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Assessment of Phytoecological Parameters of Forest Massifs in the Kwilu Province in the Democratic Republic of the Congo

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Authors' contributions

This work was carried out in collaboration among all authors. Author YBMM designed the study. Authors KNN and GNB wrote the first draft of the manuscript. Authors YBMM, KNN and JMTT managed the analyses of the study. Authors MM and GNB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Rainforests constitute the great green heart of Africa and thus they present a unique combination of ecological, climatic and human interactions. The degradation of various forest ecosystems in mainly tropical regions and more particularly in sub-Saharan Africa has been a constant reality since the emergence of man. Faced to this almost alarming picture, most often linked to the countless economic challenges and calamitous management and confronted with unavoidable climate change, it seemed appropriate and imperative to assess the quantities of Air Biomass, sequestered carbon stocks, carbon equivalent and basal area produced by various forest massifs encountered in the Kwilu province. This study was carried out at the Kiyaka Agricultural Research Station

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located in the south of Kikwit. Five blocks of 100 m / 20 m were delineated using a 200 m long nylon wire divided into 10 m intervals. The system thus delimited made it possible to inventory all the trees, of which dbh measured at 1.30 m at chest height is ≥ 10 cm. The findings showed that species are divided into 11 orders, 42 genera and 19 families. The following systematic units are best represented in terms of number of plant species. These families are namely: Fabaceae, Malvaceae, Apocynaceae, Euphorbiaceae and Olacaceae, which together contain 26 plant species, while nine families are poorly represented. However, this reserve is threatened by its occupants on all sides; they do not want to clear large areas of forest for their field work. It is therefore urgent for INERA/Kiyaka officials to take the necessary measures for its full protection.

Keywords: Phytoecology; forest massifs; Kwilu; Democratic Republic of the Congo.

1. INTRODUCTION

The rainforests are the great green heart of Africa, and present a unique combination of ecological, climatic and human interactions [1]. Recently, there has been a surge of interest in tropical forests, as there is increased appreciation of the rich biodiversity they host and the many roles they play in the functioning of the Earth system at local, regional and global scales [1]. However, Forests constitute an efficient carbon sink through actions like afforestation, forest management, forest management [2]. The degradation of various forest ecosystems in tropical regions and more particularly in sub-Saharan Africa has been a constant reality for decades [3].

It was reported that "more than 200,000 years ago, men controlled fire and used it to burn dry tropical rainforests, most often to hunt game or drive away predators [4]. Currently, there are only less than 8% left and the majority of them are located in mountainous and/or difficult to access areas. Faced to this alarming picture, most often linked to the countless economic challenges and calamitous management. This management is confronted to the unavoidable climate change issue, which seemed appropriate and imperative to assess the quantities of Above ground Biomass (AGB), sequestered carbon stocks, carbon equivalent and basal area produced by various forest massifs) encountered in the Kwilu district (Kwilu province). It is necessary to know that the implementation of improved management practices to build up carbon stocks in terrestrial ecosystems is being a proven technology to reduce the concentration of Carbon dioxide in the atmosphere [5].

The knowledge of these parameters, in particular sequestered carbon and its equivalent, the aboveground biomass and basal area produced, will help the Democratic Republic of the Congo (DRC) to access and gain carbon credits to an extend that this would participate in the temperature regulation of the atmosphere. It should be noted that forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural brake on climate change. This regulation would then allow to the reduction of currently increasing greenhouse gases emissions as stipulated in the Kyoto protocol [6]. The aim of this study was to assess different parameters, which can help in the preservation of existing forests and limits the emission of greenhouse gases.

2. METHODS

2.1 Study Area

This study was carried out at the Kiyaka Agricultural Research Station, which is located at 75 km in the South of Kikwit city in the Bandundu province and it covered 3250 ha. Its geographical coordinates are presented as follows: 5° 16' and 5° 24' South latitude, 18° 57' and 18° 43' East longitude. The altitude varies between 400 to 509 m in the valley and 735 m at plateau level.

