Journal of TROPICAL BIODIVERSITY E-ISSN : 2774-4116

Structure and Composition of Vegetation and Carbon Stock Calculation in a Natural Lowland Forest of Plantation Forest Landscape

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Abstract

In Indonesia, every concession of industrial plantation forest must leave at least 10% from the size of the concession as natural forest and set aside for protected area. We examined the forest structure and composition through a one-hectare permanent sampling plot (PSP) within three forest cover classes, open land, scrub and young regeneration forest. Surveys showed that there were 143 trees (>10 cm dbh) of 23 species in the Open Land PSP (dominated by *Euphorbiaceae*, *Myristicaceae* and *Rutace* families), 407 trees from 48 species in the Scrub PSP (*Euphorbiaceae*, *Lauraceae* and *Sapindaceae*), and 486 trees from 67 species in the Young Regeneration Forest PSP (*Euphorbiaceae*, *Lauraceae* and *Annonaceae*). Biomass and carbon stock determined through the trees ≥ 10 cm dbh in each forest cover classes. With a Chave formula found that in Open Land stored 15.6 ton C/Ha, in Scrub stored 63.4 ton C/Ha, and in Young Regeneration Forest stored 83.8 ton C/Ha. Calculated that there is around 4.7 million ton C stored in those various forest and vegetation covers within conservation area inside plantation forest concessions at landscape scale. This can be contributed to the efforts of emission reduction at the sub-national level.

Keywords: Biomass, Indonesia, industrial plantation, Jambi, permanent sampling, emission Reduction

Submission	:	Jan, 09th 2022
Revision	:	March 08th 2021
Publication	:	April 30th 2022

INTRODUCTION

It is known that generally tree growth in the tropics is faster compared to the ones in sub-tropics. This is a reason why the developed countries give much attention to the conservation of tropical forests, as their potential in sequestration of gas emissions which can lead to unwanted climate change. Thus, baseline data on the ability of Indonesia's tropical forest on carbon sequestration is extremely need as the country is the one that has a largest tropical forest in the world after Brazil and Kenya. This baseline data will be useful once the regulation concerning global carbon trade is ratified by the Indonesian government (Siregar & Heriyanto, 2010).

Clean Development Mechanism (CDM) requires developed countries to reduce their CO_2 emissions, while developing countries, which mostly located in the tropics, are require to avoid forest degradation that aims to reduce global warming (Masripatin, 2007). Primary lowland tropical rainforest is rich in species diversity, but it is also a stable dynamic ecosystem. The stability of this ecosystem can be changed due to forest disturbances, such as forest fires, natural disasters, and environment unfriendly loggings. Johns (1997) and Whitmore (1984) stated that logging activities in natural forests can damage up to 50% of trees compared to previous condition. In East Kalimantan, damage caused by logging activities at pole and tree levels jointly is 40.94% (Sist, 1994), but damage at tree level itself is 22.60% per hectare of area (Priasukmana & Sjahibar, 1986).

Blocks of natural tropical forest occur within a landscape that dominated by plantation forest concessions and oil palm plantations, in northeastern part of Jambi Province, Sumatra, is one of biological natural resources that play an important role in the ecosystem. As blocks of forest areas are located within plantation forest concessions that grow *Eucalyptus pelita* and *Acacia mangium*, they also become a germplasm resources for the companies.

One of the functions of the forest is as absorber of CO_2 from the atmosphere. According to *International Panel on Climate Change/*IPCC (2006), until the end of 1980 global carbon emission was 117 ± 35 G tons due to burning of fossil fuels and coals, forest conversions and forest fires. In Indonesia, the highest emissions occur in 2006 at 195 million tons CO_2^{-e} and the lowest was in 2010 at 74 million ton CO_2^{-e} (INCAS, 2015). Purwanta (2010) explained that CO_2 emissions in Indonesia in the period of 2001-2006 was 827,058,035 CO_2^{-e} Gg/year. Therefore, the role of the forests as CO_2 absorber must be well managed to mitigate this climate issues. Sequestration of carbon dioxide is strongly correlates with biomass of standing vegetation. The amount of biomass in an area is obtained from production of biomass density and tree species (Heriyanto & Siregar, 2007; Onrizal *et al*., 2008; Bismark *et al*., 2008; Dharmawan & Samsoedin, 2012).

Research on estimating of biomass and carbon content in tropical forests is still needed to be conducted because the potential of forest biomass is high in absorbing carbon. Furthermore, the forest has also high potential in reducing CO2 from the atmosphere through forest conservation and forest management (Heriansyah *et al*., 2007; Onrizal & Kusmana, 2009; Subiandono *et al*., 2013).

The objective of this study to determine the structure and composition of vegetation, as well as the potential of biomass and carbon content in various land cover types in protected areas within plantation forest concessions on a landscape scale, so that they can contribute to the efforts of emission reduction at the sub-national level in Jambi.

METHOD

Location

The study was carried out in February 2018, at three different stratification of forest and vegetation, such as Young Regeneration Forest/YRF, Scrub/SC, and Open Land/OL (Rosoman *et al*., 2017). OL and SC sites located at the Danau Bangko forest block, within conservation area of plantation forest concession PT. Rimba Hutani Mas (PT. RHM), while YRF site located at the District III within conservation area of PT. Wirakarya Sakti (PT. WKS). Administratively those areas are situated in Lubuk Ruso Village, Pemayungan Sub-district, Batanghari Regency, Jambi Province, approximately 40-50 kilometers northwestern of City of Jambi (Figure 1). PT. RHM and PT. WKS are industrial forest plantation concessions that supply pulp wood to Asia Pulp and Paper Group (APP).

In 2013, APP launched a commitment regarding Forest Conservation Policy one of which was stop cutting natural forest within its wood supplier concessions, and stop using wood from natural forest as raw material for its pulp and paper products. PT. RHM is

Journal of
TROPICAL BIODIVERSITY
E-ISSN : 2774-4116

operated under the license from Indonesia's Ministry of Forestry (SK. 689/Menhut-II/2010) managing production forest area of 35,814 Ha, and PT. WKS is holding a similar license (SK. 346/Menhut-II/2004) managing production area of 293,812 Ha. Within both concessions there is 57,547 Ha (14.7% from the total concession area) of forest that set aside as protected forest (conservation area). This is higher than the government regulation that requiring each plantation forest concession to leave 10% of the area and set aside for protected area.

