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Plant diversity, structure and composition of vegetation around Barumun Watershed, North Sumatra, Indonesia

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Abstract. *Rambey R, Susilowati A, Rangkuti AB, Onrizal O, Desrita, Ardhi R, Hartanto A. 2021. Plant diversity, structure and composition of vegetation around Barumun Watershed, North Sumatra, Indonesia. Biodiversitas 22: 3250-3256.* Watershed ecosystem plays an important role in water and soil conservation which is supported by vegetation around watershed. As such, vegetation analysis is beneficial to assess the current state of watershed vegetation and monitor future changes. Barumun Watershed, located in South Labuhanbatu District, North Sumatra Province, Indonesia, is under threat due to habitat degradation and land conversion for plantation and agriculture. This research aimed to investigate the diversity, structure and composition of vegetation in the Barumun River including its smaller streams (rivulets). Data were collected using a combination of line transect and quadratic plots arranged systematically. The total observation plots were 48 plots, consisting of 24 plots in Barumun River, 12 plots in Tasik Rivulet and 12 plots in Titi Kembar Rivulet. The results documented a total of 51 plants in the studied sites in Barumun Watershed in which 37 species were found in Barumun River, 20 species in Tasik Rivulet and 17 species in the Titi Kembar Rivulet. Plant species consisted of several habitus including herbs, palms, shrubs, climbers and trees. The trees consisted of 22 species (43.13%), herbs 22 species (43.13%), climbers 3 species (5.88%), shrubs two species (3.92%), and palm two species (3.92%). The highest Importance Value Index (IVI) for tree community was recorded in the Barumun River from *Hevea brasiliensis* (108.28), followed by *Cryptocarya* sp. (123.24) in the Titi Kembar Rivulet. In addition, the highest IVI for pole, sapling, seedling, and shrub was recorded from *Muntingia calabura* (Barumun River), *Nauclea orientalis* (Tasik Rivulet), *Psychotria viridiflora* (Tasik Rivulet), and *Calamus axillaris* (Titi Kembar Rivulet), respectively. The plant diversity in Barumun Watershed was categorized from low to moderate level of richness.

Keywords: Barumun river, community structure, Importance Value Index, riparian vegetation, species diversity

INTRODUCTION

Watershed ecosystem is an ecosystem unit from the largest river basins to the smaller streams (or rivulet) that holds important ecological roles to human community and other living organisms. Besides its function as physical protection of the hydrological systems, watersheds also conserve soils by controlling erosion and may prevent natural disasters such as floods and landslides. Therefore, watershed needs to be managed properly to maintain its sustainability (Halengkara et al. 2012).

Vegetation serves as an integral component in the soil and atmospheric systems (Piao et al. 2015; Liu et al. 2020; Tian et al. 2021). In general, the role of vegetation in an ecosystem is maintaining the balance of carbon dioxide and oxygen concentration in the air, improving the physical, chemical and biological properties of soil, regulating groundwater systems and other beneficial roles (Indriyanto 2006; Basrowi et al. 2018). The existence of undisturbed vegetation in a landscape will positively impact the balance of the ecosystem with greater impacts within a region. Accordingly, there is a strong inter-relationship between watershed ecosystem and the vegetation that occurred there in the context of watershed.

Indonesia is known as the mega biodiversity country due the large number of species that live in a broad range of ecosystems, including watershed ecosystems. One of the watersheds in Indonesia is the Barumun River, located in South Labuhanbatu District, North Sumatra Province. Barumun River originates from a spring in Siraisan, Padang Lawas District located in the southeastern part of the province. The river flows to the northern part through 3 districts, namely North Padang Lawas District, South Labuhanbatu District and Labuhan Batu District until reaches the eastern coast of Sumatra or an estuary in the Melaka Strait. Barumun River is recorded as the longest river in North Sumatra with a length of 440 km. The local community is highly dependent on the rivers, especially as a source of fish for consumption and livelihood. Local fishes, such as *baung* (*Hemibagus nemurus*), *belida* (*Chitala lopis*), *silais* (*Ompok hypophthalmus*), and giant prawns (*Macrobrachium rosenbergii*) are notable freshwater species that are preserved through a good and

sustainable river ecosystem management.

