopomastus aterrimus*	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	**4**	1.91	LC	3
Hylias	***Scotocercidae***																					
Green Hylia	*Hylia prasina*	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	4	0.95	LC	3
Turacos	***Musophagidae***																					
Green Turaco	*Tauraco persa*	0	2	0	1	2	0	0	0	0	0	1	0	0	0	0	0	0	**1**	1.43	LC	3
Camaropteras	***Cisticolidae***																					
Yellow-B Camaroptera	*Camaroptera superciliaris*	1	0	0	1	0	0	0	1	2	0	0	2	0	0	0	0	0	**5**	1.67	LC	3

Red-faced Cisticola	*Cisticola erythrops*	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	**3**	1.19	LC	3
Whistling Cisticola	*Cisticola lateralis*	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	**2**	0.48	LC	3
Tawny-flanked Prinia	*Prinia subflava*	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	**2**	0.72	LC	3
Grey-B Camaroptera	*Camaroptera brachyura*	1	0	1	0	0	0	2	1	1	3	4	1	0	0	3	0	1	**16**	4.30	LC	3
Olive-G Camaroptera	*Camaroptera chloronota*	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**2**	0.48	LC	3
Oriole Warbler	*Hypergerus atriceps*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.24	LC	3
Flycatchers	***Monarchidae***																					
Red P'dise Flycatcher	*Terpsiphone rufiventer*	1	2	1	2	2	1	2	1	1	0	4	3	1	0	3	1	0	**16**	5.97	LC	3
Rollers	***Coraciidae***																					
Blue bellied Roller	*Coracias cyanogaster*	0	5	1	2	0	0	0	0	1	0	1	1	0	0	0	0	0	**3**	2.63	LC	3
Coucals	***Cuculidae***																					
Senegal Coucal	*Centropus senegalensis*	1	0	3	2	0	0	1	0	0	0	2	1	0	0	1	0	0	**5**	2.63	LC	3
Yellowbill	*Ceuthmochares aereus*	0	0	2	1	1	0	0	1	1	0	0	0	0	0	1	0	0	**3**	1.67	LC	3
Klaas' Cuckoo	*Chrysococcyx klaas*	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	0.72	LC	3
Levaillant's Cuckoo	*Clamator levaillantii*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.24	LC	3
Drongos	***Dicruridae***																					
V-mantled Drongo	*Dicrurus modestus*	0	0	0	0	4	0	0	0	1	0	1	0	0	0	0	0	0	**2**	1.43	LC	3
Bee-eaters	***Meropidae***																					
White-T Bee-eater	*Merops albicollis*	0	0	1	0	3	0	3	0	4	0	0	0	0	0	0	0	0	**7**	2.63	LC	3
Kingfishers	***Alcedinidae***																					
Blue-B Kingfisher	*Halcyon malimbica*	0	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	**3**	0.95	LC	3
Afr Pygmy Kingfisher	*Ceyx pictus*	1	0	2	1	0	1	0	1	0	1	0	0	1	0	0	1	0	**4**	2.15	LC	3
Shrikes	***Prionopidae***																					

