# BUKTI-BUKTI PROSES REVIEW (PENULIS KORESPONDENSI)

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In this paper, we report in secondary forests and logged-over forests the survival and/or growth of <i>S. macrophylla</i> is limited by hard soil conditions in both. This is in accordance with the results of this study, where the soil conditions have a clay texture (rather fine) with the domination of sandy clay. Based on the characteristics of the <i>S. macrophylla</i> habitat, the species occurs in a riverside condition with a flat and gentle topography with acidic soil conditions and generally less fertile but has good microclimate conditions with temperatures between 24-26°C, high humidity between 78-86% and the light intensity is quite low 12.52 - 23.46%. This species can be recommended to be planted in tropical forest areas that have been degraded by taking into account the microclimatic factors and soil conditions.	h nis st
We hope, could be published in Biodiversitas journal.	
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# Characteristics of land habitat of *Shorea macrophylla* in Tane' Olen, Malinau District, North Kalimantan Indonesia

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Abstract. Shorea macrophylla is one of plant species in Tane' Olen forest area. This study aimed at analyzing the physical, chemical, topographical and microclimate condition as the habitat of S. macrophylla plant. Purposive sampling was applied as the methodology to identify soil condition while Pipet method was used to analyze the physical properties of the soil. Furthermore, the electrode method, ammonium Acetate pH 7 method, KCl 1 N method, Kjeldahl, Walkley N Black method, calculation method, Bray I method, and Barium chloride method were employed to analyze the chemical characteristics of soil and *S. macrophylla* abudance used INP analysis. The result of this research : The soil conditions in studi area were as follows: 1. The physical properties of the soil: a. bulk density values 0.60-1.31 gram cm<sup>3-1</sup>, soil porosity value 50.51%-77.35%, water content 34.66%-5.37%, soil texture dominated by clay, loam and dusty clay; 2. The chemical condition of the soil: pH 3.6-4.8, the value of N 0.05%-0.19%, organic C content 1.40%-3.65%, P content value 0.41-2.3 mg 100 gr<sup>-1</sup>, the content of potassium (K) 58.68-232.55 mg 100 gr<sup>-1</sup>, Cation Exchange Capacity/CEC 5.35-10.81 meg 100gr<sup>-1</sup>; 3. Topographic conditions flat – upper steep. Microclimate conditions: a. Temperature 24-26,5°C; b. Humidity 76-84%; c. Light intensity 350-750 Lm. INP  $\geq$  10% are *S. macrophylla, Madhuca spectabilis, Myristica villosa* Warb, *Scorodocarpus borneensis, Eugenia* spp, *Palaquium* spp and *M. triloba* and negative associations between *S. macropylla* with *M. spectabilis, M. villosa* Warb, *S. inophylla* and *Shorea* sp.

Keywords: Habitat, land characteristics, S. macrophylla

Running title: Characteristics of land habitat of Shorea macrophylla

#### INTRODUCTION

*Shorea macrophylla* is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). This species is very valuable for local communities as a source of wood and fruit (Randi et al. 2019). Community in West Kalimantan named *S. macrophylla* a *tengkawang tungkul* tree, and this species has been cultivated by the Dayak and Malay community (Fajri and Fernandes 2015). The distribution of *S. macrophylla* is generally clustered, can grow in tropical rain forests with A type rainfall, grows on latosol soils at altitudes up to 500 m asl, acidic pH (4.6-4.9) and quite good CEC (16.25-19.40) (Istomo and Hidayati 2010). This species is often found in sedimentary soils and spreads randomly and evenly on the banks of rivers or areas that have sloping or flat topography, rarely on hills, distribute in Sarawak, Sabah, Brunei and Kalimantan (Randi et al. 2019; Utomo et al. 2018; Perumal et al. 2017).

The use of this tree species includes: wood used for timber, veneer and plywood, besides, it can also be used for buildings, shipping wood, musical instruments, furniture or packing crates (Istomo and Hidayati 2010). The fruit locally known as *tengkawang tungkul* (Illipe nut) tree is used as raw material for cosmetics industries such as soap and brown fat substitution material and vegetable fat raw material (Maharani et al. 2016).

The existence of tengkawang in its natural habitat is now starting to diminish and is hard to find (Istomo and Hidayati 2010). As one of the prima donna woods of tropical forests, this species is starting to be difficult to find in the market because exploitation of this species is very high in line with the increasing demand for wood and forest conversion to other uses (Rikando et al. 2019).

Tane' Olen is a customary forest area having a high environmental value and is preserved by the people of Setulang Village (Hutauruk et al. 2018a), where forest management uses the wisdom of local communities and sustainable forest management (Fahrianoor et al. 2013; Kettle 2010), so that forest sustainability is maintained (Hutauruk et al. 2018). Forests are not only a place to live but can also be used as a source of food, medicine, economic, social, cultural and spiritual functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014).

56 In relation with that matter, this study aims to obtain data and information regarding the characteristics of *S.* 57 *macrophylla* habitat land in the context of developing these species. It is hoped that the results of this study will benefit 58 users in an effort to conserve this species, especially on degraded lands in Indonesia.

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#### MATERIALS AND METHODS

#### 64 Studi Area



Study was carried out in Tane' Olen forest area, Setulang village, Malinau district, North Kalimantan Utara (3°25'0.86" N and 116°25'52.59" E). Location map is presented in Figure 1.

Figure 1. Location of the research in Tane' Olen (•)

#### **Research procedure**

The 1 hectare research was conducted using the Purposive Sampling method. The plot is made in a square shape with a side length of 100 meters (Sari and Maharani, 2016). In the plot, soil sampling data is taken. Soil sampling using a purposive sampling technique with 3 sampling points in an area of 1 hectare. These 3 points were taken at locations on hills, backs and valleys respectively, so they were considered to represent the conditions of the study site. Micro climate data collection in the form of: temperature, humidity, light intensity conducted at the same location (design of soil and micro climate data collection can be seen in Figure 2). Collection og vegetation data is limited to the level of big trees (DBH  $\geq$  20.0 cm). Each plot is divided into 25 subplots (20 m x 20 m). In each subplot, all tree level species (20m x 20m) were identified and DBH recorded (Widiyatno et al. 2017). Plot making and field data collection activities, can be seen in Figure 3 and 4.



Figure 2. A. Exploration, B. Make a research plot, C. Tree inventory, D. Soil sample collection, E and F. Microclimate data collection
Soil sample collection design and micro climate data are presented the following Figures 3 and 4



 119
 Remark: A:lights intensity, B: temperature and area humidity, C: soil sampling, m:Meter

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 Figure 3. Design of soil sampling and microclimate conditions.

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#### 126 Topography data collection design can be seen in Figure 4.



The design of vegettion data can be seen in Figures 5 and 6.

			100 m	•	
	L1	L2	L3	L4	L5
¥	SP5	SP6	PU15	SP16	SP25
100	SP 4	SP7	PU14	SP17	SP24
100 m	SP3	SP8	PU13	SP18	SP23
<b>▲</b>	SP2	SP9	PU12	SP19	SP22
	SP1	SP10	PU11	SP20	SP21
I	20m	20m	20m	20m	20m

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Remarks: L: lane, SP: sub plot, 20m: distance between sub plots, 100m x 100m: plot size, m: Meter.

Figure 5. Design of vegetation analysis.



#### 143 Data analysis

#### 144 Soil analyses

The soil that has been taken is then analyzed its physical and chemical properties. Soil physical properties analyzed include: texture, bulk density, porosity and water content, using the Pipette method, while the chemical properties analyzed include pH using the electrode method, CEC Using the Ammonium acetate pH 7 method, the elements Al +++ and H + using the KCl method 1 N, total N elements using Kjeldahl method, organic C elements using Black walkley, C/N ratio 149 using arithmetic methods, elements P2O5 and K2O using Bray I methods, saturation Al using arithmetic methods. Soil data 150 analysis results in the soil laboratory will be tabulated and analyzed descriptively quantitative.

#### 153 Analytical topography

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154 The tabulated land topography data is then processed using ArcView 10.2 Software, and analyzed descriptively and 155 quantitatively.

#### 157 Micro climate analyses

Micro climate condition data will be tabulated, then will be analyzed using quantitative descriptive analysis methods.

#### 160 **Important Value Index**

161 According to Kacholi (2014), the Importance Value Index (IVI) is used in ecological studies to show the ecological importance of a species in a particular ecosystem. IVI is also used to prioritize species conservation where species with 162 163 low INP values require high conservation priority compared to species that have high IVI. The value of dominance 164 species is characterized by an index of the important value of the species where IVI = relative density + relative frequency 165 +relative dominance. The IVI value will be analyzed descriptively. 166

#### 167 Association of Vegetation

Associations between two plant species were analyzed using a 2x2 contingency table (Mueller-Dombois and Ellenberg 168 1974). A more complete description can be seen in Table 1. 169 170

171 Table 1. Contingency table form.

+	-	
a	b	a + b
с	d	c + d
a + c	b + d	N = a + b + c + d
	a c a+c	$\begin{array}{c} a & b \\ c & d \\ a+c & b+d \end{array}$

172 Reference: Mueller-Dombois and Ellenberg (1974)

173 Remarks :

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174 A = Amount of plot containing species A and species B.

B = Amount of plot containing only species A and no species B.175

- C = Amount of plot containing only species B and no A. 176
- D = Amount of plot containing neither species A nor species B. 177
- 178 N = Amount of all plots.
  - Which then aested with chi-square  $(x^2)$

$$X^2 = \frac{(ad - bc)^2 x N}{(ad - bc)^2 x N}$$

$$(a+b)(c+d)(a+c)(b+d)$$

And calculated their of coofisien assiiation (C) value

1. If  $ad \ge bc$ , so  $C = \frac{ad-bc}{(a+b)(b+d)}$ 182

183 2. If bc > ad and d > a, so 
$$C = \frac{ad-bc}{d}$$

$$(a+b)(b+c)$$

184 3. If bc > ad and a > c, so 
$$C = \frac{1}{(a+d)(c+d)}$$

185 Positive or negative values from the calculation results indicate positive or negative associations between the two species. 186

#### **RESULTS AND DISCUSSION**

#### 190 Analysis of soil physical and chemical properties

191 Results of the analysis of soil physical and chemical properties in the test area in the habitat of S. macrophylla 192 trees in the Tane' Olen plot, Setulang Village, Malinau Regency, can be seen in Table 2. 193

Table 2. Physical	properties of soil	in Tane' Olen,	Setulang, Malinau	district

Land condition	Depth (cm)	Bulk density (gram/cm <sup>3</sup> )*	Porosity (%)*	Water content (%)
Valley	0-10	0.60	77.35	95.37
	10-20	1.13	57.32	40.04
	20-30	1.18	55.54	39.20
	30-40	0.93	64.75	47.49
Slope	0-10	1.05	60.42	48.08

	10-20	1.31	50.60	41.42	
	20-30	1.23	53.72	34.88	
	30-40	1.31	50.51	39.63	
Ridge	0-10	0.83	68.75	61.68	
	10-20	1.01	61.92	44.23	
	20-30	1.20	54.66	35.53	
	30-40	1.10	58.36	34.66	

194 Remark:\* Average score for three times repetition

Table 2 showed that at the depth of 0-10 cm the valley, slope and back area having bulk density close to the rather low category (0.60-1.05). This means that the soil conditions in the study area are not able to store water due to the dense soil conditions. According to Casanova et al. (2016); Zeng et al. (2013), soil bulk density conditions are influenced by external conditions, changes associated with various factors and various natural processes such as the result of plant root growth and rainfall.

The porosity value at the depth of 0-40 cm in the valley, slope and back area included in the medium and high categories (63.74%, 53.8% and 60.92%). According to Darusman et al. (2019). the most affecting soil porosity is bulk density and soil particle density, if the bulk density is low then the porosity will increase. Water content in the valley, slope and back area was in the moderate category (41.025-55.61%) with valley area as the highest soil water content. According to Minasny and McBratney (2018), the capacity of available groundwater is an important component for water balance and terrestrial biosphere energy because it can control the rate of evapotranspiration, and support plant growth. The capacity of the soil's available water capacity can increase if there is an increase in soil organic matter.

207 Soil conditions are generally dominated by Ultisol (advanced development) soil types, namely Typic hapludults 208 (Yellowish Red Podsolik) and some Typic Paleudults (Yellow Podsolic). This soil type is the main land of lowland 209 dipterocarp forest (Ohta and Effendi, 1992). The results of soil texture analysis can be seen in Table 3.

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Table 3. Soil texture in Tane' Olen, Setulang village, Malinau district.

Land condition	Depth (cm)	Clay (%)	Sand (%)	Dust (%)	texture (USDA)
Valley	0-20	33.70	50.90	15.40	SCL
	20-40	36.50	49.50	14.00	SC
	40-60	34.00	56.80	9.20	SCL
Slope	0-20	24.70	67.20	8.10	SCL
	20-40	27.30	63.10	9.60	SCL
	40-60	33.10	60.50	6.40	SCL
Ridge	0-20	37.80	54.60	7.60	SC
	20-40	37.40	46.40	16.20	SC
	40-60	40.70	48.00	11.30	SC

212 Remark:Laboratory of soil test in B2P2EHD and PPHT, Mulawarman University

Table 3 shows that the soil at the study site had a clay texture (somewhat fine) with sandy clay dominance. According 213 to Osman (2013), soil texture refers to the level of fineness or roughness formed by soil particles of various sizes in a soil. 214 At the study site, the highest 0-10 cm water content was in the valley area (95.37%), in the back area 61.68%, and in the 215 slope area the water content was 48.08% (more detailed information can be seen in Table 1). The lower water content in 216 the slope compared to the back and valley areas, proves that water moves to the lower area. This condition will cause 217 218 surface run off and can cause erosion. Surface run off and erosion will result in loss of nutrients. Pratiwi and Narendra (2012), stated that nutrients in the soil, especially on the surface (top soil) are vulnerable to loss through surface runoff or 219 erosion. Nutrients that dissolve easily in water will be carried along with surface runoff, as well as nutrients present in 220 221 parts of soil particles will be carried away during erosion and deposited as sediments. Chemical caharacteristics at 222 study area is presented in Table 4.

Table 4. Chemical characteristics of soil in Tane' Olen, Setulang village, Malinau district.

Land	Land Depth pH (1: 25) Cation ex		Depth pH (1: 25) Cation exchange rates Organic content		content	Ratio	Mineral					
condition	(cm)			(me	eg 100gr-	)	(%)			(Mg 100 gram <sup>-1</sup> )		
		H2O	KCl	КТК	Al3+	H+	N. Tot	C.Org	C/N	P2O5	K2O	
Valley	0-20	4.6	3.3	7.26	4.92	1.50	0.19	3.65	19	0.89	116.85	
	20-40	4.6	3.4	7.25	5.56	1.08	0.12	2.65	22	0.73	73.30	
	40-60	4.4	3.4	7.18	5.75	0.92	0.10	2.12	22	1.22	59.00	
Slope	0-20	4.1	3.5	5.35	2.75	1.33	0.13	2.31	18	0.65	73.62	
	20-40	4.7	3.5	5.30	3.50	0.92	0.07	1.54	22	0.65	58.68	
	40-60	4.8	3.5	5.53	3.33	1.42	0.05	1.40	26	0.41	60.90	
Ridge	0-20	4.4	3.0	10.81	7.25	2.75	0.09	3.46	39	2.35	120.34	
	20-40	3.6	3.3	10.48	7.80	1.83	0.08	2.12	28	0.89	194.09	
	40-60	4.4	3.4	10.37	6.83	2.58	0.09	1.54	17	0.65	232.55	

225 Remark: Laboratory of soil test in B2P2EHD and PPHT, Mulawarman University

Table 4 showed that the soil in the study area is very acid (pH = 4.1-4.8). According to Schroeder and Pumphrey (2013), in acid soils, it will inhibit root and plant growth and increase Al levels in the soil. The cation exchange capacit (CEC) in the study area ranges from 5.3 to 10 meg 100 grams<sup>-1</sup>, indicating that in real studies the value of the CEC is low. According to Perumal et al. (2017a), in general, value of cation exchange capacity (CEC) is low for surface and subsurface soils in lowland dipterocarp forests.

Al content in the study site showed a high value, especially the soil in the back and valley, which indicated the presence of high toxicity in the soil in the area. Al content in the soil will decrease if the organic matter in the soil increases, because organic matter forms a very strong complex with Al. According to Zaidey et al. (2010), in lowland dipterocarp forests, the soil has a high Al content, making it a major cause of soil acidity.

The N value at the research location showed a value between 0.05% -0.19% which was in the low to very low category. This is supported by Sadeghi et al. (2016) which states that in general, the total amount of nitrogen in tropical rain forests is low. Nitrogen (N) is a plant nutrient that is important for plant growth (Omara et al. 2019) and if the lack of this element can inhibit plant growth (Mehata et al. 2019). According to Omara et al. (2019), the source of N is obtained from organic matter, mineralization and rainfall supply.

Organic C values were high in the valley and back areas and lower in the slope area. This is because the erosion area is more prone to erosion which causes nutrient leaching including organic C. According to Schlesinger and Bernhard (2013), carbon can be stored in the soil 3 times more than in the atmosphere and be an indicator of the abundance and number of species of soil microorganisms (Zhu and Zhu 2015), so that the presence of organic C in the soil will spur microorganism activities thereby increasing the process of soil decomposition and also reactions that require the help of microorganisms, for example P dissolution, and N fixation. Phosphate values were indicated from the P2O5 test value, where the Phosphate content value is high (58.78).

Table 4 showed that the phosphorus content is very low (0.41-1.22 mg 100 gram<sup>-1</sup>). According to Turner and Engelbrecht (2011), organic phosphorus has an important role in maintaining the availability of phosphorus in lowland tropical rain forests because it functions in root development and plant growth (Abdissa et al. 2011).

Potassium in the valley and slope areas is high and very high values (58.68-116.85 ppp, while for very high regions (120.34-232.55 ppm). According to Mouhamad et al. (2016), the element of potassium (K) is most abundant in the soil compared to other mineral elements. This element has an extraordinary role for plants in plant metobolism, but the availability of K for plants also depends on the nature of the soil, namely: humidity, aeration, temperature, soil treatment systems and dynamics of K. Therefore, the level of K exchange varies between different soils and finally, K absorption affects plant growth and yield.

#### Topography condition in studi area

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According to Li and McCarty (2019), topographic conditions are key parameters that affect the nature of the soil at the earth's surface. Topographic conditions can affect the content of organic matter, clay content, phosphorus, potassium and magnesium concentrations, and soil pH (Kumhalova et al. 2011).

The topography of the study site has a slope of between 0-25% or moderate undulating. Based on the above data showed that the topography of the study area was included in the flat to a rather steep, where the species of *S. macrophylla* is found in many flat and sloping areas that have high environmental humidity, low ambient temperature, water resources high so that it is suitable to live on the riverbank. Jaffar et al. (2018) stated that the root of *S. macrophylla* tree is able to survive and grow under waterlogged conditions with low oxygen availability and is considered a flood tolerant tree.

At the study site, *S. macrophylla* species dominated the tree species (tree profile can be seen in Figure 7). Besides *S. macrophylla*, other tree species were also found namely *Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Palaquium spp, Macaranga triloba, Syzygium inophyllum* and *Shorea sp.* The dominance of *S. macrophylla* was influenced by the high ability to germinate of *S. macrophylla* seeds and faster seed germination time (Appanah and Turnbull 1998), thus affecting the rate of regeneration in nature. *S. macrophylla* has wider seed distribution ability because *S. macrophylla* seeds contain *tengkawang* fat which is used by the community and cultivated by the community (Fajri and Fernandes 2015).

Num	Local name	Scientific	Family	Relatif	Relatif	Relatif	Important
ber		name		density	dominance	frequency	value index
				(%)	(%)	(%)	(%)
1.	Tengkawang	S. macropyilla	Dipterocarpaceae	7.69	15.35	5.0	28.04
2.	Kajen ase	M. spectabilis	Sapotaceae	10.25	7.29	4.61	22.16
3.	Darah-darah	M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25
4.	Bala seveny	S. borneensis	Olacaceae	5.12	5.77	5.0	15.90
5.	Ubah	<i>Eugenia</i> spp	Myrtaceae	5.59	3.64	4.61	13.85
6.	Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74
7.	Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44
8.	Ehang	S. inophyllum	Myrtaceae	5.36	3.14	3.84	12.35
9.	Kaze tenak	Shorea sp	Dipterocarpaceae	2.33	6.08	2.69	11.10

274 **Table 5.** *S. macrophylla* abundance in study area

275 Remark: Primary data



276 277 Figure 7. A. Tree of S. macrophylla and B. Leaf of S. macrophylla 278

#### 279 **Micro climate conditions**

280 Micro climate data collection consists of 3 factors: temperature, humidity and incoming light. A more complete 281 description can be seen in Table 6.

Number	Micro climate	Unit	Time	Repeat 1	Repeat 2	Repeat 3	Average	Remark
1.	Lights	Lm	Morning	350	400	452	400.67	Taken at 8.59
2.	Area temperature	°c	Morning	24	24.5	25	24.5	sunny conditions
3.	Moisture	%	Morning	81	79	80	80	
1.	Light	Lm	Mid day	750	450	207	469	Taken at 12:02
2.	Area temperature	°c	Mid day	26.5	26	24.5	25.67	sunny conditions
3.	Moisture	%	Mid day	76	79	81	78.67	
1.	Light	Lm	Afternoon	369	237	145	250.33	Taken at 16:30
2.	Area emperature	°c	Afternoon	25	24.5	23	24.17	sunny conditions
3.	Moisture	%	Afternoon	84	85	87	85.33	

Table 6 Condition of micro climate in Tane' Olen Setulang village Malinau district 282

#### 283 Remark: Primary data

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Table 6 showed that the average temperature at the study site was between 24-26° C. According to Ruchaemi (2013). the temperatures between 25-30 ° C are the optimal temperatures for plants to carry out the assimilation process.

286 The humidity value in Table 6 is at 78-86%. This showed that the study area has a high humidity. For light intensity 287 between 12.52% (250.33 Lm) -23.46% (469 Lm) which means the light intensity in the study area is quite low. values This is due to the dense tree canopy in the study area which is dominated by S. macrophylla species which have wide and 288 dense leaves so that the intensity of the light entering the forest floor is low. This is consistent with the opinion of 289 290 Panjaitan et al. (2012). the low intensity of incoming light. indicating an increasingly closed environmental condition so 291 that only a little sunlight can enter the forest floor. This is in accordance with the opinion of Ruchaemi (2013). that light 292 intensity is the most important factor for vegetation and the tropics is the most optimum area for growth. 293

#### 294 Association with other plants

295 According to Saiz and Alados (2012). the association of plant species is a fundamental aspect of the ecology of plant 296 communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic 297 interactions and seed dispersal patterns. The results of the analysis of the species association and the association coefficient 298 is presented in Table 7.

Number	Species association	X <sup>2</sup> count	Association species	C (+/-)
1.	S. macropylla with M. spectabilis	0.35	-	0.04
2.	S. macropylla with M. villosa Warb	6.82	-	0.29
3.	S. macropylla with S. borneensis	0.04	+	0.04
4.	S. macropylla with Eugenia spp	0.37	+	0.11
5.	S. macropylla with Palaquium spp	0.37	+	0.11
6.	S. macropylla with M. triloba	1.21	+	0.16
7.	S. macropylla with S. inophyllum	3.23	-	0.29
8.	S. macropylla with Shorea sp	1.92	-	0.24

<sup>299</sup> Table 7. Value of species association and coefficient of association.

300 Remark: X<sup>2</sup> tabulated value at 5% level: 3.841. X<sup>2</sup> tabulated value at 1% level: 6.35 Table 7 showed that the results of the correlation test of 2 species between *S. macropylla* with 8 dominant tree species. where the calculated X values are all smaller than the value of X tabulated except the species of *M. villosa* War, this means that the species of *S. macrophylla* has a real correlation with the *M. villosa* Warb species but has a negative coefficient of association. According to Sofiah et al. (2013). species pairs do not always produce positive relationships. Plant species that have a high presence frequency do not always provide a high positive association with other species. Likewise species that have a low existence frequency do not always provide a negative association with other species.

309 The association coefficient (C) is used as a parameter of how big is the relationship between the eight species with S. 310 macropylla, there is a positive co-efficient value of the association and there is a negative association coefficient value. 311 Positive coefficient of association is the association of S. macropylla with S. borneensis. Eugenia spp. Palaquium spp and M. triloba tree species. According to Windusari1 et al. (2011). positive associations indicated that the species likes a place 312 with the same environmental parameters. For example a place that tends to get wet and high sunlight intensity to a bit 313 314 shady. For negative associations. the association of S. macropylla with species of M. spectabilis. M. villosa Warb. S. inophyllum and Shorea sp. Negative associations indicate no tolerance for living together in the same area or the absence 315 of a mutually beneficial relationship (Pratama et al. 2012). 316

## 318 Direction of *S. macrophylla* species development

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At present various species of forests are degraded due to anthropogenic activities such as timber extraction, change of cultivation. and the establishment of commercial plantations which cause conversion. fragmentation. and degradation of tropical rain forests. As a result of deforestation. it can lead to damage to environmental conditions by producing high light intensity and severe soil mineral erosion. In general degraded forests can be divided into three types of degraded vegetation. i.e. grasslands after burning. secondary forests for initial succession. and logged-over forests after commercial logging (Daisuke et al. 2013).

Planting native trees is considered an effective rehabilitation method for degraded tropical rain forests. because these trees provide benefits such as wood. food. and medical products (Daisuke et al. 2013). According to Pratiwi et al. (2014). forest and land rehabilitation is absolutely necessary. in addition to meeting the demand for wood as well as to improve environmental conditions. One of the successes of land rehabilitation is knowing the information about the suitability of growing sites for the species being developed. One approach to determine the suitability of growing places for a species is to conduct a study of potential and economic value species in a place (local superior species). which is supported by species distribution data and growth requirements (Pratiwi et al. 2014).

*S. macrophylla* species can be recommended for planting on degraded tropical forest land. ie pasture after burning (Daisuke et al. 2013). early secondary succession forests (Daisuke et al. 2013; Perumal et al. 2012). and logged-over forests after commercial logging. According to (Perumal et al. 2019; Perumal et al. 2015; Perumal et al. 2017a; Perumal et al. 2017a; Perumal et al. 2017b; Perumal et al. 2012). *S. macrophylla* is one of the valuable wood tree species which has socio-economic and ecological benefits. is beneficial for reforestation and rehabilitation activities.

337 The importance of this species in land rehabilitation activities, because this species plays a role in maintaining water 338 quality. filtering out pollutants and deposits as well as storing carbon (Utomo et al. 2018; You et al. 2015). Things that 339 must be considered in planting the S. macrophylla species are conditions of nutrient content in clay and clay mineral 340 composition. Therefore, the last two factors can be used to evaluate soil fertility. The growth of S. macrophylla is also 341 significantly limited by high light intensity in grass land of Imperata cylindrica/pastures after burning, because of the results of this study. S. macropylla species favor habitats that have low light intensity. In secondary forests and logged-342 343 over forests the survival and/or growth of S. macrophylla is limited by hard soil conditions in both. This is in accordance 344 with the results of this study, where the soil conditions have a clay texture (rather fine) with the domination of sandy clay. 345 Based on the characteristics of the S. macrophylla habitat, this species occurs in a river side condition with a flat and gentle topography with acidic soil conditions and generally less fertile but has good microclimate conditions with 346 347 temperatures between 24-26°C, high humidity between 78-86% and the light intensity is quite low 12.52 - 23.46%. This 348 species can be recommended to be planted in tropical forest areas that have been degraded by taking into account the 349 micro climatic factors and soil conditions.

#### ACKNOWLEDGMENTS

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#### REFERENCES

Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (*Allium cepa* L) as influenced by nitrogen
 and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. African J Agricultural
 Research. Volume 6 (14): 3252–3258. https://Doi.Org/10.5897/Ajar10.1024.

