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Species Diversity of Understory Vegetation of Riparian Zone of Upper Ranoyapo River, South Minahasa, North Sulawesi

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Abstract

Riparian is a transitional ecosystem that occupies the area between land and river water bodies. The study aimed to analyze the diversity of understory vegetation of riparian zone of the Ranoyapo River upstream at Kinamang Village and Kinamang Satu Village, South Minahasa Regency. Vegetation samples were taken at two stations, namely Station I at Kinamang Village before the Ranoyapo dam and Station II in Kinamang Satu Village after dam. The purposive sampling method was used with quadrat plot vegetation analysis. Data analysis was carried out descriptively. Understory vegetation found in the riparian zone of the Ranoyapo River upstream amounted to 16 species, namely *Acmella paniculata, Arenga pinata, Aglaonema simplex, Colocasia esculenta* var. *esculenta*, *Diospyros abyssinica, Diplazium esculentum, Diplazium* sp., *Elatostema stewardii, Ficus septica, Homalomena* sp., *Hellenia speciosa, Musa paradisiaca, Pandanus amaryllifolius, Phrynium pubinerve, Piper* sp., and *Selaginella obtusa*. The diversity index of riparian vegetation understory vegetation at Station I and Station II were 1.76 and 1.95, respectively were classified as moderate diversity. This indicated that there was ecological pressure on the riparian understory vegetation of the upstream Ranoyapo River.

Keywords: *Species diversity; riparian; understory vegetation; Ranoyapo River*

INTRODUCTION

Indonesia is a megadiverse country, meaning it possesses exceptionally high biodiversity (Bisjoe, 2015). One cause of this biodiversity decline is forest conversion in the Wallacea Region (Arif, 2023).

Riparian forests are unique ecosystems, located between aquatic and terrestrial ecosystems (Pasion et al., 2021). Riparian forests are designated as special conservation areas where their native vegetation must be maintained (Bando et al., 2016). Riparian biotic components, such as riparian vegetation, have various ecological functions, including maintaining river water quality. This is because riparian forests function as buffer zones to filter sediment and absorb pollutants (Pasion et al., 2021).

The Ranoyapo River, located in the Wallacea Region, is the main river in the Ranoyapo River Watershed, which plays a vital role in North Sulawesi. Changes in the Ranoyapo River's water quality will impact the quality of life of residents who use its water.

The study aimed to analyze the diversity of understory vegetation in the riparian zone of the upper Ranoyapo River. Riparian vegetation functions to control river water quality. This is due to its ability to absorb sediment particles and pollutants from the land carried by surface water flow before entering the river. Understory vegetation, as part of the riparian vegetation, is important to maintain as one of the efforts to conserve the Upper Watershed, which functions as soil and water conservation. The body parts of the understory vegetation function to ensure the quality of river water can be maintained. The findings obtained are important because the diversity of riparian understory vegetation is one of the efforts to conserve soil and water in the upper Ranoyapo Watershed.

METHODS

The research was conducted in the upstream riparian zone of the Ranoyapo River, South Minahasa Regency, North Sulawesi. This research was conducted from November to December 2024. The research location was Kinamang Village as Station I and Kinamang Satu Village as Station II. Sampling points in the riparian zone were placed on the left and right sides of the predetermined locations. A total of 12 sampling points were taken from two stations, with three points on the left and/or right sides of the stations (**Figure 1**).