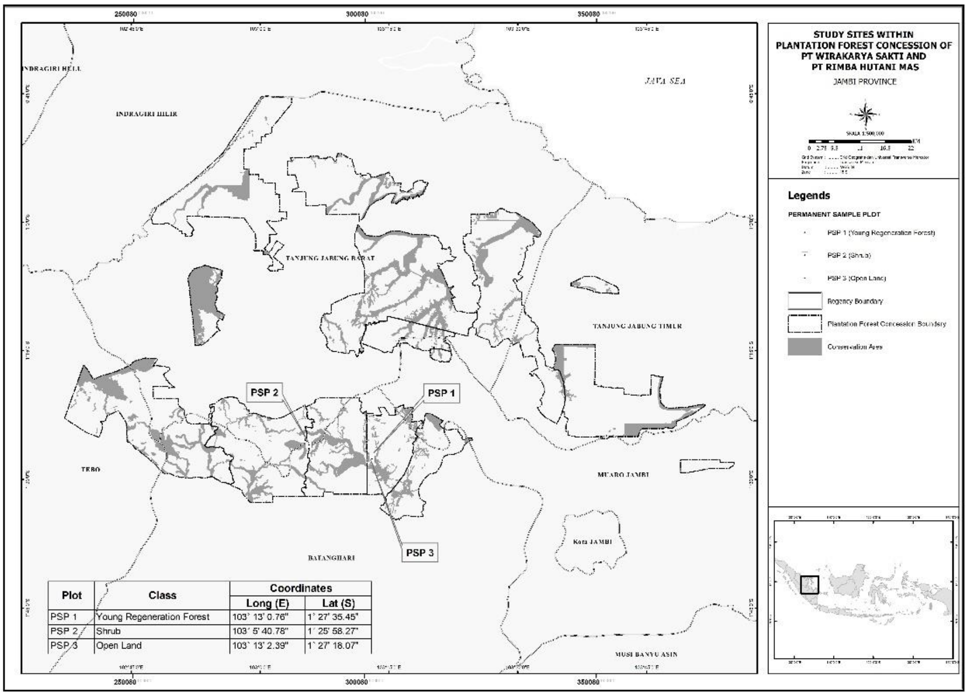

Figure 1. Map of the study area in plantation forest concession's conservation area of PT. RHM and PT. WKS in Jambi.

Study sites is a block of lowland tropical rainforest at the elevation of ± 40 m above sea level (asl), with a sloping topography and with the slope between 8 and15%. Soil type is association of Alluvial (Pusat Penelitian Tanah dan Agroklimat, 1993; Soil Survey Staff, 2003). The parent materials consist of acid tuff, sandstones and sand deposit. It has thick soil solum, the color is red to yellow with consistent texture variable, acidic, low nutrient content with permeability low to medium, and easily erodible.

Based on Schmidt & Ferguson (1951) this area classified as climate type A, with annual rainfall is 958.7 - 1,613 mm. Wet season occurs in February - June and humid month is only happened in Januari. Air temperature ranges from 31.2 ºC - 36.0 ºC (maximum) and from 24.9 ºC – 27.0 ºC (minimum). According to BPS (2016), air humudity varied between 85% and 98.1% (maximum) and between 25.9% and 60% (minimum).

Research Design and Sampling

Three plots of one hectare for the study determided randomly within concession's conservation area which covers ± 819 ha. Each one hectare plot represents forest or vegetation category: YRF, SC and OL. The sample unit is square with a size of 100 m x 100 m (1 ha). 25 subplots of 20 m x 20 m were set up within each one hectare plot (Figure 2).

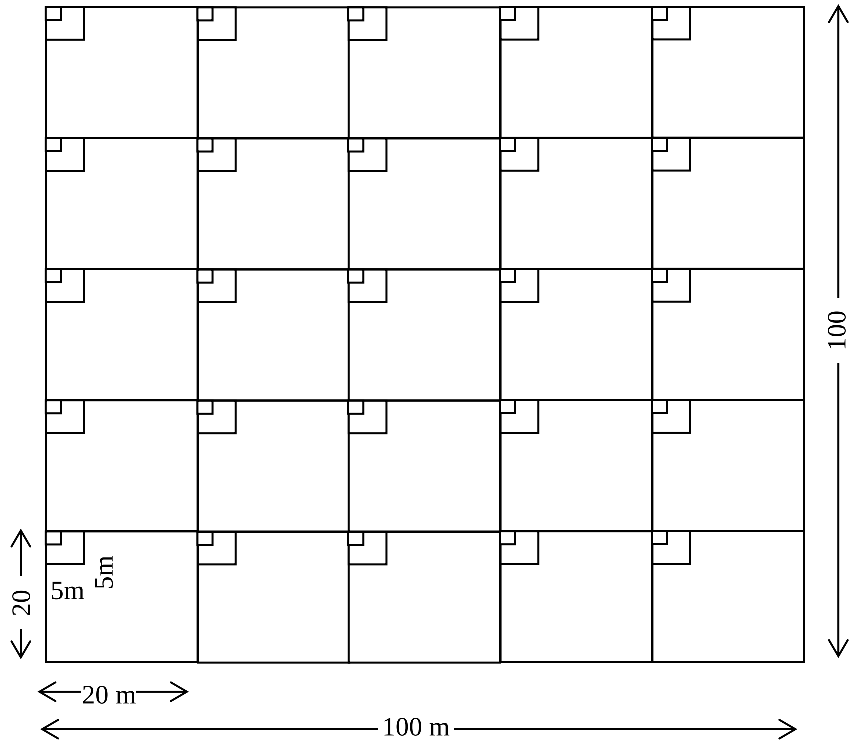

Figure 2. The design of one hectare's study measurement plot.

All trees and poles occurring within all subplots were measured, recorded and numbered with metal tags at 160 cm above ground. The DBHs were measured at 120 cm above ground. For trees with tall buttresses measurements were made 20 cm above the upper ends of the buttresses. Height of trees and poles as well as species and local names were also recorded. All seedlings were only counted their numbers, and species or local names also recorded. Herbarium samples were made and taken for further species identification in Forest Botany and Ecology Laboratory, Center of Forest Research and Development, Bogor.

Based on Kartawinata *et al*. (2004) and Irwanto (2006), the criteria of tree, pole and seedling levels are as follows:

1. Tree, has diameter ≥ 10 cm at the DBH (1.3 m above ground), for trees with tall buttresses measurements were made 20 cm above the upper ends of the buttresses, plot size 20 m x 20 m.
2. Pole, young individual that has hight > 1.5 m until young tree with DBH < 10 cm, plot size 5 m x 5 m.
3. Seedling, young individual from sprouts until invidual that has height ≤ 1.5 m, plot size 2 m x 2m.

Data Analysis

The data obtained were analyzed to determine the dominant species. The dominant species is the species that has the highest important value in each vegetation type (Kusmana, 1997). The dominant pecies can be obtained by doing an analysis of important value index (%), as the sum of the relative density, relative dominance and relative frequency of each species that found in the plot sample (Soerianegara & Indrawan, 1982).

1. Potential of vegetation type
   Potential vegetation type within the study plot is categorized into three levels of growth i.e. seedlings, poles, and trees where each is calculated in unit per unit area (ha).
2. Potential of standing
   Potential of standing is calculated including volume and number of standing stock per ha, that is classified based on diameter class: 10 cm - 19 cm, 20 cm - 29 cm, 30 cm - 39 cm, 40 cm - 49cm, ≥50 cm.
3. Biomass measurement of standing is conducted with using a formula from Chave *et al*., 2005, so that the *destructive sampling* method was not carried out.

   The equation i.e.:

   $Y = 0.0509 \times \rho \times DBH^2 \times T$ ……………………………………….(1)

   Where:
   Y = total biomass (kg), DBH = diameter breast height (cm), ρ = wood density (gr/cm^3)
   T = height (m). Average of wood density is 0.61 gr/cm^3 (Hairiah & Rahayu, 2007).

