REPORT OF PROJECT TITLED: PLANT SPECIES DIVERSITY, STRUCTURE AND ABUNDANCE OF TULA MOUNTAINS IN NORTH EAST NIGERIA SPONSORED BY THE RUFFORD FOUNDATION FROM MAY 2014 TO MAY 2015

EXECUTIVE SUMMARY

A detailed description of plant community diversity is fundamental to making conservation decisions. The Tula Mountains in Gombe state of north east Nigeria are currently unprotected. Due to the rocky nature of the terrain, farming activity is a difficult task which has worked so far in favour of the woodland conservation. The project on plant species diversity and structure was carried out with two major objectives: to document the plant species of Tula Mountains and build capacity to educate the local communities who are the direct stakeholders of the woodland about sustainable use of the woodland resources. By doing this, they will see the woodland as theirs and so work towards its conservation.

Using the point centred- quarter, about 137 plant species belonging to 39 families were recorded in 190 points of 4 quarters each. The distance of the nearest tree to the point in each quarter was measured, the tree was identified to species level, and its height and diameter at breast height (DBH) measured. Other woody trees and saplings were counted and recorded according to species in each quarter equivalent to a 100 m^2 plot. Results showed that mean distance per tree = 5.35 m, mean area covered per tree = 28.64 m^2, absolute density of trees = 349.16 trees/ha, total area covered by 552 trees = 1.58 ha, effective stem cover = 0.19 ha. The height and diameter distribution showed a reversed J- curve with about 99.1 % of the population being understory species. Diameter height relationship showed increase in height of trees with increasing DBH. Conservation status of 115 (94.3 %) out of 122 plant species recorded were not accessed on the IUCN red list of threatened species, however, *Vepris heterophylla* was considered endangered. This information is important in proposing management strategies to the government agencies for giving the woodland a status of protection from human activities.

INTRODUCTION

The Tula mountains are located in Gombe state in North eastern part of Nigeria (9° 8'36.07"N, 11° 27'27"E). The mountains which cover a total area of about 596 km^2 harbours wide stretches of guinea savannah woodland and are currently unprotected. Due to the hilly nature of the terrain and lack of infrastructure, human activity has been minimal, a factor that has worked so far in favour of its conservation. Although the rocky terrain of the woodland has made farming activity a difficult task, other activities such as grazing, logging and firewood collection is ongoing especially at the edges of the woodland. The north eastern part of Nigeria is under severe threat of desertification as a result of rapid loss in vegetation cover.

There is a great threat to plant diversity as the forest cover is being depleted without even knowing what exists. It is therefore imperative to document the plant taxa and identify their conservation status. However, conducting research itself is not means to guarantee conservation. In order to conserve the forests, a long-term participatory program needs to be installed where the research can be translated into tenets and sets of guidelines that can be used by local stakeholders, giving them the capacity to conserve.

The project on plant species diversity, composition and structure was carried out from May 2014 to March 2015. The project consisted of two major objectives: document plant species

of Tula Mountains and build capacity to create conservation awareness among communities of Tula Mountains about sustainable use of the plant resources of the woodland.

METHODOLOGY

Vegetation Sampling

Vegetation sampling was conducted using Point-Centred Quarter (PCQ). A total of 190 random points were generated along a series of line transects passing through the tree stands using the systematic random sampling with a spacing of 50 m between points using GPS unit. At each sampling point, 4 quarters (quadrat) were established using a cross. Within each quarter, the distance from the random point to the nearest tree was measured and recorded using a measuring tape, the tree was identified to species level, diameter at breast height (1.3 m high from the ground) of the tree was recorded and height of the tree was also recorded using clinometers. Other woody species of up to 5 m in height (Ihuma et al. 2011) and ≥ 5 cm in diameter at breast height (Poorbabaei and Poorrahmati 2009) within each quarter (equivalent to 100 m^2 plot) were counted and identified to species level. Tree saplings and woody shrubs ≤ 5 cm diameter at breast height were counted and identified to species level within each quarter. The plant guide: Trees, Shrubs and Lianas of West African dry zones (Arbonnier 2004) was used for identification.

