American Journal of Biological and Environmental Statistics
2024, Vol. 10, No. 4, pp. 114-123
https://doi.org/10.11648/j.ajbes.20241004.13

Research Article

Assessment of Forest Carbon Sequestered in Dead Wood from Secondary Forest, Wildlife Reserve, Lefini Republic of Congo

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Abstract

Dead wood, referred to here as necromass, is considered to be an important reservoir of forest carbon. In Congo, studies on the estimation of carbon in deadwood are scarce, so very little data exists that could contribute to the reflection on the national forest carbon measurement and monitoring program. It is in this context that this study on the estimation of forest carbon stored in dead wood from a secondary forest, in the "Bateke Plateau" landscape, was conducted. One hundred and three (103) standing deadwood samples and thirty-two (32) ground-lying deadwood samples, all ≥ 10 cm in diameter, were recorded over 1.79 km of transects, using the linear intersection sampling method. These deadwoods are mostly not in an advanced stage of decomposition, and are most abundant in smaller diameter classes. On average, the total carbon stock contained in the necromass is 0.067 t. ha-1 (±0.08). This carbon stock does not represent a significant share (0.01%) of the total above-ground carbon for trees ≥ 10 cm in diameter in plot 1. This study also showed that the carbon stock in the necromass varies very little between the study plots but not according to the type of dead wood considered. These results suggest that it is very important to reduce anthropogenic pressure on the forests of the Léfini Wildlife Reserve in order to strengthen carbon sinks.

Keywords

Forest Carbon, Necromass, Above-Ground Biomass, Dead Wood

1. Introduction

In recent years, scientists and politicians alike have been drawing attention to the new challenges facing tropical forests, mainly the forests of the Congo Basin because of the many ecosystem services they provide to global society, while these countries of the Congo Basin have a great need to develop and have been experiencing a population explosion for decades. which together put enormous pressure on natural resources and seriously threaten the diversity and values of tropical forests, particularly in deforestation or forest degradation. The demand is quite high for wood energy, agro-industry, unsustainable agricultural practices, water and soil pollution, poaching, uncontrolled urbanization, etc.

This intertwining of environmental, economic and development issues has led the international community to mobi-

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Received: 13 March 2024; **Accepted:** 19 April 2024; **Published:** 25 December 2024

lize to protect the ecosystem services provided by the tropical forests of the Congo Basin, thanks to the REDD+ system. One service in particular seems to be attracting more attention from the international community. This is the role of these forests in regulating the global carbon cycle because the forest seems to be the most important terrestrial ecosystem for carbon storage, and is an important lever for the policy of reducing anthropogenic carbon dioxide (CO_2) emissions responsible for climate change.

In this context, a better understanding of the benefits and costs of ecosystem-based management of carbon stocks is needed to inform decision-making regarding land use, and many other societal objectives [34]. To help tailor forest policies related to the development of effective ecosystem-based management plans for carbon stocks, research on carbon stocks and fluxes is increasingly in demand. It provides reliable and timely information on forest biomass and carbon stocks that is useful for assessing$_{CO2}$ emissions associated with deforestation and forest degradation.

In a forest ecosystem, above-ground biomass, dead wood, and soil organic matter are among the key reservoirs of forest carbon [6]. Above-ground biomass, which stores most of the carbon, is the most studied reservoir. However, new issues associated with the assessment of forest deadwood (carbon and also biodiversity) require that deadwood be increasingly considered in forest carbon studies as other carbon reservoirs, other than above-ground biomass, that can provide information on forest carbon dynamics. For example, the carbon stock of deadwood ranges from 1 to 50 tC/ha [11, 29] and represents 4-10% of the total vegetation carbon stock of a forest ecosystem. [25] The carbon dynamics of deadwood are therefore of great importance in determining interannual changes in the forest carbon budget [7, 31]. As a result, an accurate estimation of deadwood carbon stocks is an essential element in the biological carbon management of tropical forests in the Congo Basin.

In Central Africa, deadwood is not often taken into account in forest carbon studies, as knowledge on the volumes and dry masses of dead or necromass wood is still lacking. As a result, there is little or no understanding of deadwood carbon stocks and the environmental factors that govern them in the Congo Basin, while the role of deadwood in many ecological and environmental functions that maintain the main processes of forest ecosystem functioning has never been more evident today [21].

