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The Influence of Slope to Density and Litter Biomass in Tropical Rainforests

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Abstract Tropical rain forests have a wealth of very high vegetation, scattered on flat to very steep slopes. Slope is one of the factors affecting soil characteristics as a growing medium for vegetation. The variation of slopes is suspected to be the cause of variation on stand density and litter biomass production. The objectives of this study were to analyze the effect of slope variation on stand density and litter biomass production resulting from tropical rain forests. The research method is done by dividing the slope into 4 classes of slope that is the grade of slope 0- <15%; 15- <30%; 30- <45% and slope classes> 45%. Observation Density of stands is done by measuring the density based on the number of individual plants at the pole and tree level and the density based on the wide of the basic field (ground). Litter biomass is measured using quadratic wire measuring 50 x 50 cm, taking litter falling to the forest floor derived from parts of plants such as leaves, twigs, fruits, skins by dividing into L (fresh litter), F1 (slightly decomposed), F2 (decomposed further) and calculated the biomass based on Hairiah and Rahayu (2007) methods. The results showed that the variation of the slope gave a significant effect on the density of the stands assessed by the density based on the number of plant individuals and the density based on the area of the base and the litter biomass (P <0.001). Increasing the slope class affects the decreasing of the density of the stand and the litter bass. Slopes below 30% have higher density and litter biomass than slopes above 30%. The stand density is directly proportional to litter biomass, high density will have high litter production and low density will have low litter productivity.

Keywords Slope class, Density, Litter biomass, Tropical rain forest

1. Introduction

Tropical Rain Forests have the richest vegetation, both in terms of the number of species and the high value of land resources, according to Whitmore (1984), Tropical rain forests are divided into crown stratum with high density. According to Odum (1998), in the section of crown tropical rainforest heavily overgrown long stemmed and woody vines (Liana), such a potential situation produces high litter biomass. Tropical rain forests are spread from flat slopes to very steep slopes, with high growth variations in accordance with the topographical conditions they occupy.

Slope is one of the factors affecting soil characters (Nugroho, 2016; Hardjowigeno, 2003; Pairunan et al., 1997). The soil on the lower slopes has thicker soil layer (solum) than on the upper slopes, this is due to the process of ground erosion on the upper slopes (Hardjowigeno, 2003; Hanafiah 2012). The soil on the lower slopes tends to have deep soil solum as a result of the eroded soil erosion of the above slopes (Nugroho, 2016). The thin thickness of the soil solum is influenced by environmental factors during the formation process (Foth, 1994; Rajamuddin, 2009). Some characters that are affected as a result of the difference in slopes are into effective roots, percent rocks that show the mechanical barriers of the roots and percent of rooting in the soil / earth profile. The magnitude of mechanical barriers to the soil determines the development of plant roots, the more mechanical barriers the plant will become disrupted in its growth, because the roots are not able to penetrate the rocks and dense layers of soil (Nugroho, 2006). This results in variation in growth according to soil characteristics as a growing medium of plants.

The lower slopes we often encounter trees with denser diameter and density are more dense than the upper slopes, according to Kartasapoetra (1990) high slopes are more easily disturbed or damaged, soils with a >25% slope with high rainfall can cause the soil to become avalanche, this causes the destruction of vegetation. Some types of rehabilitation plants experience growth inhibition on higher slopes.

Increased slope effect on the decrease of soil physical characteristics, on steep slopes (30-45%) there is continuous erosion. This causes the soil solum to be shallow, low organic matter content, high density of soil, and low porosity of soil, compared to soils in flat areas with deep ground water. Differences of slopes also cause differences in the amount of water available to plants that affect the growth of vegetation

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in the place (Hardjowigeno, 1993). The rate of vegetation growth affects the production of litter biomass produced, whereas litter biomass affects organic material content in the soil (Jayanthi and Arico, 2017). Based on the phenotypic fact of growth in the field of variation of the slope causing variation of vegetation growth, it is necessary to study the effect of slopes on the stand density and production of litter biomass produced, this result will affect the policy of land rehabilitation in areas with high slope variation. The purpose of this study is to analyze the effect of slope variation on the stand density and the production of litter biomass produced.