One primary feature in the field of watershed ecology is the presence of riparian vegetation that is able to support the life of the ecosystem communities. According to Haryadi et al. (2019), habitat degradation and alteration affect the structure of the ecosystem including the native vegetation within, so it is necessary to monitor the changes that occur. In the context of Barumun River, the conversion of land into plantation areas such as oil palm (*Elaeis guineensis*) and seasonal crop farming such as cucumber (*Cucumis sativus*), cowpea (*Vigna unguiculata*), and smooth pigweed (*Amaranthus hybridus*), are potential threats to the sustainability of the watershed and its surrounding ecosystem in the Labuhanbatu District as documented from the biodiversity monitoring of its benthic organisms (Harahap et al. 2018; Harahap et al. 2021). Ideally, tree vegetation should dominate the riparian to support the sustainability of the river ecosystem. This research aimed to investigate the diversity, structure and composition of vegetation in the Barumun River including its smaller streams (rivulets). This study provides the current state of the vegetation in the Barumun watershed for the management of the freshwater region and can serve as baseline information for future studies to monitor the watershed changes.

MATERIALS AND METHODS

Study period and area

Vegetation survey was conducted from June to November 2020. The research sites were located along the streams of Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia (Figure 1). The sampling was conducted systematically following the mainstream of Barumun River (Station 1) through the two rivulets namely Tasik Rivulet (Station 2) and Titi Kembar Rivulet (Station 3).

Data collection

Data on vegetation were collected using a combination method between line transect and quadratic plots placed at each river side (Simon 2007). The total number of observation plots was 48 plots consisting of 24 plots of Barumun River, 12 plots of Tasik Rivulet and 12 plots of Titi Kembar Rivulet. The plant species were recorded for each community structure present in the sampling sites, i.e trees, poles, saplings, and seedlings based on the classification by Wyatt-Smith (1963).

The classification for each structure is defined as follows: tree having a diameter at breast height (DBH) >20 cm, pole with 10≥DBH>20 cm, sapling with a height >1.5 m, seedling with a height less than 1.5 m, and shrub with multiple woody stems and a height less than 5 m. The plots were conditioned for each structure, i.e. 20×20 m^2 for trees, 10×10 m^2 for poles, 5×5 m^2 for saplings and shrubs, and 2×2 m^2 for seedlings. Plant species were identified using a collection of identification guides (Whitmore 1973; Whitmore 1978; Soerianegara and Lemmens 1994; Lemmens et al. 1995; Balgooy et al. 2015).

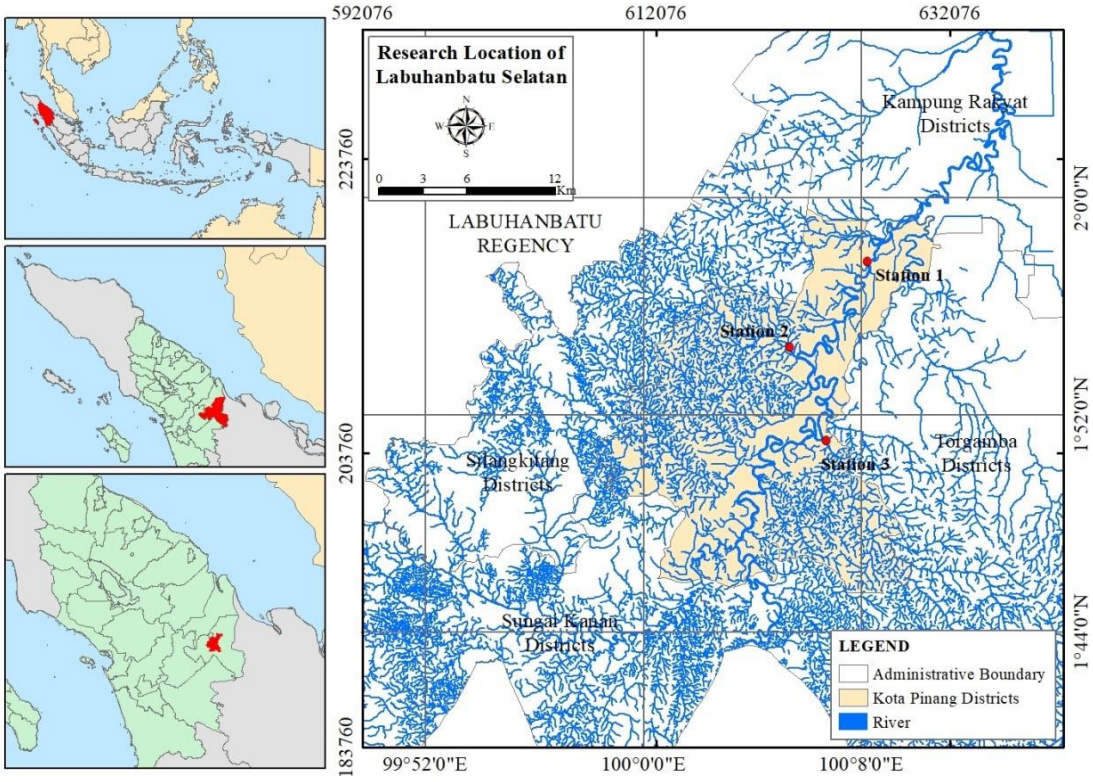

Figure 1. Map of study area showing the sampling sites (thick blue line) for riparian vegetation at Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Data analysis

