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# Biomass and carbon stocks of undergrowth and litter under *Eucalyptus pellita* f. muell plantation in ultisols

**Noor Jannah[1*], Marjenah[2], Syahrinudin[2], Wahjuni Hartati[2], Afif Ruchemi[2]**
[1] Graduate School of Forestry, Mulawarman University Samarinda, Indonesia
[2] Faculty of Forestry, Mulawarman University Samarinda, Samarinda, Indonesia

**Abstract**
Plantation productivity depends entirely on the quality of the land. High initial investment is needed in the development of industrial plantations, so the selection of land must be undertaken carefully. Land quality is also influenced by the vegetation above it, which will produce biomass production and become the largest carbon contributor which has an important role in the biogeochemical cycle. The research objective was to analyze the biomass and carbon of undergrowth (woody and non-woody), litter under the stands of *Eucalyptus pellita* F. Muell at different age classes, and to calculate the percentage of biomass and carbon in each component. The analysis showed that the biomass and carbon of non-woody undergrowth was lower than litter. Total biomass of undergrowth and litter in research plots under stands of 6 months old; 2 years; 4 years and 5 years are 29.22 Mg ha$^{-1}$; 27.17 Mg ha$^{-1}$;17.96 Mg ha$^{-1}$; 23.11 Mg ha$^{-1}$. Meanwhile the total carbon stock of undergrowth and litter is 11.64 Mg ha$^{-1}$; 7.65 Mg ha$^{-1}$; 5.39 Mg ha$^{-1}$; 9.12 Mg ha$^{-1}$. Especially research plots under stands 6 months and 2 years old, the percentage of litter biomass reaches 90.33-91.73% of the total undergrowth and litter biomass, 84.61-93.62% carbon is in the litter of the total plant carbon. bottom and litter. Each type and age of vegetation that grows on the ground affects and produces different biomass qualities. And the remaining biomass becomes a source of organic material that can be used to improve soil quality.

**Keywords:** biomass, carbon, undergrowth, litter, *Eucalyptus pellita* F. muel

## Introduction

Industrial plantation forest is a form of forestry development that is oriented towards the fulfillment of forestry industry raw materials. Well-managed industrial plantations, whose productivity is economically acceptable can only be carried out sustainably on lands that have suitable climatic and soil conditions (Jannah *et al*., 2020) [8]. Plantation productivity depends entirely on the quality of the land. High initial investment is needed in industrial plantation forest development, so the selection of land must be carried out carefully. If unproductive areas are not set aside during the selection of land early in the plantation development, then substantial (financial) losses will occur later (Mackensen, 2000) [9]. *Eucalyptus pellit*a F. Muell is one of the fast growing species (fast growing species) which very important for the pulp and paper industry. Selection of types that are developed must be tailored to the needs of the industry and which have high economic value. The advantages of this type as a fast growing plant are short rotation, less disease, many benefits, and high economic value (Sulichantini, 2016). Clone A was developed as a result of selection from a progeny test carried out in the Riau-Sumatra area in 2005-2008 and has now become a commercial clone since 2012 (Jannah, *et al*., 2020) [8], especially in HTI East Kalimantan which utilizes ultisols type soil,as reported by Denri and Albertus (2020) [4], with pH characteristics of 4.4-5.4 (very acidic), total N 0.05-0.07% (very low), K is interchangeable 0,07-0.13 ppm (very low-low), P available 6.1-10.6 ppm (low-high). Biomass is the total weight/mass or volume of organisms in a particular area or volume (IPCC glossary) or the total dry weight of all living things that can be supported on each level of the food chain (EPA glossary) (Sutaryo, 2009) [16]. Furthermore, it is also defined, that biomass is the total amount of living matter on the surface of a tree and is expressed in units of tonnes of dry weight per unit area. The undergrowth is a plant with a stem circumference (dbh) <6.3 cm which plays an important role in the forest ecosystem and determines the microclimate. Meanwhile, litter functions as a temporary water storage, improves soil structure, and increases absorption capacity (Windusari *et al*., 2012) [19]. Litter is a collection of organic materials on the forest floor that has not or is slightly decomposed. The original form can still be recognized or can still maintain its original form (not destroyed) (Sutaryo, 2009) [16]. Furthermore, it is explained by Pearson et el.(2005) [11] that the litter layer or forest floor is all dead organic matters above the soil surface. Some of organic materials can still be recognized or is still slightly decomposed and soil microorganisms are very important in the decomposition of these organic materials. The role of forests in absorbing $CO_2$ through photosynthesis is very effective in reducing greenhouse gas emissions. The amount of carbon stored by a forest area (carbon stock) is important, thus measuring the amount of carbon stored in the living plant body (biomass) and still stored in dead plant parts (necromas), and litter indirectly describes $CO_2$ which is not released into the air through combustion

