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BIOPHYSICAL ASSESSMENT OF RATTAN IN CAMEROON




INBAR
INTERNATIONAL BAMBOO AND RATTAN ORGANISATION

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International Bamboo and Rattan Organisation

INBAR, the International Bamboo and Rattan Organisation, is an intergovernmental organisation bringing together some 44 countries for the promotion of the ecosystem benefits and values of bamboo and rattan.

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Executive summary

The humid tropical forest of Cameroon is part of the Central African forests and is known as the second most important pool of biological diversity in the world. Within this rich biodiversity, Rattan palms (Arecaceae) are important components of the primary and secondary forest vegetation, because they play an important role in the physiognomy, structure and functions of these forests. In Cameroon, rattan is also used for important economic activities at both the rural and urban levels. However, rattan, especially the commercial species, has become depleted or threatened due to overexploitation through unsustainable harvesting methods, and its habitats have been lost due to land conversion. Despite their economic and ecological importance, very few quantitative studies have been carried out on the ecological distribution of rattan species, abundance and stocks.

The purpose of this study is to provide robust data of rattan resources in Cameroon, enabling the development of appropriate policy and strategy for rattan development and management in Cameroon.

The specific objectives are threefold:

- To understand current rattan distribution and stocks;
- To assess current rattan status and management practice;
- To provide recommendations for sustainable rattan management in Cameroon.

To achieve these objectives, we first used participatory rattan mapping to target the five representative areas for biophysical assessment. These representative areas cover six forest types: Atlantic evergreen forests (southwestern); littoral forests and transition forests (southern region); submontane forests (northwest region); semi-deciduous forests (centre region); and secondary forests (eastern region). A total of 23 transects of 5 m x 200 m were established for the assessment of rattan in these various forest types. Within each transect, each cluster was numbered as a single individual, and each stem within the cluster measured was numbered separately. The diameter of each stem and estimated length were recorded.

Of the 19 known rattan species in Cameroon, we recorded 15 species in this study, belonging to four genera, with a total of 2888 stems. Amongst them are some popular species such as *Calamus deërratus, Laccosperma secundiflorum, L. robustum, Eremospatha macrocarpa*, and *E. wendlandianna*, which are used for commercial purposes.

In the general inventory, the two most abundant species in terms of number of stems were *Eremospatha macrocarpa* (42 per cent) and *E. laurentii* (18 per cent).

There was a considerable regional variation in species composition among the forest type. Only a few species with high commercial value were widely distributed in four forest types: *Eremospatha macrocarpa* and *Laccosperma robustum*. Three of these six forest types showed a very strong dissimilarity in terms of floristic composition: submontane forests, secondary forests and Biafran Atlantic forests. These forests had restricted species or shared only one or two species with the other ones. The affinities between the rattan floras are closer between transition forests and littoral forests that shared five species: *Eremospatha haullevilleana, E. laurentii, E. macrocarpa, Laccosperma opacum* and *L. robustum*.

The number of species per transect varied from 1–6, with a mean of 3 ± species. The most diverse vegetation types were transition forests (Shannon diversity index, H' = 0.93) and littoral forests (H = 0.99), while the least diverse forest types were submontane forests (H' = 0).

The mean density of stems was 1260 ± 952 stems/ha (range 250–3620 stems/ha). The stem density of rattan was lowest in submontane and secondary forests (mean of 340–550 stems/ha), while the highest stem density were found in transition forests (mean = 2070 stems/ha) and littoral forests (mean = 1620 stems/ha), represented by 39 per cent and 34 per cent of the total stems respectively. All species are clustered. The density of clumps varied from 20–230/ha.

The stem volume per ha in each transect ranged from 0.04–28.4 m^3. The volumes in submontane forest transects were low (0.04 m^3) relative to the stem density as compared to those in the transition and littoral forests (mean = 20.1 m^3).

High annual rainfall and atmospheric humidity owing to the proximity of the ocean, low intensity of harvest and permanence of a forest cover during past geological times probably all contribute to explaining the high rattan diversity and density of the Atlantic forests.

Concerning traditional practice management in Cameroon, the tendency is that of free access system. So, the five commercial rattan species mentioned above are harvested from natural forests including forest reserves and community forests, without any consideration for efforts at implementation of rational management. The current exploitation of rattan is unsustainable. Indeed, there is unselective harvesting of both the mature and immature stems, and a considerable part of the mature stems (30–60 per cent) is often left entangled in the forest canopy and abandoned, leading to wastage and reducing productivity. The present intensity of harvest is exceeding that of regeneration and growth.

The number of bundles harvested per month varies from 4–30 per person, depending on the intensity of the activity. Each bundle consists of an average of 10–15 stems for big canes (a range of 3–5 m each), and an average of 3 stems for small cane (a range of 70–80 m each. The estimated annual amount collected is 27,000 m for big canes and 79,560 m for small canes.

In the localities of significant extraction of commercial rattan canes, physical accessibility to the resource has become increasingly difficult due to long distances and the scarcity of rattans. This scarcity of resources is linked to the extension of agricultural clearing and the shortening of the fallow period, contributing to the reduction in availability of the rattan resource and affecting the dynamics of rattan stands.

In order to develop an efficient strategy for the sustainable development and management of rattan stands, some recommendations were formulated and focus on three main aspects:

- Planning conservation and protection of rattan production basins;
- Development of sustainable harvesting practices;
- Development and implementation of a programme on the domestication and planting of rattan.

1. Introduction

Cameroon is located in Central Africa and extends between latitude 2° and 13° north and longitude 8° and 16° east. Cameroon has a great diversity of climates, landscapes and ecosystems. From north to south, two large floristic groups are observed: the dry tropical forest (Sudanian and Sahelian savannas) and the humid tropical forest (humid forests, Figures 1 and 2). Forest covers 21.2 million ha, and represents 45 per cent of the national territory (FRA 2010). The forests are known for their high biological richness and endemism as well as for fauna and flora. These forests are part of the Central African forests known as the second most important pool of biological diversity in the world (Mittermeier et al. 2003). Within this rich biodiversity, Rattan palms (Arecaceae) are important components of the primary and secondary forest vegetation because they play an important role in the physiognomy, structure and functions of these forests (Sunderland 2004; Sunderland and Dransfield 2002).

Rattans are spiny climbing palms belonging to the large subfamily Calamoideae and to Arecaceae (Palmae) family. There are around 600 species of rattan with 9 genera, solely concentrated in the tropics (Dransfield and Manokaran 1993; Baker 2015; Henderson and Floda 2015). In Africa, the greatest diversity of rattan species are found in the forests of Central Africa, and 19 of the 22 African rattan species that exist are known to occur in Cameroon alone (Sunderland 2001, 2007, 2012). According to the Cameroon Forest Law of 20 January 1994, rattan is one of the most important non-timber forest products (NTFPs) in Cameroon and it is classified as 'special products' (Sunderland 1999; Defo 1999).

Because of its strength, flexibility and uniformity, the stems of rattan are subjected to various uses (furniture, baskets, lampshades, bow strings, fish traps, birdcages, etc.) by rural and urban populations (FAO 2010). Rattan is also part of the 150 most important NTFPs in terms of international trade (Sastry 2001). The position of rattan on the world market is expanding, due to the increasing demand for environmentally-friendly products in Europe and the United States. The world's rattan sector is estimated to generate a global revenue of USD 10 billion annually (INBAR 2015). Rattans contribute significantly to the economies of forest-based communities throughout their range. The harvest, consumption and sale of rattan and rattan products is an integral part of livelihood strategies for many rural communities and provides an opportunity for many forest dwellers to enter the cash economy (Dransfield and Manokaran 1994; Sunderland et al. 2002; Malleson et al. 2005). In Cameroon, rattan is also used for important economic activities at both the rural and urban levels. However, rattan is currently entirely harvested from the different forests in Cameroon (Sunderland 2001; Defo 2005). Rattan has, therefore, become depleted or threatened due to overexploitation through unsustainable harvesting methods in the past decades, and their habitats have been lost due to land conversion (Sunderland and Dransfield 2002). In addition to these ecological threats, the rattan industry that depends on local communities is also threatened (Sastry 2002). Therefore, there is a need for the conservation and sustainable management of rattan populations in the rain forests of Cameroon.

Aware of these challenges, Cameroon is engaged in the sustainable management and development of these natural resources, by ratifying many international agreements (the Covention on Biodiversity, etc.). Concerning rattan specifically, this desire to develop the sector locally has been materialised by the country joining INBAR. This commitment is also part of the achievement of the Sustainable Development Goals (SDGs), especially Goal 8 (Decent work and economic growth), Goal 13 (Climate change) and Goal 15 (Sustainable management of forests ecosystems. Further, this endeavor is in line with the priority axis (ii) of the Convergence Plan of the Central Africa Forests Commission (COMIFAC) from 2015–2025 entitled 'Management and sustainable development of forest resources'. At the national level, in addition to the Forestry law 1994, Cameroon has adopted a national plan for development of NTFPs, which aims to develop channels of NTFPs, including rattan, in order to maximise their contribution to the national economy.