White Helmet-shrike	*Prionops plumatus*	0	0	5	0	0	0	0	0	0	0	0	0	2	0	0	0	0	**2**	1.67	LC	3
	Malaconotidae																					
Black-crown Tchagra	*Tchagra senegalus*	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	**1**	0.72	LC	3
																				0.00		
	Platysteiridae																			0.00		
Chestnut Wattle-eye	*Dyaphorophyia castanea*	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	0.48	LC	3
Black/white Flycatcher	*Bias musicus*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	**2**	0.48	LC	3
	Ploceida																					
Blue-billed Malimbe	*Malimbus nitens*	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	0	**3**	0.95	LC	3
Vieillot's black weaver	*Ploceus nigerrimus*	0	0	0	0	2	2	0	0	0	0	0	0	0	2	0	0	0	**2**	1.43	LC	3
Village Weaver	*Ploceus cucullatus*	0	0	0	0	0	0	0	0	0	0	6	0	0	2	0	0	0	**8**	1.91	LC	3
	Muscicapidae																					
Dusky-blue Flycatcher	*Muscicapa comitata*	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	**1**	0.72	LC	3
	Scopidae																					
Hamerkop	*Scopus umbretta*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.24	LC	3
ESTRILDIDAE																						
Chestnut-B Negrofinch	*Nigritata bicolor*	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	**1**	0.72	LC	3
Grey-head negrofinch	*Nigritata canicapillus*	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**	0.48	LC	3
Bronze Mannikin	*Spermestes cucullatus*	0	0	0	0	0	0	0	0	5	0	2	0	0	0	0	2	0	**9**	2.15	LC	3
SYLVIIDAE																						
Green Hylia	*Hylia prasina*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	0.24	LC	3
TURDIDAE																						
African Thrush	*Turdus pelios*	0	0	1	0	1	1	0	0	1	0	**0**	1	1	0	0	0	0	**3**	1.43	LC	3

Number of birds	**27**	**27**	**36**	**30**	**44**	**36**	**15**	**17**	**35**	**19**	**61**	**23**	**12**	**6**	**16**	**9**	**6**	**419**
Number of species																		

4.4 Discussion

In addition to highlighting species abundance differences especially for mammals across the two main land use types, i.e. indigenous forests and teak plantation, the study also provided clear evidence that mammal populations within the study area is increasing. Eight new mammal species including two which are of serious conservation interest on the IUCN Redlist were confirmed in the study area. Again one reptile (Dwarf Crocodile; *Osteolaemus tetraspis*) which is assessed as Vulnerable (VU) on the IUCN Redlist but was a non-target species in the current survey was recorded on several occasions along some of the main streams. In addition, overall mammal abundances had tripled from a total of 32 mammal signs recorded in 2017 to a total of 90 mammal signs that was recorded in the current 2021 survey. Birds are generally more mobile than mammals and their marginal increase between the two land use types is not surprising, considering the low hunting signs recorded in the study area.

The increasing fauna abundance, particularly mammals and some non-target but high conservation value species may in part reflect the decreasing effect of habitat disturbance and forest fragmentation, as has been noted in other forests recuperating from habitat disturbance (Newmark 1991; Chiarello 1999; Laidlaw 2000). Mammals require continuous areas of forest (Bodmer 1995; Laidlaw 2000), and it is possible that reduction in forest degradation in the study area and expansion of indigenous forest may be creating the right conditions to support these species. Another likely explanation of the increasing mammal abundances and the emergence of some forest depedent specialist like pangolins, hyraxes and monkeys registered is the relatively improved habitat conditions and decraesed hunting pressure within the area. Although hunting is officially illegal within the plantation, a few local people and outsiders (who enter the plantation illegally) hunt mammals for subsistence. While it is difficult to document the intensity and frequency of hunting within the reserve (due to its illicit nature and the unwillingness of hunters to disclose capture rates), the current surveys indicated a reduced intensity in hunting activity.

Priority biodiversity hotspots identified in the plantation are the indigenous forest (riparian areas). Fortunately, these areas have been declared ‘no go’ areas by Form Ghana. Its

continuous protection and subsequent expansion will have long-term significant and positive implications for a wide range of wildlife. This innovation itself is an opportunity that stands Form Ghana in good stead to enjoy support from many sides, especially government, ecologists and NGOs. Form Ghana should continue to enrich the indigenous forest areas with preferred fruit bearing plants, provide watering points, and salt licks where possible to ensure that the ecosystem remains healthy. They should manage the indigenous forest to improve breeding and /or survival rates by providing food/breeding sites/shelters, reduce poachers using the CREMA approach and make conscious effort to create corridors that could link the neighboring indigenous forest. Management strategies such as wildlife corridors could help create a mosaic landscape to ensure continues animal movements. Also compliance with aspects of the Forest Stewardship Council™ (FSC-C044035) principles for natural forest management are recommended.