2.2 Methods

Five blocks of 100 m/20 m were delineated using a 200 m long nylon wire divided into 10 m intervals. With this delimitation, it was possible to inventory all trees, of which the dbh measured 1.30 m from the chest height. Thus, each species having a dbh ≥ 10 cm was identified and with GPS, the position along with geographical coordinates was collected.

Since we could not directly measure the diameter of each of these trees in the field, hence, the circumference was measured at 1.30 m from the ground. For shafts with buttresses and/or deformations at this level, these measurements were taken above the buttress or deformation.

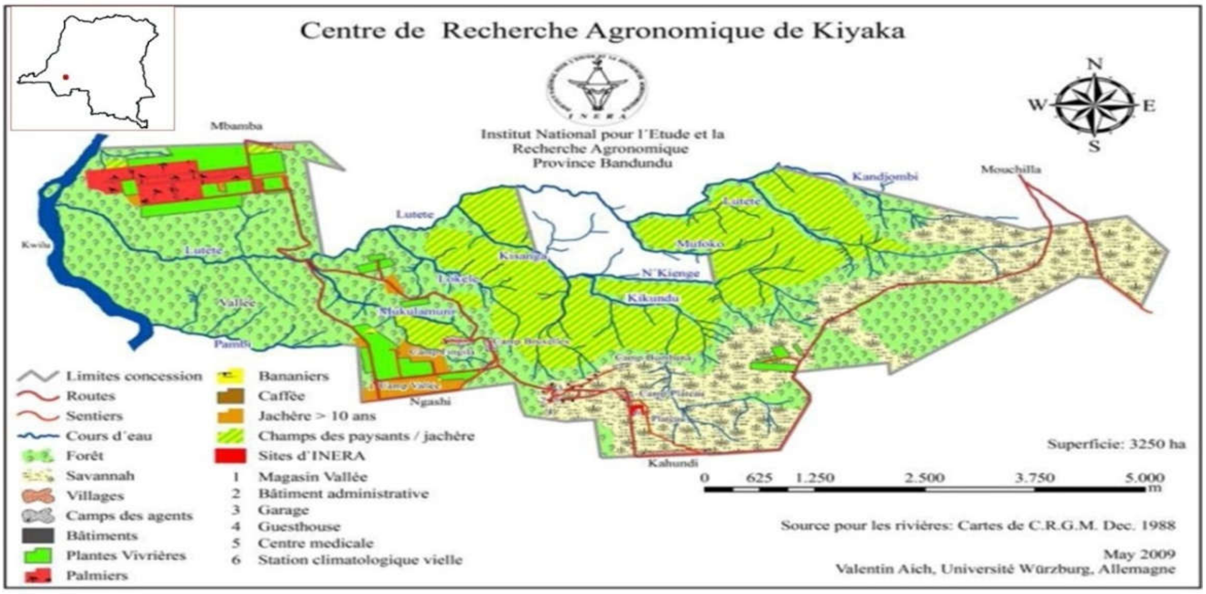

Fig. 1. Map of Kiyaka Agricultural Research Center

For botanical characterization indices, including relative species density (DeR) and relative family density (DfR), were calculated as described by Masens [7].

$$DeR = \frac{Number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ individuals}\ x\ 100 \qquad (1)$$

$$DfR = \frac{Number\ of\ individuals\ in\ a\ family}{Total\ number\ of\ individuals} \qquad (2)$$

The diameter classes of all species with a dbh > 10 cm present in different surveys were measured using a tape measure and grouped into different classes. Eco-sociological groups were differentiated as described in previous studies. Leaf size types were defined from Raunkiaer's classification [8,9]. For biological types (BT), we used Raunkiaer's classification (1934), adapted to tropical regions by Belesi and Habari along with the types of diaspore dissemination were determined [8,9].

2.3 Data Analysis

The statistical analyses of the data were carried out using the SPSS 14.0 software. It allowed us to know if the p-value value is ≤ 0.05, the parameters compared are correlated and if the p-value values are ≥ 0.05, we conclude that there is no correlation between the parameters taken into account. The ArcGIS and QGIS software were used to produce the map and to spatially distribute the species.