4. Carbon content in plants is calculated using a formula (Brown, 1997 and International Panel on Climate Change/IPCC, 2003):
   Carbon content = Dry weight of plant x 50% …………………. …...(2)
5. Sequestration of carbon dioxide:
   Sequestration of carbon dioxide (CO_2) = 3.67 x carbon content ……(3)

The use of these equations is based on the climate area of the study site that has rainfall Penggunaan persamaan tersebut didasarkan pada wilayah iklim lokasi penelitian yang memiliki 2.409 mm/year and fall into category of moist (rainfall between 1.500 - 4.000 mm/year). All data obtained then tabulated and analyzed using *Microsoft Excel* (2010).

RESULTS AND DISCUSSION

YRF/Young Regeneration Forest Plot

Composition and Vegetation Potential

A. Species Composition

Based on the result of plant species and families identification, there are found 84 species of trees belongs to 34 families (Appendix 1), where families that have the most species i.e. Euphorbiaceae, Rubiacieae and Annonaceae.

In this study, it is found 486 trees (diameter ≥ 10 cm)/ha in 25 sub-plot that sized 20 m x 20 m (Appendix 2.) The results shows from 67 tree species with ≥ 10 cm diameter there are 8 dominant species with IVI > 10%. The density and important value index of the dominant species are presented in Table 1.

B. Potetial of Vegetation Type

The research location in protected area of Danau Bangko, Batanghari, Jambi, dominated by medang kuning/*Alseodphane bancana*, pelajau/*Agelaea trinervis* and kelat jangkar/jagul/gawal/*Syzygium* sp. The potential species replaces the next stand is kelat jangkar/kopi-kopi/*Rothmania* sp. (IVI = 28.45 %), kabau/merpanai/*Archidendron bubalinum* (IVI = 21,08 %) and kedondong hutan/*Dacryodes rostrata* (IVI =16.09 %).

Table 1. Dominant tree species with ≥ 10 cm diameter (IVI > 10%) in study area.

No.	Species	Density 1 ha	Important Value Index (%)
1	Medang kuning/*Alseodphane bancana* Miq.	39	23.60
2	Pelajau/*Agelaea trinervis* (Llanos) Merr	36	18.96
3	Kelat jangkar/jagul/gawal/*Syzygium* sp.	30	17.14
4	Kabau/*Archidendron bubalinum* (Jack.) Nielsn.	35	16.09
5	Petaling/*Ochanostachys amentacea* Mast.	28	16.86
6	Sentul/*Sandoricum koetjape* (Brum.f.) Merr.	14	11.05
7	Balam putih/*Diospyros* sp.	12	11.02
8	Barangan/semasam/*Strombosia ceylanica* Gar.	12	11.02

The stand density and number of tree species is one of the indicators of biological wealth in the forest. The following is a comparison of the species and trees in other areas (Table 2).

From Table 2, it can be argues that the density and number of species in protected area of Danau Bangko, Batanghari, Jambi, classified as moderate because the forest area is a secondary forest or scrub which is in a fairly good condition.

3.1.2 Stand Structure and Regeneration

Structure of forest stand is an individual plants distribution in the canopy layer and can be interpreted as the tree distribution per unit area in various diameter classes (Bustomi *et al*., 2006). Overall, the tree stand structure in the research plot is presented in Figure 3.

In Figure 3, tree species with dominant height (> 25m) is cemanding/*Horsfieldia glabra* (32.0 m), balau/*Memecylon* sp. (28.7 m) and medang kuning/*Alseodphane bancana* (26.9 m); species that dominates the height (20 m - 25 m) are medang sendok/*Endospermum* sp. (24.9 m), barangan/*Strombosia ceylanica* (24.8 m) and sentul/*Sandoricum koetjape* (24.7 m); height (15 m - < 20 m) are meranti merah/*Monocaria* sp. (19.9 m), sentul/*Sandoricum koetjape* (19.9 m) and arang-arang/*Strombosia ceylanica* (19.9 m).

The results of all tree distribution for 10 – 19 cm, 20 – 29 cm, 30 – 39 cm, 40 – 49 cm, and ≥ 50 cm diameter classes in the study site shown in Figure 4.

Structure of forest stand is not always the same even though it is in the same place, this is caused by the differences in ability to utilize solar energy, nutrients/minerals and water, as well as the nature of competition. Therefore the tree arrangement in forest stand will form a variable diameter class distribution (Ewusie, 1980).

Table 2. The comparison of density and number of tree species with ≥ 10 cm diameter in study site and other location.

Location	Alt. (m asl)	Plot (Ha)	Density (N/ha)	N of spesies	Source
Danau Bangko, Batanghari, Jambi (belukar tua)	40	1	486	67	Penelitian sekarang (2018)
S. Bayat Selaro (belukar muda)	36	1	219	61	Penelitian (2018)
S. Bayat Selaro (belukar tua)	40	1	438	63	Penelitian (2017)
Register 45B, Lampung Barat	965	1	247	33	Heriyanto *et al.*, (2016)
Hutan Bukit Datuk, Dumai	18.2	1	354	22	Samsoedin *et al.*, 2014
Desa Mekar Makmur, TNGL	237.6	1	687	110	Samsoedin dan Heriyanto, 2010
Aek Nangali, Batang Gadis	650	1	583	184	Kartawinata *et al.*, 2004
Sekundur, TNGL	75-100	2	572.5	133	Priatna *et al.*, 2004
Ketambe, NAD	350-450	1,6	420	94	Abdulhadi, 1991
Seturan Malinau, Kaltim	100	1	759	221	Kartawinata*et al.*, 2002
Gunung Mulu, Serawak	50	1	615	223	Proctor *et al.*, 1983

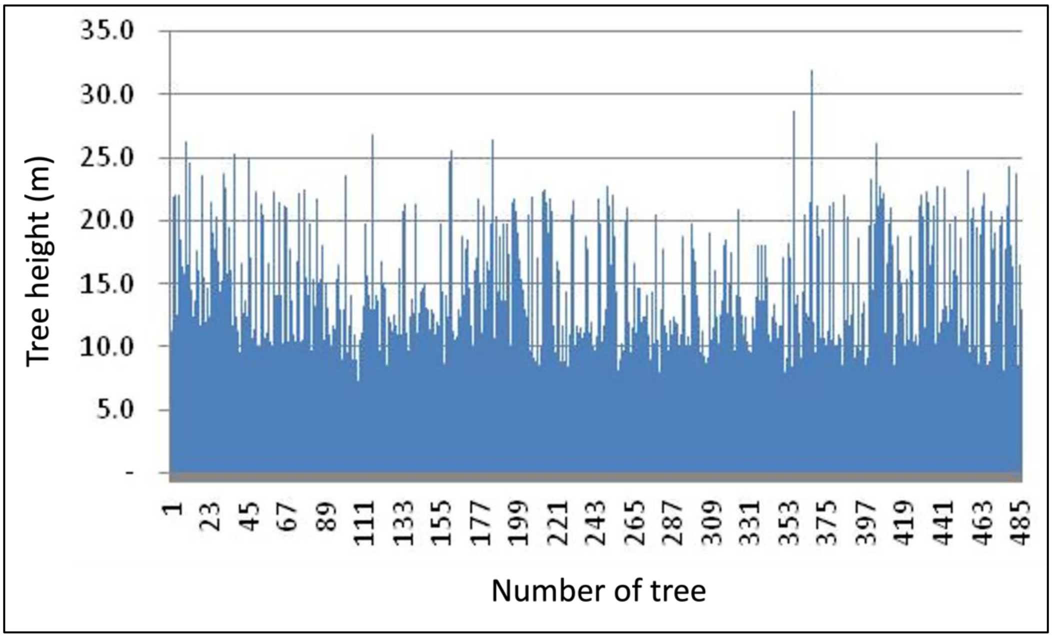

Figure 3. Profile of forest stand in study site.