- Appanah S, Turnbull JM. 1998. A review of dipterocarps : taxonomy. ecology and silviculture. Center for International
   Forestry Research.
- Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of
   central Chile. Ultural Chilean J Agric Res 76 (1):105-113. doi:10.4067/S0718-58392016000100015.
- Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using
   dipterocarp trees in Sarawak. Malaysia. Hindawi Publishing Corporation International J Forestry Research. Volume
   2013:1-12. Article ID 683017. 11 pages http://dx.doi.org/10.1155/2013/683017.
- Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int.
   J Sci. Technol.. 7(2): 93-102. doi: 10.13170/aijst.7.2. 10119.
- Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46.
- Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (*Shorea machrophylla*) dan regenerasi alaminya dikebun
   masyarakat (*The harvesting pattern of tengkawang fruit (Shorea machrophylla) and natural regeneration in community gardens*). J Penelitian Ekosistem Dipterokarpa Volume 1(2):81 [Indonesian]
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the
  conservation of non-timber forest products in Malinau District. IOP Conference. Series: Earth Environment Science.
  Volume 144: 1-9. https://doi.org/10.1088/1755-1315/144/1/012055.
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b.The prospect of the utilization of Non Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in
   Malinau. North Kalimantan. Indonesia. Biodiversitas. Volume 19 (2): 421-430. [Indonesian]
- Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (*Shorea* Spp.) di areal IUPHHK-Ha PT. Intracawood
   Manufacturing Tarakan. Kalimantan Timur (*Study of the potential and distribution of tengkawang (Shorea Spp.) in the IUPHHK-Ha area of PT. Intracawood Manufacturing Tarakan. East Kalimantan*). J Silvikultur Tropika. Volume 01
   (01): 11-17. ISSN: 2086-8227 [Indonesian]
- Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on
   survival and growth performance of planted *Shorea macrophylla* (de vriese) in riparian forest Along Kayan Ulu River.
   Sarawak. Malaysia. Hindawi International J Forestry Research Volume 2018 (2):1-11. Article ID 6329295. 11 pages
   https://doi.org/10.1155/2018/6329295.
- Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania.
   International J of Biodiversity. Volume 2014: 1-8. Article ID 516840. 8 pages. http://dx.doi.org/10.1155/2014/516840
- Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia.
   Biodiv Conserv. 19: 1137-1151.
- Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the
   effects of weather conditions. J Precision Agriculture. Volume 12 (6): 813-830. https://doi.org/10.1007/s11119-011 9221-x.
- Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties: geospatial
   analyses of earth observation (eo) data. Web of Science. http://doi: 10.5772/intechopen.86109.
- Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality
   from Sahan and Nanga Yen Villages. West Kalimantan. Indonesia. Conference Proceedings. Towards The Sustainable
   Use of biodiversity in a changing environment: From Basic To Applied Research. Aip Publishing.
- Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of
   Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. Volume 19 (4): 1280 1288. DOI: 10.13057/biodiv/d190414. [Indonesian]
- Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Hindawi International J of Agronomy. Volume 2019:1-15. Article ID 8572985. 15 pages https://doi.org/10.1155/2019/8572985.
- Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas. Volume 21 (1): 49-56. [Indonesian]
- 410 Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. European J Soil
   411 Science. 2017:1-9. https://doi: 10.1111/ejss.12475.
- Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chemistry International. 2 (1): 58 69.
- 414 Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada.
- Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef
   manure and inorganic fertilizer application/ Hindawi International Journal of Agronomy. Volume 2019:1-6. Article ID
   9594369. 6 pages. https://doi.org/10.1155/2019/9594369.
- Ohta S, Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr. 38 (2): 197-206.
- 420 Osman KT. 2013. Forest soil: properties and management. Springer. London
- 421 Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh Shorea johorensis Foxw. Di HPH

- 422 Aya Yayang Indonesia. Kalimantan Selatan (*Environmental conditions in which to grow Shorea johorensis Foxw. At* 423 *Aya Yayang HPH in Indonesia. South Kalimantan*). J Penelitian Dipterokarpa. Volume 6 (1): 11-22. [Indonesian]
- 424 Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen.
  425 Kalimantan Tengah (Association and characterization of stands in peat swamp forests in Hampagen. Central
  426 Kalimantan). J Teknologi Lingkungan. Edisi Khusus Hari lingkungan Hidup : 69-76. [Indonesian]
- Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk
   rehabilitasi hutan dan lahan di Indonesia (*Atlas of local reliable tree species for forest and land rehabilitation in Indonesia*). Forda Press. [Indonesian]
- Pratiwi, Narendra B. 2012. Pengaruh penerapan teknik konservasi tanah terhadap pertumbuhan pertanaman Mahoni
  (*Swietenia Macrophylla* King) Di Hutan Penelitian Carita. Jawa Barat (*Effect of applying soil conservation techniques*to the growth of Mahogany (Swietenia Macrophylla King) plantations in the Carita Research Forest. West Java). J
  Penelitian Hutan Dan Konservasi Alam. Volume 9 (2): 139-150. [Indonesian]
- Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality
  attributes of *Shorea macrophylla* seedlings in a tropical nursery. Biodiversitas. Volume 20 (8): 2110-2118. ISSN:
  1412-033X. E-ISSN: 2085-4722. DOI: 10.13057/biodiv/d200803.
- Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of Shorea macrophylla (de Vriese)
  after enrichment planting for reforestation purpose at Sarawak. Malaysia. Online J Biology Science. Volume 17 (1): 717.
- Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of
  planted *Shorea macrophylla* (de Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve.
  Sarawak. Malaysia. Hindawi International J Forestry Research. Volume 2017. Article ID 6721354. 16 pages.
  https://doi.org/10.1155/2017/6721354.
- Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted *Shorea macrophylla* under line planting technique. In: 4th Regional Conference on Natural Resources in the Tropics. 2012 (NTrop4) : Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices.
- 447 Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous
   448 knowledge in south-eastern Burkina Faso (West Africa). Intl J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321.
- 449 Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juling S, Bodos V, Maryani A. 2019. 450 macrophylla. IUCN red list of threatened species 2019: Shorea The e.T33620A125629642. 451 http://dx.doi.org/10.2305/IUCN.UK.20193.RLTS.T33620A125629642.en
- Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (Shorea spp) di hutan tembawang Desa Labian
  Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (Distribution of tengkawang species (Shorea spp) in the *Tembawang forest Labian Village Batang Lupar District Kapuas Hulu West Kalimantan*). J Hutan Lestari. Volume 7
  (1): 390-406. [Indonesian]
- 456 Ruchaemi A. 2013. Ilmu pertumbuhan hutan (Forest growth Science). Samarinda: Mulawarman University Press.
   457 [Indonesian]
- Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest
   after logging in Kedah. Malaysia. Malayan Nature J. Volume 68 (1 & 2): 187-201.
- Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7
   (7): 1-9. E40551. http://doi:10.1371/Journal.Pone.0040551.
- Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern
  Washington. Northern Idaho. Washington Grain Commission reports. http://washingtoncrop.com (accessed 16 Jan.
  2016). p. 56–59.
- Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego.
   CA.
- Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur (*Distribution patterns. abundance. and bamboo associations in plant communities in the Gunug Baung Nature Park in East Java*). Berita Biologi. J Ilmu-Ilmu Hayati. Volume 12 (2): 239-247.
- 471 Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry.
   472 2011:103:297–315 DOI 10.1007/s10533-010-9466-x.
- Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene
  climate change on genetic structure and diversity of *Shorea macrophylla* in Kalimantan rainforest. Tree Gen Genomes.
  Volume 14 (4): 14-44.
- Widiyatno, Budiadi, Suryanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil
  nutrients and late-succession species afters hifting cultivation In Central Kalimantan. Indonesia. J Tropical Forest
  Science. Volume 29 (2): 151-162.
- Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua (Species associations in the succession vegetation)
   Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua (Species associations in the succession vegetation)
- 481 *community in the deposition area of the double embankment in Papua's PTFI mine*). J Ilmiah Ilmu-Ilmu Hayati Biota.

482	Volume 16 (2): 242-251. [Indonesian]
483	Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN.
484	2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Intenational J Soil
485	Science. Volume 5 (3):112-130.
486	Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and
487	irrigation methods. Geoderma 193/194:290-299. doi:10.1016/j. geoderma.2012.10.013.
488	Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple
489	soil. China. Soil and Tillage Research. Volume 146: 39-46.
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Notifications

# [biodiv] Editor Decision

2020-04-13 09:59 PM

YOSEP RUSLIM, Muhammad Fajri, Yosep Ruslim, Pratiwi:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Characteristics of land habitat of Shorea macrophylla in Tane' Olen, Malinau District, North Kalimantan Indonesia".

Our decision is: Revisions Required

Nor Liza sectioneditor2@smujo.id

Reviewer L:

Dear the editor of Biodiversitas

The manuscript of Characteristics of land habitat of *Shorea macrophylla* in Tane' Olen, Malinau District, North Kalimantan Indonesia is weak of the research novelty, because the previous research in the BIODIVERSITAS 21: 1467-1475 (Characterization of soil properties in relation to Shorea macrophylla growth performance under sandy soils at Sabal Forest Reserve, Sarawak, Malaysia) is already published in 2020. So, this manuscript should find a strong background and novelty for next publication

Recommendation: Revisions Required

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# Malinau District, North Kalimantan, Indonesia Abstract. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the physical, chemical, topographical, and microclimate habitat conditions of the S. macrophylla tree. Purposive sampling method was used to distribute the subplots and to the Pipet method was used to analyze the physical properties of the soil. The electrode method, ammonium Acetate pH 7 method, KCl 1 N method, Kjeldahl, Walkley N Black method, calculation method, Bray I method, and Barium chloride method were utilized to analyze the chemical characteristics of the soil and S. macrophylla abundance was determined by IVI analysis. The physical properties of soils in the study area have a bulk density of 0.60-1.31 gram cm<sup>3-1</sup>, soil porosity of 50.60%-77.35%, water content of 34.88%-95.37%, soil texture dominated by sand, clay and dust. The chemical condition of the soil were as follows: 3.6-4.8 pH, 0.05%-0.19% N, 1.40%-3.65% organic C, 0.41-2.3 mg 100 gr<sup>-1</sup> P, 58.68-232.55 mg 100 gr<sup>-1</sup> K, and 5.35-10.81 meg 100gr<sup>-1</sup> Cation Exchange Capacity(CEC). Slope ranged between 0-25%. Microclimate conditions were as follows: 24-26.5° C temperature, 76-84% humidity; 350-750 Lm light intensity. Associations with an IVL> 10% are S. macrophylla, Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Palaquium spp, Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between S. macropylla and S. borneensis, Eugenia spp, Palaquium spp and M. triloba, and negative associations were observed between S. macropylla and M. spectabilis, M. villosa Warb, S. inophyllum, and Shorea sp. S. macrophylla grows on riversides with flat and gentle topography, acidic soil conditions, and lower fertility but good microclimate conditions. This species can be recommended to be planted in degrade tropical forest areas if microclimatic factors and soil conditions are taken into account. Keywords: Habitat, land characteristics, S. macrophylla Running title: Land habitat characteristics of Shorea macrophylla INTRODUCTION Shorea macrophylla is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). Local communities value this species as a source of wood and fruit (Randi et al. 2019). S. macrophylla is known locally in West Kalimantan as the tengkawang tungkul tree and has been cultivated by the Dayak and Malay communities, (Fajri and Fernandes 2015). S. macrophylla grows in clusters in tropical rain forests with A-type rainfall, on latosol soils at altitudes up to 500 m a.s.l., on acidic soils (pH 4.6-4.9), and a cation-exchange capacity (CEC) of 16.25-19.40 (Istomo and Hidayati 2010). In Sarawak, Sabah, Brunei and Kalimantan, this species is associated with sedimentary soils and is distributed randomly and evenly over riverbanks and areas with sloping or flat topography. It is rarely found on hills, (Randi et al. 2019; Utomo et al. 2018; Perumal et al. 2017). The wood of S. macrophylla is commonly used for timber, veneer and plywood, it is used to construct buildings, shipping wood, musical instruments, furniture, and packing crates (Istomo and Hidayati 2010). The fruit, locally known as tengkawang tungkul (Illipe) nuts, is used as a raw material in soap and other cosmetics, a substitution for brown fat, and a source of vegetable fats (Maharani et al. 2016).

41 The native population of tengkawang is declining and is, at present, hard to find (Istomo and Hidayati 2010). S. 42 macrophylla is one of the most sought-after species in tropical forests. The exploitation of the species for its wood, 43 combined with forest conversion to other uses, have resulted in *S. macrophylla* wood being difficult to find in the market 44 (Rikando et al. 2019).

45 Tane' Olen is a forested area with a high environmental value that is preserved by the people of Setulang Village 46 (Hutauruk et al. 2018a), a community that manages its forests based on the wisdom of its local communities and sustainable forest management practices (Fahrianoor et al. 2013; Kettle 2010), so that forest sustainability is maintained 47

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# Land habitat characteristics of Shorea macrophylla in Tane' Olen,

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# Figure 1. Location of the research in Tane' Olen (•)

#### 77 **Research procedure**

78 The one-hectare research site was sampled using the purposive sampling method and a square plot with a side length of 79 100 meters (Sari and Maharani 2016). Soil sampling data was taken using a purposive sampling technique with three 80 sampling points in an area of one hectare. The three selected points were located on a hill, a back, and a valley (hills 81 have the highest elevations and a 15-25% slope, backs are located between the valleys and hills and have an 8-15% slope, 82 valleys are the lowest areas and have a 0-8% slope) to ensure an accurate representation of the study site. At each sampling 83 point, soil samples were taken at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Microclimate data (temperature, humidity, and light intensity) was collected at the same locations. The soil and microclimate data collection design is 84 85 illustrated in Figure 2, Vegetation data was only collected on trees with a diameter at breast height (DBH) greater than 86 20.0 cm. (Vegetation data was only collected on large trees because these trees are at the top of the growth cycle and their 87 data can be inferred to represent characteristics favored by seedlings, saplings, and poles of S. macrophylla, Each plot was 88 divided into 25 subplots (20 m x 20 m). Within each subplot, species were identified and DBH recorded for all trees

# MATERIALS AND METHODS

- 70 Study\_area 71 The study was carried out in the Tane' Olen forest area, Setulang Village, Malinau District, North Kalimantan Utara
- 72 (3°25'0.86" N and 116°25'52.59" E). The location map is presented in Figure 1.
- 73

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48 (Hutauruk et al. 2018). Forests are not only a place to live but are also used as a source of food and medicine and economic, 49 social, cultural, and spiritual functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014). 50 S. macrophylla habitat conditions in secondary forest locations have previously been documented by Jaffar et al. (2018) 51 and Perumal et al. (2017). Perumal et al. (2017) studied the relationship between soil fertility and the growth of S. 52 macrophylla trees in enrichment plantings at Sampadi Forest Reserve, Lundu, Sarawak and an adjacent secondary forest. 53 Jaffar et al. (2018) researched the effects of soil compaction and light intensity on the establishment and growth of S. 54 macrophylla in riparian forests in Sungai Kayan Ulu Sungai, Serawak, Malaysia. Through the improvement of the 55 company's management system, which is changing the way of harvesting using long cables during skidding activity will 56 reduced the natural forest damage and can increase financial returns from natural forest concessions. Through the 57 improvement of the company's management system, which is changing the way of harvesting using long cables during 58 skidding activity will reduce soil compaction, residual stand damage on the natural forest and can increase financial returns 59 from natural forest concessions (Ruslim et al. 2016). The characteristics of S. macrophylla habitat in primary forest 60 locations has not previously been studied. This research supports and supplements previous studies on S. macrophylla 61 habitat characteristics, specifically in regards to soil conditions, microclimate, topography, and species associations within, 62 natural habitats in primary forest locations, 63 This study aims to define and describe S. macrophylla land habitat characteristics in primary forests by analyzing 64 physical and chemical soil conditions, microclimate conditions, topographic conditions, species associations, and 65 vegetation analysis to index habitat requirements in a study area with characteristic S. macrophylla land habitat traits. It is 66 also hoped that the results of this study will benefit conservation efforts of this species, especially on degraded land in the 67 tropical rain forests of North Kalimantan. 68

#### 89 (Widiyatno et al. 2017). Plot-making and field-data collection activities are presented in Figure 2, while sampling design is

90 presented in Figures 3 and 4.

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Figure 2. A. Exploration, B. Make a research plot, C. Tree inventory, D. Soil sample collection, E and F. Microclimate data collection

Soil sample collection design and micro climate data are presented the following Figures 3 and 4



99 100 101 Remark: A:lights intensity, B: temperature and area humidity, C: soil sampling, m:Meter Figure 3. Soil and microclimate sample design

102 103 104

Topography data collection design can be seen in Figure 4.

105 106 Deleted[Catherine Albert]: Plot making

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Deleted[Yosep Ruslim]: Research procedure The 1 hectare research was conducted using the Purposive Sampling method. The plot is made in a square shape with a side length of 100 meters (Sari and Maharani 2016). In the plot, soil sampling data is taken. Soil sampling using a purposiv ....

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Deleted[Catherine Albert]: Design of

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Deleted[Yosep Ruslim]: Figure 3. Design of soil sampling and microclimate conditions



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131	•	$\left  \right  \right $	Deleted[Catherine Albert]: Micro climate
132	Analytical topography		Formatted[Catherine Albert]: Font: Italic
133	The topographic analysis will describe the topographic conditions favored by S. macrophylla.		Deleted[Yosep Ruslim]: Analytical topography
134 135	Microclimate analyses The analyses of microclimate conditions will provide information on microclimate conditions favored by S		Formatted[Windows Liser]: Font color: Red
136 137	macrophylla.		Formatted[Windows User]: Font: Italic Font color: Red
138	Important Value Index	$\bigwedge$	
130 139 140	According to Kacholi (2014), the Importance Value Index (IVI) is used in ecological studies to determine the ecological importance of a species in a particular ecosystem. IVI is also used to prioritize species conservation. Species	$\langle   \rangle$	Formatted[windows User]: Font color: Red
140	with low IVL values require a higher conservation priority when compared to species with high IVI. The dominant, species with high IVI. The dominant with the dom		Formatted[Windows User]: Font color: Red
142	relative dominance), IVI values will be analyzed descriptively.		Formatted[Windows User]: Font color: Red
144	Association of vegetation		Formatted[Windows User]: Font color: Red
145 146	Associations between two tree species were analyzed using a series of 2x2 contingency tables (Mueller-Dombois and Ellenberg 1974). A more complete description is presented in Table 1.		Deleted[Catherine Albert]: show
147 148	Table 1. Contingency table form,		Deleted[Catherine Albert]: where s
	Species A + -		Deleted[Yosep Ruslim]: NP
	$\begin{array}{c ccccc} + & & a & b & & a+b \\ - & & c & d & & c+d \end{array}$		Deleted[Catherine Albert]: that have
149	a + c $b + d$ $N = a + b + c + d$ Reference: Mueller-Dombois and Ellenberg (1974)		Deleted[Catherine Albert]: value of
150 151	<u>Remarks</u> :		Deleted[Catherine Albert]: ce
152 153	<u>a = Amount of plot containing species A and species B.</u> <u>b = Amount of plot containing only species A and no species B.</u>		Deleted[Yosen Ruslim]: '
154 155	c = Amount of plot containing only species B and no A. $d = Amount of plot containing neither species A nor species B.$		Deleted[Catherine Albert]: is characterized by an index of the
156 157	$\frac{N = Amount of all plots.}{Which then tested with chi-square (x^2)}$		
150	$X^{2} = \frac{(ad - bc)^{2} x N}{(a + b)(c + d)(a + c)(b + d)}$		Deleted[Yosep Ruslim]: )
158	And calculated their association coefficient (C) values		Deleted[Catherine Albert]: The
160	1. If $ad > bc$ , so $C = \frac{a}{(a+b)(b+d)}$ (a+b)(b+d)		Deleted[Yosep Ruslim]: According to Kacholi (2014), the 🚥
161	2. If $bc > ad and d > a$ , so $C = \frac{a + b}{(a + b)(b + c)}$		Deleted[Catherine Albert]: can be seen
162	<u>5. If bc &gt; ad and a &gt; c, so <math>L = {(a+d)(c+d)}</math></u> Positive or negative values of C indicate a positive or negative relationship between the two species, respectively. A		Deleted[Yosep Ruslim]: Associations between two plant
164 165	positive relationship indicates that the association between trees is mutually beneficial to each other, while a negative value indicates that the association between trees harms one another.		Deleted[Yosep Ruslim]:
166	I		Deleted[Catherine Albert]: a
167	DESULTS AND DISCUSSION		Deleted[Catherine Albert]: of coofisien assiation
168	Analysis of soil physical and chamical properties		Deleted[Catherine Albert]: from the calculation
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169 170	Analysis of physical and chemical soil properties Results of the physical and chemical soil properties analyses for the Tane' Olen plot, Setulang Village, Malinau		Deleted[Catherine Albert]: a
1/1 172	Regency study area, as they pertain to <i>S. macrophylla</i> habitat, can be seen in Table 2.		Deleted[Catherine Albert]: relationship
1/3	1 able 2. Physical properties of soil in Tane Olen, Setulang, Malinau District		
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1.31 50.60 41.42 <u>20-40</u> 1.23 53.72 34.88 40-60 Ridge 0-20 0.83 68.75 61.68 1.01 20-40 61.92 44.23 40-60 1.20 54.66 35.53 175 Remark:\* Average score for three times repetition 176 177 At the depth of 0-20 cm, the valley, back, and hill subplots have a low bulk density (0.60-1.05) (Table 2). This means 178 that the soils within the study area are not able to store water due to the dense soil conditions. According to Casanova et al. 179 (2016) and Zeng et al. (2013), soil bulk density conditions are influenced by external conditions and natural processes such 180 as plant root growth and rainfall. 181 The soil porosity values in the valley, back, and hill subplots decrease with increasing soil depth. The valley subplot 182 has a higher porosity value than the back and hill subplots. According to Darusman et al. (2019), the properties that most 183 affect soil porosity are bulk density and soil particle density; if the bulk density is low then the soil porosity will increase. 184 Water content in the hill, back, and valley decreases with increasing soil depth. The water content in the hill subplot 185 is higher than the back subplot because the water movement is faster in the slope subplot and the water settles in the lower 186 area, i.e. the valley subplot. This phenomenon results in a higher (95.37%) water content in the valley subplot when 187 compared to the hill and back subplots. Jaffar et al. (2018) reported that S. macrophylla plant roots can adapt to high water 188 soil conditions. According to Zhang et al. (2015), water content affects soil moisture and dry soil density; the higher the 189 soil's water content, the higher the soil moisture and the lower the dry soil density. Moist soil conditions encourage S. 190 macrophylla roots growth and development. According to Minasny and McBratney (2018), the availability of groundwater 191 is an important component of water balance and the terrestrial biosphere cycle because it can affect evapotranspiration 192 rates and support plant growth. 193 The results of the soil texture analysis can be seen in Table 3. 194 195 Table 3. Soil texture in Tane' Olen, Setulang Village, Malinau District Land condition Depth (cm) Clay (%) Sand (%) Dust (%) texture (USDA) Valley 0-20 33.70 50.90 15.40 SCL 20-40 36.50 49.50 14.00 SC 40-60 34.00 56.80 9.20 SCL Slope 0-20 24.70 67.20 8.10 SCL 20-40 27.30 63.10 SCL 9.60 40-60 33.10 60.50 6.40 SCL Ridge 0-20 37.80 54.60 7.60 SC 20-40 37.40 46.40 SC 16.20 11.30 SC 40-6040.70 48.00 196 Remark: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University 197 198 The soil texture at the study site generally had a sand fraction between 45-65%, a clay fraction between 35-55%, and a 199 dust fraction between 0-20% (Table 3). This means that the soil texture is sandy clay. According to Osman (2013), soil 200 texture refers to the level of fineness or roughness created by the various-sized soil particles, 201 Soil types are generally dominated by Ultisol (advanced development) soils, namely Typic Hapludults (Red-Yellow, 202 Podsolik) and Typic Paleudults (Yellow Podsolic). These soil types are typically found in lowland dipterocarp forests 203 (Ohta and Effendi 1992). 204 Chemical soil characteristics of the study area are presented in Table 4. 205 206 Table 4. Chemical characteristics of soil in Tane' Olen, Setulang village, Malinau district Land Depth pH (1:25) Cation exchange rates **Organic content** Ratio Mineral condition (cm) (meg 100gr<sup>-1</sup>) (%) (Mg 100 gram<sup>-1</sup>) H2O C/N KCl KTK Al3+ H+ N. Tot C.Org P<sub>2</sub>O<sub>5</sub> K<sub>2</sub>O 4.92 Valley 0-20 1.50 0.89 4.6 3.3 7.26 0.19 3.65 19 116.85 20-40 22 0.73 4.6 3.4 7.25 5.56 1.08 0.12 2.65 73.30 40-60 22 4.4 3.4 7.18 5.75 0.92 0.10 2.12 1.22 59.00 0-20 5.35 0.13 18 Slope 4.1 3.5 2.75 1.33 2.31 0.65 73.62 0.92 22 20-40 4.7 3.5 5.30 3.50 0.07 1.54 0.65 58.68

Bulk density (gram/cm<sup>3</sup>)\*

0.60

1.13

1.18

1.05

Porosity (%)\*

77.35

57.32

55.54

60.42

Water content (%)

95.37

40.04

39.20

48.08

26

39

0.41

2.35

60.90

120.34

1.40

3.46

174

Land condition

Valley

Slope

Depth (cm)

0-20

20-40

40-60

0-20

40-60

0-20

Ridge

4.8

4.4

3.5

3.0

5.53

10.81

3.33

7.25

1.42

2.75

0.05

0.09

		20-40	$\begin{array}{c c} 3.6 & 3.3 \\ 4.4 & 3.4 \end{array}$	10.48 7.80 10.37 6.83	1.83 0.08 2.58 0.09	2.12	28 0.89 17 0.65	194.09	Deleted[Yosep Ruslim]: PHT
207   208	Remark:	Laboratory of soil	test in B2P2EHD	and P <u>usrehut</u> , Mulawa	rman Universit	y			Deleted[Windows User]:
209 210 211	<u>The s</u> soils inhi	<u>soil in the study</u> bit root and plan	area is very acid t growth and inc	(pH = 4.1-4.8) (Ta rease Al levels in the	ble 4). Accord soil. The CE	to Schro	eder and Pum area ranges fi	phrey (2013), acid	Deleted[Catherine Albert]: Table 4 showed that t
211 212	dipteroca	arp forests (Perur	nal et al. 2017a).	n general, the value		w in surface	and subsurfac		Deleted[Catherine Albert]: in
213	toxicity	Al content in the	soil decreases w	ith increased organic	<u>e matter becau</u>	ise organic ma	atter forms a st	rong bond with Al	. Deleted[Catherine Albert]: , it will
215	Accordin Al conten	ig to Zaidey et a	<u>I. (2010), Al 1s a</u>	major cause of soil	acidity, and so	oils in lowland	d dipterocarp	orests have a high	Deleted[Catherine Albert]: cation exchange capacit (
217 218 219	<u>Nitro</u> low total and N de	<u>gen levels at the</u> <u>N levels in trop</u> eficiency can inh	research location ical rain forest so ibit plant growth	range from 0.05% - ils. Nitrogen is a nu (Mehata et al. 2019	0.19% (low to trient that is in ). According	<u>) very low). S</u> nportant for <u>p</u> to Omara et a	<u>adeghi et al. (2</u> <u>plant growth (C</u> al. (2019), the	2016) also reported Omara et al. 2019) main sources of N	Deleted[Catherine Albert]: )
220 221	are organ	nic matter, nitrog	en mineralizatior	and rainfall/precipity	tation. plots and lowe	er in the hill s	subplot. The st	eeper slopes in the	Deleted[Catherine Albert]: g
222 223	hill subp Accordin	lot are more pror	to erosion, resi and Bernhard (2	llting in organic C and 013), carbon can be	nd other nutrie stored in the	ents leaching i soil three tim	into the valley les longer than	and back subplots in the atmosphere	Deleted[Catherine Albert]: grams
224 225	and is an soil spurs	<u>indicator of soi</u> s microorganism	activity and ther	abundance and dive by increases the rate	rsity (Zhu and es of soil deco	<u>I Zhu 2015).</u> mposition, P	The presence of dissolution, N	of organic C in the fixation, and other	Deleted[Catherine Albert]: in real studies the value of
226 227	<u>microorg</u> Phosj	anism-dependen ohate was calcula	<u>t reactions.</u> ated from P2O	5 where the Phospha	te content was	s high (58.78)	). Phosphorus (	content is very low	Deleted[Catherine Albert]: According to Perumal et al.
228 229 230	(0.41-1.2) maintain	2 mg 100 gram <sup>-</sup> ing P availability et al. 2011)	<sup>1</sup> ) (Table 4). Acc in lowland trop	ording to Turner an ical rain forests. Pho	d Engelbrecht osphorus is es	t (2011), orga sential for roo	anic P plays an ot developmen	n important role in t and plant growth	Deleted[Catherine Albert]: for
231	<u>Potas</u>	sium values rang	ge from high (58.	<u>68-116.85 ppp) in th</u>	e valley and b	ack subplots	to very high (1	20.34-232.55 ppm	) Deleted[Catherine Albert]: in
232	element	has an extraordi	nary role in plan	<u>it metabolism, plant</u>	growth, and	yield. Potass	ium availabilit	y depends on soil	Deleted[Catherine Albert]: content
234 235	level var	ies between soils	<u>.</u>	ature), soll treatment	systems, and	the dynamics	of K. Therefo	re, the K exchange	Deleted[Catherine Albert]: site showed a
236 237	<b>Topogra</b> <u>Acco</u>	<b>phy condition i</b> rding to Li and I	<mark>n the study area</mark> McCarty (2019),	topographic feature	s are key para	meters that a	ffect the natur	e of the soil at the	Deleted[Catherine Albert]: value
238 239	<u>earth's su</u> (Kumhal	urface. Topograp ova et al. 2011).	bhic features can	affect organic matte	er; clay conter	nt; P, K, and	Mg concentra	tions; and soil pH	Deleted[Catherine Albert]: the soil in the back and valley,
240 241	<u>The t</u> slopes ra	opography of th nged from flat to	e study site is m a rather steep. S	oderately undulating macrophylla is four	g with a slope nd primarily in	<u>of 0-25%. E</u> n flat to slopii	Based on the a ng areas with h	bove data, subplot igh environmental	Deleted[Catherine Albert]: d
242 243	humidity stated th	<u>the roots of</u>	mperature, and a the S. macrophy	bundant water. This <i>lla</i> tree are able to	makes it suit survive and	<u>able to live o</u> grow in ana	on riverbanks erobic waterlo	Jaffar et al. (2018) ogged soils and is	Deleted[Catherine Albert]: the presence of
244 245	<u>considered</u> <u>At th</u>	<u>e study site, S.</u>	<u>nt tree.</u> <u>macrophylla</u> wa	s the dominant tree	species (Figu	ure 7). Other	tree species i	ncluded Madhuca	Deleted[Catherine Albert]: in the soil in the area.
246 247	<u>spectabil</u> <u>Syzygiun</u>	<u>is, Myristica vi</u> i inophyllum, an	<u>llosa Warb., Sco</u> d Shorea sp. S. n	prodocarpus bornee prodocarpus bornee prodocarpus bornee	tes the study s	site due to its	<u>nuum</u> spp., <u>M</u> high germinat	ion rate and faster	Deleted[Catherine Albert]: will decrease
248 249	germinat species a	ion rate (Appana long rivers (Peru	<u>h and Turnbull 1</u> mal et al. 2017).	<u>998), its high growth</u>	<u>n rate (fastest o</u>	of the genus S	Shorea), and its	s status as a climax	Deleted[Catherine Albert]: if the
250	Table 5. S	<u>S. macrophylla</u> abu	Indance in study ar	Eamily	Dolotif	Dolotif	Dolotif	Important	Deleted[Catherine Albert]: in the soil increases,
	INUMOCI	Local hame	name	<u>raimiy</u>	density	dominance	e frequency	value index	Deleted[Catherine Albert]: verv
	1.	Tengkawang	S. macropyilla M. spectabilis	Dipterocarpaceae	c 7.69	15.35	5.0	28.04	
	2. 3.	Darah-darah	M. speciabilis M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25	Deleted[Catherine Albert]: complex
	4. 5.	Bala seveny Ubah	S. borneensis Eugenia soo	Olacaceae Myrtaceae	5.12 5.59	5.77 3.64	5.0 4.61	15.90 13.85	Deleted[Catherine Albert]: , the soil has
	6.	Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74	
	7.	Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44	Deleted[Catherine Albert]: , making it a major cause of sc $\overline{\cdots}$
	o. 9.	Enang Kaze tenak	S. mopnyllum Shorea sp	Dipterocarpaceae	2.33	5.14 6.08	5.84 2.69	12.35	- Deleted[Yosep Ruslim]: Table 4 showed that the soil in the first

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Figure 7. A. Tree of S. macrophylla and B. Leaf of S. macrophylla

#### 257 Microclimate conditions

258 Three microclimate data factors were collected: temperature, humidity, and light intensity (see Table 6 for a more complete description).

