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Assessment of Woody Plants Species and Ground Cover Status of Mandara Hills as Major Determinants of Wildlife Conservation

Michael Awi; and Hapsatu Saidu

[1]*Department of Biological Science Technology, Federal Polytechnic, Mubi, Adamawa State, Nigeria.*
[2]*Department of Forestry Technology, Federal Polytechnic, Mubi, Adamawa State, Nigeria*.

Corresponding author: mikeawi2013@gmail.com

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Abstract

The study assessed the woody plants species and ground cover status of Mandara hills to seek necessary information for its sustenance. Information on woody plants resources and ground cover will help in the design of management strategies for wildlife conservation and biodiversity preservation. The investigation involved the identification and inventory of woody plant species, assessment of crown area and the ground cover of the Mandara hills. Woody plants' species status was presented using species richness, frequency, species richness index and Simpson's diversity index. Girth and height classes, ground cover and crown area were presented using percentages. 40 species of woody plants belonging to 21 families were inventoried. The species richness was highest in Kwalkuga (24) while the lowest was in Kuthu with 18. Among the woody plants species identified; Acacia kirkii (224) had the highest frequency, followed by Anogeissus leiocarpus (211). The highest diversity index was recorded in Kwalkuga (0.09) while Fafuma and Makwan with 0.02 each were the lowest. The majority of the trees and shrubs were recorded in the girth classes of 1.0-1.99 and 2.0-2.99 and that of height in 1.1-3.0, 3.1-5.0 and 5.1-7.0 respectively. Results of crown area showed highest value in Kwalkuga (20.92%) and Fafuma had the highest ground cover of grass (34.02%). This study recommends establishment of buffer zones where partial human activity can take place and the improvement of the livelihood of the residents to reduce human pressure on the resources of the hills.

Keywords: Woody Plants, Wildlife, Species, Assessment, Resources.

Introduction

In 21st century challenges facing Nigeria, possibly none is more significant than the problem of wildlife conservation, but more often ignored and overlooked. The task before the globe is eco- restoration through solutions that can stand the global trials fronting our wilderness especially forestry and wildlife habitats. The current global mission of fighting climate change can only be possible through a well design strategy and policy of addressing the problems facing our forest ecosystems because the forest resources are being over-used and without intentions of managing the base.

The role of forest ecosystem in providing shelter, edible fruits, leaves, tree bark and roots to wildlife for survival cannot be ignored because the consequence of restoration of every species of wildlife if lost, is enormous. In addition, forest ecosystems give adequate

protection, resting, grooming and nesting/roosting sites to our wild animals in other to keep productivity and for the animals to thrive (Okeke et al., 2022).

According to Du et al. (2023) preserving and protecting our forest habitats will help wild animals to live in their natural environments for they will remain wild and can thrive. Hence the need to assess the status of woody plants and ground cover of Mandara hills in Madagali local government area of Adamawa state for the important role they play in wildlife conservation. The conservationists and those entrusted with the sustenance of biodiversity need to be provided with basic and adequate information on the woody plants resources and ground cover of Mandara hills for effective policy formulation because the more suitable a forest site, the better the performance of wild animals in terms of productivity, health and ecological needs for humans.

Historically, Mandara hills had been known to be rich in primates such as baboons (*Papio anubis*), green monkey (*Cercopithecus aethiops*), patas monkey (*Erythrocebus patas*), chimpanzee (*Pan troglodytes*) and other species such as spotted hyena (*Crocuta crocuta*), diverse species of antelopes, hare rock (*Rock hyrax*) and varieties of rodents to mention a few (Divisional Forest Office Annual Report, DFOAR, 2018). These animals cannot thrive where there are few woody plants especially trees and shrubs that provide them shelter, protection, food and reproductive sites.

In almost all communities, human activity plays a significant role in determining the existence of species. Manfredo et al. (2021) and Ripple et al. (2014) in their separate studies opined that, human activities like logging, charcoal processing, bush burning for poaching, wild fruits harvesting, the desire for agricultural land, urbanization and roads construction, increasing timber industry and the relatively poor economic status of the majority of the human population are the primary drivers of forest and wildlife loss across the globe.

