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Structure, Composition, Carbon Stocks of Dipterocarpaceae in West Batang Toru Forest Block, North Tapanuli Regency, North Sumatra

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ABSTRACT

The West Batang Toru Forest Block in the North Tapanuli Regency, North Sumatra, is one of the lowland forests in Sumatra with a variety of plant communities and populations that have not been fully documented. This area is considered a potential high-value carbon reserve of ecological significance. The purpose of the study was to determine the structure and composition of the Dipterocarpaceae at the West Batang Toru Forest Block. This research was conducted from September 2021 to March 2022. The research location was determined by using the purposive sampling method with a transect length of 300 m. Each lane had plots of 20 × 20 m measured in a zigzag position and had an interval of 10 meters. The number of plots in each lane was 10, for a total of 90 plots. Based on the observations, there were nine species of Dipterocarpaceae obtained from a total of 621 individuals. The basal area ranged from 578.02 cm^2/Ha to 397,894.43 cm^2/Ha, and the largest basal area was at the tree level. The vegetation composition ranged from 60% to 66%, and the highest composition was at tree level. Sixty-two trees were classified as having the largest basal area, followed by poles (42 individuals) and saplings (64 individuals). *Shorea platyclados* occurred consistently with a compositional percentage value at the tree level with a value of 66%, the pole level of 53%, the sapling rate of 34%, and the seedling level of 9%. The carbon stocks from Dipterocarpaceae stands were 91534 tons/ha, which is the first estimate of their ecological importance.

Keyword: Batang Toru, Carbon Stock, Composition, Dipterocarpaceae, *Shorea platyclados*

1. Introduction

Sumatra, one of the largest islands in Indonesia, is distinguished by its rich biodiversity, hosting 15 diverse ecosystems spanning from mountain forests to tropical, lowland, and sandy beach forests. Among these ecosystems, the lowland forest stands out as a primary habitat for Spermatophyta plants in Sumatra [1]. The conducive environmental conditions in the lowlands foster remarkably high tree diversity in the region.

The lowland forests of Sumatra are dominated by Dipterocarpaceae species. It is characterized by abundant climbing plants and tall buttress trees with smooth bark [2]. However, these species are unevenly distributed across Indonesia's geography. Specifically, in western Indonesia, the Sunda plains, including Sumatra, Kalimantan, and Malaya, are home to these forests, recognized for their prominent Dipterocarpaceae distribution compared to other species [3].

The Batang Toru Forest (BTF), specifically the West Block area, features diverse stand variations, encompassing lowland tropical rainforests and mossy forests. It comprises distinct habitats such as peat forests, transitional forests, and dipterocarp forests [4]. The presence of Dipterocarpaceae in the West Batang Toru Forest Block is sporadic, mainly observed along specific areas like the Goa pathway, JMK (Meranti), CGLG,

and in the vicinity of waterfalls. Understanding the structural composition of these forests is pivotal and requires a comprehensive study. Although Dipterocarpaceae forests host unique and diverse ecosystems, studies regarding their structure and composition in the BTF area are limited. Therefore, an in-depth investigation is necessary to unveil the species composition and the current vegetation structure in this region by conducting a thorough vegetation analysis [5].

2. Method

2.1 Study Area

The study was conducted in the Batang Toru Forest Research Station, West Block, North Tapanuli Regency, North Sumatra Province (Figure 1). Plant specimens were identified and analyzed at the Plant Systematics Laboratory and Herbarium, Universitas Sumatera Utara, Medan City, Indonesia. Administratively, the Batang Toru Forest Area is located in North Tapanuli, Central Tapanuli, and South Tapanuli Regencies. Geographically, it is between 98º 53' to 99º 26' E and 02º 03 to 01º 27' N. Located at an altitude of 50 to 1,875 m, including a tropical climate with high rainfall ranging from 4.500 to 5.000 mm per year and humidity ranging from 33 to 95%. The dominant vegetation types near the Leuser Ecosystem Foundation/*Yayasan Ekosistem Leuser* (YEL) monitoring station include the Sapotaceae, Myrtaceae, Lauraceae, and Fagaceae families. The remaining lowland forest is dominated by Dipterocarpaceae, Burseraceae, and Malvaceae [6].