In the Republic of Congo, there are very few studies on the quantification, dynamics and functions of deadwood carbon stocks. To date, a few known studies have been carried out, notably in gallery and secondary forests [22], in primary and secondary forests [23], in swamp forests [3], in primary forests dominated by the genus *Celtis* [24] and in logged and unlogged forests [14]. In the Léfini Wildlife Reserve, which is located in a landscape of savannahs and forests called the "Batéké Plateau Landscape", whose average annual$_{CO2}$ fluxes from deforestation and forest degradation are estimated at 1,084,494 tCO 2.yr-1 [34]. This lack of knowledge on deadwood carbon stocks shows the importance of further specifying the contribution of the deadwood basin to the carbon balance and the functioning of the forests of the "Batéké Plateau Landscape" in general and the forests of the Léfini wildlife reserve in particular.

The general objective of this work is to estimate the forest carbon stored in dead wood (necromass) ≥ 10 cm diameter of a secondary forest of the Léfini Wildlife Reserve. Specifically, this consists of:

1) Assess the carbon stocks of standing dead wood and lying dead wood on the ground;
2) Determine the relationship between these two deadwood carbon reservoirs.

2. Methodology Adopted

Experimental Design

In this study, the experimental set-up consists of two (2) rectangular plots (1 and 2) of two hectares each (200 m x 100 m, i.e. 20000 m^2), equidistant by at least 300 m from each other, located 2 km from the village of Mpoh, and easily accessible on the Ngo-Djambala road axis. The installation of the plots consisted of:

1) Opening the washes (layonnage) with machetes and using a pocket observation compass and a 50 m long dendrometric tape, following the North-South and East-West orientation (Figure 1);
2) Grid plots using large wooden stakes (about 2 m long) with red-white markings firmly planted in the ground at the corners of the plots, interspersed by small wooden stakes equidistant 10 m with red-white markings.

Figure 1. *Opening a layon with the compass.*

Each plot was subdivided into two (02) sampling units (sub-plots) of 100 m × 100 m (10,000 m²) each, i.e. a study area of 1 ha. In each of the sub-plots, four transects of 111.7 m in length have been established in a "pinwheel" plan, in which the transects extend from the corners of the sub-plot, starting at the southwest corner (transect 1) to the middle of the layon facing it, and so on (Figure 2).

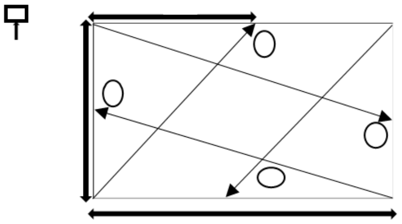

Figure 2. *Sampling method for dead wood of Ø ≥ 10 cm, standing and lying on the ground, in a 1ha subplot (Kouassi, 2018).*

These transects were established to sample dead wood standing and lying on the ground. Within the plots, each study sub-plot was subdivided into four plots of 50 m × 50 m (2500 m^2). The lines of the plot boundaries were marked with orange and yellow flags. The georeferencing of the plots was done by marking the stakes of each plot using a GPS. Inside each plot, all living trees Ø ≥10 cm were sampled.

Sampling

Deadwood sampling

Deadwood standing or standing

In each study subplot, the experimental set-up consists of two (2) rectangular plots (1 and 2) of two hectares each (200 m x 100 m, i.e. 20000 m^2), equidistant at least 300 m from each other that we have made the diametric measurements of the dead and living wood Figure 3.

Figure 3. *Measuring the height of standing dead wood with the relascope.*

Dead wood lying on the ground

In each study sub-plot and on each transect, all dead wood lying on the ground of Ø ≥10 cm, and with at least 50% of the diameter crossed by a sampling line, was systematically sampled. The diameter, di, and the length, li, were measured using a tape measure (Figures 4 and 5).

Figure 4. *Sampling line through dead wood lying on the ground.*

Figure 5. *Measurements of dead wood lying on the ground (a. diameter and b. length).*

Characterization of the degree of degradation of dead wood

During the sampling of deadwood, standing and lying on the ground, the state of decomposition was taken into account on the basis of the resistance of the wood to the penetration of a machete into the body of the dead wood [25, 12]. For this purpose, a decomposition class was assigned to each sampled deadwood, with decomposition class 1 representing newly fallen dead wood and class 5 representing rotten deadwood (Table 1).