3. RESULTS AND DISCUSSION

3.1 The Flower of the Forest Massif Studied

The floristic inventory listed 48 species, which were distributed into 11 orders, 19 families and 42 genera. The families of Fabaceae, Malvaceae, Apocynaceae, Euphorbiaceae and Olacaceae had each 26 species. While the following nine families, Annonaceae, Ebenaceae, Irvingiaceae, Lecythidaceae, Cecropiaceae, Rubiaceae, Sapotaceae, Ulmaceae and Verbenaceae were poorly represented.

Table 1 presents the floristic list of the studied area along with different parameters used.

The floristic inventory listed 48 species, which were distributed into 11 orders, 19 families and 42 genera. The families of Fabaceae, Malvaceae, Apocynaceae, Euphorbiaceae and Olacaceae had each 26 species. While these families, Ebenaceae, Rubiaceae, Ulmaceae and Verbenaceae were poorly represented in terms of species.

3.2 The Relative Density

The relative density of collected specimens in the study area is presented in the Table 2.

Table 1. Floristic inventory of Kiyaka massif forest

Scientific names of species	Number of specimens	dbh (cm)	ST (m^2)	Aerial biomass (t/ha)		Stored Carbon (t/ha)		Equivalent C (t/ha)	
				Chave	Pearson	Chave	Pearson	Chave	Pearson
Alstonia boonei	12	218	0,35	13,23	10,6	6,22	4,98	22,81	18,27
Angylocalyx margininervatus	5	108	0,22	9,86	5,8	4,63	2,73	16,99	9,99
Anonidium mannii	8	421	1,63	100,13	31,52	47,06	14,81	172,58	54,32
Barteria nigritiana var. fistulosa	5	66	0,07	2,03	2,11	0,95	0,99	3,49	3,64
Brachystegia laurentii	471	814,7	15,38	651,44	405,23	306,18	190,46	1122,75	698,41
Canarium schweinfurthii	7	322	3,81	34,54	47,69	39,73	22,42	145,7	82,21
Carapa procera	2	143	1,24	59,34	14,76	27,89	6,94	102,27	25,43
Ceiba pentandra	3	103	0,32	17,57	6,61	8,26	3,11	30,29	11,39
Celtis mildbraedii	9	273	0,67	31,28	14,75	14,7	6,99	53,92	25,42
Chrysophyllum lacourtianum	15	398	0,91	41,99	25,71	19,74	12,08	72,38	44,31
Cola acuminata	1	11	0,01	0,27	0,29	0,13	0,13	0,47	0,49
Cola bruneelii	8	247	0,55	24,87	13,84	11,69	6,22	42,87	22,82
Cola diversifolia	2	25	0,02	0,68	0,71	0,32	6,22	1,17	1,22
Cola griseiflora	2	42	0,08	3,09	1,87	1,45	0,88	5,33	3,22
Croton sylvaticus	1	16	0,02	0,69	0,73	0,33	0,34	1,2	1,25
Dacryodes klaineana	6	111	0,18	6,83	5,37	3,21	2,52	11,77	9,25
Dichostemma glauscens	8	325	1,06	57,38	19,39	26,97	5,11	98,89	33,42
Diospyros conocarpa	1	14	0,02	0,48	0,5	0,22	0,24	0,83	0,87
Duboscia viridiflora	3	201	1,96	70,98	22,12	33,36	10,39	122,33	38,12
Entandrophragma cylindricum	9	261	0,6	27,05	14,18	12,71	6,66	46,62	24,43
Entandrophragma utile	5	562	5,11	355,15	46,49	166,85	21,85	612,09	80,13
Funtumia africana	1	22	0,04	1,49	1,54	0,69	0,72	2,56	2,66
Garcinia kola	5	197	0,83	33,91	16,91	15,96	7,95	58,53	29,14
Hallea stipulosa	2	39	0,06	2,13	2,22	1	1,04	3,68	3,83
Hollarhena floribunda	10	147	0,18	5,68	5,92	2,67	2,78	9,79	10,21
Homalium longistylum	3	158	0,67	41,46	13,81	19,49	6,49	71,46	23,81
Irvingia robur	1	46	0,17	9,62	3,24	4,52	1,52	16,58	5,58
Mammea africana	2	35	0,05	1,82	1,89	0,85	0,89	3,14	3,26
Musanga cecropioides	4	179	0,63	35,31	11,91	16,59	5,59	60,86	20,52
Olax archesoniana	2	86	0,26	13,51	4,58	6,35	2,15	23,29	7,89

