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Sacred forests in the Western Highlands Cameroon: What benefits for local population and nature?

Florestas sagradas nas terras altas do oeste de Camarões: Quais são os benefícios para a população local e a natureza?

Bosques sagrados en las tierras altas occidentales de Camerún: ¿Qué beneficios aportan a la población local y a la naturaleza?

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Abstract
The sacred forests of the Western Highlands Cameroon are, like other forests, a reserve of plants and genes, both known and unknown. They are privileged places for communication with ancestors. They provide significant environmental and socio-economic benefits; despite the pressure they are increasingly coming under. The aim of this study is to categorise the different uses of the sacred forests of Bafou, Baleveng and Bamendou, and then to assess the carbon stock of the woody plants in these forests. A survey form was used to record the various benefits derived by local people from the sacred forests. Individuals were counted in 30 m x 100 m plots. All individuals with a diameter ≥5 cm at 1.30 m above ground were considered. Carbon sequestered by forests was estimated using the non-destructive method. The study shows that the traditional laws protecting these forests are increasingly being violated by local people. These forests are cultural properties for the village and provide the local population with a variety of products. The most frequently cited uses are firewood, food products, medicinal plants and sacrifices. A total of 54 species, 47 genera and 29 families have been identified. Of these species, around 40.35% are used in one way or another by local people. The values of carbon sequestered by these forests vary from one forest to another and according to the type of equation chosen. The Bamendou sacred forest recorded the highest value, 443.9 t C /ha and 287.79 t C /ha respectively, using the equations of Djomo et al. (2010) and Fayolle (2013). This work presents the benefits of sacred forests for local populations. Management strategies for these forests should be strengthened by the State to ensure more sustainable conservation of this rich heritage.
Keywords: Uses; Sacred forest; Carbon stock; Cameroon; Medicinal plants.

Resumo
As florestas sagradas das terras altas ocidentais dos Camarões são, tal como outras florestas, uma reserva de plantas e genes, conhecidos e desconhecidos. São locais privilegiados de comunicação com os antepassados. Proporcionam benefícios ambientais e socioeconómicos significativos, apesar da pressão a que estão cada vez mais sujeitas. O objetivo deste estudo é categorizar os diferentes usos das florestas sagradas de Bafou, Baleveng e Bamendou, e depois avaliar o stock de carbono das plantas lenhosas nestas florestas. Foi utilizado um formulário de inquérito para registar os vários benefícios obtidos pela população local das florestas sagradas. Os indivíduos foram contados em parcelas de 30m x 100m. Todos os indivíduos com um diâmetro ≥5 cm a 1,30 m acima do solo foram considerados. O carbono sequestrado pelas florestas foi estimado utilizando o método não destrutivo. O estudo mostra que as leis tradicionais que protegem estas florestas estão a ser cada vez mais violadas pela população local. Estas florestas são património cultural da aldeia e fornecem à população local uma variedade de produtos. As utilizações mais frequentemente citadas são a lenha, os

produtos alimentares, as plantas medicinais e os sacrifícios. Foi identificado um total de 54 espécies, 47 géneros e 29 famílias. Destas espécies, cerca de 40,35% são utilizadas de uma forma ou de outra pelas populações locais. Os valores do carbono sequestrado por essas florestas variam de uma floresta para outra e de acordo com o tipo de equação escolhida. A floresta sagrada de Bamendou registou o valor mais elevado, 443,9 t C /ha e 287,79 t C /ha, respetivamente, utilizando as equações de Djomo et al. (2010) e Fayolle (2013). Este trabalho apresenta os benefícios das florestas sagradas para as populações locais. As estratégias de gestão destas florestas devem ser reforçadas pelo Estado para garantir uma conservação mais sustentável deste rico património.
Palavras-chave: Usos; Floresta sagrada; Stock de carbono; Camarões; Plantas medicinais.