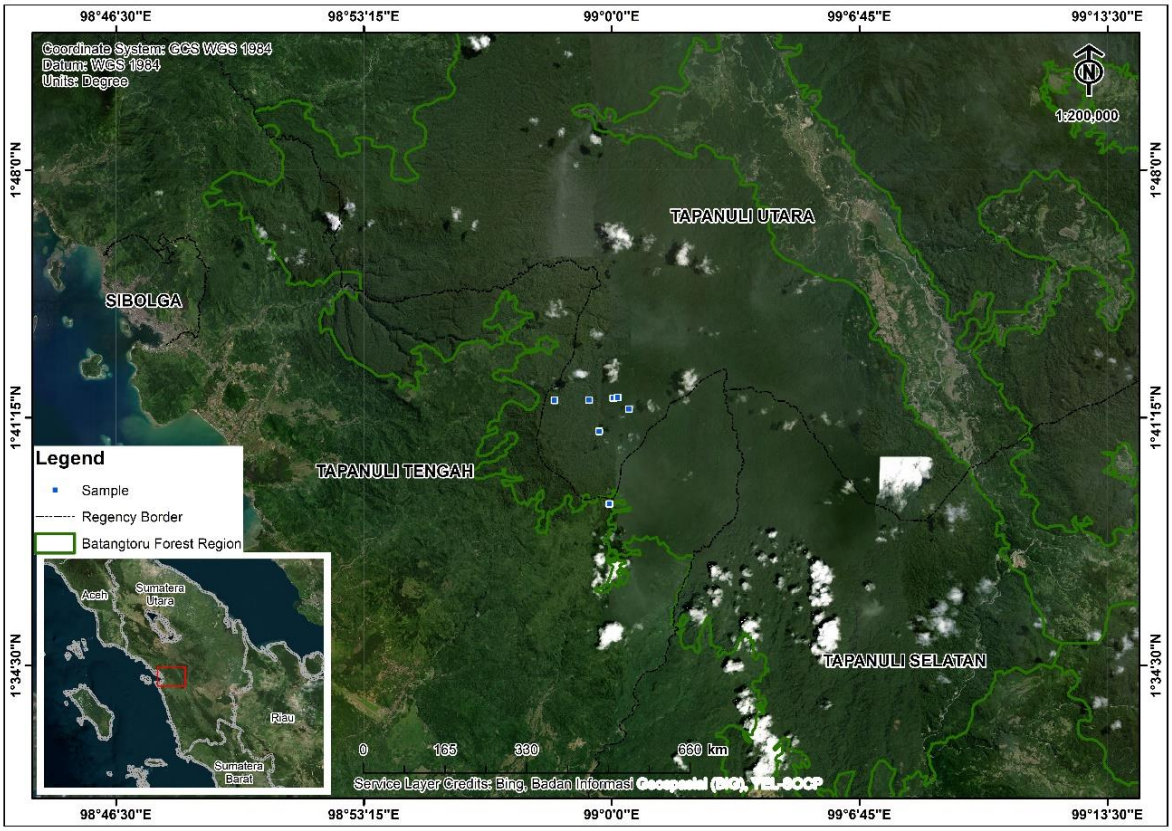

Figure 1. Map of Research Location

2.2 Research Procedure

2.2.1 Sampling procedure

The study area was determined using the purposive sampling method, deliberately selecting representative locations for Dipterocarpaceae species. The study area was located in four locations, namely the JMK Route, the Cave, the CGLG Route, and the Waterfall Route. At each location, four transect lines were made with a length of 300 m; the intervals between the lines were 50 m, with the direction of the line pulling from the bottom up. Making observation plots by Nested Sampling, namely plots that are large in size contain smaller subplots according to the growth level of the tree. On each transect line, a 20 × 20 meter plot was made for the tree level, which consisted of several subplots, namely: 10 × 10 m for the pole level, 5 × 5 m for the sapling level, and 2 × 2 m for the seedling level. The plots were systematically placed left and right (zigzag) with an

interval of 10 m [7]. There are 10 plots in each path, a total of 30 plots in each location, and a total of 90 plots in all four locations.

2.2.2 Observation and collection of specimens

The Dipterocarpaceae plant species discovered were documented through photography. All significant traits were recorded from both dry and wet specimens, labeled, wrapped in newspaper, enclosed in plastic, and evenly soaked in 70% alcohol for future identification. The altitudinal gradient was captured using an altimeter, and the GPS coordinates were noted for each Dipterocarpaceae species identified.