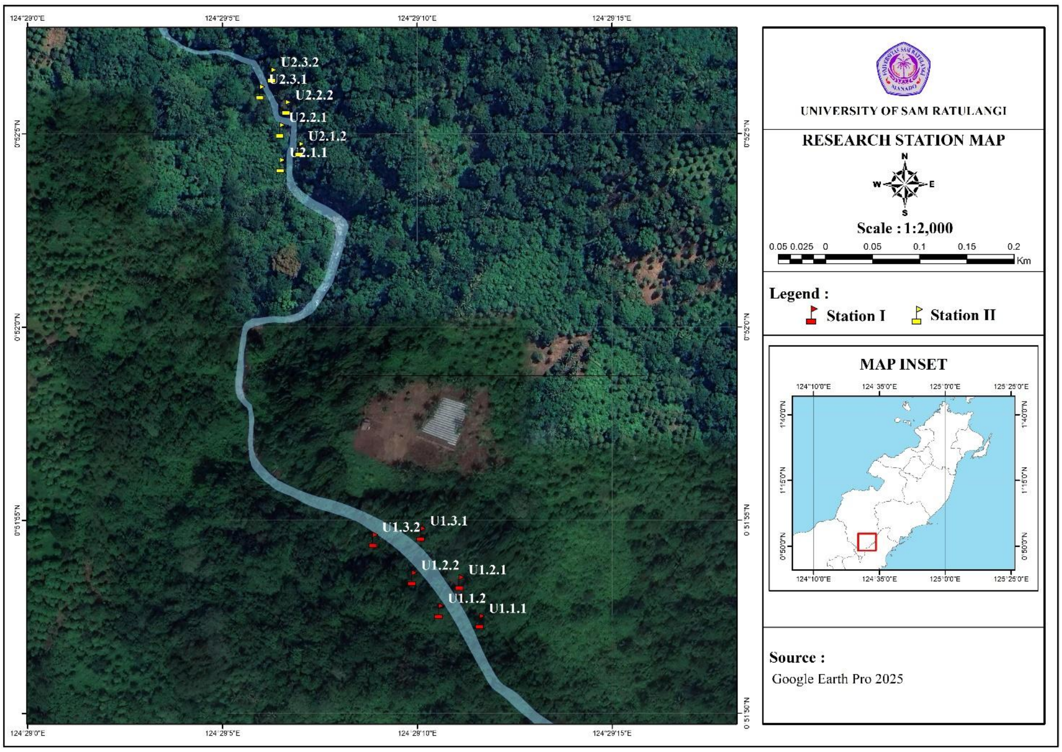

Figure 1. Research locations

Vegetation sampling in each replication used the quadrat method. The quadrat plots used in the study were 2 m x 2 m for seedling and herbaceous understory vegetation (Arbiastutie et al., 2017). Seedlings are plants ranging from seedlings/sprouts to 1.5 m tall (Lukas et al., 2021). Herbs are plants with wet, non-woody stems that reach up to 2 m tall (Diana et al., 2021).

Riparian understory vegetation samples collected in the field were preserved in 96% alcohol. The samples were then air-dried until completely dry by changing the paper and spraying with alcohol. Vegetation samples were identified in the Advanced Biology Laboratory, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University, using identification books and/or online using the websites https://powo.science.kew.org and https://plantamor.com.

Data were analyzed descriptively/qualitatively. The diversity of riparian understory vegetation structure was analyzed by calculating Abundance, Density, Relative Density (RD), Frequency, Relative Frequency (RF), Importance Value Index (IVI), and the Shannon-Wiener Diversity Index (H').

Abundance is defined as the number of understory plant individuals of a particular species in a given area (Krebs, 1989). Density is the number of individuals per unit area or volume. Relative Density (RD) is the ratio of the density of a plant species to the density of all species in a given area (Mariana & Warso, 2016). The formulas for density and relative density are as follows:

$$Kerapatan\ (K)\ =\frac{Jumlah\ total\ individu\ suatu\ jenis}{Luas\ petak\ ukur\ pengamatan\ (plot)}$$

$$Kerapatan\ relatif\ (\%)\ (KR)\ =\frac{Kerapatan\ dari\ suatu\ jenis}{Kerapatan\ seluruh\ jenis}x\ 100\%$$

