Allometry of Biomass and Carbon Stock of Planted *Eucalyptus grandis* Forest in Toba Highland

Onrizal[1], Rudi Hartono[1] and Cecep Kusmana[2]
[1]Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridharma Ujung No. 1 Kampus USU, Medan, Indonesia
[2] Faculty of Forestry, Institut Pertanian Bogor, Bogor, Indonesia

Keywords: Allometry, Forest Biomass, Forest Carbon, Plantation Forest, Toba Highland.

Abstract: Forest plantations are not only for harvesting wood products; however they could play an important role in climate change mitigation through carbon sequestration and fixation. This research aimed to create the allometry equation for estimating aboveground biomass and carbon of planted *Eucalyptus grandis* forest in Toba Plateau with harvesting method. The research showed that the biomass and carbon stock of planted *E. grandis* increased following logarithmic model. The best allometry equations for aboveground biomass and carbon stock of planted *E. grandis* were $W_{AG} = 0.0678D^{2.5794}$ (R^2 98.8%) and $C_{AG} = 0.0266D^{2.6470}$ (R^2 98.0%), respectively. Therefore, the above ground biomass and carbon storage of planted *E. grandis* could be estimated only by measuring tree diameter (D) in the field that it is very beneficial both time and cost in estimating the carbon storage in the plantation forests.

1 INTRODUCTION

In the global warming issues, carbon absorption by forest ecosystem receives considerable attention (Payn et al., 2015). Forests were recorded as main element of the carbon sink in the global ecosystem (Romijn, 2015) and they mostly influence the lives of human societies as well as other organisms. Forest plantation received significantly attention to reducing carbon dioxide (CO_2) from atmosphere (Payn et al., 2015; Payn et al., 2014).

Forest biomass could provide estimation of carbon storage in forest vegetation. Based on forest biometrics, allometry equation can be used to estimate forest biomass and carbon. In this case, the validity of carbon estimation (Manuri et al., 2017) in both natural and planted forest is one important key in valuing the capacity of forests in mitigating warming (Ellison et al., 2017). Therefore, it is important to create the tools or model to estimate the forest carbon.

Forest plantations in Toba plateau are dominated with planting *Eucalyptus*, including *E. grandis*. The planted *E. grandis* forests in Toba highland are managed by PT Toba Pulp Lestari Tbk (PT TPL) as raw material for pulping industry. The main objective of this research was to develop allometric equation of aboveground biomass and carbon stock of planted *E. grandis* forests in Toba plateau, North Sumatra.

2 MATERIALS AND METHODS

Field research was carried at Tele Sector as part of PT TPL planted forest concession. The sites distributed with varied elevation from 1,600 to 1,700 m above sea level. The mean of annual rainfall in the area was 1,002.2 mm in period of 2005-2006 (PT TPL, 2006). The minimum of monthly rainfall during this period was 23.2 mm in May, and the maximum was 166.3 mm in July (Figure 1).

Six study sites were selected at different age-stand of planted *E. grandis* forests. Then, 10 plots of 10 x 10 m in each study site were established based on some guidelines and publications (Heriyanto et al., 2002; Onrizal, 2004; Onrizal et al., 2005). For each sub-plot, we measured the stem diameter at 1.3m height (D) and tree height of all trees. After tree inventory, totally 18 trees were cut using clipping techniques based on stratified random sampling with diameter class as the basis of stratification. The stem of the sample cut trees was divided into horizons of 1 m long. From each horizon, a fresh weight of each morphological tree compartment, i.e. stem, branch, leaf, and flower and

Onrizal, ., Hartono, R. and Kusuma, C.
Allometry of Biomass and Carbon Stock of Planted Eucalyptus grandis Forest in Toba Highland.
DOI: 10.5220/0010102401290131
In *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR 2018) - Research in Industry 4.0*, pages 129-131
ISBN: 978-989-758-449-7

fruit, were separately weighed. A small amount sample of each tree compartment was taken and dried in an oven at 80ºC for 48 hours to obtain the constant dry weight (Onrizal, 2004). Carbon content of each tree compartment was analyzed by CN analyzer.

