

Productivity and rate of litter decomposition in wimbi watershed forest area, Central Sulawesi, Indonesia

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ABSTRACT: The purpose of this research was to analyze the productivity and rate of litter decomposition in the Production Forest Area of Wimbi Village, Poso Regency. This research was conducted for six months, from March to September 2021. The method used was the survey method. Litter collection was carried out using a litter trap measuring $1 \times 1 \text{ m}^2$. The litter trap was made of nylon, which was placed at a height of 50 cm. The placement of the litter collection device was expected to optimally accommodate vegetation litter. The fallen litter was collected every week and separated according to its category. Furthermore, the litter was dried by putting it in a litter decomposition bag. The placement of the litter trap was divided into three observation points based on vegetation density. To determine the density of vegetation, purposive sampling was carried out by using a plot measuring $20 \text{ m} \times 20 \text{ m}$. Each density was sampled with four litter traps. The weight measurement of the decomposition litter was carried out at the Forestry Laboratory, Faculty of Agriculture, Tadulako University. The results showed that at high density, the number of individuals obtained was 1125 ind/ha, medium density the number of individuals obtained was 875 ind/ha and at low density, the number of individuals obtained was 750 ind/ha. Total litter productivity in production forest areas at high density was $514.01 \text{ gr/m}^2/\text{week}$, at a medium density of $420.94 \text{ gr/m}^2/\text{week}$ and at a low density of $327.58 \text{ gr/m}^2/\text{week}$. The average weight loss in the forest area was 0.69 grams with a litter decomposition rate of 2.96%/week. Productivity of litter in production forest areas shows that the higher the number of individual vegetation, the higher the density of litter production, therefore it is necessary to stabilize the management of production forests in a sustainable manner.

Keywords: Decomposition rate, litter, production forest, productivity.

INTRODUCTION

Forest was one of the land-use systems in a watershed, composed of various trees with a plant understory to form a layered canopy (Bhattacharya *et al.*, 2021). Forests also have the ability to donate litter through fallen plant parts such as leaves, flowers, fruit, twigs, branches and bark (or skin) that have died and accumulated on the mineral soil (Neves *et al.*, 2021; Pradisty *et al.*, 2021). The amount of litter production was influenced by the amount of stand density (Riyanto *et al.*, 2013), in addition, other environmental factors also affect litter productivity (Farhaby and Utama, 2019; Bintoro, 2019).

Over time and in local conditions, litter undergoes decomposition and mineralization (Patty 2010; Aguilar-Cruz *et al.*, 2020). Litter decomposition was the process of changing organic materials derived from animals or plants,

both physically and chemically into inorganic compounds (simple minerals used by soil microorganisms). Litter plays an important role on the forest floor including maintaining forest soil fertility (Ge *et al.*, 2013), since most of the nutrients that are returned to the forest floor come from the litter (Salim and Budiadi, 2014). Litter decomposition converts complex organic compounds into inorganic compounds and produces mineral nutrients that are utilized by plants. The litter is part of the product forest biomass and contributes to carbon sequestration, this is in line with the opinion of Zhang *et al.* (2012) that production forests represent an important carbon sink.

The speed of the decomposition process depends on environmental conditions and the type of plant, chemical composition of the plants and the age of the stand. The

benefits that can be produced are in the form of nutrients for normal plant growth (Khoshru *et al.*, 2020). The production forest of Salukaia village was a tropical rainforest that produces high amounts of litter, because it was always green throughout the year. The high litter production will benefit the surrounding vegetation to increase its productivity due to the high availability of nutrients for this type of ecosystem.

Litter as the main component in primary productivity in production forests is an important source of carbon in the decomposition process, it is very important to study in this direction. In the Production Forest Area, West Pamona District, Poso Regency, the fast growing *Paraserianthes falcataria* is the dominant species in the area, but little is known about its efficiency with respect to litter productivity which is a stock of biomass production. This research was conducted with the aim of knowing: litter productivity and litter decomposition rate in the Production Forest Area, Salukaia Village, West Pamona District, Poso Regency.

MATERIALS AND METHODS

Time and place

The research was carried out during June to September 2021 in the Production Forest Area, in the Wimbi watershed, Poso Regency, Central Sulawesi as illustrated in Figure 1. Determination of the research location area was done by purposive sampling.

Vegetation density

At the research site, a 200 m-long transect line was made using a rope. Furthermore, on this pilot line a plot measuring 20 m x 200 m was made and 10 sub-plots measuring 20 m x 20 m were made within this plot. In each sub-plot, observations were made of tree vegetation measuring 20 cm, tree diameter and recording the name of the species.