The implementation of the above-mentioned initiatives is hampered by the lack of information on NTFPs in general and on rattan in particular. Management plans are often based on available but incomplete information on the resource. Thus, a rattan inventory is a way of evaluating the status of rattan resources in the forest. It is an important step towards proper planning in the management of depleting resources.

Although rattan palms are of high importance both ecologically and economically in Cameroon, very few quantitative studies have been carried out on the ecological distribution of rattan species in this country (but see Nzooh 2004; Sunderland 2001). Moreover, these studies are only focused in two regions (south and southwest).Therefore, little is known about the volume, stocks, abundance and distribution of rattan species and their stands in Cameroon as compared to southeast Asian countries. Therefore, data are still far from being complete on rattan in Cameroon. These data will allow for the development of efficient conservation and valorisation strategies for rattan resources.

The purpose of this study was to provide robust data on rattan resources in Cameroon, enabling the development of appropriate policy and strategy for rattan development and management in Cameroon.

Specific objectives:

- To understand current rattan distribution and stocks;
- To assess current rattan status and management practice;
- To provide recommendations for sustainable rattan management in Cameroon.

2. Methods

2.1. Study sites

In order to cover various ecosystems in which rattans are potentially present, five representative regions of Cameroon were selected for the study: the centre, south, northwest, east, and southwest regions (Figures 1 and 2). With regards to phytogeography of Cameroon (Letouzey 1985), these regions cover: the Atlantic evergreen forests (southwestern), the littoral forests and transition forests (southern region), the submontane forests (northwest region), the semi-deciduous forests (centre region) and the secondary forests (eastern region) (Figure 1). Within each region, 1–2 localities were selected for the biophysical assessment of rattan (Figure 2). The southern part of the eastern region cannot be assessed due to time and budget constraints.

2.1.1. Centre Region: Lobo area

Lobo is located in the centre region, 45 km from Yaoundé, the capital of Cameroon. The centre region covers an area of approximately 68,926 km^2 and contains almost 3,000,000 inhabitants (BUCREP 2010). This region is characterised by gentle rolling chains of hills, and numerous valleys. The soils are mostly ferralitic, acidic, red or yellow. It has an equatorial climate with an average annual rainfall of 1600 mm distributed in two rainy seasons (March to June, September to November). The average annual temperature is approximately 23 °C and the average humidity is 80 per cent. The vegetation is characterised by semi-deciduous forests with Sterculiaceae and Ulmaceae (Letouzey 1985).

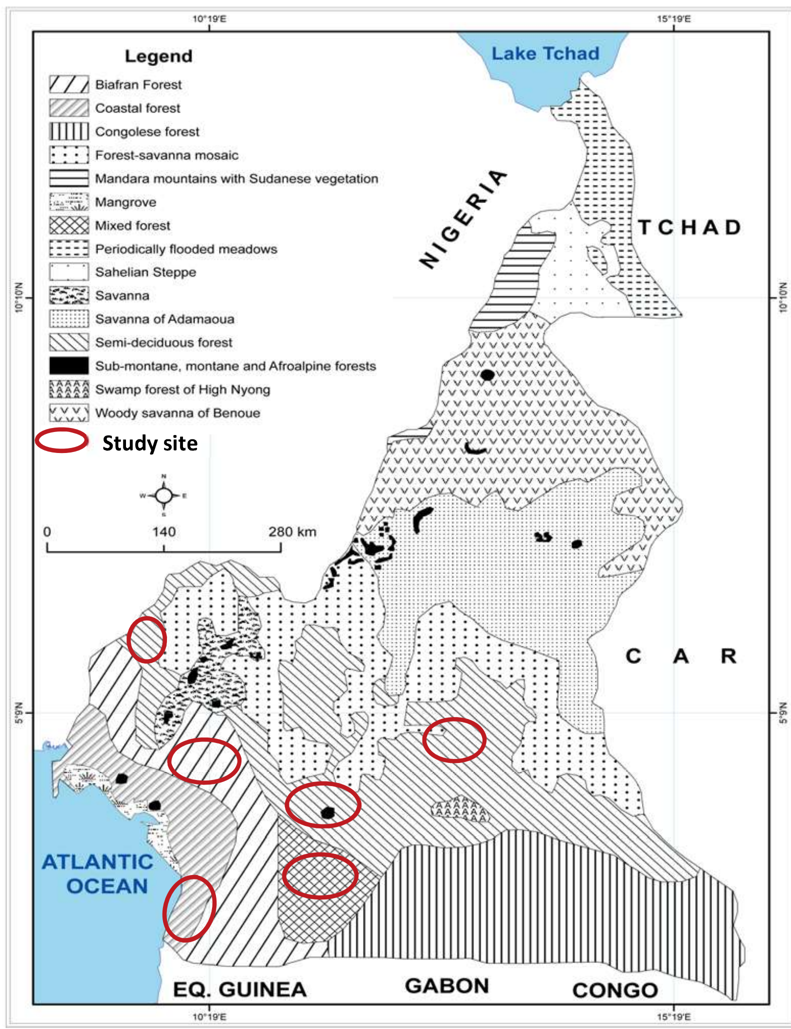

Figure 1. Phytogeographic map of Cameroon with the location of study sites (adapted from Letouzey 1985).

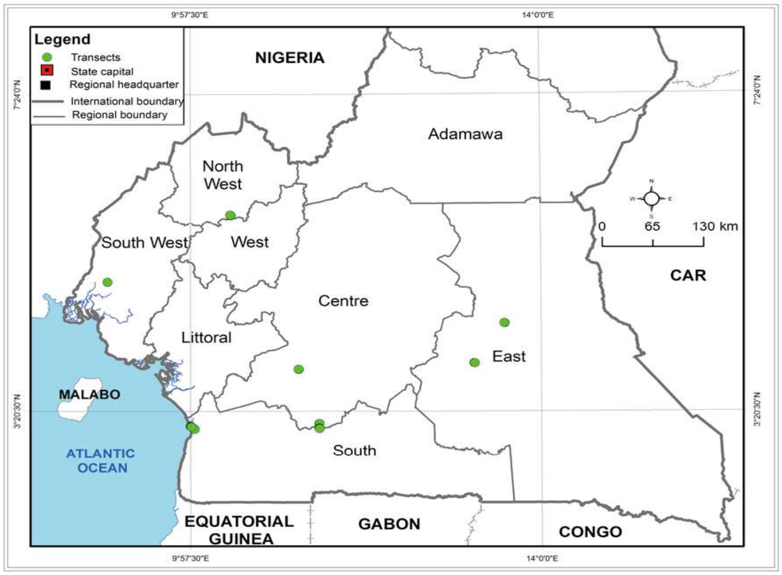

Figure 2. Location of study transects of 20 x 200 m in Cameroon.

2.1.2. East region: Nlong timbi and Ouboul 2 study sites

Nlong Timbi and Oboul 2 study sites belong to the Eastern Region. Nlong timbi is located 5 km from Bertoua, and Oboul 2 is located 15 km from Abong Mbang. The eastern region covers about 109,000 km². The climate of the region is subtropical with four seasons, two rainy seasons (mid-August to mid-November, April to June) and two dry seasons (mid-November to March, July to mid-August). The average annual rainfall varies between 1600 mm and 2000 mm. The average temperature varies between 18 °C and 30 °C with high atmospheric humidity (70–80 per cent) throughout the year. The soils are ferralitic and red clay lateritic.

Three large areas of vegetation are distinguished in this region: the forest zone, the forest-savanna transition zone and the savannah zone (Letouzey 1985). The vegetation of the two study sites is dominated by a semi-deciduous dense forest rich in economically important species such as Moabi, Iroko, Sapelli and Ayous. Swamp forests are also present in the area.

The Eastern region had about 794,963 inhabitants in 2010. It represents 4.1 per cent of the total population of the country, making this region the second-least populated. Economic activities revolve mainly around agriculture, logging, livestock farming and mining.

2.1.3. Northwest region: Bafanji

Bafanji is located in the northwest region. This region, which covers an area of approximately 17,409 km², is characterised by plains, highlands and mountains. The climate is humid-tropical with a relatively long rainy season (mid-March to mid-November) and a dry season that runs from mid-November to mid-March. The temperature varies between 19–26 °C. The soils of the northwest region are volcanic soils and therefore very fertile. Vegetation consists mainly of submontane forests, peri-forest savannas and some forest islands (Letouzey 1985).

The population of the Northwest region was about 1,728,953 in January 2010. Its density is estimated at 100 inhabitants/km². The main resources of the region come from agriculture, livestock and small trade. The craft industry is also an important economic activity for the region.

