

# 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

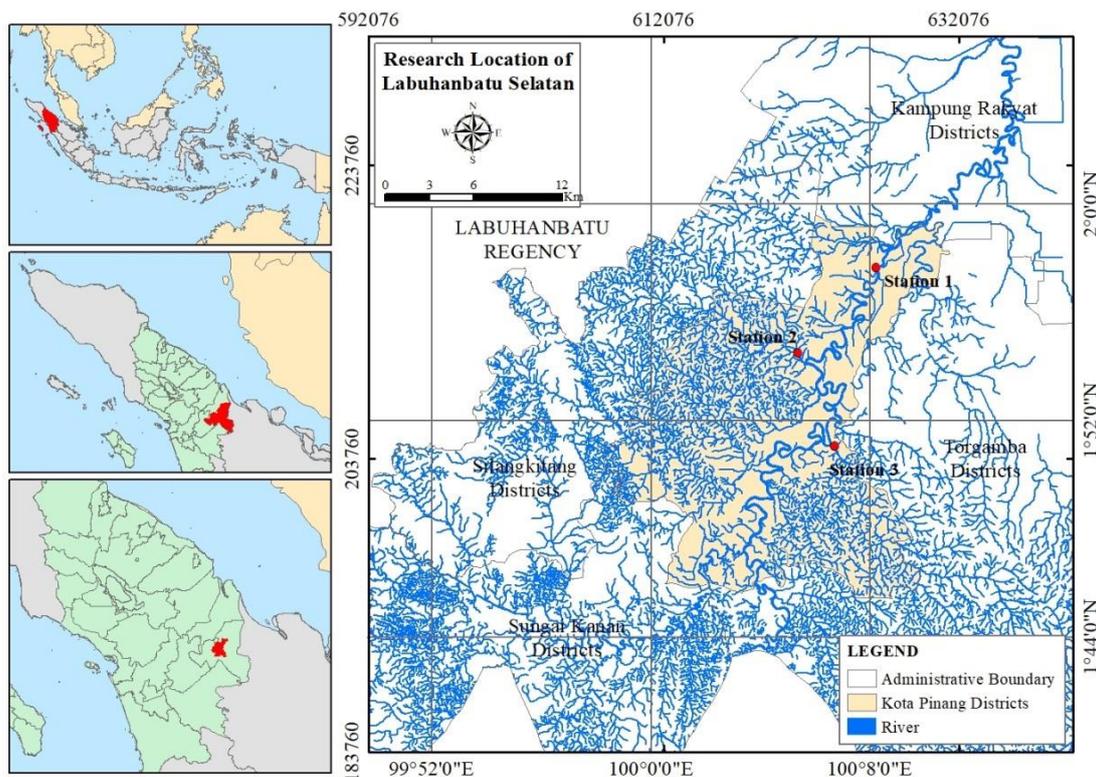
Vegetation survey was conducted from June to November 2020. The research sites were located along the

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  $10 \geq \text{DBH} > 20$  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.  $20 \times 20$  m<sup>2</sup> for trees,  $10 \times 10$  m<sup>2</sup> for poles,  $5 \times 5$  m<sup>2</sup> for saplings and shrubs, and  $2 \times 2$  m<sup>2</sup> 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:

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

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,  $\Sigma$  is the sum of calculations while  $s$  is the number of species. The level of species diversity is classified as high ( $H' > 3$ ), moderate ( $1 \leq H' \leq 3$ ), 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 ( $3.5 \leq D_{mg} \leq 5$ ), 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           | <i>Saccharum spontaneum</i>          | Poaceae          | +         | +         | -         | Herb     | Wild        |
| Rumput manis      | <i>Axonopus compressus</i>           | Poaceae          | +         | +         | -         | Herb     | Wild        |
| Pakis kawat       | <i>Gleichenia Linearis</i>           | Gleicheniaceae   | +         | -         | -         | Herb     | Wild        |
| Pakis makan       | <i>Diplazium esculentum</i>          | Athyriaceae      | +         | -         | -         | Herb     | Wild        |
| Sawit             | <i>Elaeis guineensis</i>             | Arecaceae        | +         | +         | +         | Palm     | Cultivated  |
| Panggu            | <i>Saccharum revennae</i>            | Poaceae          | +         | +         | -         | Herb     | Wild        |
| Pakis liar        | <i>Nephrolepis biserrata</i>         | Nephrolepidaceae | +         | +         | +         | Herb     | Wild        |
| Syngonium         | <i>Syngonium podophyllum</i>         | Araceae          | +         | +         | -         | Herb     | Wild        |
| Rumput rambatan   | <i>Mikania micrantha</i>             | Asteraceae       | +         | -         | -         | Herb     | Wild        |
| Rumput kawat      | <i>Thuarea involute</i>              | Poaceae          | +         | +         | -         | Herb     | Wild        |
| Andor anggur      | <i>Cayratia trifolia</i>             | Vitaceae         | +         | +         | +         | Climber  | Wild        |
| Paria gunung      | <i>Cardiospermum halicacabum</i>     | Sapindaceae      | +         | +         | -         | Herb     | Wild        |
| Kelapa            | <i>Cocos nucifera</i>                | Arecaceae        | +         | -         | -         | Palm     | Cultivated  |
| Rumput anting     | <i>Acalypha indica</i>               | Euphorbiaceae    | +         | -         | -         | Herb     | Wild        |
| Bambu kuning      | <i>Bambusa vulgaris var. striata</i> | Poaceae          | +         | -         | -         | Herb     | Cultivated  |
| Rumput teki       | <i>Cyperus rotundus</i>              | Cyperaceae       | +         | -         | -         | Herb     | Wild        |
| Rumput Israel     | <i>Justicia Gangetica</i>            | Acanthaceae      | +         | +         | -         | Herb     | Wild        |
| Senduduk bulu     | <i>Clidemia hirta</i>                | Melastomataceae  | +         | -         | -         | Shrub    | Wild        |
| Tuba ri           | <i>Derris elliptica</i>              | Fabaceae         | +         | -         | -         | Climber  | Wild        |
| Babadotan         | <i>Ageratum conyzoides</i>           | Asteraceae       | +         | -         | -         | Herb     | Wild        |
| Pakis Pucuk merah | <i>Stenochlaena palustris</i>        | Blechnaceae      | +         | +         | +         | Herb     | Wild        |