This is the typical situation in the study area because Boko Haram Insurgents has pushed almost all the communities towards the hills and quite number of them now occupy the hill base giving them easy access to the resources of the hills. Mustapha et al. (2012) opined that the drivers of deforestation and biodiversity loss listed above are done in the study area either unintentionally that transforming the natural environment and most times selectively displaces species or intentionally for particular resources that results in elimination of species.

In general, humans through unprecedented exploitation of timber, charcoal and fuelwood are the most powerful proximate force dictating the presence, loss and persistence of wildlife not only in the study area but a global issue (Bergman et al., 2022). This study considered the eminent role that well preserved and protected forests play in wildlife conservation and therefore assessed the woody plants species and ground cover of Mandara hills as basic information needed for developing better policies that could help in conservation of both fauna and flora species.

Materials and Methods

Study Area

The assessment was carried out in Madagali local government area of Adamawa state, Nigeria, which shares a boundary with Gwoza local government area of Borno State in the North, Askira Uba local government area of Borno State in the West, Michika local government area of Adamawa State in the South and Cameroon Republic in the East. The local government area lies on latitude 10° 24¹ N and longitude 13° 48¹ E with a population of 156, 230 (National Population Commission, NPC, 2011). Below (**Fig. 1**) map of the Madagali local government area showing the study locations.