Litter productivity

The method used for litter collection was the litter-trap method, the litter was analyzed descriptively qualitatively. The litter measurement was carried out using a litter trap made of nylon with a size of 1 m x 1 m. The litter trap was placed at a height of 50 cm above the ground level. The lateral placement of litter traps was divided into three observation points based on vegetation density, namely low, medium and high density within each subplot. At each observation point was placed 4 liter traps, so that the total litter trap was in 12 units. Litter trap sampling was carried out once a week for 16 weeks. The collected litter samples were first weighed for wet weight, then the samples were dried in an oven for 24 hours at a temperature of 80°C. The final constant dry litter sample weight was then measured.

Litter decomposition

Vegetation litter decomposition was measured using a litter decomposition bag measuring 20 cm x 30 cm. Each bag was filled with litter as much as 45 grams of litter. The litter bag that had been filled with litter was then placed for exposure on the subplot ground. Every week one bag was taken and then baked at 80°C until the sample weight was constant.

Data analysis

Stand density

Vegetation density was calculated by the equation:

$$K = \frac{Ni}{A} \quad (1)$$

Notes: K= Density, Ni= Total number of individuals of type, A= Area

Litter productivity

Litter productivity per plot of each observation was calculated by the equation:

$$Xi = \frac{Xi \cdot n}{n} \text{ gr/m}^2/\text{mg} \quad (2)$$

Notes: Xj= average litter production per plot per period (week), X = litter production per plot each period, n = number of traps

Estimation of decomposition rate

The reduction in weight was calculated by the equation:

$$X = \frac{W_0 - W_t}{W_{ow}} \times 100\% \quad (3)$$

Note: X = percent weight loss (grams), Wow = early dry boot (g), Wt = final dry weight (g)

The rate of decomposition was estimated by:

$$D = \frac{W}{T} \quad (4)$$

RESULTS AND DISCUSSION

Vegetation density

Vegetation density was related to the amount of vegetation per unit area, which affects vegetation growth. The results showed that at high density, the number of individuals was 1125 individuals/ha, at medium density the number of