| Rumput Israel     | <i>Asystasia gangetica</i>           | Acanthaceae      | +         | -         | -         | Herb     | Wild        |
| Meniran           | <i>Phyllanthus niruri</i>            | Phyllanthaceae   | +         | -         | -         | Herb     | Wild        |
| Sidaguri          | <i>Sida Rhombifolia</i>              | Malvaceae        | +         | -         | -         | Herb     | Wild        |
| Puri malu         | <i>Mimosa pudica</i>                 | Fabaceae         | -         | +         | -         | Herb     | Wild        |
| Duri              | <i>Leucaena sp</i>                   | Fabaceae         | -         | +         | -         | Shrubs   | Wild        |
| Pangkat           | <i>Calamus sp</i>                    | Arecaceae        | -         | +         | +         | Climbers | Wild        |
| Uppe              | <i>Saccharum sp</i>                  | Poaceae          | -         | +         | +         | Herb     | Wild        |
| Bambu             | <i>Bambusa sp</i>                    | Poaceae          | -         | -         | +         | Herb     | Wild        |
| Hatinar           | <i>Tilia tomentosa</i>               | Malvaceae        | +         | -         | -         | Tree     | Wild        |
| Waru              | <i>Hibiscus tiliaceus</i>            | Malvaceae        | +         | -         | -         | Tree     | Wild        |
| Jambu             | <i>Psidium guajava</i>               | Myrtaceae        | +         | -         | -         | Tree     | Cultivated  |
| Sikkam            | <i>Bischofia javanica</i>            | Phyllanthaceae   | +         | -         | -         | Tree     | Wild        |
| Mahoni            | <i>Swietenia mahagoni</i>            | Meliaceae        | +         | +         | +         | Tree     | Cultivated  |
| Cia               | <i>Elaeagnus angustifolia</i>        | Elaeagnaceae     | +         | -         | -         | Tree     | Wild        |
| Mangga            | <i>Mangifera indica</i>              | Anacardiaceae    | +         | -         | -         | Tree     | Cultivated  |
| Ikan-ikan         | <i>Bridelia tomentosa</i>            | Phyllanthaceae   | +         | -         | +         | Tree     | Wild        |
| Kepadon           | <i>Grewia picta</i>                  | Tilicidae        | +         | -         | +         | Tree     | Wild        |
| Seri              | <i>Muntingia calabura</i>            | Muntingiaceae    | +         | +         | -         | Tree     | Wild        |
| Karet             | <i>Hevea brasiliensis</i>            | Euphorbiaceae    | +         | -         | +         | Tree     | Cultivated  |
| Gala-gala         | <i>Ficus racemosa</i>                | Moraceae         | +         | -         | +         | Tree     | Wild        |
| Jati              | <i>Gmelina arborea</i>               | Verbenaceae      | +         | -         | -         | Tree     | Cultivated  |
| Kapas             | <i>Gossypium hirsutum</i>            | Malvaceae        | +         | -         | -         | Tree     | Wild        |
| Jambu manik       | <i>Syzygium buxifolium</i>           | Myrtaceae        | -         | -         | +         | Tree     | Wild        |
| Duri-duri         | <i>Leucaena sp</i>                   | Fabaceae         | -         | -         | +         | Tree     | Wild        |
| Cikaok            | <i>Cryptocarya sp</i>                | Lauraceae        | -         | -         | +         | Tree     | Wild        |
| Beringin          | <i>Ficus benjamina</i>               | Moraceae         | -         | -         | +         | Tree     | Wild        |
| Rambai            | <i>Baccaurea motleyana</i>           | Phyllanthaceae   | -         | -         | +         | Tree     | Wild        |
| Salung-salung     | <i>Psychotria viridiflora</i>        | Rubiaceae        | -         | +         | -         | Tree     | Wild        |
| -                 | <i>Croton argyratus</i>              | Euphorbiaceae    | -         | +         | -         | Tree     | Wild        |