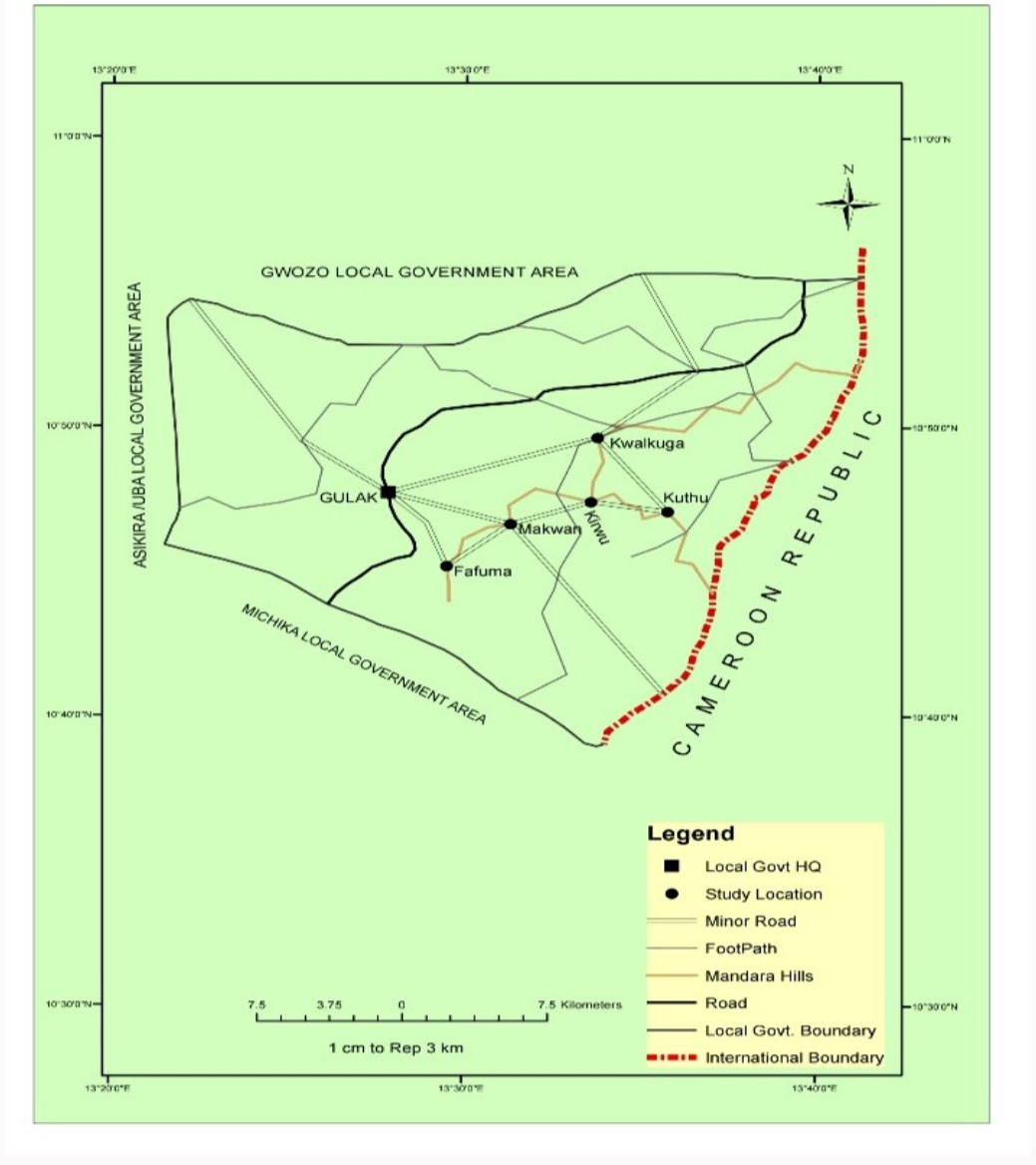

Fig. 1: Map of Madagali local government area of Adamawa state showing the study locations

Source: Environmental Survey, 2023

Data Collection

The survey of the forest areas along the Mandara hills' foot, valleys and uphill was carried out to take the inventory of the forest's characteristics in terms of woody plant species composition and ground cover. The investigation also effectively utilized the literature obtained from the Ministry of Environment Adamawa state in identifying and assessing the different hill components of Mandara hills.

The study area was stratified into five (5) locations based on valleys separating the hills namely; Kirwu, Kuthu, Fafuma, Makwan and Kwalkuga. Identification and enumeration of woody plant species for assessment of species richness, frequency, species richness index and diversity index were done in five (5) different plots measuring 50m by 50m (2500m^2) per location taking into consideration the composition and the characteristics of the woody plants community before laying the plots.

The woody plant species within the plots that are up to 10cm in girth were identified and enumerated with the aid of the West African Trees and Shrubs manual and the frequency of each species recorded. Equally, the woody plant species richness and diversity index were determined based on the woody plant species enumerated.

Correspondingly, 200 woody plants (trees and shrubs) of different species were sampled using simple random sampling technique as adopted by Kwajafa (2012) for the assessment of their performance in terms of girth and height. For each of the woody plants sampled, measurement was taken on the following:

i. Girth at breast height using a diameter tape at 1.3m above ground and before the first branching.
ii. Height was measured using 100m tape and alongside adoption of approximate measurement method.

Similarly, for the assessment of the crown area, 150 trees made of different species were sampled using simple random sampling technique as outlined by West (2016). The crown measurement using two diameters (D_1 and D_2) of a tree crown running perpendicular to each other as described by Sutherland (1999) using 100m tape as detailed below:

a. Diameter of the crown at its widest point in meters was measured as D_1
b. Diameter of the crown perpendicular to its widest point in meters was measured as D_2
c. The two (2) diameters were added and divided by four (4) as average radius, r
d. The average radius was squared, r^2
e. Finally, the average radius (r^2) was multiplied by pi (3.14) to get the crown area of woody plants.

The ground cover of the Mandara hill base, valleys and hill tops were assessed using the step point method as outline by Acar and Osman (2022) and Sutherland (1999) by taking the record of whatever the toe of the boot of the enumerator touches at a specified interval along a given length of transects. Transects of one hundred meters (100m) were used up to

30 times in each study location. The records of litter, anthill, grass, forbs, rock-out-crops and bare ground were taken.

Data Analysis

Assessment of Species Richness Index

Jayaraman (1999) species richness index model was used to determine the species richness index of the study area as adopted by Kumar et al. (2022). The model given as;

$$\text{Species Richness Index} = \frac{S}{\sqrt{N}}$$

Where S = Number of woody plant species in a collection in Mandara hills
N = Number of Individuals of all woody plants collected in Mandara hills

Assessment of Species Diversity Index

The species diversity index of woody plant species was done using Simpson's diversity index model as adopted by Livingstone (2018). The model is as follow:

$$D_{N(N-1)}^{\sum n (n-1)}$$

Where;

n = the total number of individuals of a particular species
N = the total number of individuals of all species
D = Simpson's Diversity Index

Assessment of Woody Plants Performance

(a) **Girth and Height**

The girth and height performance of the woody plants were assessed using class range technique and percentage as adopted by Livingstone (2018).