Scientific names of species	Number of specimens	dbh (cm)	ST (m^2)	Aerial biomass (t/ha)		Stored Carbon (t/ha)		Equivalent C (t/ha)	
				Chave	Pearson	Chave	Pearson	Chave	Pearson
Olax sp	1	58	0,21	13,33	4,45	6,26	2,09	22,97	7,68
Oncoba welwitschii	3	16	0,69	43,9	14,6	20,63	8,86	75,67	25,16
Pentaclethra ma crophylla	4	12	0,33	15,89	7,96	7,47	3,74	27,39	13,71
Petersianthus macrocarpus	5	209	0,71	39,12	13,19	18,38	6,2	67,42	22,74
Piptadeniastrum africanum	1	153	1,83	65,9	18,27	30,97	8,56	113,58	31,39
Plagiostyle africana	4	69	0,1	3,77	2,83	1,77	1,33	6,49	4,88
Prioria balsamifera	4	18	5,43	330,59	58,78	155,38	27,62	569,77	101,3
Pycnanthus angolensis	4	259	1,33	63,42	29,9	29,81	14,05	109,31	51,53
Ricinodendron heudelotii var. africanum	1	124	1,21	58,34	13,71	27,42	6,44	100,54	83,63
Scorodophloeus zenkeri	4	297	1,76	90,15	38,26	42,37	17,98	155,38	65,95
Staudtia kamerounensis	4	203	0,83	50,47	16,86	23,72	7,92	86,99	29,05
Sterculia tracagantha	8	157	0,33	15,46	8,57	7,26	4,03	26,64	14,78
Strombosia pustulata	3	76	0,15	6,23	4,11	2,93	1,93	10,74	7,08
Strombosia sp	1	77	0,46	17,35	11,32	8,16	5,32	29,92	19,51
Symphonia globulifera	4	153	0,47	24,81	8,89	11,65	4,18	42,75	15,32
Tabernaemontana crassa	3	88	0,21	10,09	4,81	4,74	2,26	17,4	8,29
Tetrapleura tetraptera	3	168	0,9	39,43	17,48	18,53	8,21	67,96	30,13
Vitex welwitschii	2	81	0,26	13,67	4,63	6,42	2,18	23,56	7,98
Total	201	167,93	54,31	2555,73	1030,91	1224,59	488,1	4491,12	1835,62