2.1.4. Southwest region: Manyemen

Manyemen is located in the southwest region. The southwest region has an area of 25,410 km^2, which represents about 5.43 per cent of the entire territory. The climate of the region is subtropical with two distinct dry and rainy seasons (mid-March to the end of October). However, there is hardly any month completely devoid of rainfall. Annual rainfall ranges from 3498 to 4739 mm with a mean of 4083 ± 487 mm. The average relative humidity is 80–90 per cent. The average annual temperature of the region is 26.3 °C. The relief of the region is quite varied with plains, plateaus and small mountains that culminate at 1700 m (Nta Ali, Banyang Mbo). The soils consist of granites and metamorphic rocks. The vegetation consists mainly of low and mid-altitude of Atlantic Biafran forests and submontane forests (Letouzey 1985).

The main economic activity carried out in the area is agriculture. Other activities include exploitation of timber and NTFPs, fishing, hunting and craftsmanship.

2.1.5. South region

Costal study sites: Mangogo and Bipaga

Mangogo and Bipaga are located at 30 km from Kribi, near the Atlantic Ocean coast in the south region. The area has a typical equatorial climate with two distinct dry seasons (November to March and July to mid-August) and two wet seasons (April to June and mid-August to October; Waterloo et al. 2000). The average annual rainfall is 2950 mm/year. The average annual temperature is about 25 °C (Olivry 1986). Topography is relatively plane and uniform. Altitude varies from 0 to 20 m above sea level. Following the FAO classification system, soils are generally classified as Xanthic Ferrasols (Waterloo et al. 2000). Evergreen littoral forests and Atlantic Biafrian type rich in Leguminosae–Caesalpinioideae largely cover the area (Letouzey 1985). The local people are very poor and so far rely solely on the forest resources to meet their basic needs. As a result, local pressure on the Kribi rainforest is increasing and there are several activities that are carried out in the area with varying ecological impacts on the forest ecosystem. These activities include agriculture, logging, poaching and hunting.

Inland study sites: Mbanga-Nkolmekok and Ebenbalot

The area has an equatorial climate with four seasons (two rainy seasons and two dry seasons). The average annual rainfall ranges between 1500 and 2000 mm. The average annual temperature is 24 °C. The relief is characterised by a juxtaposition of small hills. The average altitude is between 600 and 700 m. The dominant soil is ferralitic red or yellow, acidic and strongly desaturated. The vegetation is dominated by transition (mixed) forests, characterised by the simultaneous presence of semi-deciduous forest elements and those of evergreen forests (Letouzey 1985).

Agriculture is the main activity there. Hunting and harvest of NFTPs are other activities found in this area. Craft activity is poorly represented.

2.2. Participatory rattan mapping

The main areas of rattan production have been identified following investigations carried out with the craftsmen on the different supply zones of the canes of raw rattan and through a literature review.

In order to target representative areas (based on rattan abundance and rattan diversity) for biophysical assessment, we used participatory rattan mapping. We developed a questionnaire and used the focus group methods with collectors in the villages selected, to collect data on various aspects related to the ecological environment of rattan species (availability of the resource and diversity, accessibility of the resource, location of rattan activity areas, etc.). Based on existing database of the Institute of Agricultural Research and Development and other sources on rattan (maps, surveys, etc.), we mapped rattan locations in Cameroon, using GIS (ArcGIS).

Finally, by using a stratified sampling protocol, we identified and selected the representative areas for biophysical assessment from the map. This selection was based on rattan abundance, diversity, accessibility, forest type, time and funds available.

A total of 23 transects of 5 m x 200 m were established for the assessment of rattan in the five targeted regions after the participatory rattan mapping (Figures 2 and 3). About 2–5 transects inventories per study site were established. The sample study sites cover various types of forests as mentioned above (Table 1).

Table 1. Number of transects per locality and their forest type

Region	Cluster town	Locality (village)	Nb of transects	Forest type (Letouzey 1985)
Centre	Yaoundé	Lobo	3	Semi-deciduous forests
South	Kribi	Mangogo	4	Littoral forests
		Bafaga	2	Littoral forests
	Ebolowa	Mbanga-Nkolmekok	3	Transition forests
		Benebalot	2	Transition forests
East	Bertoua	Nlong timbi	2	Secondary forests
	Abong-Mbang	Oboul 2	2	Secondary forests
Southwest	Kumba/Mamfe	Mayenmen	2	Atlantic forests
Northwest	Ndop	Bafanjii	3	Submontane forests
Total		**9**	**23**	

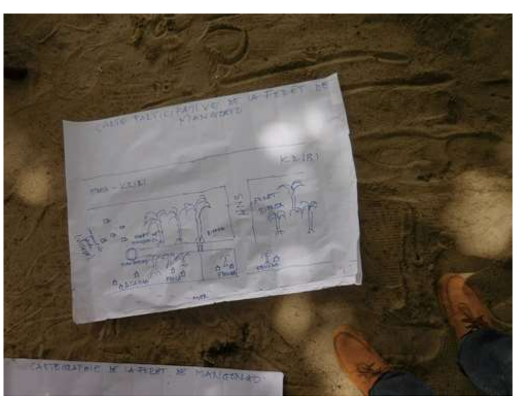

Photo 1. Participatory rattan mapping in Mangongo village.

Photo 2. Participatory rattan mapping in Mbanga-Nkolmekok village.

2.3. Data collection

A series of transects of 5 m x 200 m (0.1 ha) were established through all rattan locations identified during participatory mapping. Within each transect, each cluster (ramet) was numbered as a single individual, and each stem (genet) within the cluster measured was numbered separately. The diameter of each stem was recorded. For both ramets and genets, the species and size (height class of seedling or length of stem) was recorded. Estimating the length with a ruler as a hypsometer after pulling down the stem is significantly more accurate than estimation by eye, clinometer or internode counts (Stockdale and Power 1994). However, since rattan pulling is difficult, often destructive, money and time consuming, the total stem length of mature individuals was estimated visually and by using literature (Stockdale and Power 1994; Sunderland 2001). GPS coordinates of each transect and each cluster were recorded, GPS coordinates at the beginning and the end of each transect were also recorded and the orientation of each transect was recorded.

To provide an overview of the vegetation for each site, a qualitative vegetation description was made (the most dominant and abundant tree species, canopy height, canopy cover, topography, presence of river, etc.). Voucher specimens were collected for tree species that could not be identified with confidence in the field, and identified at the National Herbarium of Cameroon.

2.4. Data analysis

2.4.1. Density and diversity

Relative abundance = (number of trees of the species/total number of trees) x 100.

We used α diversity index to describe diversity patterns across the study plots. We assessed diversity with Shannon diversity index, which is widely used and thus facilitates comparison.

The Shannon diversity index (H'; Magurran 2004) is:

$$H' = -\sum_{i=1}^{s} \text{ni/N} * \ln(\text{ni/N})$$

Where n_i = number of individuals of a given species i and N = total number of individuals.

2.4.2. Estimated volume and stocks

The stem volume was calculated from the diameter and the estimated stem length by using this formula:

$$V = R^2 \times L \times \pi$$

where V is Volume, R is radius and H is length.

Rattan stock = volume x estimated rattan area

2.4.3. Floristic similarity

The hierarchical ascending classification (HAC) is a descriptive analysis, which allows the visualisation of the groupings of transects, according to their distances or floristic dissimilarities, illustrated by a dendrogram. Sorensen similarity index (1948) was calculated to compare the similarities of rattan species composition, between habitat types or transects. This index ranged between 0 and 1, where 0 meant the two sites were most dissimilar, and 1 meant the two sites were most similar.

2.4.4. Conservation status

A taxonomic search for potential taxa of high conservation value, such as those endemic to Cameroon and other rare and threatened species was conducted using literature (Sunderland 2012; Cosiaux et al. 2018), supplemented by the IUCN (2018) red list.

The Vegan package of R software for Windows™ was used for statistical analysis (Oksanen et al. 2010).

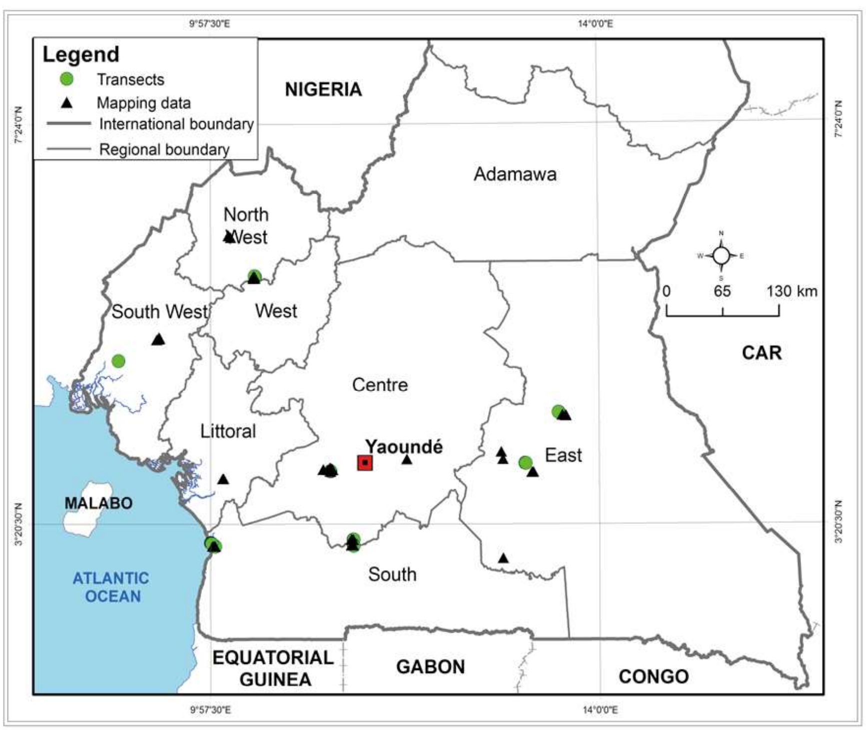

Figure 3. Location of transects and rattan stands mapping.


