

BIOMASS AND CARBON CONTENT IN TROPICAL FOREST OF CENTRAL KALIMANTAN

YETRIE LUDANG^{1*} and HERRY PALANGKA JAYA²

¹Department of Forestry, Faculty of Agriculture, University of Palangka Raya, Jalan Yos Soedarso 11, Palangka Raya 73111, Central Kalimantan, Indonesia

²Department of Forestry – Kapuas Branch Office, Jalan Tambun Bungai 6, Kuala Kapuas 73514, Central Kalimantan, Indonesia

*Corresponding Author: Phone: +62-536-3239463; Fax: +62-536-3239463; E-mail: y_ludang@yahoo.com

Received: 6th April 2007; Revised: 25th April 2007; Accepted: 27th April 2007

Abstract: A benchmarking study on biomass and carbon was carried out in Kahayan watershed. Three land uses were investigated, consisting of natural forest on peatland, damaged forest due to felling tree and forest fire. Prediction and both field and standard laboratory measurements were used in the study. Results of this research revealed that vegetation with average breast height diameter (BHD) of less than 10 cm was abundant on the peat land use, whereas BHD of more than 20 cm was characteristic of felling trees and various diameters were for the land subjected to forest fire. The natural forest on peatland contains living plants biomass (circa 600 tonne/ha) and carbon content (circa 340 tonne/ha) that were about twice of the other land uses. Dead plants on peatland, having biomass weight of circa 20 tonne/ha and carbon content of circa 11 tonne/ha were about half of the other two land uses. This revealed the paramount importance priority to conserve tropical forest on peatland in order to sequester carbon, leading to prevent air pollution.

Keywords: Above ground tree, damaged forest, dry weight, peatland, vegetation characteristics

INTRODUCTION

Natural resources such as tropical forest is vitally linked to environmental and conservation issues, as well as its economic value for human survival. One of the forest formations is on peatland that is characterised by the higher accumulation rate of organic matter than it can be decomposed [4]. Peat formation in the tropics results under constant conditions of water logging or in wet coastal areas where organic matter is produced in abundance by an adapted vegetation of mangroves, grasses or swamp forest trees [3, 6]. In Indonesia peatland covers an area of 16 Mha – 27 Mha [7, 8], and this ecosystem is subjected to various land use including forestry, agriculture, energy and horticulture [5]. During the last ten years, forest-based carbon trading has been developed to achieve global environmental health. This requires carbon accounting that is

the process of assessing the amounts of carbon found in different parts of a system. It is needed to estimate the amount of carbon that may be traded or used as an offset against greenhouse gas emissions. There are two main methods of carbon accounting in forests i.e. actually measuring carbon present in the trees, litter and soil, and using models to estimate carbon present in forest systems. Indonesia has a great concern on this issue because peatland with an average depth of 3 m and tropical forest are ecological reservoir for carbon, potentially preventing global warming. In addition, most of the peatland is unclassified land use [9] as well as forest fire, leading to deforestation. Therefore, this study took an approach to forest conservation to: (1) characterize vegetation on the different land uses, and (2) identify carbon content of above ground biomass for the investigated land use. This study supports carbon sequestration using forest-based resources.

MATERIALS AND METHODS

Satellite imaging of forest land in Kahayan watershed representing three research sites namely, natural peatland, the damaged forest due to felling trees and fire formed the basis of the present investigation (Fig. 1). Each forest was covered an area of about 0.5 Mha. This was achieved by collecting the earlier records from the local agency. Additional information from local community was considered to locate where the forest previously experienced in felling trees (1997) and fire (1997 and 2000).