Frequency indicates how widespread a plant species is in the observed plots. Relative Frequency (FR) is a percentage that compares the frequency of one plant species to the frequency of all plant species in the area (Mariana & Warso, 2016). The formula for frequency and Relative Frequency (FR) is as follows:

$$Frekuensi\ (F)\ =\frac{Jumlah\ petak\ ditemukan\ suatu\ jenis}{Jumlah\ seluruh\ petak}$$

$$Frekuensi\ relatif\ (\%)\ =\frac{Jumlah\ frekuensi\ suatu\ jenis}{Jumlah\ nilai\ frekuensi\ seluruh\ jenis}\ x\ 100\%$$

The Importance Value Index (NVI) is the result of adding Relative Frequency and Relative Density (Mariana & Warso, 2016). The formula for the Importance Index is:

$$Indeks\ Nilai\ Penting\ =\ Frekuensi\ Relatif\ +\ Kerapatan\ Relatif$$

The diversity of riparian understory plants is calculated using a species diversity index, which indicates the diversity of species within a community. This level of species diversity can also affect ecosystem stability (Ismaini, 2015). The magnitude of riparian understory plant species diversity is calculated using the Shannon-Wienner species diversity index (H') using the following formula (Aswin et al., 2020):

$$H'\ =\ -\sum(Pi)(ln\ Pi)$$

Description:
H’: Shannon-Wiener Species Diversity Index
pi: Probability for each species (ni/N)
ni: IVI for each species
N: Total IVI for all species

The Shannon-Wiener species diversity index is divided into three classes (Fachrul, 1987):
a. $H' > 3$ indicates high species diversity

b. $1 \leq H' \leq 3$ indicates moderate species diversity
c. H' < 1 indicates low species diversity

RESULTS AND DISCUSSION

The research points were located at two stations: Kinamang Village (Station I) and Kinamang I Village (Station II). The sampling coordinates are shown in **Table 1**.

Table 1. Coordinate points of research locations

Stations	Sub stations	Coordinates	
		NL	EL
Station I	U1.1	00°51'50.20"	124°29'13.53"
	U1.2	00°51'52.48"	124°29'10.98"
	U2.1	00°51'52.75"	124°29'10.56"
	U2.2	00°51'53.43"	124°29'10.51"
	U3.1	00°51'53.73"	124°29'09.72"
	U3.2	00°51'53.81"	124°29'09.16"
Station II	U1.1	00°52'01.13"	124°29'06.33"
	U1.2	00°52'04.13"	124°29'06.41"

The total abundance of understory plants at two stations in the upstream riparian zone of the Ranoyapo River at Stations I and II was 217 individuals and 160 individuals, respectively. The plant species found at both stations were 11 species each (**Table 2**) out of a total of 16 understory plant species.

Table 2. Abundance of riparian understorey in the upper Ranoyapo River

Family	Species	Abundance (individu)	
		Station I	Station II
Araceae	*Aglaonema simplex* Blume	1	6
	Colocasia esculenta var. esculenta (L.) Schott	0	1
	Homalomena Schott	6	3
Arecaceae	*Arenga pinnata* (Wurmb) Merr.	6	0
Aspleniaceae	*Diplazium esculentum* (Retz.) Sw.	2	3
	Diplazium Sw.	5	2
Asteraceae	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen	1	0
Costaceae	*Hellenia speciosa* (J. Koenig) S. R. Dutta	0	2
Ebenaceae	*Diospyros abyssinica* (Hiern) F. White	1	0
Marantaceae	*Phrynium pubinerve* Blume	5	0
Moraceae	*Ficus septica* Burm.f.	0	19
Musaceae	*Musa paradisiaca* L.	0	1
Pandanaceae	*Pandanus amaryllifolius* Roxb. ex Lindl.	2	0
Piperaceae	*Piper* sp.	0	1
Selaginellaceae	*Selaginella obtusa* (P. Beauv.) Spring	30	53
Urticaceae	*Elatostema stewardii* Merr.	158	69
	Total (N)	217	160
	Species (S)	11	11

Species *E. stewardii*, from the Urticaceae family, was found to have the highest abundance, with 158 individuals at Station I and 69 individuals at Station II. This high abundance of *E. stewardii* indicated its high adaptation to riparian environments, such as high humidity and shade. Mingkid *et a*l. (2023) also reported high abundance of *E. stewardii* in the riparian zone of the Mopilu River, South Minahasa. This species prefers riverbank or riparian habitats.