Table 2. Relative density of collected in the study area

Scientific names	Number of specimens	Relative frequency (%)
Brachystegia laurentii(De Wild.) Louis	471	70,09
Chrysophyllum lacourtianum De Wild.	15	2,33
Alstonia boonei De Wild.	12	1,78
Hollarhena floribunda (G. Don) Dur. & Schinz.	10	1,49
Celtis mildbraedii Engl.	9	1,34
Entandrophrama cylindricum Sprague	9	1,34
Anonidium mannii (Oliv.) Engl. et Diels	8	1,19
Cola bruneelii De Wild.	8	1,19
Dichostemma glauscens Pierre	8	1,19
Sterculia tracagantha Lindl.	8	1,19
Canarium schweinfurhtii Engl.	7	1,04
Dacryodes klaineana (Pierre) H.L. Lam.	6	0,89
Angylocalyx margininervatus (Baker.) Baker.	5	0,74
Barteria nigritiana Hook. f.	5	0,74
Entandrophragma utile Sprague	5	0,74
Garcinia kola Heckel	5	0,74
Petersianthus macrocarpus (P. Beauv.) Liben	5	0,74
Musanga cecropioides R. Br.	4	0,59
Pentaclethra macrophylla Benth.	4	0,59
Plagiostyle africana (Mül.-Arg.) Prain	4	0,59
Prioria balsamifera (Harms) Breteler. comb nov.	4	0,59
Pycnanthus angolense (Welw.) Exell.	4	0,59
Scorodophloeus zenkeri Harms	4	0,59
Staudtia kamerounensis Warb.	4	0,59
Symphonia globulifera L.	4	0,59
Ceiba pentandra Gaertn.	3	0,45
Duboscia viridiflora (K. Schum.) Mildbr.	3	0,45
Homalium longistylum Mast.	3	0,45
Oncoba welwitschii Oliv.	3	0,45
Strombosia pustulata Oliv.	3	0,45
Tabernaemontana crassa Benth.	3	0,45
Tetrapleura tetraptera (Thonn.) Taub.	3	0,45
Carapa procera DC.	2	0,29
Cola diversifolia	2	0,29
Cola griseiflora De Wild.	2	0,29
Hallea stipulosa (DC.) Leroy	2	0,29
Mammea africana Sabine	2	0,29
Ongokea gore (Hua) Pierre	2	0,29
Vitex welwitschii Gurke	2	0,29
Cola acuminata (P. Beauv.) Schott	1	0,15
Croton sylvaticus Hechst. ex Krauss	1	0,15
Diospyros crassiflora Hiern	1	0,15
Funtumia africana (Benth.) Stapf	1	0,15
Irvingia robur Mildbr.	1	0,15
Olax sp	1	0,15
Piptadeniastrum africanum (Hook. f.) Brenan	1	0,15
Ricinodendron heudelotii (Baill.) Pierre ex Heckel	1	0,15
Strombosia sp	1	0,15

From the Table 2, it is clearly shown that *Brachystegia laurentii* (70.09%) was the most abundant species identified, followed by *Chrysophyllum lacourtianum* (2.33%), *Alstona boonei* (1.78%), *Hollarhena floribunda* (1.49%). While *Cola acuminata, Croton sylvaticus, Diospyros crassiflora*, *Funtumia africana, Irvignia robur, Olax sp., Piptadeniastrum africanum,* *Ricinodendron heudelotii* and *Strombosia sp.* were the least represented species.

It was observed that the highest relative density were obtained in the following families: Fabaceae and Malvaceae families (14.58%) while the lowest values of the frequency was observed in the following families: Lecythidaceae, Irvingiaceae, Cecropiaceae (2.08%).

3.3 Basal Area

The highest basal area values were obtained in *Brachystegia laurentii* at 15.38 m^2/ha; then followed by *Entandrophragma utile*, *Prioria balsamifera* and *Canarium schweinfurthii* with 5.43; 5.11 and 3.81 m^2/ha respectively. The lowest basal area values were obtained in *Croton sylvaticus* and *Diospyros crassiflora* with 0.02 m^2/ha each. The total basal area is 54 m^2/ha.

3.4 The Distribution of Trees according to Diameter Classes

The structure of a forest stand depends on the distribution of the number of its species according to diameter (or circumference) classes. Thus, the distribution of species according to the diameter classes is presented in the Fig. 3.

It was observed that within the Kiyaka forest massif, different classes of dbh were designed according to the number of plants and/or stems/ha obtained. There was an abundance of species in the following classes: 10 - 29.9; 30-49.9; and 50 - 69.9, knowing the 10-29.9 cm class was the most representative with 580 specimens (85%) while classes representing emerging species (≥ 80 cm) have only 21 stems/ha. Eleven specimens had the diameter of ≥ 110 while 7 specimens were located in the class of 70-89.9.