(Ratnaningsi, 2013) [14]. Therefore, research was carried out on biomass and carbon stock in undergrowth and litter under the stands of *Eucalyptus pellita F*. Muell with the characteristics of ultisols in industrial plantations in East Kalimantan with the aim of analyzing biomass and carbon stock of undergrowth (woody and non-woody) and litter under stands of *Eucalyptus pellita* F. Muell at different age classes, and calculating the percentage of biomass and carbon stock for each component.

## Materials and Methods

### A. Study Area

The research location is in the Industrial Plantation Forest of PT Surya Hutani Jaya, Sebulu District, Kutai Kartanegara Regency, East Kalimantan Province, Indonesia. The research was conducted within 5-month period, spanning from literature study activities, field orientation, creating a plot research, observation and data collection in the field, laboratory analysis, processing and data analysis, and preparation of the article.

### B. Procedures

### 1. Plot making

The research plot is in the form of a circle with a radius of 12.6 m and an area of 0.05 ha, which is placed using proportional sampling. Within the circular plot there is a 5 m x 5 m (2 subplot) sub-plot to measure undergrowth biomass and 1 m x 1 m (2 subplots) to measure the biomass of non-woody undergrowth and litter. The plot is placed under the stands of *Eucalyptus pellita* F. Muell class stand age 6 months, 2 years, 4 years and 5 years. Each age class is made of 3 plots and 6 sub plots.

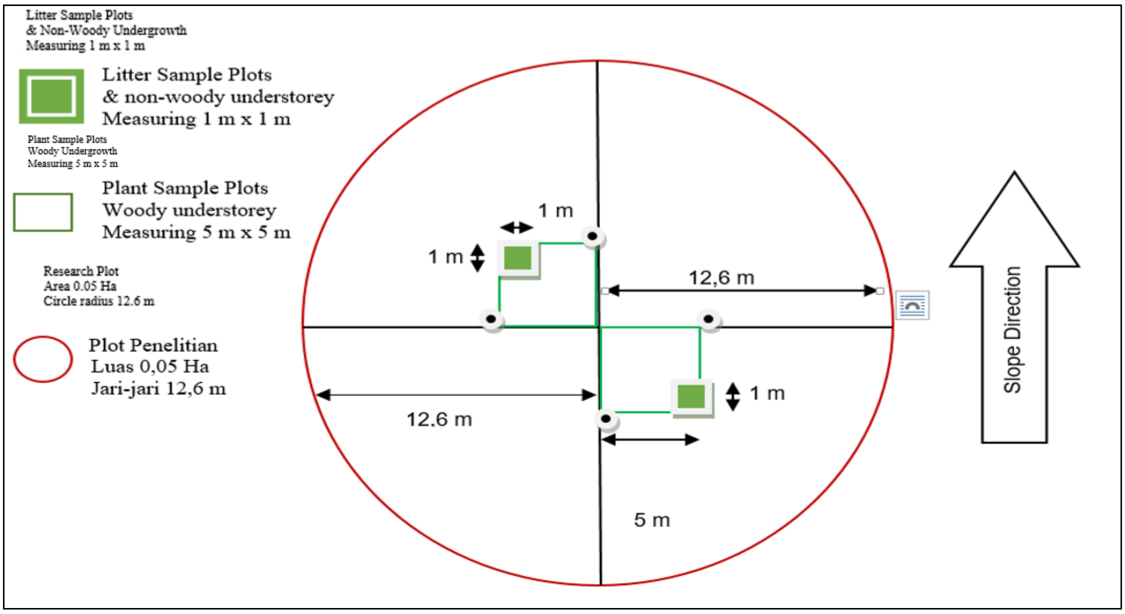



**Fig 1:** Research Plots and Sub Plots

### 2. Biomass measurement

The measurement of biomass was carried out by using the harvesting method (destructive sampling). The estimation of the biomass of woody undergrowth and non-woody undergrowth, and trees with a diameter of <5 cm is carried out by destructive methods, namely by harvesting all non-woody undergrowth and litter in the sample plots measuring 1 m x 1 m, for existing woody understoreies. In the 5 m x 5 m sample plots (Figure 1), the wet weight was then weighed in the field, then a wet biomass sample was taken with a maximum weight of 200 g. Thereupon, this biomass sample is taken to the laboratory to be electric oven dried at 80°C for 48 hours/until its weight is constant. To determine biomass, the Japan International Cooperation Agency / JICA (2002) formula is used.