Ecological parameters were analyzed including importance value index (IVI) obtained from the sum of relative density (RD), relative frequency (RF), and relative dominance (RD) or basal area for tree and pole class and without RD for sapling and seedling levels. Species diversity of each stage was measured using the following equation:

$$Shannon's\ diversity\ index\ (H') = -\sum_{i=1}^{s} pi \ln pi$$

Where, *p* is the proportion of (*n*/*N*) of individuals of a certain plant species (*n*) divided by the total number of individuals (*N*). *ln* is a natural logarithmic value, Σ is the sum of calculations while *s* is the number of species. The level of species diversity is classified as high (*H'*>3), moderate (1≤*H'*≤3), and low (*H'*<1) (Odum 1996). Margalef's species richness was calculated using the formula (Magurran 1988):

$$D_{mg} = \frac{S-1}{Ln\ N}$$

Where, D_{mg} is Margalef's species richness index, *S* is the number of documented species. *N* is the total number of individuals and *ln* is a natural logarithmic value. The level of species richness is classified as high (D_{mg}>5), moderate (3.5≤ D_{mg}≤5), and low (D_{mg}<3.5). Species evenness is a measure of the relative abundance of the different species in an area. The index was determined using the following equation:

$$J' = \frac{H'}{H_{max}}$$

Where, *H'* is Shannon's diversity index of a study site, H_{max} is the natural logarithmic value of *S* (species richness).

RESULTS AND DISCUSSION

Species composition of riparian vegetation in Barumun Watershed

The results documented a total of 51 plant species in the Barumun Watershed in which 37 species were found in the Barumun River, 20 species in the Tasik Rivulet, and 17 species in the Titi Kembar Rivulet. Plant species consisted of several habitus such as herbs, palms, shrubs, climbers and trees. The trees were composed of 22 species (43.13%), herbs with 22 species (43.13%), climbers with 3 species (5.88%), shrubs with 2 species (3.92%), and palms with 2 species (3.92%). There were 42 species of wild plants (82.35%) and 9 species of cultivated plants (17.64%). The presence of wild plant species around Barumun Watershed must be preserved as the local timber species in protecting the watershed. The species composition of riparian vegetation collected in the Barumun Watershed is presented in Table 1.

The plant species recorded in all observation sites were *Elaeis guineensis, Nephrolepis biserrata, Cayratia trifolia, Stenochlaena palustris,* and *Swietenia mahagoni. Elaeis guineensis* Jacq. (oil palm) was not considered the native plant species but commodity plant deliberately cultivated by the local community. Oil palm is a tropical plant that is thought to have originated from Nigeria (West Africa). Oil palm is an important oil-producing crop in the tropical region that can also be used as a raw material for the food and non-food industries (Herdiansyah et al. 2020). On the banks of the Barumun River, the oil palm plantations maintained by the local community are one of the primary resources of livelihood of the community. It was not surprising that the current expansion of oil palm in the Barumun Watershed may become the potential driving force of deforestation to the riparian community in the future.

Nephrolepis biserrata (Davalliaceae) is a fern species also known as gray nails. The fern was the most commonly found species around the Barumun River which may be regarded as a cosmopolite species. A study by Riastuti et al. (2018) also reported the presence of *Nephrolepis biserrata* in the Lake Aur, Musi District, Indonesia. *Cayratia trifolia* (Vitaceae) is one of the wild plants mostly found in the Southeast Asia region, including Indonesia with tendrils to grow as a climber plant (Prasetyo et al. 2016). *Stenochlaena palustris* (Blechnaceae) is a fern species that thrives on peat and sandy soils (Adawiyah and Rizki 2018). *Swietenia mahagoni* (Meliaceae) is a well-known timber species in Indonesia. The mahogany trees documented around the Barumun Watershed were also deliberately planted by the Forestry Service in order to reforest the riverbank.