#### 259 260

#### 261 **Table 6.** Microclimate conditions in Tane' Olen, Setulang Village, Malinau District 262

Number	Micro climate	Unit	Time	Repeat 1	Repeat 2	Repeat 3	Average	Remark
1.	Lights intensity	Lm	Morning	350	400	452	400.67	Taken at 8.59 sunny conditions
2.	Area temperature	°c	Morning	24	24.5	25	24.5	
3.	Moisture	%	Morning	81	79	80	80	
1.	Lights intensity	Lm	Mid day	750	450	207	469	Taken at 12:02
2.	Area temperature	°c	Mid day	26.5	26	24.5	25.67	sunny conditions
3.	Moisture	%	Mid day	76	79	81	78.67	
1.	Lights intensity,	Lm	Afternoon	369	237	145	250.33	Taken at 16:30
2.	Area emperature	°c	Afternoon	25	24.5	23	24.17	sunny conditions
3.	Moisture	%	Afternoon	84	85	87	85.33	-

The average temperature at the study site was between 24-26° C (Table 6). According to Ruchaemi (2013), the optimal

temperature for plant assimilation is 25-30° C. Humidity values were high, ranging from 78-86%. Light intensity ranged

from 12.52% (250.33 Lm) -23.46% (469 Lm), indicating low light intensity. This is due to a dense tree canopy dominated

by S. macrophylla, whose dense, wide leaves prevent light from reaching the forest floor. This low light intensity is

consistent with the findings of Panjaitan et al. (2012), who found that the closed canopy only allowed a little sunlight to reach the forest floor. These conditions benefit *S. macrophylla* seedlings, which are both shade tolerant and sun intolerant.

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# Association with other trees

According to Saiz and Alados (2012), plant species associations is a fundamental aspect of the ecology of plant communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic interactions, and seed dispersal patterns. The results of the species association analysis and the association coefficient are presented in Table 7.

 Table 7. Value of species association and coefficient of association

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Number	Species association	X <sup>2</sup> count	Association species	C (+/-)
1.	S. macropylla with M. spectabilis	0.35	-	0.04
2.	S. macropylla with M. villosa Warb	6.82	-	0.29
3.	S. macropylla with S. borneensis	0.04	+	0.04
4.	S. macropylla with Eugenia spp	0.37	+	0.11
5.	S. macropylla with Palaquium spp	0.37	+	0.11
6.	S. macropylla with M. triloba	1.21	+	0.16
7.	S. macropylla with S. inophyllum	3.23	-	0.29
8.	S. macropylla with Shorea sp	1.92	-	0.24

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#### Deleted[Yosep Ruslim]: Micro climate conditions

Micro climate data collection consists of 3 factors: temperature, humidity and incoming light. A more complete description [...]

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281Table 7 shows the results of a series of 2x2 contingency tests between S. macropylla and eight other dominant tree282species. The calculated X values are greatest between S. macropylla and M. villosa Warb, indicating that S. macrophylla283has a strong but negative association with M. villosa Warb. According to Sofiah et al. (2013), species pairs do not always284indicate positive relationships. Tree species with high populations are not always associated with another species.285Likewise, low-population species are not necessarily negatively correlated with another species.

The association coefficient (C) is used as a parameter of the magnitude of the relationship between the eight species and *S. macropylla* and indicates positive or negative associations. Species that show positive coefficients of association with *S. macropylla* are *S. borneensis, Eugenia spp., Palaquium spp*, and *M. triloba*. According to Windusari1 et al. (2011), positive associations indicate both species like the same environmental conditions; for example, wet conditions, high light intensity, or shade. *S. macropylla* showed a negative association with *M. spectabilis, M. villosa Warb, S. inophyllum*, and *Shorea* sp. Negative associations indicate an intolerance for cohabitation or the absence of a mutually beneficial relationship (Pratama et al. 2012).

#### 293 Direction of S. macrophylla development

294 At present, tropical forests are being degraded by anthropogenic activities such as timber extraction, agricultural 295 cultivation, and the establishment of commercial plantations. This results in the conversion of forests into agriculture land 296 and the fragmentation and degradation of tropical rain forests. Deforestation damages the environment by increasing light 297 intensity and causing severe mineral soil erosion. In general, degraded forests can be divided into three categories: 298 grasslands after burning, early-succession secondary forests, and commercially logged forests (Daisuke et al. 2013). 299 Planting native trees is considered to be an effective rehabilitation method for degraded tropical rain forests because 300 native trees provide benefits such as wood, food, and medical products (Daisuke et al. 2013). According to Pratiwi et al. 301 (2014), tropical forest rehabilitation is necessary to both meet the demand for wood and to improve environmental 302 conditions. One key to rehabilitation success is understanding the suitability of each growing sites for each species being 303 developed. One approach to determine the suitability of growing sites for each species is to identify each species' potential identify locally superior species, and correlate this with species distribution data and growth requirements (Pratiwi et al. 304 305 2014). 306 S. macrophylla is a recommended species for replanting degraded tropical forest land, ie pastures after burning 307 (Daisuke et al. 2013), early-succession secondary forests (Daisuke et al. 2013; Perumal et al. 2012), and commercially 308 logged forests. In commercially logged forests, S. macrophylla can be planted using the lines planting model or gaps 309 planting model. In early-succession secondary forests and pasture after burning, S. macrophylla requires pioneer plants to 310 assist growth. S.macrophylla, S. macrophylla is a valuable wood tree species that has socio-economic and ecological

benefits and is beneficial for reforestation and rehabilitation activities (Perumal et al. 2012; Perumal et al. 2015; Perumal et al. 2017a; Perumal et al. 2017b; Perumal et al. 2019).
 This species is important to land rehabilitation activities because it plays a role in maintaining water quality, filtering

out pollutants and deposits, and storing carbon (Utomo et al. 2018; You et al. 2015). Things that must be considered when planting *S. macrophylla* are the nutrient content in clay and the clay mineral composition. These two factors can be used to evaluate soil fertility. The growth of *S. macrophylla* is also significantly limited by the high light intensity in grasslands (*Imperata cylindrica*/ pastures after burning). *S. macropylla* species favor habitats with low light intensity. In secondary forests and logged-over forests, the survival and/or growth of *S. macrophylla* is limited by hard soil conditions. This agrees with the results of this study, where fine sandy clay soils were found.

S. macrophylla grows on riversides with flat and gentle topography, acidic soil conditions, and lower fertility but good
 microclimate conditions (temperatures between 24-26°C, high humidity between 78-86%, and a low light intensity
 between 12.52 - 23.46%). This species can be recommended to be planted in degrade tropical forest areas if microclimatic
 factors and soil conditions are taken into account.

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At present various species of forests are degraded due to anthropogenic activities such as timber extraction, change of cultivation. and the establishment of commercial plantation

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#### REFERENCES

- Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (*Allium cepa* L) as influenced by nitrogen and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. African J Agricultural Research. Volume 6 (14): 3252–3258. https://Doi.Org/10.5897/Ajar10.1024.
- Appanah S, Turnbull JM. 1998. A review of dipterocarps : taxonomy. ecology and silviculture. Center for International Forestry Research.
- Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Ultural Chilean J Agric Res 76 (1):105-113. doi:10.4067/S0718-58392016000100015.
- Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using dipterocarp trees in Sarawak. Malaysia. Hindawi Publishing Corporation International J Forestry Research. Volume 2013:1-12. Article ID 683017. 11 pages http://dx.doi.org/10.1155/2013/683017.
- Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int. J Sci. Technol.. 7(2): 93-102. doi: 10.13170/aijst.7.2. 10119.
- Eviati and Sulaeman. 2009. Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk, Edisi 2. ISBN 978-602-8039-21-5. Balai Penelitian Tanah, Bogor. [Indonesian]
- Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46.
- Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (*S. machrophylla*) dan regenerasi alaminya dikebun masyarakat. J. Penelitian Ekosistem Dipterokarpa Volume 1 (2): 81-88. https://doi.org/10.20886/jped.2015.1.2.81-88. [Indonesian]
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the conservation of non-timber forest products in Malinau District. IOP Conference. Series: Earth Environment Science. Volume 144: 1-9. https://doi.org/10.1088/1755-1315/144/1/012055.
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b. The prospect of the utilization of Non-Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in Malinau. North Kalimantan. Indonesia. Biodiversitas. Volume 19 (2): 421-430. [Indonesian]
- Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (*Shorea* Spp.) di areal IUPHHK-Ha PT. Intracawood Manufacturing Tarakan. Kalimantan Timur (*Study of the potential and distribution of tengkawang (Shorea Spp.) in the IUPHHK-Ha area of PT. Intracawood Manufacturing Tarakan. East Kalimantan*). J Silvikultur Tropika. Volume 01 (01): 11-17. ISSN: 2086-8227. [Indonesian]
- Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on survival and growth performance of planted *Shorea macrophylla* (de vriese) in riparian forest Along Kayan Ulu River. Sarawak. Malaysia. Hindawi International J Forestry Research Volume 2018 (2):1-11. Article ID 6329295. 11 pages https://doi.org/10.1155/2018/6329295.
- Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania. International J of Biodiversity. Volume 2014: 1-8. Article ID 516840. 8 pages. http://dx.doi.org/10.1155/2014/516840.
- Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv. 19: 1137-1151.
  Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the effects of weather conditions. J Precision Agriculture. Volume 12 (6): 813-830. https://doi.org/10.1007/s11119-011-9221-x.
- Kurnia, U, Agus f, Adimihardja A, Dariah A. 2006. Sifat fisik tanah dan metode analisisnya. Balai Besar Litbang Sumberdaya Lahan Pertanian. Agro inovasi. Bogor. [Indonesian]
- Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties: geospatial analyses of earth observation (eo) data. Web of Science. http://doi: 10.5772/intechopen.86109.
- Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality from Sahan and Nanga Yen Villages. West Kalimantan. Indonesia. Conference Proceedings. Towards The Sustainable Use of biodiversity in a changing environment: From Basic To Applied Research. Aip Publishing.
- Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. Volume 19 (4): 1280-1288. DOI: 10.13057/biodiv/d190414. [Indonesian]
- Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Hindawi International J of Agronomy. Volume 2019:1-15. Article ID 8572985. 15 pages https://doi.org/10.1155/2019/8572985.
- Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas. Volume 21 (1): 49-56. [Indonesian]
- Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. European J Soil Science. 2017:1-9. https://doi: 10.1111/ejss.12475.
- Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chemistry International. 2 (1): 58-69.
- Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada.
- Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef manure and inorganic fertilizer application/ Hindawi International Journal of Agronomy. Volume 2019:1-6. Article ID 9594369. 6 pages. https://doi.org/10.1155/2019/9594369.
- Ohta S, Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr. 38 (2): 197-206.
- Osman KT. 2013. Forest soil: properties and management. Springer. London.
- Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh Shorea johorensis Foxw. Di HPH Aya Yayang Indonesia. Kalimantan Selatan (Environmental conditions in which to grow Shorea johorensis Foxw. At Aya Yayang HPH in Indonesia. South Kalimantan). J Penelitian Dipterokarpa. Volume 6 (1): 11-22. [Indonesian]
- Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen. Kalimantan Tengah (Association and characterization of stands in peat swamp forests in Hampagen. Central Kalimantan). J Teknologi Lingkungan. Edisi Khusus Hari lingkungan Hidup : 69-76. [Indonesian]
- Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk rehabilitasi hutan dan lahan di Indonesia (*Atlas of local reliable tree species for forest and land rehabilitation in Indonesia*). Forda Press. [Indonesian]
- Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality attributes of *Shorea macrophylla* / seedlings in a tropical nursery. Biodiversitas. Volume 20 (8): 2110-2118. ISSN: 1412-033X. E-ISSN: 2085-4722. DOI: 10.13057/biodiv/d200803.
- Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of Shorea macrophylla (de Vriese) after enrichment planting for reforestation purpose at Sarawak. Malaysia. Online J Biology Science. Volume 17 (1): 7-17.
- Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of planted *Shorea macrophylla* (de Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve. Sarawak. Malaysia. Hindawi International J Forestry Research. Volume 2017. Article ID 6721354. 16 pages. https://doi.org/10.1155/2017/6721354.

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Deleted[Windows User]: Pratiwi, Narendra B. 2012. Pengaruh penerapan teknik konservasi tanah terhadap pertumbuhan pertanaman Mahoni (*Swietenia Macrophylla* King) Di Hutan Penelitian Carita. Jawa Barat (*Effect of applying soil conservation techniques to the growth of Mahogany* (Swietenia Macrophylla King) *plantations in the Carita Research Forest. West Java*). J Penelitian Hutan Dan Konservasi Alam. Volume 9 (2): 139-150. [Indonesian]

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402

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Conference on Natural Resources in the Tropics. 2012 (NTrop4) : Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Faso (West Africa). Intl J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321. Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juling S, Bodos V, Maryani A. 2019. Shorea macrophylla. The IUCN red list of threatened species 2019: e.T33620A125629642. http://dx.doi.org/10.2305/IUCN.UK.20193.RLTS.T33620A125629642.en\_ Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (Shorea spp) di hutan tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (Distribution of tengkawang species (Shorea spp) in the Tembawang forest Labian Village Batang Lupar District Kapuas Hulu West Kalimantan). J Hutan Lestari. Volume 7 (1): 390-406. [Indonesian] Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228. [Indonesian] Ruchaemi A. 2013. Ilmu pertumbuhan hutan (Forest growth Science). Samarinda: Mulawarman University Press. [Indonesian] Deleted[Yosep Ruslim]: Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest after logging in Kedah. Malaysia. Malayan Nature J. Volume 68 (1 & 2): 187-201. Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7 (7): 1-9. E40551. http://doi:10.1371/Journal.Pone.0040551. Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern Washington. Northern Idaho. Washington Grain Commission reports. http://washingtoncrop.com (accessed 16 Jan. 2016). p. 56-59. Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego. CA. Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur (Distribution patterns. abundance. and bamboo associations in plant communities in the Gunug Baung Nature Park in East Java). Berita Biologi. J Ilmu-Ilmu Hayati. Volume 12 (2): 239-247. Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry. 2011:103:297-315 DOI 10.1007/s10533-010-9466-x. Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene climate change on genetic structure and diversity of Shorea macrophylla in Kalimantan rainforest. Tree Gen Genomes. Volume 14 (4): 14-44. Widiyatno, Budiadi, Survanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil nutrients and late-succession species afters hifting cultivation In Central Kalimantan. Indonesia. J Tropical Forest Science. Volume 29 (2): 151-162. Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua (Species associations in the succession vegetation community in the deposition area of the double embankment in Papua's PTFI mine). J Ilmiah Ilmu-Ilmu Hayati Biota. Volume 16 (2): 242-251. [Indonesian] Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN. 2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Intenational J Soil Science. Volume 5 (3):112-130. Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and irrigation methods. Geoderma 193/194:290-299. doi:10.1016/j. geoderma.2012.10.013. Zhang J, Jiang Q, Zhang Y, Dai L, Wu H. 2015. nondestructive measurement of water content and moisture migration of unsaturated red clays in South

Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted Shorea macrophylla under line planting technique. In: 4th Regional

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- China. Hindawi Publishing Corporation Advances in Materials Science and Engineering, Volume 2015, Article ID 542538, 7 pages <a href="http://dx.doi.org/10.1155/2015/542538">http://dx.doi.org/10.1155/2015/542538</a>.
- 444 Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple soil. China. Soil and Tillage 445 Research. Volume 146: 39-46

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Muhammad Fajri, Pratiwi and Yosep Ruslim

# **Document title:** Characteristics of land habitat of

Characteristics of land habitat of Shorea macrophylla in Tane' Olen, Malinau District, North Kalimantan Indonesia Date Issued:

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Deleted[asus]: Land habitat Formatted[asus]: Font: Not Italic Deleted[asus]: , Deleted[asus]: topographical Deleted[asus]: habitat conditions The characteristics of *Shorea macrophylla*'s habitat in Tane' Olen, 1 Deleted[asus]: the Malinau District, North Kalimantan Province, Indonesia 2 Deleted[asus]: tree Deleted[asus]: Purposive 3456789 Deleted[asus]: sampling Deleted[asus]: distribute 10 Deleted[asus]: and to the Pipet method was used to analy ... 11 Abstract. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the soil's physical and chemical properties, Deleted[asus]: and S. macrophylla abundance was determ 12 topography, and microclimate of S. macrophylla's habitat. A purposive method was used to select a sampling plot and to place the 13 subplots. Soil was analyzed to determine the physical properties, i.e., texture, bulk density, porosity, and water content, and the chemical Deleted[asus]: physical properties of 14 properties, i.e., pH, CEC, total N, organic C, C/N ratio, P, K, and Al saturation, Importance value index was determined for each tree 15 species to know the species composition in the study area. Only the dominant species were presented, The soil in the study area had bulk 16 density of 0.60-1.31 gram cm<sup>3-1</sup>, porosity 50.60%-77.35%, water content 34.88%-95.37%, and soil texture sandy clay. The chemical Deleted[asus]: s 17 properties of the soil were as follows: pH was 3.6-4.8, N 0.05%-0.19%, organic C 1.40%-3.65%, P 0.41-2.3 mg 100 gr<sup>-1</sup>, K 58.68-232.55 mg 100 gr<sup>-1</sup> and Cation Exchange Capacity (CEC) 5.35-10.81 meg 100gr<sup>-1</sup> Slope ranged between 0 and 25%. The microclimate 18 Deleted[asus]: have 19 characteristics were as follows: temperature was 24-26.5° C, relative humidity 76-84% and light intensity 350-750 Lm, Trees species 20 21 22 23 with an IVI  $\geq 10\%$  were S. macrophylla, Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Deleted[asus]: a Palaquium spp, Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between S. macropylla and S. borneensis, Eugenia spp, Palaquium spp and M. triloba, and negative associations were observed between S. macropylla and M. spectabilis, M. villosa Warb, S. inophyllum, and Shorea sp. S. macrophylla grows on riversides with flat and gentle topography, acidic Deleted[asus]: 24 25 soil, and lower fertility but with suitable microclimate. This species can be recommended to be planted in degraded tropical forest areas but the microclimate and soil properties should be taken into account. Deleted[asus]: soil Deleted[asus]: of 26 Keywords: Habitat, land characteristics, S. macrophylla Deleted[asus]: of 27 Running title: The characteristics of Shorea macrophylla's habitat Deleted[asus]: dominated by sand, clay and dust 28 Deleted[asus]: condition **INTRODUCTION** 29 Deleted[asus]: pH Shorea macrophylla is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). Local 30 communities value this species as a source of timber and fruit (Randi et al. 2019). S. macrophylla is known locally in West 31 Kalimantan as the tengkawang tungkul tree and has been cultivated by the Dayak and Malay communities (Fajri and Deleted[asus]: N 32 Fernandes 2015). S. macrophylla grows in clusters in tropical rain forests with type A climate, on latosol soils at altitudes 33 up to 500 m on acidic soils (pH 4.6-4.9), and a cation-exchange capacity (CEC) of 16.25-19.40 (Istomo and Hidayati Deleted[asus]: organic C 2010). In Sarawak, Sabah, Brunei and Kalimantan, this species is associated with sedimentary soils and is distributed 34 35 randomly and evenly over riverbanks and areas with sloping or flat topography. It is rarely found on hills. (Randi et al. Deleted[asus]: P 36 2019; Utomo et al. 2018; Perumal et al. 2017). 37 The timber from S. macrophylla is commonly used for construction and to make veneer and plywood, musical Deleted[asus]: K 38 instruments, furniture, and packing crates (Istomo and Hidayati 2010). The fruit, locally known as tengkawang tungkul 39 (Illipe) nuts, is used as a raw material for soap and other cosmetics, a substitution for brown fat, and a source of vegetable Deleted[asus]: Cation Exchange Capacity(CEC) 40 fat (Maharani et al. 2016). 41 The natural population of tengkawang is declining and is, at present, hard to find (Istomo and Hidayati 2010) because S. Deleted[asus]: 42 macrophylla is one of the most sought-after species in tropical forests. The exploitation of the species for its timber, 43 combined with forest conversion to other uses, has resulted in S. macrophylla timber being difficult to find in the market 44 (Rikando et al. 2019). Deleted[asus]: -45 Tane' Olen is a forested area with a high environmental value preserved by the people of Setulang Village (Hutauruk et 46 al. 2018a), a community that manages its forests based on the local wisdom and sustainable forest management practices Deleted[asus]: Microclimate (Fahrianoor et al. 2013; Kettle 2010), so the forest sustainability is maintained (Hutauruk et al. 2018). Forests are not only 47 Deleted[asus]: conditions

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#### 48 a place to live for them, but are also used as a source of food and medicine and economic, social, cultural, and spiritual 49 functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014).

50 S. macrophylla's habitat characteristics in secondary forest locations have been documented by Jaffar et al. (2018) and

51 Perumal et al. (2017). Perumal et al. (2017) studied the relationship between soil fertility and the growth of S. macrophylla 52 in enrichment plantings at Sampadi Forest Reserve, Lundu, Sarawak and an adjacent secondary forest. Jaffar et al. (2018) 53 researched the effects of soil compaction and light intensity on the establishment and growth of S. macrophylla in riparian 54 forests in Sungai Kavan Ulu Sungai, Serawak, Malaysia, The improvement of the company's management system, which 55 is changing the way of harvesting using long cables during skidding activity, reduced the natural forest damage and could 56 increase financial returns from natural forest concessions (Ruslim et al. 2016). The characteristics of S. macrophylla 57 habitat in primary forest locations had not previously been studied. So, this study aimed to describe the characteristics of S. 58 macrophylla's habitat in primary forests by analyzing the physical and chemical properties of soil, the microclimate, 59 topography, species associations, and vegetation. It is hoped that the results of this study will benefit conservation efforts 60 of this species, especially on degraded land in the tropical rain forests of North Kalimantan.

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62

#### **MATERIALS AND METHODS**

#### 63 Study area

64 The study was carried out in Tane' Olen forest area, Setulang Village, Malinau District, North Kalimantan Utara 65 Province (3°25'0.86" N and 116°25'52.59" E). The location map is presented in Figure 1.

66



67 68

69 Figure 1. Location of the research in Tane' Olen (•)

#### 70 **Research procedure**

71 A one-hectare research site was selected purposively and sampled using a square plot with a side length of 100 meters 72 (Sari and Maharani 2016). Soil sampling was taken from purposively selected three sampling points, located on a hill, a 73 slope, and a valley (the hill had the highest elevations and a 15-25% slope; the slope was located between the valley and 74 hill, and had an 8-15% slope; the valley, was the lowest area, and had a 0-8% slope) to ensure an accurate representation of 75 the study site. At each sampling point, soil samples were taken at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Microclimate data (temperature, humidity, and light intensity) were collected at the same locations. The soil and 76 microclimate data collection design is illustrated in Figure 2. Vegetation data were only collected for trees with a diameter 77 78 at breast height (DBH) greater than 20.0 cm, Each plot was divided into 25 subplots (20 m x 20 m). Within each subplot, 79 the species were identified and DBH recorded for all trees (Widiyatno et al. 2017). Plot-making and field-data collection 80 activities are presented in Figure 2, while sampling design is presented in Figures 3 and 4.



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Topography data collection design can be seen in Figure 4.



#### 97 98 99

9 **Figure 4.** Plot design across topographic features

100 101

The design of vegetation data <u>collection</u> can be seen in Figures 5 and 6.