| Longkidae         | <i>Nauclea orientalis</i>            | 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    |
|------------------------------|------------------|--------------------|---------------------|--------|
| <b>Barumun River</b>         |                  |                    |                     |        |
| <i>Hevea brasiliensis</i>    | 47.62            | 12.50              | 48.16               | 108.28 |
| <i>Muntingia calabura</i>    | 23.81            | 12.50              | 13.38               | 49.69  |
| <i>Hibiscus tiliaceus</i>    | 9.52             | 25.00              | 11.10               | 45.63  |
| <i>Ficus racemosa</i>        | 9.52             | 25.00              | 16.72               | 51.25  |
| <i>Gmelina arborea</i>       | 4.76             | 12.50              | 4.70                | 21.97  |
| <i>Gossypium hirsutum</i>    | 4.76             | 12.50              | 5.92                | 23.19  |
| <b>Titi Kembar Rivulet</b>   |                  |                    |                     |        |
| <i>Cryptocarya</i> sp        | 44.44            | 37.50              | 41.29               | 123.24 |
| <i>Ficus benjamina</i>       | 22.22            | 25.00              | 16.67               | 63.89  |
| <i>Hevea brasiliensis</i>    | 11.11            | 12.50              | 10.20               | 33.81  |
| <i>Baccaurea motleyana</i>   | 11.11            | 12.50              | 11.94               | 35.55  |
| <i>Anthocephalus cadamba</i> | 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    |
|----------------------------|------------------|--------------------|---------------------|--------|
| <b>Barumun River</b>       |                  |                    |                     |        |
| <i>Muntingia calabura</i>  | 50.00            | 50.00              | 70.37               | 170.37 |
| <i>Swietenia mahagoni</i>  | 50.00            | 50.00              | 29.63               | 129.63 |
| <b>Titi Kembar Rivulet</b> |                  |                    |                     |        |
| <i>Swietenia mahagoni</i>  | 42.86            | 40.00              | 68.06               | 150.92 |
| <i>Cryptocarya</i> sp      | 42.86            | 40.00              | 9.68                | 92.54  |
| <i>Ficus racemosa</i>      | 14.29            | 20.00              | 22.26               | 56.55  |
| <b>Tasik Rivulet</b>       |                  |                    |                     |        |
| <i>Muntingia calabura</i>  | 77.78            | 50.00              | 2.21                | 226.88 |
| <i>Swietenia mahagoni</i>  | 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   |
|-------------------------------|------------------|--------------------|-------|
| <b>Barumun River</b>          |                  |                    |       |
| <i>Tilia tomentosa</i>        | 38.46            | 11.11              | 49.57 |
| <i>Eucalyptus alba</i>        | 15.38            | 22.22              | 37.61 |
| <i>Bischofia javanica</i>     | 7.69             | 11.11              | 18.80 |
| <i>Swietenia mahagoni</i>     | 7.69             | 11.11              | 18.80 |
| <i>Elaeagnus angustifolia</i> | 7.69             | 11.11              | 18.80 |
| <i>Mangifera indica</i>       | 7.69             | 11.11              | 18.80 |
| <i>Bridelia tomentosa</i>     | 7.69             | 11.11              | 18.80 |
| <i>Grewia picta</i>           | 7.69             | 11.11              | 18.80 |
| <b>Titi Kembar Rivulet</b>    |                  |                    |       |
| <i>Bridelia tomentosa</i>     | 50.01            | 40.00              | 87.00 |
| <i>Ficus benjamina</i>        | 16.67            | 20.00              | 36.67 |
| <i>Cryptocarya</i> sp         | 16.67            | 20.00              | 36.67 |
| <i>Grewia picta</i>           | 16.67            | 20.00              | 36.67 |