Importance Value Index (IVI) of the vegetation structure in Barumun Watershed

Important Value Index (IVI) is used to rank species based on their ecological importance. This indicator is used to determine the dominant species at each growth stage in a particular community (Susilowati et al. 2020). Smith (1977) stated that the dominant species is a species that can utilize its environment efficiently from other species in the same place. The IVI from each stage from trees, poles, saplings, seedlings, and shrubs are presented in Tables 2-6. The highest IVI for tree species at Barumun River was *Hevea brasiliensis* (108.28) while at Titi Kembar Rivulet was *Cryptocarya* sp. (123.24). There was no record of tree species at Tasik Rivulet (Table 2). *Muntingia calabura* had the highest IVI for pole stage at Tasik Rivulet and Barumun River with 170.37 and 170.37, respectively while *Swietenia mahagoni* had the highest IVI at Titi Kembar Rivulet with 150.92 (Table 3). The highest IVI for sapling stage was *Nauclea orientalis* (200) at Tasik Rivulet, *Bridelia tomentosa* (87.00) at Titi Kembar Rivulet, and *Tilia tomentosa* (49.57) at Barumun River (Table 4). The highest IVI for seedling species was *Psychotria viridiflora* (158.33) at Tasik Rivulet, *Hibiscus tiliaceus* (94.44) at Barumun River, and *Bridelia tomentosa* (61.58) at Titi Kembar Rivulet. The highest IVI for shrub species was *Calamus axillaris* (62.70) at Titi Kembar Rivulet, *Axonopus compressus* (40.45) at Barumun River, and *Elaeis guineensis* (37.07) at Tasik River (Table 6).

Table 1. Species list and composition of riparian vegetation around the Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Local name	Scientific name	Family	Station 1	Station 2	Station 3	Habitus	Growth mode
Gelagah	*Saccharum spontaneum*	Poaceae	+	+	-	Herb	Wild
Rumput manis	*Axonopus compressus*	Poaceae	+	+	-	Herb	Wild
Pakis kawat	*Gleichenia Linearis*	Gleicheniaceae	+	-	-	Herb	Wild
Pakis makan	*Diplazium esculentum*	Athyriaceae	+	-	-	Herb	Wild
Sawit	*Elaeis guineensis*	Arecaceae	+	+	+	Palm	Cultivated
Panggu	*Saccharum revennae*	Poaceae	+	+		Herb	Wild
Pakis liar	*Nephrolepis biserrata*	Nephrolepidaceae	+	+	+	Herb	Wild
Syngonium	*Syngonium podophyllum*	Araceae	+	+		Herb	Wild
Rumput rambatan	*Mikania micrantha*	Asteraceae	+	-	-	Herb	Wild
Rumput kawat	*Thuarea involute*	Poaceae	+	+		Herb	Wild
Andor anggur	*Cayratia trifolia*	Vitaceae	+	+	+	Climber	Wild
Paria gunung	*Cardiospermum halicacabum*	Sapindaceae	+	+	-	Herb	Wild
Kelapa	*Cocos nucifera*	Arecaceae	+	-	-	Palm	Cultivated
Rumput anting	*Acalypha indica*	Euphorbiaceae	+	-	-	Herb	Wild
Bambu kuning	*Bambusa vulgaris var. striata*	Poaceae	+	-	-	Herb	Cultivated
Rumput teki	*Cyperus rotundus*	Cyperaceae	+	-	-	Herb	Wild
Rumput Israel	*Justicia Gangetica*	Acanthaceae	+	+	-	Herb	Wild
Senduduk bulu	*Clidemia hirta*	Melastomataceae	+	-	-	Shrub	Wild
Tuba ri	*Derris elliptica*	Fabaceae	+	-	-	Climber	Wild
Babadotan	*Ageratum conyzoides*	Asteraceae	+	-	-	Herb	Wild
Pakis Pucuk merah	*Stenochlaena palustris*	Blechnaceae	+	+	+	Herb	Wild
Rumput Israel	*Asystasia gangetica*	*Acanthaceae*	+	-	-	Herb	Wild
Meniran	*Phyllanthus niruri*	Phyllanthaceae	+	-	-	Herb	Wild
Sidaguri	*Sida Rhombifolia*	Malvaceae	+	-	-	Herb	Wild
Puri malu	*Mimosa pudica*	Fabaceae	-	+	-	Herb	Wild
Duri	*Leucaena sp*	Fabaceae	-	+	-	Shrubs	Wild
Pangkat	*Calamus sp*	Arecaceae	-	+	+	Climbers	Wild
Uppe	*Saccharum sp*	Poaceae	-	+	+	Herb	Wild
Bambu	*Bambusa sp*	Poaceae	-	-	+	Herb	Wild
Hatinar	*Tilia tomentosa*	Malvaceae	+	-	-	Tree	Wild
Waru	*Hibiscus tiliaceus*	Malvaceae	+	-	-	Tree	Wild
Jambu	*Psidium guajava*	Myrtaceae	+	-	-	Tree	Cultivated
Sikkam	*Bischovia javanica*	Phyllanthaceae	+	-	-	Tree	Wild
Mahoni	*Swietenia mahagoni*	Meliaceae	+	+	+	Tree	Cultivated
Cia	*Elaeagnus angustifolia*	Elaeagnaceae	+	-	-	Tree	Wild
Mangga	*Mangifera indica*	Anacardiaceae	+	-	-	Tree	Cultivated
Ikan-ikan	*Bridelia tomentosa*	Phyllanthaceae	+	-	+	Tree	Wild
Kepadan	*Grewia picta*	Tiliciae	+	-	+	Tree	Wild
Seri	*Muntingia calabura*	Muntingiaceae	+	+	-	Tree	Wild
Karet	*Hevea brasilensis*	Euphorbiaceae	+	-	+	Tree	Cultivated
Gala-gala	*Ficus racemosa*	Moraceae	+	-	+	Tree	Wild
Jati	*Gmelina arborea*	Verbenaceae	+	-	-	Tree	Cultivated
Kapas	*Gossypium hirsutum*	Malvaceae	+	-	-	Tree	Wild
Jambu manik	*Syzygium buxifolium*	Myrtaceae	-	-	+	Tree	Wild
Duri-duri	*Leucaena sp*	Fabaceae	-	-	+	Tree	Wild
Cikaok	*Cryptocarya sp*	Lauraceae	-	-	+	Tree	Wild
Beringin	*Ficus benjamina*	Moraceae	-	-	+	Tree	Wild
Rambai	*Baccaurea motleyana*	Phyllanthaceae	-	-	+	Tree	Wild
Salung-salung	*Psychotria viridiflora*	Rubiaceae	-	+	-	Tree	Wild
-	*Croton argyratus*	Euphorbiaceae	-	+	-	Tree	Wild
Longkidae	*Nauclea orientalis*	Rubiaceae	-	+	-	Tree	Cultivated
Total			37	20	17		