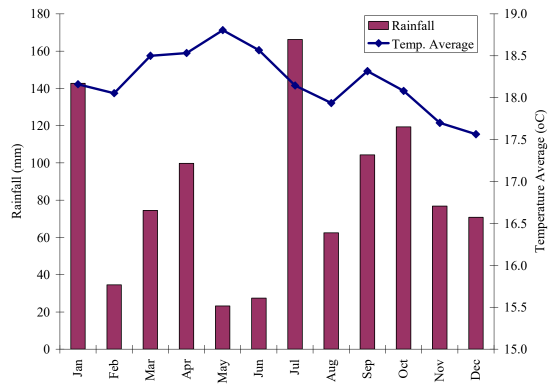

Figure 1: Distribution of monthly precipitation and temperature in study site.

In terms of aboveground tree biomass and carbon were estimated using simple allometry equation in the form of $Y = aX^b$, where Y is dry weight (biomass) or carbon of tree components, X is predictor variable (D), a is Y intercept, and b is regression coefficient.

3 RESULTS AND DISCUSSIONS

Tree diameter (D) of planted *E. grandis* significantly increased following the stand age (Figure 2). Based on carbon content analyses by CN Analyzer showed that the carbon content of *E. grandis* tree part was 44.92% of biomass with varying from 36.72 to 54.01% of biomass.

Allometry expressions of each above-ground morphological tree compartment both biomass and carbon follows logarithmic function with high correlation for each part of trees. In this case, the aboveground biomass and carbon stock of planted *E. grandis* were significant correlation to the single predictor, i.e. tree diameter (D) as shown at Table 1 and 2.

Table 3 shows the allometry coefficients which were calculated from the allometry relations between the biomass of various tree compartments on tree diameter (D) for some tree species in tropical region. Comparison of planted *E. grandis* forests stand's allometry coefficients obtained with those reported for some trees shows that the allometry coefficient "b" of total above-ground biomass for planted *E. grandis* forests stand in study area was comparable to that tropical tree species, such as general tropical tree species, rubber tree (*Hevea brasiliensis*), and non-rubber tree in the tropic.

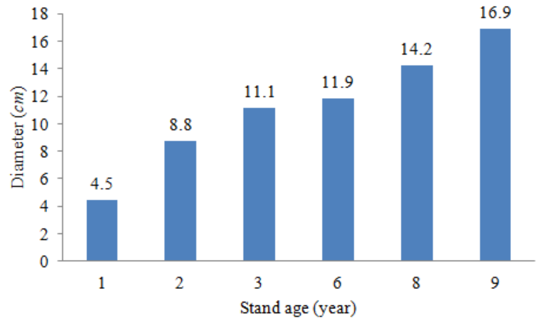

Figure 2: Tree diameter of planted *E. grandis* plantation at Toba plateau followed the stand age.

Table 1: Allometry biomass coefficient ($W_n = a*D^b$) of every tree-parts of planted *E. grandis* plantations in Toba plateau

No.	Tree part	Coefficient		R^2	R_a^2
		a	b	(%)	(%)
1.	Stem	0.0436	2.6883	98.28	98.17
2.	Branch	0.0228	2.0779	82.03	80.90
3.	Leaf	0.5775	0.6549	31.73	27.47
4.	Aboveground	0.0678	2.5794	98.80	98.73

Table 2: Allometry carbon stock coefficient ($C_n = a*D^b$) of every tree-parts of planted *E. grandis* plantations in Toba plateau

No.	Tree part	Coefficient		R^2	R_a^2
		a	b	(%)	(%)
1.	Stem	0.0176	2.7511	97.40	97.24
2.	Brach	0.0097	2.0848	83.66	82.64
3.	Leaf	0.2167	0.7199	35.08	31.02
4.	Aboveground	0.0266	2.6470	98.04	97.92