2.3 Data Analysis

The vegetation composition was determined by counting the *Dipterocarpacean* individuals within a species and its proportion (%) of species within a family. Basal area (BA) was calculated using;

$$BA = 1/4\ \pi d^2 \quad (1)$$

Note:
d = stem diameter (cm)
π = phi (3.14)
The biomass of each habitus was estimated by measuring the diameter at breast height (DBH) or stem diameter at 1.3 m above ground, which was plotted into an allometric equation [8];

$$\text{Dry Weight (DW)} = 0.11 \times r \times DBH^{2.62} \quad (2)$$

Note:
r = specific gravity (g/cm^3).
The specific gravity of each species can be retrieved from ICRAF (https://www.worldagroforestry.org/). Total biomass is the sum of each individual biomass at each level of habitus (tree, pole, and sapling). The carbon stocks were then measured by multiplying the tree biomass per unit area by a factor of 0.46 (ton/ha).

3. Result and Discussion

3.1 Dipterocarpaceae Assemblage

Four genera from nine Dipterocarpaceae species, such as *Shorea*, *Dipterocarpus*, *Hopea*, and *Vatica* (Table 1), were found in this study. *Shorea* was the most prevalent in BTF due to its strong adaptability, environmental tolerance, and robust reproductive capabilities. In comparison to other studies, the diversity of Dipterocarpaceae species at this research site was relatively low. For instance, a study in the Salau Forest Area in Central Kalimantan found 36 species across four genera (*Shorea, Dipterocarpus, Hopea*, and *Vatica*) [9], while another study in the Mount Lumut Protection Forest in East Kalimantan recorded 38 species from six genera (*Shorea, Vatica, Dipterocarpus, Dryobalanops, Hopea*, and *Anisoptera*) [10]. This disparity in species richness may be influenced by environmental factors, such as tree loss due to natural disturbances and increased competition among seedlings and saplings at the study site.

Table 1. Population structure of Dipterocarpaceae species in the West Batang Toru Forest Block

No	Genera	Species	Tree	Pole	Sapling	Seedling	Total Individuals
1	*Dipterocarpus*	*D. eurhynchus*	8	18	20	30	76
2	*Hopea*	*H. beccariana*	1	2	-	-	3
3	*Shorea*	*S. platyclados*	64	39	56	23	182
4	*Shorea*	*S. balangeran*	3	13	30	12	58
5	*Shorea*	*S. laevis*	1	4	3	5	13
6	*Shorea*	*S. gratissima*	1	-	-	3	4
7	*Shorea*	*S. ovata*	1	15	20	23	59
8	*Shorea*	*S. macroptera*	4	15	25	156	200
9	*Vatica*	*V. umbonata*	5	6	9	6	26
Number of species			**9**	**8**	**7**	**8**	**-**
Total			**88**	**112**	**163**	**258**	**621**

Table 1 shows the type of *Shorea macroptera* dominant at the seedling level, namely 156 individuals. Based on the research results, *Shorea macroptera* was found to grow at an altitude of 900 to 925 m. According to Rikando et al. [11], *Shorea macroptera* can live in well-drained soil, especially in hilly areas, on plate soil to sandy plates with a height of 900 m. *Shorea macroptera* has the ability to regenerate quickly, so it has a wide distribution and is quite adaptive to its environment. *Shorea platyclados* is one of the many species found, with a total of 182 individuals. Based on field observations, *Shorea platyclados* was found growing in hilly areas with altitudes ranging from 500 to 1000 m.

3.2 Stand Structure

It is evident that the highest basal area class at the tree level occurs within the 0-5000 cm² basal area (BA) category, consisting of 62 individuals (Table 2). Similarly, at the pole level, the highest basal area class is within the 10-15 cm² BA, comprising 42 individuals. For saplings, the most prevalent basal area class ranges from 1-2 cm² BA, with a total of 64 individuals. The distribution of diameter classes across all stages appears uniform, primarily influenced by the varying stem diameters within each BA class. As mentioned by Istomo et al. [12], variations in tree diameter are linked to stand density, where denser stands have smaller tree diameters compared to sparse stands, leading to differing BA values. Additionally, Rudjiman et al. [13] highlighted the significant influence of tree age on BA values, with older trees displaying wider diameters.

