BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of Botanical Research
https://ojs.bilpublishing.com/index.php/jbr

ARTICLE

Floristic Inventory and Evaluation of Carbon Sequestration Potential of the Misomuni Forest Massif, Kikwit City (Democratic Republic of the Congo)

Masens Da-Musa Y.B.[1*] Briki K. Cyril[2] Masens Mandung[3] Koto-Te-Nyiwa Ngbolua[1]

1. Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of Congo
2. University of Kikwit, Kikwit, Democratic Republic of Congo
3. Lumbi Higher Institute of Medical Techniques, Lumbi, Democratic Republic of Congo

ARTICLE INFO

Article history
Received: 2 August 2021
Accepted: 25 August 2021
Published Online: 7 September 2021

Keywords:
Forest ecosystem
Plant biodiversity
Carbon sequestration
Reducing Emissions from Deforestation and Forest Degradation project
Democratic Republic of the Congo

ABSTRACT

The aim of this study was to inventory plant biodiversity and to evaluate the carbon sequestration potential of the Misomuni forest massif. An inventory of all trees with diameter at breast height (dbh) ≥ 10 cm measured at 1.30 m height was performed. The aerial biomass (AGB) was used for estimating the stored CO_2 and its carbon equivalent. 88 plant species belonging to 71 genera and 32 families were inventoried. Fabaceae family displayed the highest number of species and genera. The highest basal area values were displayed by *Scorodophloeus zenkeri* (7.34 ± 2.45 m^2/ha), *Brachystegia laurentii* (5.82 ± 1.94 m^2/ha), *Entandrophragma utile* (5.28 ± 1.94 m^2/ha), *Pentadesma butyracea* (4.53 ± 1.51 m^2/ha). The highest values of stored carbon and their carbon equivalent were observed in *Pentadesma butyracea* (15.13 ± 5.00 and 50.55 ± 16.85 t/ha), *Picralima nitida* (7.02 ± 2.34 and 23.66 ± 7.88 t/ha), *Strombosia tetandra* (6.56 ± 2.18 and 22.10 ± 7.36 t/ha). The Misomuni forest massif is thus much floristically diversified and plays a significant role in the sequestration of CO_2. The total AGB of the inventoried trees is 183.78 ± 61.26 t/ha corresponding to stored carbon and carbon equivalent of 96.63 ± 32.21 t/ha and 289.92 ± 96.64 t/ha respectively. The protection of this ecosystem is highly needed for combatting climatic changes at local, national and regional scales and for the conservation biodiversity habitat.

1. Introduction

The Democratic Republic of the Congo (DRC) is a reservoir (hotspot) of biodiversity in the world [1]. Preserving the DRC's plant biodiversity and forest ecosystems is an imperative that can help mitigate climate change at local and regional scales reducing thus emissions from deforestation and other land-use changes, and enhancing carbon sinks.

The Misomuni forest massif is located in the south of Kikwit city (Kwilu province) in the West part of DRC. Actually, the observed loss of biological diversity in this region is essentially linked to human activity. Indeed, the above-mentioned massif is currently fragmented into several forest islands because of the numerous excessive anthropic activities undertaken in this phytocenosis. Although, three forest islands still retain certain homogeneity due to their particular status as "farms"; so

**Corresponding Author:*
Masens Da-Musa Y.B.,
Department of Biology, Faculty of Science, University of Kinshasa, Kinshasa, Democratic Republic of Congo;
Email: jpngbolua@unikin.ac.cd

 DOI: https://doi.org/10.30564/jbr.v3i4.3505

providing service such as microclimate regulation and supporting service like photosynthesis, soils formation and nutrient cycling [2]. The geographical coordinates of these patches are practically the same, although the Mbala Ding portion is located ± 3 km from two other patches and separated from them by an anthropogenic savanna. These coordinates are: 05°08' south latitude, 18°58' East longitude, and 140 to 458 m of elevation [3]. It will be necessary to evaluate the quantity of carbon stored by this phytocenosis and that released following the destruction of the trees which compose this forest massif from the manufacture of charcoal. This would allow in the near future evaluating the impact of the degradation of this plant formation on the climate change currently observed in this region of the country. Indeed, in recent years, there has been an increased demand for traditional bioenergy from the populations of the region concerned, because there is no or little electricity in many areas of our country [4]. To confirm this situation, it is necessary to travel along the National Highway 1 from Kinshasa to km 622 after the town of Kikwit to realize this. Many thousands of bags of embers are spread out along this main road beyond view. These products are the result of the destruction or indiscriminate deforestation of both forest and savannah ecosystems (shrubby savannahs, woodlands, etc.). The combustion of this traditional bioenergy releases tons and tons of CO_2, a greenhouse gas, into the atmosphere [5]. The aim of this study was to inventory plant biodiversity and to evaluate the carbon sequestration potential of the Misomuni forest massif. Indeed, assessing carbon sequestration in such forest ecosystem is required to supply information to monitor, report and verify for reducing deforestation and forest degradation (REDD) program as well as for biodiversity conservation in order to ensure ecosystem functioning.

2. Material and Methods

The Misomuni forest massif, currently divided into several forest islands including Kisalangundu, Mbala Ding and Mambala, is located at least 30 km south of the town of Kikwit on the Batsamba and/or Mukulu road (Figure 1).

It is located geographically between 5°08' south latitude and 18°58' west longitude and an altitude varying between 140 and 458 m. Floristic inventory and dendrometric measurements were conducted within these islands (one-hectare plot by island/site i.e. 3 ha in total). The inventory was based on rectangular plots measuring 100 m in length and 20 m in width (i.e. an area of 0.2 ha), joined together, and laid out along parallel inventory paths. For this purpose, a network of five plots was set up along the paths. Only trees with dbh measured at 1.30 m from the ground and ≥ 10 cm were considered. All specimens of inventoried trees and shrubs were identified according to APG versions II, III, and IV. The ecological spectra (biological type, diaspora type and foliar type)