Sampling of live trees

In each demarcated plot of 2500 m², all living trees Ø ≥10 cm were sampled by measuring the diameter at 1.30 m from ground level or 30 cm above buttresses or other deformations with a tape measure, and identifying them according to the nomenclature of the APGIII (Angiosperm Phylogeny Group, 2009). Species identification was based on the edge (colour and odour of the exudate), the appearance of the inner bark, the characteristics of the leaves and possibly the flowers and/or fruits. However, when necessary, a leaf sample and a photo of the slice were collected for each individual in order to ensure later ex situ precise botanical determination.

Data processing and statistical analysis

The data collected in the field were recorded in an Excel file to be processed and analysed by statistical means by applying the appropriate formulas found in the literature, but also to test the correlation between the two carbon pools. All statistical analyses were performed with the RStudio interface of the R software [32].

Calculating the Volume of Standing Dead Wood

For each standing deadwood (<1.3 m>) per transect, the volume, v_s, was calculated from the diameter and height measurements using the Smalian formula [19]:

$$v_s = h\left(\frac{\Pi\left(\frac{d_b}{2}\right)^2 + \Pi\left(\frac{d_t}{2}\right)^2}{2}\right) \quad (1)$$

V_S: Volume of standing dead wood (m^3).

d_t: diameter at the top (m).

d_b: diameter at the base or 1.3 m from the ground (m).

h: height of standing dead wood (m).

However, for any standing dead wood greater than 1.3 m in height, d_t was estimated by applying the taper function proposed by [7]:

$$d_t = 1{,}59 d_b (h^{-0{,}091}) \quad (2)$$

To determine the volume per ha of standing deadwood, V_s, all volumes of standing deadwood, v_s, (<1.3 m>) per transect were added together, and then the result was divided by the area of the transect (length of transect, L, × 20):

$$V_s = \frac{1}{20.L}\,\Sigma v_s \quad (3)$$

V_s: volume of standing dead wood per ha (m^3. $^{ha-1}$).

L: transect length (m) = 446.8 m in the case of our study.

Calculation of the volume of dead wood lying down

Using measurements of diameter and transect length, the volume per ha of dead wood accumulated on the ground, V_f, was calculated from the mathematical formula proposed by [39]:

$$V_f = \frac{\Pi^2.\Sigma d_i^{\,2}}{8.L} \quad (4)$$

V_f: volume of dead wood accumulated on the ground (m 3.ha^{-1})

d_i: diameter of each dead wood lying on the ground (m).

L: transect length (m) = 446.8 m in the case of our study.

Calculation of the carbon stock of the necromass

The necromass per ha (kg.ha-1) of all dead wood, standing and lying down, *BM*, was calculated as the product of the volume per ha (V_s and v_f, $m^{3.ha-1}$) and the density of the wood (Carlson *et al.* 2016). To make this calculation, the average value of the default wood density of 0.48 kg. $^{MS.m-3}$ was considered [22]. Second, since about half of the dry organic matter stored in dead wood is carbon, the conversion of necromass, *BM*, to carbon stock per ha (kg.ha-1), *CBM*, was achieved according to [4] as follows:

$$CBM = BM\ x\ 0{,}5 \quad (5)$$

CBM: carbon stock of standing and/or lying dead wood ($^{kg.ha-1}$ then t. $^{ha-1}$).

BM: dry mass of standing and/or lying dead wood (kg.ha-1).

The estimated carbon stocks, *CBMs*, between standing and lying dead wood on the ground, sampled in the two experimental plots were compared by performing a student's test (t-test) with a significance threshold of 5%.

Calculating the carbon of living trees

The estimate of dry above-ground biomass of living trees (AGB) was obtained from the equation of Fayolle *et al.* (2018). The mathematical expression for this equation is:

$$AGB = \exp[0.046 + 1.156 \times \log(WD) + 1.123 \times \log(D) + 0.436 \times (\log(D))^2 - 0.045 \times (\log(D))^3] \quad (6)$$

AGB: estimate aboveground biomass (estimated above-ground biomass, $^{kg.ha-1}$ then t. $^{ha-1}$).