4.4.1 Conservation implications

By providing basic information on flora and fauna communities within the study area and comparing the relative impact of different land use types on this taxon, the study serves as a useful basis for conservation planning and management within the area and provides an opportunity for which future studies can be compared. Although there were slight differences in the bird data, the overall patterns were similar and point to similar conservation recommendations.

Two main conservation lessons arise from the work. First, efforts to conserve biodiversity within Form Ghana's Akumadan Teak Plantation should continue to give highest priority to retaining and conserving all existing indigenous forests, as these forests have the most diverse flora and fauna communities and harbor the greatest number of forest dependent species. Second, high priority must be given in order to ensure continuous prevention of illegal human activities within the plantation so that biodiversity can recover. If this is not done, all efforts to conserve fauna populations through other means (e.g. forest conservation, maintenance of sufficient habitat, resources and landscape connectivity, etc.) are likely to be unsuccessful.

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Appendices

Appendix 1a: The International Union for Conservation of Nature and Natural Resources (IUCN, 2016)

The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (2016) provides taxonomic, conservation status and distribution information on taxa that have been evaluated using the IUCN Red List Categories and Criteria. The main purpose of the IUCN Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on taxa that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e. are Data Deficient); and on taxa that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e. Near Threatened) (http://www.redlist.org)

The following categories have been developed:

(1) EX (Extinct) - No reasonable doubt that the last individual has died
(2) EW (Extinct in the Wild) - Known only to survive in captivity or as a naturalized populations well outside its previous range
(3) CR (Critically Endangered) - The species is in imminent risk of extinction in the wild
(4) EN (Endangered) - The species is facing an extremely high risk of extinction in the wild
(5) VU (Vulnerable) - The species is facing a high risk of extinction in the wild
(6) NT (Near Threatened) - The species does not meet any of the criteria that would categorize it as risking extinction but it is likely to do so in the future
(7) LC (Least Concern) - There are no current identifiable risks to the species
(8) DD (Data Deficient) - There is inadequate information to make an assessment of the risks to this species

Appendix 1b: Ghana Wildlife Conservation Regulations, 1971 (L.I. 685)

The following categories have been developed:

(1) **Schedule 1** – the hunting, capturing or destroying of any species listed in this schedule is absolutely prohibited
(2) **Schedule 2** – the hunting, capturing or destroying of any species listed in the schedule is absolutely prohibited between 1 August and 1 December in any year. The hunting, capturing or destroying of any young or adult accompanied by his young of any specie listed in this schedule is absolutely prohibited at all times.
(3) **Schedule 3** – the hunting, capturing or destroying of any species listed in the schedule is absolutely prohibited between 1 August and 1 December in any year.

Schedule 1: Species Completely Protected

The hunting, capturing or destroying of any species listed in this schedule is absolutely prohibited at all time.

SERIES A – MAMMAL	SCIENTIFIC NAME
Primata	
Chimpanzee	*Pan troglodytes*
Black and White colobus	*Colobus polykomos*
Olive colobus	*Colobus verus*
Red colobus	*Colobus badius*
Diana monkey	*Cercopithecus diana*
Bosman's potto	*Perodicticus potto*
Bush baby	*Galago senegalensis*
	Galagoides demidovi
Philidota:	
Giant pangolin	*Manis gigantean*
Long tailed	*Manis tetradactyla*
Tree pangolin	*Manis tricuspis*
Tubulidentata	
Aardvark	*Crycteropus afer*
Sirenia	
Manatee	*Trichechus senegalensis*
Carnivora	
Lion	*Panthera leo*
Leopard	*Panthera pardus*
Cheetah	*Acinonyx jubatus*
Rate; pr Honey Badger	*Mellivora capensis*
Clawless otter	*Anonyx capensis*
Golden cat	*Felis*
Proboscidea	
Elephant	*Loxodonta africana*
Rodentia	
Palm squirrels	*Expixerus ebii*
Artiodactyla	
Hippopotamus	*Hippopotamus amphibious*
Pygym hippopotamus	*Cheropsis libriensis*
Senegal hartebeest	*Damaliscus lunatus*
Sitatunga	*Tragelephas spekei*
Eland	*Taurotragus derbianus*
Water chevrontain	*Hyyamoshcus aquaticus*
Bongo	*Boocercus eucrycerus*
Roan antelope	*Hippopotamus*
SERIES B – REPTILES	SCIENTIFIC NAME
Crocodile:	
Nile crocodile	*Crocodilus niloticus*
Long snouted crocodile	*Crocodiles cataphratus*

