Original Research Article

Savannas highlands of Cameroon: floristic composition, functional traits and conservation status

ABSTRACT

Background: The savannas flora has been widely neglected in science and conservation policy throughout the world, so that this biodiversity component remains largely unknown.

Aims: The objective of this study was to assess floristic diversity, ecological characteristics and conservation status of the savannas of the mounts Bamboutos.

Study design: The savannas studied ~~was~~ were located in the Eastern slope of the mounts Bamboutos, in the Western Highlands of Cameroon. The natural savannas ecosystems had a significant biodiversity, a level of disturbance by local people like overgrazing, bush fires, collection of fuelwoods, etc.

Place and Duration of Study: The field work was conducted in the Eastern slope of the mounts Bamboutos (5°30' - 5°45' N and 10°03' - 10°15' E) between May and November 2012, 2013 and 2014.

Methodology: Plant species identified were characterized by floristic diversity and life traits (habit, life form, leaf size, type of diaspore, dispersal syndromes and phytogeographical affinities).

Results: The flora consisted of 231 plant species belonging to 154 genera and 70 families. Poaceae (39 species), Asteraceae (37 species) and Fabaceae (20 species) were the dominant

families. The most frequent life forms were phanerophytes (41.12%) followed by chamaephytes (21.64%) and therophytes (20.34%). Leaf size classes of plants consisted of mesophylls (30.73%), nanophylls (25.54%) and microphylls (25.10%). Anemochory (45.88%) was dominated dispersal mode followed by zoochory (30.73%). Investigation of the geographical distribution of plant species indicated that 27.27 % belonged to the afrotropical zone and 18.61% pantropical species. Four species were endemic and four subendemic to Cameroon dorsal. 17 species were threatened according to IUCN red list.

Conclusion: Protection and conservation of natural resources of savannas is crucial for sustainable utilization of accessible natural flora so, it is strongly suggested to overgrazing and agricultural activities.What does it mean ?

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Keywords: Cameroon; endemic species; ecological characteristics; floristic composition; mounts Bamboutos; savannas

1. INTRODUCTION

Mountain environments throughout the world host highly specialized flora and fauna [1]. The ~~mounts~~ Mount Bamboutos ~~are~~ is part of the Western Highlands of Cameroon, high-elevation habitats are represented by few isolated peaks. This area contains endemics and rare plants and constitute hotspots of plant diversity [1, 2]. The vegetation of this area was in in the past largely covered with forest. It has been progressively ~~destroyed~~ deforested and degraded to give way to the savanna, cropland or pasture; though today only very few patches of forests are ~~can be observed~~present [3].

The floristic diversity and functional traits are among the most significant ecological attributes of a particular ecosystem, which show variations in response to environmental and anthropogenic factors, and elucidating how these factors drive the assemblage of plant communities remains an important challenge in ecological research [4]. The diversity in mountain environments is in part, due to the particular climatic conditions that which rapidly vary over very short distances along altitudinal gradients. In addition to altitude, small scale topography and geomorphological processes also play an important role in creating a great variety of microhabitats that differ significantly in species composition over short spatial scales [5]. On the other hand, the microhabitat diversity may allow the cold-adapted species to maintain a refugium along valley slopes following local temperature gradients and within topographic/geomorphological traps [6].

Previous studies on the flora and vegetation of the mount s Bamboutos have been carried out by several authors [7, 8, 9, 10, 11]. Very few studies have focused on the drivers of variations of floristic composition and functional traits of plant communities. Such information is useful not only in understanding plant community to the impact of changed of environmental conditions on plant community structure , but also in providing insight into the environmental requirements of the species needed for successful ecological restoration and biodiversity protection.

The aim of this study was to assess floristic diversity, ecological characteristics and conservation status of the savannas of the mounts Bamboutos.

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2. MATERIALS AND METHODS

2.1 Study Site

The study was carried out in the Eastern slope of the mounts Bamboutos, in the Western Highlands of Cameroon. The study area is located between 5°30’ - 5°45’ N and 10°03’ - 10°15’

E (Figure 1). This mountain with its maximum height of 2740 m is one of the major volcanic mountains in Cameroon. The climate is defined as Cameroonian altitude type, with a long rainy season (March-November) and a short dry season (December-February). The annual average rainfall varies ~~according to the relief from~~between 1750 to 2500 mm yearly. The annual average temperature varies from 10-12 to 23.5 °C. The predominant soils are andosols, andic ferralitic soils and battleship ferralitic soils. The selected community savannas are natural ecosystems having significant biodiversity ~~as well as a certain~~and level of disturbances due to ~~activities performed by local people~~anthropogenic activities like overgrazing, bush fires, collection of fuelwoods, etc. The herbaceous stratum is dominated by *Pennisetum purpureum* and *Imperata cylindrica*. The ligneous cover is also strongly influenced by anthropogenic activities [9, 10].