WD: wood density ($^{g.cm-3}$).

D: diameter (reference diameter, cm).

The wood density of each species was obtained from the DRYAD database [9, 30]. The average wood density of 0.582 $^{g.cm-3}$ of dry land moist dense forest species in Central Africa [15] was attributed to species whose wood density was not included in the DYAD database [7, 26].

To calculate the carbon stock in living trees, AGC, the dry above-ground biomass conversion coefficient of trees, AGB, to carbon of 0.5 was used [4].

$$AGC = AGB\ x\ 0{,}5 \quad (7)$$

AGC: estimate aboveground carbon (kg.ha-1 or t. $^{ha-1}$).,

AGB: estimated above-ground biomass (t. $^{ha-1}$).

These AGC data were then used to make the qualitative comparison of the total carbon stock of the dead wood and the total carbon stock of the live trees sampled in Plot 1 (where the above-ground biomass measurements were made) by comparing *CBM* to *AGC* multiplied by 100.

3. Results and Discussion

3.1. Results

Characterization of necromass

Diameter distribution

The distribution of the diameters of standing and lying dead wood on the ground is shown in Figure 6.

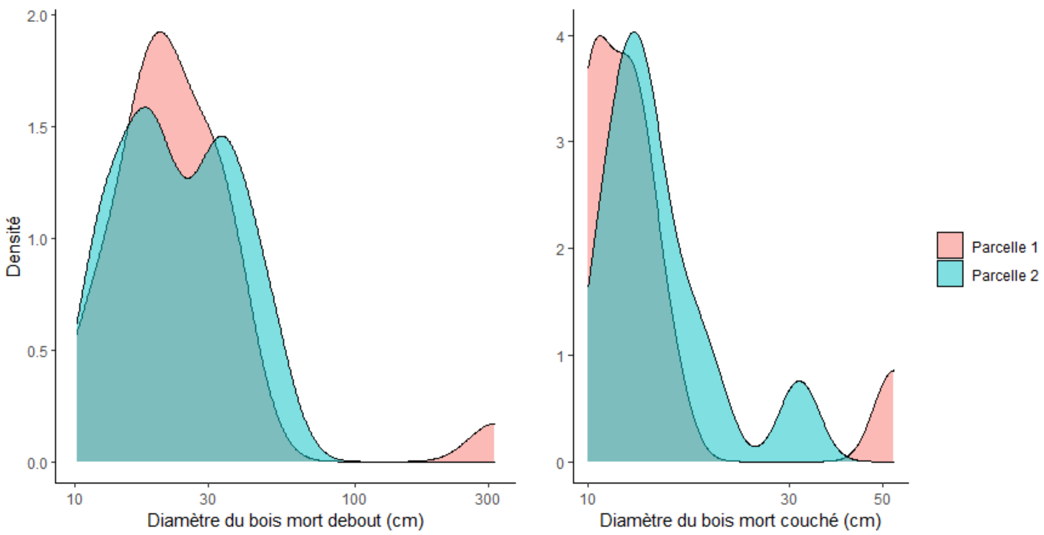

Figure 6. *Diameter distribution (≥ 10 cm) of dead wood standing and lying on the ground.*

In the two study plots, there are an average of 52 standing dead wood samples per hectare and 16 dead wood samples lying on the ground recorded per 100 m of walking. The densities of the diameters are characterized by a decrease in the diameter distribution: it is observed that wood samples are more abundant in the small diameter classes and decrease with the increase in diameter for the two types of dead wood considered. The maximum diameters of standing dead timber and ground-lying dead timber measured in the two study plots are, respectively, in plot 1, 53.3 cm (lying deadwood) and 317 cm (standing deadwood), in plot 2, 32 cm (lying deadwood) and 59.87 cm (standing deadwood).

Height distribution of standing dead wood

The distribution of standing dead wood height is shown in Figure 7.