Broad fronted crocodile	*Osteolaemus tetraspis*
Lacertilia:	
Nile monitor	*Varanus niloticus*
Chelonia: all marine turtle	
Hawksbill turtle	*Eretmochelys imbricate*
Green or Edible turtle	*Chelonia mydas*
Leathery turtle	*Dermochelys coriacea*
SERIES C – BIRDS	*SCIENTIFIC NAME*
All birds of prey including:	
Falcons, kites, hawks	*Falconidae*
Eagles, buzzards, kestrels	
Etc	
Owls	*Tytonidae and Strigidae*
Egrets	
Great white egret	*Casmarodius albus*
Little egret	*Egretta garzetta*
Cattle egret	*Bubulcus ibis*
Sagittariidae:	
Secretary bird	*Sagittarius serpentarius*
Ciconiidea (storks:	
Marabou	*Leptoptilos crumeniferus*
Jabiru or saddle-bill	*Ephippiorynchus*
	Senegalensis
Sacred ibis	*Threskiornis aethiopicus*
Hadada	*Hagedashia hagedash*
Spotted brested ibis	*Lampribis rara*
Goliath heron	*Typhon goliath*
Balearicidea (cranes):	
Crowned crane	*Balearica pavonina*
Phasianidae (Game birds)	
White breated	
Guinea fowl	*Agelastes meleagrides*
Picathartidae	
Bare headed rock fowl	*Picathartes gymnocephalus*

Schedule 2: Species Protected by closed season and reproductive status

The hunting, capturing or destroying of any species listed in the schedule is absolutely prohibited between 1st August and 1st December in year any year. The hunting, capturing or destroying of any young or adult accompanied by its young of any species listed in this schedule is absolutely prohibited at all times.

SERIES A – MAMMALS	**SCIENTIFIC NAME**
Primata:	
White coloured mangabey	*Cerocebus torquatus*
Mona monkey	*Cercopithecus mona*
Spot nosed monkey	*Cercopithecus petaurista*
Green monkey	*Cercopithecus aethiops*
Patas monkey	*Erythrocebus patas*
Carnivora:	
Lynx	*Felis caracal*
Serval	*Felis serval*
Africa civet	*Viverra civetta*
Two spotted palm civet	*Nandinia binotata*
Forest genet	*Genetta maculate*
Bush genet	*Genetta tigrina*
Wild cat	*Felis libyca*
Gambian mongoose	*Mungos gambianus*
Cusimanse	*Mungos obscurus*
Dwarf mongoose	*Herpestes sanguinus*
Marsh mongoose	*Atilax paludinosus*
White tailed mongoose	*Ichenumia albicaudaS*
Egyptian mongoose	*Herpestes inchneumon*
Spotted hyena	*Crocuta crocuta*
Hunting dog	*Lycaon Pietus*
Side striped Jackal	*Canis adutus*
Lagomorpha:	
Togo hare	*Lepus capensis*
Rodentia:	
Creste porcupine	*Hystrix sp.*
Brush tailed porcupine	*Artherurus africanus*
Pel's flying squirrel	*Animalurus peli*
Flying squirrel	*Animalurus spp.*
Pygym flying squirrel	*Idiurus spp.*
Hyracoidea:	
Tree bear	*Dendrohyrax arboreus*
Rock hyrax	*Procavia capensis*
Artiodactyla:	