Table 2. The number of individuals for each grown stage based on the BA class in the West Batang Toru Forest Block, North Sumatera

No	Grown Stage					
	Tree		Pole		Sapling	
	Size class at DBH (cm^2/ha)	Total individuals	Size class at DBH (cm^2/ha)	Total individuals	Size class at DBH (cm^2/ha)	Total individuals
1	0-5.000	62	0-5	-	0-1	46
2	5.000-10.000	26	5-10	16	1-2	64
3	10.000-15.000	5	10-15	42	2-3	23
4	15.000-20.000	1	15-20	28	3-4	19
5	20.000-25.000	2	20-25	23	5-6	7
6	> 25.000	1	25-30	3	6-8	4
	Total	**97**		**112**		**163**

3.3 Vegetation Composition

The species *Shorea platyclados* has the highest percentage value, namely 66%, and the lowest is found in the type of *Shorea macroptera*, namely 4% (Figure 2). According to Hidayat [14], the presence of a dominant S. *platyclados* shows the ability to adapt to its environment. There are two limiting factors for S. *platyclados*, namely climatic factors and altitude [15]. Fitrada [16] stated that differences in vegetation composition within a community are caused by environmental factors such as temperature, humidity, soil, and topography.

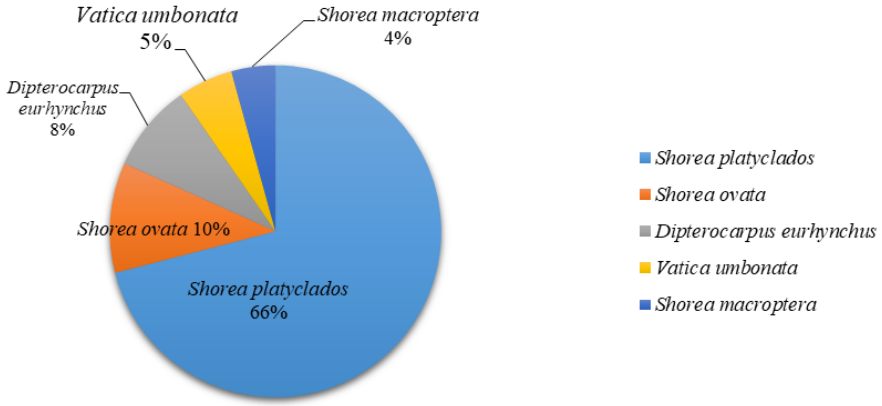

Figure 2. Five representative genera of Dipterocarpaceae with the highest composition at tree level

The highest percentage value is found in *Shorea platyclados*, and the lowest is found in *Shorea balangeran* (Figure 3). The dominant species has the highest value in the ecosystem, so it can affect the stability of the ecosystem. The high presence of Dipterocarpaceae species indicates that the Batang Toru forest is still well preserved. According to Maridi [17], the dominant presence of Dipterocarpaceae indicates that the area is a type of tropical forest. According to Kusuma [18], tropical forests in Sumatra are in the range of 0 to 1000 mdpl and are characterized by abundant Dipterocarpaceae tribes.

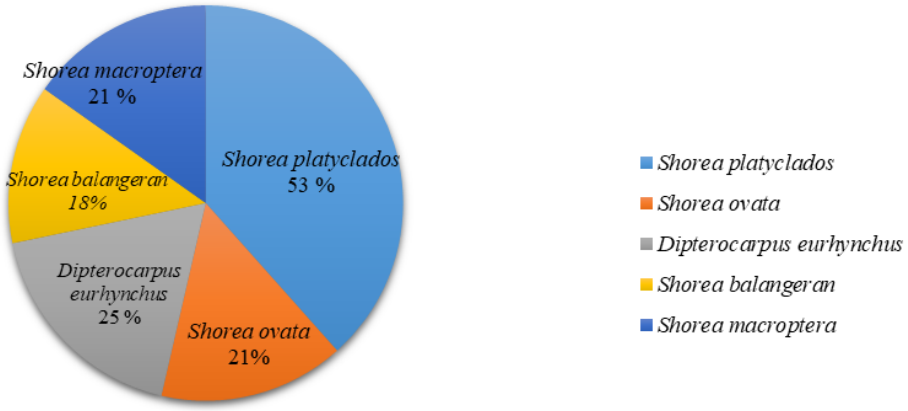

Figure 3. Five representative genera of Dipterocarpaceae with the highest composition at pole level

The highest composition percentage is attributed to *Shorea platyclados*, while the lowest is observed in *Shorea balangeran* (Figure 4). *Shorea platyclados* demonstrates a higher representation, influenced by favorable environmental conditions that support its growth [19]. Environmental factors, like rainfall and soil fertility, play a significant role in species composition within a region [20]. Moreover, the abundance of species in an area is directly influenced by soil conditions, as noted by Septria [21].