$$\text{Biomass} = \frac{BKc}{BBc} \times BBt$$

Note:
BKc = Example dry weight (Mg $ha^{-1}$)
BBc = Wet weight example (Mg $ha^{-1}$)
BBt = Total wet weight (Mg $ha^{-1}$)

### 3. Measurement C

C-Organic (%) Walkley-Black modification, using concentrated $K_2Cr_2O_7$ and $H_2SO_4$ reagents. Extracts were measured with a Unicam Spectrophotometer at a wavelength of 500 µm in the laboratory (Budianta, 2013) [3], for undergrowth plants consisting of wood, bark and leaves, woody undergrowth and litter based on the age class of the stands.

**4. Data analysis**

Calculation of carbon from undergrowth biomass using the formula of the Indonesian National Standard (2011) is as follows:

Cb = B x %Corganik

Note:
Cb = Carbon content of biomass (Mg $ha^{-1}$)
B = Total biomass (Mg $ha^{-1}$)
% C = Organic carbon content is a percentage value, use value of percent carbon obtained from measurements in the laboratory

Afterwards, author calculated the mean value, standard deviation and the percentage of each component that is the value of biomass and carbon stocks for woody undergrowth which consists of components of wood, bark and leaves, woody undergrowth and litter.

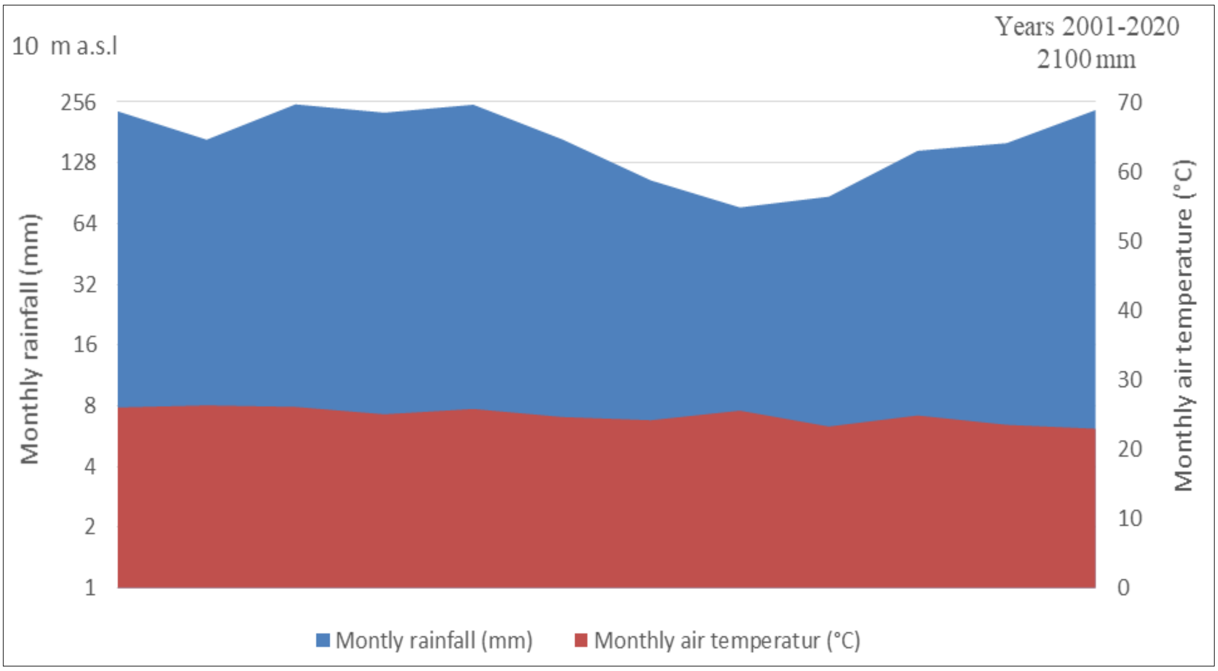
**Results and Discussion**

**A. Research Location Description**

The research locations are located at the location map is shown in Figure 1, with Ultisols soil type at site class II and the fifth crop rotation, based on planting registration of PT Surya Hutani Jaya Sebulu District, East Kalimantan, Indonesia. Ultisols are the most widely distributed land orders in PT Surya Hutani Jaya. Where the soil has a sufficiently strong level of development characterized by the presence of an argillic characteristic horizon (clay leaching to the bottom layer) and base saturation <35%. This land is generally well drained (Prasetyo and Suriadikarta, 2006; Hardjowigeno, 2015). At the group level ground in the area of research, including into Tropudults (SRH, 2018; Denri and Albertus, 2020) [4].

**B. Climatic Conditions at Research Sites**

The research location has the following climatic conditions as shown in Figure 2. Where the climatic conditions in the research location are included in climate type A (very wet) based on Schmidt and Ferguson, with a value of Q = 0% because almost every year there is no dry month. Dry month is the month that has rainfall < 60 mm/month, however it should be noted that August is the month with lower average rainfall compared to other months,approximately 76.95 mm/month. Besides, March is the month with the highest average rainfall rain that takes approximately 249,75 mm/month or 2100 mm/year. For low humidity in September is 68.55% and the highest in May is 79.25%. Furthermore, the lowest air temperature in December is 22.94 °C and highest in March which is 26.09 °C.




(Source PTPH, 2020 and BMKG, 2020)

**Fig 2:** Graph Monthly Rainfall (mm) and Air Temperature (° C) Monthly Year 2001-2020

**C. The estimation of the biomass of woody undergrowth and non-woody undergrowth Non-Timber) and Litter**

Lower vegetation is a type of basic vegetation found under forest stands consisting of grass, herbs and shrubs. The types of undergrowth are annual, biennial, perennial and their distribution patterns can occur randomly, clumps/groups and evenly. In the research location, there were more fast growing vegetation types from the previous vegetation types, including Liana, *Macarangnga* and *Acacia mangium*, *Melastoma malabatricum* and others, more non-woody undergrowth species were found in *Scleria* sp., *Asystasia* sp., *Ageratum* sp., N*ephrolepsis* sp., and *Musa* sp. The vegetation of undergrowth on the forest floor plays an important role in the forest ecosystem and determines the microclimate, it also functions as a barrier to rainwater and surface runoff thereby minimizing the danger of erosion (Hilwan *et al*., 2013) [7]. Biomass and carbon of non-woody undergrowth are lower than litter, this is thought to be related to the slower decomposition process of organic matter in the litter under *E. pellita* stands and is also supported by Viera (2019) [18]. Especially the research plots under stands 6 month and 2 years old, the percentage of litter biomass reaches 90.33-91.73% of the total undergrowth and litter biomass. Likewise, the percentage of 88.79-89.87% carbon was in the litter of the total carbon of undergrowth biomass and litter, in the research plots under 6 month and 2 year old stands. This is thought to be due to the land factor which is the fifth crop rotation, where the remaining vegetation is still piled up, especially the remaining *E. pellita* plants that are not transported by harvests such as bark, branches, twigs and leaves that decompose slowly (Ratnaningsi, 2013) [14]. Each vegetation produces a different quality of biomass. And the remaining biomass becomes a source of organic material that can be used to improve soil quality. Forest plantations play an important role in the global carbon Estimates of biomass and carbon of woody and non-woody undergrowth and litter under stands of *Eucalyptus pellita* F. Muell at different age classes are shown in Tables 1 and 2. Some of the factors that influence the rate of decomposition are soil tillage, temperature, soil moisture, pH, depth. and soil aeration. Soil microorganisms play a major role and is very active, especially in wet tropical climates, which throughout the year based on climate data in Figure 3, showing dominance in wet throughout the year, it is very influential in the decomposition of soil organic matter and release $CO_2$. The loss of organic matter due to decomposition is offset by the supply of organic material from the cover vegetation which is formed from the synthesis of roots, litter, and other parts of the plant that experience decomposition (Barchia, 2009). In the research plot under stands *Eucalyptus pellita* F. Muell aged 6 months; 2 years, 4 years and 5 years respectively as follows: the value of biomass ±sd (% of total biomass) in woody undergrowth is 0.58 Mg $ha^{-1}$ ± 0.23 (1.97%); 0.54 Mg $ha^{-1}$ ±2.26 (1.99%); 4.00 Mg $ha^{-1}$ (22.27%) ±2.26 5.99 Mg $ha^{-1}$ ±2.55 (25.93%). Biomass for non-woody undergrowth is as follows: 1.84 Mg $ha^{-1}$ ±1.26 (6.29%); 2.09 Mg $ha^{-1}$ ±1.37 (7.68%); 2.74 Mg $ha^{-1}$ ±1.37 (15.28%); 1.76 Mg $ha^{-1}$ ±0.97 (7.63%). Biomass for litter is as follows: 26.80 Mg $ha^{-1}$ ±12.34 (91.73%); 24.54 Mg $ha^{-1}$ ±6.76 (90.33%); 11.22 Mg $ha^{-1}$ ±6.76 (62.46%); 15.35 Mg $ha^{-1}$ ±7.01 (66.44%). The carbon in the research plot under *E. pellita* stands was 6 months; 2 years, 4 years and 5 years are as follows: carbon ±sd (% of total carbon) in non-woody undergrowth is 0.51 Mg $ha^{-1}$ ±0.45 (4.36%); 0.96 Mg $ha^{-1}$ ±0.62 (12.56%); 0.57 Mg $ha^{-1}$ ±0.54 (10.64%); 0.68 Mg $ha^{-1}$ ±0.35 (7.42%). Carbon stocks for woody undergrowth are as follows: 0.23 Mg $ha^{-1}$ ±0.07 (2.01%); 0.22 Mg $ha^{-1}$ ±0.03 (2.83%); 1.56 Mg $ha^{-1}$ ±0.68 (28.90%); 3.06 Mg $ha^{-1}$ ±0.60 (33.57%); The carbon in the litter is also in the following sequence: 10.90 Mg $ha^{-1}$ ±4.90 (93.62%); 6.47 Mg $ha^{-1}$ ±1.62 (84.61%); 3.26 Mg $ha^{-1}$ ±0.74 (60.46%); 5.38 Mg $ha^{-1}$ ±2.47 (59.01%).