Data analysis

Data analysis was carried out using Microsoft excel and R statistical package version 3.0.3. Shannon Weiner diversity index was used to calculate plant species diversity index. DBH and height distribution was plotted using histogram. DBH and height relationship was determined using regression graph of DBH as the independent variable and height as the response variable. The woodland stratification was determined by grouping plant species into emergent, upper story and understory according to height as suggested by Felfile (1997). All looped trees were excluded to remove any alteration in height as a result of human or environmental impact.

RESULTS AND DISCUSSION

Woody plant species diversity and composition

A total of 135 plant species were recorded, 122 species belonging to 39 families were identified to species level, 8 species were identified to genus level while 5 were unidentified. Total number of tree stands recorded was 1,777 and 11,068 saplings. The family Fabaceae had a total of 20 species, 10 each belonging to the subfamilies Caesalpinioideae and Mimosoideae ranking highest in total number of species recorded. A total of 12 species belonging to the genera *Combretum* and *Terminalia* were recorded under the family Combretaceae which ranked second highest in number of species. However, the most abundant woody species was *Detarium macrocarpum* of the family Mimosoideae with a total of 236 tree stands and 4,017 saplings comprising 13.3 % and 36.3 % respectively of total trees and saplings recorded. Other abundant species included *Combretum glutinosum*: 12.9 % trees and 8.1 % saplings; *Hexalobus monopetalus*: 7.9 % trees and 2.3 % saplings; *Annona senegalense*: 3.8 trees and 13.6 saplings.

Mean diversity index of plant species of Tula Mountains is 0.29. A plant database was created using excel with list of species, plant family, populations and IUCN status of the trees.

Vegetation structure and woody species density

Records of height, DBH and distance were obtained only for the nearest tree to a random point, other trees in each quarter were only identified and counted. Total number of trees with recorded height, DBH and distance in 4 quarters each of 190 points was 552 out of 772 total number of trees recorded. The summary of density measures are presented on table 1:

Table 1: Summary of density measures of tree species

S/No	Variable	Value
1	Mean distance per tree	5.35 m
2	Mean area covered per tree	28.64 m^2
3	Absolute density of trees	349.16 trees/ha
4	Total area covered by 552 trees	1.58 ha
5	Stem cover of 552 trees	0.19 ha
6	Percentage stem 552 trees	12.14 %

The tree with maximum height recorded was *Sysyzium guineense* measuring up to 30 m high, 38.5 cm DBH while *Prosopis africana* had the maximum DBH of 97 cm and 12 m height. Species such as *Saba florida, Sclerocarya birrea and Syzygium guineense* had only one individuals in record, hence, their DBH and stand level averages were not considered along with other species. However, the DBH and height relationship shows their distribution in the horizontal component (DBH) and the vertical stratification (height) of the woodland structure (fig. 2). Excluding the mentioned species afore, the DBH and stand level averages of all species were considered for species that have a minimum of two individuals. The plant species showed variation in DBH and stand level average ranging from average DBH of 7.5 cm in *Dichrostachys cineria* to 47 cm in *Terminalia avicennioides,* and average height of 1 m in *Vitex simplicifolia* to 22 m in *Ficus abutilifolia*. *Terminalia avicennioides* and *Manilkara multinervis* were the largest tree species recorded with DBH to height ratios of 47 cm: 9.4 m and 41.2 cm: 15.3 m respectively. The histogram of DBH and height distribution of the individual trees showed a reversed J- pattern of distribution when individuals were combined together. This pattern of distribution is consistent in several studies of other scientists (Richards 1952; Felfili 1983; Hubbell & Foster 1987; Felfili & Silva Junior 1988, Silva Junior & Silva 1988; Ramos 1989; Campbell et al. 1992; Nascimento & Saddi 1992; Oliveira-Filho et al. 1994; Felfile 1997). The largest number of the population were skewed to the left side of the histogram with lower DBH values of 2.3 to 50 cm and lower height of 1 to 10.2 m. About 99.1 % (547 out of 552) of the woodland species are predominantly understory species having stand level height of less than 15 m and DBH up to 50 cm. Only three species had a maximum height of more than 20 m qualifying them as emergent, while two species fall under the upper middle layer with height between 15 m and 20 m (fig. 1). The emergent and upper story species which included *Ficus abutilifolia, Manilkara multinervis, Saba florida, Sclerocarya birrea and Syzygium guineense* were recorded in the gallery forest (fig. 2). These species showed a higher height to DBH ratio.