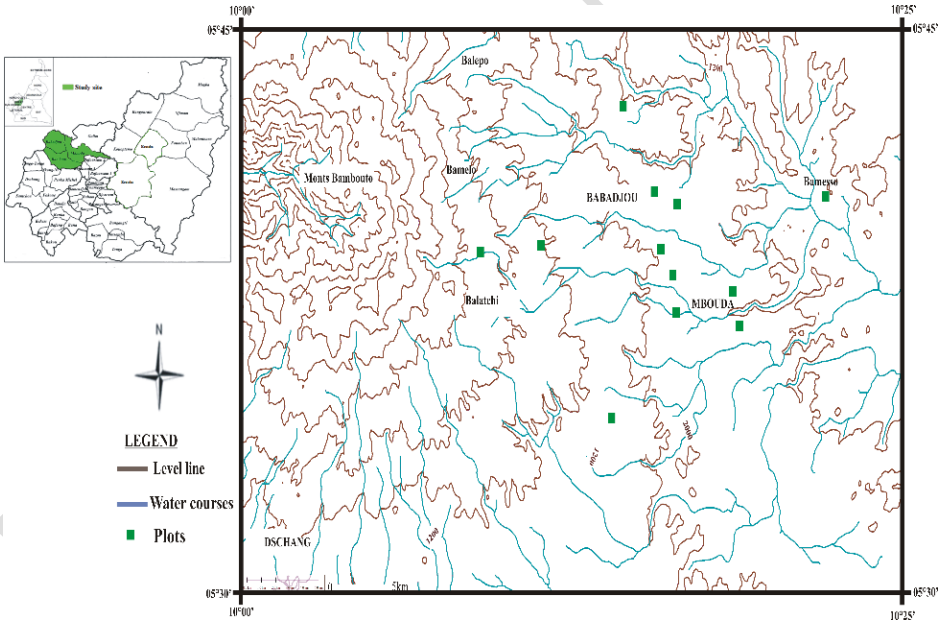

Fig 1: Location of the study area on the Bamboutos Mountains, West Cameroon

2.2 Data Collection

The field work was conducted in the rainy season ~~in~~ during the months of May and June 2012, 2013 and 2014. A total of 54 ~~sample~~ plots of 10 m × 10 m were ~~established~~ marked randomly to sample the floristic data and ~~concerned all~~ vascular plants. The trees and shrubs were observed within quadrats of 100 m² and herbs within five sub-quadrats of size 1×1m² placed within 10m × 10 m quadrats. Some Plants species were identified directly in the field using monograph; for other species, specimens were collected and compared to those available in the National herbarium of Cameroon.

The habit of the plant's species was determined in field by the observation ~~of plants~~. Life form were determined and classified according to please write the method details instead of merely mentioning the references [14]. Leaf size were determined and classified according to [15]. The types and modes of diaspore dispersal were determined and classified according to morphological criteria of [16]. Phytogeographical distribution types adopted corresponds to the major chorological subdivisions accepted for Africa to please write the method details instead of merely mentioning the references ~~according to~~ [17]. The Red List of threatened species in the Cameroon was used to establish IUCN Conservation status of species [18].

3. RESULTS AND DISCUSSION

3.1 Floristic Diversity

3.1.1 Floristic Composition

A total number of 231 plant species belonging to 154 genera and 70 families (APG III) were recorded in 54 plots from the study area (Appendix A). The Shannon-Weaver diversity index was 4.72 and the evenness index was 0.61. The families Poceae (39 species), Asteraceae (37 species), Fabaceae (20 species), Rubiaceae (8 species), Lamiaceae (7 species), and Cyperaceae,

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Hypericaceae, Malvaceae, Moraceae each represented with ~~respectively~~ 6 species were the richest families in terms of the number of species. The remaining families were represented by five or less than five species.