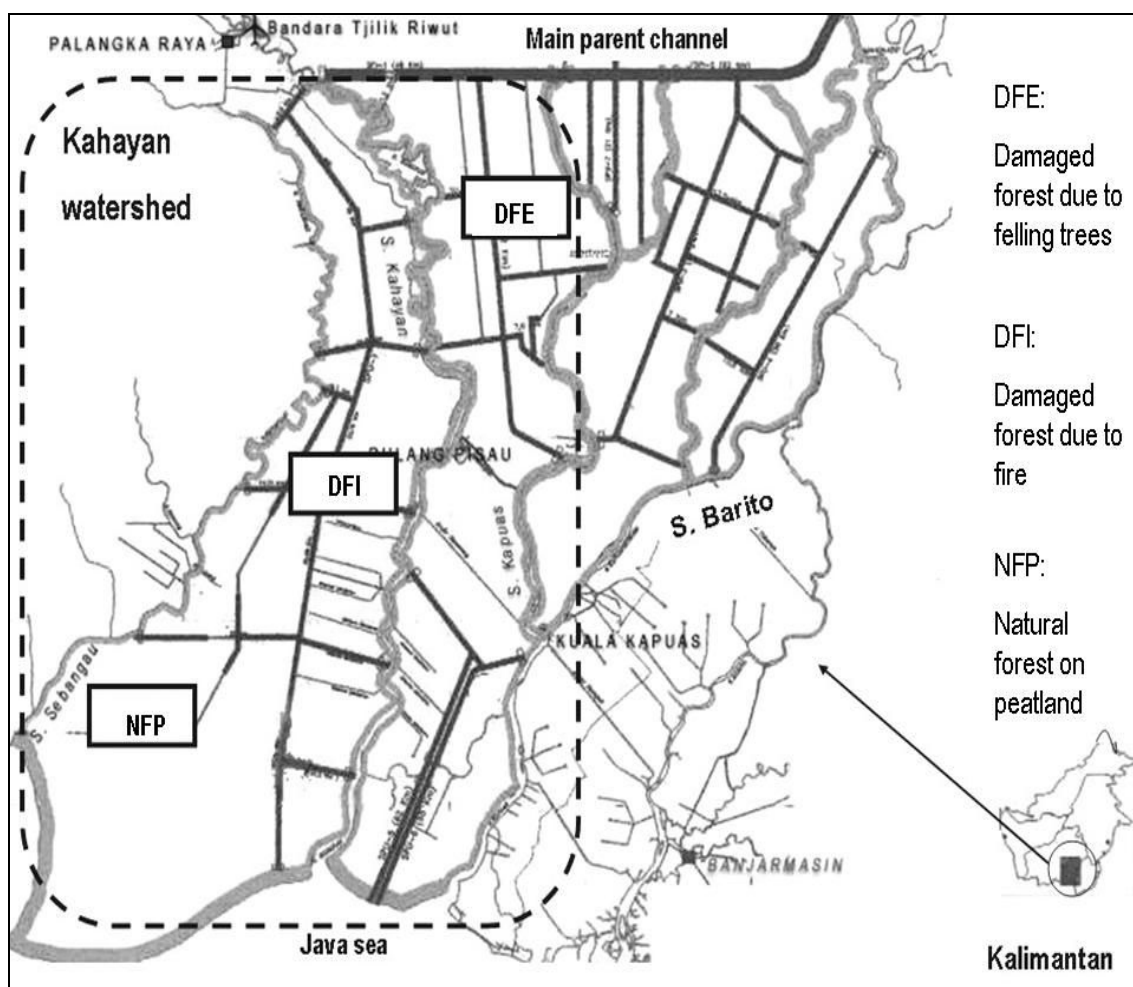


Fig. 1: Map of research sites

Field equipment consisting of measuring tape, chainsaw, and balances of various scales (1 Kg, 20 Kg and 50 Kg) were used to measure fresh weight measurement on site. Three plots, each measuring 10 m x 10 m square plot, were chosen randomly from each forest area. Each plot was divided into five subplots of 2 m x 2 m where samples were taken.

Living plants was measured at breast height diameter (BHD) above ground level before cutting. After felling the trees, the above biomass was cut into small pieces that could be weigh. An amount of 100 g – 200 g was collected and preserved for dry weight measurement. Dead plants were collected in a separate sack, the fresh weight was measured, and an amount of 100 g – 200 g was taken and preserved for dry weight measurement.

Water content was determined according to Indonesian standard laboratory practice [1]. Biomass dry weight was measured gravimetrically by drying it in an oven at 80 °C – 90 °C till constant weight (2 - 4 days). Carbon content was measured by ashing the dried biomass at 700 °C for 5 hours. The result of the measurements could be converted into tonne/ha since the plot area was known.

In addition, biomass weight was predicted using Brown's formula [2] in equation 1 as follows:

$$\text{Above ground biomass weight} = 38.4908 - 11.7883 (D) + 1.1926 D^2 \quad (1)$$

where D is plant diameter in cm and applicable for breast height diameter.

Hydrometeorology data consisting of water table, rainfall and peat surface temperatures were obtained from Sulistyanto [10]. The data were confirmed and updated yearly by local agencies located at Natural Watershed Laboratory, Tjilik Riwut Airport and Kota Palangka Raya. Temperature and precipitation influence biomass distribution of forests [13].

RESULTS AND DISCUSSION

The average annual rainfall measured in the three research sites varies between 2,124 mm and 2,301 mm. The amount of rainfall in the rainy season (October to April) covers 82 % of annual rainfall. Ground water table only came above the surface of about 10 cm – 40 cm between March and June 2001. Most of the surface temperatures (88 %) in the destroyed forest lay between 26 °C to 30 °C. In areas with denser vegetation cover, temperature ranges from 23 °C to 28 °C. The data were not show significant different among the three sites, and this is a typical tropical forest conditions.