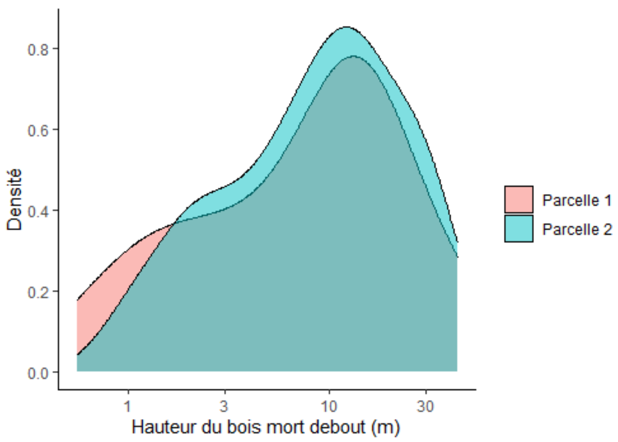

Figure 7. *Height distribution of standing dead wood grouped by plot.*

In both study plots, a greater number of standing deadwood samples with heights ranging from 10 to 30 m recorded were observed. This may mean that the distribution of standing dead wood does not vary much across the site: standing dead wood between 10 and 30 m in height appears to be the most abundant in the secondary forests of the L éfini Wildlife Reserve.

Length distribution of dead lying wood

The distribution of the length of dead wood lying on the ground is shown in Figure 8.

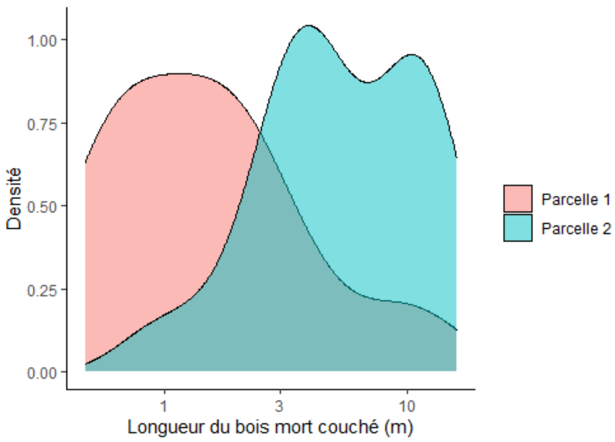

Figure 8. *Length distribution of lying dead wood grouped by plot.*

In plot 1, there are a large number of samples of dead wood lying on the ground recorded per 100 m of walking with a length of less than 3 m. Whereas in plot 2, samples of dead wood lying on the ground recorded per 100 m of walking with a length varying from 3 to 10 m are the most abundant. This difference in the length distribution of dead wood lying on the ground in the two study plots shows that there is a spatial variability in dead wood lying on the ground recorded per 100 m of walking in the secondary forests of the

Léfini Wildlife Reserve.

Distribution of deadwood decomposition classes in the two study plots

The distribution of dead wood decomposition classes in the two study plots is shown in Table 1.

Table 1. *Proportion of total deadwood decomposition classes.*

Decomposition Class	Proportion of dead wood (%)
Class 1	30,15
Class 2	23,53
Class 3	25,00
Class 4	18,38
Class 5	2,94

The results obtained show that there is more dead wood in class 1 (30.15%), which represents newly fallen solid wood, than in class 5 (2.94%), which represents friable or rotten wood with a lack of solid structure. It should also be noted that in the two study plots, only one standing dead wood of Class 5 and one dead wood lying on the ground of class 1 were sampled. This shows that dead wood lying on the ground recorded per 100 m of walking represents almost the entire highly decomposed class (class 5).

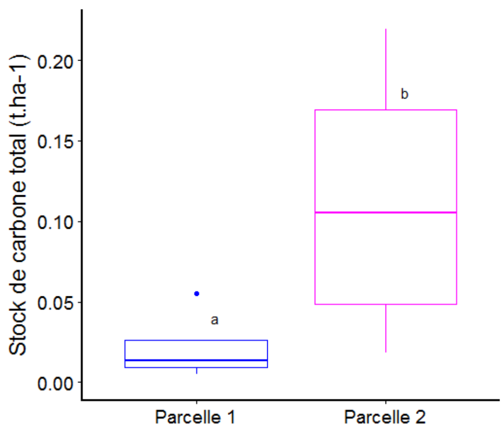

Figure 9. *Spatial variability between the two study plots of the total carbon stock.*

Changes in necromass carbon stock

Change in total carbon stock

The totalcarbon stock difference between the two study plots is shown in Figure 9.