Poaceae, Asteraceae and Fabaceae have emerged as the common families in the investigated area. These findings are similar with the results of [19] in Venezuela, [20, 21] in Abidjan in Ivory Coast, [22] in Burundi, [23] in Pakistan and [10] in Cameroon. [10] stated that the high presence of species of the ~~Gramineae~~ Poaceae family is explained by the fact that savannahs are grass-dominated ecosystems. Moreover, Poaceae taxa have a high tilling potential and a high regrowth rate after grazing if environmental conditions are favourable. The abundance of Asteraceae can be attributed to their great range of ecological tolerance and great capacity of seed dispersion [9]. The species of Poaceae and Asteraceae due to their wide ecological amplitude are diverse in their habitat occurrence. The high value of the Shannon-Weaver diversity index and the Pielou equitability index showed that this site was diversified. The diversity could be explained by the diversity of the observed biotope diversity (lowland, hilltop and slope zone).

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3.1.2 Endemic and Subendemic Taxa

In term of endemism, 8 plant taxa belonging to 8 genera and 7 families were recorded. *Brachystelma omissum* (Asclepiadaceae), *Bafutia tenuicaulis* (Asteraceae), *Helichrysum cameroonense* (Asteraceae), *Adenocarpus mannii* (Fabaceae) were endemics to and *Impatiens sakerlana* (Basalminaceae), *Lobelia columnaris* (Campanulaceae), *Erica mannii* (Ericaceae) and *Helictotrichon mannii* (Poaceae) were subendemic to Cameroonian mountains archipelago included Bioko.

The presence of eight endemic species of the Cameroon dorsal ~~found~~ in the study area is not surprising. Indeed, these mountains are on the Cameroon volcanic line which belongs to the ‘‘25 hotspots’’ of biodiversity identified as priority zones of conservation at worldwide scale [1]. According to [21], these hotspots are particularly rich in floristic biodiversity, but also shelter many endemic species.

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3.2 Functional Traits

3.2.1 Plant Habits

On the basis of habit ~~that~~ the most common species were herbs (157 species, 67.96%) followed by shrubs (39 species, 16.88%) and trees (28 species, 12.12%) (Figure 2).

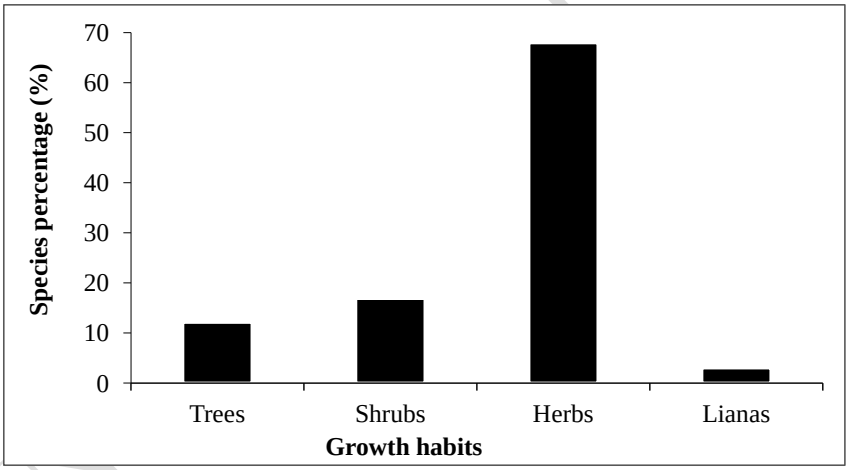

Fig 2. Growth habit of plant species recorded from the study area

The high proportion of herbs should be explained by climatic factors (dry relatively climate) and anthropogenic pressures ~~(bush fire, overgrazing and fuel wood collection)~~. The dominance of herbaceous species in savannas communities agree with previous studies [11, 19].

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3.2.2 Life Forms Spectrum

The life form gives us an idea of the physiognomy of the flora and vegetation structure, which are the effects of all life processes in combination with environment. Life form classification is more dependable, which is measure upon the major of position and degree of protection to perennating bud during the unfavourable and favourable condition. The dominated life form were phanerophytes (95 species, 41.12%) represented by nanophanerophytes (33 species, 14.28%), microphanerophytes (24 species, 10.38%), macrophanerophytes (23 species, 9.95%), mesophanerophytes (11 species, 5.26%) and megaphanerophytes (3 species, 1.29%). They were followed by chamaephytes (50 species, 21.64%) and therophytes (47 species, 20.34%) (Figure 3). The least represented life forms were the geophytes (10.38%) and hemicryptophytes (6.49%).