Resumen

Los bosques sagrados del altiplano occidental camerunés son, como otros bosques, una reserva de plantas y genes, tanto conocidos como desconocidos. Son lugares privilegiados para la comunicación con los antepasados. Proporcionan importantes beneficios medioambientales y socioeconómicos, a pesar de la presión a la que están sometidos cada vez más. El objetivo de este estudio es clasificar los diferentes usos de los bosques sagrados de Bafou, Baleveng y Bamendou y, a continuación, evaluar las reservas de carbono de las plantas leñosas de estos bosques. Se utilizó un formulario de encuesta para registrar los diversos beneficios que la población local obtiene de los bosques sagrados. Se contaron los individuos en parcelas de 30 x 100 metros. Se consideraron todos los individuos con un diámetro ≥5 cm a 1,30 m del suelo. El carbono secuestrado por los bosques se estimó utilizando el método no destructivo. El estudio demuestra que la población local viola cada vez más las leyes tradicionales que protegen estos bosques. Estos bosques son bienes culturales para el pueblo y proporcionan a la población local diversos productos. Los usos más citados son la leña, los productos alimenticios, las plantas medicinales y los sacrificios. Se han identificado un total de 54 especies, 47 géneros y 29 familias. De estas especies, alrededor del 40,35% son utilizadas de un modo u otro por la población local. Los valores de carbono secuestrado por estos bosques varían de un bosque a otro y según el tipo de ecuación elegida. El bosque sagrado de Bamendou registró el valor más elevado, 443,9 t C /ha y 287,79 t C /ha respectivamente, utilizando las ecuaciones de Djomo et al. (2010) y Fayolle (2013). Este trabajo presenta los beneficios de los bosques sagrados para las poblaciones locales. El Estado debería reforzar las estrategias de gestión de estos bosques para garantizar una conservación más sostenible de este rico patrimonio.
Palabras clave : Usos; Bosque sagrado; Reservas de carbono; Camerún; Plantas medicinales.

1. Introduction

Sacred forests constitute a reservoir of biological diversity due to the rich flora and fauna with which they abound in Africa, Asia and Latin America. Like other forests, they produce very considerable socio-economic and environmental benefits (Koutchika, 2022); for example, they help maintain climatic equilibrium, play a part in infiltrating run-off water, protect soils against erosion and improve the microclimate, thereby reducing the temperature at ground level (Ngougni, 2017; Bergonzini & Lanly, 2000). They are privileged places of communication with supernatural entities or divinised ancestors and heroes (Soumah, 2018). However, there has been widespread degradation of natural ecosystems (Rachad et al. 2014) in recent decades due to ever-increasing population growth, agriculture, logging, subdivision and debarking of woody species coupled with a change in mentality. Yet tropical forests constitute a major reservoir of plants and genes, both known and unknown, that are presumably of great value, particularly for medicinal purposes. Consequently, one of the direct effects of excessive logging is the disappearance of a large number of animal and plant species, which can be useful in pharmacopoeia and for traditional, national and international purposes (Soumah, 2018; Soury, 2007; Kempf, 2006). Conservation of these forests has hitherto been based on traditional governance (Hunyet, 2013). These forests are therefore the only places where we can still find a high diversity of flora equivalent or close to that of natural forests, and even the water sources on which villages depend in all seasons (Kokou et al. 2005). From isolated trees to more or less extensive forest formations, these cultural heritages are under increasing threat.

In Cameroon, scientists have studied these forests with interest, particularly in the Western Highlands of Cameroon. A number of studies have shown that these forests have been preserved thanks to prohibitions passed down from generation to generation (Tiokeng et al., 2007; Noumi, 2012; Noumi & Tiam, 2016). The species richness of woody plants in these forests is generally low, with densities of individuals per hectare sometimes comparable to those regularly observed in other dense forests (Tiokeng, 2024; Tiokeng, 2020). They provide significant goods and services to local populations and the environment (Tiokeng et al., 2019; Gatchou, 2023). Data on their biological diversity, ecological value and diverse uses remains fragmentary, and few