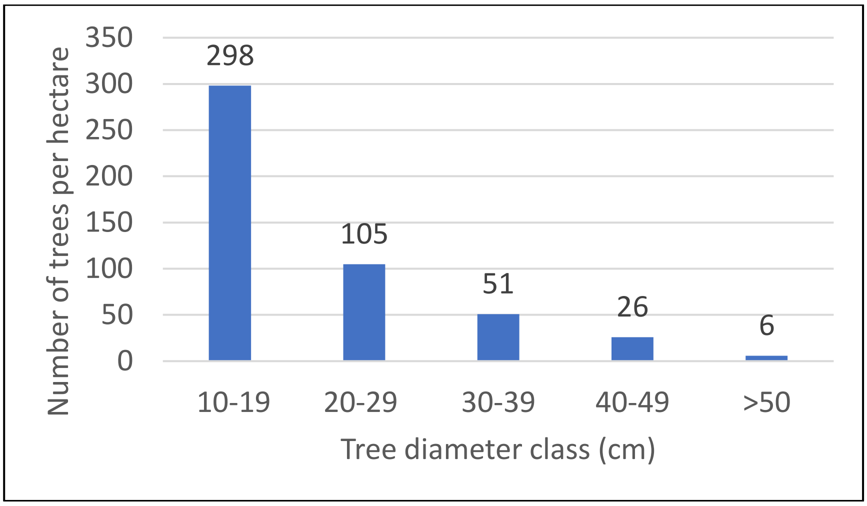

Figure 4. Structure of tree stand based on the relationship between diameter classes and the number of trees in study site.

From Figure 4 above, it can be stated that the forest stand structure in research location shows the number of decreasing trees from small to large diameter classes, so the curve shape is generally characterized by the distribution number that resemble an upside down **"J"**. Forest stand structure in research location shows normal growth characteristics, normally in natural forests small diameter classes are a lot more than the large diameter classes (Samsoedin & Heriyanto, 2010).

Regeneration is a natural phenomenon where younger trees will replaces an adult trees for some reason, such as being felled, burned, fallen (natural disaster) or physiologically dead. There are complete plant species regeneration (in each strata: trees, poles and seedlings) there are 18 species (Table 3.)

Table 3. Tree species with complete regeneration in the study site.

No.	Species	Family	IVI (%)		
			Seedling	Pole	Tree
1.	Antui/*Litsea tomentosa* Blume	Lauraceae	1.77	3.28	4.95
2.	Arang-arang/*Strombosia ceylanica* Gardn	Olacaceae	5.98	2.59	4.21
3.	Kabau/*Archidendron bubalinum* (Jack.) Nielsn	Leguminosae	20.36	4.94	16.09
4.	Kedongdong hutan/*Dacryodes rostrata* H.J.L.	Burseraceae	1.77	16.09	4.20
5.	Kelat/*Aporusa micosphaera* Hook.f.	Euphorbiaceae	28.12	28.45	0.56
6.	Kelat jambu/*Ixora simalurensis* Brem.	Rubiaceae	9.53	7.39	3.34
7.	Kelat jangkar/*Syzygium* sp.	Myrtaceae	19.25	20.77	10.35
8.	Kelat samak/*Antidesma neurocarpum* Miq.	Euphorbiaceae	4.21	2.45	5.87
9.	Keranji/*Hydnocarpus woodii* Merr.	Flacourtiaceae	1.77	14.65	4.27
10.	Medang kuning/*Alseodphane bancana* Miq.	Lauraceae	1.77	8.00	23.60
11.	Meranti merah/*Monocaria* sp.	Annonaceae	24.12	17.00	10.15
12.	*Unidentified*/*Canarium* sp.	Burseraceae	1.77	16.14	10.11
13.	Pelajau/*Agelaea trinervis* (Llanos) Merr	Connaraceae	1.77	2.57	18.96
14.	Petaling/*Ochanostachys amentacea* Mast.	Olacaceae	4.21	13.14	16.86
15.	Semasam/*Strombosia* sp.	Olacaceae	12.41	12.87	1.20
16.	Sempagar/*Gompia serrata* (Gaertn) Kanis.	Ochnaceae	7.09	2.23	3.50
17.	Tampui/*Baccaurea motleyana* (Muell.Arg.) Muell.Arg	Euphorbiaceae	8.87	5.59	4.20
18.	Tangunan/*Syzygium jamboloides* K.et V.	Myrtaceae	1.77	3.40	0.54

In Table 3, it can be argued that the species that dominates complete regeneration: tree level is medang kuning/*Alseodphane bancana* (IVI = 23.60%), poles level is kelat jangkar/*Syzygium* sp. (IVI = 28.45%), and for seedlings level is kelat/*Aporusa micosphaera* with IVI of 28.12%.

3.1.3 Biomass and Carbon Content

Forest biomass is expressed in oven dry units weight per unit area, which is consist the weight of leaves, flowers, fruit, branches, twigs, stems, roots, and dead trees (Brown *et al.*, 1989). The amount of forest biomass is determined by diameter, height, wood density, density, and soil fertility. Estimation of tropical plantation forest biomass is needed because it influences the carbon cycle (Morikawa, 2002). From forest biomass, approximately between 45 and 50 percent contains carbon (Brown, 1997; International Panel on Climate Change, 2006). Furthermore, Nelson *et al*. (1999) stated that biomass data of an ecosystem is very useful to evaluate productivity pattern of various ecosystem.

Forest stands, especially younger trees (poles, saplings and seedlings) have great potential in absorbing and reducing carbon dioxide levels in the atmosphere. It can be explained that growth process of younger trees are relatively faster compared to older trees. In growth/photosysnthesis process carbon dioxide and water converted into carbohydrate, then through metabolic process into lipid, nucleic acids, and protein, these materials will be converted into plant organs (Anonymous, 1981 dan Campbell *et al*., 2002).

Based on the Chave equation $Y = 0.0509 \times \rho \times DBH^2 \times T$, the biomass and carbon content of forest stands with ≥10 cm diameter in the study site are presented in Table 4.

Table 4. Prediction of biomass, carbon content, and sequestrtation of carbon dioxide in the research forest.