Biomass was classified into eight classes based on the breast height diameter (DBH) with an increment range of 5 cm. The diameter frequency (f) and biomass (b) were presented in Table 1 for the three land uses. It could be generalized that peatland was characterized by abundance of vegetation of less than 10 cm diameter and small portion of biomass of less than 10 %, whereas vegetation with its diameter of more than 25 cm had more than 50 % biomass. Vegetation at the damaged forest due to felling tree was tended to lowering biomass as its diameter increased. The vegetation characteristics of the damaged forest due to fire were in between the two land uses.

Table 1: Biomass distribution on forest peatland and land subjected to felling trees and forest fire

	DBH, cm	-5	5-10	10-15	15-20	20-25	25-30	30-35	35+
Natural forest on peatland									
Plot 1	f, %	43.90	26.83	4.88	4.88	4.88	0.00	9.76	4.88
	b, %	0.77	1.37	1.91	3.69	5.59	0.00	34.14	52.53
Plot 2	f, %	64.71	19.61	7.84	0.00	0.00	3.92	1.96	1.96
	b, %	6.41	3.33	5.89	0.00	0.00	25.10	21.07	38.21
Plot 3	f, %	57.14	28.57	3.90	2.60	2.60	1.30	2.60	1.30
	b, %	1.82	6.30	2.05	5.09	31.45	10.76	23.51	19.02

Damaged forest due to felling tree									
Plot 1	f, %	68.22	21.50	6.54	0.00	1.87	0.93	0.93	0.00
	b, %	4.20	11.85	16.18	0.00	21.64	20.53	25.60	0.00
Plot 2	f, %	55.41	24.81	10.81	2.70	2.70	2.70	0.00	1.35
	b, %	1.17	4.58	10.75	8.22	13.62	21.17	0.00	40.49
Plot 3	f, %	57.89	14.47	17.11	6.58	2.63	1.32	0.00	0.00
	b, %	2.41	6.43	25.49	27.50	22.60	15.57	0.00	0.00

Damaged forest due to fire									
Plot 1	f, %	49.20	42.95	4.67	1.32	1.91	0.00	1.52	0.00
	b, %	11.26	39.65	13.93	7.05	18.83	0.00	36.13	0.00
Plot 2	f, %	57.89	14.47	17.11	6.58	2.63	1.32	0.00	0.00
	b, %	2.41	6.43	25.49	27.50	22.60	15.57	0.00	0.00
Plot 3	f, %	49.20	42.95	4.67	1.32	1.91	0.00	1.52	0.00
	b, %	11.26	39.65	13.93	7.05	18.83	0.00	36.13	0.00

Results of biomass dry weight and carbon content for 152 samples were presented in Table 2. The paired-t-test between predicted and measured biomass showed that the two measurements were highly correlated (coefficient correlation of 0.945) and no significant difference between predicted and measured biomass. Thus Brown's formula (eq.1) could be applied to predict biomass dry weight in central Kalimantan tropical forest conditions.

Based on F-test at p 0.05, biomass weight as well as carbon content in the two damaged forest were not significantly different. However, the natural forest on peatland was significantly different with them. It was shown that natural peatland contains living plants biomass and carbon content about twice of the other land uses. Contrarily, the dead plants in natural peatland were about half of the other two land uses. Carbon contents were on average 56 % of the biomass production.

Table 2: Biomass dry weight and carbon content

	Predicted biomass dry weight using Brown's formula, tonne/ha		Measured biomass dry weight, tonne/ha		Measured carbon content, tonne/ha	
	Living plants	Dead plants	Living plants	Dead plants	Living plants	Dead plants
Natural forest on peatland						
Plot 1	935.78	18.55	908.91 ± 26.30	18.55 ± 1.86	518.40 ± 12.63	10.48 ± 0.93
Plot 2	425.06	58.39	371.66 ± 37.17	58.39 ± 1.71	242.79 ± 21.28	33.23 ± 0.32
Plot 3	602.91	14.56	491.62 ± 98.20	14.56 ± 0.15	292.69 ± 61.12	8.28 ± 0.82
Damaged forest due to felling tree						
Plot 1	366.62	44.54	372.10 ± 4.21	44.54 ± 0.45	221.98 ± 2.19	21.66 ± 0.22
Plot 2	377.26	40.43	331.13 ± 33.11	40.43 ± 0.34	188.22 ± 2.02	19.81 ± 0.18
Plot 3	253.80	24.02	197.54 ± 53.19	24.02 ± 0.42	110.25 ± 21.11	7.78 ± 0.08
Damaged forest due to fire						
Plot 1	282.94	78.66	280.65 ± 2.82	78.66 ± 0.79	102.90 ± 1.29	46.25 ± 0.63
Plot 2	444.15	43.09	417.66 ± 12.41	43.09 ± 0.39	237.80 ± 6.24	29.44 ± 0.34
Plot 3	157.27	56.76	156.42 ± 1.63	56.76 ± 0.68	89.33 ± 1.12	26.65 ± 0.27