Species *S. obtusa*, from the Selaginellaceae family, was found at high abundance, with 30 individuals at Station I and 53 individuals at Station II. The high abundance of *S. obtusa* indicated its high adaptability to environments with high soil moisture. This species is known to often dominate the understory of tropical humid forest vegetation and plays an important ecological role as ground cover, helping retain moisture and reduce erosion (Setyawan et al., 2021).

The distribution of understory plants in the riparian zone of the upper Ranoyapo River showed differences between observation stations (Table 3). *E. stewardii* has a wide distribution, being found at all stations except U3.2. In contrast, species such as *Acmella paniculata, Colocasia esculenta*, and *Ficus septica* have a limited distribution, appearing at only one or two stations.

The distribution of understory plants in the riparian zone of the upper Ranoyapo River shows differences between observation stations (**Table 3**). The species E. stewardii has a wide distribution, as it was found at all stations except U3.2. In contrast, species such as Acmella paniculata, Colocasia esculenta, and Ficus septica have a limited distribution, appearing at only one or two stations.

Table 3. Distribution of riparian undergrowth in the upper Ranoyapo River

No	Spesies	Distribution
1	*A. paniculata*	U1.2.1
2	*A. pinnata*	U1.1.2; U1.2.1; U1.3.1
3	*A. simplex*	U1.1.2; U2.1.1
4	*C. esculenta*	U2.2.1
5	*D. abyssinica*	U1.2.1
6	*D. esculentum*	U2.3.1
7	*Diplazium* sp.	U1.1.1; U1.2.1; U1.2.2; U2.1.2
8	*E. stewardii*	U1.1.1; U1.1.2; U1.2.1; U1.2.2; U1.3.1; U1.3.2; U2.1.1; U2.1.2; U2.2.1; U2.2.2; U2.3.1
9	*F. septica*	U2.3.2
10	*Homalomena* sp.	U1.2.1; U2.2.1; U2.2.2
11	*H. speciosa*	U2.3.1
12	*M. paradisiaca*	U2.1.2
13	*P. amaryllifolius*	U1.3.1
14	*P. pubinerve*	U1.2.1; U1.3.1
15	*Piper* sp.	U2.2.1
16	*S. obtusa*	U1.3.1; U2.3.1; U2.3.2
	Total	37

The distribution of understory plant species at each station is strongly influenced by environmental factors, including climate, topography, soil, and anthropogenic activities. These factors influence riparian ecological processes and play a crucial role in the distribution of understory plant species. Soil moisture and nutrient availability are factors that direct riparian vegetation adaptation (Yang et al., 2022). Overall, the distribution of understory plants in the upper Ranoyapo River riparian zone reflects the complexity of interactions between biotic and abiotic factors. Continuous monitoring and management are necessary to maintain the diversity and ecological function of this area.

Species dominance within a community can be assessed using the Importance Value Index (IVI). *E. stewardii* was the dominant species at both Stations I and II, with IVIs of 101.38% and 72.5%, respectively. *S. obtusa* was the subdominant species, with IVIs of 18.59% and 44.9%, respectively (**Table 4**).