Variation in carbon stock by type of dead wood

a. Across the two study plots

The variationof carbon stocks of standing dead wood and dead wood lying on the ground in the two study plots is shown in Figure 10.

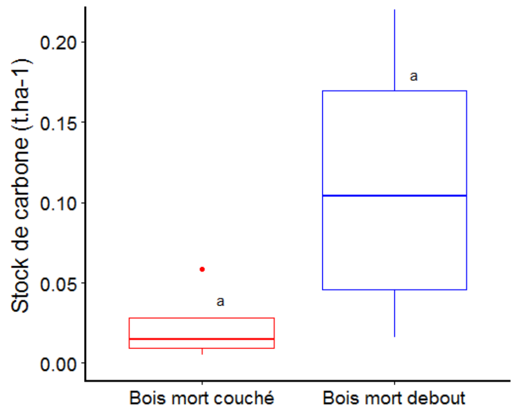

Figure 10. *Difference in carbon stocks of standing dead wood and dead wood lying on the ground across the two plots.*

Across the two study plots, the carbon stock varies on average depending on the type of dead wood considered. The carbon stock of dead wood lying on the ground (0.023±0.024 t.ha-1) is significantly lower than that of standing dead wood (0.11±0.09 t.ha-1). However, based on the Kruskal–Wallis test, this difference was not statistically significant (P=0.15).

b. In each of the two study plots

The carbonstock growth of standing dead wood and dead wood lying on the ground in each of the two study plots is shown in Figure 11.

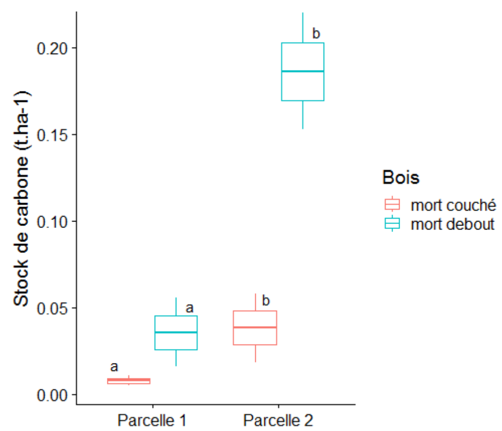

Figure 11. *Difference in carbon stocks of standing dead wood and dead wood lying on the ground according to plot type.*

The carbon stock also varies on average according to the type of dead wood considered, regardless of the plot. Carbon stocks in Plot 1 are 0.04 t for standing dead wood and 0.01 t for dead wood lying on the ground. Plot 2 has the highest carbon stocks of standing dead wood (0.19 t) and lying on the ground (0.04 t). However, the Kruskal–Wallis test showed *no statistically significant difference (P = 0.12) between the carbon stocks of standing dead wood and dead wood lying on the ground in both Plot 1 and Plot 2.*

Qualitative comparison of carbon stocks of necromass and living trees

When comparing the carbon stored in the necromass with the carbon stored in the living trees in plot 1 (for which the above-ground biomass measurements were carried out), it is found that the carbon stock in the necromass represents only about 0.01% of the total above-ground carbon storage for trees with a diameter ≥ 10 cm with a value of 0.022 t.C.ha-1 for dead wood compared to 238.67 t.C.ha-1 for living trees.

3.2. Discussion

On the Characterization of Structural Parameters: In both study plots, deadwood is more abundant in the smaller diameter classes and becomes less and less frequent as the diameter class increases due to the demographics of forest trees. This is evident from the result where the distribution of standing dead wood heights is similar in the two study plots. But the distribution of the lengths of dead wood lying on the ground showed a different result in the two study plots. This difference in the distribution in height and length is somewhat surprising. According to [24], in a mature forest, dead wood comes mainly from young trees that are suppressed by competition with large trees. According to [17], trees taller than 30 metres are more resilient to changes in precipitation than trees less than 20 metres tall. These tall trees also feature... Regarding the distribution of decomposition classes: A living tree is composed of more than 90% dead cells that form a long-term stock of wood awaiting decomposition [16]. To this end, necromass can be considered as a vital attribute of the forest ecosystem [1]. In this study, all the necromass collected was analysed using a classification of the stages of decomposition of dead wood into 5 classes defined according to different characteristics (Table 1).