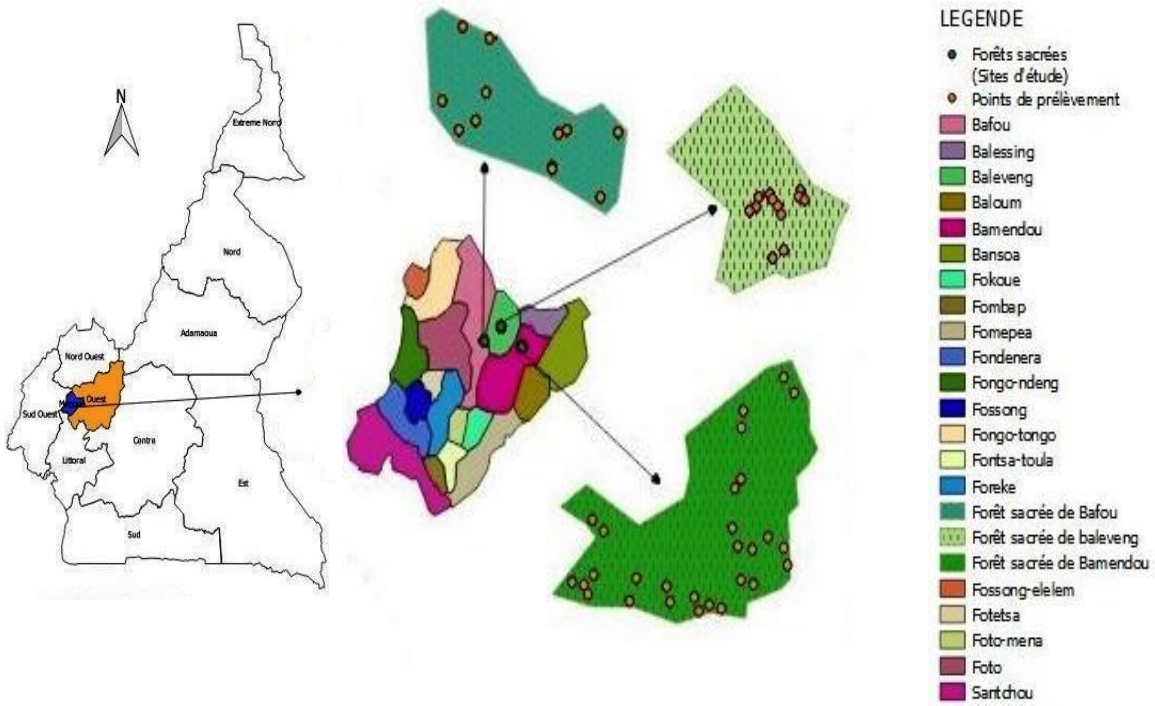
studies have been carried out to assess the amount of carbon in these forests. The aim of this study is to categorise the different uses of the sacred forests of Bafou, Baleveng and Bamendou, and then to assess the carbon stock of the woody plants in these forests.

2. Materials and Methods

2.1 Study setting

The study was carried out in the Western Highlands Cameroon, more specifically in Menoua division. This part of the country has an average altitude of 1,500 m and a surface area of 2,500 ha (1,380 km2). The forest formations that were the subject of our study are the sacred forests of Men lepeh (latitude 5°46' 827"N, longitude 10°11′ 622″ E, altitude 1510 m) Baleveng (latitude 5°49′ 497″ N, longitude 10°15′ 264″ E, altitude 1460 m) and Bamendou (latitude 5°45'793" N, longitude 10°19'846" E, altitude 1473 m). The relief is made up of alternating hills and valleys. The soil is generally brown earth derived from basic rocks. They are hydromorphic but also ferrallitic. The climate is Cameroons equatorial, with a rainy season from mid-March to mid-November and a dry season from mid-November to mid-March. Annual rainfall can reach 1872.3 mm (CVUC, 2007). The original montane forest vegetation has given way to shrub savannah. There are also forest galleries in the lowlands. Figure 1 shows the different villages in which our work takes place.

Figure 1 - Location of the sacred forests of Bafou, Baleveng and Bamendou.



Source: Authors.

2.2 Data collection and analysis

A qualitative research approach was adopted to identify the various uses. This was based on individual and group interviews, observations and analysis of documents (FES, 2016). A survey form prepared in advance was used to survey the populations of the villages concerned. Semi-structured interviews were used. The respondents were adult men and women, as well as young girls and boys. A total of 180 people aged between 15 and 80 were interviewed. The information sought was based on socio-demographic aspects, general knowledge of the forest, different uses of the forest, frequency of harvesting of products,

rites performed in the forest and indications of degradation of these forests. The people interviewed were chosen taking into account their proximity to the sacred forest (a radius of 100 to 200 m around the sacred forests) and their accessibility to the forests (Sidia & Coly, 2009).

The relative frequency of citation (FRC) was calculated. It is used to calculate the response rate for a given type of use. It is expressed by the formula used by Dossou et al. (2012), which is as follows:

RFC $=\frac{S}{N} * 100$ where S is the number of people who gave a response for a given use and N is the total number of people interviewed.

For the estimation of biomass and carbon, the census of individuals of species in each forest was carried out beforehand on transects measuring 30 m x 100 m (3000 m^2). The location of these transects was chosen randomly, but in such a way as to exploit more than half of the forest area. Within each transect, all individuals with a diameter greater than or equal to 5 cm measured at 1.30 m from the ground were taken into account. Morphological criteria such as leaf shape, trunk texture, flowers, fruit, exudate color, exudate type, presence of a characteristic odor and notch color have been used to identify specimens *in situ* using several works on tropical flora (Aubréville, 1950; Letouzey, 1982; Meunier et al., 2015).