Table 4. IVI of riparian understorey of the upperRanoyapo River

No	Species	Station I			Station II		
		RD	RF	IVI	RD	RF	IVI
1	*A. paniculata*	0,5%	4,8%	5,22%	0,0%	0,0%	0,0%
2	*A. pinnata*	2,8%	14,3%	17,05%	0,0%	0,0%	0,0%
3	*A. simplex*	0,5%	4,8%	5,22%	3,8%	5,9%	9,6%
4	*C. esculenta*	0,0%	0,0%	0,0%	0,6%	5,9%	6,5%
5	*D. abyssinica*	0,5%	4,8%	5,22%	0,0%	0,0%	0,0%
6	*D. esculentum*	0,9%	4,8%	5,68%	1,9%	5,9%	7,8%
7	*Diplazium* sp.	2,3%	14,3%	16,59%	1,3%	5,9%	7,1%
8	*E. stewardii*	72,8%	28,6%	101,38%	43,1%	29,4%	72,5%
9	*F. septica*	0,0%	0,0%	0,0%	11,9%	5,9%	17,8%
10	*Homalomena* sp.	2,8%	4,8%	7,53%	1,9%	11,8%	13,6%
11	*H. speciosa*	0,0%	0,0%	0,0%	1,3%	5,9%	7,1%
12	*M. paradisiaca*	0,0%	0,0%	0,0%	0,6%	5,9%	6,5%
13	*P. amaryllifolius*	0,9%	4,8%	5,68%	0,0%	0,0%	0,0%
14	*P. pubinerve*	2,3%	9,5%	11,83%	0,0%	0,0%	0,0%
15	*Piper* sp.	0,0%	0,0%	0,0%	0,6%	5,9%	6,5%
16	*S. obtusa*	13,8%	4,8%	18,59%	33,1%	11,8%	44,9%
	Jumlah	100,0%	100,0%	200,0%	100,0%	100,0%	200,0%

The high IVI values for both species indicate that they play a significant role in the riparian understory vegetation structure. The high abundance of *E. stewardii* makes it the dominant species at both stations. This reflects its ability to adapt to humid, shady, and relatively stable environments such as riparian zones. This species is commonly found along rivers with high canopy cover, and its presence is an indicator of healthy riparian conditions and minimal disturbance (Mingkid et al., 2023).

S. obtusa was the subdominant species at both stations. This species is known as a heterosporous fern commonly found in humid areas such as riparian zones. This species acts as ground cover, retaining moisture, reducing erosion, and enriching the soil layer with organic matter (Setyawan et al., 2021).

Dominance by one or two species characterized by high INP generally occurs in stable ecosystems or those with specific environmental conditions such as extreme shade or anthropogenic disturbance (Wibowo & Dwiatmaka, 2020). The dominance of these two species is due to environmental factors that support their presence and growth.

The species diversity index (H') of understory plants in the riparian zone of the upper Ranoyapo River at Stations I and II was 1.76 and 1.95, respectively (**Table 5**). The H' index indicates moderate understory plant species diversity, as it is above 1 but less than 3 ($1 \leq H' \leq 3$).

Table 5. Diversity of understory plant species

No	Species	Station I				Station II			
		IVI	pi	lnpi	pilnpi	IVI	pi	lnpi	pilnpi
1	*A. paniculata*	5,22%	0,51	-0,68	-0,34	0,0%	0,36	-1,01	-0,37
2	*A. pinnata*	17,05%	0,08	-2,49	-0,21	0,0%	0,04	-3,33	-0,12
3	*A. simplex*	5,22%	0,03	-3,56	-0,10	9,6%	0,04	-3,25	-0,13
4	*C. esculenta*	0,0%	0,09	-2,46	-0,21	6,5%	0,00	0,00	0,00
5	*D. abyssinica*	5,22%	0,03	-3,65	-0,10	0,0%	0,05	-3,03	-0,15
6	*D. esculentum*	5,68%	0,03	-3,65	-0,10	7,8%	0,00	0,00	0,00
7	*Diplazium* sp.	16,59%	0,03	-3,65	-0,10	7,1%	0,00	0,00	0,00
8	*E. stewardii*	101,38%	0,06	-2,83	-0,17	72,5%	0,00	0,00	0,00
9	*F. septica*	0,0%	0,04	-3,28	-0,12	17,8%	0,07	-2,69	-0,18
10	*Homalomena* sp.	7,53%	0,03	-3,56	-0,10	13,6%	0,00	0,00	0,00
11	*H. speciosa*	0,0%	0,00	0,00	0,00	7,1%	0,09	-2,42	-0,21
12	*M. paradisiaca*	0,0%	0,00	0,00	0,00	6,5%	0,03	-3,43	-0,11
13	*P. amaryllifolius*	5,68%	0,00	0,00	0,00	0,0%	0,04	-3,33	-0,12
14	*P. pubinerve*	11,83%	0,00	0,00	0,00	0,0%	0,03	-3,43	-0,11
15	*Piper* sp.	0,0%	0,09	-2,38	-0,22	6,5%	0,22	-1,49	-0,34
16	*S. obtusa*	18,59%	0,00	0,00	0,00	44,9%	0,03	-3,43	-0,11
	Total	200,0%	1	-32,1	-1,76	200,0%	1	-30,8	-1,95
	H’				1,76				1,95