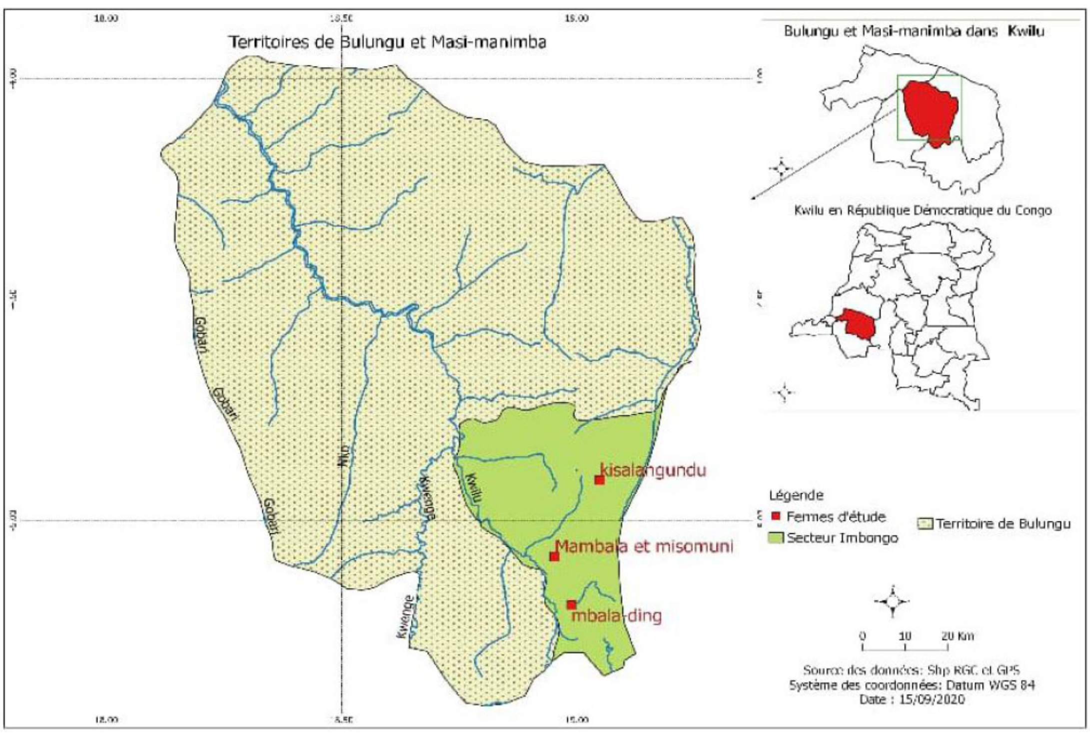

Figure 1. Location of the study sites

DOI: https://doi.org/10.30564/jbr.v3i4.3505

were determined using the Raunkiaer classification as previously reported [6-10]. The Raunkiaer system was used to determine the types of leaf size [11-15]. The morphological classification of Dansereau & Lems and the ecomorphological classification of Molinier & Mùller were used to determine the types of dissemination [16-18]. The phytogeographical distribution types defined in this study were established according to Lebrun as reported by several authors for tropical Africa region [17,19-22]. The determination of ecosociological groups was carried out according to the research of Lubini [23]. The calculations of (AGB), stored carbon (CSe), carbon equivalent (EqC) and basal area (BA or G) were carried out according to the following equations as previously reported [24-28]:

$$AGB = Exp\left(-0.37 + 0.333 * \ln(DBH) + 0.933\, ln(DBH)^2 - 0.122 * \ln(\mathrm{DBH})\right) \tag{1}$$

$$CSe = 0.47 * AGB \tag{2}$$

$$EqC = 3.667 * CSe \tag{3}$$

$$G = \frac{\pi}{4S}\sum_{i=1}^{n} di^2 \tag{4}$$

Where DBH is the diameter at breast height; S is the surface of the plot; di is the diameter of the tree I, n is the total number of trees with (dbh) ≥ 10 cm measured at 1.30 m height; Ht is the total height; d is the specific density of the wood.

The Microsoft Excel 2007 and IBM SPSS statistics version 14.0 software packages were used for data analysis while the allometric the equations were used to evaluate the correlation between some parameters (AGB and density, AGB and dbh, AGB and G, etc.).

3. Results

88 different plant species have been listed and identified overall. These species are divided into 71 genera, and 32 families (Table 1). Fabaceae is the group with the highest number of species and genera. Indeed, this group contains 24 species in total, or 27.27% and 15 genera, or 21.43%. It is very distantly followed by Sapotaceae; Clusiaceae and Myristicaceae with respectively 6; 4 and 4 species each, which is to say 6.82; 4.54 and 4.54%. Eight families have 3 species each, i.e. 24 species in all. These are Annonaceae; Apocynaceae; Chrysobalanaceae; Malvaceae; Meliaceae; Moraceae; Strombosiaceae and Ulmaceae. As for the twelve remaining families, they are monospecific. The genera *Celtis*, *Chrysophyllum* and *Distemonanthus* each have three different plant species. They are followed by twelve others with 2 species each. In terms of number of individuals, *Scorodophloeus zenkeri* Harms*, Staudtia kamerunensis* Warb. and *Anonidium mannii* (Oliv.) Engl. & Diels have a high number of plants, respectively 152 ± 50.67 trees/ha; 119 ± 39.67 trees/ha and 108 ± 36.00 trees/ha. Six species are weakly represented. These include *Entandrophragma angolense* (Welw.) C.DC. (1 tree/ha); *Celtis tenuifolia* Nutt. (1 tree/ha). The numerical number of trees varying between 10 and 28 was observed in 11 species, including *Petersianthus macrocarpus* (P.Beauv.) Liben (85 ± 28.33 trees/ha), *Maranthes chrysophylla* (Oliv.) Prance ex F.White (65 ± 21.66 trees/ha), *Pterocarpus mildbraedii* Harms (59 ± 19.66 trees/ha), *Duboscia viridiflora* (K.Schum.) Mildbr. (34 ± 11.33 trees/ha), etc.

