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Estimation of above Ground Biomass in Logged over Areas, North Borneo, Indonesia

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Abstract

Determination of the number of trees felled sample is conducted using stratified random sampling based on tree diameter class (stratum) in accordance with the results of the analysis of vegetation, which consists of class diameter as a follows: 5-20 cm, 20-30 cm, 30-40 cm, 40-50, 50-60 cm and > 60 cm. Based on the tree sample selected, algometric equation was $W=0.041586D^{2.70}$. Developing algometric equation of the biomass, potential biomass of trees on loggeg over areas of conventional logging (CL) and reduced impact logging (RIL) plots can be expected. Algometric equation estimate total biomass of tree instance by using independent variables and the response variable diameter was used to estimate total biomass of trees in natural tropical forests. The result of the estimation of the potential biomass aboveground biomass in primary forest and logged over areas of conventional logging (CL) plots and reduced impact logging (RIL) plots in natural tropical forest was 301.60 Mg ha^{-1}, 93.16 Mg ha^{-1} and 223.8 Mg ha^{-1}, respectively. This research indicated that biomass on RIL plots larger than the CL plots. While the highest standing biomasses in this study are primary forests have not been disturbed due to activity of timber harvesting

Keywords: algometric equation, above ground biomass, logged over area, timber harvesting

Introduction

Deforestation and forest degradation of tropical natural forest in Indonesia is very worrying. Forests are an important role in the global carbon cycle. Forests can carbon in vegetation and soil, to absorb CO_2 from the atmosphere through photosynthesis. However, forests can become sources of CO_2 emissions in the atmosphere when forests are disturbed (eg, timber transportation, clearing and burning of forests and forest fires. Forest type classification was found to be an important determinant of the above-ground biomass estimation when altitudinal and other complex environmental gradients are included (Alvarez et al. 2012). The new models presented here can be considered as an alternative option for assessing carbon stocks in the above-ground biomass of natural forests.

The existence and preservation of natural tropical forests has become an important issue at the international level. Globally, changes in forest stands are a source of CO_2 emissions into the atmosphere. Ekoungoulou et al. (2014) indicated that forests are an important carbon reservoir, and they can also play a key role in mitigation of climate change. Biomass and carbon in forest masses affect the global carbon cycle. Brown (1997) states that 50% of the forest biomass is carbon (C). This biomass can be CO_2 emissions in the atmosphere when the forest is disturbed (Mitra et al. 2011; Munishi and Shear 2004).

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Forestry activities greatly influence the mass reserve potential of carbon present in the forest. Activities on land use, land use change and forestry (land use, land-use change and forestry/LULUCF) is one source of CO_2 emissions and a contributor to an increase in temperature of the earth (Kanninen et al. 2007; Murdiyarso 2007). Changes in land cover, use and management of forests influence sources (sources) and deposits (sinks) CO_2. Forestry activities that affect forest carbon stocks include timber harvesting activities (Putz et al. 2008). Some of the main options for mitigating CO_2 emissions including avoiding CO_2 emissions and protect forest carbon, such as by reducing deforestation and improving timber harvesting. Increased concentrations of CO_2 as a result of forestry activities and their effects on global climate led to improved forest management in preventing CO_2 emissions received great attention. Mechanical harvesting Reduced Impact Logging (RIL) is an attempt to improve management of tropical forests is expected to contribute to reducing CO_2 emissions in the atmosphere.

Material and Methods

In this study compiled algometric equations carbon mass dominant tree species in the stand according to the analysis of vegetation, by felling trees selected samples. Determination of the number of trees felled sample was conducted using stratified random sample by based on tree diameter in accordance with the results of the analysis of vegetation, which consists of class diameter of 5-20 cm, 20-30 cm, 30-40 cm, 40-50, 50 -60 cm and > 60 cm. The selected sample trees are cut, then separated by parts of trees, the stems, branches, leaves, flowers, fruits and roots. The branches are divided into several segments. All parts of the tree are then weighed example, in order to know the wet weight of each of its parts. Wet weight of the tree is the sum of all the wet weight of the part of the tree. After weighing, each section of the test sample taken trees and then analyzed in the laboratory.