Conservation status of plant species

The conservation status of the 122 identified species were checked on the IUCN red list of threatened species version 2014.3. Out of the 122 species, only one species (*Vepris heterophylla*) was reported to be endangered, 2 species were reported vulnerable (*Khaya senegalensis* and *Afzelia africana*), *Dichrostachys cinerea, Isoberlinia doka* and *Philenoptera laxiflora* were reported least concern, 115 (94.3%) species were not assessed for conservation status while 3 species (*Ancylobotrys amoena, Cassia arerah* and *Syzygium guineense*) were not found on the IUCN catalogue (table 2).

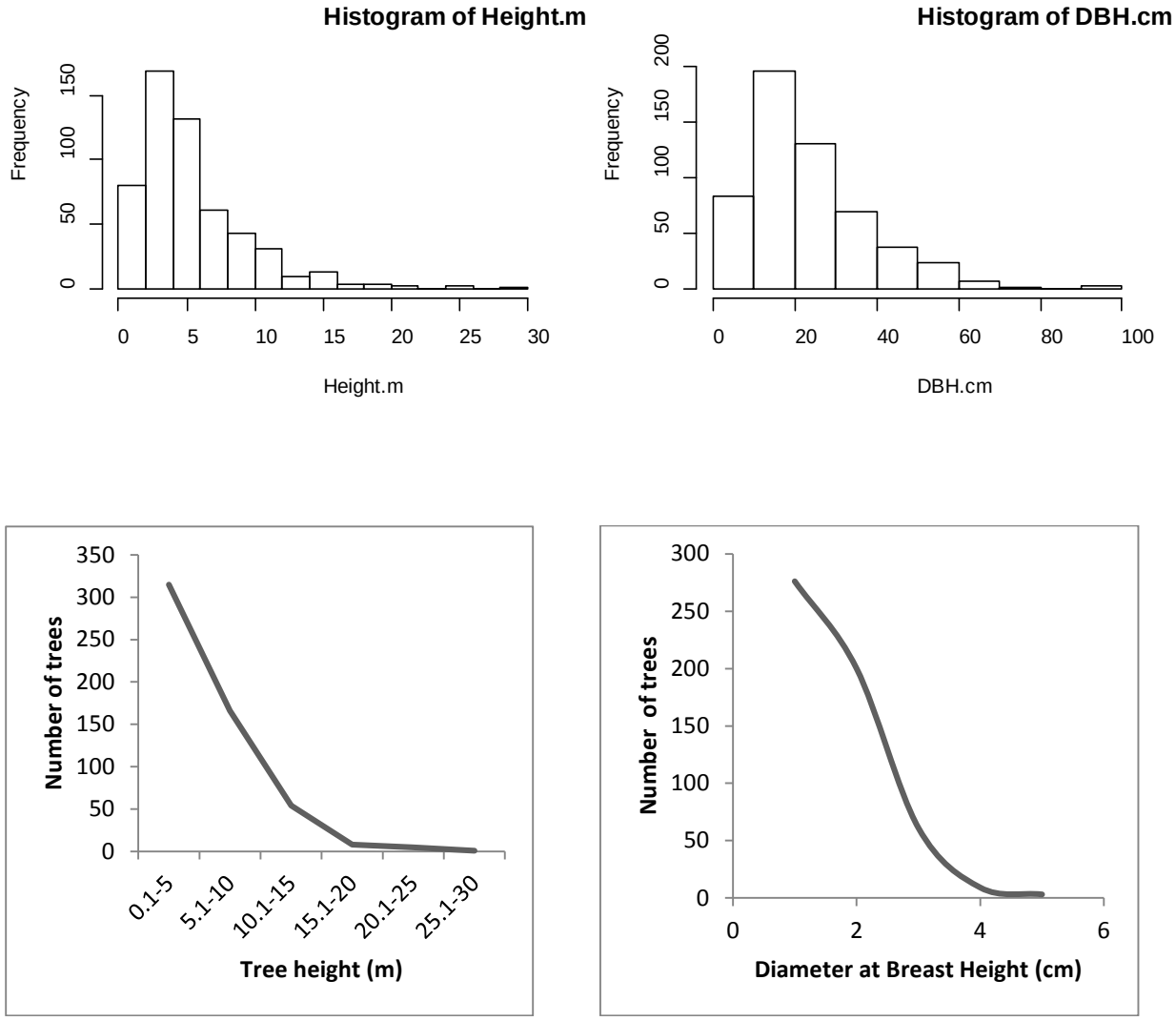

Figure 1: DBH and Height distribution of tree species

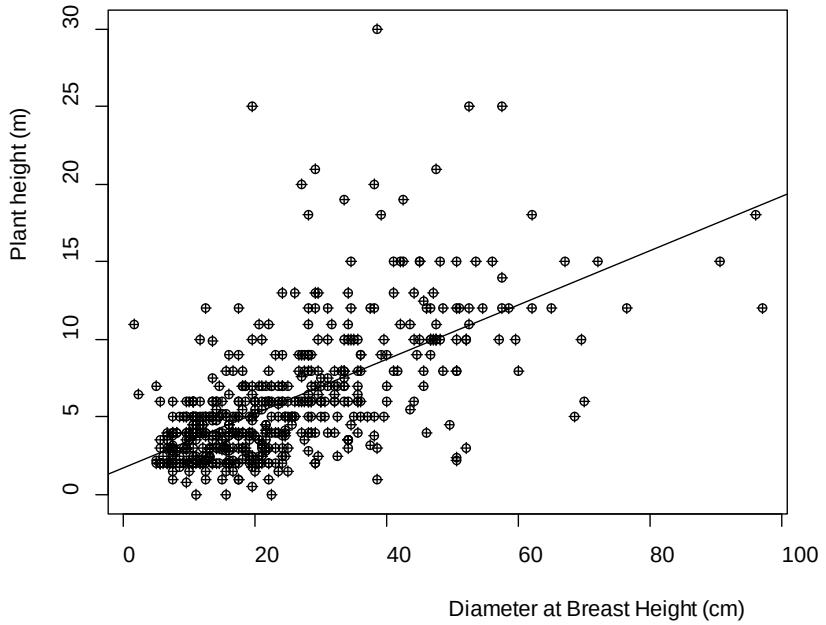

Figure 2: Diameter-height relationship of individual woody species

Table 2: Checklist of plant species recorded with IUCN status and local populations

S/NO	Scientific name of plant species	Family	Total Trees	Total saplings	IUCN status
1	*Acacia senegal* **(L.) Willd.**	Mimosoideae	2	75	NAS
2	*Acacia seyal* **Delile.**	Mimosoideae	7	10	NAS