Table 1. List of identified plant species and their ecological characteristics

Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Albizia adiantifolia (Schumach) W.Wight	Fabaceae	GC	MgPh	Bal	Mi
Albizia gummifera Var. *(*Schum W.F.Wight.)	Fabaceae	GC	MsPh	Bal	Me
Amphimas ptercarpoïdes Harmas	Fabaceae	GC	MsPh	Bal	Me
*Angylocallyx marginervatus(*Baker) Baker.F	Fabaceae	GC	MsPh	Bal	Me
Anisophyllea polyneura Engl.	Anisophylleaceae	CG	MsPh	Sar	Me
Anodium mannii (Oliv.)Engl et Diels	Annonaceae	GC	MsPh	Sar	Ma
Anthocleista shweinfurthii Gilg.	Gentianaceae	GC	McPh	Sar	Ma
Anthrocaryon micraster De Wild.	Anacardiaceae	GC	MsPh	Sar	Me
Antrocaryon klaineanum Pierre	Anacardiaceae	GC	MsPh	Sar	Me
Aubrecavillea kerstingii Brenan	Fabaceae	CG	MsPh	Pte	Me
Brachystegia laurentii Louis ex.Hoyle	Fabaceae	CG	MgPh	Bal	Me
Brachystegia sp (De Wild.) Louis ex Hoyle.	Fabaceae	CG	MgPh	Bal	Me

Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Brenania brieyi Petit	Rubiaceae	CG	MsPh	Sar	Me
Canarium schweinfurthii Engl.	Burseraceae	CG	MsPh	Sar	Me
Canthium arnoldianum (De Wild.et Th.Dur) Hepper	Rubiaceae	CG	MgPh	Sar	Me
Celtis sp	Ulmaceae	GC	MsPh	Sar	Me
Celtis tenuifolia Nutt.	Ulmaceae	CG	MsPh	Sar	Mi
Celtis zenkzri Engl.	Ulmaceae	GC	MsPh	Sar	Me
Chrysophyllum africanum Pierre.	Sapotaceae	CG	MgPh	Sar	Me
Chysophyllum lacourtianum De Wild.	Sapotaceae	CG	MgPh	Sar	Me
Coelocaryon preussii Warb.	Myristicaceae	CG	MsPh	Sar	Me
Cola lateritia K.Schum.	Malvaceae	CG	MsPh	Sar	Me
Detarium macrocarpus Guill& perr.	Fabaceae	CG	MgPh	Sar	Me
Diospyros crassiflora Hiern.	Ebenaceae	BGC	MsPh	Sar	Me
Distemonanthus benthamianus Baill	Fabaceae	CG	MsPh	Sar	Me
Distemonathus macrophylla Baill.	Fabaceae	GC	MsPh	Sar	Me
Duboscia viridiflora Boca.	Malvaceae	CG	MsPh	Sar	Me
Enanthia clorantha Oliv.	Annonaceae	GC	MsPh	Sar	Me
Entandrophragma angolense (Deilt.) A Chev	Meliaceae	GC	MgPh	Sar	Me
*Entandrophragma utile (*Dawe et Sprague)	Melaceae	GC	MgPh	Pte	Me
Eriocoelum macrocarpum	Sapindaceae	GC	MsPh	Pte	Me
Erismadelphus exsul Mildbr.	Vochysiaceae	GC	MsPh	Pte	Me
Erythroxylum mannii Oliv.	Erythroxylaceae	CG	MsPh	Sar	Me
Ficus mucuso Welw. Ex.Ficalho	Moraceae	At	MsPh	Sar	Me
Furtumia elastica (Preuss) Staf	Apocynaceae	GC	MsPh	Scl	Me
Gambeya beguei Aubrev. & peller	Sapotaceae	CG	MsPh	Sar	Me
Gilbertiodendron dewevrei L.	Fabaceae	GC	MgPh	Sar	Me
Guarea thompsonii (A. Chev) Pellegr.	Meliaceae	GC	MgPh	Sar	Me
Homalium sp	Salicaceae	GC	MsPh	Sar	Me
Irvingia robur Mildbr.	Irvingiaceae	CG	MsPh	Sar	Me
Lovoa trichiliodes Harms	Meliaceae	GC	MsPh	Scl	Me
Manilkara sp	Sapotaceae	CG	MgPh	Sar	Me
Maranthes chrysophylla (Oliv) Prance	Chrysobalanaceae	CG	MsPh	Sar	Me
Maranthes glabra (Oliv) Prance	Chrysobalanaceae	CG	MsPh	Sar	Me
Mildbraediodendrom excelsum Harms	Fabaceae	CG	MsPh	Bal	Me
Milicia excelsa (Welw.) Berg.	Moraceae	GC	MgPh	Sar	Me
Musanga cecropioides Roxb. Br.	Urticaceae	GC	MgPh	Sar	Me
Nesogordonia papaverifera (A. Chev.) Copur	Malvaceae	GC	MsPh	Sar	Me
Omphalocarpum elatu Miers	Sapotaceae	GC	MgPh	Sar	Me
Oncoba welwitschii	Salicaceae	GC	McPh	Sar	Me
Ongokea gore Pierre	Olacaceae	GC	MgPh	Sar	Me
Pachyelasma mannii Sabine	Fabaceae	GC	MgPh	Bal	Me

DOI: https://doi.org/10.30564/jbr.v3i4.3505

Botanical name	Family	Phyto distribution	Biological type	Diaspora type	Foliar type
Pachyelasma tessmannii Harms	Fabaceae	GC	MgPh	Bal	Me
Pachypodianthium staudtii (Engl.et Diels)	Annonaceae	CG	MsPh	Sar	Me
Panda oelosa Pierre	Pandaceae	GC	McPh	Sar	Me
Parinari excelsa Sarbine	Chrysobalanaceae	CG	MgPh	Sar	Me
Pentaclethra macrophylla Benth.	Fabaceae	GC	MsPh	Sar	Me
Pentadesma butyracea Sabine	Clusiaceae	FC	MsPh	Sar	Me
Pentadesma excelliana Staner.	Clusiaceae	FC	MsPh	Sar	Me
Pentadesma grandiflora Staner	Clusiaceae	FC	MsPh	Sar	Me
Petersianthus macrocarpus Beauv. Liben.	Lecythidaceae	GC	MgPh	Sar	Me
Picralima nitida (Baill.) Urb.	Apocynaceae	GC	MgPh	Sar	Me
Poga oleosa Gurke	Rhizophoraceae	GC	MsPh	Sar	Me
Polyscias fulva (Hiern) Harms	Araliaceae	CG	MgPh	Pte	Me
Prioria balsamifera Vern.	Fabaceae	GC	MgPh	Bal	Me
Pterocarpus mildbraedii Taub.	Fabaceae	GC	MsPh	Pte	Me
Pterocarpus tinctorius Hams	Fabaceae	At	MgPh	Sar	Me
Pycnanthus angolensis Warb.	Myristicaceae	GC	MsPh	Sar	Me
Sacoglottis gabonensis L.F.Baill.	Humiriacea	GC	MsPh	Sar	Me
*Santiria trimera (*Oliv.) Aubreu.	Burseraceae	CG	MsPh	Sar	Me
Schrebera arborea Welw.	Oleaceae	At	MsPh	Pte	Me
Scorodophloeus zenkeri Harms	Fabaceae	CG	MgPh	Bal	Me
Scyphocephallium mannii W.orb.	Myristicaceae	GC	MsPh	Sar	Me
Staudtia kamerunensis Warb.	Myristicaceae	CG	MsPh	Sar	Me
Strombosia pustulata Hook.F.	Olacaceae	CG	MsPh	Sar	Me
Strombosia tetandra Hook.F.	Olacaceae	CG	MsPh	Sar	Me
Symphonnia globulifera L.F.	Clusiaceae	At	MsPh	Sar	Me
Synsepalum msolo (Engl.) T.D.Penn.	Sapotaceae	GC	MsPh	Sar	Me
Tabernaemontana crassa Benth.	Apocynaceae	GC	McPh	Sar	Me
Tessmania africana Harms.	Fabaceae	GC	MgPh	Bal	Me
Trilepisium madagascariense DC.	Moraceae	GC	MsPh	Sar	Me
Vitex congolensis Dewild et Th. Dur.	Verbenaceae	GC	MsPh	Sar	Me
Vitex grandifolia(Gurk) W.piep	Verbenaceae	CG	MsPh	Sar	Me
Vitex welwitschii Gurke	Verbenaceae	GC	MsPh	Sar	Me