A stage of the work done is as follows:

1. Select sample trees. Trees that represent must grow up healthy and includes a variety of tree sizes on share class 5-20 cm diameter, 20-30 cm, 30-40 cm, 40-50 cm, 50-60 and> 60 cm and the weight of each type of < 0.5 and ≥ 0.5.
2. Measure the dimensions of the tree, including stem diameter, total height, height freely branching, and the average diameter of the canopy.
3. Cutting down trees and separated into parts of trees. Trees are cut as close as possible to the ground. The tree trunks were separated into groups (including stump), branches, twigs and leaves.
4. Measure and weigh the parts of the tree. Trunk divided into short sortimen 2 m and measured the diameter of the tip. The entire trunk, branches, twigs and leaves are weighed to obtain the wet weight.
5. Test sampling entire sample trees. Samples consist of the stem portion of the sample (base, middle, and end of the rod), branches, leaves and roots. Samples packed in plastic sealed to prevent reduced water content in the test sample.
6. Analysis of the laboratory test sample to get the density value, volatile matter content, ash content and carbon content in the biomass of trees.
7. Calculating the weight of a heavy mass of biomass and carbon on any parts of the tree
8. Analysis of the relationship between biomass and carbon mass entire sample trees with dimensions of sample trees. Analysis of the relationship is done by regression analysis approach.
9. Use the best algometric models for the assessment of biomass and carbon mass stands.

Results and Discussions

Algometric Equations of Tree Biomass

Biomass is organic material of an organism's weight per unit area at a time. Trees are the largest component of above ground biomass. Biomass whole tree stand was allegedly using algometric equations. The equation is based on the sample tree that is felled stems, branches, leaves, and roots and total parts of the tree based on the relationship between the biomass of each section with the parameters (tree diameter, height and density of trees). Sample trees felled destructively to develop algometric equations.

Table 1 showed that the algometric equations to estimate the potency of biomass of stems, branches, leaves, and roots. Based on the standard deviation and greatest coefficient determination, the best model was a model with a single explanatory variable diameter (D) with the response variable tree. Another reason in the selection of the model was accuracy and practicality in the forests stand to estimate biomass that the selected model was $W=0.041586D^{2.70}$.

Table 1: Algometric equations of tree biomass

	Algometric equations	S	R-sq(adj)	P-value
Stems	W=0.018873D2.86	0.36380	97.70%	0.000
Branches	W=0.014996D2.39	0.61902	91.00%	0.000
Leaves	W=0.027052D1.93	0.62760	86.40%	0.000
Trees	W=0.041586D2.70	0.34124	97.70%	0.000
Roots	W=0.018499D2.57	0.37373	97.00%	0.000

Based on the selected algometric equation was $W=0.041586D^{2.70}$, the biomass of trees on logg over areas of CL and RIL plots can be expected. Algometric equation estimate total biomass of tree instance by using independent variables and the response variable diameter is used to estimate total biomass of trees in natural tropical forests, north Borneo.

Algometric equations, relating dry weight of foliage, branches, stemwood, stembark, roots, and total biomass to diameter at breast height (DBH), were developed to estimate above- and below-ground biomass (Wang et al. 2000). Katterings et al. (2001) reported on 29 tree biomass data (kg/tree) with a range of examples of tree diameter from 7.6 to 48.1 cm in secondary forests of Sepunggur, Sumatra obtain biomass equation $W=0.066D^{2.59}$. Alometric similarities generated in this study are greater than the algometric equation in Sumatra. In some of the results of the research to estimate biomass and carbon forest types suggest only using parameter N diameter with reasons was practicality and efficiency and without compromising the accuracy of the allegations. This difference could be due to differences in the distribution pattern of the tree and diameter at the study site because site conditions that affect the growth and stand density.

Above Ground Biomass in Logged Over Areas

The result of above ground biomass in the logged over areas of CL, RIL and primary forest plots can be seen in Figure 1. The average above ground biomass on conventional logging (CL), RIL and and primary forest plots was 274.91 Mg ha^{-1}, consisting of biomass derived from vegetation was 206.19 Mg ha^{-1} and litter and necromass was 68.70 Mg ha^{-1}.

Total biomass in conventional logging (CL) plots was lower than in reduced impact logging (RIL) plots. Total biomass in conventional logging (CL) plots and reduced impact logging (RIL) plots was 200.97 Mg ha^{-1} and 288.63 Mg ha^{-1}, respectively. Vegetation biomass in conventional logging (CL) plots was lower than in reduced impact logging (RIL) plots that vegetation biomass in CL and RIL plots was 93.16 Mg ha^{-1} (46.36%) and 223.80 Mg ha^{-1} (77.53%), respectively. Litter and necromass in conventional logging plots was higher than in RIL plots that litter and necromass was 107.80 Mg ha^{-1} (53.64%) and 64.80 Mg ha^{-1} (22.45%), respectively. This showed that the composition of the biomass of vegetation and litter as well as necromass on both plots of different timber harvesting. Biomass derived from the vegetation as a result of damage to remaining trees and undergrowth in a conventional logging plots because decreased vegetation biomass and litter and necromass increased.