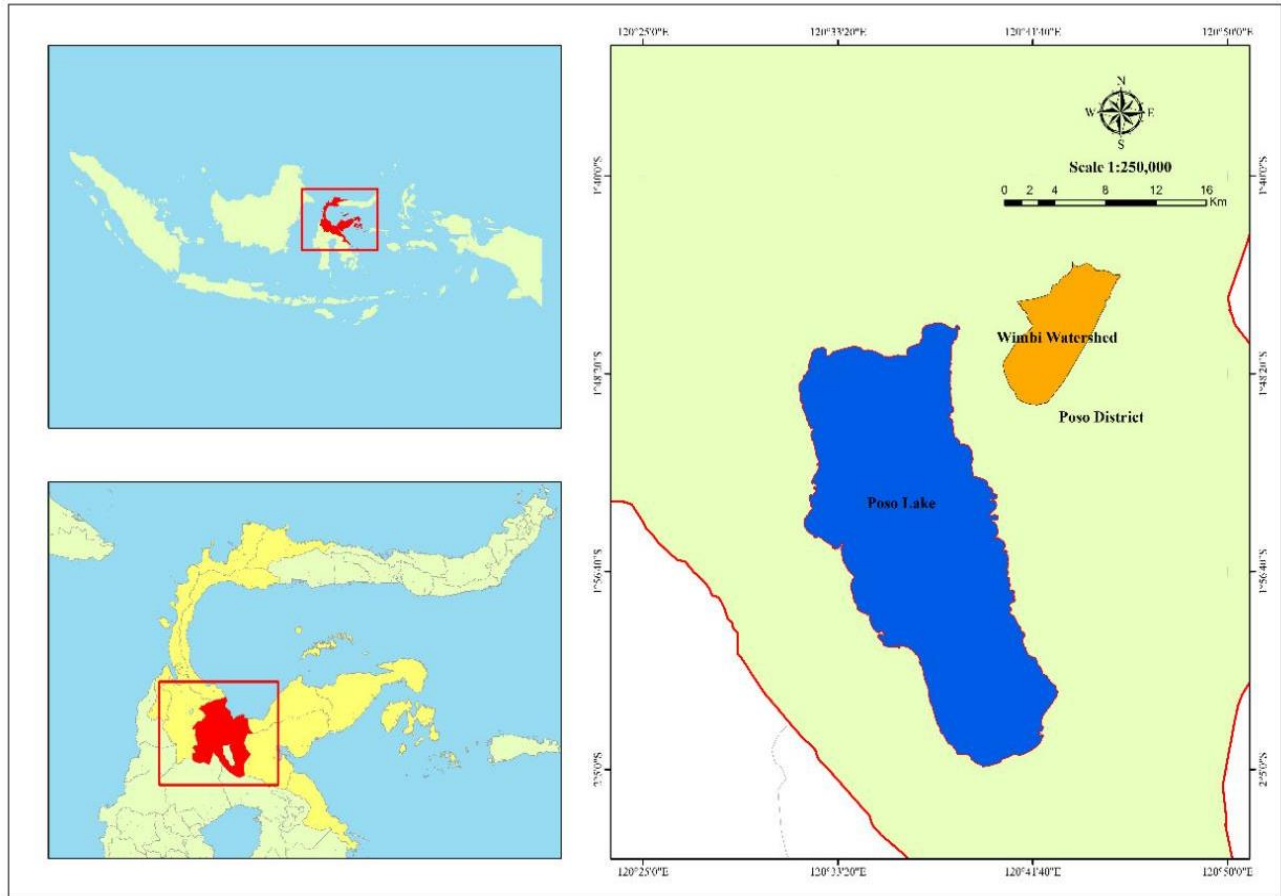


Figure 1. Research location map.

Table 1. Total litter based on four litter components during the research period

Litter component	Weight(g/m ² /mg)		
	K. High	K. Medium	K. Low
Leaf	410.48	335.54	273.43
Skin	16.92	14.49	5.94
Branch/twig	42.82	32.57	20.32
Fruits and flowers	43.79	38.34	27.89
Totals:	514.01	420.94	327.58

individuals was 875 individuals/ha, and at low density the number of individuals was 750 individuals/ha.

The difference in density was due to the large number of individuals found in large numbers and evenly distributed in the area. In addition, this is in line with the opinion Brandt *et al.* (2020) who states that the higher the density of stands, the higher the litter production. However, the higher the number of plant species, the higher the amount of litter production, because not all plant species shed their leaves easily. The condition of topographic factors also plays a role in determining the number of populations in an area.

Litter productivity

The categorical vegetation litter productivity of each component in the Production Forest Area of Salukaia Village for 16 weeks of observations was presented in full in Table 1.

Based on Table 1, it can be seen that the greatest total litter productivity during 16 weeks of observation was at a high density of 514.01 g/m²/mg, then at a medium density of 420.94 g/m²/mg and the smallest at a low density of 327.58 g/m²/mg. Of the three densities, the leaf component had the highest weight and percentage

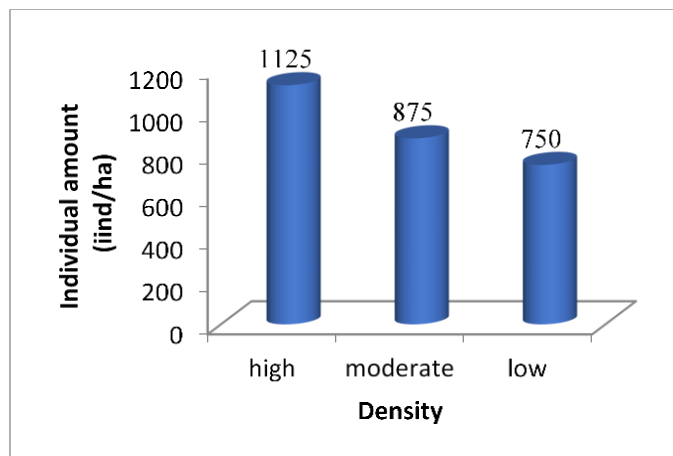


Figure 2. Density of vegetation on observation plot.

compared to other components. This is in line with opinion Abdullah *et al.* (2020) that leaf biomass has greater potential compared to other plant organs. Biomass or plant waste has 3 main components namely cellulose, hemicellulose and lignin besides that extractives and minerals (Mansora *et al.*, 2019).

The difference in litter productivity was due to the structure and composition of the stands being different, the leaf component was 410.48 g/m²/mg (213.45 tons/ha/yr) at high density with a percentage of 79.86%, at medium density, the litter productivity in the leaf component was 335.54 g/m²/mg (174.82 tons/ha/year with a percentage of 76.71%), and at low density the productivity of litter in the leaf component was 273.43 g/m²/mg (142.18 tons/ha/year with a percentage of 83.47%). Based on this, it can be said that litter productivity was influenced by vegetation density. The productivity of the flower/fruit component litter was 43.79 g/m²/mg (22.77 tons/ha/year) with a percentage of 8.52%, the branch/twig component litter productivity was 42.82 g/m²/mg (22.27 tons/ha/year) with a percentage of 8.33% and the lowest litter productivity was the skin component of 16.92 g/m²/mg (8.79 tons/ha/year) with a percentage of 3.29%. The description of litter productivity during the observation period was presented in Figure 2.