The highest basal area (BA) and above-ground biomass (AGB) values were obtained for the following plant species (Figure 2): *Scorodophloeus zenkeri* Harms (7.34 ± 2.45 m^2/ha), *Brachystegia laurentii* (De Wild.) Hoyle (5.82 ± 1.94 m^2/ha), *Entandrophragma utile* (Dawe & Sprague) Sprague (5.28 ± 1.94 m^2/ha), *Pentadesma butyracea* Sabine (4.53 ± 1.51 m^2/ha) (for BA) and *Pentadesma butyracea* Sabine (31.44 ± 10.48t/ha), *Picralima nitida* (Stapf) T.Durand & H.Durand (14.95 ± 4.98 t/ha), *Antrocaryon micraster* A.Chev. & Guillaumin (9.56 ± 3.19 t/ha), *Synsepalum msolo* (Engl.) T.D.Penn. (6.96 ± 2.32 t/ha), *Poga oleosa* Pierre (6.36 ± 2, 12 t/ha), *Entandrophragma utile* (Dawe & Sprague) Sprague (5.02 ± 1.67 t/ha), *Brenania brieyi* (De Wild.) E.M.A.Petit (4.71 ± 1.57 t/ha), *Aphanocalyx margininervatus* J.Leonard (4.61 ± 1.54 t/ha), etc. for AGB. The highest values of stored carbon and their carbon equivalent were observed in the following species: *Pentadesma butyracea* Sabine (15.13 ± 5.00 and 50.55 ± 16.85 t/ha), *Picralima nitida* (Stapf) T.Durand & H.Durand (7.02 ± 2.34 and 23.66 ±

7.88 t/ha), *Strombosiopsis tetandra* Engl. (6.56 ± 2.18 and 22.10 ± 7.36 t/ha), etc. The lowest values of these parameters were obtained in *Piptadeniastrum africanum* (Hook.f.) Brenan with 0.05 ± 0.01 and 0.18 ± 0.06 t/ha of sequestered carbon and its carbon equivalent (Figure 2). The average dbh of the species, measured at 1.30 m above the ground, is 28.82 m, and the highest dbh value was observed in *Poga oleosa* Pierre with 85.43 m. The lowest dbh value characterizes the species *Manilkara sp* with 14.17 m. The diametric structure of the sampled trees by class is shown in Figure 3.

It illustrates the density structure (number of stems/ha) according to the dbh classes. The range of dbh classes considered is 15.99. In total 4 classes of dbh were determined. These include: class 1 (10 - 25.99 cm), class 2 (26 - 41.99 cm), class 3 (42 - 57.99 cm) and ≥58 cm. Class 2 has the highest number of stems per hectare, 41 trees, followed by class 1 with 37 stems/ha. Class 4 is sparsely represented at 2 stems/ha.

According to ecological spectra and phytogeographic distribution, Mesophanerophytes represented 69.32% (Figure 4); Mesophylls (88.64%: Figure 5) and Sarcochores (68.18%: Figure 6) while Guinean-Congolese species were the most represented (60.23%: Figure 7). Table 2 and Figure 8 established the correlation between AGB and BA. From their analysis, it appears that the two compared parameters are positively correlated (R^2 >0.75; p value < 0.05).

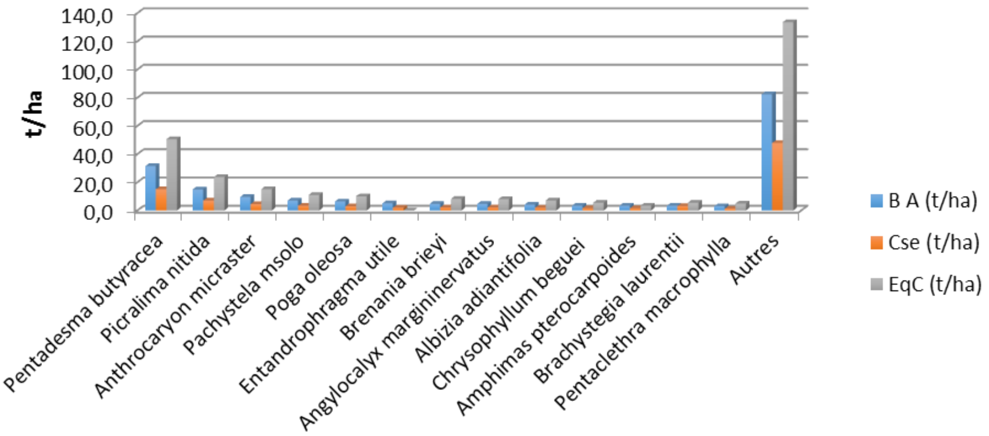

Figure 2. Measurement of BA, Cse and EqC

(Legend: BA = Basal area; Cse = Sequestered carbon; EqC = Carbon equivalent)