| <b>Tasik Rivulet</b>          |                  |                    |       |
| <i>Nauclea orientalis</i>     | 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    |
|-------------------------------|------------------|--------------------|--------|
| <b>Barumun River</b>          |                  |                    |        |
| <i>Hibiscus tiliaceus</i>     | 50.00            | 44.44              | 94.44  |
| <i>Psidium guajava</i>        | 30.00            | 33.33              | 63.33  |
| <i>Tilia tomentosa</i>        | 20.00            | 22.22              | 42.22  |
| <b>Titi Kembar Rivulet</b>    |                  |                    |        |
| <i>Bridelia tomentosa</i>     | 31.58            | 30                 | 61.58  |
| <i>Leucaena</i> sp            | 26.32            | 20                 | 46.32  |
| <i>Hevea brasiliensis</i>     | 15.79            | 20                 | 35.79  |
| <i>Syzygium buxifolium</i>    | 15.79            | 10                 | 25.79  |
| <i>Cryptocarya</i> sp         | 5.26             | 10                 | 15.26  |
| <i>Ficus racemosa</i>         | 5.26             | 10                 | 15.26  |
| <b>Tasik Rivulet</b>          |                  |                    |        |
| <i>Psychotria viridiflora</i> | 83.33            | 75                 | 158.33 |
| <i>Croton argyrateus</i>      | 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   |
|-------------------------------|------------------|--------------------|-------|
| <b>Barumun River</b>          |                  |                    |       |
| <i>Axonopus compressus</i>    | 28.13            | 12.33              | 40.45 |
| <i>Saccharum spontaneum</i>   | 18.55            | 17.81              | 36.36 |
| <i>Elaeis guineensis</i>      | 18.16            | 17.81              | 35.97 |
| <i>Saccharum</i> sp           | 7.81             | 8.22               | 16.03 |
| <b>Titi Kembar Rivulet</b>    |                  |                    |       |
| <i>Calamus axillaris</i>      | 38.89            | 23.81              | 62.70 |
| <i>Cayratia trifolia</i>      | 11.11            | 28.57              | 39.68 |
| <i>Elaeis guineensis</i>      | 19.44            | 14.29              | 33.73 |
| <i>Stenochlaena palustris</i> | 11.11            | 14.29              | 25.40 |
| <i>Saccharum</i> sp           | 9.26             | 4.76               | 14.02 |
| <i>Nephrolepis biserrata</i>  | 4.63             | 4.76               | 10.00 |
| <i>Thuarea involute</i>       | 4.63             | 4.76               | 10.00 |
| <b>Tasik Rivulet</b>          |                  |                    |       |
| <i>Elaeis guineensis</i>      | 18.14            | 18.92              | 37.07 |
| <i>Axonopus compressus</i>    | 23.16            | 5.41               | 28.57 |
| <i>Cyperus rotundus</i>       | 12.74            | 12.74              | 20.85 |
| <i>Saccharum</i> sp           | 7.72             | 10.81              | 18.53 |
| <i>Saccharum revennae</i>     | 10.03            | 8.11               | 18.15 |
| <i>Saccharum spontaneum</i>   | 5.40             | 10.81              | 16.22 |
| <i>Nephrolepis biserrata</i>  | 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  |
|----------------------------|------------------------------------|----------|--|----------|-------------------------|-----------|
| <b>Barumun River</b>       |                                    |          |  |          |                         |           |
| 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  |
| <b>Titi Kembar Rivulet</b> |                                    |          |  |          |                         |           |
| 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  |
| <b>Tasik Rivulet</b>       |                                    |          |  |          |                         |           |
| 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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