Photo 3. The team in the field during rattan inventory.


Photo 4. Collection of botanical specimen for identification at the National Herbarium.

Photo 5. *Laccosperma robustum* with its infrutescences.

Photo 6. Rattan stands threatened by agriculture.

3. Results

3.1. Overview on tree floristic composition of different forest types

The 23 transects were established in six forest types: semi-deciduous forests, secondary forests, submontane forests, littoral forests, transition forests and atlantic forests. Each of these forests are characterised by the most dominant species in Table 2.

Table 2. Most dominant species of the six forest types censused

Region	Forest type	Alt (m)	Most dominant tree species
Centre	Semi-deciduous forest	660–670	*Piptadeniastrum africanum, Afzelia bipindensis, Desbordesia glaucescens, Celtis zenkeiri, Raphia farinifera, Sterculia rhinopetala, Musanga cecropioides, Nauclea diderrichii, Pynanthus angolensis*
East	Secondary forests	650–700	*Astonia boonei, Musanga cecropioides, Piptadeniastrum africanum, Funtumia elastica, Sterculia rhinopetala, Entandrophragma cylindricum, Ceiba pentadra, Petersianthus macrocarpus, Entandrophragma candollei, Pterocarpus soyauxii, Raphia farinifera*
Northwest	Submontane forests	993–1670	*Raphia farinifera, Ficus sp. Vitex sp. Arungana madagascariensis*
South	Littoral forests	1–25	*Raphia farinifera, Ceiba pentandra, Pterocarpus soyauxii, Uapaca sp., Pycnanthus angolensis, Afzelia bipendensis, Lophira alata*
	Transition forests	660–720	*Sterculia rhinopetala, Antrocaryon klaineanum, Alstonia boonei, Terminalia superba, Musanga cecropioides, Petersianthus macrocarpus, Celtis tessmannii, C. zenkeri, Piptadeniostrum africanum,*
Southwest	Atlantic forests	370	*Lophira alata, Pynanthus angolensis, Distemonanthus benthamianus, Alstonia boonei Piptadeniostrum africanum, Perocarpus soyauxii, Petersianthus macrocarpus*

3.2. Rattan species composition and distribution

The 23 transects established contained a total of 2888 stems, belonging to 15 rattan species and four genera (Table 3). Amongst them are some popular species such as *Calamus deërratus*, *Laccosperma secundiflorum*, *L. robustum*, *Eremospatha macrocarpa*, and *E. wendlandianna*, which are used for commercial purposes. In addition to these 15 species, there are four other species present in Cameroon that were not recorded during this study (Table 3).

In the general inventory, the two most abundant species in terms of number of stems were *Eremospatha macrocarpa* (42 per cent) and *E. laurentii* (18 per cent; mainly in Mbanga and Benebalot, southern region with transition forests), while the least abundant species were *Calamus deërratus* (1.7 per cent), *Laccosperma opacum* (1.6 per cent), *L. laeve* (1.2 per cent) and *Oncocalamus mannii* (0.7 per cent; Table 5). The most diverse genera were *Eremospatha* (seven species) and *Laccosperma* (five species).

There was considerable regional variation in species composition among the forest types. Most species occurred in one or two forest types, and only a few species with high commercial value were widely distributed in four forest types: *Eremospatha macrocarpa* and *Laccosperma robustum*. *Eremospatha tessmanniana* was only found in submontane forests.

The rattan species classification of the different sites studied allows the distinguishing of six main groups (Figure 5) which are:

- A group formed by the submontane forests (BAF1 & 2) of the northwest region;
- A group formed by the five transitional forests (BENE 1 & 2, MBANGA 1-3) of the southern inland region;
- A group of semi-deciduous forests (EKOUMTIK 1-3) in the central region;
- A group of littoral forests (BIPAGA 1-2, MANGO 1-4) in the southern coastal region;
- A group formed by the Biafran Atlantic forests (MANYE 1-2) of the Ssouthwest region;
- A group formed by the secondary forests (OUBOUL 1-2, NLONG 1-2) of the eastern region.

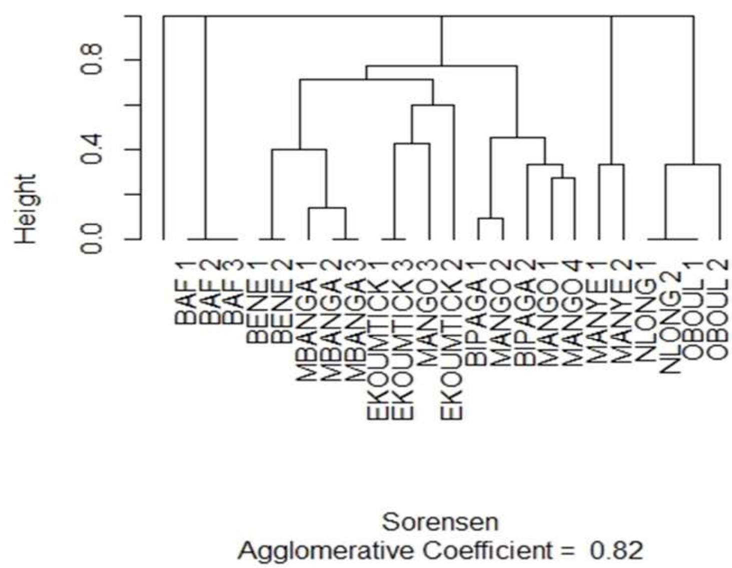

Figure 4. Dendrogram showing the six main groups of rattan stand identified.

Three of these six forest types showed a very strong dissimilarity in terms of floristic composition: submontane forests, secondary forests and Biafran Atlantic forests. These forests had restricted species or shared only one or two species with the other ones. Indeed, *Eremospatha tessmanniana* was only found in submontane forests; secondary forests had only two species *Laccosperma robustum* and *L. secundiflorum*; Biafran Atlantic forests had two abundant species, *Laccosperma laeve* and *Laccosperma* sp. *Laccosperma* sp. is only found in Biafran Atlantic forests.

At the threshold of 80 per cent of dissimilarity, three groups can be distinguished: littoral forests, transitional forests and semi-deciduous forests. The affinities between the rattan floras are closer between transition forests and littoral forests that shared five species: *Eremospatha haullevilleana, E. laurentii, E. macrocarpa, Laccosperma opacum* and *L. robustum*. The semi-deciduous forests also share their two species *E. macrocarpa* and *L. robustum* with the transitional and littoral forests.

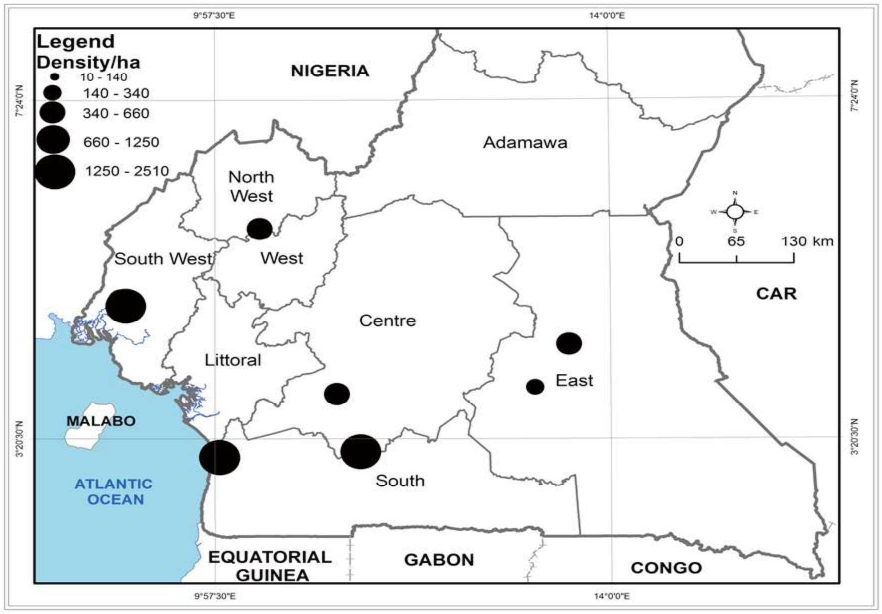

Figure 5. Abundance distribution of rattan species recorded in the 23 0.1-ha transects in Cameroon.