3	*Afzelia africana* **Pers**	Caesalpinioideae	6	3	VU
4	*Albizia zygia* **(DC.) J.F.Macbr.**	Mimosoideae	4	13	NAS
5	*Allophylus africanus* **P. Beauv.**	Sapindaceae	1	5	NAS
6	*Alstonia boonei* **De Wild.**	Apocynaceae	1	29	NAS
7	*Amblygonocarpus andongensis* **(Oliv.) Harms.**	Mimosoideae	5	16	NAS
8	*Ancylobotrys amoena* **Hua**	Apocynaceae	0	1	NIC
9	*Annona senegalensis* **Pers.**	Annonaceae	68	1509	NAS
10	*Anogeissus leiocarpa* **(DC.) Guill. & Perr.**	Combretaceae	1	1	NAS
11	*Antidesma venosum* **E.Mey. Ex Tul.**	Euphorbiaceae	5	2	NAS
12	*Azadirachta indica* **A.Juss.**	Meliaceae	2	1	NAS
13	*Balanites aegyptiaca* **(L.) Delile**	Balanitaceae	1	3	NAS
14	*Bombax costatum* **Pellegrin & Vuillet**	Bombacaceae	11	9	NAS
15	*Boscia angustifolia* **A.Rich**	Capparaceae	0	1	NAS
16	*Boswellia dalzielii* **Hutchinson**	Burseraceae	6	37	NAS
17	*Bridelia ferruginea* **Benth**	Euphorbiaceae	1	1	NAS
18	*Bridelia micrantha* **(Hochst.) Baill**	Euphorbiaceae	0	1	NAS
19	*Burkea africana* **Hook.**	Caesalpinioideae	58	227	NAS
20	*Cassia arerah* **Delile**	Caesalpinioideae	22	38	NIC
21	*Cissus populnea* **Guill & Perr.**	Vitaceae	0	1	NAS