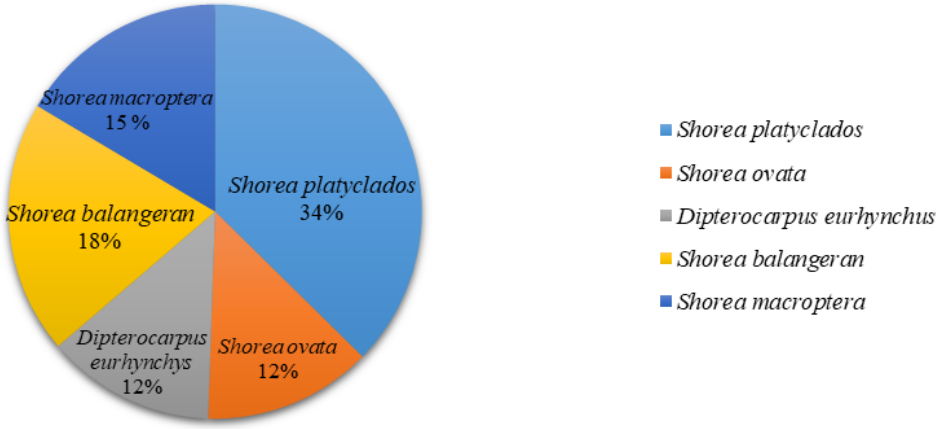

Figure 4. Five representative genera of Dipterocarpaceae with the highest composition at sapling level

The dominant species was *Shorea macroptera*, while the lowest was found in *Vatica umbonata* (Figure 5). The high percentage composition value of *Shorea marcoptera* is due to the number of individuals and the presence of this species, which is very abundant in one of the observation plots. In addition, the plot is open enough that sunlight penetrates the forest floor. Haryadi [20] said that the high amount of vegetation at the seedling level occurs due to the opening of the canopy, which causes sunlight to enter, and the lack of dominance of tree growth, so that seedling growth is very optimal. According to Prayoga et al. [21], the high density of the seedling level indicated that the research location had a good regeneration process.

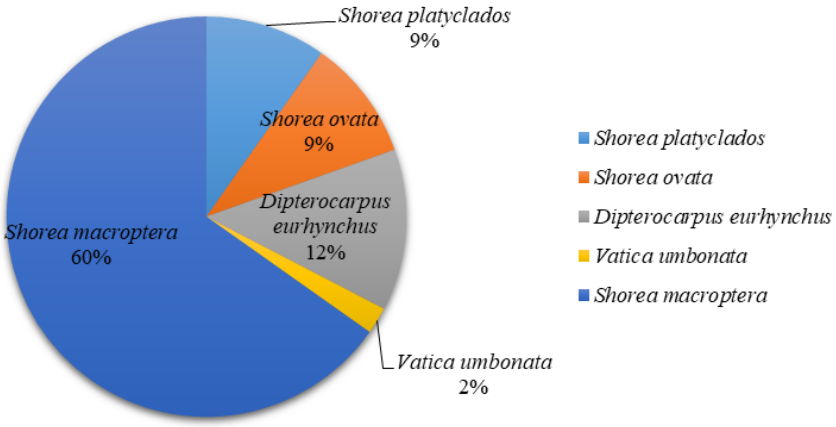

Figure 5. Five representative genera of Dipterocarpaceae with the highest composition at seedling level

3.4 Biomass and Carbon Stock

The pole-level biomass and carbon storage peak at 197,899 tons/ha and 91,534 tons/ha (Table 3). The findings indicate relatively lower biomass and carbon stocks in the Batang Toru Forest when compared to the study [24] in the Dipterocarp Natural Forest of Balik Papan Botanical Gardens, which reported values of 58.99 tons and 41.09 tons/ha, respectively. Biomass and carbon stocks are determined by stand composition, age, circumference, and soil factors within the study area. Irundu et al. [25] highlighted that carbon storage isn't influenced by a single parameter but by multiple factors like tree size, species diversity, and individual density. Dharmawan [26] suggested that the diameter class impacts stored biomass and carbon, where larger tree diameters absorb more carbon. Tree age affects the trunk diameter and carbon absorbed, with older trees accumulating more carbon [27].