The non-destructive method was used to estimate biomass; it is based on allometric equations already developed by other researchers in the tropical zone. The allometric equations generally take into account the wood density of each individual in addition to the diameter and/or height of the individuals. Given that the heights were not measured for the purposes of this study, the equations of Djomo et al. (2010) and Fayolle et al. (2013) were chosen in order to see which could present the highest values of biomass and carbon; they consider only the diameter, which is a parameter that can be easily measured during inventories of the various species. These equations are:

- $BA= \exp(-1{,}2665 + 1{,}3919\ln(D) + 0{,}5477\ln(D)^2 - 0{,}0725\ln(D)^3 + 0{,}3529\ln(\rho))$ (Djomo et al., 2010)
- $BA = \rho \times \exp(-1{,}183 + 1{,}940 \times \ln(D) + 0{,}239 \times \ln(D)^2 - 0{,}0285\ln(D)^3)$ (Fayolle *et al*.,2013)

BA= Above-ground biomass kg Ms/ha; ρ = specific density of wood (g/cm^3); DBH = diameter at breast height (cm).

The density of each woody species was obtained from the Reyes et al. (1992) database. For species for which the density was not available in the database, the standard density (0.58) was used.

Below-ground biomass was calculated using the following allometric equation from Cairns et al. (1997): BS = exp (-1, 0587 + 0, 8836 x ln (BA)), with BS: Below-ground biomass and BA: Above-ground biomass.

To assess the carbon stock in each of the forests, the following relationship was used:

Stock C = CF*(AGB+BGB) avec CF = Carbon Fraction (carbon ratio) with a default value of 0.47 for all species combined (IPCC, 2006).

3. Results

Surveys of interviewees showed that people in one of the following age groups [40-45[(30.55%), [15-20[(22.8%) were the most represented among those interviewed. The Table 1 shows interviewee categories by age group.

Table 1 - Categories of people interviewed by age group F: female; M: male.

Age groups (years)	Category	Bafou		Baleveng		Bamendou		Fréquence	Percentage
		M	F	M	F	M	F		(%)
[15-20[	Young	0	0	0	0	8	33	41	22,8
[20-25[	Young	0	0	0	0	0	4	4	2,22
[25-30[	Young	0	8	0	0	0	4	12	6,66
[30-35[	Young	0	4	6	0	0	0	10	5,55
[35-40[	Adult	0	4	0	6	0	0	10	5,55
[40-45[	Adult	8	10	10	10	10	7	55	30,55
[45-50[	Adult	0	0	0	0	0	4	4	2,22
[50-55[	Adult	0	3	0	0	6	0	9	5
[55-60[	Adult	0	0	6	0	0	0	6	3,33
[65-70[	Adult	0	2	0	0	0	2	4	2,22
[70-75[	Adult	10	0	10	0	5	0	25	13,9
[75-80[	Adult	0	0	2	3	0	3	8	4,44

Source: Authors.

3.1 Knowledge and conservation of sacred forests

Analysis of the results concerning people's knowledge and preservation of these forests reveals that these sacred forests are preserved by traditional rules that are prohibitions. For these sacred forests, people are forbidden to enter the chiefdom's sacred forest; except for the inhabitants of the chiefdom, initiates have access with the chief's authorization. It is also forbidden to set fire to them. Farming and hunting are not permitted in the sacred forests; but, if necessary, they can be carried out by a mandated initiate. In the case of fraudulent entries, the culprit risks attracting curses from the gods, which can lead to sterility for women. However, the traditional authorities maintain that these laws are increasingly being broken by the younger generations, despite the penalties to which they are liable.

3.2 Contribution of sacred forests to people's well-being

The forests studied offer various services to the local population.

- Socio-cultural services

Surveys of the local population revealed that the sacred groves are places for meditation, secret meetings, preservation of tradition, protection of the village and sacrifices: the sacred forest is the place where people enter into communication with the invisible world, because the gods and all the powers of the village can be found there. Secret meetings are held in these sacred forests with only notables as members. The chiefs and notables are the people's spokesmen before the gods. They implore the blessing and protection of the ancestors over the population. The sacred forest is also the place where the chief and his retinue prepare the defence of the village in the event of an attack, and the ideal place for the spiritual animals of the village's influential people to recreate.