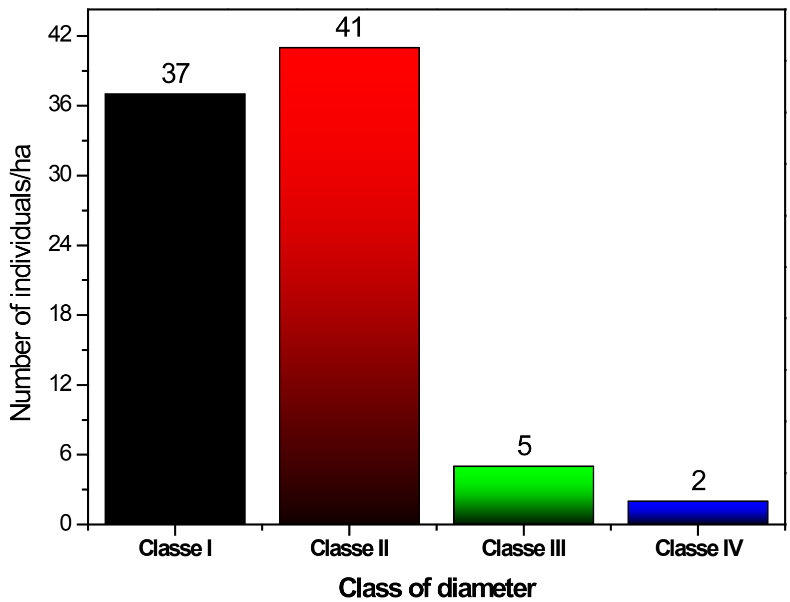

Figure 3. Diameter structure of trees listed by class

DOI: https://doi.org/10.30564/jbr.v3i4.3505

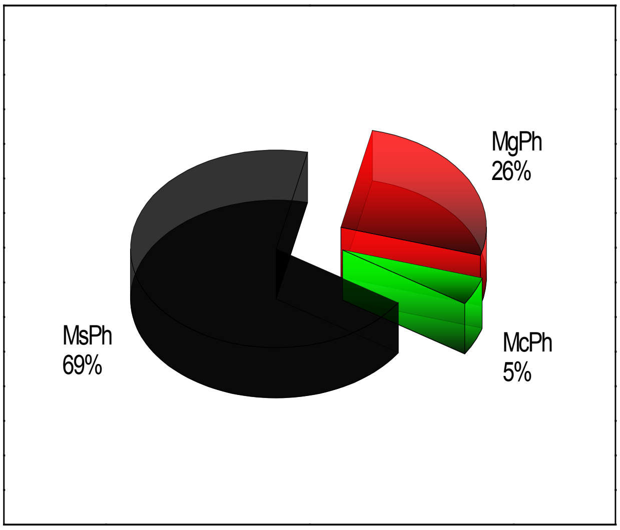

Figure 4. Biological types

(Legend: MsPh: Mesophanerophyte; MgPh: Megaphanerophyte; McPh: Microphanerophyte)

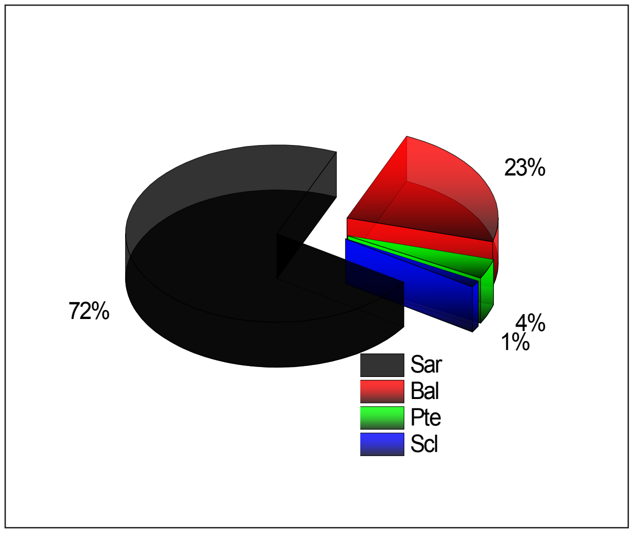

Figure 6. Types of diaspora

(Legend: Sar: Sarcochores; Bal: Ballochores; Pte: Pterochores; Scl: Sclerochores)

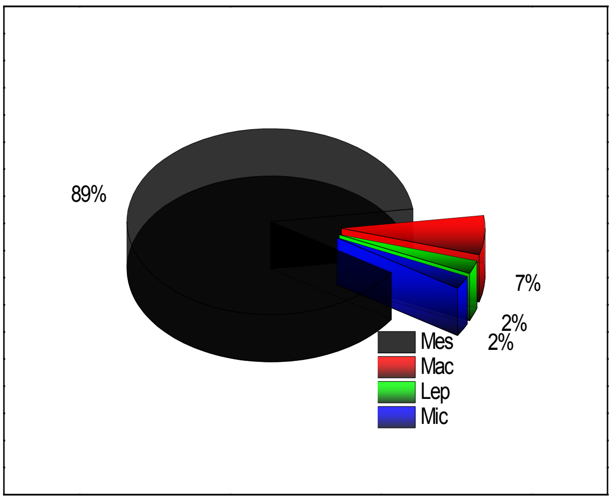

Figure 5. Types of leaf size

(Legend: Mes: Mesophyll; Mac: Macrophyll; Lep: Leptophyll; Mic: Microphyll)

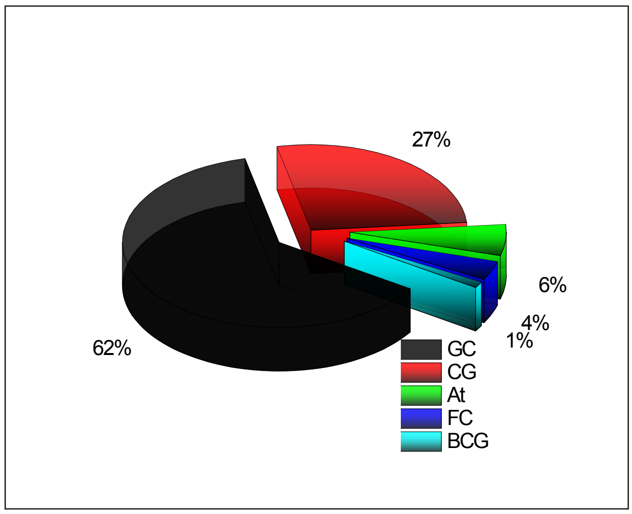

Figure 7. Phytogeographic distribution types

(Legend: GC: Guinean-Congolese species; CG: Central Guinean species; At: Afro-tropical species; FC: Central forester; BCG: Lower Guinean-Congolese species species)