In the two study plots, most of the dead wood is not in an advanced stage of decomposition. Decomposition classes 1, 2 and 3 contain the largest proportion of necromass stocks in contrast to Kouassi's study in a forest in northern Congo which found a large proportion of necromass in classes 4 and 5. According to [8], in a system of five decomposition classes, class 1 is the one that often has a low number of dead wood samples, quite the opposite of what was found in this study. The result in this study therefore does not seem to be typical of most tropical rainforests where decomposition rates are quite high [20].

In addition, the density of dead wood in classes 1 (less decomposed) and 5 (more decomposed) varies by type of dead wood considered. According to the literature, a dead tree with little contact with soil moisture (standing dead wood) degrades more slowly than a dead tree lying on the ground [40]. This is consistent with what is found in this study with a higher number of lying dead wood in class 5 than standing dead wood. This higher rate of decomposition of dead wood lying on the ground therefore very often depends on the mesos and microclimates that determine the activity of the decomposers [2].

Finally, on Necromass and carbon stock: The total carbon stored in the necromass varies significantly but very slightly (P = 0.04) between the two study plots, with an average of 0.067 t.ha-1 (±0.08). This average total carbon stock obtained in this study is different and lower compared to the averages found in the studies carried out mainly in Congo [22]: 109.93 tCha-1 and 141.72 tCha-1; [22, 3]: 9.45 tCha-1; [33]: 0.975 tCha-1; [14, 24]. This difference in necromass carbon stocks compared to these studies was expected. It can be explained by factors such as the age, structure and dynamics of the forests studied [35], but also by winds and natural windthrow phenomena [23].

Apart from these factors, the study method used to sample deadwood is also often put forward to explain differences in necromass stocks [2] in an attempt to show that these stocks tend to increase with the length of the study transect line, given the low frequency of large dead trees [18]. In this study, a transect line of 446.8 m per sampling unit was used, and therefore a priori a higher sampling intensity compared to the studies of [22, 3, 23, 36, 14] which respectively used transect lines of 160 m, 100 m, 100 m, 71 m and 200 m per sample unit. Yet, significantly lower mean values of necromass stocks were found in this study, which seems to contradict the assertion that necromass stocks, and thus its carbon, increase with the length of the study transect line. This could certainly be explained by: (1) the degree of forest disturbance, and (2) differences in dead wood size classes.

Regarding the degree of disturbance, the two study plots were set up about 2 km from the village of Mpoh established within the boundary of the Léfini Wildlife Reserve. The people of the nearby Mpoh village practice various farming activities in the reserve and often use the easily harvestable dead wood for cooking and heating, but sometimes also for the production and marketing of wood energy. Thus, the disturbance due to the collection of dead tree remains for wood energy may justify the low accumulation of necromass stocks and its carbon in this study. These high removal rates of dead wood, mainly lying on the ground, may also explain why, contrary to what is reported in the literature, the carbon stocks of standing dead wood are higher compared to those of dead wood lying on the ground.

Indeed, it was found in this study that more than half of the total carbon stock comes from standing dead wood (82.73%) than from ground-lying dead wood (17.27%), although no statistically significant difference was found between these two necromass carbon pools (P = 0.15; Figure 11).

(2) According to [10], the sample size of dead wood is the most important factor in the carbon pool of dead wood, as large dead trees have high necromass and longer decomposition time. But there aren't many large dead trees in a rainfor-

est. Also, in many studies in the tropics, such as that of [22] carried out in the "Batéké Plateau Landscape", smaller size classes (generally less than 10 cm in diameter) are often taken into account in the sampling of dead wood. According to [38, 15], these smaller size classes contribute up to 21% of the total deadwood stock.

However, the latter are likely to include a significant component of small branches that are sometimes cut due to physical damage resulting from crown interactions, animal activity, and many other processes that may not result in mortality of the entire tree [5]. It could therefore be that the necromass stocks found in some studies overestimate the carbon production due to the actual death of the trees compared to that of this study.

For the Proportion of Necromass Carbon to Total Airborne Carbon: In our case, the ratio CBM to AGC is very low at 0.01%. This means that in a secondary forest in the Léfini Wildlife Reserve, the total carbon stock of the necromass does not increase with the increase in the carbon of living trees. This estimate is much lower than that proposed by [27] who estimated the proportion of necromass carbon at 12.7% of above-ground biomass in tropical Africa.