The number of understory plant species at both stations was the same, at 11 species, but the abundance of individuals differed, at 217 individuals at Station I and 160 individuals at Station II. The Shannon-Wiener diversity index is influenced by species richness and evenness. If species abundance is high but density is low, the H' index will decrease. This is why the H' index at Station I

(1.76) is lower than the H' index at Station II (1.95), despite the higher abundance. The lower diversity index at Station I is due to the dominance of one or more specific species, such as *E. stewardii* and *S. obtusa*, which can lower the H' value. This aligns with Strong's (2016) opinion, which stated that high dominance of one or more species can cause an imbalance in the distribution of species abundance, thus reducing the index value even though species richness is relatively high.

The H' value in the moderate category also reflects ecological pressures, both from natural and anthropogenic factors, such as land cover change and erosion. These disturbances can affect community composition and cause structural dynamics in the understory vegetation (Rahman et al., 2021).

CONCLUSION

Sixteen species of riparian undergrowth were found in the riparian zone of the upstream Ranoyapo River, *namely Acmella paniculata, Arenga pinnata, Aglaonema simplex, Colocasia esculenta* var. *esculenta, Diospyros abyssinica, Diplazium esculentum, Diplazium* sp., *Elatostema stewardii, Ficus septica*, *Homalomena* sp., *Hellenia speciosa, Musa paradisiaca, Pandanus amaryllifolius*, *Phrynium pubinerve, Piper* sp., and *Selaginella obtusa*. There were 11 species at Stations I and II. The abundance of undergrowth species at Stations I and II was 217 and 160, respectively. The riparian undergrowth diversity index was moderate, with 1.76 at Station I and 1.95 at Station II. This shows that there is pressure that affects the diversity of riparian understorey species in the upper Ranoyapo River.

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REFERENCES

Arbiastutie, Y., Marsono, D., Wahyuningsi, & Purwanto, R. (2017). Inventarisasi tumbuhan bawah berkhasiat obat di Taman Nasional Gunung Gede Pangrango Provinsi Jawa Barat berbasiskan analisis spasial. *Jurnal Tengkawan*, *7*(1), 28-45.

Arif, A. (2023, Maret 16). Keragaman hayati di Kepulauan Wallacea dalam ancaman. KOMPAS. Keragaman Hayati di Kepulauan Wallacea dalam Ancaman - Kompas.id.

Aswin, P., Anggrini, L. S., Pathori, M. A., Jumiarni, D., & Singkam, A. R. (2020). Keanekaragaman vegetasi riparian di Sungai Kampai Kabupaten Seluma. *Prosiding Seminar dan Rapat Tahunan BKS PTN Wilayah Barat Bidang MIPA Bengkulu*. p.873-882

Bando, A. H., Siahaan, R., & Langoy, M. D. (2016). Keanekaragaman vegetasi riparian di Sungai Tewalen, Minahasa Selatan-Sulawesi Utara. *Jurnal Ilmiah Sains*, 16 (1), 7-11. https://doi.org/10.35799/jis.16.1.2016.12197.