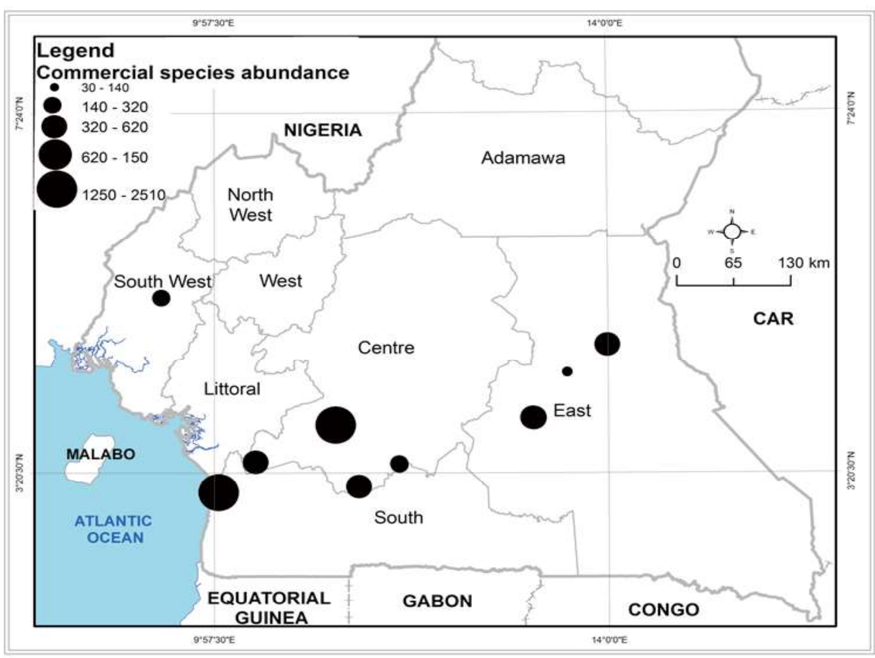

Figure 6. Abundance distribution of the four commercial rattan species in the study sites.

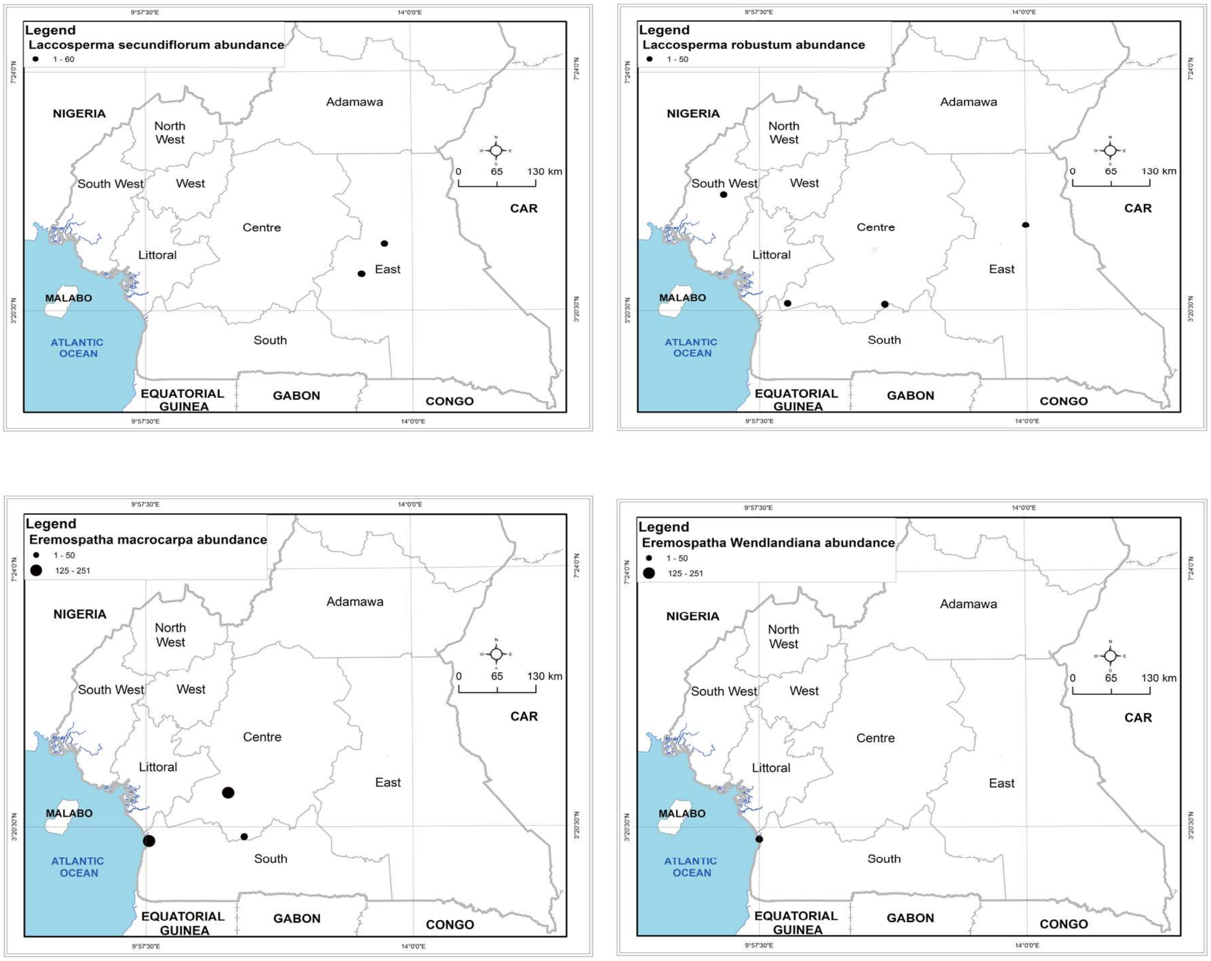

Figure 7. Abundance distribution of each commercial rattan species in the study sites.

Table 3. Number of rattan species per genus and their conservation status (IUCN 2018)

Genus	Species	Conservation status (IUCN 2018)	Range Description	Population	Habitat and Eccology	Major threats	Conservation Actions
Calamus							
	*Calamus deërratus***	Least concern (LC)	Very widely distributed, from the Gambia, to northern Angola and Zambia, and eastwards to southern Sudan and Uganda	Unknown	Usually occurs in the understory of lowland forests. Also present in sub-montane, swamp and riparian forests	Locally threatened by habitat loss	The species occurs in 38 protected areas across its range, and is present in three ex situ conservation collections
Eremospatha							
	*Eremospatha barendii**	Critically Endangered B1ab(iii)+2ab(iii);	Only known from two sites in south Cameroon, near Lolodorf	Unknown	Occurs in gaps in high forest and riverbanks	Habitat loss due to logging and land conversion to agriculture.	Does not occur in any protected areas, nor is it present in ex situ conservation collections
	*Eremospatha cuspidata**	Least concern (LC)	Distributed across the Congo Basin and in Zambia and Angola	Unknown	Occurs in deep white sand savanna areas characteristic of the coastal forests of the Congo Basin	No major threats	Currently occurs in two protected areas
	Eremospatha haullevilleana	Least concern (LC)	Distributed across the lowland forest of the Congo Basin	Unknown	Prefers growing in closed-canopy forest, particularly in riverine and swamp forests	No major threats	Occurs in 13 protected areas
	Eremospatha hookeri	Least concern (LC)	Wide distribution from west to central Africa	Unknown	Occurs underneath forest canopy, also common in gap vegetation and forest margins	No major threats	Found in 15 protected areas

Genus	Species	Conservation status (IUCN 2018)	Range Description	Population	Habitat and Eccology	Major threats	Conservation Actions
	Eremospatha laurentii	Least concern (LC)	Distributed in the northern part of the Congo Basin	Unknown	Encountered in open areas as well as in high canopy forest	No major threats	Present in 8 protected areas over its entire range
	*Eremospatha macrocarpa***	Least concern (LC)	Distributed from west to central Africa	Unknown	Encountered in tree fall gaps, forest margins of dense forest and swamp forests. It is also commonly found in secondary vegetation at road sides and along logging roads	No major threats	The species is present in 27 protected areas
	*Eremospatha quinquecostulata**	Vulnerable (VU)	Cameroon, Gabon, Nigeria	Unknown	Only found in high forest	No major threats, but locally threatened by habitat degradation or habitat loss.	
	Eremospatha sp.		Cameroon	Unknown			
	Eremospatha tessmanniana	Vulnerable (VU)	Cameroon, Congo, Equatorial Guinea	Unknown	It grows on well-drained soils in closed-canopy forests	No major threats, but locally threatened by habitat degradation or habitat loss.	Occurs in 2 protected areas:
	*Eremospatha Wendlandiana***	Least concern (LC)	Distributed from southeast Nigeria to the Cabinda	Unknown	Commonly encountered in gap vegetation and forest margins, swampy sites	No major threats	Occurs in 7 protected areas
Indet	*Indet*		Cameroon	Unknown			