			100 m			
	L1	L2	L3	L4	L5	
	SP5	SP6	PU15	SP16	SP25	
	SP 4	SP7	PU14	SP17	SP24	
100 m	SP3	SP8	PU13	SP18	SP23	
	SP2	SP9	PU12	SP19	SP22	
	SP1	SP10	PU11	SP20	SP21	
k	20m	20m	20m	20m	20m	

#### 103 104

105 106 Figure 5. Design of plot and sub-plots for vegetation sampling Deleted[asus]: analysis 107 20 m 20 m  $\begin{array}{c} 108 \\ 109 \end{array}$ Remark: 20m x 20m: Tree level sub plot, m: Meter. 110 111 Figure 6. Vegetation inventory design for trees > 20.0 cm in DBH. 112 Data analyses Deleted[asus]: analysis 113 Soil analyses Deleted[asus]: are 114 Soil samples were analyzed for both physical and chemical properties (Kurnia et al. 2006; Eviati and Sulaeman 2009). 115 Physical properties analyzed were texture, bulk density, porosity, and water content (using the Pipette method). Chemical Deleted[asus]: included 116 properties analyzed were pH (using the electrode method), CEC (using the ammonium acetate pH 7 method), elements 117 Al+++ and H+ (using the KCl method 1 N), total N elements (using the Kjeldahl method), organic C elements (using 118 Deleted[asus]: included Walkley-Black method), C/N ratio (using arithmetic methods), elements P<sub>2</sub>O5 and K<sub>2</sub>O (using Bray No I methods), and 119 saturation Al (using arithmetic methods). Soil data analysis results from the soil laboratory were tabulated and analyzed 120 descriptively and quantitatively. Deleted[asus]: will be

			Deleted[asus]:	Analytical
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121			Deleted[asus]:	topographic conditions favored by
122	Analysis of topography		Deleted[asus]:	Microclimate
123	The topographic analysis was done qualitatively to describe the topography suitable for <i>S. macrophylla</i> .			
124	Analysis of microclimate,		Deleted[asus]:	analyses
125	The <u>analysis</u> of microclimate <u>was done qualitatively to provide information on microclimates <u>characteristics suitable</u> for S. macrophylla</u>	$\langle$	Deleted[asus]:	analyses
120	<u>Ioi</u> S. macrophylia.	$\sum$	Deleted[asus]:	conditions
128	<b><u>Importance</u></b> Value Index		Deleted[equal:	
129 130	According to Kacholi (2014), the Importance Value Index (IVI) is used in ecological studies to determine the	$\langle \rangle$	Deleted[asus]:	wiii
130	with low IVI values require a higher conservation priority than those with high IVI, which is the dominant species,		Deleted[asus]:	conditions favored by
132	frequency + relative dominance, IVI values were analyzed descriptively.		Deleted[asus]:	Important
134	Association of vegetation		Deleted[asus]:	when compared to
135 136	Associations between two tree species were analyzed using a series of 2x2 contingency tables (Mueller-Dombois and Ellenberg 1974). A more complete description is presented in Table 1.		Deleted[asus]:	species
137 138	Table 1 Contingency table form			
139			Deleted[asus]:	. The
	Species B + -		Deleted[asus]:	,
	$\begin{array}{cccc} + & & A & B & a+b \\ - & & c & D & c+d \end{array}$		Deleted[asus]:	.(
140	a + c $b + d$ $N = a + b + c + d$ Reference: Mueller-Dombois and Ellenberg (1974)		Deleted[asus]:	)
141			Deleted[equal:	
142 143	Remarks : a = number of plots containing species A and species B.		Deleted[asus]:	will be
144	b = number of plots containing only species A, but no species B.		Deleted[asus]:	Amount
145 146	c = number of plots containing only species B, but no species A.d = number of plots containing neither species A nor species B.	$\sum$	Deleted[asus]:	Amount
147	N = number of all plots.			
148	<u>Then, the data were</u> tested with chi-square $(x^2)$		Deleted[asus]:	and
150	$(ad - bc)^2 \times N$		Deleted[asus]:	Amount
151	$x^{2} = \frac{1}{(a+b)(c+d)(a+c)(b+d)}$		Deleted[asus]:	and
152	The association coefficient (C) values were determined as follows:		Deleted[asus]:	Amount
154 155	1. If ad > bc, so $C = \frac{ad-bc}{c}$		Deleted[asus].	Amount
156	2. If $bc > ad$ and $d > a$ , so $C = \frac{ad-bc}{(a+b)(b+d)}$			
157	3. If bc > ad and a > c, so $C = \frac{ad-bc}{(a+d)(a+d)}$		Deleted[asus]:	which then
158	Positive or negative values of C indicate a positive or negative relationship between the two species. A positive		Deleted[asus]:	And calculated their
160	indicates that the association between trees harms one another.		Deleted[asus]:	, respectively
161		/	Deleted[asus]:	Analysis of soil physical and chemical
162	RESULTS AND DISCUSSION		Deleted[asus]:	soil
163	The soil's physical and chemical properties	_	Deleted[asus].	Results of t
164	The physical and chemical properties in S. macrophylla's habitat can be seen in Table 2.		Dereteu[asus].	Nosaito 01 t
165		$\backslash$	Deleted[asus]:	analyses for the Tane' Olen plot, Setulang
		$\mathbb{N}$	Formatted[asu	s]: Font: Not Italic

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166 Table 2. Physical properties of soil in Tane'Olen, Setulang, Malinau District

Location of soil	Depth (cm)	Bulk density (gram/cm <sup>3</sup> )*	Porosity (%)*	Water content (%)
Valley	0-20	0.60	77.35	95.37
	20-40	1.13	57.32	40.04
	40-60	1.18	55.54	39.20
Slope	0-20	1.05	60.42	48.08
	20-40	1.31	50.60	41.42
	40-60	1.23	53.72	34.88
Ridge	0-20	0.83	68.75	61.68
_	20-40	1.01	61.92	44.23
	40-60	1.20	54.66	35.53

<sup>168</sup> Remark:\* Average score from three repetitions

169

170 At the depth of 0-20 cm, the valley, slope, and hill subplots had a low bulk density (0.60-1.05) (Table 2). According to 171 Casanova et al. (2016) and Zeng et al. (2013), soil bulk density is influenced by external conditions and natural processes 172 such as plant root growth and rainfall.

173 The soil porosity values in the valley, slope, and hill subplots decreased with the increasing soil depth. The valley 174 subplot had higher porosity value than the slope and hill subplots. According to Darusman et al. (2019), the properties that

175 affect soil porosity the most are bulk density and soil particle density; if the bulk density is low then the soil porosity will 176 increase. 177 Water content in the hill, slope, and valley decreased with the increasing soil depth. The water content in the hill

178 subplots was higher than the slope subplots because the water movement is faster in the slope subplots and the water 179 settles in the lower area, i.e., the valley subplots, which resulted in a higher (95.37%) water content in the valley subplots 180 than in the hill and slope subplots. Jaffar et al. (2018) state that S. macrophylla plant roots can adapt to high water soil

181 content. Moist soils stimulate S. macrophylla roots growth and development. According to Minasny and McBratney

182 (2018), the availability of groundwater is an important component of water balance and the terrestrial biosphere cycle

183 because it can affect evapotranspiration rates and support plant growth.

184 The results of the soil texture analysis can be seen in Table 3. 185

186 Table 3. Soil texture in Tane' Olen. Setulang Village. Malinau District

Location of soil	Depth (cm)	Clay (%)	Sand (%)	<mark>.Silt (%</mark> )	texture (USDA)
Valley	0-20	33.70	50.90	15.40	SCL
•	20-40	36.50	49.50	14.00	SC
	40-60	34.00	56.80	9.20	SCL
Slope	0-20	24.70	67.20	8.10	SCL
1	20-40	27.30	63.10	9.60	SCL
	40-60	33.10	60.50	6.40	SCL
Ridge	0-20	37.80	54.60	7.60	SC
2	20-40	37.40	46.40	16.20	SC
	40-60	40.70	48.00	11.30	SC

187 Remark: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University

188

189 The soil texture at the study site generally had a sand fraction of 45-65%, a clay fraction 35-55%, and a silt fraction 0-

190 20% (Table 3). This means that the soil texture is sandy clay. According to Osman (2013), soil texture refers to the level of

191 fineness or roughness created by the variously-sized soil particles.

192 Soil types are generally dominated by Ultisol (advanced development) soils, namely Typic Hapludults (Red-Yellow 193 Podsolik) and Typic Paleudults (Yellow Podsolic). These soil types are typically found in lowland dipterocarp forests 194 (Ohta and Effendi 1992).

195

Ridge

40-60

0-20

20-40

Chemical soil characteristics of the study area are presented in Table 4.

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3.6

Table 4. Chemical characteristics of soil in Tane' Olen, Setulang village, Malinau district

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Location of	Depth	рН (1:	25)	Cation	exchang	ge rates	Organic	content	Ratio	Minera	al
<u>soil</u>	(cm)			(meg 1	00gr <sup>-1</sup> )		(%)			(Mg 10	)0 gram <sup>-1</sup> )
		H <sub>2</sub> O	KCl	<b><u>CEC</u></b>	Al3 <sup>+</sup>	$H^+$	<u>Tot.</u> N.,	Org C	C/N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Valley	0-20	4.6	3.3	7.26	4.92	1.50	0.19	3.65	19	0.89	116.85
-	20-40	4.6	3.4	7.25	5.56	1.08	0.12	2.65	22	0.73	73.30
	40-60	4.4	3.4	7.18	5.75	0.92	0.10	2.12	22	1.22	59.00
Slope	0-20	4.1	3.5	5.35	2.75	1.33	0.13	2.31	18	0.65	73.62
-	20-40	4.7	3.5	5.30	3.50	0.92	0.07	1.54	22	0.65	58.68

3.33

7.25

7.80

1.42

2.75

1.83

0.05

0.09

0.08

1 40

3.46

2.12

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0.41

2.35

0.89

5.53

10.81

10.48

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73.62 58.68

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		40-60	44 34	10.37 6.83	2 58 0 09	1 54	17 0.65	232 55		Deleted[asus]:	are
198	Remark: I	Laboratory of soil	test in B2P2EHD an	d Pusrehut, Mulawarm	an University	/	17 0.05			4	
199	The o	oil in the study	oran was yery oold	$h_{0}(pH - 4.1.4.8)$ (7)	Fable 1) Ac	poording to Sal	roader and D	umphray (2013)	/	Deleted[asus]:	back
200 201 202	acid <u>ic</u> soi	ls inhibit root at	nd plant growth and	l increase Al levels i s low In general th	in the soil. The value of (	The CEC in the	study area rai	<u>nged</u> from 5.3 to		Deleted[asus]:	indicates
202	lowland d	lipterocarp fores	sts (Perumal et al. 20	017a).	the slope of	nd wallow subm	lota which in	lighted high soil	/	Deleted[asus]:	decreases
204	toxicity.	Al content in the	e soil decreased wi	th the increasing or	anic matter	because organ	ic matter forn	ns a strong bond		Delete alle surely	· ,
206	with Al. A	According to Zai	idey et al. (2010), A	I is a major cause of	soil acidity	, and soils in lo	wland diptero	carp forests have		Deleted[asus]:	increased
207	high Al co	ontent. ren levels at the	a research location	ranged from 0.05%	to 0.10% (	low to very lo	w) Sadechi e	t al. (2016) also		Deleted[asus]:	a
208	reported l	ow total N leve	ls in tropical rain fo	prest soils. Nitrogen	is important	t for plant grov	wh (Omara et	al. 2019), and N			
210	deficiency	y can inhibit pla	ant growth (Mehata	a et al. 2019). Accor	rding to Om	nara et al. (201	9), the main s	ources of N are		Deleted[asus]:	-
211	organic m	natter and rainfal	ll/precipitation.	law and clone subpla	te then in t	ha hill subplot	The steener	alones in the hill		Deleted[asus]·	a nutrient that is
212	subplots a	are more prone	to erosion, resultin	g in the leaching of	organic C	and other nutr	ents into the	valley and slope	$\mathbb{N}$	Deleteu[d3d3].	a nument that is
214	subplots.	According to S	chlesinger and Ber	nhard (2013), carbon	n can be sto	ored in the soil	three times lo	nger than in the	$\mathbb{N}$	Deleted[asus]:	, nitrogen mineralization
215	atmosphe	re and is an in	dicator of soil mic	roorganism abundan	ice and dive	ersity (Zhu and	l Zhu 2015).	The presence of			
216 217	organic C	in the soil spur	rs microorganism a	tivity and thereby in the treations	ncreases the	rates of soil d	ecomposition,	P dissolution, N		Deleted[asus]:	are
218	Phosp	hate was calcula	ated from $P_2O_5$ v	where the Phosphate	_content wa	us high (58.78)	but the phose	horus content is		Deleted[asus]·	back
219	very low	(0.41-1.22 mg 1	00 gram <sup>-1</sup> ) (Table 4	4). According to Tur	ner and Eng	elbrecht (2011)	), organic P pl	ays an important		Deletea[asas].	
220	role in ma	aintaining P ava	ailability in lowland	l tropical rain forests	s. Phosphoru	is is essential f	or root develo	pment and plant		Deleted[asus]:	and
$\frac{221}{222}$	Potass	sium values rang	ged from high (58.0	68-116.85 ppp) in th	e vallev and	d <u>slope</u> subplot	s to verv high	(120.34-232.55			
223	ppm) in	the hill subplot	s. According to M	ouhamad et al. (201	16), K is m	ore abundant	in the soil the	in other mineral		Deleted[asus]:	lower
224	elements. This element has an essential role in plant metabolism, growth, and yield. Potassium availability depends on soil									Deleted[asus]:	leaching
225	properties (humidity, aeration, and temperature), soil treatment systems, and the dynamics of K. Therefore, the K exchange										
	lever vull									Deleted[asus]:	back
227	Topogra	phy in the study	y area	1		1		A.1		Famoattadfaa.	al. Cubaariat
228	Accor earth's su	ding to Li and I	McCarty (2019), to bic features can af	pographic features a	re key parai	meters that affe	ect the nature	of the soil at the		Formatted[asu	sj: Subscript
230	(Kumhalo	ova et al. 2011).	fine reatures can ar	leet organic matter,	ciay conten	it, I, IX, and IV		his, and son pri		Formatted[asu	s]: Subscript
231	The to	pography of the	e study site is mode	rately undulating wit	th a slope of	0-25%. <u>The</u> su	bplot slopes r	ange from flat to			
232	moderate	y steep. S. mac	<u>crophylla was</u> foun	d primarily in flat t	to sloping a	reas with high	environmenta	l humidity, low		Deleted[asus]:	. P
233	are able to	o survive and gr	ow in anaerobic wa	terlogged soils and is	s considered	a flood-tolerar	it tree.	s. macrophylia		Dolotod[acus]:	hack
235	•	<u> </u>								Deleteu[asus].	Dack
236	Dominan	t trees in the st	udy area	ha dominant traa ar	aning (Figu	ura 7) Othar ti	a spacias in	Judad Madhuaa		Deleted[asus]:	extraordinary
237	spectabili	s. Myristica vi	llosa Warb., Score	odocarpus borneens	is. Eugenia	spp., <i>Palaqui</i>	<i>um</i> species ma	caranga triloba.			
239	Syzygium	inophyllum, and	d Shorea sp. S. mac	rophylla dominated	the study sit	te due to its fas	germination	process and high		Deleted[asus]:	plant
240	<u>germinati</u>	on rate (Appana	th and Turnbull 199	8), its high growth ra	ate (fastest o	of the genus Sho	orea), and its s	tatus as a climax		Deleted[asus]:	between
241	species ai	ong rivers (Peru	imai et al. 2017).								
243	Table 5.	<u>The importance va</u>	lue index of the domi	nant tree species in the	study area	D. 1. //4	D 1 //4			Deleted[asus]:	condition
	Number	Local name	Scientific Name	Family	density	dominance	Relatif frequency	Amportance value index		Deleted[eque]	Decad on the above data
			~		<u>(%)</u>	(%)	<u>(%)</u>	(%)		Deleteu[asus].	Dased on the above data,
	1. 2.	Tengkawang Kaien ase	S. macropyilla M. spectabilis	Dipterocarpaceae Sapotaceae	/.69	15.35 7.29	5.0 4.61	28.04 22.16		Deleted[asus]:	d
	3.	Darah-darah	M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25			
	4. 5	Bala seveny Ubah	S. borneensis Fugenia spp	Olacaceae Myrtaceae	5.12 5.59	5.77 3.64	5.0 4.61	15.90 13.85		Deleted[asus]:	a rather
	6.	Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74		Deletod[acus]:	ic
	7.	Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44			15
	8. 9.	Ehang Kaze tenak	S. inophyllum Shorea sp	Myrtaceae Dipterocarpaceae	5.36 2.33	3.14 6.08	3.84 2.69	12.35 11.10		Deleted[asus]:	. This makes it suitable to live on
244			··· 1				-				
245										Deleted[asus]:	tree

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Figure 7. A. Tree of S. macrophylla and B. Leaves of S. macrophylla

#### 249 Microclimate, 250

Three microclimate factors were collected, i.e., temperature, humidity, and light intensity (see Table 6 for a more complete description).

253 Table 6. Microclimate in Tane' Olen forest 254

Location	Microclimate	Unit	Time	<u>∎1-st</u>	<b>₽<u>-nd</u></b>	<mark>,3<u>−rd</u></mark>	Average	Remark
				<u>record</u>	<u>record</u>	<u>record</u>		
1.	Light, intensity	Lm		350	400	452	400.67	Taken at 8.59 sunny
			Morning					conditions
2.	Area temperature	°c	Morning	24	24.5	25	24.5	
3.	Moisture	%	Morning	81	79	80	80	
1.	Lights intensity	Lm	Mid day	750	450	207	469	Taken at 12:02
2.	Area temperature	°c	Mid day	26.5	26	24.5	25.67	sunny conditions
3.	Moisture	%	Mid day	76	79	81	78.67	
1.	Lights intensity	Lm	Afternoon	369	237	145	250.33	Taken at 16:30
2.	Area emperature	°c	Afternoon	25	24.5	23	24.17	sunny conditions
3.	Moisture	%	Afternoon	84	85	87	85.33	-

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262

256 The average temperature at the study site was 24-26° C (Table 6). According to Ruchaemi (2013), the optimal 257 temperature for plant assimilation is 25-30° C. Humidity values were high, ranging from 78 to 86%. Light intensity was 258 low, ranging from 12.52% (250.33 Lm) to 23.46% (469 Lm), due to dense canopy dominated by S. macrophylla, which 259 prevented light from reaching the forest floor. This low light intensity is consistent with the findings of Panjaitan et al. 260 (2012), who found that the closed canopy only allowed a little sunlight to reach the forest floor. These conditions benefit S. 261 macrophylla seedlings, which are both shade tolerant and sun intolerant.

#### 263 Association with other trees

264 According to Saiz and Alados (2012), plant species association, is a fundamental aspect of the ecology of plant 265 communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic 266 interactions, and seed dispersal patterns. The results of the species association analysis and the association coefficient are 267 presented in Table 7. 268

#### 269 Table 7. Association of *S. macropylla* with other species

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Species association	X <sup>2</sup> count	Association species	C (+/-)
S. macropylla with M. spectabilis	0.35	-	0.04
S. macropylla with M. villosa Warb	6.82	-	0.29
S. macropylla with S. borneensis	0.04	+	0.04
S. macropylla with Eugenia spp	0.37	+	0.11
S. macropylla with Palaquium spp	0.37	+	0.11
S. macropylla with M. triloba	1.21	+	0.16
S. macropylla with S. inophyllum	3.23	-	0.29
S. macropylla with Shorea sp	1.92	-	0.24

271

Remark: X<sup>2</sup> tabulated value at 5% level: 3.841. X<sup>2</sup> tabulated value at 1% level: 6.35 272

Deleted[asus]: Leaf Deleted[asus]: conditions Deleted[asus]: data Deleted[asus]: : Deleted[asus]: conditions Deleted[asus]: , Setulang Village, Malinau District Deleted[asus]: Number Deleted[asus]: Deleted[asus]: Repeat Deleted[asus]: Repeat Deleted[asus]: Repeat Deleted[asus]: s Deleted[asus]: between Deleted[asus]: -Deleted[asus]: ranged Deleted[asus]: -Deleted[asus]: , indicating low light intensity. This is Deleted[asus]: a Deleted[asus]: tree Deleted[asus]: , whose dense, wide leaves Deleted[asus]: s Deleted[asus]: Value of species a Deleted[asus]: and coefficient of association Formatted Table[asus]

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Table 7 shows the results of a series of 2x2 contingency tests between *S. macropylla* and <u>each of the</u> eight other dominant tree species. The calculated  $X_{\pm}^2$  values <u>were</u> greatest between *S. macropylla* and *M. villosa* Warb, indicating that *S. macrophylla* had a strong but negative association with *M. villosa* Warb. According to Sofiah et al. (2013), species pairs do not always indicate positive relationships. Tree species with high populations are not always associated with another species. Likewise, low-population species are not necessarily negatively correlated with another species. The association coefficient (C) was used as a parameter of the magnitude of the relationship between the eight species

and *S. macropylla* and indicates positive or negative associations. Species that show<u>ed</u> positive coefficients of association with *S. macropylla* were *S. borneensis, Eugenia spp., Palaquium spp,* and *M. triloba.* According to Windusari1 et al. (2011), positive associations indicate both species <u>have</u> the same <u>requirement of</u> environmental conditions; for example, wet conditions, high light intensity, or shade. *S. macropylla* showed a negative association with *M. spectabilis, M. villosa Warb, S. inophyllum,* and *Shorea* sp. Negative associations indicate intolerance for cohabitation or the absence of a mutually beneficial relationship (Pratama et al. 2012).

#### 285 Direction of *S. macrophylla* plantation

At present, tropical forests are being degraded by anthropogenic activities such as timber extraction, agricultural cultivation, and the establishment of commercial plantations. This results in the conversion of forests into agriculture land and the fragmentation and degradation of tropical rain forests. Deforestation damages the environment by increasing light intensity and causing severe mineral soil erosion. In general, degraded forests can be divided into three categories: grasslands after burning, early-succession secondary forests, and commercially logged forests (Daisuke et al. 2013). Planting native trees is considered to be an effective rehabilitation method for degraded tropical rain forests because

291 native trees is considered to be an effective relabilitation include for degraded hopical rain forests because 292 native trees provide benefits such as <u>timber</u>, food, and medical products (Daisuke et al. 2013). According to Pratiwi et al. 293 (2014), tropical forest rehabilitation is necessary to both meet the demand for <u>timber</u> and <u>improve</u> environmental 294 conditions. One key to rehabilitation success is <u>the</u> understanding <u>of</u> the suitability of each growing site, for each species 295 being <u>planted</u>. One approach to determine the suitability of growing sites for each species is to identify each species' 296 potential, identify locally superior species, and correlate this with species distribution data and growth requirements 297 (Pratiwi et al. 2014).

*S. macrophylla* is a recommended species for replanting degraded tropical forest land, i.e., pastures after burning (Daisuke et al. 2013), early-succession secondary forests (Daisuke et al. 2013; Perumal et al. 2012), and commercially logged forests. In commercially logged forests, *S. macrophylla* can be planted using the line, planting <u>system</u> or gap, planting <u>system</u>. In early-succession secondary forests and pasture after burning, *S. macrophylla* requires pioneer plants to assist growth. *S. macrophylla* is a valuable tree species that has socio-economic and ecological benefits and is beneficial for reforestation and rehabilitation activities (Perumal et al. 2012; Perumal et al. 2015; Perumal et al. 2017a; Perumal et al. 2017b; Perumal et al. 2019).

This species is important for land rehabilitation activities because it plays a role in maintaining water quality, filtering out pollutants and deposits, and storing carbon (Utomo et al. 2018; You et al. 2015). Things that must be considered when planting *S. macrophylla* are the nutrient content in clay and the clay mineral composition. These two factors can be used to evaluate soil fertility. The growth of *S. macrophylla* is also significantly limited by the high light intensity in grasslands (*Imperata cylindrica*/ pastures after burning). *S. macropylla*, grows well in habitats with low light intensity. In secondary forests and logged-over forests, the survival and growth of *S. macrophylla* is limited by soil compaction. This agrees with the results of this study, where fine sandy clay soils were found.

S. macrophylla grows on riversides with flat and gentle topography, acidic soil, and lower fertility, but with the suitable microclimate (temperature of 24-26°C, high humidity 78-86%, and a low light intensity 12.52 - 23.46%). This species can be recommended to be planted in degraded tropical forest areas if microclimatic factors and soil conditions are taken into account.

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## ACKNOWLEDGMENTS

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#### REFERENCES

- Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (*Allium cepa* L) as influenced by nitrogen and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. African J Agricultural Research. Volume 6 (14): 3252–3258. https://Doi.Org/10.5897/Ajar10.1024.
- Appanah S, Turnbull JM. 1998. A review of dipterocarps : taxonomy. ecology and silviculture. Center for International Forestry Research.
- Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Ultural Chilean J Agric Res 76 (1):105-113. doi:10.4067/S0718-58392016000100015.
- Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using dipterocarp trees in Sarawak. Malaysia. Hindawi Publishing Corporation International J Forestry Research. Volume 2013:1-12. Article ID 683017. 11 pages http://dx.doi.org/10.1155/2013/683017.
- Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int. J Sci. Technol.. 7(2): 93-102. doi: 10.13170/aijst.7.2. 10119.
- Eviati and Sulaeman. 2009. Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk. Edisi 2. ISBN 978-602-8039-21-5. Balai Penelitian Tanah, Bogor. [Indonesian]
- Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46.
- Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (*S. machrophylla*) dan regenerasi alaminya dikebun masyarakat. J. Penelitian Ekosistem Dipterokarpa Volume 1 (2): 81-88. https://doi.org/10.20886/jped.2015.1.2.81-88. [Indonesian]
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the conservation of non-timber forest products in Malinau District. IOP Conference. Series: Earth Environment Science. Volume 144: 1-9. https://doi.org/10.1088/1755-1315/144/1/012055.
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b. The prospect of the utilization of Non-Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in Malinau. North Kalimantan. Indonesia. Biodiversitas. Volume 19 (2): 421-430. [Indonesian]
- Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (Shorea Spp.) di areal IUPHHK-Ha PT. Intracawood Manufacturing Tarakan. Kalimantan Timur (Study of the potential and distribution of tengkawang (Shorea Spp.) in the IUPHHK-Ha area of PT. Intracawood Manufacturing Tarakan. East Kalimantan). J Silvikultur Tropika. Volume 01 (01): 11-17. ISSN: 2086-8227. [Indonesian]
- Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on survival and growth performance of planted *Shorea macrophylla* (de vriese) in riparian forest Along Kayan Ulu River. Sarawak. Malaysia. Hindawi International J Forestry Research Volume 2018 (2):1-11. Article ID 6329295. 11 pages https://doi.org/10.1155/2018/6329295.
- Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania. International J of Biodiversity. Volume 2014: 1-8. Article ID 516840. 8 pages. http://dx.doi.org/10.1155/2014/516840.
- Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv. 19: 1137-1151. Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the effects of weather conditions. J
- Precision Agriculture. Volume 12 (6): 813-830. https://doi.org/10.1007/s11119-011-9221-x.
- Kurnia, U, Agus f, Adimihardja A, Dariah A. 2006. Sifat fisik tanah dan metode analisisnya. Balai Besar Litbang Sumberdaya Lahan Pertanian. Agro inovasi. Bogor. [Indonesian]
- Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties: geospatial analyses of earth observation (eo) data. Web of Science. http://doi: 10.5772/intechopen.86109.
- Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality from Sahan and Nanga Yen Villages. West Kalimantan. Indonesia. Conference Proceedings. Towards The Sustainable Use of biodiversity in a changing environment: From Basic To Applied Research. Aip Publishing.
- Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. Volume 19 (4): 1280-1288. DOI: 10.13057/biodiv/d190414. [Indonesian]
- Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Hindawi International J of Agronomy. Volume 2019:1-15. Article ID 8572985. 15 pages https://doi.org/10.1155/2019/8572985.
- Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas. Volume 21 (1): 49-56. [Indonesian]
- Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. European J Soil Science. 2017:1-9. https://doi: 10.1111/ejss.12475.
- Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chemistry International. 2 (1): 58-69.
- Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada.
- Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef manure and inorganic fertilizer application/ Hindawi International Journal of Agronomy. Volume 2019:1-6. Article ID 9594369. 6 pages. https://doi.org/10.1155/2019/9594369.
- Ohta S. Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr. 38 (2): 197-206.
- Osman KT. 2013. Forest soil: properties and management. Springer. London.
- Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh Shorea johorensis Foxw. Di HPH Aya Yayang Indonesia. Kalimantan Selatan (Environmental conditions in which to grow Shorea johorensis Foxw. At Aya Yayang HPH in Indonesia. South Kalimantan). J Penelitian Dipterokarpa. Volume 6 (1): 11-22. [Indonesian]
- Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen. Kalimantan Tengah (Association and characterization of stands in peat swamp forests in Hampagen. Central Kalimantan). J Teknologi Lingkungan. Edisi Khusus Hari lingkungan Hidup : 69-76. [Indonesian]
- Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk rehabilitasi hutan dan lahan di Indonesia (*Atlas of local reliable tree species for forest and land rehabilitation in Indonesia*). Forda Press. [Indonesia]
- Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality attributes of *Shorea macrophylla* seedlings in a tropical nursery. Biodiversitas. Volume 20 (8): 2110-2118. ISSN: 1412-033X. E-ISSN: 2085-4722. DOI: 10.13057/biodiv/d200803.
- Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of Shorea macrophylla (de Vriese) after enrichment planting for reforestation purpose at Sarawak. Malaysia. Online J Biology Science. Volume 17 (1): 7-17.
- Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of planted *Shorea macrophylla* (de Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve. Sarawak. Malaysia. Hindawi International J Forestry Research. Volume 2017. Article ID 6721354. 16 pages. https://doi.org/10.1155/2017/6721354.