Warthog	*Phacochoerus aethipicus*
Red River hog (bush dog)	*Potamochoerus porcus*
Giant forest hog	*Hylochoesrus meinertzhagenei*
Bush buck	*Tragelaphus scriptus*
Buffalo	*Syncerus caffer*
Reedbuck	*Redunca redunca*
Western hartebeest	*Alcelaphus bucelaphus*
Waterbuck	*Kobus defassa*
Kob	*Kobus kob*
Oribi	*Ourebia ourebi*
Royal antelope	*Neotragus pgmaeus*
Red fronted gazelle	*Gazella rufifrons*
Yellow backed duiker	*Cephalophus sylvicultor*
Black duiker	*Cephaslophus niger*
Bay duiker	*Cephalophus dorsalis*
Red flanked duiker	*Cephalophus rufitatus*
Red duiker	*Cephalophus natalensis*
Maxwell's duiker	*Cephalophus maxwelli*
Gray duiker	*Sylvicapra grimmia*
SERIES B – REPTILES	**SCIENTIFIC NAME**
Ophidia:	
African python	*Python sabae*
Royal python	*Python regia*
Chelonia:	
Bell's hinged tortoise	*Kinixys belliana*
Common hinged tortoise	*Kinixys sp.*
Gaboon terrapin	*Pelusios sp.*
Marsh terrpin	*Polemedusa subrufa*
Soft shelled turtle	*Trionyx triunguis*
SERIES C – BIRDS	**SCIENTIFIC NAME**
Psittacidae:	All parrots
Columbidae:	All doves and pigeos
Musophagidae:	All touracos and plaintain eaters
Ploceidae:	All weavers, waxbills, mannikins, bishop bird, fire finches, cordonsbleus, whydahs and canaries
Sterninze;	All terms

Schedule 3: Species Protected by closed season only

The hunting, capturing or destroying of any species listed in this schedule is absolutely prohibited between 1st August and 1st December in any year.

SERIES A – MAMMALS	**SCIENTIFIC NAME**
Primata:	
Baboon	*Papio anubis*
Erinaceidae:	
Hedgehogs	*Atelerix sp.*
	Erinaceus sp.
	Paraechinus sp.
Rodentia:	
Tree squirrels	*Helioscriurus sp.*
	Funisciurus sp.
	Protoxerus stangeri
Ground squirrels	*Xerus sp.*
Giant rat (pouched rat)	*Cricetomys gambianus*
SERIES – BIRDS	**SCIENTIFIC NAME**
Phasianidae:	
All francolins (bush fowl)	*Fancolinus sp.*
Stone partridge	*Ptilopacus petrosus*
Quails	*Coturnix sp.*
All Guinea – fowls	*Numida meleagris*
Otididae:	
All bustards	*Ardeotis arabs*
	Neotis denhami
	Eupodotis melanogaster
Anatidae:	
Hartlaubs's duck	*Pteronetta hartlaubii*
White faced duck	*Dendrocygna viduata*
Fulvous duck	*Dendrocygna fulva*
Pygmy goodr	*Nettapus auritus*
Knob billed goose	*Sarkidiornis melanotos*
Egyptian goose	*Alopochen aegytiacus*
Spur winged goose	*Plectropeterus gambensis*