Table 3: The allometry coefficient of aboveground morphological compartment biomass on tree diameter (D) for some tree species in tropical region

Tree Species	Coefficient*		R^2
	a	b	
1. Rubber tree (*H. brasiliensis*) [#]	0.095	2.62	99.6
2. Non-rubber tree [#]	0.091	2.59	99.6
3. *E. grandis* [$]	0.068	2.58	98.8

*Allometry coefficients were calculated from the allometry equation $W_x = a*D^b$, [#] = Pamoengkas et al. (2000); [$] = this study

Based on Table 3, the aboveground biomass (ABG) of planted *E. grandis* was similar than the planted forest in tropical lowland region. It means that the planted *E. grandis* forest is potential activity to carbon sequestration in the tropical highland.

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the results, we were able to provide allometry equations that it was suitable for estimating the biomass and carbon stock of *E. grandis* plantation forests. Aboveground biomass and carbon stock of *E. grandis* plantation forests showed a very significant relation with tree diameter at breast height (*D*) which forms a logarithmic function. Therefore, the aboveground biomass and carbon stock of *E. grandis* plantation forests could estimate easily.

ACKNOWLEDGEMENTS

We express our gratitude to Director General Higher Education, National Education Ministry which funded under PEKERTI grant scheme in Fiscal Year of 2006 and 2007. We would also like to acknowledge the PT TPL Tbk officers for their cooperation and assistance in fieldwork. Special thanks to Ecology Laboratory, Research Center for Biology, Indonesia Institute of Sciences for tree carbon analyses by CN Analyzer.

REFERENCES

Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., ... and Gaveau, D. (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, *43*, 51-61.

Heriyanto, N. M., Heriansyah, I., Siregar, C. A. and Kiyoshi, M. 2002. *Measurement of biomass in forests.* Bogor: JICA and FORDA.

Manuri, S., Brack, C., Rusolono, T., Noor'an, F., Verchot, L., Maulana, S. I., ... and Budiman, A. (2017). Effect of species grouping and site variables on aboveground biomass models for lowland tropical forests of the Indo-Malay region. *Annals of Forest Science*, *74*(1), 23.

Onrizal, O., Kusmana. C., Saharjo. B. H., Handayani, I. P., and Kato, T. 2005. Komposisi jenis dan struktur hutan kerangas bekas kebakaran di Taman Nasional Danau Sentarum, Kalimantan Barat. *Biodiversitas, Journal of Biological Diversity*, 6(4), 263-265

Onrizal. 2004. *Model Penduga Biomassa dan Karbon Tegakan Hutan Kerangas di Taman Nasional Danau Sentarum, Kalimantan Barat*. [Master's thesis] Bogor: Institut Pertanian Bogor.

Pamoengkas, P., van Noordwijk, M., and Indrawan, I. 2000. Pendugaan Biomassa Pohon Berdasarkan Model Fractal Branching pada Hutan Sekunder di Rantau Pandan, Jambi. *Jurnal Manajemen Hutan Tropika*, *6*(1), 1-5

Payn, T., Carnus, J. M., Freer-Smith, P., Kimberley, M., Kollert, W., Liu, S., ... and Wingfield, M. J. (2015). Changes in planted forests and future global implications. *Forest Ecology and Management*, *352*, 57-67.

Payn, T., Carnus, J. M., Freer-Smith, P., Orazio, C., and Nabuurs, G. J. 2014. Third International Congress on Planted Forests: Planted Forests on the Globe-Renewable Resources for the Future. In *New Zealand Journal of Forestry Science* (Vol. 44, No. 1, p. S1). Nature Publishing Group.

PT TPL. 2006. *Climatic data of Tele Sector Year 2005-2006*. Prosea: PT Toba Pulp Lestari, Tbk.

Romijn, E., Lantican, C. B., Herold, M., Lindquist, E., Ochieng, R., Wijaya, A., ... and Verchot, L. (2015). Assessing change in national forest monitoring capacities of 99 tropical countries. *Forest Ecology and Management*, *352*, 109-123.