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- Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted *Shorea macrophylla* under line planting technique. In: 4th Regional Conference on Natural Resources in the Tropics. 2012 (NTrop4) : Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices.
- Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Faso (West Africa). Intl J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321.
- Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juiling S, Bodos V, Maryani A. 2019. Shorea macrophylla. The IUCN red list of threatened species 2019: e.T33620A125629642. http://dx.doi.org/10.2305/IUCN.UK.20193.RLTS.T33620A125629642.en.
- Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (*Shorea* spp) di hutan tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (*Distribution of tengkawang species* (Shorea spp) in the Tembawang forest Labian Village Batang Lupar District Kapuas Hulu West Kalimantan). J Hutan Lestari. Volume 7 (1): 390-406. [Indonesian]
- Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228. [Indonesian]
- Ruchaemi A. 2013. Ilmu pertumbuhan hutan (Forest growth Science). Samarinda: Mulawarman University Press. [Indonesian]

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- Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest after logging in Kedah. Malaysia. Malayan Nature J. Volume 68 (1 & 2): 187-201.
- Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7 (7): 1-9. E40551. http://doi:10.1371/Journal.Pone.0040551.
- Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern Washington. Northern Idaho. Washington Grain Commission reports. http://washingtoncrop.com (accessed 16 Jan. 2016). p. 56–59.
- Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego. CA.
- Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur (*Distribution patterns. abundance. and bamboo associations in plant communities in the Gunug Baung Nature Park in East Java*). Berita Biologi. J Ilmu-Ilmu Hayati. Volume 12 (2): 239-247.
- Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry. 2011:103:297-315 DOI 10.1007/s10533-010-9466-x.
- Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene climate change on genetic structure and diversity of *Shorea macrophylla* in Kalimantan rainforest. Tree Gen Genomes. Volume 14 (4): 14-44.
- Widiyatno, Budiadi, Suryanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil nutrients and late-succession species afters hifting cultivation In Central Kalimantan. Indonesia. J Tropical Forest Science. Volume 29 (2): 151-162.
- Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua (Species associations in the succession vegetation community in the deposition area of the double embankment in Papua's PTFI mine). J Ilmiah Ilmu-Ilmu Hayati Biota. Volume 16 (2): 242-251. [Indonesian]
- Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN. 2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Intenational J Soil Science. Volume 5 (3):112-130.
- Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and irrigation methods. Geoderma 193/194:290-299. doi:10.1016/j. geoderma.2012.10.013.
- Zhang J, Jiang Q, Zhang Y, Dai L, Wu H. 2015. nondestructive measurement of water content and moisture migration of unsaturated red clays in South China. Hindawi Publishing Corporation Advances in Materials Science and Engineering, Volume 2015, Article ID 542538, 7 pages http://dx.doi.org/10.1155/2015/542538.
- Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple soil. China. Soil and Tillage Research. Volume 146: 39-46.

## Messages

Note	From
Dear Managing Editor, Please find attached is the revised and edited for the manuscript " The characteristics of <i>Shorea macrophylla</i> 's habitat in Tane' Olen, Malinau District, North Kalimantan Province, Indonesia	yruslim 2020-06-19 09:11 AM
We are very happy to say thank you for your appreciation on our journal as well as all valuable comments in order to refine the article. All of the comments from the reviewers are very meaning full. We tried to added and changed all comments from reviewer. We hope the revised manuscript has met the requirements for publication in the Biodiversitas Journal. Thank you very much for your help and attention.	
Thank you and best regards,	
Corresponding author,	
Yosep Ruslim	
🗅 yruslim, 5693-24463-1-5-20200615 Revised_June 19, 2020.doc	
Kindly use attached file for updates. Do not send any other files and do not forget to turn on TRACK CHANGES.	editors 2020-06-19 10:32 AM

Deleted[asus]: Land habitat Formatted[asus]: Font: Not Italic Deleted[asus]: , Deleted[asus]: topographical Deleted[asus]: habitat conditions The characteristics of *Shorea macrophylla*'s habitat in Tane' Olen, Deleted[asus]: the Malinau District, North Kalimantan Province, Indonesia Deleted[asus]: tree Deleted[asus]: Purposive Deleted[asus]: sampling Deleted[asus]: distribute Deleted[asus]: and to the Pipet method was used to analy ... Abstract. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the soil's physical and chemical properties, Deleted[Windows User]: area topography, and microclimate of S. macrophylla's habitat. A purposive method was used to select a sampling plot and to place the subplots. Soil was analyzed to determine the physical properties, i.e., texture, bulk density, porosity, and water content, and the chemical Deleted[asus]: and S. macrophylla abundance was determ ... properties, i.e., pH, CEC, total N, organic C, C/N ratio, P, K, and Al saturation, Importance value index was determined for each tree species to know the species composition in the study site. Only the dominant species were presented. The soil at the study site had bulk density of 0.60-1.31 gram cm<sup>3-1</sup>, porosity 50.60%-77.35%, water content 34.88%-95.37%, and soil texture sandy clay. The chemical Deleted[asus]: physical properties of properties of the soil were as follows: pH was 3.6-4.8, N 0.05%-0.19%, organic C 1.40%-3.65%, P 0.41-1.22, mg 100 gr 1, K 58.68-232.55 mg 100 gr<sup>-1</sup> and Cation Exchange Capacity (CEC) 5.35-10.81 meg 100gr<sup>-1</sup> Slope ranged between 0 and 25%. The microclimate Deleted[asus]: s characteristics were as follows: temperature was 24-26.5°C, relative humidity 76-87% and light intensity 145,750 Lm. Trees species with an IVI  $\geq 10\%$  were S. macrophylla, Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Deleted[Windows User]: in Palaquium spp, Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between S. macropylla and S. borneensis, Eugenia spp, Palaquium spp and M. triloba, and negative associations were observed between S. macropylla and M. spectabilis, M. villosa Warb, S. inophyllum, and Shorea sp. S. macrophylla grows on riversides with flat and gentle topography, acidic Deleted[Windows User]: area soil, and lower fertility but with suitable microclimate. This species can be recommended to be planted in degraded tropical forest areas but the microclimate and soil properties should be taken into account. Deleted[asus]: have Deleted[asus]: a Keywords: Habitat, land characteristics, S. macrophylla Deleted[asus]: Running title: The characteristics of Shorea macrophylla's habitat Deleted[asus]: soil Deleted[asus]: of **INTRODUCTION** Shorea macrophylla is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). Local Deleted[asus]: of communities value this species as a source of timber and fruit (Randi et al. 2019). S. macrophylla is known locally in West Kalimantan as the tengkawang tungkul tree and has been cultivated by the Dayak and Malay communities (Fajri and Deleted[asus]: dominated by sand, clay and dust Fernandes 2015). S. macrophylla grows in clusters in tropical rain forests with type A climate, on latosol soils at altitudes up to 500 m on acidic soils (pH 4.6-4.9), and a cation-exchange capacity (CEC) of 16.25-19.40 (Istomo and Hidayati Deleted[asus]: condition 2010). In Sarawak, Sabah, Brunei and Kalimantan, this species is associated with sedimentary soils and is distributed evenly over riverbanks and areas with sloping or flat topography. It is rarely found on hills. (Randi et al. 2019; Utomo et al. Deleted[asus]: pH 2018; Perumal et al. 2017). The timber from S. macrophylla is commonly used for construction and to make veneer and plywood, musical Deleted[asus]: N instruments, furniture, and packing crates (Istomo and Hidayati 2010). The fruit, locally known as tengkawang tungkul (Illipe) nuts, is used as a raw material for soap and other cosmetics, a substitution for brown fat, and a source of vegetable Deleted[asus]: organic C fat (Maharani et al. 2016). The natural population of tengkawang is declining and is, at present, hard to find (Istomo and Hidayati 2010) because S. Deleted[Windows User]: 0.41-2.3 macrophylla is one of the most sought-after species in tropical forests. The exploitation of the species for its timber, combined with forest conversion to other uses, has resulted in S. macrophylla timber being difficult to find in the market (Rikando et al. 2019). Deleted[asus]: P Tane' Olen is a forested area with a high environmental value preserved by the people of Setulang Village (Hutauruk et al. 2018a), a community that manages its forests based on the local wisdom and sustainable forest management practices Deleted[asus]: K (Fahrianoor et al. 2013; Kettle 2010), so the forest sustainability is maintained (Hutauruk et al. 2018). Forests are not only

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48 a place to live <u>for them</u>, but are also used as a source of food and medicine and economic, social, cultural, and spiritual
49 functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014).

50 *S. macrophylla*'s habitat <u>characteristics</u> in secondary forest locations have been documented by Jaffar et al. (2018) and 51 Perumal et al. (2017). Perumal et al. (2017) studied the relationship between soil fertility and the growth of *S. macrophylla* 

52 in enrichment plantings at Sampadi Forest Reserve, Lundu, Sarawak and an adjacent secondary forest. Jaffar et al. (2018) 53 researched the effects of soil compaction and light intensity on the establishment and growth of S. macrophylla in riparian 54 forests in Sungai Kavan Ulu Sungai, Serawak, Malaysia, The improvement of the company's management system, which 55 is changing the way of harvesting using long cables during skidding activity, reduced the natural forest damage and could 56 increase financial returns from natural forest concessions (Ruslim et al. 2016). The characteristics of S. macrophylla 57 habitat in primary forest locations had not previously been studied. So, this study aimed to describe the characteristics of S. 58 macrophylla's habitat in primary forests by analyzing the physical and chemical properties of soil, the microclimate, 59 topography, species associations, and vegetation. It is hoped that the results of this study will benefit conservation efforts 60 of this species, especially on degraded land in the tropical rain forests of North Kalimantan.

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## MATERIALS AND METHODS

## 63 Study area

64 The study was carried out in Tane' Olen forest area, Setulang Village, Malinau District, North Kalimantan Utara 65 Province (3°25'0.86" N and 116°25'52.59" E). The location map is presented in Figure 1.

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69 Figure 1. Location of the research in Tane' Olen (•)

## 70 **Research procedure**

71 A one-hectare research site was selected purposively and sampled using a square plot with a side length of 100 meters 72 (Sari and Maharani 2016). Soil sampling was taken from purposively selected three sampling points, located on a ridge, a 73 slope, and a valley (the ridge had the highest elevations and a 15-25% slope, the slope was located between the valley and 74 ridge, and had an 8-15% slope; the valley, was the lowest area and had a 0-8% slope) to ensure an accurate representation 75 of the study site. At each sampling point, soil samples were taken at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Microclimate data (temperature, humidity, and light intensity) were collected at the same locations. The soil and 76 microclimate data collection design is illustrated in Figure 2. Vegetation data were only collected for trees with a diameter 77 78 at breast height (DBH) greater than 20.0 cm, Each plot was divided into 25 subplots (20 m x 20 m). Within each subplot, 79 the species were identified and DBH recorded for all trees (Widiyatno et al. 2017). Plot-making and field-data collection 80 activities are presented in Figure 2, while sampling design is presented in Figures 3 and 4.

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Topography data collection design can be seen in Figure 4.



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Association of v	between two tree spe	ecies were analyzed using a seri	es of 2x2 contingency	v tables (Mueller-Dombois and	Deleted[asus]. and
Ellenberg 1974).	A more complete des	scription is presented in Table 1.			Deleted[asus]: Amount
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-		$\begin{array}{ccc} A & B \\ c & D \\ a+c & b+c \end{array}$	$\begin{array}{c} a+b\\ c+d\\ N=a\end{array}$	+ b $+$ c $+$ d	Deleted[asus]: Amount
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a = number o b = number o	f plot <u>s</u> containing spe	y species A and species B.			
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N = number	of all plots.				Deleted[asus]: Analysis of soil physical and chemical
Then, the data	a were tested with chi	i-square (x <sup>2</sup> )			Deleted[asus]: soil
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The association	on coefficient (C) val	ues were determined as follows:			Formatted[asus]: Font: Not Italic
. If $ad \ge bc$ , so	$C = \frac{ad-bc}{(a+b)(b+d)}$				
2. If $bc > ad$ and	$d d > a$ , so $C = \frac{ad}{(a+b)}$	bc			Deleted[asus]: ,
If $bc > ad and$	$d a > c$ , so $C = \frac{ad}{(a+d)}$	-bc )(c+d)			Formatted[Yosep Ruslim]: Font color: Black
Positive or n elationship indi	negative values of C cates that the associ	indicate a positive or negative ation between trees is mutuall	e relationship betwee y beneficial to each	n the two species. A positive other, while a negative value	Deleted[Windows User]: in Tane'Olen, Setulang, Malina
ndicates that the	association between	trees harms one another.			Deleted[Windows User]:
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		RESULTS AND DISCU	ISSION		Deleted[asus]: for
The physical	cal and chemical pro and chemical propert	operties <u>ies of</u> soil properties <u>in</u> S. macro	<i>phylla's</i> habitat can be	e seen in Table 2.	Deleted[asus]: times
Table 2. Physical 1	properties of soil at the	study site			Deleted[asus]: back
Location of soil	Depth (cm)	Bulk density (gram/cm <sup>3</sup> )*	Porosity (%)*	Water content (%)	
/alley	0-20 20-40	0.60	77.35 57.32	95.37 40.04	Deleted[Windows User]: hill
	40-60	1.13	55.54	39.20	Deleted[asus]: have
lope	0-20 20-40	1.05 1.31	60.42 50.60	48.08 41.42	
	40-60	1.23	53.72	34.88	Deleted[asus]: This means that the soils within the study $\epsilon$ $\overline{\cdots}$
Lidge	0-20	0.83	68.75 61.92	61.68 44 23	A polotodiously on 11
	40-60	1.01	54.66	35.53	Deleted[asus]: conditions are
Remark:* Average	e score <u>from</u> three repeti	tions			Deleted[asus]: back
At the depth	of 0-20 cm the valley	v slope and ridge subplots had	a low bulk density (0	60-1 05) (Table 2) According	
o Casanova et a	al. (2016) and Zeng	et al. (2013), soil bulk densit	$\frac{1}{2}$ influenced by example.	xternal conditions and natural	Deleted[Windows User]: hill
The soil porc	posity values in the va	lley, <u>slope</u> , and <u>ridge</u> subplots of	decreased with the inc	creasing soil depth. The valley	Deleted[asus]: has
subplot <mark>had high</mark>	er porosity value tha	n the <u>slope</u> and <u>ridge</u> subplots.	According to Darusm	an et al. (2019), the properties	Deleted[asus]: a
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that affect soil porosity the most are bulk density and soil particle density; if the bulk density is low then the soil porosity
will increase.

172 Water content in the <u>ridge</u>, <u>slope</u>, and valley <u>decreased</u> with <u>the</u> increasing soil depth. The water content in the <u>ridge</u>,

173 subplots was higher than the slope subplots because the water movement is faster in the slope subplots and the water

settles in the lower area, i.e., the valley subplots, which resulted in a higher (95.37%) water content in the valley subplots

175 than in the ridge, and slope subplots. Jaffar et al. (2018) state that S. macrophylla plant roots can adapt to high water soil

176 <u>content</u>. Moist soils <u>stimulate</u> S. macrophylla roots growth and development. According to Minasny and McBratney

177 (2018), the availability of groundwater is an important component of water balance and the terrestrial biosphere cycle

178 because it can affect evapotranspiration rates and support plant growth.

179 The results of the soil texture analysis can be seen in Table 3.

- 180
- 181 **Table 3.** Soil texture <u>at the study site</u>

Location of soil	Depth (cm)	Clay (%)	Sand (%)	<mark>_Silt (%)</mark>	texture (USDA)
Valley	0-20	33.70	50.90	15.40	SCL
	20-40	36.50	49.50	14.00	SC
	40-60	34.00	56.80	9.20	SCL
Slope	0-20	24.70	67.20	8.10	SCL
	20-40	27.30	63.10	9.60	SCL
	40-60	33.10	60.50	6.40	SCL
Ridge	0-20	37.80	54.60	7.60	SC
-	20-40	37.40	46.40	16.20	SC
	40-60	40.70	48.00	11.30	SC

182 Remark: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University183

184 The soil texture at the study site generally had a sand fraction of 45-65%, a clay fraction 35-55%, and a silt fraction of

185 20% (Table 3). This means that the soil texture is sandy clay. According to Osman (2013), soil texture refers to the level of fineness or roughness created by the variously-sized soil particles.

180 Theness or roughness created by the variousity-sized soil particles

Soil types are generally dominated by Ultisol (advanced development) soils, namely Typic Hapludults (Red-Yellow
 Podsolik) and Typic Paleudults (Yellow Podsolic). These soil types are typically found in lowland dipterocarp forests
 (Ohta and Effendi 1992).

190 Chemical soil characteristics of the study <u>site</u> are presented in Table 4.

191 **Table 4.** Chemical characteristics of soil <u>at the study site</u>

Location of Depth soil (cm)		рН (1:	pH (1: 25) Cation exchange (meg 100gr <sup>-1</sup> )		ge rates	rates Organic content			Ratio Mineral		
5011	(em)	H <sub>2</sub> O	KCl	CEC	Al3 <sup>+</sup>	<b>H</b> <sup>+</sup>	<u>Tot.</u> N.	Org C	C/N	$P_2O_5$	K <sub>2</sub> O
Valley	0-20	4.6	3.3	7.26	4.92	1.50	0.19	3.65	19	0.89	116.85
2	20-40	4.6	3.4	7.25	5.56	1.08	0.12	2.65	22	0.73	73.30
	40-60	4.4	3.4	7.18	5.75	0.92	0.10	2.12	22	1.22	59.00
Slope	0-20	4.1	3.5	5.35	2.75	1.33	0.13	2.31	18	0.65	73.62
	20-40	4.7	3.5	5.30	3.50	0.92	0.07	1.54	22	0.65	58.68
	40-60	4.8	3.5	5.53	3.33	1.42	0.05	1.40	26	0.41	60.90
Ridge	0-20	4.4	3.0	10.81	7.25	2.75	0.09	3.46	39	2.35	120.34
D	20-40	3.6	3.3	10.48	7.80	1.83	0.08	2.12	28	0.89	194.09
	40-60	44	34	10.37	6.83	2 58	0.09	1 54	17	0.65	232 55

Remark: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University

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The soil <u>at</u> the study <u>site</u> <u>was</u> very acidic (pH = 4.1-4.8) (Table 4). According to Schroeder and Pumphrey (2013), acidic soils inhibit root and plant growth and increase Al levels in the soil. The CEC <u>at</u> the study <u>site</u> <u>ranged</u> from 5.3 to 10 meq/100 g<sup>-1</sup>, indicating that the CEC <u>was</u> low. In general, the value of CEC is low in surface and subsurface soils of

197 lowland dipterocarp forests (Perumal et al. 2017a).

Aluminum levels <u>at</u> the study <u>site</u> were high, especially in the <u>slope</u> and valley subplots, which <u>indicated</u> high soil toxicity. Al content in the soil <u>decreased</u> with <u>the increasing</u> organic matter because organic matter forms a strong bond with Al. According to Zaidey et al. (2010), Al is a major cause of soil acidity, and soils in lowland dipterocarp forests have high Al content.

Nitrogen levels <u>at the study site</u> ranged from 0.05% to 0.19% (low to very low). Sadeghi et al. (2016) also reported low total N levels in tropical rain forest soils. Nitrogen is important for plant growth (Omara et al. 2019), and N deficiency can inhibit plant growth (Mehata et al. 2019). According to Omara et al. (2019), the main sources of N are organic matter and rainfall/precipitation.

Organic C values were higher in the valley and <u>slope</u> subplots <u>than</u> in the <u>ridge</u> subplots. The steeper slopes in the ridge subplots are more prone to erosion, resulting in <u>the leaching of organic C</u> and other nutrients into the valley and <u>slope</u> subplots. According to Schlesinger and Bernhard (2013), carbon can be stored in the soil three times longer than in the atmosphere and is an indicator of soil microorganism abundance and diversity (Zhu and Zhu 2015). The presence of

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organic C in the soil spurs microorganism activity and thereby increases the rates of soil decomposition, P dissolution, N 210 211 fixation, and other microorganism-dependent reactions.

212 Phosphate was calculated from  $P_2O_5$ , where the Phosphate \_content\_is very low (0.41-1.22 mg 100 gram<sup>-1</sup>) (Table 4). According to Turner and Engelbrecht (2011), organic P plays an important role in maintaining P availability in lowland 213 tropical rain forests. Phosphorus is essential for root development and plant growth (Abdissa et al. 2011). According to 214

215 Carstensen, et al. (2018), P deficiency has a major impact on plant growth, development and productivity.

216 Potassium values ranged from high (58.68-116.85 mg 100 gr<sup>-1</sup>) in the valley and slope subplots to very high (120.34-217 232.55 mg 100 gr<sup>-1</sup>) in the ridge subplots. According to Mouhamad et al. (2016), K is more abundant in the soil than other 218 mineral elements. This element has an essential role in plant metabolism, growth, and yield. Potassium availability 219 depends on soil properties (humidity, aeration, and temperature), soil treatment systems, and the dynamics of K. Therefore, 220 the K exchange level varies <u>among</u> soils.

#### 221 Topography in the study area

222 According to Li and McCarty (2019), topographic features are key parameters that affect the nature of the soil at the 223 earth's surface. Topographic features can affect organic matter; clay content; P, K, and Mg concentrations; and soil pH 224 (Kumhalova et al. 2011).

225 The topography of the study site is moderately undulating with a slope of 0-25%. The subplot slopes range from flat to 226 moderately steep. S. macrophylla was found primarily in flat to sloping areas with high environmental humidity, low 227 ambient temperature, and abundant water, such as riverbanks. Jaffar et al. (2018) stated that the roots of the S. macrophylla 228 are able to survive and grow in anaerobic waterlogged soils and is considered a flood-tolerant tree. 229

#### Dominant trees at the study area

At the study site, S. macrophylla was the dominant tree species (Figure 6). Other tree species included Madhuca spectabilis, Myristica villosa Warb., Scorodocarpus borneensis, Eugenia spp., Palaquium spp., Macaranga triloba, Syzygium inophyllum, and Shorea sp. S. macrophylla dominated the study site due to its fast germination process and high germination rate (Appanah and Turnbull 1998), its high growth rate (fastest of the genus Shorea), and its status as a climax species along rivers (Perumal et al. 2017).

Table 5. The importance value index of the dominant tree species at the study site,

Figure 6. A. Tree of S. macrophylla and B. Leaves of S. macrophylla

Number	Local name	Scientific	Family	Relatif	Relatif	Relatif	<b>Importa</b>	nce
		Name		density	dominance	frequency	value	index
				(%)	(%)	(%)	(%)	
1.	Tengkawang	S. macropyilla	Dipterocarpaceae	7.69	15.35	5.0	28.04	
2.	Kajen ase	M. spectabilis	Sapotaceae	10.25	7.29	4.61	22.16	
3.	Darah-darah	M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25	
4.	Bala seveny	S. borneensis	Olacaceae	5.12	5.77	5.0	15.90	
5.	Ubah	<i>Eugenia</i> spp	Myrtaceae	5.59	3.64	4.61	13.85	
6.	Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74	
7.	Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44	
8.	Ehang	S. inophyllum	Myrtaceae	5.36	3.14	3.84	12.35	
9.	Kaze tenak	<i>Shorea</i> sp	Dipterocarpaceae	2.33	6.08	2.69	11.10	

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#### 243 Microclimate,

Three microclimate factors were collected, i.e., temperature, humidity, and light intensity (see Table 6 for a more complete description).

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### 246 **Table 6.** Microclimate at the study site

Location	Microclimate	Unit	Time	<u> ∎1-st</u>	<u>,2-nd</u>		Average	Remark
				<u>record</u>	<u>record</u>	<u>record</u>		
1.	Light, intensity	Lm	Morning	350	400	452	400.67	Taken at 8.59 sunny
2.	Temperature	°c	Morning	24	24.5	25	24.5	conditions
3.	Relative humidity	%	Morning	81	79	80	80	
1.	Lights intensity	Lm	Mid day	750	450	207	469	Taken at 12:02
2.	Temperature	°c	Mid day	26.5	26	24.5	25.67	sunny conditions
3.	Relative humidity	%	Mid day	76	79	81	78.67	
1.	Lights intensity	Lm	Afternoon	369	237	145	250.33	Taken at 16:30
2.	Temperature	°c	Afternoon	25	24.5	23	24.17	sunny conditions
3.	Relative humidity	%	Afternoon	84	85	87	85.33	-

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The temperature <u>values</u> at the study <u>site</u>, was  $24-26.5^{\circ}$  C (Table 6). According to Ruchaemi (2013), the optimal temperature for plant assimilation is 25-30° C. <u>Relative humidity</u> values were high to very high, ranging from 76 to 87%. Lights intensity was very low to low, <u>ranging</u> from 7.25% (145, Lm) to 23.46% (469 Lm), due to dense canopy dominated by *S. macrophylla*, which prevented light from reaching the forest floor. This low light intensity is consistent with the findings of Panjaitan et al. (2012), who found that the closed canopy only allowed a little sunlight to reach the forest floor. These conditions benefit *S. macrophylla* seedlings, which are sun intolerant.

#### 255 Association with other trees

According to Saiz and Alados (2012), plant species association, is a fundamental aspect of the ecology of plant communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic interactions, and seed dispersal patterns. The results of the species association analysis and the association coefficient are presented in Table 7.

261 Table 7. Association of *S. macropylla* with other species.

Species association	X <sup>2</sup> count	Association species	C (+/-)
S. macropylla with M. spectabilis	0.35	-	0.04
S. macropylla with M. villosa Warb	6.82	-	0.29
S. macropylla with S. borneensis	0.04	+	0.04
S. macropylla with Eugenia spp	0.37	+	0.11
S. macropylla with Palaquium spp	0.37	+	0.11
S. macropylla with M. triloba	1.21	+	0.16
S. macropylla with S. inophyllum	3.23	-	0.29
S. macropylla with Shorea sp	1.92	-	0.24
Remark: X <sup>2</sup> tabulated value at 5% level: 3.841.	X <sup>2</sup> tabulated value at 1%	level: 6.35	

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Table 7 shows the results of a series of 2x2 contingency tests between *S. macropylla* and <u>each of the</u> eight other dominant tree species. The calculated  $X_x^2$  values <u>were</u> greatest between *S. macropylla* and *M. villosa* Warb, indicating that *S. macrophylla* had a strong but negative association with *M. villosa* Warb. According to Sofiah et al. (2013), species pairs do not always indicate positive relationships. Tree species with high populations are not always associated with another species. Likewise, low-population species are not necessarily negatively correlated with another species.

species. Likewise, low-population species are not necessarily negatively correlated with another species.

The association coefficient (C) was used as a parameter of the magnitude of the relationship between the eight species and *S. macropylla* and indicates positive or negative associations. Species that showed positive coefficients of association with *S. macropylla* were *S. borneensis, Eugenia spp., Palaquium spp,* and *M. triloba.* According to Windusaril et al. (2011), positive associations indicate both species have the same requirement of environmental conditions; for example, wet conditions, high light intensity, or shade. *S. macropylla* showed a negative association with *M. spectabilis, M. villosa Warb, S. inophyllum,* and *Shorea* sp. Negative associations indicate intolerance for cohabitation or the absence of a

275 mutually beneficial relationship (Pratama et al. 2012).

## 276 Direction of S. macrophylla plantation,

At present, tropical forests are being degraded by anthropogenic activities such as timber extraction, agricultural cultivation, and the establishment of commercial plantations. This results in the conversion of forests into agriculture land and the fragmentation and degradation of tropical rain forests. Deforestation damages the environment by increasing light intensity and causing severe mineral soil erosion. In general, degraded forests can be divided into three categories: grasslands after burning, early-succession secondary forests, and commercially logged forests (Daisuke et al. 2013).