(b) **Crown Area**

The Crown Area was assessed using the method of Hamilton (1994). The model is given as:

$$CA = \{(D_1 + D_2)\}^2 \pi$$
$$4$$

Where CA = Crown area of woody plant species
D_1 = Diameter of Crown first measured between two-points marked
D_2 = Diameter of Crown second measured between two-points later marked
π = 3.14

(c) **Assessment of Ground Cover**

The ground cover was analyzed using percentage (%).

Results and Discussion

The results in Table 1 show the checklist of woody plant species of Mandara Hills assessed in terms of frequency across each study location, species richness, species richness index and species diversity index. The result shows that forty (40) species of woody plants belonging to 21 families were inventoried. The species frequency indicates that Kwalkuga had the highest with 617 woody plants, followed by Kirwu (466), Kuthu (383), Fafuma (307) and Makwan had the least (289).

The results of species richness per location in order of descending values shows Kwalkuga (24), Fafuma (22), Makwan (21), Kirwu (20) and Kuthu (18). Similarly, computation of the species richness index showed that Fafuma was highest with 1.26, followed by Makwan (1.24), Kwalkuga (0.97), Kirwu (0.93) and the least was Kuthu with 0.92.

Assessment of species diversity shows that Kwalkuga has the highest diversity index of 0.09, followed by Kirwu with 0.05 and the least were Fafuma and Makwan with 0.02 diversity index each. The implication of these findings means that under effective conservation Kwalkuga will show luxuriant vegetation, followed by Kirwu making them important savannah ecosystems for wildlife conservation.

In addition, the representatives of woody plant species inventoried (Table 1) are typical of savanna ecosystem which is similar to that of Morrison's (1999) study carried out in Mukogodo forest, Kenya. The present result compared to Divisional Forest Office Annual Report, DFOAR (2018) showed a decline in woody plant species richness in Mandara hills. This loss may not be unconnected with the human pressure on the resources of the hills as earlier reported by Kissinger *et al.* (2014).

Table 1: Woody Plant species of Mandara Hills showing Distribution per Location

Family	Scientific Name	Hausa Name			Frequency			
			Kirwu (n)	Kuthu (n)	Fafuma (n)	Makwan (n)	Kwalkuga (n)	Total
Ahamnaceae	*Ziziphus mauritania*	Magarya	53	29	63	21	36	202
Anacardiaceae	*Haematostaphis barteri*	Jini kafri	-	7	-	6	18	31
Annonaceae	*Anona senegalensis*	Gwandan daji	3	-	7	1	47	58
Asclepiadaceae	*Calotropis procera*	Tufafiya	4	-	-	-	3	7
Balanicaceae	*Balanites aegyptiaca*	Aduwa	2	4	7	-	12	25
Bignoniaceae	*Stereospermum kunthianum*	Samsami	45	23	-	29	-	97
Bombacaceae	*Bombax costatum*	Garjiya	26	34	31	57	-	148
Bombacaceae	*Adansonia digitata*	Kuka	17	19	9	3	14	62
Burseraceae	*Boswellia dalzielli*	Hanno	3	-	-	-	29	32
Burseraceae	*Commiphora africana*	Dashi	6	35	10	46	44	141
Caesalpinoideae	*Tamarindus indica*	Tsamiya	5	-	4	-	6	15
Caesalpinoideae	*Poliostigma reticulatum*	Kalgo	19	53	27	19	24	142
Caesalpinoideae	*Isoberlinia tomentosa*	Farar doka	-	-	-	-	1	1
Combretaceae	*Anogeissus leiocarpus*	Marke	38	53	43	32	45	211
Combretaceae	*Combretum nigrica*	Chiriri	-	-	1	-	168	169
Combretaceae	*Guiera senegalensis*	Kenta	19	-	4	-	12	35
Combretaceae	*Terminalia laxiflora*	Farin haramata	-	-	3	-	-	3
Ebenaceae	*Diospyros mespiliformis*	Kanya	7	22	14	16	33	92

Table 1 Continued: Woody Plant species of Mandara Hills showing Distribution per Location