Appendix 2: Ghana's Endangered Fauna Species list

Scientific Name	Common Name	IUCN Status
Mammals		
Anomalurus pelii	Pel's Flying Squirrel (E)	DD
Cephalophus dorsalis	Bay Duiker (E)	NT
Cephalophus silvicultor	Yellow-Backed Duiker (E)	NT
Cercocebus atys	Red-Capped Monkey (E) Sooty Mangabey (E)	VU
Cercocebus torquatus	Collared Mangabey (E) Red-Capped Mangabey (E) Sooty Mangabey (E) White-Collared Mangabey (E)	EN
Cercopithecus diana	Diana Guenon (E) Diana Monkey (E)	EN
Chaerephon russata	Russet Free-Tailed Bat (E)	DD
Colobus polykomos	King Colobus (E) Ursine Black-And-White Colobus (E) Western Black-And-White Colobus (E) Colobe Blanc Et Noir D'afrique Occidentale (F)	EN
Colobus vellerosus	Geoffroy's Black-And-White Colobus (E) White-Thighed Black-And-White Colobus (E)	CR
Crocidura grandiceps	Large-Headed Shrew (E)	NT
Funisciurus substriatus	Kintampo Rope Squirrel (E)	DD
Gazella rufifrons	Red-Fronted Gazelle (E)	VU
Genetta johnstoni	Johnston's Genet (E)	NT
Graphiurus crassicaudatus	Jentink's Dormouse (E)	DD
Heliosciurus punctatus	Small Sun Squirrel (E)	DD
Hippopotamus amphibius	Common Hippopotamus (E)	VU
Hipposideros jonesi	Jones's Roundleaf Bat (E)	NT
Hyaena hyaena	Striped Hyaena (E) Hyène Rayée (F)	NT
Hylomyscus baeri	Baer's Hylomyscus (E) Baer's Wood Mouse (E)	EN
Leimacomys buettneri	Groove-Toothed Forest Mouse (E)	DD
Loxodonta africana	African Elephant (E)	VU
Lycaon pictus	African Wild Dog (E)	EN
Mops petersoni	Peterson's Free-Tailed Bat (E)	NT
Mops trevori	Trevor's Free-Tailed Bat (E)	DD
Neoromicia brunneus	Dark-Brown Serotine (E)	NT
Oenomys ornatus	Ghana Rufous-Nosed Rat (E)	DD
Otomops martiensseni	Large-Eared Free-Tailed Bat (E)	VU
Pan troglodytes	Chimpanzee (E)	EN
Panthera leo	African Lion (E)	VU
Pipistrellus inexspectatus	Aellen's Pipistrelle (E)	DD
Procolobus badius	Red Colobus (E)	EN
Procolobus verus	Olive Colobus (E)	VU

Profelis aurata	African Golden Cat (E)	VU
Protoxerus aubinnii	Slender-Tailed Squirrel (E)	NT
Birds		
Agelastes Meleagrides	White-Breasted Guineafowl (E)	VU
Bathmocercus Cerviniventris	Black-Capped Rufous Warbler (E)	DD
Bleda Eximius	Green-Tailed Bristlebill (E)	NT
Bubo Shelleyi	Shelley's Eagle-Owl (E)	VU
Bycanistes Cylindricus	Brown-Cheeked Hornbill (E)	VU
Campephaga Lobata	Western Wattled Cuckoo-Shrike (E)	VU
Ceratogymna Elata	Yellow-Casqued Hornbill (E)	VU
Criniger Olivaceus	Yellow-Throated Olive Greenbul (E)	VU
Illadopsis Rufescens	Rufous-Winged Illadopsis (E)	NT
Lamprotornis Cupreocauda	Copper-Tailed Glossy-Starling (E)	NT
Malaconotus Lagdeni	Lagden's Bush-Shrike (E)	NT
Melignomon Eisentrauti	Yellow-Footed Honeyguide (E)	NT
Picathartes Gymnocephalus	White-Necked Picathartes (E)	VU
Scotopelia Ussheri	Rufous Fishing-Owl (E)	VU

Source: IUCN Red list (https://www.iucnredlist.org/)