22	*Combretum fragrans* **F. Hoffm.**	Combretaceae	104	235	NAS
23	*Combretum glutinosum* **Perr. ex DC.**	Combretaceae	230	900	NAS
24	*Combretum molle* **R.Br. Ex G.Don**	Combretaceae	5	28	NAS
25	*Combretum nigricans* **Lepr. Ex Guill & Perr.**	Combretaceae	17	94	NAS
26	*Combretum nioroense* **Aubrev. Ex Keay**	Combretaceae	0	5	NAS
27	*Commiphora pedunculata* **(Kotschy & Peyr.) Engl.**	Burseraceae	3	61	NAS
28	*Crossopteryx febrifuga* **(Afzel. ex G.Don) Benth.**	Rubiaceae	64	77	NAS
29	*Daniellia oliveri* **(Rolfe) Hutch. & Dalziel**	Caesalpinioideae	33	52	NAS
30	*Detarium macrocarpum* **Harms.**	Mimosoideae	236	4017	NAS
31	*Detarium senegalense* **J.F.Gmel.**	Mimosoideae	3	26	NAS
32	*Dialium guineense* **Willd**.	Caesalpinioideae	3	3	NAS
33	*Dichrostachys cinerea* **(L.) Wright & Arn.**	Mimosoideae	15	547	LC
34	*Entada abyssinica* **A. Rich.**	Mimosoideae	1	0	NAS
35	*Entada africana* **Guill. & Perr.**	Mimosoideae	4	7	NAS
36	*Erythrina sigmoidea* **Hua**	Papilionoideae	3	0	NAS
37	*Feretia apodanthera* **Delile**	Rubiaceae	10	52	NAS
38	*Ficus abutilifolia* **(Miq.) Miq.**	Moraceae	5	2	NAS
39	*Ficus coronata* **Spin**	Moraceae	1	0	NAS
40	*Ficus glumosa* **Delile**	Moraceae	8	4	NAS
41	*Ficus ovata* **Vahl**	Moraceae	1	7	NAS
42	*Ficus petiolaris* **Kunth**	Moraceae	3	4	NAS
43	*Ficus thonningii* **Blume**	Moraceae	0	1	NAS
44	*Ficus umbellata* **Vahl**	Moraceae	1	3	NAS
45	*Ficus vallis-choudae* **Delile**	Moraceae	2	5	NAS
46	*Flacourtia indica* **(Burm.f.) Merr.**	Flacourtiaceae	13	27	NAS
47	*Garcinia livingstonei* **T.Anderson**	Guttiferae	1	2	NAS
48	*Garcinia ovalifolia* **Oliv**.	Guttiferae	5	3	NAS
49	*Gardenia aqualla* **Stapf & Hutch.**	Rubiaceae	7	16	NAS
50	*Gardenia erubescens* **Stapf & Hutch.**	Rubiaceae	8	7	NAS
51	*Grewia cissoides* **Hutch. & Dalziel**	Tiliaceae	0	2	NAS
52	*Grewia flavescens* **Juss**	Tiliaceae	1	1	NAS
53	*Grewia mollis* **Juss**	Tiliaceae	6	0	NAS
54	*Grewia venusta* **Fresen**.	Tiliaceae	0	5	NAS
55	*Guiera senegalensis* **J. F. Gmel**	Combretaceae	3	181	NAS
56	*Haematostaphis barteri* **Hooke.f**.	Anacardiaceae	5	1	NAS
57	*Hexalobus monopetalus* **(A. Rich.) Engl. & Diels**	Hernandiaceae	141	251	NAS
58	*Holarrhena africana*	Apocynaceae	1	32	NAS
59	*Holarrhena floribunda* **(G. Don) T. Durand & Schinz.**	Apocynaceae	0	3	NAS
60	*Hymenocardia acida* **Tul**.	Hymenocardiaceae	30	126	NAS
61	*Isoberlinia doka* **Craib & Stapf**	Caesalpinioideae	6	9	LC
62	*Jasminum dichotomum* **Vahl**	Oleaceae	0	17	NAS
63	*Jasminum obtusifolium* **Baker**	Oleaceae	0	63	NAS
64	*keetia cornelia* **(Cham. & Schltdl.) Bridson**	Rubiaceae	3	3	NAS
65	*Keetia venosa* **(Oliv.) Bridson**	Rubiaceae	3	13	NAS
66	*Khaya senegalensis* **(Desv.) A.Juss.**	Meliaceae	18	13	VU