The populations of the village go to the sacred places with goats, chickens, bags of salt, food and drink to ask the gods for their blessing or to celebrate their success. According to the inhabitants of these villages, the sacred forest is a mysterious place where all problems find a solution and each child grows up with all these ancestral beliefs and passes them on to his or her generation. According to local people, certain plants have particular mythical functions: *Solanum aculeastrum* planted near houses keeps vampires away. *Dracaena deisteliana*, commonly known as the tree of peace, is used to disperse the force of the

wind carrying evil spirits; this plant also protects concessions when planted close together. Other plants have a symbolic role: in chiefdoms, *Ceiba pentandra* represents power, and the fall of a large branch indicates the death of a prince.

- Supply services

Supply services are the most concrete and are generally in the form of goods. They include:

-Firewood: wood harvesting in the sacred forests is limited to collecting dry branches that have fallen to the ground, as cutting down trees can provoke the wrath of the gods. There are also species in these forests which are only burnt in the forest during traditional ceremonies.

-Timber: sacred forests contain species that are used for a variety of construction purposes, but their exploitation is reserved for a certain category of people given the sacred nature of the site. presided over by the women of the chiefdom who gave birth to the twins. Among the species most widely exploited for timber is *Eucalyptus saligna,* which was introduced to Africa and now forms a belt around several sacred forests. It is used for many purposes, including the construction of house frames, animal pens and fences. In addition to the above species, *Cordia platythyrsa* is also widely used for building purposes and for making kitchen utensils (ladles, pestles, mortars).

-Foodstuffs: the most sought-after foodstuffs in the forest are fruit, sweet bananas, plantains and sometimes mushrooms. In these sacred forests, the *Cola verticillata* species is considered to host edible mushrooms. The fruit is generally picked by the children of the chieftaincy and the initiates, but also by some local residents who enter the forest illegally. This is the case for the fruits of *Persea americana* and *Aframomum* sp. found in the sacred forest of Bamendou and those of *Cola verticillata*, *Canarium schweinfurthii and Pseudospondias microcarpa* found in the three sacred forests. Hunting is only carried out using traps adapted to the type of animal you want to catch. The use of firearms is strictly prohibited and is subject to very severe penalties. The animals caught are generally rats, squirrels and hedgehogs. Sweet bananas (*Musa parasidiaca*) and plantains *(Musa sapientum*) have also been recorded in the sacred forests of Bafou. Game is only hunted using traps adapted to the type of animal to be caught. The animals caught are generally *Rattus rattus* (rats), *Sciurus vulgaris* (squirrels)*and Erinaceus europaeus* (hedgehogs). In addition to food plants, there are also medicinal plants; the population benefits from the therapeutic virtues of some of these plants through traditional village healers who have the chief's permission to harvest them. Table 2 shows some of the medicinal plants mentioned by the population in these study areas.

Table 2 - Medicinal plants from sacred forests used by local people.

Villages	Scientific name	Parts used	Illness treated	Method of preparation	Method of administration
Baleveng	*Piper umberlatum*	Leaves	Typhoid fever	Decoction	Oral
	Commelina bengalensis	Leaves	Typhoid fever	Decoction	Oral
	Polyscias fulva	Young leavess	Malaria	Decoction	Oral
	Ficus thonningii	Bark and Leaves	Fractures and burns	Powder + palm kernel oil	Cutaneous
	Eucalyptus saligna	Leaves	Coughs and colds	Decoction	Oral
	Psidium guajava	Leaves	Amoebic dysentery	Maceration or mastication	Oral
Bamendou	Eremomastax speciosa	Leaves	Red buttocks in babies	Crushed leaves + palm kernel oil	Cutaneous
	Rauvolfia vomitoria	Root	Diarrhea	Decoction or maceration	Oral
	Eucalyptus saligna	Leaves	Coughs and colds	Decoction	Oral
Bafou (Men lepeh)	*Canarium schweinfurthii*	Fruits	Amoebic dysentery	Carbonised fruit + Palm kernel oil	Oral
	Basella alba	Leaves	Straightening the baby in the womb	maceration	Nasal
	Polyscias fulva	Bark	Epilepsy	maceration	Oral
	Eucalyptus saligna	Leaves	Coughs and colds	Decoction	

Source: Authors.

The most commonly used parts and methods of preparation are the leaves and decoction respectively. The oral route of administration is the one most favoured by local populations. *Polyscia fulva* is used as a medicinal plant in two of the three villages, but also treats a variety of ailments, notably typhoid fever in Baleveng and epilepsy in Bafou. *Eucalyptus saligna* helps to fight coughs and colds in all three villages.

- Regulatory services

The presence of a stream serving as a source of drinking water for the village has been reported in the sacred forest of Bafou. According to the villagers, this stream has therapeutic properties.