Genus	Species	Conservation status (IUCN 2018)	Range Description	Population	Habitat and Eccology	Major threats	Conservation Actions
Laccosperma							
	*Laccosperma acuti orum**	Least concern (LC)	Widely distributed from west to central Africa		It grows in seasonally inundated and swamp forests, disturbed areas and secondary vegetation.	No major threats	Occurs in 4 protected areas
	*Laccosperma korupensis**	Near threatened (NT)	Cameroon, Congo		It grows in the lowland and sub-montane forest (understory)	Threatened by habitat loss	Only occurs in one protected area, the Korup National Park
	Laccosperma laeve	Least concern (LC)	Widely distributed from west to central Africa		Shade-tolerant species commonly found under a forest canopy, but it may also be found in disturbed forests and secondary vegetation	No major threats, but locally threatened by habitat degradation or habitat loss	Occurs in 11 protected areas.
	Laccosperma opacum	Least concern (LC)	Distributed from west to central Africa		Extremely shade-tolerant species. It grows in high forest in the lower to mid-canopy	No major threats, but locally threatened by habitat degradation or habitat loss	Occurs in 17 protected areas
	*Laccosperma robustum***	Least concern (LC)	Widely distributed from southeast Nigeria to the central Congo Basin		It occurs in forest gaps and disturbed areas	No major threats, but locally threatened by habitat degradation or habitat loss	Occurs in 9 protected areas

Genus	Species	Conservation status (IUCN 2018)	Range Description	Population	Habitat and Eccology	Major threats	Conservation Actions
	*Laccosperma secundi orum***	Least concern (LC)	Widely distributed from west to central Africa		Commonly encountered under canopy of high forest	No major threats, but locally threatened by habitat degradation or habitat loss	Occurs in 26 protected areas.
Oncocalamus							
	*Oncocalamus macrospathus**	Least concern (LC)	Distributed from Cameroon to Angola		Encountered in forest margins, tree fall gaps and other open areas		No known conservation actions
	Oncocalamus mannii	Least concern (LC)	Wide geographic distribution across central Africa		Common in open areas, roadsides and forest gaps		
	*Oncocalamus tuleyi**	Least concern (LC)	Distributed from southeast Nigeria to southwest Cameroon		Often encountered in logged forests, roadsides or farm regrowth		Occurs in 2 protected areas in Cameroon

(*) Rattan species present in Cameroon but not recorded in this study.

(**) Commercial species of rattans used in Cameroon (Sunderland 2001; Defo 2005).

3.3. Diversity and density

The number of species per transect varied from 1 to 6, with a mean of 3 ± species. The Shannon diversity index (H0) varied from 0 to 1.4. Values of the Shannon diversity index were highest in BIPAGA 1 & 2, and BENE 1 transects (H0 = 1.43 and 1.30; and 1.3) and lower in BAF1, BAF 2, BAF 3, EKOUMTICK 2 and OBOUL 2 transects (H0 = 0). The most diverse vegetation types were transition forests (H = 0.93) and littoral forests (H = 0.99), while the least diverse forest types were submontane forests (H = 0; Table 4). Indeed, littoral forests and transition had 10 and 7 species, respectively, on 15 species collected, while submontane forests had only one species.

The mean density of stems was 1260 ± 952 stems/ha (range 250–3620 stems/ha). The stem density of rattan was lowest in submontane and secondary forests (mean of 340–550 stems/ha), while the highest stem density were found in transition forests (mean = 2070 stems/ha) and littoral forests (mean = 1620 stems/ha), represented respectively 39 per cent and 34 per cent of the total stems. The density of clumps varied from 20 to 230/ha. Concerning forest type, the highest densities of clumps were found in littoral and transition forests (mean = 140 clumps), and the lowest density was found in the semi-deciduous forest (mean = 40 clumps; Table 4). All species are clustered.

3.4. Stem volume and rattan stocks density

The stem volume per ha in each transect ranged from 0.04 to 28.4 m^3 (Table 4). The volumes in submontane forest transects were low (0.04 m^3) relative to the stem density as compared to those in the transition and littoral forests (mean = 20.1 m^3). Among the species with high volume value, were *Eremospatha laurentii* (02.2 m^3), *E. macrocarpa* (01.8 m^3), *Laccosperma robustum* (02.6 m^3) and *L. secundiflorum* (01.1m^3). *L. secundiflorum* is dominant in secondary forests while the three other species were dominant in transition and littoral forests. Transects with high stem density also presented high volume values because, most of these species which are abundant, have relatively thick or long stems (40–80 m), and thus contributed greatly to the total volume (Table 5).

The estimated stock density in different forest types varied from 3922–2,636,345 m^3 (Table 6). The littoral forests, secondary forests and transitional forests showed the highest value of rattan stocks (more than 2,037,402–2,636,345 m^3; Figure 7), while the submontane forests and the semi-deciduous forests showed the lowest values: 3922 and 146,907 m^3, respectively. Four species presented high stock density values, varying from 223,342 to 346,112 m^3: *Laccosperma robustum, Eremospatha macrocarpa, Laccosperma secundiflorum* and *Eremospatha laurentii*. The three first listed are commercial species. *Eremospatha macrocarpa* and *E. Wendlandiana* showed high stock density in littoral forests while *Laccosperma robustum* and *L. secundiflorum* showed high stock density in secondary and transitional forests.

Photo 7. *Laccosperma robustum.*

Photo 8. Fruits of *Laccosperma robustum.*

Photo 9. *Laccosperma secundiflorum.*

Photo 10. *Laccosperma* leaves.

Photo 11. *Laccosperma opacum.*

Photo 12. *Eremospatha hookeri.*

Photo 13. *Eremospatha wendlandiana.*

Photo 14. *Eremospatha tessmanniana.*

Photo 15. *Eremospatha macrocarpa.*

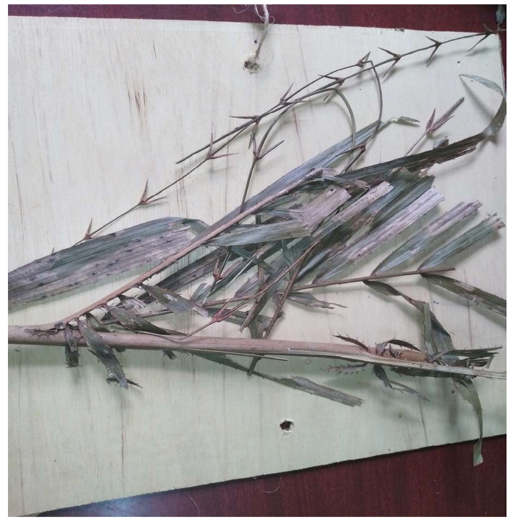

Photo 16. *Eremospatha sp.*

Table 4. Diversity and structural features of rattan in the 23 transects

Forest type	Transect code	Altitude (m)	Stem density	Clump density	Species richness	Shannon-Wiener index (H›)	Stem Volume (m^3/ha)
Biafran forests	MANYE 1	370	1820	110	3	0.45	4.6
	MANYE 2	373	250	30	3	0.97	1.9
Mean			1040			0.71	3.3
Littoral forests	BIPAGA 1	23	630	100	6	1.44	3
	BIPAGA 2	25	1050	130	6	1.3	7.7
	MANGO 1	1	2300	230	6	0.6	16.5
	MANGO 2	10	1710	150	5	1.2	20
	MANGO 3	6	2220	130	4	0.37	4.6
	MANGO 4	9	1830	120	5	0.98	16.8
Mean			1620			0.99	11.5
Secondary forests							
	NLONG 2	670	300	80	2	0.58	4.2

Forest type	Transect code	Altitude (m)	Stem density	Clump density	Species richness	Shannon-Wiener index (H')	Stem Volume (m^3/ha)
	NLONG1	650	730	100	2	0.64	13
	OBOUL 1	702	530	40	2	0.48	9.2
	OBOUL 2	672	620	100	1	0	12
Mean			550			0.43	9.6
Semi-deciduous forests	EKOUMTICK1	666	1110	60	3	1.04	9.4
	EKOUMTICK2	679	880	20	1	0	1.6
	EKOUMTICK3	671	510	40	3	1.02	3.6
Mean			830			0.69	4.9
Submontane forests	BAF1	993	490	70	1	0	0.2
	BAF2	1152	250	50	1	0	0.05
	BAF3	1169	290	60	1	0	0.06
Mean			340				0.1
Transition forests	BENE 1	660	3620	200	6	1.1	17.4
	BENE 2	665	2050		6	1.26	7.0
	MBANGA 1	709	2260		4	0.63	21.9
	MBANGA 2	695	2860	160	3	0.76	28.4
	MBANGA 3	720	570		3	0.88	7.6
Mean			2070			0.92	16.5

Table 5. Relative abundance and stem volume of rattans species at different forest types.