Note: + = Present, – = Absent

Table 2. Importance Value Index (IVI) of tree stage in Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Species	Relative density	Relative frequency	Relative basal area	IVI
Barumun River				
Hevea brasiliensis	47.62	12.50	48.16	108.28
Muntingia calabura	23.81	12.50	13.38	49.69
Hibiscus tiliaceus	9.52	25.00	11.10	45.63
Ficus racemosa	9.52	25.00	16.72	51.25
Gmelina arborea	4.76	12.50	4.70	21.97
Gossypium hirsutum	4.76	12.50	5.92	23.19
Titi Kembar Rivulet				
Cryptocarya sp	44.44	37.50	41.29	123.24
Ficus benjamina	22.22	25.00	16.67	63.89
Hevea brasiliensis	11.11	12.50	10.20	33.81
Baccaurea motleyana	11.11	12.50	11.94	35.55
Anthocephalus cadamba	11.11	12.50	19.90	43.51

Table 3. Importance Value Index (IVI) of pole stage in Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Species	Relative density	Relative frequency	Relative basal area	IVI
Barumun River				
Muntingia calabura	50.00	50.00	70.37	170.37
Swietenia mahagoni	50.00	50.00	29.63	129.63
Titi Kembar Rivulet				
Swietenia mahagoni	42.86	40.00	68.06	150.92
Cryptocarya sp	42.86	40.00	9.68	92.54
Ficus racemosa	14.29	20.00	22.26	56.55
Tasik Rivulet				
Muntingia calabura	77.78	50.00	2.21	226.88
Swietenia mahagoni	22.22	50.00	0.02	73.12

Table 4. Importance Value Index (IVI) of sapling stage in Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Species	Relative density	Relative frequency	IVI
Barumun River			
Tilia tomentosa	38.46	11.11	49.57
Eucalyptus alba	15.38	22.22	37.61
Bischovia javanica	7.69	11.11	18.80
Swietenia mahagoni	7.69	11.11	18.80
Elaeagnus angustifolia	7.69	11.11	18.80
Mangifera indica	7.69	11.11	18.80
Bridelia tomentosa	7.69	11.11	18.80
Grewia picta	7.69	11.11	18.80
Titi Kembar Rivulet			
Bridelia tomentosa	50.01	40.00	87.00
Ficus benjamina	16.67	20.00	36.67
Cryptocarya sp	16.67	20.00	36.67
Grewia picta	16.67	20.00	36.67
Tasik Rivulet			
Nauclea orientalis	100	100	200

Table 5. Importance Value Index (IVI) of seedling stage in Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Species	Relative density	Relative frequency	IVI
Barumun River			
Hibiscus tiliaceus	50.00	44.44	94.44
Psidium guajava	30.00	33.33	63.33
Tilia tomentosa	20.00	22.22	42.22
Titi Kembar Rivulet			
Bridelia tomentosa	31.58	30	61.58
Leucaena sp	26.32	20	46.32
Hevea brasiliensis	15.79	20	35.79
Syzygium buxifolium	15.79	10	25.79
Cryptocarya sp	5.26	10	15.26
Ficus racemosa	5.26	10	15.26
Tasik Rivulet			
Psychotria viridiflora	83.33	75	158.33
Croton argyratus	16.67	25	41.67