Diameter class (cm)	**Calculation based on Chave's formula**		
	Biomass (ton/ha)	**Carbon (ton C /ha)**	**Carbon diocide (ton CO_2/ha)**
10 – 19	32.12	16.06	58.93
20 – 29	42.88	21.44	78.68
30 - 39	43.51	21.75	79.84
40 – 49	36.36	18.18	66.72
≥50	12.77	6.39	23.44
Total	**167.6**	**83.82**	**307.6**

In Table 5, it can be seen that the biomass and carbon content of forest stands with ≥ 10 cm diameter in protected area of Danau Bangko, Batanghari, Jambi (YRF) calculated by Chave equation *et al.*, (2005) classified as high with 167.6 tons/ha or 83.82 tons C/ha equivalent to 307.6 ton CO_2/ha. If compared with Dharmawan (2012) research results in Central Kalimantan peat swamp primary forest up to 73.08 tons C/ha, while Bismark *et al.* (2008) in Siberut National Park as big as 65.96 tons C/ha. In North Sumatra Batang Toru primary forest is as big as 109.36 tons C/ha (Samsoedin *et al.*, 2009). Biomass in Gede Pangrango National Park, is equal to 275.56 tons C/ha (Siregar, 2007) and in Serawak, Malaysia at 165-202.5 tons C/ha (Brown, 1997).

3.2. SC/Scrub Plot

3.2.1Composition and Vegetation Potential

A. Species Composition

Based on the result of tree species and families identification, there are found 57 species of trees belongs to 29 families (Appendix 5), where Euphorbiaceae, Lauraceae and Sapindaceae are family that has the most species.

In this research, it is found 48 species with ≥ 10 cm diameter in total 0f 407trees/ha in 25 sub-plot that sized 20 m x 20 m with ≥ 10 cm diameter (Appendix 6).

The research results shows from 48 tree species with ≥ 10 cm diameter there are 9 dominant species with IVI > 10%. Forest stands is dominated by aprika/*Maesopsis eminii* with IVI = 39.99%, sungkai/*Peronema canescens* (IVI = 39.72%) and mahang/*Macaranga gigantea* (IVI = 17.62%). The density and important value index of the dominant species are presented in Table 5.

Table 5. Dominant tree species with ≥ 10 cm diameter (IVI > 10%) in research location.

No.	Species	Density 1 ha	Important Value Index (%)
1	Aprika/*Maesopsis eminii* Engl.	66	39.99
2	Sungkai/ *Peronema canescens* Jack.	73	39.72
3	Mahang/*Macaranga gigantea* (L.) Muell.Arg.	25	17.62
4	Pinang/*Areca catechu* L.	29	17.53
5	Kelat/*Aporusa micosphaera Hook.f.*	15	12.99
6	Jerunjing/*Goniothalamus macrophyllus*	13	12.84
7	Rambutan hutan/*Nephelium lappaceum* L.	14	12.53
8	Ketapang *Terminalia catappa*	15	10.19
9	Arang-arang/*Diospyros bantamensis* Koord.& Valeton ex Bakh.	14	10.11

B. Potential of Vegetation Type

The research location in protected area of Danau Bangko, Batanghari, Jambi (Scrub) dominated by aprika/*Maesopsis eminii*, sungkai/*Peronema canescens* and mahang/*Macaranga gigantean*. The potential species replaces the next stand is mahang/*Macaranga gigantea* (IVI = 39.46%), afrika/*Maesopsis eminii* (IVI = 20.23 %) and medang serai/*Antidesma paunticulatum* (IVI = 18.28 %).

From Table 2, it can be argues that the density and number of species in protected area of Danau Bangko, Batanghari, Jambi proctected area (Scrub), classified as moderate because the forest area is a secondary forest/young thicket are growing and succession well.

3.2.2 Stand Structure and Regeneration

Structure of forest stand is an individual plants distribution in the canopy layer and can be interpreted as the tree distribution per unit area in various diameter classes (Bustomi *et al*., 2006). Overall, the tree stand structure in the research plot is presented in Figure 5.

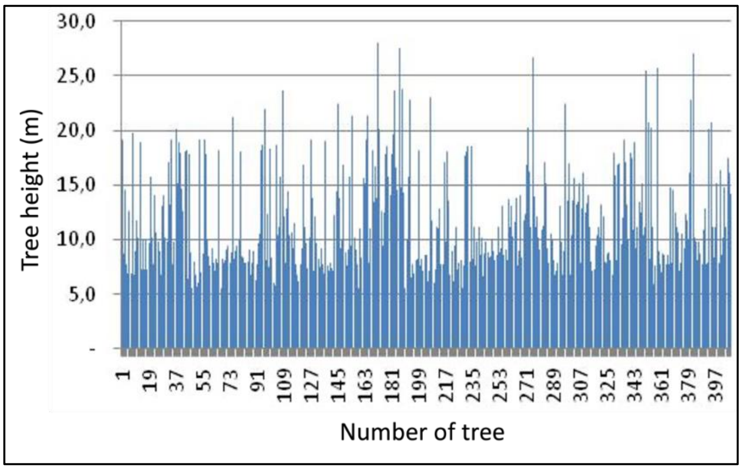

Figure 5. The profile of forest stand in research location.

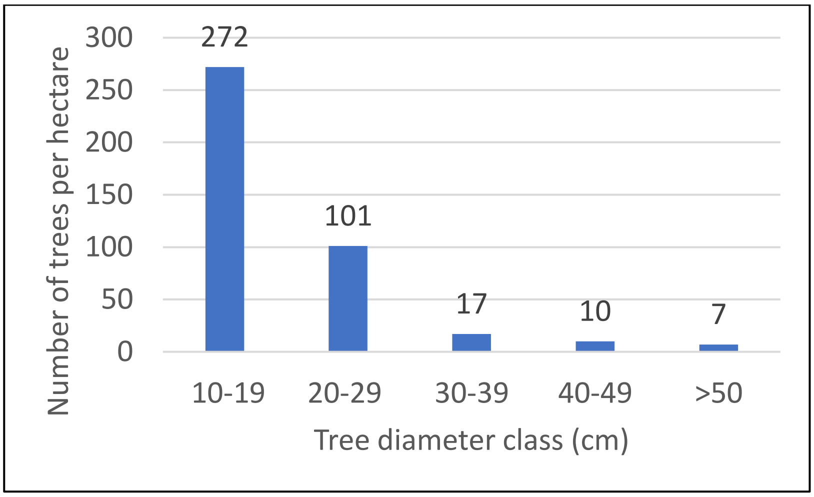

Figure 6. Structure of tree stand based on the relationship between diameter classes and the number of trees in research location.

In Figure 5, tree species with dominant height (>25 m) is laban/*Vitex quinata* (28.0 m), punak/*Tetramerista glabra* (27.6 m) and rambutan hutan/*Nephelium lappaceum* (27.1 m); species that dominates the height (20 m – 25 m) is meranti merah/*Monocaria* sp. (23.8 m), sengon/*Paraserianthes falcataria* (23.7 m) dan aro/*Sterculia oblongata* (23.7 m); height (15 m - < 20 m) is kelat jangkar/*Syzygium* sp. (19.8 m), damar/*Ochanostachys amentacea* (19.7 m) and jerunjing/*Goniothalamus macrophyllus* (19.2 m).