The high leaf litter was caused because among other essential functions, the leaves are a tissue system which help plants adapt to environmental factors to reduce water loss in order to survive. The highest litter productivity occurred in the sixth week of 62.04 g/m²/mg, while the smallest occurred in week nine which was equal to 9.82 g/m²/mg (Figure 3).

Factors that affect litter productivity include climate, in this case rainfall. Litter productivity will increase in the rainy season (Giweta, 2020). This was due to the force of rain accelerating the abscission of senescent leaves. In addition to rain, another factor that affects litter productivity was wind, in this case wind speed which can remove healthy branches and leaves from vegetation.

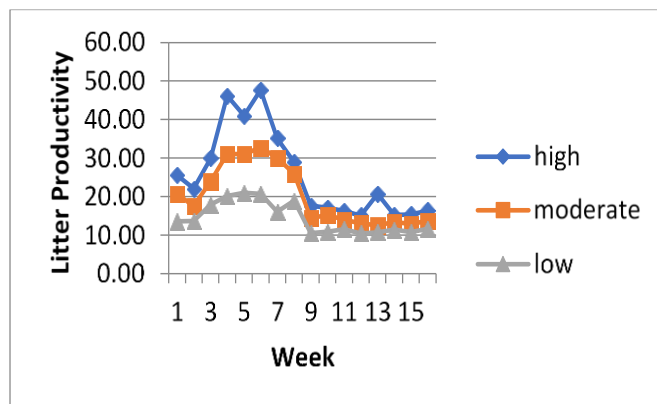


Figure 3. Litter productivity every week at different densities.

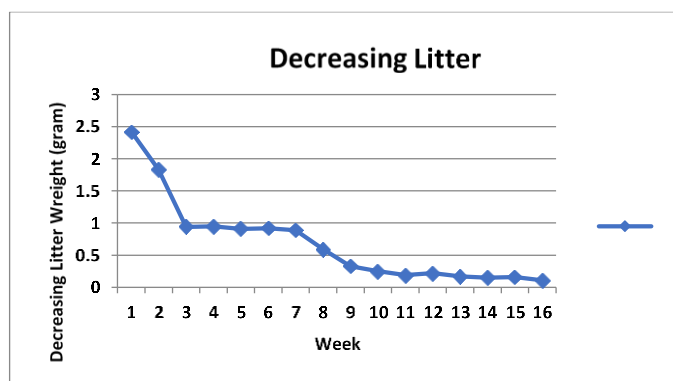


Figure 4. The rate of decomposition was affected by rainfall.

Litter decomposition rate

Litter decomposition in terrestrial ecosystems had a major role in the biogeochemical cycles of elements in the environment. Among other influences, climatic factors, such as temperature, rainfall, humidity, and seasonal variations affect the rate of litter decomposition (Cui *et al.*, 2021).

Based on the results of the study, after the litter was decomposed for 16 weeks (Figure 3), it showed that the average weight loss was 0.69 g with an average litter decomposition rate of 2.96%/week. Litter decomposition rate has a response to the decomposition time. The longer the decomposition time, the lower the rate of decomposition for each period. The Figure 4 shows a graph of the rate of litter weight loss in the forest.

Based on Figure 4, it can be seen that the average litter weight reduction was 0.69 grams with a litter decomposition rate of 2.96%/week. The rate of decrease in litter weight was influenced by abiotic environmental factors such as temperature, rainfall, humidity. Rainfall affects the decomposition rate of litter (Salamanca *et al.*, 2003), although these factors are not dominant (Wei *et al.*, 2020). Furthermore, Haque *et al.* (2021) states that the

time factor affects the rate of litter destruction, because the time factor was closely related to environmental factors so it can be said that abiotic environmental factors affect the rate of litter decomposition (Veen *et al.*, 2015). There are two major components that affect decomposition, namely environmental factors above the soil surface including temperature and rainfall and environmental factors below the soil surface including soil microorganisms. Decomposition occurs due to the activity of microorganisms, where micro-organisms obtain energy for their life needs.

Conclusion

At high density, the number of individuals obtained was 1125 ind/ha, medium density the number of individuals obtained was 875 ind/ha and at low density the number of individuals obtained was 750 ind/ha. Total productivity of litter in production forest areas at high density was 514.01gr/m²/week, at a medium density of 420.94 gr/m²/week and at a low density of 327.58gr/m²/week. The average weight loss in the forest area was 0.69 grams with a litter decomposition rate of 2.96%/week. The higher the number of individual vegetation, the higher the density of litter production, therefore it is necessary to stabilize the management of production forests in a sustainable manner.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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