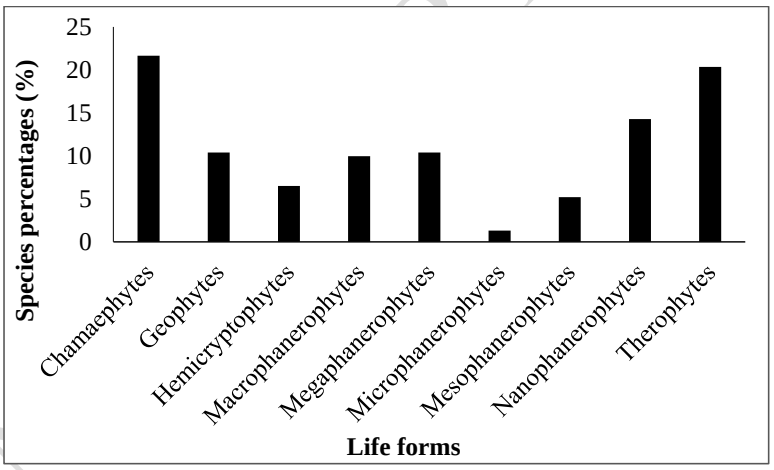

Fig 3. Distribution of plant species in the various life form spectra

Besides the spatial variations in the species composition of plant communities, the dominance of phanerophytes, chamaephytes, therophytes over other life forms might be a response to the hot climate, topographic variations and the anthropogenic pressure ~~like fuel, wood collection, overgrazing and bush fire~~. Similar conclusions were also reported by [23] in Khanpur Dam, Pakistan. The dominance of phanerophytes translates the adaptive strategies of plants which correspond to the competitive strategy. The high representation of nanophanerophytes showed of

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preponderance of shrubs formation. Indeed, the coexistence of the species is based on the sharing and the use of the common resources, where the species adapt to the various forms of competition, stress or disturbance [24]. The phanerophytes of this study are mainly made-up by trees and shrubs of savannas which are equipped with devices enabling them to resist the passage current fires (the thickening of the bark): *Protea madiensis* (Proteaceae), *Entada africana* (Fabaceae), *Terminalia glaucescens* (Combretaceae), *Vitellaria paradoxa* (Sapotaceae) are particularly demonstrative in this respect ; these trees are never jointed. [22] made the same report in wooded savannas with *Protea madiensis*, *Cussonia arborea*, *Combretum* sp., *Hymenocardia acida*, *Pericopsis angolensis*, and *Entada abyssinica* met in the Ruvubu National Park, Burundi. The plants of the regions which undergo bush fires with certain periodicity present a series of adaptations assuring survival or allowing a fast colonization of the medium. Among these adaptations, underline the capacity to reject stumps, the existence of underground organs (bulbs, rhizomes), a thick bark allowing to resist to the high temperatures, the release of seeds or the stimulation of their germinative capacities after the passage of fires [25]. Therophytes life form indicates disturbed environmental conditions in the study area and biotic pressure on vegetation which increase the short live species, ~~more or less~~ higher occurrence of this life form indicates some anthropogenic and overgrazing effects in the study area. The preponderance of therophytes can also be related to their high reproductive capacity, ecological, morphological and genetic plasticity under ~~a~~ higher degree of disturbance [26].

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3.2.3 Leaf Size Spectrum

Leaf size are a response to altitude, local weather conditions and regional orographic gradient. The most common leaf size were mesophylls with 71 species (30.73%), followed by notophylls 59 species (25.54%) and microphylls 58 species (25.10%) (Figure 4). The species with large leaf size (megaphylls and macrophylls) and small leaf size (nanophylles and leptophylles) were ~~little represented~~lower in abundance. Aphyllous species were absent.