Family	Scientific Name	Hausa Name			Frequency			
			Kirwu (n)	Kuthu (n)	Fafuma (n)	Makwan (n)	Kwalkuga (n)	Total
Hymenocardiaceae	*Irvingia gabonensis*	Goron biri	-	6	-	6	-	12
Meliaceae	*Azadirachta indica*	Dogonyaro	-	-	-	-	7	7
Meliaceae	*Khaya senegalensis*	Madaci	-	-	2	2	-	4
Mimosoideae	*Faidherbia albida*	Amarije	-	-	2	-	-	2
Mimosoideae	*Acacia sieberiana*	Farar kaya	-	25	21	-	28	74
Mimosoideae	*Acacia kirkii*	Kayar auno	176	-	-	18	30	224
Mimosoideae	*Acacia hockii*	Bakar kaya	-	-	5	-	-	5
Mimosoideae	*Acacia seyal*	Dushe	-	-	8	-	8	16
Mimosoideae	*Acacia nilotica*	Kare gatari	2	-	4	-	6	12
Mimosoideae	*Parkia biglobosa*	Dorowa	-	-	-	1	-	1
Moraceae	*Ficus lutea*	Awayo	-	-	11	5	-	16
Moraceae	*Ficus sycomorus*	Baure	-	15	-	7	-	22
Moraceae	*Ficus platyphylla*	Gamji	-	13	-	-	34	47
Moraceae	*Ficus glumosa*	Kawuri	-	11	19	-	-	30
Rhamnaceae	*Ziziphus abyssinica*	Magaryan kura	22	-	12	13	3	50
Rubiaceae	*Sarcocephalus latifolius*	Tawashiya	14	-	-	3	-	17
Sapotaceae	*Vitellaria paradoxa*	Kadanya	3	2	-	2	-	7
Tebaceae	*Pericopsis laxiflora*	Kinkiya	-		-	2	-	2
Tiliaceae	*Grewia lasiodiscus*	Namijin marke	-	17	-	-	-	17
Tiliaceae	*Grewia bicolor*	Markin dutse	-	-	-	-	5	5
Ulmaceae	*Trema orientalis*	Kendo	-	15	-	-	-	15
Verbenaceae	*Vitex doniana*	Dinya	2	-	-	1	4	7
Total (N)			466	383	307	289	617	2062
Species Richness			20	18	22	21	24	
Species Richness Index			0.93	0.92	1.26	1.24	0.97	
Simpson's Diversity Index			0.05	0.03	0.02	0.02	0.09	

Source: Field Survey (2023)

Girth Classes of Woody Plant species of Mandara Hills Expressed using Percentages

The Table 2 below indicates the percentages of girth classes of woody plant species in Kirwu, Kuthu, Fafuma, Makwan and Kwalkuga.

In Kirwu, the girth class that ranged from 1.0 - 1.99m with 33.1% was the highest followed by the girth class of 2.0 - 2.99m (30.6%) while the least was recorded for the girth class of 8.0 - 8.99m with only 0.4%. In Kuthu, the girth class range of 2.0 - 2.99m with 28.8% was highest, followed by the girth class of 0.0 - 0.99m (23.6%). No woody plant was recorded for the girth class of 8.0 - 8.99m in Kuthu. This means that the majority of woody plants were recorded in the girth classes of 0.0 - 0.99m and 2.0 - 2.99m representing a total of 52.4% of the 200 woody plants assessed for girth classes.

In Fafuma, 38.3% of woody plants were recorded in the girth class of 1.0 - 1.99m while the girth class of 2.0 - 2.99m had 34.1%. No woody plants species were recorded in girth class of 7.0 -7.99. Similarly, 42.5% of woody plants were recorded in the girth class of 1.0 - 1.99m and 26.9% for the girth class of 2.0 - 2.99m in Makwan. No woody plant was recorded for

girth class of 8.0 - 8.99m in Makwan. In Kwalkuga, the girth class range of 1.0 - 1.99m had the highest record of woody plants of 50.2% while the girth class of 2.0 - 2.99 had 22.3%.

The above results showed that there seems to be a continuous cutting of the tree branches or shrubs top thereby decreasing the development in terms of girth as shown by high percentages of woody plants with low girth values.