Table 2. Relationship between AGB and basal area

Equation	Summary of models					Estimates of the parameters			
	R Square	F	ddl1	ddl2	p-value	Constant	b1	b2	b3
Linear	0,981	474,205	1	33	0,000	31,383	7,399		
Logarithmic	0,829	39,211	1	37	0,001	430,276	191,018		
Quadratic	0,858	424,527	2	26	0,002	20,920	3,600	0,046	
Cubic	0,798	435,374	2	46	0,002	20,910	2,410	0,057	0,001

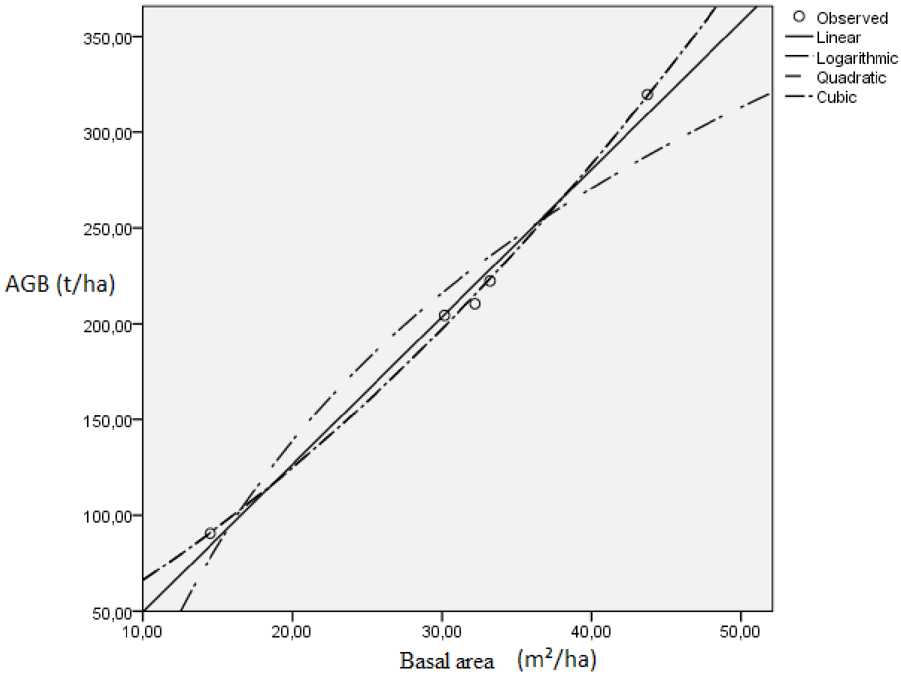

Figure 8. Regression equation curves between AGB and basal area

4. Discussion

The results obtained in this study in terms of density are similar to those obtained by Kidikwadi et *al*. [28] in the Luki Biosphere Reserve (194 individuals/ha). The Misomuni forest has a large number of plant species density compared to that obtained by Ngo [29] in the INERA/Kiyaka reserve (density: 5 trees/ha) and those obtained by Kibe [30] in the Ngoso forest. The difference in the results of different studies could be justified by the fact that the present work considered trees with a dbh measured at 1.30 cm from the ground ≥ 10 cm which is also a syntaxons made up of small trees and undergrowth shrubs or by habitat fragmentation. The density of the studied stand is high; it is about 1651 ± 550 trees/ha. This value of 550 trees/ha is in accordance with those reported by Lejoly [31] in the Ngotto forest and by Masens [21,22] in the forest ecosystems of Kamaba (Kipuka) and Nzundu (Imbongo) in the same region; the forest massif studied is specifically poor and fairly homogeneous. Similar observations had already been made by Kidikwadi et *al*. [28] and Lubini et *al.* [32] who studied respectively the *Prioria balsamifera* and *Hylodendron* stand in the Luki reserve and the semi-evergreen rainforest with *Celtis milbraedii* and *Gambeya lacourtiana* in the Kikwit region (Zaire/DRC), and by Pierlot [33] in the *Scorodophloeus zenkeri* forest (Yangambi, inventory n° 25). In Zaire, Malaisse [34] inventoried 1463 plants/ha in the dense dry forest; Devineau [35], in Côte d'Ivoire, listed 2884 plants/ha in the *Celtis sp.* forest (Lamto). The results obtained by these authors are highly superior to those observed in the Misomuni forest. This situation can be attributed to the very young age of this phytocenosis.

Among the most abundant trees, *Scorodophloeus zenkeri* has 50.67 individuals/ha, *Staudtia kamerunensis*, 39.67 individuals/ha; *Anonidium mannii* 36.00 individuals/ha, *Petersianthus macrocarpus*, 28.33 individuals/ha; *Maranthes chrysophylla*, 21.67 individuals/ha; *Brachystegia laurentii*, 21.33 individuals/ha; *Prioria balsamifera*, 20 individuals/ha; *Pterocarpus mildbraedii*, 19.67 individuals/ha and *Tessmannia africana*, 18.33 individuals/ha, etc. These results are compatible with those already observed in the same region by Kakiki [36], Masens [22]; but superior to those obtained in Kiyaka Forest Reserve by Lula [37]; Mungubushi [38]. It should also be noted that Gentry [39] obtained densities ranging from 167 to 1947 trees/ha for species with dbh ≥ 10 cm in neotropical forest ecosystems. Thus, our results are well within the ranges determined by Rollet [40] for Africa and America and those established by Gentry [39] for neotropical forests.