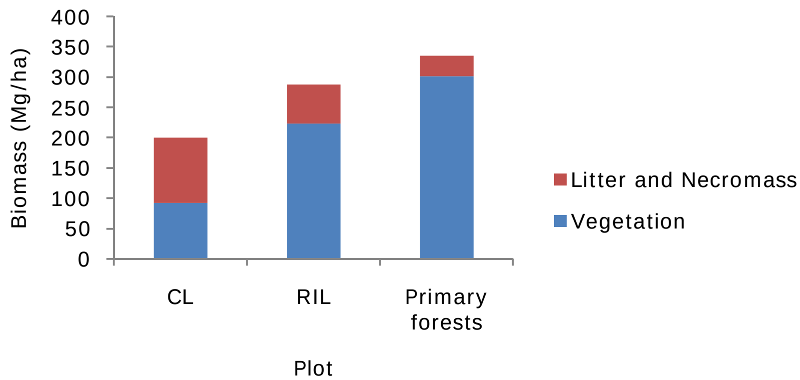

Figure 1: Above ground biomass on conventional logging, RIL and and primary forests.

Based on this study, RIL plots still good enough to maintain the biomass in natural tropical forests. Residual stand damage caused by timber harvesting can be reduced so that the damage and death of residual stand due to the continuing impact can be minimized. Above ground biomass of vegetation in logged over areas of RIL and conventional logging was lower than the primary forest. The impact of conventional logging activities resulted in a reduction in biomass is very large. Differences in biomass in the logged over areas on conventional plots compared with primary forests was 40.05%, while the difference biomass RIL plot with primary forests was 13.88%.

Above Ground Biomass of Vegetation

The result of the calculation of the potential above ground biomass of vegetation in primary forest and logged over areas of conventional logging plots and RIL plots in the natrual tropical forests, north Borneo was 301.60 Mg ha^{-1}, 93.16 Mg ha^{-1} and 223.8 Mg ha^{-1}, respectively (Figure 2). Figure 2 showed that the average biomass of vegetation on conventional logging and RIL plots that poles and trees stage was 68.27 Mg ha^{-1} (equivalent to 73.28% of the total biomass of vegetation) and 195,01 Mg ha^{-1} (87,13%). Similarly, the primary forest biomass at a rate poles and trees mostly from poles and trees was 269 Mg ha^{-1} (89.33% of the total biomass of vegetation).

Hertel et al. (2009) result that the studied forest plots on Sulawesi follow the general trend of higher biomasses and productivity found for paleotropical pre-montane forest compared to neotropical ones. However, biomass stocks and productivity appear to be lower in these Fagaceae-rich forests on Sulawesi than in dipterocarp forests of Malaysia.

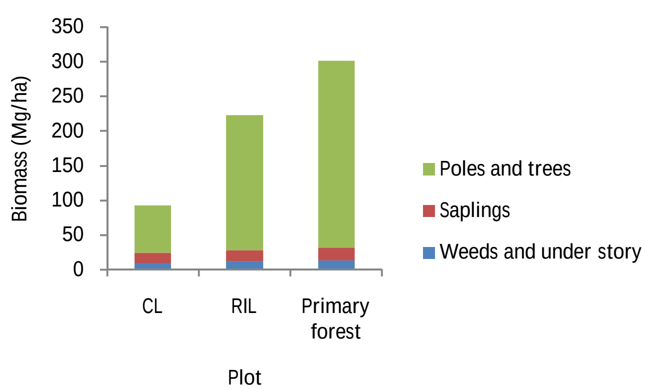

Figure 2: Above ground biomass of vegetation in the logged over areas in the conventional logging (CL), reduced impact logging (RIL) and primary forest.

This research indicated that biomass on RIL plots larger than the CL plots. While the highest standing biomass in this study are primary forests have not been disturbed due to stand as akitivitas timber harvesting so that it has the potential of stands when compared to CL and RIL plots. Several types of tropical forests that are selected showed different biomass between components. Weight rod is greater than the weight of heavy roots and leaves. Nutrient content on the stems tend to dominate all the components in the woods (Blanc et al. 2009). Total forest biomass in India ranged from 24.5 to 218 Mg ha^{-1} or an average of 92 Mg ha^{-1} (Haripriya 2001). When compared with the results of this study suggest that forest biomass is lower than in India.