The findings of this investigation agree with Alvarez et al. (2013) who reported that in tropical trees lopped or pruned by humans, the girth shows relatively poor development because of the incessant harvesting of branches for essential services such as fuelwood, charcoal and others that retards growth and development. The above factor may be the reason why the majority of woody plant species assessed has their girth within the range of 1.0 - 3.0m

Table 2: Percentage Distribution and Range of Woody Plant Species in Mandara Hills by Girth Classes

Location				Girth	Classes	(m)			
	0.0-0.99	1.0-1.99	2.0-2.99	3.0-3.99	4.0-4.99	5.0-5.99	6.0-6.99	7.0-7.99	8.0-8.99
Kirwu	11.4	33.1	30.6	10.3	5.5	4.2	3.4	1.1	0.4
Kuthu	23.6	18.2	28.8	9.5	8.5	6.7	4.0	0.7	0.0
Fafuma	20.1	38.3	34.1	5.2	1.4	0.4	0.3	0.0	0.2
Makwan	15.8	42.5	26.9	11.6	2.0	0.9	0.2	0.1	0.0
Kwalkuga	19.7	50.2	22.3	5.0	1.6	0.7	0.3	0.1	0.1

Source: Field Survey (2023)

Height Classes of Woody Plant species of Mandara Hills Expressed using Percentages

The result of height assessment in Mandara hills (Table 3) showed that in Kirwu the percentage of woody plant species in the height classes ranged from 1.3% in the height class of 17.1 - 19.0m to 41.5% in the height class of 3.1-5.0m. The majority of woody plants were recorded in the height classes of 1.1-3.0m, 3.1-5.0 and 5.1-7.0 represented by 19.5%, 21.0% and 41.5% respectively.

The height classes were assessed in Kuthu and the result showed that the percentage of woody plant species in the height classes ranged from 0.6% in the class of 17.1-19.0m to 36.9% in the height class of 3.1-5.0m. The majority of the woody plant species were recorded in the height classes of 1.1-3.0m (17.8%), 3.1-5.0 (36.9%) and 5.1-7.0m (19.3%) as presented in ascending order of height.

In Fafuma, the percentage of woody plant species in the height classes ranged from 0.2% in the class of 13.1-15.0m to 33.7% in the height class of 1.1-3.0m. However, no tree was recorded in the height classes of 15.1-17.0m. From the analysis, the majority of the woody plants were recorded in the height classes of 1.1-3.0m (33.7%) and 3.1-5.0m (31.2%).

Also, in Makwan, the percentage of woody plant species in the height classes ranged from 0.3% in the class of 11.1-13.0m to 42.1% in the height class of 3.1-5.0m. No tree was

recorded in the height classes of 15.1-17.0m and 17.1-19.0m. The bulk of the woody plants were recorded in the height classes of 3.1-5.0m (42.1%) and 1.1-3.0m (28.6%).

Similarly, in Kwalkuga, the percentage of woody plant species in the height classes ranged from 0.2% in the class of 17.1-19.0m to 52.3% in the height class of 3.1-5.0m. The majority of the woody plants were recorded in the height classes of 3.1-5.0m (52.3%) and 1.1-3.0m (21.4%).

The ecological importance of this result (Table 3) is that the woody plant species in the study area tend to suffer serious human interference, hence low values of height were recorded due to continuous demand for fuelwood, charcoal and timber that reduced growth and development. This study affirms the report of Yang (2020) that savanna trees tend to grow tall only under ecologically ideal conditions where the ecological area is secured.

Table 3: Percentage Distribution and Range of Woody Plant species in Mandara Hills by Height Classes

Location				Height	Classes	(m)			
	1.1-3.0	3.1-5.0	5.1-7.0	7.1-9.0	9.1-11.0	11.1-13.0	13.1-15.0	15.1-17.0	17.1-19.0
Kirwu	19.5	41.5	21.0	7.0	3.0	2.0	3.1	1.6	1.3
Kuthu	17.8	36.9	19.3	10.1	6.5	5.1	2.3	1.4	0.6
Fafuma	33.7	31.2	24.0	4.6	2.8	2.7	0.2	0.0	0.5
Makwan	28.6	42.1	19.7	6.2	2.6	0.3	0.5	0.0	0.0
Kwalkuga	21.4	52.3	15.6	5.2	2.7	1.4	0.9	0.3	0.2

Source: Field Survey (2023)

Assessment of Crown Area of Mandara Hills

The result of crown area of the Woody plants species (trees) in the study area (Kirwu, Kuthu, Fafuma, Makwan and Kwalkuga) are presented in Table 4. From the result, Kwalkuga was highest with 2,614.73m^2, followed by Kirwu with 1,786.40m^2 and the least was Fafuma with 1,259.64m^2. These figures represent the total crown area of each hill location by 150 individual trees assessed. It can be deduced that crown area in Kwalkuga is quantitatively high, hence the site is of ecological interest for conservation of wildlife and other resources therein.