The total biomass weight in each land use was slightly higher than the results obtained by previous researchers in Central Kalimantan [12]. This was probably due to the difference in diameter classification that the earlier investigations were based on diameter classification of more than 5 cm. However, this result was in agreement with the earlier studies that validated 55 % - 70 % of forest peatland dominated by vegetation of 5 cm – 10 cm diameter. The measured carbon content was about 56 % of biomass dry weight, and therefore, it could be used to predict carbon loss due to fires or illegal tree felling. In 1997, forest fire occurred at the site and therefore, 0.56 tonne of carbon/tonne of biomass dry weight was lost. Comparatively, the damaged forest due to felling trees in Jambi, Sumatera, resulted in biomass loss of about 46%, or 159 tonne/ha [11].

CONCLUSIONS

There was significant difference of biomass and carbon content between natural forest on peatland and the forest damaged due to tree felling and forest fire. Biomass weight ranging from 400 tonne/ha to 900 tonne/ha, carbon content in the range of 240 tonne/ha – 400 tonne/ha, and breast height diameter of tree of the natural forest on peatland characterized. Damaging forest would result in releasing carbon of about half of the potential content and therefore such inhumane activities should be prevented. In addition, Brown's formula for predicting biomass weight based on breast height diameter of tree could be applied. However, carbon content of 56 % biomass dry weight should be used for Central Kalimantan tropical forest conditions.

References

1. Badan Standardisasi Nasional, 2000. Kayu Lapis Penggunaan Umum. Standard Nasional Indonesia Nomor 01-508.2. Jakarta
2. Brown, S., 1997. Estimating Biomass and Biomass Change of Tropical Forests. FAO, Forestry Paper 134. A Forest Resources Assessment Publication, Rome. Pp, 1
3. Driessen, P. M., 1977. Peat Soil: Their occurrence, properties, reclamation and suitability for rice cultivation. Soil and Rice Symposium, Manila. pp. 763-779.
4. Gore, A. J. P., 1983. Mires: Swamp, Bog, Fen and Moor Ecosystems of the World. Elsevier Scientific Publishing Company. New York.
5. MacDicken, K.G., 2002. Cash for Tropical Peat: Land Use Change and Forestry Projects for Climate Change Mitigation. Proceeding of Jakarta Symposium on Peatlands for People. BPPT and Indonesian Peat Association.
6. Radjaguguk, B., 2000. The changes on physical and chemical characteristics of peat due to peatland reclamation for agriculture (In Bahasa Indonesia). Jurnal ilmu tanah dan lingkungan 2(1):1-15.
7. Radjaguguk, B., 1992. Utilisation and Management of Peatlands in Indonesia for Agriculture and Forestry. Proceedings of the International Symposium on Tropical Peatland. Kuching, Sarawak, Malaysia. May 1991. Malaysia, Ministry of Agriculture, MARDI. pp. 21-27.
8. Rieley, J.O., Ahmad-Shah, A.A. and M.A. Brady, 1996. The Extent and Nature of Tropical Peat Swamps. In Tropical Lowland Peatlands of Southeast Asia. Ed. E. Maltby, C.P. Immirzi and R.J. Safford. Proceedings of a Workshop on Integrated Planning and Management of Tropical Lowland Peatlands held at Cisarua, Indonesia, 3-8 July 1992. IUCN. pp. 17-53.
9. Siregar, U.J., Massijaya, MY., Jaya, A., and C.A. Siregar, 2004. Baseline Study on Peat Swampy Forest Area in Central Kalimantan. Forest Research and Development Agency Japan International Cooperation Agency.
10. Sulistiyanto, Y., 2003. Nutrient dynamics in different sub-types of peat swamp forest in Central Kalimantan, Indonesia. Report in support of transfer to PhD. The University of Nottingham. 43pp.
11. Tresnawan, H., and U. Rosalina, 2002. Estimating Aboveground Biomass in the Primary and Logged Over Forest Ecosystem (Case Study Dusun Aro Forest, Jambi) in Indonesian. Jurnal Manajemen Hutan Tropika. 1:15-29.
12. Waldes, N. and S. Page, 2002. Forest Structure and Tree Diversity of a Peat Swamp Forest in Central Kalimantan, Indonesia. Proceedings of the International Symposium on Tropical Peatland: Peatlands for People Natural Resource Functions and Sustainable Management. Ed. Rieley, J.O. and Page, S. BBPT and Indonesian Peat Association. pp 16-22.
13. Xiao-Quan Zhang, 2003. Current Methodologies for Assessing Carbon Budgets in China's Forests. Proceedings of an International Workshop on "Facilitating International Carbon Accounting in Forests" Held at Csiro Forestry and Forest Products, Canberra, 24 February 2003.