Species	Biafran forests	Littoral forests	Secondary forests	Semi-deciduous forests	Submontane forests	Transitional forests	Number of stems	Relative abundance	Mean volume
Calamus deërratus				48			48	1.66	0.2
Eremospatha haullevilleana		26				59	85	2.94	0.2
Eremospatha hookeri		74					74	2.567	0.27
Eremospatha laurentii	8	3				503	514	17.80	2.2
Eremospatha macrocarpa	3	630		126		444	1203	**41.66**	1.8
Eremospatha sp.		5					5	0.17	0.00
Eremospatha tessmanniana					103		103	3.57	0.00
Eremospatha Wendlandiana		122					122	4.22	0.3
Indet						23	23	0.80	0.00
Laccosperma laeve	24	11					35	1.21	0.2
Laccosperma opacum		34				11	45	1.56	0.2
Laccosperma robustum		44	80	76		86	286	9.90	2.6
Laccosperma secundi orum			138			10	148	**5.12**	**1.0**
Laccosperma sp.	172						172	5.96	0.00
Oncocalamus mannii		25					25	0.86	0.2
Total	**207**	**974**	**218**	**250**	**103**	**1136**	**2888**		

Values in bold are the most dominant species in terms of total number of stem and stem volume/ha.

Table 6. Stock density of rattan species in different forest types

	Biafran forests		Littoral forests		Secondary forests		Semi-deciduous forests		Submontane forests		Transitional forests		
Species	Estimated area (ha)	Stock density	Estimated area (ha)	Stock density	Estimated area (ha)	Stock density	Estimated area (ha)	Stock density	Estimated area (ha)	Stock density	Estimated area (ha)	Stock density	**Mean stock density**
Laccosperma robustum**		0	228811	414879.3	242087	950 594.5	30 265	77 423.9		-	123886	633 774.3	**346 112**
Eremospatha macrocarpa**	186 648	125655.8	228811	1197787.3		-	30 265	21122.4		-	123886	134 275.9	**246 473.6**
Laccosperma secundi orum**		0		0	242087	1 363 994.3		-		-	123886	27 277.55	**231 878.6**
Eremospatha laurentii	186 648	130633.4	228811	4178.8		-		-		-	123886	1 205 242	**223 342.4**
Laccosperma laeve	186 648	258087.7	228811	59446.5		-		-		-		-	52 922.4
Eremospatha Wendlandiana**		0	228811	241416.7		-		-		-		-	40 236.1
Eremospatha hookeri		0	228811	236789.9		-		-		-		-	39 465.0
Oncocalamus mannii		0	228811	207429.4		-		-		-		-	34 571.6
Laccosperma opacum		0	228811	155938.1		-		-		-	123886	15 146.2	28 514.1
Eremospatha haullevilleana		0	228811	111570.1		-		-		-	123886	13 878.4	20 908.1
Laccosperma sp.	186 648	97427.8		0		-		-		-		-	16 238.0
Calamus deërratus**		0		0		-	30 265	48 361.2		-		-	8 060.2
Indet		0		0		-		-		-	123886	7 808.2	1 301.4
Eremospatha sp.		0	228811	6908.8		-		-		-		-	1 151.5
Eremospatha tessmanniana		0		0		-		-	33644	3922.2		-	653.7
Total stocks		**611 804.7**		**2 636 345.1**		**2 314 588.7**		**146 907.4**		**3922.1**		**2 037 402.7**	

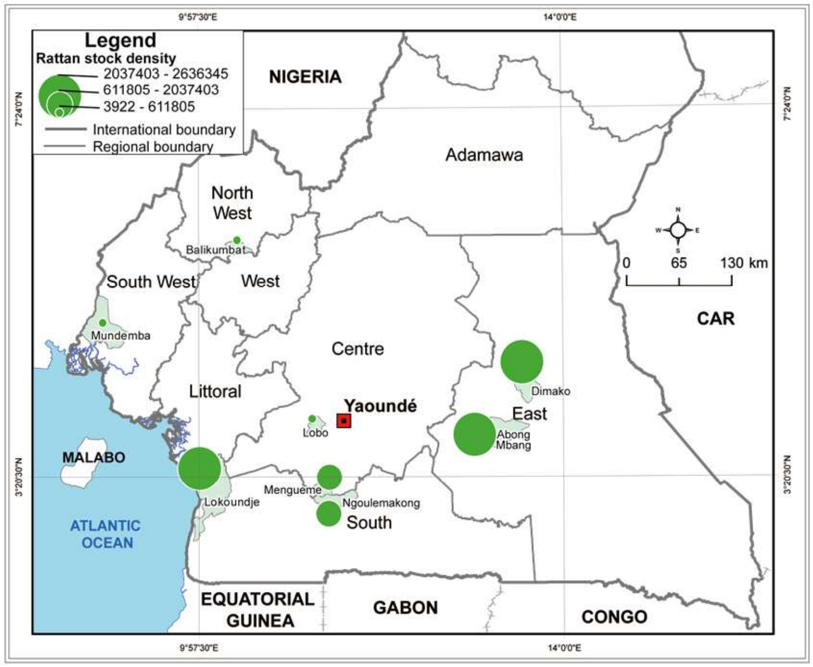

Figure 8. Distribution of estimated rattan stock density in different localities surveyed.

3.5. Traditional management practice

In Cameroon, the five commercial rattan species mentioned above are harvested from natural forests without any consideration for implementation of rational management. The harvest of rattan occurs in natural forests, swamp forests, old fallows and secondary forests. In many forest stands, there is a tendency towards a free access system, which could subject the ecosystem to irrational exploitation. Collectors also harvest from forest reserves and community forests. In addition, stakeholders in the sector are already expressing concerns about the rarefaction of some popular rattan species. So, there is no doubt that the current exploitation of rattan is unsustainable and it is clear that the present intensity of harvest is exceeding that of regeneration and growth. Indeed, harvesters use empirical and traditional techniques as transmitted by their parents. In addition to these traditional techniques, they use rudimentary equipment such as machetes, boots, caps, hooks, gloves, pants, and long sleeved shirts. Cameroonian rattan species are clustered (Sunderland 2012), so harvesters select the clumps to cut, clean them and use a hook to clear the vines in the canopy while pulling on them. More often, there is unselective harvesting of both the mature and immature cane stems, thus reducing the rate of regeneration. In addition to the damage of immature stems, a considerable part of the mature stems (30–60 per cent) is often left entangled in the forest canopy and abandoned, leading to wastage and reducing productivity.

Harvesting takes place in various places. However, the harvesting rotation in a given area can take 3–4 years. When all rattans in a given area are harvested, the cutters identify new areas to exploit in order to allow the regeneration of rattan in the first exploited area. After 3–4 years, they come back to the stands that were first exploited and start harvesting again after regeneration. The frequency of cuts depends on the demand and availability of rattan in a given area. It can be weekly, bi-monthly or monthly. Since rattan is not a seasonal plant, its exploitation is done throughout the year, but the activity is more intense during the dry season.

The number of bundles per harvest varies and depends on the species and whole size of the liana (1–3 bundles). A collector can harvest between 4–30 bundles per month depending on the intensity of the activity. Each bundle consists of an average of 10–15 stems for big canes (a range of 3–5 m each), and an average of 3 stems for small cane (a range of 70–80 m each. The average length of cane per harvest is about 225 m for big canes and 663 m for small canes. Therefore, on the basis of 30 bundles harvested per month, the estimated annual amount collected is 27,000 m for big canes and 79,560 m for small canes. However, considering the fact that rattans are always very heavy, some of the harvesters tie the cane in smaller bundles that they can transport by head from the forest to their house.

In the localities where there is significant extraction of commercial rattan canes, physical accessibility to the resource has become increasingly difficult due to long distances and scarcity of rattans. Indeed, distances to collect the resource have increased over the years. Harvesters must walk about 6–9 km to reach the resource (Zamakoe). This was not the case 10 years ago, when it was necessary to walk only 1–2 km to reach the rattan stands in the forest. On the other hand, in areas where commercial exploitation is not important or completely absent, the rattan stands are located not far from the roads or just after the fields (Nguti). This scarcity of resources is linked to the extension of agricultural clearing and the shortening of the fallow period, all of which have contributed to the reduction in availability of rattan resources and has affected the dynamics of rattan stands. Undeniably, with the increase in the prices of cocoa and coffee, people are clearing huge areas of rattan stands, because they do not perceive them to be important. This scarcity forces harvesters to spend a lot of time and energy searching for harvestable stems.

The harvesters have a good knowledge of rattan. The taxonomy criteria used by them is based on morphology, mainly the diameter and the colour of the stem. According to the harvesters, the commercial rattans are of two types: the large-diameter rattans they call 'real rattan' and small-diameter rattans they call 'liana'. However, part of the actors surveyed think that depletion and extinction of rattan is not possible. According to them, rattans are abundant, have great capacity for regeneration and 'grow fast like sugar cane' or 'like herbs', hence the need to train the inhabitants on how to manage rattan resources.