A value of 183.78 ± 61.26 t/ha of AGB was obtained in this forest massif; this value of AGB obtained is largely inferior in comparison with those observed by Sokpon [41] in the various forest stands of Benin. According to this author, the biomass values obtained in these stands vary from 378.8 to 391 t/ha. Synthesizing woody biomass values for moist and semi-deciduous forests, Bernhardt-Versat et *al*. [42], report that woody biomass values range from 233 t/ha for secondary forests in Ghana to 475 t/ha for primary forests in Malaya. Edouard and Grubb [43]

  DOI: https://doi.org/10.30564/jbr.v3i4.3505

studying dense rainforests in New Guinea obtained biomass values between 330 and 430 t/ha. The low values of AGB, as well as those of basal area (G), obtained in this phytocenosis are attributed to the state of degradation of this forest massif and the scarcity of large trees. Indeed, we numbered 7 emergent with dbh measured at 1.30 m at breast height and ≥ 40 cm against 81 trees and shrubs with dbh located between 10 and 39.9 cm. This would prove the immature state of this ecosystem and hence the low values obtained for the relevant parameters. The structure of the studied stand correlates with this assertion (i.e., the distribution of the listed and identified trees in dbh classes).

As shown in the figure for an uneven-aged stand, characterized by trees of all ages and sizes, the distribution of wood numbers by size categories takes the form of a curve with a decreasing trend [41]. Referring to the G, Malaisse [13] demonstrated that the G is a good tool for the classification of earth forma plant formations. He suggested that there is 30-40 m^2/ha of G in the *Entandrophragma delevoyi* dry forest in Zaire (DRC). In the Yapo forest, Bernhard-Reversat et *al*. [42], estimated 1 m^2/ha of BA and 30 m^2/ha for the Khade forest (Ghana). When considering the entire area prospected, i.e. 3 ha, the BA value obtained in this study is in the same order of magnitude as those of the authors mentioned above. It is however very low when it is reduced to one hectare. Indeed, the value of BA obtained is 55.18 ± 18.39 m^2/ha. This is probably due to the rarity of large emergent in this plant community. Indeed, the plant species presenting elevated values of basal area (BA) are also those that produce important quantities of aerial biomass (AGB). Thus, more BA increase, more AGB are important (expressed as CO_2 sequestration), it shows that the production of the aerial biomass is linked to the density of the individuals. The protection and the conservation of such a forest massif permits to fight so much against the climatic changes on a local scale (regulation of microclimate) as well as at the regional level.

5. Conclusions and Suggestions

The Misomuni forest massif is much floristically diversified (88 plant species belonging to 71 genera and 32 families) and plays a significant role in the sequestration of CO_2. The total AGB of the inventoried trees is 183.78 ± 61.26 t/ha corresponding to stored carbon and carbon equivalent of 96.63 ± 32.21 t/ha and 289.92 ± 96.64 t/ha respectively. The protection of this ecosystem is highly needed for combatting climatic changes at local scale and for the conservation biodiversity habitat.

It is therefore a necessity for the Congolese government to establish a partnership with universities and research institutes across the country in order to finance the related themes, and to extend such research within the forest ecosystems, or at least what is left of it in this country, as recommended by the REDD+ program. This would help our country to assert its rights to the payment of the environmental services related to the stock of carbon credit in these types of ecosystems.

Acknowledgements

The authors are indebted to Alfred Clément Inkoto, Santos Kavumbu, Blaise Mbembo-Wa-Mbembo, Laurent Gbanzo and Peter Mpilembo for their collaboration and assistance.

References

[1] Ngbolua, K.N., Ngemale, G.M., Masengo, A.C., Motende, B.N., Ndolete, G.J-P., Djolu, D.R., Libwa, M.B. and Bongo, N.G. (2019), Evaluation of Artisanal Logging Sector in Democratic Republic of the Congo: A Case Study of Peri-urban Forest of Gbadolite City, Nord-Ubangi. Int. J. Plant Sci. Ecol., 5(2), 25-30.

[2] Sinsi, B. and Kampmann, D. (Eds) (2010), Atlas de la biodiversité de l'Afrique de l'Ouest. Tome I: Benin. Cotonou & Frankfurt/Main.

[3] Masens, D.-M.Y.B., Ngbolua, K.N., Briki, K.C. and Muhammad, R. (2021), Survey on the Production of Traditional Bioenergy in the Democratic Republic of the Congo: The Case Study of Kwilu Province. BIo-Ex Journal 3(2), 84-90.

[4] Ngbolua, K.N., Ndanga, A.A., Gbatea, A., Djolu, R., Ndaba, M., Masengo, C., Likolo, J., Falanga, C., Yangba, S., Gbolo, B. and Mpiana P. (2018), Environmental Impact of Wood-Energy Consumption by Households in Democratic Republic of the Congo: A Case Study of Gbadolite City, Nord-Ubangi. International Journal of Energy and Sustainable Development 3(4), 64-71.

[5] Ngbolua, K.N., Falanga, M.C., Djolu, D.R., Masengo, A.C., Nzamonga, G.A., Bongo, N.G., Gbolo, B.Z., Mudogo, V. and Mpiana P.T. (2019), Socio-economic and Environmental Impacts of Clay Brick Manufacturing in Gbado-Lite City (Nord Ubangi Province, DR Congo). Journal of Environment Protection and Sustainable Development 5(3), 126-131.

[6] Raunkiaer, C. (1934), The life forms of plants and statistical plant geography. Oxford Clarendon Press, p632.

[7] Schmitz, A. (1988), Revision of the described plant groups of Zaire, Rwanda and Burundi, 315p. Publl.