2. Method of Research

The research location is located in a special purpose forest area (KHDTK) University of Lambung Mangkurat Mandiangin Kabupaten Banjar, South Kalimantan. The study sites have flat topography until very steep, located at an altitude of 63 - 1,373 meters above sea level. Geographically located at coordinates 126°54'- 127°25' E and 3°21 '- 3°48' S. Administratively located in the subdistrict of Aranio and Karang Intan district Banjar (Anonymous, 2016). There are several types of soil namely typic kandiudox, typic kanhapludult and typic kandiudox derived from the degradation and decomposition of the main material, especially from igneous rocks and sedimentary rocks. The average annual rainfall classification ranges from 1,150 mm to 2000 mm per year. Average humidity 73 - 82% and average temperature 20° -35°C and climate type B (Anonymous, 2009).

The data collection procedure in the field is done by direct measurement in the field. The way of data collection of each parameter is done as follows:

1) Determining the observation point with the consideration of the slope map, then divide the slope into 4 classes of slope that is the slope class 0 <15%, 15- <30%, 30- <45% and the slope class> 45%.
2) Measure the density of stands on each slope class with repetition of 3 replications of observations. Density of stands by measuring basal area (LBDs) at the growth rate of poles and trees according to Simon (1993) as follows:

   LBDs = $\frac{1}{4}\pi.d^2$
   LBDs = basal area (m^3)
   d = diameter
   π = constants (22/7)
3) Measuring soil biomass:

Using quadratic wire measuring 50 cm x 50 cm on the intact forest floor. Taking litter by differentiating into parts L (liter) is new litter, water content is still high, shape is still intact, greenish color and brownish, still somewhat fresh. Section F1 (fermentation stage 1) in the form of litter that begins to decompose, the shape is not intact anymore, the original litter form is still visible, brownish color, still a unit litter / not sticky litter. Separate each part into leaves, stems / branches, flowers / fruit and others in separate labeled bags. Section F2 (fermentation stage 2) is a decomposed litter, brownish color, litter one attached to another litter / sticky. Section H (Humus) in the form of litter that has been decomposed perfectly so that it is shaped like compost, the shape is not visible anymore, black color, crumb structure, loose in separate bag labeled. Weighing wet and dry weight with oven temperature 80°C for 2x24 hours until it reaches the absolute dry weight. Calculation of water content is done by using the formula (Hairiah and Rahayu, 2007).

$$\textbf{\% Water content} = (BBc - BKc) / BKc \times 100\%$$

Information:

% KA : Percentage of water content
BBc : Wet weight of test sample (g)
BKc : Dry weight of test sample (g)

Biomass calculations are performed using the formula (Hairiah and Rahayu, 2007).

$$B = Bb / (1 + (\% KA / 100))$$

Information:

% KA : Percentage of water content
Bb : Wet weight
B : Biomass

Data analysis using variant analysis according to Yitnosumitro, 1993; Gomez & Gomez 1995, with its analytical tools assisted with statistical analysis of sigma plot software version 12.

3. Results and Discussion

1. Stand Density

The stand density of the study area is part of exploited tropical rainforests, but the typical tropical rainforest has a high diversity and density and is always green throughout the year (Riyanto et al., 2013). Density of the stands based on the number of individuals per hectare measured at pole and tree level shows that the variation of the slope class gives a very significant difference (P <0.001) to the number of individuals every hectare, the slope increases the number of individual plants at the pole and tree level every hectare.

The stand density was based on the highest number of individuals every hectare on the slope class 0- <15% and did not show any difference in the slope class of 15- <30%, the number of individuals decreased on the slope class 30 <45% and> 45%. According to Nugroho (2016) soil solum will decrease depth along with increasing slope position, this will be one limiting plant growth. The highest number of individuals every hectare in the 0- <15% slope class of 908 individuals / hectare, compared to tropical rainforests is still moderate, according to Jayanthi and Arico (2017) Tropical rainforest stand density clasified in tight if 1025 individuals / hectare. Limiting factors on population existence are heavy topography, thin topsoil and unstable growth sites, dominance of pioneer species and low nutrients (Chua, et al., 2013).