67	*Lannea barteri* **(Oliv.) Engl.**	Anacardiaceae	20	28	NAS
68	*Lannea schimperi* **(Hochst. ex A. Rich.) Engl.**	Anacardiaceae	26	11	NAS
69	*Lophira lanceolata* **Tiegh. ex Keay**	Ochnaceae	15	21	NAS
70	*Manilkara multinervis* **(Baker) Dubard**	Sapotaceae	8	2	NAS
71	*Maranthes polyandra* **(Benth.) Prance**	Chrysobalanaceae	27	7	NAS
72	*Margaritaria discoidea* **(Baill.) G. L. Webster**	Euphorbiaceae	1	0	NAS
73	*Maytenus senegalensis* **(Lam.) Exell**	Celastraceae	38	245	NAS
74	*Mitragyna inermis* **(Wild.) Kuntze**	Rubiaceae	0	2	NAS
75	*Olax subscorpioidea* **Oliver**	Olacaceae	2	3	NAS
76	*Parinari curatellifolia* **Planch. ex Benth.**	Chrysobalanaceae	8	87	NAS
77	*Pericopsis laxiflora* **(Baker) Meeuwen**	Papilionoideae	30	156	NAS
78	*Philenoptera laxiflora* **(Guill. & Perr.) Roberty**	Papilionoideae	1	12	LC
79	*Phyllanthus muellerianus* **(Kuntze) Exell**	Phyllanthaceae	1	32	NAS
80	*Piliostigma thonningii* **(Schum.) Milne-Redh.**	Caesalpinioideae	5	18	NAS
81	*Prosopis africana* **(Guill. & Perr.) Taub.**	Mimosoideae	36	56	NAS
82	*Pterocarpus erinaceus* ***Poir***	Papilionoideae	3	2	NAS
83	*Pterocarpus lucens* **Guill. & Perr.**	Papilionoideae	1	0	LC
84	*Rhus natalensis* **Bernh. ex C.Krauss**	Anacardiaceae	2	0	NAS
85	*Rytigynia senegalensis* **Blume**	Rubiaceae	0	1	NAS
86	*Saba florida* **(Benth.) Bullock**	Apocynaceae	4	1	NAS
87	*Santaloides afzelii* **(R.Br. ex Plan)**	Connaraceae	4	9	NAS
88	*Sarcocephalus latifolius* **(Sm.) E.A.Bruce**	Rubiaceae	3	2	NAS
89	*Sclerocarya birrea* **(A.Rich.) Hochst.**	Anacardiaceae	3	0	NAS
90	*Securidaca longipedunculata* **Fresen**.	Polygalaceae	1	7	NAS
91	*Senna singueana* **(Delile) Lock**	Caesalpinioideae	2	7	NAS
92	*Sesbania sesban* **(L.) Merr.**	Papilionoideae	0	2	NAS
93	*Steganotaenia araliacea* **(Hochst.)**	Apiaceae	0	16	NAS
94	*Sterculia rhinopetala* **K.Schum**	Sterculiaceae	5	0	NAS
95	*Sterculia setigera* **Delile**	Sterculiaceae	8	1	NAS
96	*Sterculia tragacantha* **Lindl**.	Sterculiaceae	1	11	NAS
97	*Stereospermum kunthianum* **Cham.**	Bignonaceae	36	249	NAS
98	*Strophanthus sarmentosus* **DC.**	Apocynaceae	3	14	NAS
99	*Strychnos asterantha* **Leeuwenb.**	Loganiaceae	0	1	NAS
100	*Strychnos innocua* **Delile**	Loganiaceae	51	433	NAS
101	*Strychnos spinosa* **Lam.**	Loganiaceae	12	38	NAS
102	*Swartzia madagascariensis* **Desv.**	Caesalpinioideae	1	89	NAS
103	*Syzygium guineense* **Wall**	Myrtaceae	9	30	NIC
104	*Tamarindus indica* **L.**	Caesalpinioideae	1	0	NAS
105	*Terminalia avicennioides* **Guill. & Perr.**	Combretaceae	14	44	NAS
106	*Terminalia flavicans* **Boivin & Tul.**	Combretaceae	0	3	NAS
107	*Terminalia glaucescens* **Planch. ex Benth.**	Combretaceae	46	42	NAS
108	*Terminalia laxiflora* **Engl.**	Combretaceae	2	6	NAS
109	*Terminalia mollis* **M. A. Lawson**	Combretaceae	7	11	NAS
110	*Trichilia emetica* **Vahl.**	Meliaceae	2	5	NAS
111	*Uvaria chamae* **P. Beauv.**	Annonaceae	44	42	NAS
112	*Vepris heterophylla* **(Engl.) Letouzey**	Rutaceae	8	38	EN