Table 3. Biomass and carbon stock of the Dipterocarpaceae in the West Batang Toru Forest Block

Grown Stage	Biomass (ton/ha)	Carbon Stocks (ton C/ha)
Sapling	400.25	184.11
Pole	879.20	404.43
Tree	197.989	91.534

4. Conclusion

Based on the research conducted in the West Batang Toru Forest Block, North Tapanuli Regency, North Sumatra, we discovered nine Dipterocarpaceae species, totaling 621 individuals. The Dipterocarpaceae distribution included the highest tree-level basal area class at 0-5000 cm^2/ha, with 62 individual trees, and the highest pole-level basal area class at 10-15 cm, amounting to 42 individuals. For saplings, the highest basal area class was at 1-2 cm, with 64 individuals. *Shorea platyclados* comprised 66% of the tree level, 53% of the pole level, 34% of the sapling level, and 9% of the seedling level. The total carbon stored within all growth stages of Dipterocarpaceae in the West Batang Toru Forest Block measured 680.074 tons C/ha.

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References

[1] Supriatna J. "*Melestarikan Alam Indonesia"*. Yayasan Obor Indonesia. Jakarta, 2008.

[2] Asrianny, Paweka CB, Achmad A, Oka NP. "Komposisi Jenis dan Struktur Vegetasi Hutan Dataran Rendah di Kompleks Gunung Bulusarang Sulawesi Selatan". *Jurnal Perennial*, vol.15, no.1, pp. 32-41. 2019.

[3] Purwaningsih. "Sebaran Ekologi Jenis-jenis Dipterocarpaceae di Indonesia". *Biodiversitas*, vol.5, no.2, pp. 89-95. 2004

[4] YEL-SOCP (Yayasan Ekosistem Lestari-*Sumatran Orangutan Conservation Programme*) "*Menuju Pengelolaan Lestari Ekosistem Batang Toru"*. Medan, 2007.

[5] Kusmana C. "Keragaman Komposisi Jenis Dan Struktur Vegetasi pada Kawasan Hutan Lindung Dengan Pola Phbm di Bkph Tampomas, Kph Sumedang, Perum Perhutani Divisi Regional Jawa Barat dan Banten". *Jurnal Silvikulturtropika*, vol.8, no.2, pp.123-129. 2017.

[6] Fredriksson G, Indra M. "*Hutan Batang Toru Harta Karun Tapanuli"*. YEL- SOCP. Medan, 2017.

[7] Nursanti, Saleh Z, Ulfa M. "Natural Regeneration of Post Fire Lowland Tropical Forests in the Grand Forest Park Sultan Thaha Syaifuddin Jambi". *Media Konservasi*, vol.28, no.2, pp.142-147. 2023.

[8] Ketterings QM, Coe R, Noordwijk MV, Ambagau Y, Palm CA. "Reducing Uncertainty in the Use of Allometric Biomass Equations for Predicting Above-ground Tree Biomass in Mixed Secondary Forests. *Forest Ecology and Management*, vol.146, pp.199-209. 2001.

[9] Wardani M, Susilo A. "Evaluasi Keberadaan *Shorea platyclados* Slooten ex Endert Di Hutan Lindung Bukit Daun". *Widyariset*. Vol.3, no.2, pp. 151-160. 2017.

[10] Ngadiman, Saridan A. "Eksplorasi Jenis-Jenis Dipterokarp di Kabupaten Paser, Kalimantan Timur'. *Jurnal Penelitian Dipterokarpa.* vol.6, no.1. Balai Besar Penelitain dan Pengembangan Kehutanan. Kementrian Kehutanan. Samarinda, 2012.

[11] Rikando R, Latifah S, Manurung TF,. "Sebaran Jenis Tekawang (*Shorea* Spp) di Hutan Tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat". *Jurnal Hutan Lestari,* vol.7, no.1, pp.390-406. 2019.