The most important dbh was observed in *Prioria balsamifera* (162.42 cm), the smallest in *Alstonia boonei*, *Canarium schweinfurthii* and *Sterculia tracagantha* with 10.19 cm for each; the average tree dbh is 80.30 cm.

3.5 AGB, Sequestered Carbon Stock and Carbon Equivalent

The findings of the AGB, stored carbon stock and carbon equivalent obtained in this forest massif are presented in Table 1. The highest values obtained for these three parameters were observed in *Brachystegia laurentii* (651.44; 306.18 and 1122, 75 t/ha), *Entandrophragma utile* (355.15; 166.85 and 612.09 t/ha) and *Prioria balsamifera* (330.59; 155.38 and 569.77 t/ha).

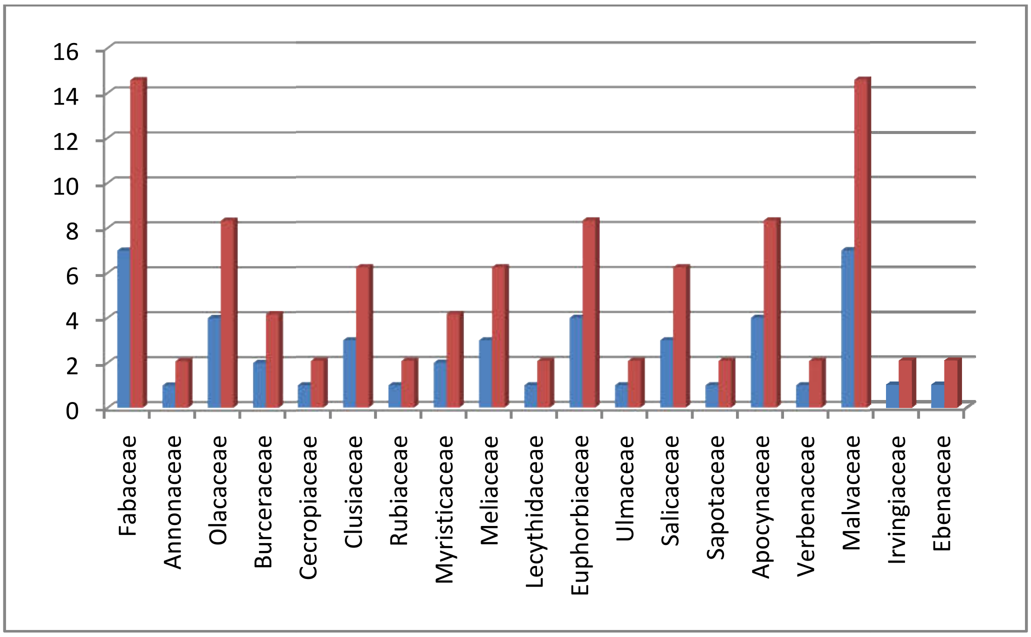

Fig. 2. Relative density of listed families

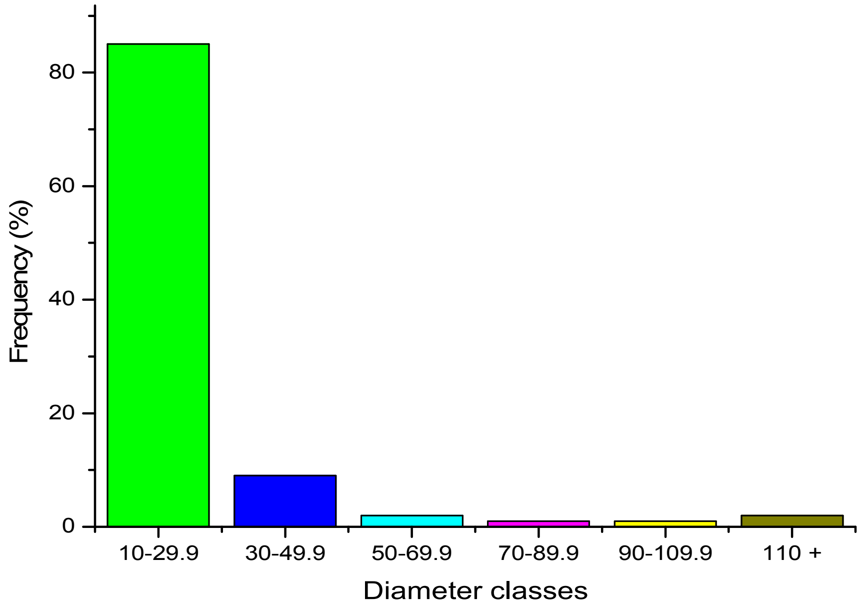

Fig. 3. Distribution of trees according to the diameter classes (dbh)

3.6 Ecological Spectra

The different values of the raw ecological spectra (BT, DT and FT) of the species at dbh ≥ 10 cm listed were determined according the correlation done between different parameters, of which: The AGB and the basal area. It was observed that Mesophanerophytes, sarcochores and mesophyls are more abundant 68.75, 66.67 and 72.92% respectively. Microphanerophytes (10.42%) are the most poorly represented while megaphanerophytes are relatively well represented. Barochores and pleochores, macrophyles and microphylls are the rare diaspore and foliar types found in the listed flora. According to the chorology, the Guinean base element represented 83.8% out of all species found in the florule studied. Species with a wide geographical distribution (At and Pan) are rare, with 2.08% for each of these groups.

3.7 Correlation between AGB and Basal Area

The correlation between AGB and basal area is presented in Table 3.

The proportionality relationship between the AGB and basal area from the Chave and Pearson model shows that the highest AGB value is the highest basal area value and the lowest AGB value is the lowest basal area value. Thus, the linear, logarithmic, quadratic and cubic equations gave acceptable coefficients of determination (r^2), i.e. ≥ 0.900 and the p-value ≤ 0.001. This leads to the conclusion that there is a correlation between the two parameters concerned (Table 4).