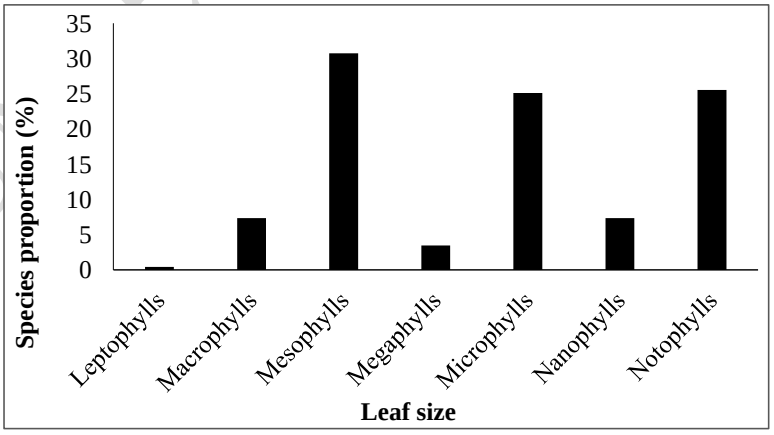

Fig 4. Distribution of plant species according to leaf size spectra

Species with large leaves take place in warmer wet climates while smaller leaves are characteristic of cold and arid climates and degraded habitats. The higher ~~proportions~~ abundance of mesophyllous, microphyllous and notophyllous plants could be ~~explained by the~~due to environmental fluctuations ~~mainly in terms of~~ such as temperature, altitude and edaphic factors. The percentage of microphylls and nanophylls were positively linked with the increasing altitude. During our field survey, microphyllous species were mostly observed at hilly tracks, where vegetation was comparatively rich due to fewer anthropogenic activities. The species with microphyllous leaves were abundant due to ecological adaptation for these arid conditions. The present findings agree with those of [27] in the Vegetation of Sheikh Maltoon Town District Mardan, Pakistan. The high proportion of nanophyllous is linked to the presence of highlander species e.g *Adenocarpus mannii*, *Erica mannii*, *Gnidia glauca* and *Hypericum revolutum* which have small~~est~~ leaves due to climatic and edaphic constraints. The presence of leptophylls and nanophylls reveals the adaptive nature of vegetation to unfavourable conditions.

3.2.4 Types of Diaspores and Seed Dispersal Syndromes

The types and modes of diaspore dispersal expresses ~~on~~ the ability of species to colonize new sites ~~, to~~and to regenerate and persist locally. Our description of dispersal syndromes is based on the total data set (N= 228). The sarcochores (25.11%) were the most dominant diaspores type followed by sclerochores (20.34%) and ballochores (19.48%). ~~The majority of~~Most of the diaspores taxa in the mount~~s~~ Bamboutos (45.88%) ~~is~~ are dispersed by wind (anemochorous species) followed by zoochory (30.73%) and autochory (22.51%) (Table 1).

Table 1. *Species proportion showing different types of diaspores and dispersal syndromes*

Diaspores types	Dispersal syndrome	Species number	Proportion (%)
	Anemochory	106	45.88
Sclerochores		47	20.34
Pterochores		10	4.33
Pogonochores		39	16.88
Sporochores		10	4.33
	Zoochory	71	30.73
Acanthochores		6	2.59
Sarcochores		58	25.11
Desmochores		7	3.03
	Autochory	51	22.07
Ballochores		45	19.48
Barochores		6	2.59
Undetermined		3	1.30

The seed dispersal spectrum of the studied mounts Bamboutos savannas was characterized by the dominance of anemochory, followed by zoochory and autochorous species. These results are consistent with those reported for other savannas [22, 28]. Anemochory species (sclerochores, pterochores, sporochores and pogonochores) are widely spread throughout the world but are especially prominent in open habitats as summits and high mountain slopes, steppes, prairies, garrigue, screes and deserts [29]. Seed dispersal is often regulated by climatic conditions e.g. the local climatic variability significantly impacts seed dispersal distances. The importance of sarcochores ~~on~~ over other types of diaspores ~~could~~ can be justified by the fact that these species are transported either by the birds or by other animals and have the chances to arrive at destination. Moreover, the observed abundance of species with zoochorous seed dispersal in

high-altitude environments, has been previously found in other open habitats [5, 22]. Zoochory is a common strategy for the dispersal of diaspores at lower altitudes, in disturbed habitats and in grazed vegetation types [12]. The relative abundance of autochores would be due to the species of Fabaceae family.

3.2.5 Phytogeographical Affinities

Investigation on the geographical distribution of plants species indicated that the total flora was composed mostly of afro-tropical ~~elements~~ species (27.27%) followed by pantropical species (18.61%), Sudano-Zambezian (10.82%) and paleotropical (10.39%) (Table 2).