Table 1. Density of stands at various slope classes

No.	Slope Class (%)	Number of Individuals (per hectare)	Basal Area (m^2/ha)
1.	0-<15	908^{c}	245,83^{d}
2.	15-<30	867^{c}	241,33^{c}
3.	30-<45	650^{b}	209,25^{b}
4.	>45	475^{a}	179,75^{a}
Information: Lsd = least significant different; The notation marks a, b, c are distinguishing marks, in the same notation has no value difference		Mean: 725 individuals / ha Lsd: 45 Standard deviation: 23.33 Alpha = 0.05	Mean: 219 m^2 / ha Lsd: 2,82 Standard deviation: 1.16 Alpha = 0.05

Density of stands based on basal area (LBDs) shows that the variation of slope has a significant effect on the stand density as judged by the size of the wide basic field (P <0.001), the slope class increases, the decreasing of basal area measured at the level of pole growth and trees. The large area of the basic field shows that the speed of plant growth, the greater the area of the basic field shows higher plant growth. Plant growth in addition to influenced by genetic factors is also influenced by environmental factors especially quality place to grow (Na'iem, 2005).

The influence of the slopes has an effect on the quality of the soil site, either physical or chemical soil characteristics (Nugroho, 2017; Hardjowigeno, 2003; Pairunan et al., 1997). Soil characteristics affected by the slopes are soil solum, bulk density, soil porosity, soil pH, exchangeable bases in soil and others (Arsyad, 1989; Purwowidodo, 199; Hardjowigeno, 2003). The decline in the area of the ground with increased slopes is thought to be due to the growing quality of the steep slopes tending to decrease when compared to flat slopes, this is due to the thinner soil solum due to soil erosion process. Soil erosion not only carries the soil material but the nutrients contained therein. Soils with thin solum of plant roots strengthen the strengthening of the stems to decrease, consequently if a large wind causes the trees to collapse. In addition to increasing the size of the ground requires adequate nutrition, so that if the quality grows not optimal then the growth of vegetation will be disrupted.

2. Litter Biomass

Litter is the ingredients of plant parts such as leaves, twigs, small branches, stem barks, rotten flowers and fruits, located above the soil surface and undergoing decomposition and mineralization. The important role of litter is to return nutrients to the forest floor through decomposition, by converting the organic compounds into the litter into inorganic compounds and producing mineral nutrients for plant growth. The amount of litter production on the forest floor is strongly influenced by the amount of stand density (Riyanto et al., 2013). Based on Table 2 It shows that the variation of slope class gives a very real difference (P <0.001) to litter biomass production. Increased slope classes affect the decline in litter biomass production.

Table 2. Litter Biomass Production on Various Slope Classes

No.	Slope Classes (%)	Litter Biomass (ton/ha)
1.	0-<15	4,06^{c}
2.	15-<30	3,47^{b}
3.	30-<45	3,23^{b}
4.	>45	2,18^{a}
Keterangan: *Lsd = least significant different; The notation a,b,c is a distinguishing mark, on the same notation has no difference in value.*		Mean: 324 ton/ha Lsd: 45 Standart deviation: 0,37 Alpha=0,05

One characteristic of tropical rain forest is the dominance of broad-leaved plants with high litter production rates (Marsono, 1992). According to (Malhi, 2012) states that tropical rain forests have a high amount of litter productivity that is very influential on soil fertility. According to Jayanthi and Arico (2017) states that the highest average litter productivity is produced from stands with high density. Litter production is directly proportional to the stand density measured by the density of the individual number per hectare and the density based on the wide of basic field. This is in line with the results of the observations in Table 1 and Table 2 indicating that the increase in slope classes, stand density tends to decrease as well as the production of litter on the forest floor. According to Sinaga (2015) High density of trees do pattern of distribution of litter evenly and litter production in relatively large quantities.

Litter production on both steep and very steep slopes is lower as a result of low vegetation density, in addition to the resultant litter may allow for displacement to the lower slopes due to the water mass during rainfall. Wind speed is also one of the causes of litter movements, as well as landslides will reduce litter concentration on the forest floor. Several things are done to increase the density and production of litter on the high slope class by making the introduction of fast growing species for rock climbing, making conservative buildings such as bench terraces.

4. Conclusions

Slope class variations lead to changes in stand density and litter biomass production, decreasing the density of the stand and the litter biomass by increasing the slope class. Slopes below 30% have higher densities than slopes above 30% have higher density, standing density is proportional to litter biomass, high density will have high litter production and low density will have low litter productivity.

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