The results of all tree distribution for 10 – 19 cm, 20 – 29 cm, 30 – 39 cm, 40 – 49 cm, and ≥ 50 cm diameter classes in research location shown in Figure 6.

Forest stand structure is not always the same even though it is in the same place, this is caused by the differences in ability to utilize solar energy, nutrients / minerals and water, and the nature of competition. Therefore the tree arrangement in forest stand will form a variable diameter class distribution (Ewusie, 1980).

From Figure 6 above, it can be stated that the forest stand structure in research location shows the number of decreasing trees from small to large diameter classes, so the curve shape is generally characterized by the distribution number that resemble an upside down

"J". Forest stand structure in research location shows normal growth characteristics, normally in natural forests small diameter classes are a lot more than the large diameter classes (Samsoedin & Heriyanto, 2010).

Regeneration is a natural phenomenon where younger trees replaces an adult trees for some reason, such as being felled, burned, fallen (natural disaster) or physiologically dead. There are complete plant species regeneration (in each strata: trees, poles and seedlings) presented in Table 6.

In Table 6, it can be argued that the species that dominates complete regeneration: trees level is *Peronema canescens* (IVI = 39.72 %), and for the poles and seedlings level is *Macaranga gigantea* is 39.46 % and 34.01 %.

3.2.3Biomass and carbon Content

Forest biomass is expressed in oven dry units weight per unit area, which is consist the weight of leaves, flowers, fruit, branches, twigs, stems, roots, and dead trees (Brown *et al*., 1989). The amount of forest biomass is determined by diameter, height, wood density, density, and soil fertility. Estimation of tropical plantation forest biomass is needed because it influences the carbon cycle (Morikawa, 2002). From forest biomass, approximately between 45 and 50 percent contains carbon (Brown, 1997; International Panel on Climate Change, 2006). Furthermore, stated by Nelson *et al*. (1999), that biomass data of an ecosystem is very useful to evaluate productivity pattern of various ecosystem.

Forest stands, especially younger trees (poles and seedlings) have great potential in absorbing and reducing carbon dioxide levels in the air. It can be explained that growth process of younger trees are relatively faster compared to older trees. In growth/photosysnthesis process carbon dioxide and water converted into carbohydrate, then through metabolic process into lipid, nucleic acids, and protein, these materials will be converted into plant organs (Anonymous, 1981 dan Campbell *et al*., 2002).

Based on the Chave equation $Y = 0.0509 \times \rho \times DBH^2 \times T$, the biomass and carbon content of forest stands with ≥10 cm diameter in research location are presented in Table 7.

Table 6. Tree species with complete regeneration in research area.

No.	Species	Family	IVI (%)		
			Seedling	Pole	Tree
1	*Archidendron bubalinum* (Jack.)Nielsen	Leguminosae	11.34	6.48	6.37
2	*Baccaurea motleyana* (Muell.Arg.)	Euphorbiaceae	6.58	2.23	0.82
3	*Bauhanania sessilifolia* Bl.	Anacardiaceae	16.79	2.42	5.80
4	*Diospyros bantamensis* Koord.& Valeton ex Bakh.	Ebenaceae	9.52	7.70	10.11
5	*Heliciaserrata* (R.Br.)Blume, Var. *serrata* Sleum	Protaceae	9.52	6.21	6.43
6	*Hydnocarpus woodii* Merr.	Flacourtiaceae	4.76	14.20	1.75
7	*Macaranga gigantea* (L.) Muell.Arg.	Euphorbiaceae	34.01	39.46	17.62
8	*Nephelium lappaceum* L.	Sapindaceae	9.52	4.65	12.53
9	*Ochanostachys amentacea* Mast.	Olacaceae	4.76	16.28	9.62
10	*Peronema canescens* Jack.	Verbenaceae	14.97	11.33	39.72
11	*Sterculia oblongata* R.Br.	Sterculiaceae	23.80	11.11	6.56
12	*Syzygium laxiflora* K.et. V.	Myrtaceae	23.37	18.00	1.92
13	*Tetramerista glabra* Miq.	Theaceae	9.52	3.18	5.50

Table 7. Prediction of biomass, carbon content, and carbon dioxide uptake in research forest.

Diameter Class (cm)	Calculation based on Chave's formul		
	Biomass (ton/ha)	Carbon (ton C /ha)	Carbon dioxide (ton CO_2/ha)
10 - 19	25.73	12.87	47.22
20 - 29	40.14	20.07	73.67
30 - 39	15.90	7.95	29.17
40 - 49	20.94	10.47	38.43
≥50	24.02	12.01	44.07
Amount	**126.73**	**63.37**	**232.56**

In Table 7. It can be seen that the biomass and carbon content of forest stands with ≥ 10 cm diameter in Danau Bangko, Batanghari, Jambi protected area (Scrub) calculated by Chave equation *et al.* (2005) is moderate which is equal to 126.73ton/ha or 63.37 ton C/ha equivalent to 232.56ton CO_2/ha. If compared with Dharmawan (2012) research results in Central Kalimantan peat swamp primary forest up to 73.08 tons C/ha, while Bismark *et al.* (2008) in Siberut National Park as big as 65.96 tons C/ha. In North Sumatra Batang Toru primary forest is as big as 109.36 tons C/ha (Samsoedin *et al*., 2009). Biomass in Gede Pangrango National Park, is equal to 275.56 tons C/ha (Siregar,2007) and in Serawak, Malaysia at 165-202.5 tons C/ha (Brown, 1997).

OL/Open Land Plot

Composition and Vegetation Potential

A. Species Composition

Based on the resulst of plant species and families identification, there are found 29 species of trees belongs to 20 families (Appendix 9), where Euphorbiaceae, Myristicaceae dan Rutaceae has the most species. In this research, it is found 143 trees/ha in 25 sub-plot sized 20 m x 20 m (Appendix 10).

The research results shows from 23 tree species with ≥ 10 cm diameter there are 8 dominant species with IVI > 10%. Forest stands is dominated by *Acacia mangium* with IVI = 97.62 %, mahang/*Macaranga semiglobosa* (IVI = 47.35 %) and kelat/*Aporusa micosphaera* (IVI = 25.15 %) The density and important value index of the dominant species are presented in Table 8.

Table 8. Dominant tree species with ≥ 10 cm (IVI >10%) in research location.

No.	Species	Density 1 ha	Important Value Index (%)
1	Mangium/*Acacia mangium* Willd.	62	97.62
2	Mahang/*Macaranga semiglobosa* J.J.Smith.	28	47.35
3	Kelat/*Aporusa micosphaera* Hook.f.	9	25.15
4	Pulai/*Alsttonia scholaris* R. Br.	7	17.34
5	Keranji/*Hydnocarpus woodii* Merr.	4	13.85
6	Rambutan hutan/*Nephelium lappaceum* L.	6	13.54
7	Medang/*Dehaasia sp.*	3	12.62
8	Medang kuning/*Alseodphane bancana* Miq.	2	10.13

B. Potential of Vegetation Types

The research location in protected area of Danau Bangko, Batanghari, Jambi, (OL) dominated by mangium/*Acacia mangium*, mahang/*Macaranga semiglobosa* and kelat/*Aporusa micosphaera*. The potential species replaces the next stand is mahang/*Macaranga semiglobosa* (IVI = 57.30 %), senduduk/*Melastoma malabathricum* (IVI= 53.17%) and kelat/*Aporusa micosphaera* (IVI= 33.55%).