Riparian trees are important factors to indicate the water quality of springs and their drains (Semiun et al., 2013). A high riparian tree diversity may be associated with high oxygen levels in rivers and streams, which serve as clean water resources (ecosystem service) for human and livestock (Luke et al. 2018). However, due to some concerning anthropogenic activities, the diversity of riparian vegetation is being threatened as documented in previous studies in human-altered sites (Izzati and Hasibuan 2019; Takarina et al. 2021). Rubber (*Hevea brasiliensis*) was documented as the highest IVI for tree stage in Barumun River. The dominant rubber tree

(Euphorbiaceae) in the study area may be explained due to its adaptive trait by forming an early wide canopy and sturdy root system to obtain an optimum amount of water and soil nutrients (Bibiana et al. 2015). Hence, the species also survive under low sunlight intensity which then outcompeting the surrounding plant species. A study by Guardiola-Claramonte et al. (2010) also revealed that *H. brasiliensis* may dominate landscapes around catchment explaining their abundant presence in the riparian ecosystem. The phenology of rubber is affected by the high physiological demand of water, which may later replace native riparian vegetation. In addition, the rubber was also planted as industrial crops with the center of production in the North Sumatra, South Sumatra and Riau Province which also explained the distribution of this species in other adjacent and undisturbed areas (Hytonen et al. 2019). Meanwhile, the documentation of *Cryptocarya* sp. (Lauraceae) in our study was still limited compared to another region in the northern part of Sumatra. The species has been well documented in freshwater swamp forests, Riau (Lisdayanti et al. 2016), freshwater swamp forest, West Sumatra (Yusuf and Purwaningsih 2009), and riverine forest, Aceh (Sambas and Siregar 2004).

Species diversity, richness, and evenness index of riparian vegetation around Barumun Watershed

The Shannon diversity index in the study area was ranged between 0.38 (Titi Kembar Rivulet) to 2.26 (Tasik Rivulet) classified as low to moderate level of diversity. In general, low species diversity was recorded in all pole stages in the Barumun Watershed (0.38-0.69). The diversity index was quite stable in the Barumun River (*H'* = 0.69-2.24) and Titi Kembar Rivulet (*H'* = 0.38-1.72) but not in Tasik Rivulet due to the absence of sapling and tree stage. Following a similar trend, the highest species richness or D_{mg} in the study sites was recorded in Barumun River (23.83), followed by Tasik Rivulet (16.82) and Titi Kembar Rivulet (6.50). All documented species richness belonged to the shrub structure. In addition, the level of species richness in the study area was categorized from low to high. The species evenness (*J'*) in the study area was noted for some dominance in the Titi Kembar Rivulet (0.35) for the pole structure while other sites such as in the Barumun River and Titi Kembar Rivulet showed a moderate to equal species distribution.

Table 6. Importance Value Index (IVI) of shrub stage in Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Species	Relative Density	Relative Frequency	IVI
Barumun River			
Axonopus compressus	28.13	12.33	40.45
Saccharum spontaneum	18.55	17.81	36.36
Elaeis guineensis	18.16	17.81	35.97
Saccharum sp	7.81	8.22	16.03
Titi Kembar Rivulet			
Calamus axillaris	38.89	23.81	62.70
Cayratia trifolia	11.11	28.57	39.68
Elaeis guineensis	19.44	14.29	33.73
Stenochlaena palustris	11.11	14.29	25.40
Saccharum sp	9.26	4.76	14.02
Nephrolepis biserrata	4.63	4.76	10.00
Thuarea involute	4.63	4.76	10.00
Tasik Rivulet			
Elaeis guineensis	18.14	18.92	37.07
Axonopus compressus	23.16	5.41	28.57
Cyperus rotundus	12.74	12.74	20.85
Saccharum sp	7.72	10.81	18.53
Saccharum revennae	10.03	8.11	18.15
Saccharum spontaneum	5.40	10.81	16.22
Nephrolepis biserrata	9.65	2.70	12.36

Table 7. Shannon's diversity index, Margalef's species richness, and evenness index of the riparian community structure in the Barumun Watershed, South Labuhanbatu District, North Sumatra, Indonesia