In many studies, necromass stock often includes dead trees and branches less than 10 cm in diameter. The fact that the carbon production of the necromass of small classes (dead trees and branches < 10 cm in diameter) is not taken into account may therefore explain this very large difference in the ratios. This highlights the importance of including smaller size classes in field deadwood sampling during forest carbon inventories.

4. Conclusion and Perspectives

According to the IPCC guidelines for greenhouse gas (GHG) inventories, the consideration of carbon stocks in deadwood is of great importance for a more accurate estimation of forest carbon budgets. The main objective of this study was to estimate the amount of forest carbon that can be stored by different types of dead wood ≥ diameter 10 cm from a secondary forest in the Léfini Wildlife Reserve. In addition to the linear intersection sampling method, different classes of deadwood decomposition were also considered because of their influence in estimating carbon stocks.

The first hypothesis made at the beginning of this study, according to which the total carbon stock of the necromass varies between plots, is valid. The difference in total carbon stocks between two study plots within a secondary forest in the Léfini Wildlife Reserve is on average very small but statistically significant (P= 0.04). On the other hand, in plot 1, the ratio between the total carbon stock in the necromass and the total carbon stock in living trees is very low (0.01%). This seems to show that dead wood carbon does not represent a significant portion of the total above-ground carbon for trees ≥ 10 cm in diameter in a secondary forest in the Léfini Wildlife Reserve.

The second hypothesis, stating that carbon stocks differ according to the type of dead wood considered, is invalidated. Indeed, although higher carbon stocks were found in standing dead wood (82.73%) than in dead wood lying on the ground (17.27%), and even depending on the plot, on average this difference was not significant (P= 0.15).

The interest of this study lies above all in its attempt to estimate the carbon stocks of dead wood in the forests of the Léfini Wildlife Reserve, for which data are not yet available at the national level. To this end, by estimating the carbon stocks of dead wood, specifically from a secondary forest in the Léfini Protected Area (PA), this study contributes in a modest way to the constitution of a database on the carbon of dead wood from the forests of the "Batéké Plateau Landscape", which will serve as references and indications in subsequent studies.

As prospects for future studies on deadwood carbon in the Lefini PA, it can be considered to:

1. Extend the sampling of dead wood to so-called gallery forests which are located far from the surrounding villages;
2. Sample dead wood from Ø < 10 cm;
3. Estimate the specific wood density of each dead wood sampled.

As for practical recommendations, the results obtained in this study can be used in strategic reflections on the effectiveness of the REDD+ process in the Republic of Congo. One of the objectives of the ACFAP, working in the "Batéké Plateau Landscape", is to manage the AP of the Léfini. As the objectives of the REDD+ process and ACFAP are not contradictory, the implementation of a common strategy can be carried out. According to [37], leaving large chunks or fragments of dead wood in forest ecosystems can contribute to strengthening the forest carbon sink. The interest of this common strategy would therefore be to develop community projects by creating a wood energy and agroforestry sector (by planting fast-growing species such as pine and acacia) in the villages on the outskirts of the reserve, with the aim of increasing the availability of wood energy and keeping the local population away from the forest.

Abbreviations

AGC	Estimate Aboveground Carbon (carbone aérien estimé, kg.ha^{-1} out. ha^{-1}).
AGB	Biomasse Aérienne estimée (t. ha^{-1}).
WD	Wood Density (densité spécifique du bois, g.cm^{-3})
CBM	Stock de Carbone du Bois Mort Debout et/ou couché (kg.ha^{-1} puis t. ha^{-1})
BM	Masse Sèche du Bois Mort Debout et/ou couché (kg.ha^{-1})
GPS	Global Positioning System
CO_2	Emissions Anthropiques de Dioxyde de carbone

REDD+	Réduction des émissions de gaz à effet de serre dues à la déforestation et à la dégradation des forêts
APGIII	Angiosperm Phylogeny Group, 2009
GIEC	Le Groupe d'experts Intergouvernemental Sur l'évolution du Climat
GES	*Gaz à effet de serre*
AP	Aire Protégée
ACFAP	American College of Foot and Ankle Pediatrics

Conflicts of Interest

The authors declare no conflicts of interest.

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