[12] Istomo, Farida NE. "Potensi Simpanan Karbon di Atas Permukaan Tanah Tegakan *Acacia nilotica* L. (Willd) ex. Del. Di Taman Nasional Baluran Jawa Timur". *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan,* vol.7, no.2. pp. 155-162. 2017.

[13] Rudjiman dan Dwi T. "*Identification manual of Shorea species*. Faculty of Forestry". Gajah Mada University. Yogyakarta, 2002.

[14] Hidayat S. "Struktur Vegetasi Hutan Perenget Dipterocarpaceae di Bukit Nahuang, Pegunungan Muller, Kalimantan Tengah". *Media Konservasi*, vol.12, no.1, pp. 33-37. 2017.

[15] Pratiwi A, Oktoriani Y, Arlita T. "Persebaran Pohon Dipterocarpaceae di Sepanjang Jalur Utama Patroli Taman Hutan Raya Sultan Syarif Hasyim Provinsi Riau". *Jom Faperta UR*, vol.4, no.1. 2017.

[16] Fitrada W, Handika RA, Rodiyah Z. "Potensi Vegetasi Hutan Kota Dalam Reduksi Emisi Karbondioksida (CO2) di Kota Jambi". *Biospecies*, vol.13, no.1, pp.23-28. 2020.

[17] Maridi, Saputra A, Agustina P. "Analisis Struktur Vegetasi di Kecamatan Ampel Kabupaten Boyolali". *Bioedukasi*, vol.8, no. 1, pp. 28-42. 2015.

[18] Kusuma C. "*Metode Survei Vegetasi*." IPB Press. Bogor. 1997.

[19] Ririhena M. "Kajian Komposisi dan Struktur Tegakan Dalam Penerapan Sistem Silvikultur Intensif di UUPHK/HA PT. Sarmiento Parakanjta Timber Kalimantan Tengah". Thesis, Program Magister Pengelolaan Sumber Daya Alam dan Lingkungan Universitas Palangkaraya, 2010.

[20] Alimuddin LO. "Komposisi dan Struktur Vegetasi Hutan Produksi Terbatas Di Kabupaten Kolaka Provinsi Sulawesi Tenggara". *Agriplus*, vol.20, no.2. 2010.

[21] Septria D, Fernando TM, Tavita GE. "Keanekaragaman Jenis Pohon Famili Dipterocarpaceae Hutan Adat Bukit Benuah Kecamatan Sungai Ambawang Kabupaten Kubu Raya". *Jurnal Hutan Lestari*, vol.6, no.1, pp. 114-122. 2018.

[22] Haryadi N. "Struktur dan Komposisi Vegetasi Pada Kawasan Lindung Air Terjun Telaga Kameloh Kabupaten Gunung Mas". Ziraa'ah, vol.42, no.2, pp. 137-149. 2017.

[23] Prayoga R, Indriyanto, Riniarti M. "Pola Distribusi Jenis Meranti (*Shorea* spp.) di Resort Pemerihan Taman Nasional Bukit Barisan Selatan". *Jurnal Hutan* Tropis, vol.7, no.2. 2019.

[24] Usmadi D, Hidayat S, Yuzammi, Asikin D. "Potensi Biomassa dan Cadangan Karbon Kebun Raya Balikpapan, Kalimantan Timur". *Buletin Kebun Raya*, vol.18, no.1. 2015.

[25] Irundu D, Beddu MA, Najmawati. "Potensi Biomassa dan Karbon Tersimpan Tegakan di Ruang Terbuka Hijau Kota Polewali, Sulawesi Barat". *Jurnal Hutan dan Masyarakat*, vol.12, no.1, pp. 49-57. 2020.

[26] Dharmawan IWS, Siregar CA. "Karbon Tanah dan Pendugaan Karbon Tegakan Karbon Tegakan *Avicennia marina* (Forsk.) Vierh. di Ciasem Purwakarta". *Jurnal Penelitian Hutan dan Alam*, vol.4, no.1, pp. 317-326. 2008.

[27] Arifanti CB, Dharmawan IWS, Donny W. "Potensi Cadangan Karbon Tegakan Sub Montana di Taman Halimun Salak". *Jurnal Penelitian Sosial dan Ekonomi Kehutanan*, vol.11, no.1, pp.13-31. 2014.