3.8 Correlation between AGB and Density

The correlation between AGB and the density is presented in the Table 4.

The findings show that the AGB is not approximately proportional to the diversity. The parameters considered in this way are not significantly correlated. The p-values from all equations are greater than 0.05 i.e. there is no correlation between these two parameters.

3.9 Discussion

The floristic inventory carried out in the forest massif of Kwilu province precisely at Kiyaka station was limited to trees only, of which the dbh measured at 1.30m above the ground starting from trees having the dbh ≥ 10 cm. This methodology enabled the census of 682 individuals distributed into 48 plant species, 19 families and 11 orders.

Among the families listed, the Fabaceae and Malvaceae have a large number of individuals (29.16%). These findings are in the same magnitude as those obtained in previous studies in the phytocenosis of the same station [10]. Contrary to what has been observed in the same

Table 3. Relation between AGB and basal area

Equation	Different models					Parameter estimation			
	r^2	F	ddl1	ddl2	p-value	Constant	b1	b2	b3
Linear	0,999	355,134	1	4	0,000	87,383	8,699		
Logarithmic	0,909	88,232	1	2	0,000	630,276	290,018		
Quadratic	0,938	559,780	2	3	0,000	40,990	5,840	0,068	
Cubic	0,918	662,472	2	2	0,002	30,990	4,840	0,068	0,000

Table 4. Correlation between AGB and density

Equation	Different models					Parameter estimation			
	r^2	F	ddl1	ddl2	p-value	Constant	b1	b2	b3
Linear	0.889	335,122	1	0	0,000	665,994	97,765		
Logarithmic	0.978	43,379	3	1	0,001	557,342	33,010		
Quadratic	0.787	203,643	4	1	0,000	99,874	40,112	0,063	
Cubic	0.676	571,89	2	2	0,001	40832	64,376	0,099	0,001

region, the families of Rubiaceae, Annonaceae and Sapotaceae are among the poorly represented [7,11]. The rarity of species observed within these families could be explained by the fact that our study only took into account species at dbh ≥ 10 cm. Indeed, these families are made up in the majority of cases of trees (Sapotaceae) and/or sub-shrubs, shrubs rarely trees for Annonaceae and Rubiaceae families.