Bisjoe, A. R. H. (2015). Kawasan Wallacea dan implikasinya bagi penelitian integratif lingkungan hidup dan kehutanan. *Buletin EBONI*, 12(2), 141-148. DOI: 10.20886/buleboni.5065.

Diana, R., Mercury, Y. H., & Nurhidayah. (2021). *Ekologi tumbuhan herba dan liana*. CV. Pustaka Learning Center. Malang.

Fachrul, M. F. (2007). Metode Sampling Bioekologi. Bumi Aksara, Jakarta.

Ismaini, L. 2015. Pengaruh alelopati tumbuhan invasif (*Clidemia hirta*) terhadap germinasi biji tumbuhan asli (*Impatiens platypetala*). *Pros Sem Nas Masy Biodiv Indon, 1*(4), 834-837. doi:10.13057/psnmbi/m010429

Krebs, C.J. 1989. Experimental Analysis of Distribution and Abundanc. Third Edition. New York.

Lukas, Hastari, B., Ardianor., & Gumiri, S. (2021). Diversity of riparian plants of black water ecosystem in the Sebangau River of Central Kalimantan Indonesian. *IOP Conf. Ser.: Earth Environ. Sci*, 744, 012040. doi:10.1088/1755-1315/744/1/012040

Mariana & Warso, F. W. (2016). Analisis komposisi dan struktur vegetasi untuk menentukan indeks keanekaragaman di Kawasan Hutan Kota Pekanbaru. *Jurnal Pendidikan Biologi*, *3*(2), 90-96. https://doi.org/10.31849/bl.v3i2.339.

Mingkid, J. M., Siahaan, R., Katili, D. Y., & Tampemawa, R. M. (2023). Distribusi Elatostema J. R. Foster & G. Foster di riparian Sungai Mopilu, Minahasa Selatan – Sulawesi Utara. *Journal of Biotechnology and Conservation in Wallacea*, 3(1), 15-19. DOI: https://doi.org/10.35799/jbcw.v3i1.47231.

Pasion, B. O., Barrias, C. D. P., Asuncion, M. P., Angadol, A. H., Pabiling, R. R., Pasion, A., Braulio, A. A., & Baysa, A. M. (2021). Assessing tree diversity and carbon density of a riparian zone within a protected area in southern Philippines. *Journal of Asia-Pacific Biodiversity*, 14(1), 78-86. https://doi.org/10.1016/j.japb.2020.10.006.

Rahman, A., Sulistyaningsih, E., & Handayani, T. (2021). Keanekaragaman tumbuhan bawah pada tegakan Pinus di Hutan Pendidikan Gama Giri Mandiri. *Biosfera: Jurnal Biologi dan Pendidikan Biologi*, 34(2), 65-73.

Setyawan, A. D., Supriatna, J., Nisyawati, Nursamsi, I., Sutarno, Sugiyarto, Sunarto, Pradan, P., Budiharta, S., Pitoyo, A., Suhardono, S., Setyono, P., & Indrawan, M. (2021). Projecting Expansion Range of Selaginella zollingeriana in the Indonesian Archipelago Under Future Climate Condition. *Biodiversitas*, 22(4), 2088–2103. https://doi.org/10.13057/biodiv/d220458.

Wibowo, A., & Dwiatmaka, W. (2020). Komposisi dan struktur tumbuhan bawah pada hutan lindung kawasan perbukitan kapur. *Jurnal Hutan Lestari*, 8(3), 712–720.

Yang, J., Li, E., Zhou, R., Xia, Y., Yang, C., & Zhang, Y. (2022). The effects of edaphic factors on riparian plants in the middle and lower reaches of the Hanjiang River, China. *Plants (Basel)*, 11(4), 531. doi: 10.3390/plants11040531.