From Table 2, it can be argues that the density and number of species in protected area of Danau Bangko, Batanghari, Jambi (OL), classified as low because the forest area is a secondary forest/OL formerly a camp. According to Richards (1996), generally the number of treee species (≥ 10 cm in diameter) in wet tropical rain forest ranges from 60 – 150 species/ha, while the number of stems/ha (N/ha) ranges from 300 – 700 trees/ha.

3.3.2 Stand Stucture and Regeneration

The structure of forest stand is an individual plants distribution in the canopy layer and can be interpreted as the tree per unit area in various diameter classes distribution (Bustomi *et al*., 2006). Overall, the tree stand structure in the research plot is presented in Figure 7.

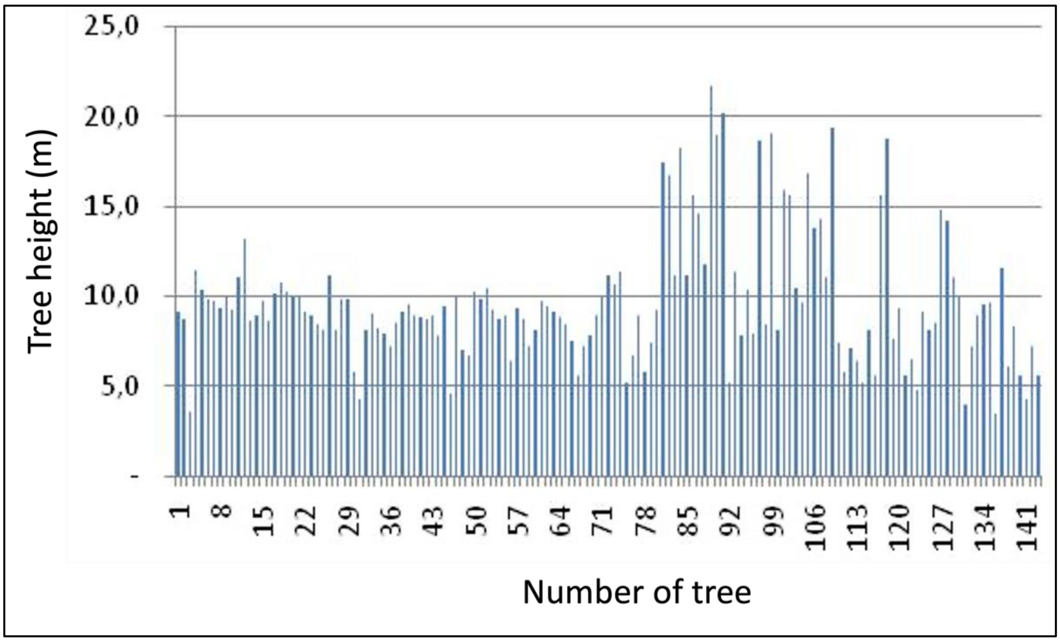

Figure 7. Forest stand profile in research location.

In Figure 7, tree species with dominant height (> 20 m) is mangium/*Acacia mangium* (21.7 m) and meranti papat/*Syzygium paucipuntata* (20.2 m); species that dominates the height (15 m – <20 m) is mahang/*Macaranga semiglobosa* (19.4 m); medang/*Dahaasia* sp. (19.1 m) and keranji/*Hydnocarpus woodii* (19.0 m); height (10 m - < 15 m) is jerunjing/*Goniothalamus macrophyllus* (14.8 m), rambutan hutan/*Nephelium lappaceum* (14.6 m) and mahang/ *Macaranga semiglobosa* (14.3 m).

The results of all tree distribution for 10 – 19 cm, 20 – 29 cm, 30 – 39 cm, 40 – 49 cm, and ≥ 50 cm diameter classes in research location shown in Figure 8.

Forest stand structure is not always the same even though it is in the same place, this is caused by the differences in ability to utilize solar energy, nutrients / minerals and water, and the nature of competition. Therefore the tree arrangement in forest stand will form a variable diameter class distribution (Ewusie, 1980).

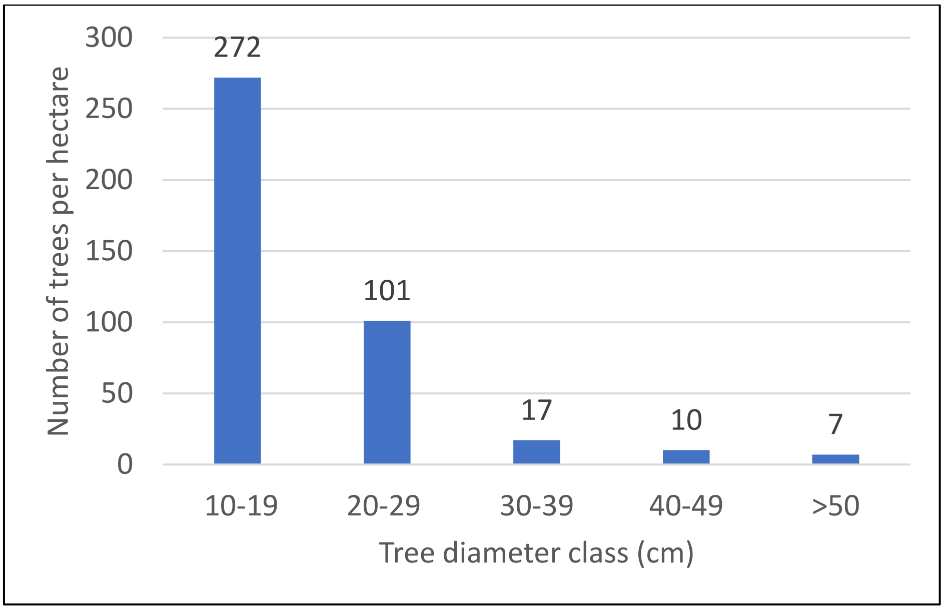

Figure 8. The structure of tree stand based on the relationship between diameter classes and the number of trees in research location.

From Figure 8 above, it can be stated that the forest stand structure in research location shows the number of decreasing trees from small to large diameter classes, so the curve shape is generally characterized by the distribution number that resemble an upside down **"J"**. Forest stand structure in research location shows normal growth characteristics, normally in natural forests small diameter classes are a lot more than the large diameter classes (Samsoedin & Heriyanto, 2010).

Regeneration is a natural phenomenon where younger trees replaces an adult trees for some reason, such as being felled, burned, fallen (natural disaster) or physiologically dead. There are complete plant species regeneration (in each strata: trees, poles and seedlings), presented in Table 9.

Table 9. Tree species with complete regeneration in research area.