Table 4: Crown Area by 150 Randomly Sampled Trees species of Mandara Hills per 12,500m^2

Name of Hill	Crown Area per 12,500m^2	Percentage (%)
Kirwu	1,786.40	14.29
Kuthu	1,376.21	11.01
Fafuma	1,259.64	10.08
Makwan	1,532.19	12.26
Kwalkuga	2,614.73	20.92

Source: Field Survey (2023)

Ground Cover of Mandara Hills

The ground cover in the study area was assessed on location basis. The parameters measured include litter, anthill, grass, forbs, rock-out-crops and bare ground. The results are as presented in Table 5 for the five locations Kirwu, Kuthu, Fafuma, Makwan and Kwalkuga respectively.

The ground cover result of Kirwu indicates that grass dominated the area (27.33%) followed by the rock-out-crops (23.73%) while the least parameter was anthill (1.33%). Result of ground cover of Kuthu shows that forbs covered 30.77%, followed by grass (19.87%) and the least was anthill (0.51%).

In Fafuma, grass covered 34.02% of the site being the highest, followed by rock-out-crops (26.73%) and the least was anthill (0.73%). The result of ground cover for Makwan showed that Grass covered 27.70%, followed by rock-out-crop (24.41%) and the least was anthill (1.06%).

Finally, the result of assessment of ground cover of Kwalkuga showed that grass was the most dominant vegetation (32.91%), followed by forbs (22.78%) while the least was anthill (0.63%).

In general, assessment of ground cover indicates that the highest percentage of 34.02 was recorded for grass in Fafuma, followed by (32.91%) in Kwalkuga. The outcome of this investigation also reveals that grass was the dominant parameter as indicated by Fafuma (34.02%), Kwalkuga (32.91%), Makwan (27.70%), Kirwu (27.33%) and Kuthu (19.87%). The relatively good grass cover in the area indicates that the ecology of Mandara hills can support a range of grazers. In addition, it is an excellent site for rodents, lagomorphs and different species of antelopes

Table 5: Ground Cover of Mandara Hills showing Frequency and Percentage (%)

Parameter	Kirwu n	Kuthu n	Fafuma n	Makwan n	Kwalkuga n
Litter	105(14%)	125(16.03%)	205(24.91)	115(15.17%)	60(7.60%)
Anthill	10(1.33%)	4(0.51%)	6(0.73%)	8(1.06%)	5(0.63%)
Grass	205(27.33%)	155(19.87)	280(34.02)	210(27.70%)	260(32.91%)
Forbs	156(20.8%)	240(30.77%)	32(3.89%)	80(10.55%)	180(22.78%)
Rock-out-crops	178(23.73%)	136(17.44%)	220(26.73%)	185(24.41%)	175(22.15)
Bare ground	96(12.8%)	120(15.38%)	80(9.72%)	160(21.11%)	110(13.92%)

Source: Field Survey (2023)

*Figures in parenthesis are in percentages

Conclusion

From the available findings, it can be concluded that Mandara hills contain representative samples of woody plants species found in savanna ecosystems. These species are however not very diverse because of over-exploitation resulting from unprecedented demand by the local dwellers and beyond, and the relative size of the study area which is now more of an

island within a farming community. The ground cover is also encouraging for the conservation of fauna species of savanna.

In general, this study has provided baseline information on the woody plants species richness and diversity alongside with ground cover of the Mandara hills for policy development.

Recommendations

This study recommends that:

i. Buffer zones should be established where partial human activity can take place in order to protect the core areas
ii. Government should enhance her approach in improving the livelihood of the local residents in order to reduce human pressure on the Mandara hills
iii. Awareness be created among the users of the Mandara hills on the importance of conservation
iv. Change in status of the area to forest or game reserve for better protection and conservation

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