CIDAI, Mus. Roy. Afr. Centr. Tervuren.
[8] Trochain, J.L. (1980), Plant ecology of the intertropical non-desert zone. Univ. Paul Sabatier Toulouse, France, p468.
[9] Lubini, A.C. (1997), The vegetation of the Luki Biosphere Reserve in Mayombe (Zaire). Jard. Bot. Nat. Belg. Opera Botanica. Meise, p155.
[10] Habari, M. (2009), Floristic, phytogeographic and phytosociological study of the vegetation of Kinshasa in the Democratic Republic of the Congo. PhD Thesis, University of Kinshasa.
[11] Raunkiaer, C. (1934), The life forms of plants and statistical plant geography. Oxford: Clarendon Press, p.632.
[12] Mullenders, W. (1954), The vegetation of Kaniama (between Lubishi-Lubilash). Publ. INEAC. Sér. Sc. p61.
[13] Malaisse, F. (1984), Contribution to the study of the dense dry forest ecosystem (Muhulu). 4. Structure of a Zambezi dry forest near Lubumbashi (Zaire). Bull. Soc. Roy. Bot. 117, 428-458.
[14] Masens, D.-M.Y.B. (1997), Phytosociological study of the Kikwit region (Bandundu, Zaire). PhD Thesis, U.L.B., Bruxelles, p382.
[15] Mandango, M.A. (1982), Flora and vegetation of the islands of the Zaire River in the Tshopo Sub-Region (Haut-Zaire). PhD Thesis, Faculty of Science : University of Kisangani. Tomes 1 & 2, p425.
[16] Dansereau, P. and Lems, K. (1957), The grading of dispesal types in plant communities and their significance. Contrib. Inst. Bot. Montréal (71), 52.
[17] Evrard, C. (1968), Ecological research on the forest stand of hydromorphic soils in the central Congolese basin. Publ. INEAC., sér. Sc. p110.
[18] Mollinier, R. and Müller, P. (1938), The spread of plant species. Rev. Gén. Bot., L., p53-670, passim.
[19] Lebrun, J. (1947), Vegetation of the floodplain south of Lake Edouard. Exp. Parc Nat., Bruxelles, p153.
[20] Lubini, A.C. (2001), Phytogeographic analysis of the forest flora of the Kasai sector in Congo Kinshasa. In: Proceedings of the XVIth plenary meeting of the l'AETFAT, vol. 72 n°2, Bull. Jard. Bot. Nat. Belg., Bruxelles, p859-872.
[21] Masens, D.-M.Y.B. (2015), Contribution to the phytoecological study of the Kamaba forest (Kipuka, district du Kwilu, province de Bandundu, R. D. Congo) Congo Sci. (online ACASTI & CEDESURK Journal); 3 :31-32.
[22] Masens, D.-M.Y.B., Ngbolua, K.N., Tembeni, M.T. and Bongo, N.G. (2017), Phytosociological study of Nzundu massif forest of Imbongo city, Kwilu province, Democratic Republic of the Congo. Tropical Plant Research 4 (3), 363-375.
[23] Lubini, Q.C. (1982), Messicultural and post-cultivation vegetation in the Kisangani and Tshopo sub-regions (Haut Zaire). PhD Thesis, Faculty of Science: University of Kisangani, p489.
[24] Chave, J., Andalo, C., Brown, S., Cairns, M.A., Chambers, J.A., Eamus, D., Foilster, H., Frormard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B.W., Ogawa, H., Puig, H., Riera, B. and Yamakura, T. (2005), Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145, 87-99.
[25] Ibrahima, A. and Fanta, A.C. (2008), Estimation of carbon stock in tree and shrub facies in the Sudano-Guinean savannahs of Ngaoundéré, Cameroun. Cameroun Journal of Experim. Biology (4)3, 1-11.
[26] Toung, D. (2010), Estimation of the quantity of carbon stored by a forest under reconstitution. Case of a young fallow in the classified forest of Mondah. MSc Thesis. National School of Water and Water of Cap-Estérias, Gabon.
[27] Lubini, A.C., Belesi, K., Kidikwadi, T. and Kisompa, R. (2014), Preliminary note on the measurement of above-ground biomass and carbon stock in a forest patch in Kinshasa. Congo Sciences 2(2), 114-1119.
[28] Kidikwadi, E.T., Lubini, A.C., Luyindula, N. and Belesi, H. (2015), Preliminary note on the ecology and biomass measurement of *Prioria balsamifera* in the INERA forest stations of Luki and Kiyaka in DR Congo. International Journal of Innovation and Applied Studies 11(4), 914-927.
[29] Ngo, O. (2015), Contribution to the ecological study of the above ground biomass and carbon sequestration in the INERA/Kiyaka forest. BSc Thesis, ISP Kikwit: Democratic Republic of the Congo.
[30] Kibe, R. (2017). Contribution to the ecological and above ground biomass and carbon sequestration study in Ngoso village forest. BSc Thesis, ISP Kikwit: Democratic Republic of the Congo.
[31] Lejoly, J. (1996). Regional synthesis on the plant biodiversity of woody plants in the 6 sites of the ECOFAC Project in Central Africa, Groupement AGRECO-CTFT. Bruxelles, p81.
[32] Lubini, K.K. (1996). The semi-evergreen rainforest with *Celtis mildbraedii* and *Gambeya lacourtiana* in the Kikwit (Zaïre). Bull. Jard. Bot. Nat. Belg. 61, 305-334.
[33] Piélou, E.C. (1996). Species diversity and pattern diversity in study of ecological succession. J. Theor. Biol. 10, 370-383.

  DOI: https://doi.org/10.30564/jbr.v3i4.3505

[34] Malaisse, F. (1984), Contribution to the study of the dry dense forest ecosystem (Muhulu). 4. Structure of a dense dry Zambezian Forest near Lubumbashi (Zaire). Bulletin of the Royal Botanical Society of Belgium 117, 428-458.

[35] Devineau, J.L. (1984). Structure and dynamics of some West African tropical forests (Ivory Coast), Stat. Ecol. Trop. Lamto, University of Abidjan, p294.

[36] Kakiki, K. (2015), Contribution to the ecological and aerial study and carbon sequestration in the INERA/Kiyaka forest. BSc Thesis, ISP Kikwit: Democratic Republic of the Congo.

[37] Lula, M. (2015), Contribution to the ecological and above ground biomass study and carbon sequestration in the INERA/Kiyaka forest. BSc Thesis, ISP Kikwit: Democratic Republic of the Congo.

[38] Mungubushi, N. (2015), Contribution to the ecological study of above ground biomass and carbon sequestration in INERA/Kiyaka forest. BSc Thesis, PSI/Kikwit.

[39] Gentry, A.H. (1982), Patterns of neotropical plant species diversity. In: Hecht M.K., Wallace B., Prance G.T. (eds) Evolutionary Biology. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-6968-8_1.

[40] Rollet, B. (1974), The architecture of dense lowland evergreen forests. C.T.F.T., Paris, p208.

[41] Sokpon, N. (1995), Ecological research on the dense semi-deciduous forest of Pobe in south-east Benin: Plant groups, structure, natural regeneration and litterfall. PhD Thesis, U.L.B., Bruxelles, p365.

[42] Bernhard-Reversat, C.H. and Lemée G. (1978), The evergreen forest of Lower Cote d'Ivoire. Problem of ecology, Terrestrial ecosystems. Masson. Paris, pp. 313-345.

[43] Edouard, P.J. and Grubb, P.J. (1977), Studies of mineral cycling in a montane rain forest in New Guinea I. The distribution of organic matter in the vegetation and soil. Journal of Ecology 65, 943-969.