No.	**Species**	**Family**	**IVI (%)**		
			Seedling	**Pole**	**Tree**
1	Kelat/*Aporusa micosphaera* Hook.f.	Euphorbiceae	27,78	33,50	25,15
2	Kandis/*Ardisia* sp.	Myrisinaceae	27,78	5,55	2,67
3	Kelat jangkar/*Rothmania* sp.	Rubiaceae	50,00	24,55	2,86

In Table 9, it can be argued that the species that dominates complete regeneration: poles and tree level is kelat/*Aporusa micosphaera* (IVI = 33.50% and 25.15%), and for seedlings level is kelat jangkar/*Rothmania* sp. IVI of 50.00%.

3.3.3 Biomass and Carbon Content

Forest biomass is expressed in oven dry units weight per unit area, which is consist the weight of leaves, flowers, fruit, branches, twigs, stems, roots, and dead trees (Brown *et al.*, 1989). The amount of forest biomass is determined by diameter, height, wood density, density, and soil fertility. Estimation of tropical plantation forest biomass is needed because it influences the carbon cycle (Morikawa, 2002). From forest biomass, approximately between 45 and 50 percent contains carbon (Brown, 1997; International Panel on Climate Change, 2006). Furthermore, stated by Nelson *et al*. (1999), that biomass data of an ecosystem is very useful to evaluate productivity pattern of various ecosystem.

Forest stands, especially younger trees (poles, saplings and seedlings) have great potential in absorbing and reducing carbon dioxide levels in the air. It can be explained that growth process of younger trees are relatively faster compared to older trees. In growth/photosysnthesis process carbon dioxide and water converted into carbohydrate, then through metabolic process into lipid, nucleic acids, and protein, these materials will be converted into plant organs (Anonymous, 1981 dan Campbell *et al*., 2002).

Based on the Chave equation $Y = 0.0509 \times \rho \times DBH^2 \times T$, the biomass and carbon content of forest stands with ≥10 cm diameter in research location are presented in Table 10.

Table 10. Prediction of biomass, carbon content, and carbon dioxide uptake in research forest.

Diameter class (cm)	**Calculation based on Chave's formula**		
	Biomass (ton/ha)	**Carbon (ton C /ha)**	**Carbon dioxide (ton CO_2/ha)**
10 – 19	9.41	4.71	17.28
20 – 29	8.73	4.36	16.01
30 - 39	1.72	0.86	3.16
40 – 49	4.68	2.34	8.59
≥50	6.67	3.33	12.24
Jumlah	**31.21**	**15.60**	**57.28**

In Table 10, it can be seen that the biomass and carbon content of forest stands with ≥ 10 cm diameter in protected area of Danau Bangko, Batanghari, Jambi (OL) calculated by Chave equation *et al.* (2005) is low which is equal to 31.21 tons/ha or 15.60 tons C/ha equivalent to 57.28 ton CO_2/ha. If compared with Dharmawan (2012) research results in Central Kalimantan peat swamp primary forest up to 73.08 tons C/ha, while Bismark *et al.* (2008) in Siberut National Park as big as 65.96 tons C/ha. In North Sumatra Batang Toru primary forest is as big as 109.36 tons C/ha (Samsoedin *et al*., 2009). Biomass in Gede Pangrango National Park, is equal to 275.56 tons C/ha (Siregar, 2007) and in Serawak, Malaysia at 165-202.5 tons C/ha (Brown, 1997).

CONCLUSION

Based on the research results in protected area with category of Young Regeneration Forest (YRF) in Danau Bangko, Batanghari, Jambi, in a 1 ha plot has 84 species of trees belongs to 34 families where Euphorbiaceae, Rubiacieae and Annonaceae has the most species, there are 67 species and 486 trees with ≥ 10 cm diameter.

In protected area with catagory of Scrub (SC) there are 57 species of trees belongs to 29 families where Euphorbiaceae, Lauraceae, and Sapindaceae has the most species; there are 48 species and 407 trees with ≥ 10 cm diameter.

In protected area with catagory Open Land (OL) there are 29 species of trees belongs to 20 families where Euphorbiaceae, Myristicaceae, and Rutaceae has the most species; there are 23 species and 143 trees with ≥ 10 cm diameter.

The dominant tree species in YRF area are medang kuning/*Alseodphane bancana* Miq. (IVI = 23.60%), pelajau/*Agelaea trinervis* (Llanos) Merr. (IVI = 18.96%) and kelat jangkar/jagul/gawal/*Syzygium* sp. (IVI = 17.14%). In SC area are afrika/*Maesopsis eminii* Engl. with IVI = 39.99%, sungkai/*Peronema canescens* Jack. (IVI = 39.72%) and mahang/*Macaranga gigantea* (L.) Muell.Arg. (IVI = 17.62%). In OL area are *Acacia mangium* Willd. with IVI = 97.62%, mahang/*Macaranga semiglobosa* J.J.Smith. (IVI = 47.35%) and kelat/*Aporusa micosphaera* Hook.f. (IVI = 25.15%).

The species that dominates complete regeneration in YRF area at tree level is medang kuning/*Alseodphane bancana* Miq. (IVI = 23.60%), at poles level kelat jangkar/*Syzygium* sp. (IVI = 28.45%), and for seedlings level is kelat/*Aporusa micosphaera* Hook.f. with IVI of 28.12%. In SC area at tree level is *Peronema canescens* Jack. (IVI = 39.72%), poles and seedlings level is *Macaranga gigantea* (L.) Muell.Arg. with each IVI of 39.46% and 34.01%. In OL area at tree and poles level is kelat/*Aporusa micosphaera* Hook.f. (IVI = 33.50 % and 25.15 %), seedlings level is kelat jangkar/*Rothmania* sp. With IVI of 50.0 %.

Biomass and carbon content of forest stand (which in ≥ 10 cm diameter) in YRF areacalculated with Chave equation is equal to 167.6 tons/ha or 83.82 tons C/ha equivalent to 307.6 tons CO_2/ha. In SC area is equal to 126.73 tons/ha or 63.37 tons C/ha equivalent to 232.56 tons CO_2/ha and in OL area equal to 31.21 tons/ha or 15.60 tons C/ha equivalent to 57.28 tons CO_2/ha.

Overall, based on this study, within a 57,547 ha of conservation area or protected area in PT. RHM and PT WKS concessions is stored 4,698,601 tons C.

This result of this study is also to provide an overview of land cover conditions in low land forest areas in landscapes around Bukit Tigapuluh National Park in Tebo and Batanghari, Jambi.

ACKNOWLEDGEMENT

We are grateful to all persons who assisted us in many ways that made this study and paper possible, particularly Putri Permatasari, Vera Favorita, Tri Hardoko, Eki Rahman, Head of District III PT. Wirakarya Sakti, and Head District PT. Rimba Hutani Mas Jambi, Arif Rahman Putra, Eki Rahman, Vina Octaviana, Amdani, Umardi, J.J. Afriastini, Giry Waldy Rusmawan, Nurpiansyah, and Ardhianto Muhammad. This study assisted by Asia Pulp and Paper Sinarmas, which is part of the collaboration with Puslitang SEKPI and Puslitbang Hutan of Ministry of Environment and Forestry.

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