Planting native trees is considered to be an effective rehabilitation method for degraded tropical rain forests because native trees provide benefits such as <u>timber</u>, food, and medical products (Daisuke et al. 2013). According to Pratiwi et al. (2014), tropical forest rehabilitation is necessary to both meet the demand for <u>timber</u> and <u>improve</u> environmental

conditions. One key to rehabilitation success is the understanding of the suitability of each growing site for each species

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288 (Pratiwi et al. 2014). 289 S. macrophylla is a recommended species for replanting degraded tropical forest land, i.e., pastures after burning 290 (Daisuke et al. 2013), early-succession secondary forests (Daisuke et al. 2013; Perumal et al. 2012), and commercially 291 logged forests. In commercially logged forests, S. macrophylla can be planted using the line planting system or gap 292 planting system. In early-succession secondary forests and pasture after burning. S. macrophylla requires pioneer plants to 293 assist growth. S. macrophylla is a valuable tree species that has socio-economic and ecological benefits and is beneficial 294 for reforestation and rehabilitation activities (Perumal et al. 2012; Perumal et al. 2015; Perumal et al. 2017a; Perumal et al. 295 2017b; Perumal et al. 2019). 296 This species is important for land rehabilitation activities because it plays a role in maintaining water quality, filtering 297 out pollutants and deposits, and storing carbon (Utomo et al. 2018; You et al. 2015). Things that must be considered when 298 planting S. macrophylla are the nutrient content in clay and the clay mineral composition. These two factors can be used to 299 evaluate soil fertility. The growth of S. macrophylla is also significantly limited by the high light intensity in grasslands 300 (Imperata cylindrica/ pastures after burning). S. macropylla, grows well in habitats with low light intensity. In secondary 301 forests and logged-over forests, the survival and growth of S. macrophylla is limited by soil compaction. This agrees with 302 the results of this study, where fine sandy clay soils were found. 303 S. macrophylla grows on riversides with flat and gentle topography, acidic soil, and lower fertility, but with the suitable 304 microclimate (temperature of 24-26,5°C, high humidity 76-87%, and a low light intensity 7,25-23.46%). This species can 305 be recommended to be planted in degraded tropical forest areas if microclimatic factors and soil conditions are taken into 306 account. 307 308 **ACKNOWLEDGMENTS** We thank the Center for Research and Development of Dipterocarp Forest Ecosystems (B2P2EHD) for giving the research team the opportunity to conduct research, as well as the Head of Setulang village. Malinau district for his cooperation and assistance in the field. Our gratitude also goes to Umbar Sujoko and Aji for his help in creating the map of the study site. In addition, the authors thanks to Riskan Effendy and C. Albert for editing and proofreading for the English manuscript. We would like to express gratitude to acknowledge anonymous reviewers for their constructive feedback to improve the manuscript. REFERENCES 317 318 319 320 321 322 323 324 325 326 327 328 329 330 3312 332 333 334 335 336 337 338 339 340 341 342 343 344 Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (Allium cepa L) as influenced by nitrogen and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. Aftr J Agric Res 6 (14): 3252-3258. Appanah S, Turnbull JM. 1998. A review of dipterocarps : taxonomy. ecology and silviculture. Center for International Forestry Research. Carstensen A, Herdean A, Schmidt SB, Sharma A, Spetea C, Pribil M, and Husted S. 2018. The impacts of phosphorus deficiency on the photosynthetic electron transport chain. Plant Physiology 177: 271-284. https://doi.org/10.1104/pp.17.01624 Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Ultural Chilean J Agric Res 76 (1):105-113. doi:10.4067/S0718-58392016000100015. Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using dipterocarp trees in Sarawak. Malaysia. Hindawi Publishing Corporation Int J For Res 2013:1-12. Article ID 683017. 11 pages http://dx.doi.org/10.1155/2013/683017. Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int. J Sci. Technol.. 7 (2): 93-102. doi: 10.13170/aijst.7.2. 10119. Eviati and Sulaeman. 2009. Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk. Edisi 2. ISBN 978-602-8039-21-5. Balai Penelitian Tanah, Bogor. [Indonesian] Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46. Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (S. machrophylla) dan regenerasi alaminya dikebun masyarakat. J. Penelitian Ekosistem Dipterokarpav1 (2): 81-88. https://doi.org/10.20886/jped.2015.1.2.81-88. [Indonesian] Hutauruk TR, Lahije AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the conservation of non-timber forest products in Malinau District. IOP Conference. Series: Earth Environment Science. 144: 1-9. https://doi.org/10.1088/1755-1315/144/1/012055. Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b.The prospect of the utilization of Non-Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in Malinau. North Kalimantan. Indonesia. Biodiversitas 19 (2): 421-430. [Indonesian] Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (Shorea Spp.) di areal IUPHHK-Ha PT. Intracawood Manufacturing Tarakan. Kalimantan Timur (Study of the potential and distribution of tengkawang (Shorea spp.) in the IUPHHK-Ha area of PT. Intracawood Manufacturing Tarakan. East Kalimantan). J Silvikultur Tropika. 01 (01): 11-17. ISSN: 2086-8227. [Indonesian] Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on survival and growth performance of planted Shorea macrophylla (de vriese) in riparian forest Along Kayan Ulu River. Sarawak. Malaysia. Hindawi Int J For Res 2018 (2):1-11. Article ID 6329295. 11 pages https://doi.org/10.1155/2018/6329295. Deleted[Yosep Ruslim]: , Volume

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being <u>planted</u>. One approach to determine the suitability of growing sites for each species is to identify each species'

potential, identify locally superior species, and correlate this with species distribution data and growth requirements

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Deleted[Yosep Ruslim]: of Deleted[Yosep Ruslim]: . Volume Deleted[Yosep Ruslim]: ion Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania. Int, J, Biodiversity, 2014: 1-8. Article ID 516840. 8 pages. http://dx.doi.org/10.1155/2014/516840. Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv. 19: 1137-1151. Deleted[Yosep Ruslim]: ulture. Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the effects of weather conditions. J Precis Agric 12 (6): 813-830. https://doi.org/10.1007/s11119-011-9221-x. Kurnia, U, Agus f, Adimihardja A, Dariah A. 2006. Sifat fisik tanah dan metode analisisnya. Balai Besar Litbang Sumberdaya Lahan Pertanian. Agro Deleted[Yosep Ruslim]: Volume inovasi. Bogor. [Indonesian] Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties: geospatial analyses of earth observation Deleted[Yosep Ruslim]: Volume (eo) data. Web of Science. http://doi: 10.5772/intechopen.86109. Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality from Sahan and Nanga Yen Villages. West Kalimantan. Indonesia. Conference Proceedings. Towards The Sustainable Use of biodiversity in a changing environment: From Deleted[Yosep Ruslim]: DOI: 10.13057/biodiv/d190414. Basic To Applied Research. Aip Publishing. Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. 19 (4): 1280-1288. [Indonesian] Deleted[Yosep Ruslim]: ernational Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Hindawi Int J Agron, 2019:1-15. Article ID 8572985. 15 pages Deleted[Yosep Ruslim]: of https://doi.org/10.1155/2019/8572985. Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas, 21 (1): 49-56. [Indonesian] Deleted[Yosep Ruslim]: omy. Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. Eur J Soil Sci 2017:1-9. https://doi: 10.1111/ejss.12475. Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chem Int 2 (1): 58-69. Deleted[Yosep Ruslim]: Volume Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada. Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef manure and inorganic fertilizer Deleted[Yosep Ruslim]: . application\_Hindawi Int J\_Agron\_2019:1-6. Article ID 9594369. 6 pages. https://doi.org/10.1155/2019/9594369. Ohta S, Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr. 38 (2): 197-206. Osman KT. 2013. Forest soil: properties and management. Springer. London. Deleted[Yosep Ruslim]: Volume Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh Shorea johorensis Foxw. di HPH Aya Yayang Indonesia. Kalimantan Selatan (Environmental conditions in which to grow Shorea johorensis Foxw. at Aya Yayang HPH in Indonesia. South Kalimantan). J Penelitian Dipterokarpa. 6 (1): 11-22. [Indonesian] Deleted[Yosep Ruslim]: opean Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen. Kalimantan Tengah (Association and characterization of stands in peat swamp forests in Hampagen. Central Kalimantan). J Teknologi Lingkungan. Edisi Khusus Hari Deleted[Yosep Ruslim]: ence. lingkungan Hidup : 69-76. [Indonesian] Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk rehabilitasi hutan dan lahan di Indonesia (Atlas of local reliable tree species for forest and land rehabilitation in Indonesia). Forda Press. [Indonesia] Deleted[Yosep Ruslim]: istry Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality attributes of Shorea macrophylla seedlings in a tropical nursery. Biodiversitas 20 (8): 2110-2118. [Indonesian] Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of Shorea macrophylla (de Vriese) after enrichment planting for Deleted[Yosep Ruslim]: ernational. reforestation purpose at Sarawak. Malaysia. Online J Biol Sci 17 (1): 7-17. Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of planted Shorea macrophylla (de Deleted[Yosep Ruslim]: / Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve. Sarawak. Malaysia. Hindawi Int, J For, Res, Volume, 2017. Article ID 6721354. 16 pages. https://doi.org/10.1155/2017/6721354. Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted Shorea macrophylla under line planting technique. In: 4th Regional Deleted[Yosep Ruslim]: ernational Conference on Natural Resources in the Tropics. 2012 (NTrop4) : Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices. Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Deleted[Yosep Ruslim]: ournal of Faso (West Africa). Intl J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321. Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juling S, Bodos V, Maryani A. 2019. Shorea macrophylla. The Deleted[Yosep Ruslim]: omy. Volume IUCN red list of threatened species 2019: e.T33620A125629642. http://dx.doi.org/10.2305/IUCN.UK.20193.RLTS.T33620A125629642.en. Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (Shorea spp) di hutan tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (Distribution of tengkawang species (Shorea spp) in the Tembawang forest Labian Village Batang Lupar District Kapuas Deleted[Yosep Ruslim]: D Hulu West Kalimantan). J Hutan Lestari 7 (1): 390-406. [Indonesian] Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228. [Indonesian] Formatted[Yosep Ruslim]: Font: Not Italic Ruchaemi A. 2013. Ilmu pertumbuhan hutan (Forest growth Science). Samarinda: Mulawarman University Press. [Indonesian] Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest after logging in Kedah. Malaysia. Formatted[Yosep Ruslim]: Font: Not Italic Malayan Nature J 68 (1 & 2): 187-201. Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7 (7): 1-9. E40551. http://doi:10.1371/Journal.Pone.0040551. Deleted[Yosep Ruslim]: A Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern Washington. Northern Idaho. Washington Grain Commission reports. http://washingtoncrop.com (accessed 16 Jan. 2016). p. 56-59. Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego. CA. Formatted[Yosep Ruslim]: Font: Not Italic Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur (Distribution patterns, abundance, and bamboo associations in plant communities in the Gunug Baung Nature Park in East Deleted[Yosep Ruslim]: Volume Java). Berita Biologi. J Ilmu-Ilmu Hayati, 12 (2): 239-247. Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry. 2011:103:297-315 DOI 10.1007/s10533-010-9466-x. Deleted[Yosep Ruslim]: . Volume Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene climate change on genetic structure and diversity of Shorea macrophylla in Kalimantan rainforest. Tree Gen Genomes. Volume 14 (4): 14-44. Widiyatno, Budiadi, Suryanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil nutrients and late-succession Deleted[Yosep Ruslim]: . ISSN: 1412-033X. E-ISSN: 208 ... species afters hifting cultivation In Central Kalimantan. Indonesia. J Trop For Sci 29 (2): 151-162. Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di Formatted[Yosep Ruslim]: Font: Italic pertambangan PTFI Papua (Species associations in the succession vegetation community in the deposition area of the double embankment in Papua's PTFI mine). J Ilmiah Ilmu-Ilmu Hayati Biota, 16 (2): 242-251. [Indonesian]

Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN. 2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Int J Soil Sci 5 (3):112-130.

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- Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and irrigation methods. Geoderma 193/194:290-299. doi:10.1016/j. geoderma.2012.10.013.
  Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple soil. China. Soil and Tillage Research 146: 39-46.

Deleted[Windows User]: Zhang J, Jiang Q, Zhang Y, Dai L, Wu H. 2015. nondestructive measurement of water content and moisture migration of unsaturated red clays in South China. Hindawi Publishing Corporation Advances in Materials Science and Engineering, Volume 2015, Article ID 542538, 7 pages http://dx.doi.org/10.1155/2015/542538.

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**BIODIVERSITAS** Volume 21, Number 8, August 2020 Pages: xxxx

# The characteristics of Shorea macrophylla's habitat in Tane' Olen, Malinau District, North Kalimantan Province, Indonesia

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Abstract. Fajri M, Pratiwi, Ruslim Y. 2020. The characteristics of Shorea macrophylla's habitat in Tane' Olen, Malinau District, North Kalimantan Province, Indonesia. Biodiversitas 21: xxxx. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the soil's physical and chemical properties, topography, and microclimate of S. macrophylla's habitat. A purposive method was used to select a sampling plot and to place the subplots. Soil was analyzed to determine the physical properties, i.e., texture, bulk density, porosity, and water content, and the chemical properties, i.e., pH, CEC, total N, organic C, C/N ratio, P, K, and Al saturation. Importance value index was determined for each tree species to know the species composition in the study site. Only the dominant species were presented. The soil at the study site had bulk density of 0.60-1.31 gram cm<sup>3-1</sup>, porosity 50.60%-77.35%, water content 34.88%-95.37%, and soil texture sandy clay. The chemical properties of the soil were as follows: pH was 3.6-4.8, N 0.05%-0.19%, organic C 1.40%-3.65%, P 0.41-1.22 mg 100 gr<sup>-1</sup>, K 58.68-232.55 mg 100 gr<sup>-1</sup>, and Cation Exchange Capacity (CEC) 5.35-10.81 meg 100gr<sup>-1</sup>. Slope ranged between 0 and 25%. The microclimate characteristics were as follows: temperature was 24-26.5°C, relative humidity 76-87%, and light intensity 145-750 Lm. Trees species with an IVI  $\geq$  10% were S. macrophylla, Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Palaquium spp, Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between S. macropylla and S. borneensis, Eugenia spp, Palaquium spp and M. triloba, and negative associations were observed between S. macropylla and M. spectabilis, M. villosa Warb, S. inophyllum, and Shorea sp. S. macrophylla grows on riversides with flat and gentle topography, acidic soil, and lower fertility but with suitable microclimate. This species can be recommended to be planted in degraded tropical forest areas but the microclimate and soil properties should be taken into account.

Keywords: Habitat, land characteristics, S. macrophylla

### **INTRODUCTION**

Shorea macrophylla is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). Local communities value this species as a source of timber and fruit (Randi et al. 2019). S. macrophylla is known locally in West Kalimantan as the tengkawang tungkul tree and has been cultivated by the Dayak and Malay communities (Fajri and Fernandes 2015). S. macrophylla grows in clusters in tropical rain forests with type A climate, on latosol soils at altitudes up to 500 m, on acidic soils (pH 4.6-4.9), and a cation-exchange capacity (CEC) of 16.25-19.40 (Istomo and Hidayati 2010). In Sarawak, Sabah, Brunei and Kalimantan, this species is associated with sedimentary soils and is distributed evenly over riverbanks and areas with sloping or flat topography. It is rarely found on hills. (Randi et al. 2019; Utomo et al. 2018; Perumal et al. 2017).

The timber from S. macrophylla is commonly used for construction and to make veneer and plywood, musical instruments, furniture, and packing crates (Istomo and Hidayati 2010). The fruit, locally known as tengkawang tungkul (Illipe) nuts, is used as a raw material for soap and other cosmetics, a substitution for brown fat, and a source of vegetable fat (Maharani et al. 2016). The natural population of tengkawang is declining and is, at present, hard to find (Istomo and Hidayati 2010) because S. macrophylla is one of the most sought-after species in tropical forests. The exploitation of the species for its timber, combined with forest conversion to other uses, has resulted in S. macrophylla timber being difficult to find in the market (Rikando et al. 2019).

Tane' Olen is a forested area with a high environmental value preserved by the people of Setulang Village (Hutauruk et al. 2018a), a community that manages its forests based on the local wisdom and sustainable forest management practices (Fahrianoor et al. 2013; Kettle 2010), so the forest sustainability is maintained (Hutauruk et al. 2018). Forests are not only a place to live for them, but are also used as a source of food and medicine and economic, social, cultural, and spiritual functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014).

S. macrophylla's habitat characteristics in secondary forest locations have been documented by Jaffar et al. (2018) and Perumal et al. (2017). Perumal et al. (2017) studied the relationship between soil fertility and the growth of S. macrophylla in enrichment plantings at Sampadi Forest Reserve, Lundu, Sarawak and an adjacent secondary forest. Jaffar et al. (2018) researched the effects of soil compaction and light intensity on the establishment and growth of S. macrophylla in riparian forests in Sungai Kayan Ulu Sungai, Serawak, Malaysia. The improvement of the company's management system, which is changing the way of harvesting using long cables during skidding activity, reduced the natural forest damage and could increase financial returns from natural forest concessions (Ruslim et al. 2016). The characteristics of S. macrophylla habitat in primary forest locations had not previously been studied. So, this study aimed to describe the characteristics of S. macrophylla's habitat in primary forests by analyzing the physical and chemical properties of soil, the microclimate, topography, species associations, and vegetation. It is hoped that the results of this study will benefit conservation efforts of this species, especially on degraded land in the tropical rain forests of North Kalimantan.

#### MATERIALS AND METHODS

#### Study area

The study was carried out in Tane' Olen forest area, Setulang Village, Malinau District, North Kalimantan Utara Province (3°25'0.86" N and 116°25'52.59" E). The location map is presented in Figure 1.

#### **Research procedure**

A one-hectare research site was selected purposively and sampled using a square plot with a side length of 100 meters (Sari and Maharani 2016). Soil sampling was taken from purposively selected three sampling points, located on a ridge, a slope, and a valley (the ridge had the highest elevations and a 15-25% slope; the slope was located between the valley and ridge, and had an 8-15% slope; the valley was the lowest area and had a 0-8% slope) to ensure an accurate representation of the study site. At each sampling point, soil samples were taken at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Microclimate data (temperature, humidity, and light intensity) were collected at the same locations. The soil and microclimate data collection design is illustrated in Figure 2. Vegetation data were only collected for trees with a diameter at breast height (DBH) greater than 20.0 cm Each plot was divided into 25 subplots (20 m x 20 m). Within each subplot, the species were identified and DBH recorded for all trees (Widiyatno et al. 2017). Plot-making and field-data collection activities are presented in Figure 2, while sampling design is presented in Figures 3 and 4. Soil sample collection design and microclimate data are presented in Figure 3 and 4. Topography data collection design can be seen in Figure 4. The design of vegetation data collection can be seen in Figures 5.

#### **Data analyses**

#### Soil analyses

Soil samples were analyzed for both physical and chemical properties (Kurnia et al. 2006; Eviati and Sulaeman 2009). Physical properties analyzed were texture, bulk density, porosity, and water content (using the Pipette method). Chemical properties analyzed were pH (using the electrode method), CEC (using the ammonium acetate pH 7 method), elements Al+++ and H+ (using the KCl method 1 N), total N elements (using the Kjeldahl method), organic C elements (using Walkley-Black method), C/N ratio (using arithmetic methods), elements P<sub>2</sub>O5 and K<sub>2</sub>O (using Bray No I methods), and saturation Al (using arithmetic methods). Soil data analysis results from the soil laboratory were tabulated and analyzed descriptively and quantitatively.



Figure 1. Location of the research in Tane' Olen  $(\bullet)$ 



Figure 2. A. Exploration, B. Research plot making, C. Tree inventory, D. Soil sample collection, E and F. Microclimate data collection



Figure 3. Soil and microclimate sample design. Note: A:lights intensity, B: temperature and area humidity, C: soil sampling, m:meter



Figure 4. Plot design across contour line.

		→ [	100 m	]≁	•		
1	L1	L2	L3	 L4	L5		
1	SP5	SP6	SP15	SP16	SP25		
	SP4	SP7	SP14	SP17	SP24		
n	SP3	SP8	SP13	SP18	SP23		
	SP2	SP9	SP12	SP19	SP22		
100	SP1	SP10	SP11	SP20	SP21		
	20m	20m	20m	20m	20m		

**Figure 5.** Design of plot and sub-plots for vegetation sampling. Note: L: lane, SP: sub plot, 20m: distance between sub plots, 100m x 100m: plot size, m: meter.

#### Analysis of topography

The topographic analysis was done qualitatively to describe the topography suitable for *S. macrophylla*.

#### Analysis of microclimate

The analysis of microclimate was done qualitatively to provide information on microclimates characteristics suitable for *S. macrophylla*.

#### *Importance Value Index*

According to Kacholi (2014), the Importance Value Index (IVI) is used in ecological studies to determine the ecological importance of a species in a particular ecosystem. IVI is also used to prioritize species conservation. Species with low IVI values require a higher conservation priority than those with high IVI, which is the dominant species. IVI value is a function of several characteristics, and calculated with this formula: IVI = relative density + relative frequency + relative dominance. IVI values were analyzed descriptively

#### Association of vegetation

Associations between two tree species were analyzed using a series of 2x2 contingency tables (Mueller-Dombois and Ellenberg 1974). A more complete description is presented in Table 1.

Then, the data were tested with chi-square  $(x^2)$ 

$$X^{2} = \frac{(ad - bc)^{2} x N}{(a + b)(c + d)(a + c)(b + d)}$$

The association coefficient (C) values were determined as follows:

follows: If  $ad \ge bc$ , so  $C = \frac{ad-bc}{(a+b)(b+d)}$ If bc > ad and d > a, so  $C = \frac{ad-bc}{(a+b)(b+c)}$ If bc > ad and a > c, so  $C = \frac{ad-bc}{(a+b)(c+d)}$ 

Positive or negative values of C indicate a positive or negative relationship between the two species. A positive relationship indicates that the association between trees is mutually beneficial to each other, while a negative value indicates that the association between trees harms one another.

 Table 1. Contingency table form (Mueller-Dombois and Ellenberg 1974)

Species A Species B	+	-	
+	А	В	a + b
-	c	D	c + d
	a + c	b + d	N = a + b + c + d
NT /			

Note:

a = number of plots containing species A and species B.

b = number of plots containing only species A, but no species B. c = number of plots containing only species B, but no species A. d = number of plots containing neither species A nor species B.

N = number of all plots.

#### **RESULTS AND DISCUSSION**

#### The soil's physical and chemical properties

The physical and chemical properties of soil properties in S. *macrophylla*'s habitat can be seen in Table 2.

At the depth of 0-20 cm, the valley, slope, and ridge subplots had a low bulk density (0.60-1.05) (Table 2). According to Casanova et al. (2016) and Zeng et al. (2013), soil bulk density is influenced by external conditions and natural processes such as plant root growth and rainfall.

The soil porosity values in the valley, slope, and ridge subplots decreased with the increasing soil depth. The valley subplot had higher porosity value than the slope and ridge subplots. According to Darusman et al. (2019), the properties that affect soil porosity the most are bulk density and soil particle density; if the bulk density is low then the soil porosity will increase.

Water content in the ridge, slope, and valley decreased with the increasing soil depth. The water content in the ridge subplots was higher than the slope subplots because the water movement is faster in the slope subplots and the water settles in the lower area, i.e., the valley subplots, which resulted in a higher (95.37%) water content in the valley subplots than in the ridge and slope subplots. Jaffar et al. (2018) state that *S. macrophylla* plant roots can adapt to high water soil content. Moist soils stimulate *S. macrophylla* roots growth and development. According to Minasny and McBratney (2018), the availability of groundwater is an important component of water balance and the terrestrial biosphere cycle because it can affect evapotranspiration rates and support plant growth.

The results of the soil texture analysis can be seen in Table 3.

The soil texture at the study site generally had a sand fraction of 45-65%, a clay fraction 35-55%, and a silt fraction 0-20% (Table 3). This means that the soil texture is sandy clay. According to Osman (2013), soil texture refers to the level of fineness or roughness created by the variously-sized soil particles.

Soil types are generally dominated by Ultisol (advanced development) soils, namely Typic Hapludults (Red-Yellow Podsolik) and Typic Paleudults (Yellow Podsolic). These soil types are typically found in lowland dipterocarp forests (Ohta and Effendi 1992).

Chemical soil characteristics of the study site are presented in Table 4.

The soil at the study site was very acidic (pH = 4.1-4.8) (Table 4). According to Schroeder and Pumphrey (2013), acidic soils inhibit root and plant growth and increase Al levels in the soil. The CEC at the study site ranged from 5.3 to 10 meq/100 g<sup>-1</sup>, indicating that the CEC was low. In general, the value of CEC is low in surface and subsurface soils of lowland dipterocarp forests (Perumal et al. 2017a).

Aluminum levels at the study site were high, especially in the slope and valley subplots, which indicated high soil toxicity. Al content in the soil decreased with the increasing organic matter because organic matter forms a strong bond with Al. According to Zaidey et al. (2010), Al is a major cause of soil acidity, and soils in lowland dipterocarp forests have high Al content.

Nitrogen levels at the study site ranged from 0.05% to 0.19% (low to very low). Sadeghi et al. (2016) also reported low total N levels in tropical rain forest soils. Nitrogen is important for plant growth (Omara et al. 2019), and N deficiency can inhibit plant growth (Mehata et al. 2019). According to Omara et al. (2019), the main sources of N are organic matter and rainfall/precipitation.

Organic C values were higher in the valley and slope subplots than in the ridge subplots. The steeper slopes in the ridge subplots are more prone to erosion, resulting in the leaching of organic C and other nutrients into the valley and slope subplots. According to Schlesinger and Bernhard (2013), carbon can be stored in the soil three times longer than in the atmosphere and is an indicator of soil microorganism abundance and diversity (Zhu and Zhu 2015). The presence of organic C in the soil spurs microorganism activity and thereby increases the rates of soil decomposition, P dissolution, N fixation, and other microorganism-dependent reactions.

Phosphate was calculated from  $P_2O_5$ , where the Phosphate content is very low (0.41-1.22 mg 100 gram<sup>-1</sup>) (Table 4). According to Turner and Engelbrecht (2011), organic P plays an important role in maintaining P availability in lowland tropical rain forests. Phosphorus is essential for root development and plant growth (Abdissa et al. 2011). According to Carstensen, et al. (2018), P deficiency has a major impact on plant growth, development and productivity.

Potassium values ranged from high (58.68-116.85 mg 100 gr<sup>-1</sup>) in the valley and slope subplots to very high (120.34-232.55 mg 100 gr<sup>-1</sup>) in the ridge subplots. According to Mouhamad et al. (2016), K is more abundant in the soil than other mineral elements. This element has an essential role in plant metabolism, growth, and yield. Potassium availability depends on soil properties (humidity, aeration, and temperature), soil treatment systems, and the dynamics of K. Therefore, the K exchange level varies among soils.

#### Topography in the study area

According to Li and McCarty (2019), topographic features are key parameters that affect the nature of the soil at the earth's surface. Topographic features can affect organic matter; clay content; P, K, and Mg concentrations; and soil pH (Kumhalova et al. 2011).

The topography of the study site is moderately undulating with a slope of 0-25%. The subplot slopes range from flat to moderately steep. *S. macrophylla* was found primarily in flat to sloping areas with high environmental humidity, low ambient temperature, and abundant water, such as riverbanks. Jaffar et al. (2018) stated that the roots of the *S. macrophylla* are able to survive and grow in anaerobic waterlogged soils and is considered a floodtolerant tree.

**Table 4.** Chemical characteristics of soil at the study site.

#### Dominant trees at the study area

At the study site, *S. macrophylla* was the dominant tree species (Figure 6). Other tree species included *Madhuca* spectabilis, Myristica villosa Warb., Scorodocarpus borneensis, Eugenia spp., Palaquium spp., Macaranga triloba, Syzygium inophyllum, and Shorea sp. S. macrophylla dominated the study site due to its fast germination process and high germination rate (Appanah and Turnbull 1998), its high growth rate (fastest of the genus Shorea), and its status as a climax species along rivers (Perumal et al. 2017).

Table 2. Physical properties of soil at the study site.