This is also supported by Ratnaningsi (2013) [14] which stated that litter carbon> 60%, Viera (2019) stated that litter carbon 85.27% of the total undergrowth and litter carbon. Biomass and carbon of undergrowth increase with increasing age of the stands above.

**Table 1:** Biomass Estimation of Woody Undergrowth, Non-Woody Undergrowth and Litter Under the Stand of *Eucalyptus pellita* F. Muell at Different Age Classes

| Age Classes | | Biomass (Mg $ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Woody undergrowth | | | Total WU | Non-woody undergrowth | Litter | Total biomass |
| | | Stem | Bark | Leaf | | | | |
| 6 months | Average | 0.42 (1.43%) | 0.04 (0.14%) | 0.12 (0.40%) | 0.58 (1.97%) | 1.84 (6.29%) | 26.80 (91.73%) | 29.22 (100.00%) |
| | Sd | 0.17 | 0.03 | 0.03 | 0.23 | 1.26 | 12.34 | 13.82 |
| 2 years | Average | 0.44 (1.60%) | 0.05 (0.18%) | 0.06 (0.21%) | 0.54 (1.99%) | 2.09 (7.68%) | 24.54 (90.33%) | 27.17 (100.00%) |
| | Sd | 1.23 | 0.46 | 0.57 | 2.26 | 1.37 | 6.76 | 10.40 |
| 4 years | Average | 2.36 (13.14%) | 0.55 (3.06%) | 1.09 (6.07%) | 4.00 (22.27%) | 2.74 (15.28%) | 11.22 (62,46%) | 17.96 (100.00%) |
| | Sd | 1.23 | 0.46 | 0.57 | 2.26 | 1.37 | 6.76 | 10.40 |
| 5 years | Average | 3.46 (14.96%) | 1.04 (4.52%) | 1.49 (6.46%) | 5.99 (25.93%) | 1.76 (7.63%) | 15.35 (66.44%) | 23.11 (100.00%) |
| | Sd | 1.32 | 0.69 | 0.53 | 2.55 | 0.97 | 7.01 | 10.53 |