Indigenous forest

Teak Plantation

Duiker Footprint

Cartridge Case

Pangolin Feeding Signs

Dwarf Crocodile Nest

Mongoose Feeding Signs

Squirrel Feeding Signs

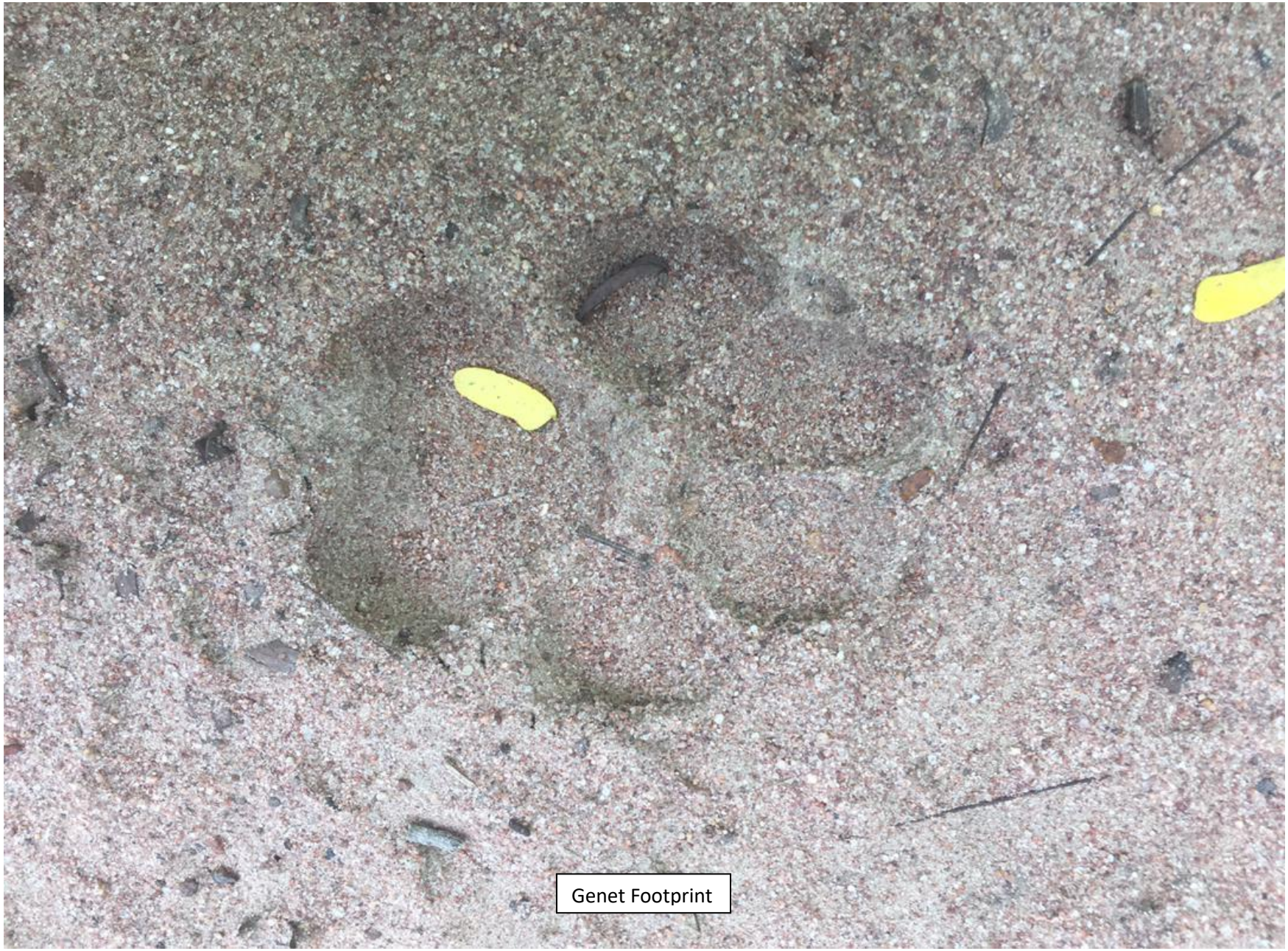
Giant Rat Hole

Duiker Footprint

Young Civet Footprint

Bushbuck Footprint

Civet Footprint


Genet Footprint