Location of soil	Depth (cm)	Bulk density (gram/cm³)*	Porosity (%)*	Water content (%)	-
Valley	0-20	0.60	77.35	95.37	
	20-40	1.13	57.32	40.04	
	40-60	1.18	55.54	39.20	
Slope	0-20	1.05	60.42	48.08	
	20-40	1.31	50.60	41.42	
	40-60	1.23	53.72	34.88	
Ridge	0-20	0.83	68.75	61.68	
	20-40	1.01	61.92	44.23	
	40-60	1.20	54.66	35.53	

Note: \*Average score from three repetitions

#### Table 3. Soil texture at the study site.

Location of soil	Depth (cm)	Clay (%)	Sand (%)	Silt (%)	texture (USDA)
Valley	0-20	33.70	50.90	15.40	SCL
	20-40	36.50	49.50	14.00	SC
	40-60	34.00	56.80	9.20	SCL
Slope	0-20	24.70	67.20	8.10	SCL
	20-40	27.30	63.10	9.60	SCL
	40-60	33.10	60.50	6.40	SCL
Ridge	0-20	37.80	54.60	7.60	SC
	20-40	37.40	46.40	16.20	SC
	40-60	40.70	48.00	11.30	SC

Note: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University

Location of soil	Depth (cm)	pH (1:	25)	Cation (meg 10	exchang )0gr <sup>-1</sup> )	e rates	Organic (%)	content	Ratio	Minera (Mg 10	l 0 gram <sup>-1</sup> )
		H <sub>2</sub> O	KCI	CEC	Al3 <sup>+</sup>	$\mathbf{H}^{+}$	Tot. N.	Org C	C/N	P2O5	K <sub>2</sub> O
Valley	0-20	4.6	3.3	7.26	4.92	1.50	0.19	3.65	19	0.89	116.85
	20-40	4.6	3.4	7.25	5.56	1.08	0.12	2.65	22	0.73	73.30
	40-60	4.4	3.4	7.18	5.75	0.92	0.10	2.12	22	1.22	59.00
Slope	0-20	4.1	3.5	5.35	2.75	1.33	0.13	2.31	18	0.65	73.62
	20-40	4.7	3.5	5.30	3.50	0.92	0.07	1.54	22	0.65	58.68
	40-60	4.8	3.5	5.53	3.33	1.42	0.05	1.40	26	0.41	60.90
Ridge	0-20	4.4	3.0	10.81	7.25	2.75	0.09	3.46	39	2.35	120.34
-	20-40	3.6	3.3	10.48	7.80	1.83	0.08	2.12	28	0.89	194.09

	40-60	4.4	3.4	10.37	6.83	2.58	0.09	1.54	17	0.65	232.55
Note: Laborato	ry of soil test in I	B2P2EHD	and Pusreh	ut, Mulaw	varman Uni	iversity					

#### Microclimate

Three microclimate factors were collected, i.e., temperature, humidity, and light intensity (see Table 6 for a more complete description). The temperature values at the study site was 24-26,5° C (Table 6). According to Ruchaemi (2013), the optimal temperature for plant assimilation is 25-30° C. Relative humidity values were high to very high, ranging from 76 to 87%. Lights intensity was very low to low, ranging from 7,25% (145 Lm) to 23.46% (469 Lm) due to dense canopy dominated by *S. macrophylla* which prevented light from reaching the forest floor. This low light intensity is consistent with the findings of Panjaitan et al. (2012), who found that the closed canopy only allowed a little sunlight to reach the forest floor. These conditions benefit *S. macrophylla* seedlings, which are sun intolerant.

#### Association with other trees

According to Saiz and Alados (2012), plant species association is a fundamental aspect of the ecology of plant communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic interactions, and seed dispersal patterns. The results of the species association analysis and the association coefficient are presented in Table 7. Table 7 shows the results of a series of 2x2 contingency tests between *S. macropylla* and each of the eight other dominant tree species. The calculated X<sup>2</sup> values were greatest between *S. macropylla* and *M. villosa* Warb, indicating that *S. macropylla* had a strong but negative association with *M. villosa* Warb. According to Sofiah et al. (2013), species pairs do not always indicate positive relationships. Tree species with high populations are not always associated with another species. Likewise, low-population species are not necessarily negatively correlated with another species.

The association coefficient (C) was used as a parameter of the magnitude of the relationship between the eight species and *S. macropylla* and indicates positive or negative associations. Species that showed positive coefficients of association with *S. macropylla* were *S. borneensis, Eugenia spp., Palaquium spp,* and *M. triloba.* According to Windusari1 et al. (2011), positive associations indicate both species have the same requirement of environmental conditions; for example, wet conditions, high light intensity, or shade. *S. macropylla* showed a negative association with *M. spectabilis, M. villosa, S. inophyllum,* and *Shorea* sp. Negative associations indicate intolerance for cohabitation or the absence of a mutually beneficial relationship (Pratama et al. 2012).

Table 5. The importance value index of the dominant tree species at the study site

Local name	Scientific Name	Family	Relatif density (%)	Relatif dominance (%)	Relatif frequency (%)	Importance value index (%)
Tengkawang	S. macropyilla	Dipterocarpaceae	7.69	15.35	5.0	28.04
Kajen ase	M. spectabilis	Sapotaceae	10.25	7.29	4.61	22.16
Darah-darah	M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25
Bala seveny	S. borneensis	Olacaceae	5.12	5.77	5.0	15.90
Ubah	<i>Eugenia</i> spp	Myrtaceae	5.59	3.64	4.61	13.85
Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74
Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44
Ehang	S. inophyllum	Myrtaceae	5.36	3.14	3.84	12.35
Kaze tenak	Shorea sp	Dipterocarpaceae	2.33	6.08	2.69	11.10



Location	Microclimate	Unit	Time	1-st record	2-nd record	3-rd record	Average	Remark
1.	Light intensity	Lm	Morning	350	400	452	400.67	Taken at 8.59 sunny
2.	Temperature	°c	Morning	24	24.5	25	24.5	conditions
3.	Relative humidity	%	Morning	81	79	80	80	
1.	Lights intensity	Lm	Mid day	750	450	207	469	Taken at 12:02 sunny
2.	Temperature	°c	Mid day	26.5	26	24.5	25.67	conditions
3.	Relative humidity	%	Mid day	76	79	81	78.67	
1.	Lights intensity	Lm	Afternoon	369	237	145	250.33	Taken at 16:30 sunny
2.	Temperature	°c	Afternoon	25	24.5	23	24.17	conditions
3.	Relative humidity	%	Afternoon	84	85	87	85.33	

**Figure 6**. A. Tree of *Shorea macrophylla* and B. Leaves of *S. macrophylla* **Table 6.** Microclimate at the study site

Table 7. Association of S. macropylla with other species.

Species association	X <sup>2</sup> count	Assoc. species	C (+/-)
S. macropylla with M. spectabilis	0.35	-	0.04
S. macropylla with M. villosa Warb	6.82	-	0.29
S. macropylla with S. borneensis	0.04	+	0.04
S. macropylla with Eugenia spp	0.37	+	0.11
S. macropylla with Palaquium spp	0.37	+	0.11
S. macropylla with M. triloba	1.21	+	0.16
S. macropylla with S. inophyllum	3.23	-	0.29
S. macropylla with Shorea sp	1.92	-	0.24

Note: X  $^{2}$  tabulated value at 5% level: 3.841. X<sup>2</sup> tabulated value at 1% level: 6.35

#### Direction of S. macrophylla plantation

At present, tropical forests are being degraded by anthropogenic activities such as timber extraction, agricultural cultivation, and the establishment of commercial plantations. This results in the conversion of forests into agriculture land and the fragmentation and degradation of tropical rain forests. Deforestation damages the environment by increasing light intensity and causing severe mineral soil erosion. In general, degraded forests can be divided into three categories: grasslands after burning, early-succession secondary forests, and commercially logged forests (Daisuke et al. 2013).

Planting native trees is considered to be an effective rehabilitation method for degraded tropical rain forests because native trees provide benefits such as timber, food, and medical products (Daisuke et al. 2013). According to Pratiwi et al. (2014), tropical forest rehabilitation is necessary to both meet the demand for timber and improve environmental conditions. One key to rehabilitation success is the understanding of the suitability of each growing site for each species being planted. One approach to determine the suitability of growing sites for each species is to identify each species' potential, identify locally superior species, and correlate this with species distribution data and growth requirements (Pratiwi et al. 2014).

Shorea macrophylla is a recommended species for replanting degraded tropical forest land, i.e., pastures after burning (Daisuke et al. 2013), early-succession secondary forests (Daisuke et al. 2013; Perumal et al. 2012), and commercially logged forests. In commercially logged forests, *S. macrophylla* can be planted using the line planting system or gap planting system. In early-succession secondary forests and pasture after burning, *S. macrophylla* is a valuable tree species that has socio-economic and ecological benefits and is beneficial for reforestation and rehabilitation activities (Perumal et al. 2012; Perumal et al. 2017a; Perumal et al. 2017b; Perumal et al. 2019).

This species is important for land rehabilitation activities because it plays a role in maintaining water quality, filtering out pollutants and deposits, and storing carbon (Utomo et al. 2018; You et al. 2015). Things that must be considered when planting *S. macrophylla* are the nutrient content in clay and the clay mineral composition. These two factors can be used to evaluate soil fertility. The growth of *S. macrophylla* is also significantly limited by the high light intensity in grasslands (*Imperata cylindrica/* pastures after burning). *S. macropylla* grows well in habitats with low light intensity. In secondary forests and logged-over forests, the survival and growth of *S. macrophylla* is limited by soil compaction. This agrees with the results of this study, where fine sandy clay soils were found.

*S. macrophylla* grows on riversides with flat and gentle topography, acidic soil, and lower fertility, but with the suitable microclimate (temperature of 24-26,5°C, high humidity 76-87%, and a low light intensity 7,25-23.46%). This species can be recommended to be planted in degraded tropical forest areas if microclimatic factors and soil conditions are taken into account.

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#### REFERENCES

- Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (*Allium cepa* L) as influenced by nitrogen and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. Afr J Agric Res 6 (14): 3252–3258.
- Appanah S, Turnbull JM. 1998. A review of dipterocarps: taxonomy. ecology and silviculture. Center for International Forestry Research.
- Carstensen A, Herdean A, Schmidt SB, Sharma A, Spetea C, Pribil M, and Husted S. 2018. The impacts of phosphorus deficiency on the photosynthetic electron transport chain. Plant Physiology 177: 271-284. DOI: 10.1104/pp.17.01624.
- Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Ultural Chilean J Agric Res 76 (1): 105-113. DOI: 10.4067/S0718-58392016000100015.
- Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using dipterocarp trees in Sarawak. Malaysia. Int J For Res. DOI: 10.1155/2013/683017.
- Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int. J Sci Technol 7 (2): 93-102. DOI: 10.13170/aijst.7.2. 10119.
- Eviati and Sulaeman. 2009. Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk. Balai Penelitian Tanah, Bogor. [Indonesian]
- Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46.
- Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (S. machrophylla) dan regenerasi alaminya dikebun masyarakat. Jurnal Penelitian Ekosistem Dipterokarpa 1 (2) : 81-88. DOI: 10.20886/jped.2015.1.2.81-88. [Indonesian]
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the conservation of nontimber forest products in Malinau District. IOP Conference. Series: Earth Environment Science. 144: 1-9. DOI: 10.1088/1755-1315/144/1/012055.
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b.The prospect of the utilization of Non-Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in Malinau. North Kalimantan. Indonesia. Biodiversitas 19 (2): 421-430. [Indonesian]
- Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (Shorea Spp.) di areal IUPHHK-Ha PT. Intracawood Manufacturing Tarakan. Kalimantan Timur. Jurnal Silvikultur Tropika. 01 (01): 11-17. [Indonesian]
- Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on survival and growth performance of planted *Shorea macrophylla* (de vriese) in riparian forest Along Kayan Ulu River. Sarawak. Malaysia. Int J For Res 2018 (2): 1-11. DOI: 10.1155/2018/6329295.
- Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania. Int J Biodivers 2014: 1-8. DOI: 10.1155/2014/516840.
- Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv. 19: 1137-1151.
- Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the effects of weather conditions. J Precis Agric 12 (6): 813-830. DOI: 10.1007/s11119-011-9221-x.
- Kurnia, U, Agus f, Adimihardja A, Dariah A. 2006. Sifat fisik tanah dan metode analisisnya. Balai Besar Litbang Sumberdaya Lahan Pertanian. Agro inovasi. Bogor. [Indonesian]
- Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties. Geospatial Analyses of Earth Observation (EO) data. DOI: 10.5772/intechopen.86109
- Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality from Sahan and

Nanga Yen Villages. West Kalimantan. Indonesia. AIP Conf Proc 1712, 050022 (2016). DOI: 10.1063/1.4941905.

- Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. 19 (4): 1280-1288. [Indonesian]
- Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Int J Agron 2019: 1-15. DOI: 10.1155/2019/8572985.
- Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas 21 (1): 49-56. [Indonesian]
- Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. Eur J Soil Sci 2017:1-9. DOI: 10.1111/ejss.12475.
- Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chem Int 2 (1): 58-69.
- Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada.
- Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef manure and inorganic fertilizer application. Int J Agron 2019: 1-6. DOI: 10.1155/2019/9594369.
- Ohta S, Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr 38 (2): 197-206.
- Osman KT. 2013. Forest soil: properties and management. Springer. London.
- Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh *Shorea johorensis* Foxw. di HPH Aya Yayang Indonesia. Kalimantan Selatan (Environmental conditions in which to grow *Shorea johorensis* Foxw. at Aya Yayang HPH in Indonesia. South Kalimantan). J Penelitian Dipterokarpa. 6 (1): 11-22. [Indonesian]
- Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen. Kalimantan Tengah. Jurnal Teknologi Lingkungan. Edisi Khusus Hari lingkungan Hidup 69-76. [Indonesian]
- Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk rehabilitasi hutan dan lahan di Indonesia. Forda Press. [Indonesian]
- Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality attributes of *Shorea macrophylla* seedlings in a tropical nursery. Biodiversitas 20 (8): 2110-2118. [Indonesian]
- Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of *Shorea macrophylla* (de Vriese) after enrichment planting for reforestation purpose at Sarawak, Malaysia. OnLine J Biol Sci 17 (1): 7-17.
- Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of planted *Shorea macrophylla* (de Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve. Sarawak. Malaysia. Int J For Res 2017. DOI: 10.1155/2017/6721354.
- Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted *Shorea macrophylla* under line planting technique. In: 4th Regional Conference on Natural Resources in the Tropics. 2012 (NTrop4): Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices. Universiti Malaysia Sarawak.
- Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Faso (West Africa). Int J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321.
- Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juiling S, Bodos V, Maryani A. 2019. *Shorea macrophylla*. The IUCN red list of threatened species 2019: e.T33620A125629642.
   DOI: 10.2305/IUCN.UK.20193.RLTS.T33620A125629642.en.
- Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (Shorea spp) di hutan tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (Distribution of tengkawang species (Shorea spp) in the Tembawang forest Labian Village Batang Lupar District Kapuas Hulu West Kalimantan). J Hutan Lestari 7 (1): 390-406. [Indonesian]

- Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228.
- Ruchaemi A. 2013. Ilmu pertumbuhan hutan. Samarinda: Mulawarman University Press. [Indonesian]
- Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest after logging in Kedah Malaysia. Malaysian Nature Journal 68 (1 & 2): 187-201.
- Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7 (7): 1-9. E40551. DOI: 10.1371/Journal.Pone.0040551.
- Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern Washington. Northern Idaho. WGC Reports. http://washingtoncrop.com/wpcontent/uploads/2011/11/Aluminum-Toxicity-article-from-January-2013-Wheat-Life.pdf
- Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego. CA.
- Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur. Berita Biologi. Jurnal Ilmu-Ilmu Hayati 12 (2): 239-247. [Indonesian]
- Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry. 103 (1): 297-315. DOI: 10.1007/s10533-010-9466-x.

- Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene climate change on genetic structure and diversity of *Shorea macrophylla* in Kalimantan rainforest. Tree Genet Genomes 14 (4): 44.
- Widiyatno, Budiadi, Suryanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil nutrients and latesuccession species afters hifting cultivation In Central Kalimantan. Indonesia. J Trop For Sci 29 (2): 151-162.
- Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua. Jurnal Ilmiah Ilmu-Ilmu Hayati Biota 16 (2): 242-251. [Indonesian]
- Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN. 2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Int J Soil Sci 5 (3):112-130.
- Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and irrigation methods. Geoderma 193/194:290-299. DOI: 10.1016/j. geoderma.2012.10.013.
- Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple soil. China. Soil Tillage Res 146: 39-46.

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Thank you.	
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Thank you for your help and attenttion. I hear soon your information					
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# The characteristics of *Shorea macrophylla*'s habitat in Tane' Olen, Malinau District, North Kalimantan Province, Indonesia

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Abstract. Fajri M, Pratiwi, Ruslim Y. 2020. The characteristics of Shorea macrophylla's habitat in Tane' Olen, Malinau District, North Kalimantan Province, Indonesia. Biodiversitas 21: xxxx. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the soil's physical and chemical properties, topography, and microclimate of S. macrophylla's habitat. A purposive method was used to select a sampling plot and to place the subplots. Soil was analyzed to determine the physical properties, i.e., texture, bulk density, porosity, and water content, and the chemical properties, i.e., pH, CEC, total N, organic C, C/N ratio, P, K, and Al saturation. Importance value index was determined for each tree species to know the species composition in the study site. Only the dominant species were presented. The soil at the study site had bulk density of 0.60-1.31 gram cm<sup>3-1</sup>, porosity 50.60%-77.35%, water content 34.88%-95.37%, and soil texture sandy clay. The chemical properties of the soil were as follows: pH was 3.6-4.8, N 0.05%-0.19%, organic C 1.40%-3.65%, P 0.41-1.22 mg 100 gr<sup>-1</sup>, K 58.68-232.55 mg 100 gr<sup>-1</sup>, and Cation Exchange Capacity (CEC) 5.35-10.81 meg 100gr<sup>-1</sup>. Slope ranged between 0 and 25%. The microclimate characteristics were as follows: temperature was 24-26.5°C, relative humidity 76-87%, and light intensity 145-750 Lm. Trees species with an IVI  $\geq$  10% were S. macrophylla, Madhuca spectabilis, Myristica villosa Warb, Scorodocarpus borneensis, Eugenia spp, Palaquium spp, Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between S. macropylla and S. borneensis, Eugenia spp, Palaquium spp and M. triloba, and negative associations were observed between S. macropylla and M. spectabilis, M. villosa Warb, S. inophyllum, and Shorea sp. S. macrophylla grows on riversides with flat and gentle topography, acidic soil, and lower fertility but with suitable microclimate. This species can be recommended to be planted in degraded tropical forest areas but the microclimate and soil properties should be taken into account.

Keywords: Habitat, land characteristics, S. macrophylla

#### INTRODUCTION

Shorea macrophylla is one of the fastest growing climax tree species of the genera Shorea (Perumal et al. 2017). Local communities value this species as a source of timber and fruit (Randi et al. 2019). S. macrophylla is known locally in West Kalimantan as the tengkawang tungkul tree and has been cultivated by the Dayak and Malay communities (Fajri and Fernandes 2015). S. macrophylla grows in clusters in tropical rain forests with type A climate, on latosol soils at altitudes up to 500 m, on acidic soils (pH 4.6-4.9), and a cation-exchange capacity (CEC) of 16.25-19.40 (Istomo and Hidayati 2010). In Sarawak, Sabah, Brunei and Kalimantan, this species is associated with sedimentary soils and is distributed evenly over riverbanks and areas with sloping or flat topography. It is rarely found on hills. (Randi et al. 2019; Utomo et al. 2018; Perumal et al. 2017).

The timber from *S. macrophylla* is commonly used for construction and to make veneer and plywood, musical instruments, furniture, and packing crates (Istomo and Hidayati 2010). The fruit, locally known as *tengkawang* 

*tungkul (Illipe)* nuts, is used as a raw material for soap and other cosmetics, a substitution for brown fat, and a source of vegetable fat (Maharani et al. 2016). The natural population of *tengkawang* is declining and is, at present, hard to find (Istomo and Hidayati 2010) because *S. macrophylla* is one of the most sought-after species in tropical forests. The exploitation of the species for its timber, combined with forest conversion to other uses, has resulted in *S. macrophylla* timber being difficult to find in the market (Rikando et al. 2019).

Tane' Olen is a forested area with a high environmental value preserved by the people of Setulang Village (Hutauruk et al. 2018a), a community that manages its forests based on the local wisdom and sustainable forest management practices (Fahrianoor et al. 2013; Kettle 2010), so the forest sustainability is maintained (Hutauruk et al. 2018). Forests are not only a place to live for them, but are also used as a source of food and medicine and economic, social, cultural, and spiritual functions (Merang et al. 2020; Matthew et al. 2018; Quedraogo et al. 2014).

S. macrophylla's habitat characteristics in secondary forest locations have been documented by Jaffar et al.

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(2018) and Perumal et al. (2017). Perumal et al. (2017) studied the relationship between soil fertility and the growth of S. macrophylla in enrichment plantings at Sampadi Forest Reserve, Lundu, Sarawak and an adjacent secondary forest. Jaffar et al. (2018) researched the effects of soil compaction and light intensity on the establishment and growth of S. macrophylla in riparian forests in Sungai Kayan Ulu Sungai, Serawak, Malaysia. The improvement of the company's management system, which is changing the way of harvesting using long cables during skidding activity, reduced the natural forest damage and could increase financial returns from natural forest concessions (Ruslim et al. 2016). The characteristics of S. macrophylla habitat in primary forest locations had not previously been studied. So, this study aimed to describe the characteristics of S. macrophylla's habitat in primary forests by analyzing the physical and chemical properties of soil, the microclimate, topography, species associations, and vegetation. It is hoped that the results of this study will benefit conservation efforts of this species, especially on degraded land in the tropical rain forests of North Kalimantan.

#### **MATERIALS AND METHODS**

#### Study area

The study was carried out in Tane' Olen forest area, Setulang Village, Malinau District, North Kalimantan Utara Province (3°25'0.86" N and 116°25'52.59" E). The location map is presented in Figure 1.

#### **Research procedure**

A one-hectare research site was selected purposively and sampled using a square plot with a side length of 100 meters (Sari and Maharani 2016). Soil sampling was taken from purposively selected three sampling points, located on

a ridge, a slope, and a valley (the ridge had the highest elevations and a 15-25% slope; the slope was located between the valley and ridge, and had an 8-15% slope; the valley was the lowest area and had a 0-8% slope) to ensure an accurate representation of the study site. At each sampling point, soil samples were taken at three depths: 0-20 cm, 20-40 cm, and 40-60 cm. Microclimate data (temperature, humidity, and light intensity) were collected at the same locations. The soil and microclimate data collection design is illustrated in Figure 2. Vegetation data were only collected for trees with a diameter at breast height (DBH) greater than 20.0 cm Each plot was divided into 25 subplots (20 m x 20 m). Within each subplot, the species were identified and DBH recorded for all trees (Widiyatno et al. 2017). Plot-making and field-data collection activities are presented in Figure 2, while sampling design is presented in Figures 3 and 4. Soil sample collection design and microclimate data are presented in Figure 3 and 4. Topography data collection design can be seen in Figure 4. The design of vegetation data collection can be seen in Figures 5.

### Data analyses

Soil analyses

Soil samples were analyzed for both physical and chemical properties (Kurnia et al. 2006; Eviati and Sulaeman 2009). Physical properties analyzed were texture, bulk density, porosity, and water content (using the Pipette method). Chemical properties analyzed were pH (using the electrode method), CEC (using the ammonium acetate pH 7 method), elements Al+++ and H+ (using the KCl method 1 N), total N elements (using the Kjeldahl method), organic C elements (using Walkley-Black method), C/N ratio (using arithmetic methods), elements P<sub>2</sub>O5 and K<sub>2</sub>O (using Bray No I methods), and saturation Al (using arithmetic methods). Soil data analysis results from the soil laboratory were tabulated and analyzed descriptively and quantitatively.



Figure 1. Location of the research in Tane' Olen (•)

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Figure 2. A. Exploration, B. Research plot making, C. Soil sample collection, D. Tree inventory, E and F. Microclimate data collection



100 m L2L3 L4 L5 L1 **SP15** SP5 SP6 SP16 SP25 SP4 SP7 SP14 **SP17** SP24 100 m SP3 SP8 SP13 **SP18** SP23 SP2 SP9 **SP12 SP19** SP22 SP1 **SP10** SP11 SP20 SP21 20m 20m 20m 20m 20m

**Figure 3.** Soil and microclimate sample design. Note: A:lights intensity, B: temperature and area humidity, C: soil sampling, m:meter



Figure 4. Plot design across contour line.

**Figure 5.** Design of plot and sub-plots for vegetation sampling. Note: L: lane, SP: sub plot, 20m: distance between sub plots, 100m x 100m: plot size, m: meter.

Analysis of topography

The topographic analysis was done qualitatively to describe the topography suitable for *S. macrophylla*.

### Analysis of microclimate

The analysis of microclimate was done qualitatively to provide information on microclimates characteristics suitable for *S. macrophylla*.

## Importance Value Index

According to Kacholi (2014), the Importance Value Index (IVI) is used in ecological studies to determine the ecological importance of a species in a particular Deleted[Yosep Ruslim]: Tree inventory,

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ecosystem. IVI is also used to prioritize species conservation. Species with low IVI values require a higher conservation priority than those with high IVI, which is the dominant species. IVI value is a function of several characteristics, and calculated with this formula: IVI = relative density + relative frequency + relative dominance. IVI values were analyzed descriptively

#### Association of vegetation

Associations between two tree species were analyzed using a series of 2x2 contingency tables (Mueller-Dombois and Ellenberg 1974). A more complete description is presented in Table 1.

Then, the data were tested with chi-square  $(x^2)$ 

$$X^{2} = \frac{(ad - bc)^{2} x N}{(a + b)(c + d)(a + c)(b + d)}$$

The association coefficient (C) values were determined as follows:

If 
$$ad \ge bc$$
, so  $C = \frac{ad-bc}{(a+b)(b+d)}$   
If  $bc > ad$  and  $d > a$ , so  $C = \frac{ad-bc}{(a+b)(b+c)}$   
If  $bc > ad$  and  $a > c$ , so  $C = \frac{ad-bc}{(a+d)(c+d)}$ 

Positive or negative values of C indicate a positive or negative relationship between the two species. A positive relationship indicates that the association between trees is mutually beneficial to each other, while a negative value indicates that the association between trees harms one another.

 Table 1. Contingency table form (Mueller-Dombois and Ellenberg 1974)

Species A Species B	+	-	
+	a,	b,	a + b
-	с	<u>d</u>	c + d
	a + c	b + d	N = a + b + c + d
Note:			

a = number of plots containing species A and species B.

b = number of plots containing only species A, but no species B.

c = number of plots containing only species B, but no species A.

d = number of plots containing neither species A nor species B.

N = number of all plots.

#### **RESULTS AND DISCUSSION**

#### The soil's physical and chemical properties

The physical and chemical properties of soil properties in S. *macrophylla*'s habitat can be seen in Table 2.

At the depth of 0-20 cm, the valley, slope, and ridge subplots had a low bulk density (0.60-1.05) (Table 2). According to Casanova et al. (2016) and Zeng et al. (2013), soil bulk density is influenced by external conditions and natural processes such as plant root growth and rainfall.

The soil porosity values in the valley, slope, and ridge subplots decreased with the increasing soil depth. The valley subplot had higher porosity value than the slope and ridge subplots. According to Darusman et al. (2019), the properties that affect soil porosity the most are bulk density and soil particle density; if the bulk density is low then the soil porosity will increase.

Water content in the ridge, slope, and valley decreased with the increasing soil depth. The water content in the ridge subplots was higher than the slope subplots because the water movement is faster in the slope subplots and the water settles in the lower area, i.e., the valley subplots, which resulted in a higher (95.37%) water content in the valley subplots than in the ridge and slope subplots. Jaffar et al. (2018) state that *S. macrophylla* plant roots can adapt to high water soil content. Moist soils stimulate *S. macrophylla* roots growth and development. According to Minasny and McBratney (2018), the availability of groundwater is an important component of water balance and the terrestrial biosphere cycle because it can affect evapotranspiration rates and support plant growth.

The results of the soil texture analysis can be seen in Table 3.

The soil texture at the study site generally had a sand fraction of 45-65%, a clay fraction 35-55%, and a silt fraction 0-20% (Table 3). This means that the soil texture is sandy clay. According to Osman (2013), soil texture refers to the level of fineness or roughness created by the variously-sized soil particles.

Soil types are generally dominated by Ultisol (advanced development) soils, namely Typic Hapludults (Red-Yellow Podsolik) and Typic Paleudults (Yellow Podsolic). These soil types are typically found in lowland dipterocarp forests (Ohta and Effendi 1992).

Chemical soil characteristics of the study site are presented in Table 4.

The soil at the study site was very acidic (pH = 4.1-4.8) (Table 4). According to Schroeder and Pumphrey (2013), acidic soils inhibit root and plant growth and increase Al levels in the soil. The CEC at the study site ranged from 5.3 to 10 meq/100 g<sup>-1</sup>, indicating that the CEC was low. In general, the value of CEC is low in surface and subsurface soils of lowland dipterocarp forests (Perumal et al. 2017a).

Aluminum levels at the study site were high, especially in the slope and valley subplots, which indicated high soil toxicity. Al content in the soil decreased with the increasing organic matter because organic matter forms a strong bond with Al. According to Zaidey et al. (2010), Al is a major cause of soil acidity, and soils in lowland dipterocarp forests have high Al content.