The forest density values of the INERA/Kiyaka station, a relatively hygrophilic lowland phytocenosis, are the highest compared to those observed in the forest massifs of Kamaba and Nzundu [7,11], located on slopes (varying between 3 and 5%) and/or at the top of hills. The values of this parameter, obtained in this phytocenosis, are also higher than those obtained by Sokpon [12] in the *Strombosia glauscens* and *Triplochiton scleroxylon* forest in Benin, Pierlot [13] in the *Scorodophloeus zenkeri* forest (Lubilu, Itasukulu and Lusambila). However, they are lower in the dry dense forest at *Celtis sp* (Lamto) and in the dry dense forest at *Anogerssus leiocarpus* in Côte d'Ivoire, by Lejoly and Sonké [14] in the Dja reserve in Cameroon and Lejoly [15] in the Ngoto forest in the Central African Republic. Rollets [16], inventories give values ranging from 372 vines/ha in the Banco forest in Côte d'Ivoire to 546 vines/ha in Gabon (1st ha, Camp A4) for Africa; 321 plants/ha in the Ducke reserve (Brazil) to 581 plants/ha in Caxuana for America; while in Asia, this author obtains values ranging from 449 plants/ha in Kalimantan Timur Samarinda to 677 plants/ha in Sumatra (Perawang n° 2). Among the families listed, the Fabaceae are the best represented with 471 stalks/ha (70.09%), while the families of Annonaceae, Ebenaceae, Irvingiaceae, Lecythidaceae, Cecropiaceae, Rubiaceae, Sapotaceae, Ulmaceae and Verbenaceae are the poorest with respectively One foot/ha.

These results differ from those obtained by Masens [7,11] in the same region. This difference could be explained by the fact that the first phytocenoses are located in the lowlands while the author's is located at the top of a hill. With regard to basal area, Malaisse [17] indicated that it is a commonly used parameter for distinguishing forest formations on land. The basal area value obtained in the studied phytocenosis is 54.21 m^2/ha. Compared to basal area values obtained in some phytocenoses studied and located in some intertropical countries, it is clear that the land areas of equatorial dense forests are generally between 23 and 50 m^2/ha. Although slightly higher, this value is nevertheless in the same order of magnitude. However, it is lower than that obtained by Golley et al. [18] in the riparian forest in Panama, at 59.6 m^2/ha. As for the distribution of trees in diameter classes, several studies reported that the structure of a forest stand corresponds to the distribution of the number of its trees according to diameter or circumference classes [13,19].

The different values observed for the first two classes of diameter (10-29.9 cm and 30-49.9 cm) have a high proportion of individuals, most of them have a dbh between 10 and 49.9 cm and they are mostly shrubs. Species of which the dbh measured at 1.30 m from the ground in the other 4 classes have a high proportion of large trees. Their distribution follows a curve whose concavity is turned upwards, which testifies, the presence of a large number of shade species. This shows that the dbh of trees increases with the evolution of vegetation. This corroborates with Pierlots [13] study on humic forests of medium altitude in Zaire. The production of AGB contained in a given species depends on its growth in thickness. Thus, the larger the diameter, the greater the AGB increases. This explains the AGB values, the highest obtained in individuals of the *Brachystegia laurentii* species.

4. CONCLUSION

This study provided information not only on the current floristic composition of the lowland forest massif of the INERA/Kiyaka reserve, but also on the aerial biomass, the basal area produced and the amount of sequestered carbon and its carbon equivalent.

The values obtained from the parameters studied allow us to conclude that the forest massif of this reserve plays a significant role in mitigating the global warming currently observed throughout the world and therefore has a slight impact on reducing the rate of greenhouse gases, particularly $C0_2$. However, this reserve is threatened by its inhabitants on all sides; they do want to clear large areas of forest for their field work. It is therefore urgent for INERA/Kiyaka officials to take the necessary measures for its full protection.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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