4. Discussion

Lianas are a prominent component of moist tropical forests, both on the forest floor and in the canopy into which they climb (Siebert 2005). Although the threshold of dissimilarity is high (80 per cent), we found three floristic groups: littoral forests, transitional forests and semi-deciduous forests. The differentiation between these forests are related to climate variation especially rainfall, seasonality and temperature gradients (White 1983; Letouzey 1985; Kouob 2009). As already shown for tree species in several studies (Letouzey 1985; Kouob 2009), the similarity between these three forest types is due to the fact that transitional forests contain semi-deciduous species and those from evergreen forests (Atlantic forests). This similarity is, however, very weak for rattan. The similarities between the rattan floras are closer between transition forests and littoral forests, which shared five species. Adaptability to a wide range of environmental conditions (for example, climate, soil) may explain the wide distribution of these five species (Siebert 2005).

It is well known that soil factors are among the most important ecological parameters determining the spatial distribution of tree species in tropical forests, especially at small spatial scales such as those of our study (Condit et al. 2002; Slik et al. 2009). So, soil conditions could also play an important role in rattan species distribution. The distribution of African rattan tends to be profoundly clumped (Sunderland 2001; 2012). Rattan in this study conforms to that pattern.

Of the 19 known rattan species in Cameroon, we assessed 15 species in this study. It is speculated that rattan diversity is positively correlated to overall species diversity (Dransfield, 1992; Sunderland 2001; Watanabe and Suziki 2008). Although quantitative data on trees were not assessed in this study, it is well-known that Atlantic central African forests harbour higher levels of diversity and endemism than inland forests (White 1983; Letouzey 1985; Parmentier 2011; Gonmadje et al. 2011). Our results provide evidence to support this hypothesis, with the greatest rattan diversity in Atlantic forests (littoral and Biafran forests) than inland (secondary and semi-deciduous forests). The overall stem density is higher than those found in other Cameroonian forests (485 to 1446 stems/ha; Sunderland 2001) but falls in the range of 162–5997 stems/ha found in Asian tropical forests (Watanabe and Suziki 2008).

The abundance and distribution of lianas are known to vary with abiotic factors including elevation, total rainfall, seasonality of rainfall, soil fertility and disturbances (Gentry 1991). Anthropogenic disturbance could explain differences in rattan density and diversity observed in these forests. Indeed, the high level of diversity and stem density observed in these Atlantic forests may be due to the fact that they were relatively undisturbed by agricultural activities and rattan exploitation. On the contrary, the relative paucity of harvestable cane in inland forests (secondary and semi-deciduous forests), is undoubtedly a result of the high level of cane exploitation from the area. In inland forests, the population harvest rattan in natural forests, and also use land for farming and logging. These human activities have a negative impact on the rattan population. Similar results were found in Malaysia (Nur Supardi et al. 1996; 1999). However, this is in contrast with other studies which found that logging has a beneficial impact on the regeneration of many of the light-demanding species of rattan in Africa (Sunderland 1999; 2001). Indeed, the harvesting cycle is considerably short and the levels of exploitation are currently beyond the capacity of the rattan to regenerate sufficiently; hence, this exploitation is currently unsustainable.

In addition to human factors, ecological and historical factors could explain the difference in diversity and stem density between Atlantic forests and others (secondary and submontane forests). The history of the Atlantic forests bordering the Gulf of Guinea related to forest refuge may have played a role in their high levels of biodiversity, including rattan (Maley 1987; Sosef 1994). It is also well known that rainfall is the best predictor of diversity (Linder 2001). Thus, the lower annual rainfall (1500–2000 mm) and longer periods of dry-season stress (1–4 months) observed in secondary and semi-deciduous forest areas, might contribute to explaining the lower diversity of these inland sites, compared with Atlantic forests (2000–4000 mm). Otherwise, owing to its geographically intermediate position, transitional forests may have been able to recruit species from two distinct pools in phytogeographic regions, semi-deciduous forests and evergreen forests (Atlantic forests). This might also contribute to explaining the high biodiversity levels, including those of rattan, recorded in this area.

Although rattan species occur in a wide range of ecological conditions, the majority of these species occur naturally in closed forests and are early gap colonisers (Sunderland 2007). Based on density parameter, *Eremospatha wendlandiana*, *E. laurentii* and *E. macrocarpa* mainly preferred moist environmental conditions, with high annual rainfall as found in the littoral and transitional forests. *Laccosperma secundiflorum* is mainly found in secondary forests, while *L. robustum* is a cosmopolite species.

This study also shows that rattan exhibited the lowest diversity and density at higher altitudes. Similar results were found in Central Sulawesi (Thonhofer et al. 2015). Thus, within their geographical range, most rattans are distributed in tropical lowlands forests. The altitudinal distribution range indicates that rattans have a low tolerance to low temperatures; the decrease of temperature with an increase of altitude would limit the distribution of rattans along the altitudinal gradient (Dransfield and Manokaran 1994; Watanabe and Suziki 2008).

5. Conclusion and recommendations

5.1. Conclusion

We have shown here that, in terms of rattan diversity, southern Cameroon is one of the richest areas within the central African rainforests, with 15 species assessed in this study in six forest types. In the general inventory, the two most abundant species were *Eremospatha macrocarpa* and *E. laurentii*. There was considerable variation in species composition among the forest types. Rattans grow in varied ecological conditions, however, most of the species are restricted to one or two forest types. The most diverse vegetation types were transition forests and littoral forests, while the least diverse forest types were submontane forests. Indeed, transition and littoral forests are known to be among the richest areas in terms of biodiversity (Letouzey 1985). They are also probably hotspots for rattan species, particularly for commercial value species *Laccosperma secundiflorum, L. robustum, Eremospatha macrocarpa*, and *E. wendlandianna*. Although we do not have quantitative data on trees to demonstrate through statistical analysis, it seems that there is a positive correlation between overall species diversity and rattan diversity as shown by several studies (Sunderland 2001). The stem volume also varied among different forest types and appeared to depend on whether the predominant rattan species had thick or long stems. It is necessary to preserve these forests for conservation of rattan species diversity. Although some species have low or no commercial value, they also play an important role in the ecosystem functioning and maintenance of biodiversity.

The tendency in Cameroon is that of a free access system. So, the five commercial rattan species mentioned above are harvested from natural forests without any efforts for rational management. The current exploitation of rattan is unsustainable. The harvest of rattan occurs in natural forests, swamp forests, old fallows, secondary forests, forest reserves and community forests.

5.2. Recommendations

This work is only a prospective study and gives an initial idea of the diversity, distribution and rattan stocks in Cameroon. More quantitative data are needed to estimate rattan stocks available and to implement an efficient strategy for better valuation and sustainable management of rattan stands. So, for the main constraints identified for sustainable management of rattan in Cameroon, some recommendations could be formulated.

- Planning conservation and protection of rattan production basins.

This level of management requires the development and implementation of management plans, based on sound inventory data and an understanding of the population dynamics of the species concerned. To achieve this, the following actions should be taken:

- o Develop and adopt standards for the inventory of rattan;
- o Identify production areas and rattan hotspots in order to protect them;
- o Develop and implement simple management plans of these forests;
- o Develop, in collaboration with NGOs, communication tools, sensitisation and environmental education on the importance of rattan production areas, the need to conserve and sustainably manage them.

- Develop and popularise sustainable harvesting practices particularly for Cameroonian clustering species.

Two simple interventions can be implemented to improve rattan harvesting practices:

  - o Younger stems, often indiscriminately cut during harvesting, should be left to regenerate and provide future sources of cane. Rotational harvesting systems could be increased if this was the case;
  - o Harvest intensity and rotation should be based on long-term assessments of growth rates and recruitment.

- Develop and implement a programme of domestication and planting of rattan in collaboration with specialised structures.

Although some on-farm, silvicultural, and enrichment planting trials were carried out in Cameroon by the African Rattan Research Programme in order to improve rattan sustainability, this initiative was unsuccessful because they faced many constraints. These rattan plantations are either abandoned or no longer exist today. Indeed, farmer adoptability has proven to be low due to the influence of a wide range of socio-economic factors, notably land and resource tenure issues and the reluctance of farmers to try new and untested crops. In addition to these constraints, field experiment results showed high levels of seed mortality (63 per cent) and very high mortality rates for the new plantings. These experiments were carried out for the three commercially valuable species: *Laccosperma secundiflorum, L. robustum* and *Eremospatha macrocarpa*. Thus, ecological feasibility of rattan cultivation in Cameroon and its socio-economic acceptability, remains questionable (Sunderland et al. 2008).

Therefore, it appears clearly that the domestication of rattan palms requires sound knowledge about their biology, phenology, and ecology. As a research perspective, especially for the most popular rattan species, it would be necessary to conduct in-depth inventories of various rattan ecosystems, to study the relationships between the abundance and distribution of rattan and environmental factors, to carry out work on seed biology, rhythm of production of seedlings, phenology, population dynamic (growth, mortality and recruitment), improvement and genetic enhancement of rattan, ethnobotanical, sociological and anthropological studies, etc. This information will be necessary to ensure a regular supply of cane through better forest management and development of cultivated systems for rattan.

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