Nitrogen levels at the study site ranged from 0.05% to 0.19% (low to very low). Sadeghi et al. (2016) also reported low total N levels in tropical rain forest soils. Nitrogen is important for plant growth (Omara et al. 2019), and N deficiency can inhibit plant growth (Mehata et al. 2019). According to Omara et al. (2019), the main sources of N are organic matter and rainfall/precipitation.

Organic C values were higher in the valley and slope subplots than in the ridge subplots. The steeper slopes in the ridge subplots are more prone to erosion, resulting in the leaching of organic C and other nutrients into the valley and slope subplots. According to Schlesinger and Bernhard Deleted[Yosep Ruslim]: A

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(2013), carbon can be stored in the soil three times longer than in the atmosphere and is an indicator of soil microorganism abundance and diversity (Zhu and Zhu 2015). The presence of organic C in the soil spurs microorganism activity and thereby increases the rates of soil decomposition, P dissolution, N fixation, and other microorganism-dependent reactions.

Phosphate was calculated from  $P_2O_5$ , where the Phosphate content is very low (0.41-1.22 mg 100 gram<sup>-1</sup>) (Table 4). According to Turner and Engelbrecht (2011), organic P plays an important role in maintaining P availability in lowland tropical rain forests. Phosphorus is essential for root development and plant growth (Abdissa et al. 2011). According to Carstensen, et al. (2018), P deficiency has a major impact on plant growth, development and productivity.

Potassium values ranged from high (58.68-116.85 mg 100 gr<sup>-1</sup>) in the valley and slope subplots to very high (120.34-232.55 mg 100 gr<sup>-1</sup>) in the ridge subplots. According to Mouhamad et al. (2016), K is more abundant in the soil than other mineral elements. This element has an essential role in plant metabolism, growth, and yield. Potassium availability depends on soil properties (humidity, aeration, and temperature), soil treatment systems, and the dynamics of K. Therefore, the K exchange level varies among soils.

### Topography in the study area

According to Li and McCarty (2019), topographic features are key parameters that affect the nature of the soil at the earth's surface. Topographic features can affect organic matter; clay content; P, K, and Mg concentrations; \_ and soil pH (Kumhalova et al. 2011).

The topography of the study site is moderately undulating with a slope of 0-25%. The subplot slopes range from flat to moderately steep. *S. macrophylla* was found primarily in flat to sloping areas with high environmental humidity, low ambient temperature, and abundant water, such as riverbanks. Jaffar et al. (2018) stated that the roots of the *S. macrophylla* are able to survive and grow in anaerobic waterlogged soils and is considered a floodtolerant tree.

### Dominant trees at the study area

At the study site, *S. macrophylla* was the dominant tree species (Figure 6). Other tree species included *Madhuca* spectabilis, Myristica villosa Warb., Scorodocarpus borneensis, Eugenia spp., Palaquium spp., Macaranga triloba, Syzygium inophyllum, and Shorea sp. S. macrophylla dominated the study site due to its fast germination process and high germination rate (Appanah and Turnbull 1998), its high growth rate (fastest of the genus Shorea), and its status as a climax species along rivers (Perumal et al. 2017).

Table 2. Physical properties of soil at the study site.

Location of soil	Depth (cm)	Bulk density (gram/cm³)*	Porosity (%)*	Water content (%)
Valley	0-20	0.60	77.35	95.37
	20-40	1.13	57.32	40.04
	40-60	1.18	55.54	39.20
Slope	0-20	1.05	60.42	48.08
	20-40	1.31	50.60	41.42
	40-60	1.23	53.72	34.88
Ridge	0-20	0.83	68.75	61.68
	20-40	1.01	61.92	44.23
	40-60	1.20	54.66	35.53

Note: \*Average score from three repetitions

 Table 3. Soil texture at the study site.

Location of soil	Depth (cm)	Clay (%)	Sand (%)	Silt (%)	texture (USDA)
Valley	0-20	33.70	50.90	15.40	SCL
	20-40	36.50	49.50	14.00	SC
	40-60	34.00	56.80	9.20	SCL
Slope	0-20	24.70	67.20	8.10	SCL
	20-40	27.30	63.10	9.60	SCL
	40-60	33.10	60.50	6.40	SCL
Ridge	0-20	37.80	54.60	7.60	SC
	20-40	37.40	46.40	16.20	SC
	40-60	40.70	48.00	11.30	SC

Note: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University

Location of	Depth	рН (1:	25)	Cation	exchang	e rates	Organic	content	Ratio	Minera	ıl
soil	(cm)			(meg 100gr <sup>-1</sup> )		(%)			(Mg 100 gram <sup>-1</sup> )		
		H <sub>2</sub> O	KCl	CEC	Al3 <sup>+</sup>	$H^+$	Tot. N.	Org C	C/N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Valley	0-20	4.6	3.3	7.26	4.92	1.50	0.19	3.65	19	0.89	116.85
	20-40	4.6	3.4	7.25	5.56	1.08	0.12	2.65	22	0.73	73.30
	40-60	4.4	3.4	7.18	5.75	0.92	0.10	2.12	22	1.22	59.00
Slope	0-20	4.1	3.5	5.35	2.75	1.33	0.13	2.31	18	0.65	73.62
	20-40	4.7	3.5	5.30	3.50	0.92	0.07	1.54	22	0.65	58.68
	40-60	4.8	3.5	5.53	3.33	1.42	0.05	1.40	26	0.41	60.90
Ridge	0-20	4.4	3.0	10.81	7.25	2.75	0.09	3.46	39	2.35	120.34
	20-40	3.6	3.3	10.48	7.80	1.83	0.08	2.12	28	0.89	194.09
	40-60	4.4	3.4	10.37	6.83	2.58	0.09	1.54	17	0.65	232.55

**Table 4.** Chemical characteristics of soil at the study site.

Note: Laboratory of soil test in B2P2EHD and Pusrehut, Mulawarman University

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## Microclimate

Three microclimate factors were collected, i.e., temperature, humidity, and light intensity (see Table 6 for a more complete description). The temperature values at the study site was 24-26,5° C (Table 6). According to Ruchaemi (2013), the optimal temperature for plant assimilation is 25-30° C. Relative humidity values were high to very high, ranging from 76 to 87%. Lights intensity was very low to low, ranging from 7,25% (145 Lm) to 23.46% (469 Lm) due to dense canopy dominated by *S. macrophylla* which prevented light from reaching the forest floor. This low light intensity is consistent with the findings of Panjaitan et al. (2012), who found that the closed canopy only allowed a little sunlight to reach the forest floor. These conditions benefit *S. macrophylla* seedlings, which are sun intolerant.

#### Association with other trees

According to Saiz and Alados (2012), plant species association is a fundamental aspect of the ecology of plant communities. Analysis of plant species associations provides information on environmental heterogeneity, biotic interactions, and seed dispersal patterns. The results of the species association analysis and the association coefficient are presented in Table 7.

## ISSN: 1412-033X E-ISSN: 2085-4722 DOI: 10.13057/biodiv/d2108xx Table 7 shows the results of a series of 2x2 contingency

tests between *S. macropylla* and each of the eight other dominant tree species. The calculated  $X^2$  values were greatest between *S. macropylla* and *M. villosa* Warb, indicating that *S. macropylla* had a strong but negative association with *M. villosa* Warb. According to Sofiah et al. (2013), species pairs do not always indicate positive relationships. Tree species with high populations are not always associated with another species. Likewise, lowpopulation species are not necessarily negatively correlated with another species.

The association coefficient (C) was used as a parameter of the magnitude of the relationship between the eight species and *S. macropylla* and indicates positive or negative associations. Species that showed positive coefficients of association with *S. macropylla* were *S. borneensis, Eugenia spp., Palaquium spp,* and *M. triloba.* According to Windusari1 et al. (2011), positive associations indicate both species have the same requirement of environmental conditions; for example, wet conditions, high light intensity, or shade. *S. macropylla* showed a negative association with *M. spectabilis, M. villosa, S. inophyllum,* and *Shorea* sp. Negative associations indicate intolerance for cohabitation or the absence of a mutually beneficial relationship (Pratama et al. 2012).

Table 5. The importance value index of the dominant tree species at the study site

Local name	Scientific Name	Family	Relatif density (%)	Relatif dominance (%)	Relatif frequency (%)	Importance value index (%)
Tengkawang	S. macropyilla	Dipterocarpaceae	7.69	15.35	5.0	28.04
Kajen ase	M. spectabilis	Sapotaceae	10.25	7.29	4.61	22.16
Darah-darah	M. villosa Warb	Myristicaceae	7.45	4.79	5.0	17.25
Bala seveny	S. borneensis	Olacaceae	5.12	5.77	5.0	15.90
Ubah	Eugenia spp	Myrtaceae	5.59	3.64	4.61	13.85
Nyatok	Palaquium spp	Sapotaceae	4.42	3.70	4.61	12.74
Beneva	M. triloba	Euphorbiaceae	4.66	4.32	3.46	12.44
Ehang	S. inophyllum	Myrtaceae	5.36	3.14	3.84	12.35
Kaze tenak	Shorea sp	Dipterocarpaceae	2.33	6.08	2.69	11.10



Figure 6. A. Tree of Shorea macrophylla and B. Leaves of S. macrophylla

Table 6. Microclimate at the study site

Location	Microclimate	Unit	Time	1-st record	2-nd record	3-rd record	Average	Remark
1.	Light intensity	Lm	Morning	350	400	452	400.67	Taken at 8.59 sunny
2.	Temperature	°c	Morning	24	24.5	25	24.5	conditions
3.	Relative humidity	%	Morning	81	79	80	80	
1.	Lights intensity	Lm	Mid day	750	450	207	469	Taken at 12:02 sunny
2.	Temperature	°c	Mid day	26.5	26	24.5	25.67	conditions
3.	Relative humidity	%	Mid day	76	79	81	78.67	
1.	Lights intensity	Lm	Afternoon	369	237	145	250.33	Taken at 16:30 sunny
2.	Temperature	°c	Afternoon	25	24.5	23	24.17	conditions
3.	Relative humidity	%	Afternoon	84	85	87	85.33	

Table 7. Association of S. macropylla with other species.

Species association	X <sup>2</sup> count	Assoc. species	C (+/-)
S. macropylla with M. spectabilis	0.35	-	0.04
S. macropylla with M. villosa Warb	6.82	-	0.29
S. macropylla with S. borneensis	0.04	+	0.04
S. macropylla with Eugenia spp	0.37	+	0.11
S. macropylla with Palaquium spp	0.37	+	0.11
S. macropylla with M. triloba	1.21	+	0.16
S. macropylla with S. inophyllum	3.23	-	0.29
S. macropylla with Shorea sp	1.92	-	0.24

Note: X  $^{\rm 2}$  tabulated value at 5% level: 3.841. X² tabulated value at 1% level: 6.35

#### Direction of S. macrophylla plantation

At present, tropical forests are being degraded by anthropogenic activities such as timber extraction, agricultural cultivation, and the establishment of commercial plantations. This results in the conversion of forests into agriculture land and the fragmentation and degradation of tropical rain forests. Deforestation damages the environment by increasing light intensity and causing severe mineral soil erosion. In general, degraded forests can be divided into three categories: grasslands after burning, early-succession secondary forests, and commercially logged forests (Daisuke et al. 2013).

Planting native trees is considered to be an effective rehabilitation method for degraded tropical rain forests because native trees provide benefits such as timber, food, and medical products (Daisuke et al. 2013). According to Pratiwi et al. (2014), tropical forest rehabilitation is necessary to both meet the demand for timber and improve environmental conditions. One key to rehabilitation success is the understanding of the suitability of each growing site for each species being planted. One approach to determine the suitability of growing sites for each species is to identify each species' potential, identify locally superior species, and correlate this with species distribution data and growth requirements (Pratiwi et al. 2014).

Shorea macrophylla is a recommended species for replanting degraded tropical forest land, i.e., pastures after burning (Daisuke et al. 2013), early-succession secondary forests (Daisuke et al. 2013; Perumal et al. 2012), and commercially logged forests. In commercially logged forests, *S. macrophylla* can be planted using the line

planting system or gap planting system. In early-succession secondary forests and pasture after burning, *S. macrophylla* requires pioneer plants to assist growth. *S. macrophylla* is a valuable tree species that has socio-economic and ecological benefits and is beneficial for reforestation and rehabilitation activities (Perumal et al. 2012; Perumal et al. 2017a; Perumal et al. 2017b; Perumal et al. 2019).

This species is important for land rehabilitation activities because it plays a role in maintaining water quality, filtering out pollutants and deposits, and storing carbon (Utomo et al. 2018; You et al. 2015). Things that must be considered when planting *S. macrophylla* are the nutrient content in clay and the clay mineral composition. These two factors can be used to evaluate soil fertility. The growth of *S. macrophylla* is also significantly limited by the high light intensity in grasslands (*Imperata cylindrica/* pastures after burning). *S. macropylla* grows well in habitats with low light intensity. In secondary forests and logged-over forests, the survival and growth of *S. macrophylla* is limited by soil compaction. This agrees with the results of this study, where fine sandy clay soils were found.

*S. macrophylla* grows on riversides with flat and gentle topography, acidic soil, and lower fertility, but with the suitable microclimate (temperature of 24-26,5°C, high humidity 76-87%, and a low light intensity 7,25-23.46%). This species can be recommended to be planted in degraded tropical forest areas if microclimatic factors and soil conditions are taken into account.

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#### REFERENCES

- Abdissa Y, Tekalign T, Pant LM. 2011. Growth. bulb yield and quality of onion (*Allium cepa* L) as influenced by nitrogen and phosphorus fertilization on vertisol i. growth attributes. biomass production and bulb yield. Afr J Agric Res 6 (14): 3252–3258.
- Appanah S, Turnbull JM. 1998. A review of dipterocarps: taxonomy. ecology and silviculture. Center for International Forestry Research.
- Carstensen A, Herdean A, Schmidt SB, Sharma A, Spetea C, Pribil M, and Husted S. 2018. The impacts of phosphorus deficiency on the photosynthetic electron transport chain. Plant Physiology 177: 271-284. DOI: 10.1104/pp.17.01624.
- Casanova M, Tapia E, Seguel O, Salazar O. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Ultural Chilean J Agric Res 76 (1): 105-113. DOI: 10.4067/S0718-58392016000100015.
- Daisuke H, Tanaka K, Jawa KJ, Ikuo N, Katsutoshi S. 2013. Rehabilitation of degraded tropical rainforest using dipterocarp trees in Sarawak. Malaysia. Int J For Res. DOI: 10.1155/2013/683017.
- Darusman, Devianti, Husen E. 2018. Improvement of soil physical properties of cambisol using soil amendment. Aceh Int. J Sci Technol 7 (2): 93-102. DOI: 10.13170/aijst.7.2. 10119.
- Eviati and Sulaeman. 2009. Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk. Balai Penelitian Tanah, Bogor. [Indonesian]
- Fahrianoor, Windari T, Taharudin, Mar'i R, Maryono. 2013. The practice of local wisdom of Dayak people in forest conservation in South Kalimantan. Indon J Wetlands Environ Manag 1 (1): 37-46.
- Fajri M, Fernandes A. 2015. Pola pemanenan buah tengkawang (S. machrophylla) dan regenerasi alaminya dikebun masyarakat. Jurnal Penelitian Ekosistem Dipterokarpa 1 (2) : 81-88. DOI: 10.20886/jped.2015.1.2.81-88. [Indonesian]
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2018a. Setulang forest conservation strategy in safeguarding the conservation of nontimber forest products in Malinau District. IOP Conference. Series: Earth Environment Science. 144: 1-9. DOI: 10.1088/1755-1315/144/1/012055.
- Hutauruk TR, Lahjie AM, Simarangkir BDAS, Aipassa MI, Ruslim Y. 2018b.The prospect of the utilization of Non-Timber Forest Products from Setulang Village forest based on local knowledge of the Uma Longh community in Malinau. North Kalimantan. Indonesia. Biodiversitas 19 (2): 421-430. [Indonesian]
- Istomo, Hidayati T. 2010. Studi potensi dan penyebaran tengkawang (*Shorea* Spp.) di areal IUPHHK-Ha PT. Intracawood Manufacturing Tarakan. Kalimantan Timur. Jurnal Silvikultur Tropika. 01 (01): 11-17. [Indonesian]
- Jaffar ANNM, Wasli ME, Perumal M, Lat J, Sani H. 2018. Effects of soil compaction and relative light intensity on survival and growth performance of planted *Shorea macrophylla* (de vriese) in riparian forest Along Kayan Ulu River. Sarawak. Malaysia. Int J For Res 2018 (2): 1-11. DOI: 10.1155/2018/6329295.
- Kacholi DS. 2014. Analysis of structure and diversity of the kilengwe forest in the Morogoro Region. Tanzania. Int J Biodivers 2014: 1-8. DOI: 10.1155/2014/516840.
- Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv. 19: 1137-1151.
- Kumhalova J, Kumhala F, Kroulik M, Matejkova S. 2011. The impact of topography on soil properties and yield and the effects of weather conditions. J Precis Agric 12 (6): 813-830. DOI: 10.1007/s11119-011-9221-x.
- Kurnia, U, Agus f, Adimihardja A, Dariah A. 2006. Sifat fisik tanah dan metode analisisnya. Balai Besar Litbang Sumberdaya Lahan Pertanian. Agro inovasi. Bogor. [Indonesian]
- Li X, McCarty GW. 2019. Application of topographic analyses for mapping spatial patterns of soil properties. Geospatial Analyses of Earth Observation (EO) data. DOI: 10.5772/intechopen.86109
- Maharani R, Fernandes A, Pujiarti R. 2016. Comparison of tengkawang fat processings effect on tengkawang fat quality from Sahan and Nanga Yen Villages. West Kalimantan. Indonesia. AIP Conf Proc 1712, 050022 (2016). DOI: 10.1063/1.4941905.
- Matius P, Tjwa SJM, Raharja, Sapruddin, Noor S, Ruslim Y. 2018. Plant diversity in traditional fruit gardens (munaans) of Benuaq and Tunjung Dayaks tribes of West Kutai. East Kalimantan. Indonesia. Biodiversitas. 19 (4): 1280-1288. [Indonesian]

- Mehata M, Cortus E, Niraula S, Spiehs MJ, Darrington J, Chatterjee A, Rahman S, Parker DB. 2019. Aerial nitrogen fluxes and soil nitrate in response to fall-applied manure and fertilizer applications in Eastern South Dakota. Int J Agron 2019: 1-15. DOI: 10.1155/2019/8572985.
- Merang OP, Lahjie AM, Yusuf S, Ruslim Y. 2018. Productivity of three varieties of local upland rice on swidden agriculture field in Setulang village. North Kalimantan. Indonesia. Biodiversitas 21 (1): 49-56. [Indonesian]
- Minasny B, Mcbratney AB. 2017. Limited effect of organic matter on soil available water capacity. Eur J Soil Sci 2017:1-9. DOI: 10.1111/ejss.12475.
- Mouhamed R, Alsaede A, Iqbal M. 2016. Behavior of potassium in soil: a mini review. Chem Int 2 (1): 58-69.
- Mueller-Dombois D, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Willey and Sons. Canada.
- Omara P, Aula L, Raun WR. 2019. Nitrogen uptake efficiency and total soil nitrogen accumulation in long-term beef manure and inorganic fertilizer application. Int J Agron 2019: 1-6. DOI: 10.1155/2019/9594369.
- Ohta S, Effendi S. 1992. Ultisols of "lowland dipterocarp forest" in East Kalimantan. Indonesia. Soil Sci. Plant Nutr 38 (2): 197-206.
- Osman KT. 2013. Forest soil: properties and management. Springer. London.
- Panjaitan S, Wahuningtyas RS, Adawiyah R. 2012. Kondisi lingkungan tempat tumbuh Shorea johorensis Foxw. di HPH Aya Yayang Indonesia. Kalimantan Selatan (Environmental conditions in which to grow Shorea johorensis Foxw. at Aya Yayang HPH in Indonesia. South Kalimantan). J Penelitian Dipterokarpa. 6 (1): 11-22. [Indonesian]
- Pratama, Arief B, Alhamd L, Rahajoe JS. 2012. Asosiasi dan karakterisasi tegakan pada hutan rawa gambut di Hampagen. Kalimantan Tengah. Jurnal Teknologi Lingkungan. Edisi Khusus Hari lingkungan Hidup 69-76. [Indonesian]
- Pratiwi, Narendra BH, Hartoyo GME, Kalima T, Pradjadinata S. 2014. Atlas jenis-jenis pohon andalan setempat untuk rehabilitasi hutan dan lahan di Indonesia. Forda Press. [Indonesian]
- Perumal M, Wasli ME, and Ying. HS. 2019. Influences of inorganic and organic fertilizers to morphological quality attributes of *Shorea macrophylla* seedlings in a tropical nursery. Biodiversitas 20 (8): 2110-2118. [Indonesian]
- Perumal M. Wasli ME, Ying HS, Sani H. 2017a. Survivorship and growth performance of *Shorea macrophylla* (de Vriese) after enrichment planting for reforestation purpose at Sarawak, Malaysia. OnLine J Biol Sci 17 (1): 7-17.
- Perumal M, Wasli ME, Ying HS, Lat J, Sani H. 2017b. Association between soil fertility and growth performance of planted *Shorea macrophylla* (de Vriese) after Enrichment Planting at Rehabilitation Sites of Sampadi Forest Reserve, Sarawak, Malaysia. Int J For Res 2017. DOI: 10.1155/2017/6721354.
- Perumal M, Wasli ME, Sani H, Nahrawi H. 2012. Growth performance of planted *Shorea macrophylla* under line planting technique. In: 4th Regional Conference on Natural Resources in the Tropics. 2012 (NTrop4): Sustaining Tropical Natural Resources Through Innovations. Technologies and Practices. Universiti Malaysia Sarawak.
- Quedraogo I, Nacoulma BMI, Hahn K, Thiombiano A. 2014. Assessing ecosystem services based on indigenous knowledge in south-eastern Burkina Faso (West Africa). Int J Biodivers Sci Ecosyst Serv Manag 10 (4): 313-321.
- Randi A, Julia S, Kusumadewi Y, Robiansyah I, Shomat F, Tanggaraju S, Hamidi A, Juling S, Bodos V, Maryani A. 2019. Shorea macrophylla, Light Red Meranti. The IUCN red list of threatened species 2019 e.T33620A125629642. DOI: 10.2305/IUCN. UK.20193.RLTS.T33620A125629642.en.
- Rikando R. Latifah S. Manurung TF. 2019. Sebaran jenis tengkawang (Shorea spp) di hutan tembawang Desa Labian Kecamatan Batang Lupar Kapuas Hulu Kalimantan Barat (Distribution of tengkawang species (Shorea spp) in the Tembawang forest Labian Village Batang Lupar District Kapuas Hulu West Kalimantan). J Hutan Lestari 7 (1): 390-406. [Indonesian]
- Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228.
- Ruchaemi A. 2013. Ilmu pertumbuhan hutan. Samarinda: Mulawarman University Press. [Indonesian]
- Sadeghi SM, Hanum IF, Abdu A, Kamziah IK, Hakeem KR, Ozturk M. 2016. Recovery of soil in hill dipterocarp forest after logging in Kedah Malaysia. Malaysian Nature Journal 68 (1 & 2): 187-201.
- Saiz H, Alados CL. 2012. Changes in semi-arid plant species associations along a livestock grazing gradient. Plos One 7 (7): 1-9. E40551. DOI: 10.1371/Journal.Pone.0040551.
- Schroeder K, Pumphrey M. 2013. It's all a matter of pH: acid soils. aluminum toxicity are on the rise in Eastern Washington. Northern Idaho. WGC Reports. http://washingtoncrop.com/wpcontent/uploads/2011/11/Aluminum-Toxicity-article-from-January-2013-Wheat-Life.pdf
- Schlesinger WH, Bernhard ES. 2012. Biogeochemisty: an analysis of global change. 3rd ed. Academic Press. San Diego. CA.
- Sofiah S, Setiadi D, Widyatmoko D. 2013. Pola penyebaran. kemelimpahan. dan asosiasi bambu pada komunitas tumbuhan di Taman Wisata Alam Gunug Baung Jawa Timur. Berita Biologi. Jurnal Ilmu-Ilmu Hayati 12 (2): 239-247. [Indonesian]
- Turner BL, Engelbrecht BMJ. 2011. Soil organic phosphorus in lowland tropical rain forests. Biogeochemistry. 103 (1): 297-315. DOI: 10.1007/s10533-010-9466-x.
- Utomo S, Uchiyama S, Ueno S, Matsumoto A, Widiyatno, Indrioko S, Na'iem M, Tsumura Y. 2018. Effects of pleistocene climate change

on genetic structure and diversity of *Shorea macrophylla* in Kalimantan rainforest. Tree Genet Genomes 14 (4): 44.

- Widiyatno, Budiadi, Suryanto P, Rinarno YDBM, Prianto SD, Hendro Y. 2017. Recovery of vegetation structure. soil nutrients and latesuccession species afters hifting cultivation In Central Kalimantan. Indonesia. J Trop For Sci 29 (2): 151-162.
- Windusari Y, Susanto RH, Dahlan Z, Susetyo W. 2011. Asosiasi jenis pada komunitas vegetasi suksesi di kawasan pengendapantailing tanggul ganda di pertambangan PTFI Papua. Jurnal Ilmiah Ilmu-Ilmu Hayati Biota 16 (2): 242-251. [Indonesian]
- Zaidey AK, Arifin A, Zahari I, Hazandy AH, Zaki MH, Affendi H, Wasli ME, Hafiz YK, Shamsuddin, Muhammad MN. 2010. Characterizing soil properties of lowland and hill dipterocarp forest at Peninsular Malaysia. Int J Soil Sci 5 (3):112-130.
- Zeng C, Wang Q, Zhang F, Zhang J. 2013. Temporal changes in soil hydraulic conductivity with different soil types and irrigation methods. Geoderma 193/194:290-299. DOI: 10.1016/j. geoderma.2012.10.013.
- Zhu X, Zhu B. 2015. Diversity and abundance of soil fauna as influenced by longterm fertilization in cropland of purple soil. China. Soil Tillage Res 146: 39-46.

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	Title & Abstract	Title	
	Contributors	The characteristics of Shorea macrophylla's habitat in Tane' Olen, Malinau District, North Kalimantan Prc	
	Metadata	Abstract	
	References	$B  I  \times^{i}  \times_{i}  \mathscr{O}$	
	Galleys	Abstract. Fajri M, Pratiwi, Ruslim Y. 2020. The characteristics of Shorea macrophylla's habitat in Tane' Olen, Malinau District. North Kalimantan Province, Indonesia. Biodiversitas 21: 3454-3462. Shorea macrophylla is a tree species in Tane' Olen forest area. This study analyzed the soil's physical and chemical properties, topography, and microclimate of S. macrophylla's habitat. A purposive method was used to select a sampling plot and to place the subplots. Soil was analyzed to determine the physical properties, i.e., texture, bulk density, porosity, and water content, and the chemical	

index was determined for each tree species to know the species composition in the study site. Only the dominant species were presented. The soil at the study site had bulk density of 0.60-1.31 gram cm<sup>3-1</sup>, porosity 50.60%-77.35%, water content 34.88%-95.37%, and soil texture sandy clay. The chemical properties of the soil were as follows: pH was 3.6-4.8, N 0.05%-0.19%, organic C 1.40%-3.65%, P 0.41-1.22 mg 100 gr<sup>-1</sup>, K 58.68-232.55 mg 100 gr<sup>-1</sup>, and Cation Exchange Capacity (CEC) 5.35-10.81 meg 100gr<sup>-1</sup>. Slope ranged between 0 and 25%. The microclimate characteristics were as follows: temperature was 24-26.5°C, relative humidity 76-87%, and light intensity 145-750 The. Trees species with an IVL? 10% were *S. macrophylla*, Madhuca spectabilis, Myristica villosa Warb, *Scorodocarpus borneensis*, Eugenia spp., Palaquium spp., Macaranga triloba, Syzygium inophyllum and Shorea sp. Positive associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* and *S. borneensis*, Eugenia spp., and M. triloba, and negative associations were observed between *S. macropylla* grows on riversides with flat and gentle topography, acidic soil, and lower fertility but with suitable microclimate. This species can be recommended to be planted in degrad

the microclimate and soil properties should be taken into account.

properties, i.e., pH, CEC, total N, organic C, C/N ratio, P, K , and AI saturation. Importance value