Structure	Shannon's Diversity Index (*H'*)	Category	Margalef's species richness (D_{mg})	Category	Evenness Index (*J'*)	Category
Barumun River						
Shrub	2.24	Moderate	23.83	High	0.70	Moderate
Seedling	1.03	Moderate	2.56	Low	0.93	Equal
Sapling	1.84	Moderate	7.51	High	0.88	Moderate
Pole	0.69	Low	1.27	Low	0.99	Equal
Tree	1.43	Moderate	5.67	High	0.79	Moderate
Titi Kembar Rivulet						
Shrub	1.72	Moderate	6.50	High	0.78	Moderate
Seedling	1.60	Moderate	5.66	High	0.89	Moderate
Sapling	1.49	Moderate	4.41	Moderate	0.92	Equal
Pole	0.38	Low	2.48	Low	0.35	Dominance
Tree	1.42	Moderate	4.54	Moderate	0.88	Moderate
Tasik Rivulet						
Shrub	2.26	Moderate	16.82	High	0.79	Moderate
Seedling	0.45	Low	1.44	Low	0.65	Moderate
Sapling	-	Low	0.63	Low	-	-
Pole	0.53	Low	1.54	Low	0.76	Moderate
Tree	-	-	-	-	-	-

In conclusion, our study documented a total of 51 plant species at three studied sites in the Barumun Watershed, South Labuhanbatu District with details of 37 species at the Barumun River, 20 species at the Tasik Rivulet, and 17 species at the Titi Kembar Rivulet. The habitus recorded among all species were herbs, palms, shrubs, climbers and trees. The composition of tree habitus was 22 species (43.13%), herbs with 22 species (43.13%), climbers with 3 species (5.88%), shrubs with 2 species (3.92%), and palms with 2 species (3.92%). The presence of the timber species around Barumun Watershed must be preserved in order to protect the hydrological function of the riverbanks.

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REFERENCES

Adawiyah R, Rizki MI. 2018. Aktivitas antioksidan ekstrak etanol akar Kalakai (*Stenochlaena palustris* Bedd) asal Kalimantan Tengah. Jurnal Pharmascience 5 (1): 71-77. DOI: 10.20527/jps.v5i1.5788. [Indonesian]

Balgooy MMJV, Low YW, Wong KM. 2015. Spot Characters for the Identification of Malesian Seed Plants: A Guide. Natural History Publications, Borneo.

Basrowi M, Hendra M, Hariani N. 2018. Komposisi dan struktur pohon riparian di Sungai Kahala Kabupaten Kutai Kartanegara. Jurnal Pro Life 5 (3): 637-649. [Indonesian]

Bibiana A, Burhannudin, Iswan D. 2015. Struktur dan komposisi vegetasi di areal petak ukur permanen (PUP) PT. Kawedar Wood Industry Kabupaten Kapuas Hulu. Jurnal Hutan Lestari 3 (1): 150-159. [Indonesian]

Guardiola-Claramonte M, Troch PA, Ziegler AD, Giambelluca TW, Durcik M, Vogler JB, Nullet MA. 2010. Hydrologic effects of the expansion of rubber (*Hevea brasiliensis*) in a tropical catchment. Ecohydrology 3 (3): 306-314. DOI: 10.1002/eco.110.

Halengkara L, Gunawan T, Purnama S. 2012. Analisis kerusakan lahan untuk pengelolaan daerah aliran sungai melalui integrasi teknik penginderaanjauh dan sistem informasi geografis. Majalah Geografi Indonesia 26 (2): 149-173. [Indonesian]

Harahap A, Barus TA, Mulya MB, Ilyas S. 2018. Macrozoobenthos diversity as bioindicator of water quality in the Bilah River, Rantauprapat. J Phys Conf Ser 1116 (5): 052026. DOI: 10.1088/1742-6596/1116/5/052026

Harahap A, Mahadewi EP, Ahmadi D, Tj HW, Ganiem LM, Rafika M, Hartanto A. 2021. Monitoring of macroinvertebrates along streams of Bilah River, North Sumatra, Indonesia. Intl J Conserv Sci 12 (1): 247-258.

Haryadi, Sunarto, Sugiyarto. 2019. Vegetation analysis of the secondary forest area in Cangkringan Resort, Mount Merapi National Park. Jurnal Biodjati 4 (1): 50-57. DOI: 10.15575/biodjati.v4i1.4239

Herdiansyah H, Negoro HA, Rusdayanti N, Shara S. 2020. Palm oil plantation and cultivation: Prosperity and productivity of smallholders. Open Agric 5 (1): 617-630. DOI: 10.1515/opag-2020-0063

Hytonen J, Nurmi J, Kaakkurivaara N, Kaakurivaara T. 2019. Rubber tree (*Hevea brasiliensis*) biomass, nutrient content, and heating values in Southern Thailand. Forest 10: 638. DOI: 10.3390/f10080638

Indriyanto. 2006. Ekologi Hutan. PT Bumi Aksara, Jakarta. [Indonesian]

Izzati U, Hasibuan HS. 2019. Riparian tree and bird diversity in Cisadane River, South Tangerang City, Indonesia. Biodiversitas 20 (2): 595-603. DOI: 10.13057/biodiv/d200241.