Note: Sd = Standard deviation WU = Woody undergrowth
(*) = Percentage of total biomass/carbon (undergrowth+litter)

**Table 2:** Carbon Estimation of Woody Undergrowth, Non-Woody Undergrowth and Litter Under the Stand of *Eucalyptus pellita* F. Muell at Different Age Classes

| Age Classes | | Carbon (Mg $ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Woody undergrowth | | | Total WU | Non-woody undergrowth | Litter | Total carbon |
| | | Stem | Bark | Leaf | | | | |
| 6 months | Average | 0.18 (1.55 %) | 0.01 (0.10%) | 0.04 (0.37%) | 0.23 (2.01%) | 0.51 (4.36%) | 10.90 (93.62%) | 11.64 (100.00%) |
| | Sd | 0.06 | 0.01 | 0.02 | 0.07 | 0.45 | 4.90 | 5.17 |
| 2 years | Average | 0.19 (2.44%) | 0.01 (0.17%) | 0.02 (0,22%) | 0.22 (2.83%) | 0.96 (12.56%) | 6.47 (84.61%) | 7.65 (100.00%) |
| | Sd | 0.03 | 0.01 | 0.01 | 0.03 | 0.62 | 1.62 | 1.72 |
| 4 years | Average | 0.99 (18.37%) | 0.21 (3.85%) | 0.36 (6.68%) | 1.56 (28.90%) | 0.57 (10.64%) | 3.26 (60.46%) | 5.39 (100.00%) |
| | Sd | 0.40 | 0.18 | 0.19 | 0.68 | 0.54 | 0.74 | 1.42 |
| 5 years | Average | 1.05 (11.52%) | 0.31 (16.20%) | 0.53 (5.85%) | 3.06 (33.57%) | 0.68 (7.42%) | 5.38 (59.01%) | 9.12 (100.00%) |
| | Sd | 0.30 | 0.11 | 0.11 | 0.60 | 0.35 | 2.47 | 3.07 |

## Conclusion

Biomass and carbon of undergrowth plants are lower than litter. The total biomass of undergrowth and litter in research plots under stands of 6 months old; 2 years; 4 years and 5 years are 29.22 Mg $ha^{-1}$; 27.17 Mg $ha^{-1}$; 17.96 Mg $ha^{-1}$; 23.11 Mg $ha^{-1}$. Meanwhile, the total carbon stock of undergrowth and litter is 11.64 Mg $ha^{-1}$; 7.65 Mg $ha^{-1}$; 5.39 Mg $ha^{-1}$; 9.12 Mg $ha^{-1}$. Especially the research plot under stands 0.5 and 2 years old, the percentage of litter biomass reaches 90.33-91.73% of the total undergrowth and litter biomass, with a carbon percentage of 84.61-93.62% being in the total litter, undergrowth carbon and litter. Each type of vegetation that grows above the ground affects and produces a different quality of biomass. And the remaining biomass becomes a source of organic material that can be used to improve soil quality. The highest biomass from the total biomass of undergrowth and litter ±sd (percentage of total carbon stock) for woody undergrowth was obtained in the research plot under 5 year old *Eucalyptus pellita* F. Muell stands, namely 5.99 Mg $ha^{-1}$ ±2.55 (25.93%), the highest biomass was obtained in the research plot under 4 year old stands, namely 2.74 Mg $ha^{-1}$ ±1.37 (15.28%) and the highest litter biomass was obtained in the research plot in under stands of 6 months old, namely 26.80 Mg $ha^{-1}$ ±12.34 (91.73%). The highest carbon ±sd (percentage of total carbon stock) for woody undergrowth is 3.06 Mg $ha^{-1}$ ±0.60 (33.57%) under 5 years old stands, the lowest is 0.22 Mg $ha^{-1}$ ±0.03 (2.83%) were under 2 year old stands. For non-woody undergrowth, the highest carbon stock was obtained in the research plot under 2 year old stands, namely 0.96 Mg $ha^{-1}$ ±0.62 (12.56%) and the lowest was 0.51 Mg $ha^{-1}$ ±0.45 (4.36%) who are under a 6 months old stand. The next highest litter carbon stocks gained on research plots under 6 months old stand that is 10.90 Mg $ha^{-1}$ ±4.90 (93.62%), while the lowest was 3.26 Mg $ha^{-1}$ ±0,74 (64.77%) were under 4 year old stands.

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