113	*Vitalleria paradoxa* **C.F.Gaertn.**	Sapotaceae	6	5	NAS
114	*Vitex doniana* **Kotschy & Peyr.**	Verbanaceae	2	13	NAS
115	*Vitex madiensis* **Oliv.**	Verbanaceae	0	1	NAS
116	*Vitex phaeotricha* **W.Piep.**	Verbanaceae	0	63	NAS
117	*Vitex simplicifolia* **C.B.Clarke**	Verbanaceae	11	4	NAS
118	*Ximenia americana* **L.**	Olacaceae	4	1	NAS
119	*Ziziphus abyssinica* **Hochst. ex A.Rich.**	Rhamnaceae	0	12	NAS
120	*Ziziphus mauritiana* **Lam.**	Rhamnaceae	18	152	NAS
121	*Ziziphus mucronata* **Willd.**	Rhamnaceae	6	63	NAS
122	*Ziziphus spina-christi* **(Mill.) Georgi**	Rhamnaceae	5	44	NAS
	Unidentified species				
123	Acacia sp		0	1	
124	Bridellia sp		2		
125	Croton sp		2		
126	Ficus sp1		5		
127	Ficus sp2		1		
128	Keetia sp		1		
129	Parkia spp		1		
130	Sterculia sp		1		
131	Unidentified (5 species)		5		

OUTCOMES

Capacity building

An effective conservation approach involves working with local communities who are direct stakeholder of the woodland to appreciate the importance of the natural resources around them and thus, work towards their conservation. At the commencement of this project, a meeting was held with the village head, some community members, APLORI director and the research team where the content of the project was explained to them. The project was welcomed by the village head and community members and a local field guard was assigned to the research team who participated in the project and was trained in some of the field skills such as plant identification, plant pressing, measuring DBH and height of plants. Conservation education was carried out in Tula Yiri community Secondary School on sustainable use of tree resources. Students were taught the importance of trees for food and medicinal uses, capturing pollutants in the air, as home to wild animals as well as the dangers of deforestation in shortening the supply of these services to them. Afterwards, students were taken out to the field to practically identify some plant species in their environment and their local uses. For example, students mentioned *Prosopis africana* uses in making their local soup seasoning. Customized T shirts and posters were used to aid conservation awareness.

Herbarium specimens

A total of 50 plant species were pressed and preserved in the APLORI as herbarium specimens for further plant identification.

Conservation action plan and publication of results

Findings from this study will be used to approach stakeholders (government agencies and local communities) in order to evaluate the possibility of granting the area a status of protection from intensive human use. Results obtained from this survey will be used as a tool to propose conservation strategies to the Gombe State government so that illegal activities such as grazing, farming and logging currently going on in the woodland are stopped or are done sustainably. Our data can be used for information so that activities such as road construction can be carried out with minimal impact on cover and biodiversity. Data will also be shared with Global Plant Data base and West African Plants Database. Results will also be published in open access peer reviewed journals.


Plates 1 & 2: Research team from left to right: Myself, Rahila Meribah Yilangai (in brown t shirt), Onoja Joseph Daniel (in cream t shirt), Elisha Emmanuel (In green t shirt; plate 2) during vegetation sampling (Photos by: Elisha Emmanuel and Rahila Yilangai respectively)


Plates 3 & 4: Magaji Yiri, the local guard employed during the project pressing plant samples; grazing activity around the degraded out sketch of the woodland (Photos by: Rahila Yilangai and Emmanuel Elisha respectively)


Plates 5 & 6: Tula Yiri secondary school students during conservation education programme (Photos by Rahila Yilangai)

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