The relative frequency of citation varies from one sacred forest to another according to the type of use (Table 3). In Baleveng, the most frequently cited uses are medicinal plants (64%) and sacrifices (60%). In the village of Bafou, the sacred forest of Men lepeh is much more highly regarded by the population as a place of sacrifice and a source of medicines, with a relative frequency of 75% and 70% respectively. Firewood, with a relative frequency of 67.74%, and food products (61.29%) are among the most frequent uses in the sacred forest of Bamendou. Certain uses are common to all three sites: medicines and sacrifices. The populations of these three villages consider the sacred forest to be a source of medicines and an undeniable place for various rituals and sacrifices.

Table 3 - Relative frequency of citation of each use by sacred forest.

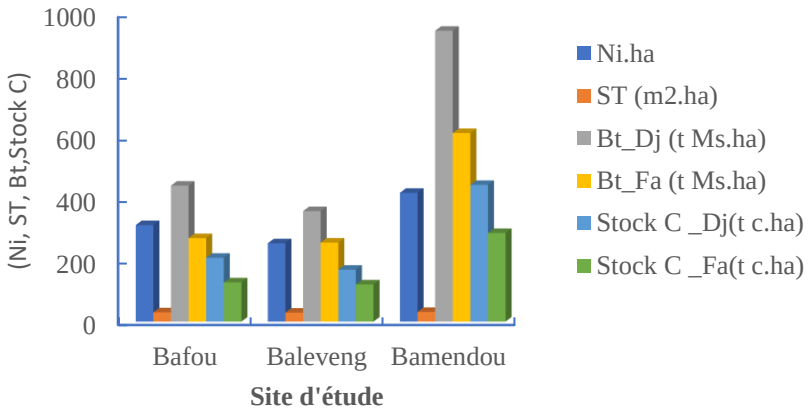
Sacred forest / **Use**	**Baleveng**		**Bafou**		**Bamendou**	
	S	RCF (%)	S	RCF(%)	S	RCF(%)
Firewood	12	48	4	20	21	67,74
Timber	4	16	3	15	3	9,68
Hunting	3	12	3	15	5	16,12
Drinking water	4	16	11	55	2	6,45
Habitat for spirit animals	8	32	3	15	/	/
Medicines	16	64	14	70	17	54,84
Food products	5	20	12	60	19	61,29
Cemetery	3	12	/	/	/	/
Place where the blessing is requested	3	12	/	/	/	/
Protecting the village	5	20	/	/	1	3,23
Preserving tradition	/	/	/	/	2	6,45
Place of remembrance	/	/	/	/	2	6,45
Place of secret meetings	/	/	/	/	2	6,45
Sacrifices	15	60	15	75	9	29,03

S: number of informants who cited the use, RCF: relative frequency of citation. Source: Authors.

A rapid view of these uses by age group shows that the age group between [40-45] has a great deal of knowledge about the various uses of the Bafou sacred forest, unlike the other age groups. The age group with the best knowledge of medicinal plants in the Baleveng sacred forest is between [40- 80[. In the Bamendou forest, people aged between [15-45] are mainly represented for uses such as firewood, hunting, medicines and food products.

As well as purifying water, these forests also purify nature by absorbing atmospheric CO_2. Inventories carried out to assess the quantities of carbon stored by these forests have identified 1,414 individuals with a diameter at breast height ≥ 5 cm, divided into 54 species, 47 genera and 29 families. In accordance with the allometric equations, the formulae of Djomo et al. (2010) and Fayolle et al. (2013) selected yielded the highest total carbon values in the sacred forests of Bamendou; 443.9 tonnes of carbon/ha and 287.79 tonnes of carbon/ha respectively. The number of individuals is 418.09 per hectare, with a basal area of 31. 24 m^2 per hectare. Figure 2 shows some structural parameters and the carbon stock recorded in the sacred forests studied. Overall, the Djomo equation showed the highest carbon stock.

Figure 2 - Number of individuals (Ni), basal area (ST), total biomass (Bt) and carbon stock (C) recorded by Djomo and Fayolle for each forest studied.



Source: Authors.

Biomass values vary from one species to another and also according to the type of equation used. The Table 4 shows the ten species with the highest biomass in each forest. The Djomo and Fayolle equations gave the highest biomass for the species *Strombosia grandifolia* (148.03 t Ms.ha and 98.91 t Ms.ha respectively) in the Bafou forest, *Pseudospondias microcarpa* in Baleveng (133.3 t Ms.ha and 129.13 t Ms.ha respectively) and *Cola verticillata* in the Bamendou sacred forest (120.11 t Ms.ha and 105.4 t Ms.ha respectively). The families that have accumulated the most biomass is the Olacaceae, Anacardiaceae, Malvaceae and Moraceae.