Litter and Necromass

Result of litter and and necromass in primary forest and logged over areas in conventional logging and RIL plots in natural tropical forests, north Borneo was 33.54 Mg ha^{-1}, 107.81 Mg ha^{-1} and 64.83 Mg ha^{-1}, respectively (Figure 3). Figure 3 showed that the conventional logging plots had the highest litter and necromass that the litter an necromaas was 107.81 Mg ha^{-1}. This condition is due to the plots of conventional logging litter there are many remnants of damage to remaining trees and dead trees, so that the biomass was in the big woods. Mazzei et al. (2010) resulted that above-ground biomass (AGB) immediately converted into necromass by logging (harvested and destroyed trees) averaged 94.5 Mg ha^{-1} or 23% of the pre-harvest AGB. This total represented respective ABG losses of 69.3 Mg ha^{-1} and 25.2 Mg ha^{-1}.

Average biomass of vegetation on plots of conventional logging mostly from small necromass sebesr 55.83 Mg ha^{-1} or by 51.78%. While the RIL plots of timber harvesting and primary forest biomass mostly come from large necromass respectively by 27.53 Mg ha^{-1} (42.46%) and 14.03 Mg ha^{-1} (41.86%) of the total litter and necromass,

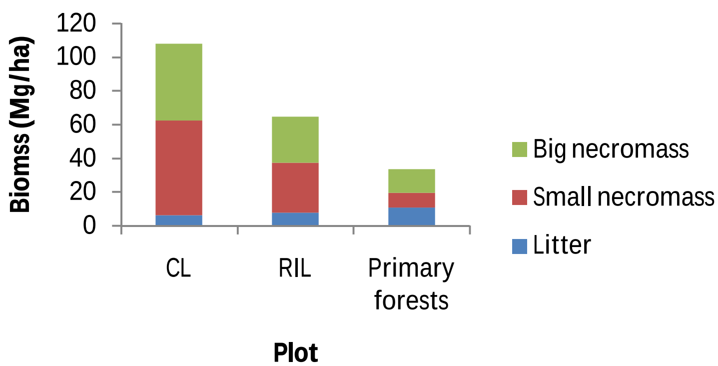

Figure 3: Litter and necromass in logged over areas on CL and RIL plots, and primary forests.

Biomass derived from litter and necromass conventional logging on plots was larger than with conventional plots RIL and primary forest. This is due to the many remnants of damage to remaining trees in the form of a dead tree on a patch of conventional logging. Mazzei et al. (2010) showed that in the Amazon rainforest, plots with the lowest residual basal area after logging generally continued to lose more large trees (dbh >70 cm), and consequently showed the greatest AGB losses and the slowest overall AGB gains. Biomass stand before the harvesting of timber in the Monts de Cristal, Gabon, according to research Medjibe et al. (2011) ranged from 293.4 to 511.1 Mg ha^{-1} or an average of 420.4 Mg ha^{-1}. After harvesting techniques RIL average biomass stands at 386.2 Mg ha^{-1}.

Hertel et al. (2009) showed that the fine and coarse root inventories and above-ground structural investigations of the six forest plots together with biomass estimates from above-ground algometric regression models allowed for a comparison of above- and below-ground biomass fractions and carbon pools. Accordingly, mean total phytomass (above- and below-ground) of the standswas 302.7 Mg ha^{-1},whichis equivalent to a carbon storage of 128 Mg ha^{-1}. Zheng et al. (2006) stated that in the area of tropical rain forests of Xishuangbanna, China's forest biomass ranged from 362.1 up to 692.6 Mg ha^{-1} which consists of biomass tree diameter (DBH) $\geq$ 5 cm as much as 98.2%, shrubs (0.9%), liana (0.8%), and turf (0.2%). In additon, Preece et al. (2012) showed that the revenue from carbon credits from rainforest stands could promote reforestation for biodiversity conservation on private land.

Conclusions

Above ground biomass of vegetation in logged over areas of RIL and conventional logging was lower than the primary forest. The impact of conventional logging activities resulted in a reduction in biomass is very large. Biomass derived from litter and necromass on conventional logging plots larger than RIL and primary forest plots. This is due to the many remnants of damage to remaining trees in the form of a dead tree on a patch of conventional logging.

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