Table 2. Geographical distribution of plants showing number of species in each chorotype

Phytogeographical affinities	Proportion (%)
Afro-American	2.16
Afro-Tropical	27.27
Afro-Magaches	3.03
Cosmopolitan	6.49
Guineo-Congolian	3.89
Paleotropical	10.39
Pantropical	18.61
Pluriregional African	4.76
Sudano-Guinean	0.43
Sudano-Zambezian	10.82
Only in Cameroonian mountain	6.93
Linked of Sudano-Zambesian region	1.29
Undetermined	3.89

The high proportion of species with continental distribution (afro-tropical) and with broad distribution (paleotropical and pantropical) indicate~~d a~~ disturb zone [13]. The importance of species with broad phytogeographical amplitude translates the loss of identity of the vegetation by the ~~penetration of~~invasion of exotic species with broad distribution. The high proportion of largely distributed taxa express the opening of this flora to external influences. These species (afro-tropical, cosmopolitan, paleotropical and pantropical) are generally ruderary or species of disturbed mediums, can be ~~an indication~~ used as indicator of ~~degradation~~degraded ecosystem. This disturbance could be due to the grazing and agricultural activities which highly modify the original flora. Most of the pantropical species are weedy annuals. These results ~~were~~ are similar to previous investigations, African distribution species constitute a remarkable proportion of the studied flora [22].

3.3 Conservation Status of the Species

Many endangered plants are found in this study, identifying it as of great importance in terms of the biodiversity of Cameroon. So far, 17 threatened tree species representing 7.36% of total flora have been recorded (Table 3). Amongst these, 9 species were vulnerable, 5 near threatened and 3 endangered.

Table 3. Threatened species of the mounts Bamboutos

N°	Species	Family	IUCN Status
1	*Allophylus abyssinicus*	Sapindaceae	VU
2	*Bafutia tenuicaulis*	Asteraceae	VU
3	*Echinops giganteus*	Asteraceae	NT
4	*Eriosema bauchiense*	Fabaceae	NT

5	*Helichrysum cameroonense*	Asteraceae	EN
6	*Helictotrichon mannii*	Poaceae	EN
7	*Impatiens sakerlana*	Basalminaceae	VU
8	*Lobelia columnaris*	Campanulaceae	VU
9	*Phyllanthus mannianus*	Phyllanthaceae	NT
10	*Psorospermum aurantiacum*	Hypericaceae	VU
11	*Raphia mambillensis*	Arecaceae	NT
12	*Schefflera hierniana*	Araliaceae	VU
13	*Schefflera mannii*	Araliaceae	VU
14	*Sporobolus montanus*	Poaceae	EN
15	*Vernonia acrocephala*	Asteraceae	NT
16	*Vernonia bamendae*	Asteraceae	VU
17	*Vernonia guinensis*	Asteraceae	VU

EN: Endangered, VU: Vulnerable, NT: Near Threatened

Presence of ~~Threatened~~ threatened species ~~found~~ /vulnerable/endangered species in the study ~~showed that~~ highlights the fact that this savanna ~~remains the~~is an important ecosystem ~~s~~that needs to be identified as a ~~for the~~plot for the conservationof the species. The study site is highly subjected to various anthropogenic activities such as grazing, bush fires and agriculture. The government must take immediate steps for intensive conservation of ~~These~~ these mountains ~~need more intensive conservation~~ by preserving understory vegetation. Judicious use of available forest resources must be ensured by the ~~It~~ government and measures taken to ~~is essential to~~ control human and animals ~~use of the~~exploitation of the mountains, ~~if not they will be exploited~~to prevent ~~until their~~ extinction in the next decades ~~and will not be~~and make it available for the

future generations. The rapid and extensive land-use change to the mount~~s~~ Bamboutos vegetation reinforces the need to implement effective conservation strategies, and our study can ~~help to guide future.~~provide necessary inputs for devising these strategies

4. CONCLUSION

The current study provides an insight into the floristic diversity, habit, life-form, leaf size, types of diaspores, dispersal modes, chorological spectrum and IUCN status of mounts Bamboutos. The results revealed the presence of 231 plant taxa, belonging to 154 genera and 70 families. Poaceae, Asteraceae and Fabaceae were dominant families. Four taxa were endemics while four taxa were subendemics. Phanerophytes were the most frequent life form followed by chamaephytes and therophytes. The most dominant leaf size were mesophylls, microphylls and notophylls. Anemochory was the main strategy of dispersion followed by zoochory. Chorological analysis revealed that the afro-tropical species was the most dominant chorotype followed by pantropical and paleotropical species. In order to conserve the threatened species, effective in-situ conservation strategies should be adopted.

ETHICAL APPROVAL

Not Applicable.

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