Table 4 - Total biomass of 10 species with values ≥1 in the three sacred forests.

	Bafou		**Baleveng**		**Bamendou**	
Espèces	B_Dj (t Ms.ha)	B_Fa (t Ms.ha)	B_Dj (t Ms.ha)	B_Fa (t Ms.ha)	B_Dj (t Ms.ha)	B_Fa (t Ms.ha)
Strombosia grandifolia	148,03	98,91	/ /		/ /	
Pseudospondia sp.	69,25	49,93	/ /		120,11	105,4
Aleurites cf moluccana	38,26	12,91	32,56	15,64		
Cola verticillata	37,33	24,19	/ /		125,41	87,73
Schefflera barteri	32,5	21,08	/ /		65,31	47,33
Canarium schweinfurthii	25,04	16,54	/ /		64,03	34,85
Shirakiopsis ellipticum	23,37	13,93	/ /		/ /	
Eucalyptus saligna	19,14	10,74	/ /		/ /	
Cordia platythyrsa	16,01	6,82	/ /		41,73	18,08
Monodora myristica	7,61	4,2	/ /		/ /	
Ficus exasperata	/ /		60,11	34,72	/ /	
Celtis gomphophylla	/ /		33,74	21,5	101,12	59,47
Maranthes chrysophylla	/ /		25,46	15,57	/ /	
Ficus sp	/ /		23,88	12,64	/ /	
Trichilia sp	/ /		17,63	9,64	/ /	
Pauridiantha floribunda	/ /		7,71	4,47	/ /	
Ficus lutea	/ /		7,3	2,83	/ /	
Ficus thonningii	/ /		3,44	1,29	/ /	
Pterygota sp	/ /		/ /		49,81	72,05
Bersama abyssinica	/ /		/ /		46,41	25,8
Ceiba pentandra	/ /		/ /		45,44	19,17
Ficus exasperata	/ /		/ /		41,77	16,59
Pseudospondias microcarpa	/ /		133,3	129,13		

B_Dj: Biomass Djomo, B_DFa: Biomass Fayolle. Source: Authors.

Sacred forest degradation index

The results of the surveys show that the area of these forests is being increasingly reduced by the local population, as in the case of Bamendou, in favour of arable land, or involuntarily, as in Baleveng, due to numerous succession problems; to this effect, reforestation initiatives of degraded areas with forest species such as *Baillonella toxisperma*, *Entandrophragma candollei*, *Nauclea diderrichii* and *Eucaluptus saligna* are already underway in the sacred forests of Baleveng and Bamendou with the aim of improving local management of these sacred forests.

Regarding the influence of ritual activities on vegetation, it was pointed out that there is no ritual that requires the felling of trees. However, certain parts of plants such as leaves, bark or herbaceous plants may be used in certain ritual ceremonies. This is also sometimes the case for dry wood, which can be collected and burnt in the forest during rituals. The people interviewed said that they were aware of the importance of sacred forests in their lives and for the village as a whole, as it is the place where they find the gods of their ancestors who are able to provide solutions to the various problems they face. However, the majority believe that, in addition to the village chief, a government official could help to better preserve the forest in order to reduce the growing anthropic pressure that is increasingly threatening this cultural heritage.

4. Discussions

The socio-demographic information showed a response rate of 30.55% for the 40-45 age group, the highest of all respondents. This may be due to the availability of this segment of the population during the interviews. After these adults comes the category of young people aged between 15 and 20. In addition, the reluctance of some villagers to answer questionnaires, which was noted here and there during the surveys, could explain the low rate observed in the other age groups. These people think that activities or information relating to sacred forests are "sacred" and should be treated with great discretion because they are part of the village's cultural heritage. The results also confirmed at socio-cultural level that these places are protected from generation to generation by traditional laws based on a certain number of prohibitions coupled with penalties in the event of violation of these laws; this would testify to the importance of the local knowledge of the populations in the preservation of biodiversity. These results have been recorded by other researchers in Africa and Asia (Kokou & Sopkon, 2006; Hounto et al., 2016; Fodé, 2018; Tiokeng et al., 2019; Uday, 2019; Gatchou, 2023).