Lemmens RHMJ, Soerianegara I, Wong WC. 1995. Plant Resources of South-East Asia No. 5 (2) Timber Trees: Minor Commercial Timbers. Prosea Foundations, Bogor.

Lisdayanti, Hikmat A, Istomo. 2016. Komposisi flora dan keragaman tumbuhan di hutan rawa musiman, Rimbo Tujuh Danau Riau. Jurnal Penelitian Hutan dan Konservasi Alam 3 (1): 15-28. [Indonesian]

Liu L, Gudmundsson L, Hauser M, Qin D, Li S, Seneviratne SI. 2020. Soil moisture dominates dryness stress on ecosystem production globally. Nature 11: 4892. DOI: 10.1038/s41467-020-18631-1

Luke SH, Slade EM, Gray CL, Annammala KV, Drewer J, Williamson J, Agama AL, Ationg M, Mitchell SL, Vairappan CS, Struebig MJ. 2019. Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy. J Appl Ecol 56 (1): 85-92. DOI: 10.1111/1365-2664.13280

Magurran AE. 1988. Ecological Diversity and Its Measurement. Princeton University Press, Princeton.

Odum EP. 1996. Dasar-dasar Ekologi. Gadjah Mada University Press, Yogyakarta. [Indonesian]

Piao S, Yin G, Tan J, Cheng L, Huang M, Li Y, Liu R, Mao J, Myneni RB, Peng S, Poulter B, Shi X, Xiao Z, Zeng N, Wang Y. 2015. Detection and attribution of vegetation greening trend in China over the last 30 years. Glob Change Biol 21 (4): 1601-1609. DOI: 10.1111/gcb.12795

Prasetyo B, Linda R, Mukarlina. 2016. Pemanfaatan tumbuhan lakum (*Cayratia trifolia* (L.) Domin.) oleh etnis Melayu di Kecamatan Sungai Kunyit Kabupaten Mempawah. Protobiont 5 (2): 25-33. DOI: 10.26418/protobiont.v5i2.15929. [Indonesian]

Riastuti RD, Sepriyaningsih S, Ernawati D. 2018. Identifikasi divisi pteridophyta di Kawasan Danau Aur Kabupaten Musi Rawas. Jurnal Pendidikan Biologi dan Sains 1 (1): 52-70. DOI: 10.31539/bioedusains.v1i1.253. [Indonesian]

Sambas EN, Siregar M. 2004. Flora of Alas River Bank, Ketambe, Gunung Leuser National Park. BioSmart 6 (1): 33-38.

Semiun CG, Arisoesilaningsih E, Retnaningdyah C. 2013. Degradation of riparian tree diversity on spring-fed drains and its impacts to water quality, East Java. J Trop Life Sci 3 (2): 120-126.

Simon H. 2007. Metode Inventore Hutan. Pustaka Pelajar, Yogyakarta. [Indonesian]

Smith RL. 1977. Elements of Ecology and Field Biology. Harper & Row Publisher, New York.

Soerianegara I, Lemmens RHMJ. 1994. Plant Resources of South-East Asia No. 5(1) Timber Trees: Major Commercial Timbers. Prosea Foundations, Bogor.

Susilowati A, Elfiati D, Rachmat HH, Yulita KS, Hadi AN, Kusuma YS, Batu SAL. 2020. Vegetation structure and floristic composition of tree species in the habitat of *Scaphium macropodum* in Gunung Leuser National Park, Sumatra, Indonesia. Biodiversitas 21 (7): 3025-3033. DOI: 10.13057/biodiv/d210720

Takarina ND, Sinaga IL, Kultsum TR. 2021. Riparian plant diversity in relation to artisanal mining sites in Cikidang River, Banten, Indonesia. Biodiversitas 22 (1): 401-407. DOI: 10.13057/biodiv/d220149

Tian F, Liu LZ, Yang JH, Wu JJ. 2021. Vegetation greening in more than 94% of the Yellow River Basin (YRB) region in China during the 21st century caused jointly by warming and anthropogenic activities. Ecol Indic 125: 107479. DOI: 10.1016/j.ecolind.2021.107479

Whitmore TC. 1973. Tree Flora of Malaya: A Manual for Foresters. Volume Two. Longman Malaysia SDN, Malaysia.

Whitmore TC. 1978. Tree Flora of Malaya: A Manual for Foresters. Volume Three. Longman Malaysia SDN, Malaysia.

Wyatt-Smith J. 1963. Manual of Malayan Silviculture for Inland Forest. Forest Research Institute Malaysia, Malaysia.

Yusuf R, Purwaningsih. 2009. Studi vegetasi hutan rawa air tawar di Cagar Alam Rimbo Panti, Sumatera Barat. Berita Biologi 9 (5): 491-508. [Indonesian]