This study revealed several uses of sacred forests by local people, depending on the value that society places on them. They are habitats for totem poles, places of meditation, secret meetings, conservation of tradition, protection of the village and sacrifices, and customary courts. Certain plant species, taken individually, have roles that are not only mythical but also symbolic. All these social interests provided by sacred places could justify the high level of attachment of populations to their culture and to the value of trees in nature. These different roles of the tree have been demonstrated in other sacred forests and sacred groves in general (Soury, 2007; Keshav, 2019, Atakpama et al., 2022;) and in other sacred forests in Cameroon in particular (Gautier,1994; Salpeteur, 2010; Amadoudji, 2021; Tiokeng et al, 2019).

In the case of medicinal plants, the leaves are the most frequently used parts of the plant for treatment; this choice may be explained by the ease and speed with which they can be harvested, but also by the fact that they are the site of photosynthesis and sometimes of the storage of secondary metabolites responsible for the plant's biological properties. These comments have also been made by other researchers (Bigendako-Polygenis & Lejoly, 1990; Souad, 2010). The most common method of preparation is decoction. This method allows the active ingredients to be extracted and reduces or eliminates the toxic effect of certain recipes (Souad, 2010). Palm kernel oil is widely used by local populations; this could be justified by the presence of lauric acid, which has excellent antimicrobial and antiviral properties (Mboui, 2003). Some of the plants mentioned by local people are used to treat respiratory, dermatological and digestive diseases. However, it has been noted that certain increasingly common illnesses such as diabetes, high blood pressure, cancer and even sterility are absent from the list of plants mentioned by

these populations. It may be that people do not have sufficient knowledge about these diseases and are sometimes unaware of the symptoms of these conditions, which could also be rife in their locality. This could also indicate that rural populations are not very exposed to these diseases (Tiokeng, 2019).

The frequencies of quotation showed the highest proportions according to the different uses per village. Medicinal plants and sacrifices were cited the most in the sacred forest of Baleveng and Bafou, which would mean that the plants present in these forests are well known to the people, as are the daily ritual activities.

With regard to the carbon recorded in the sacred forests studied, the highest values (443.9 t C/ha) are those obtained in the Bamendou forests from the equations of Djomo et al. (2010), in contrast to the values from the equation of Fayolle et al. (2013), which are 287.79 t C/ha.

These differences would indicate the difficulty in choosing the type of equation for assessing carbon stock using the non-destructive approach. In general, the Djomo et al. (2010) equation produced the highest carbon values in all three forests. This equation was established from 71 trees belonging to 32 species, with a diameter range of 1.3-79.4 cm, whereas that of Fayolle et al. (2013) was established from 138 trees belonging to 47 plant species, with a diameter range of 5.30-192.50 cm. The characteristics of these equations suggest that the density of the individuals and the size of the diameter would have a significant influence on the value of the carbon sequestered by the plants. The results of this work are close to those obtained by Tiokeng et al.,2024 which are 286.89 t C/ha and 215.67 t C/ha respectively in the sacred forests of Balengou and Bangangté; then the sacred forests of Baloum and Bansoa with 286.84 t C/ha and 232.44 t C/ha respectively (Tiokeng et al., 2023). They are higher than those found by Fréderic et al. (2018) in the sacred forests of Batoufam (128 t C/ha) and those of Tsalefack et al. (2016) in the Baleng forest reserve (West Cameroon) (120 t C/ha). All these differences could be justified by the type of equation chosen, but also by the density and diameter of the individuals of the species surveyed.

5. Conclusion

This study reveals that the sacred forests of the West Cameroon Highlands, over and above their involvement in the conservation of biological diversity, are part of the daily life of the village, as they are the site of secret meetings and various ritual ceremonies. They house the gods who are worshipped and respected by the entire village. They are a symbol of identity and religion in this part of the country. The sacred forests of West Cameroon provide basic necessities for a whole section of the population, who depend on them to varying degrees. These forests provide firewood, medicinal plants and foodstuffs, not forgetting the water sources that sometimes supply the whole village. These forests also modulate the climate by absorbing some of the CO2 released into nature by human activities. However, these sacred forests, long protected by the villagers, are under increasing threat from the invasion of exotic plants, the conquest of agricultural land, the proliferation of new religions and the erosion of traditional values. It would be necessary for the state to join forces with the traditional authorities in order to consolidate endogenous conservation strategies, the effectiveness of which seems to have diminished nowadays with the change in mentalities. The degraded areas of these forests should be restored using mainly endogenous plant species in order to preserve the ancient flora for future generations. In the future, chemical screening could be carried out on the medicinal species mentioned, with the aim of scientifically confirming the information gathered from populations concerning the efficacy of their extracts on pathogenic germs, as well as detecting the active principles of medicinal plants and toxic ions.

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