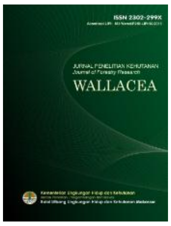

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RIPARIAN VEGETATION IN PRODUCTION FOREST AT CEMORO-MODANG RIVER, CEPU, CENTRAL JAVA

(Vegetasi Riparian dalam Hutan Produksi di Sungai Cemoro-Modang, Cepu, Jawa Tengah)

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ABSTRACT

Production forest management is aimed at achieving not only economic benefit, but also environmental and social benefit. Riparian vegetation supports the improvement of environmental protection functions in the production forests. Riparian vegetation offers a number of environmental benefits related to water quality, streambank stabilization, and habitat. The study aims to study the potency of riparian vegetation (i.e. species composition, diversity, and similarity of species composition) in Cemoro and Modang river. This research was conducted in the forest for special purposes of Cemoro-Modang, Blora Regency, Central Java Province at BKPH Pasarsore and BKPH Cabak, KPH Cepu, Perum Perhutani Unit I. The inventory of riparian vegetation was conducted by making transects along the river sides combined with sample plots sized 20 mx20 m for trees, 10 mx10 m for poles, 5 mx5 m for saplings, 2 mx2 m for seedlings and 1 mx1 m for understory. The data collected were analyzed by vegetation analysis: Importance Value Index (IVI), species diversity, and similarity index. The result of the study showed that there are 114 species in the riparian zone of Cemoro-Modang river. There are 6, 2, 20, 16, and 85 species of vegetation for trees, poles, saplings, seedlings and understory vegetation, respectively. Riparian vegetation was dominated by *Tectona grandis.* Species diversity index for trees and poles were low, saplings and seedlings were moderate and understory was high. Similarity index between Cemoro and Modang river was low (i.e. 40.4%).

Kata Kunci:
Hutan produksi,
Sungai Cemoro dan Modang,
Vegetasi riparian

ABSTRAK

Pengelolaan hutan produksi bertujuan tidak hanya untuk memperoleh manfaat ekonomi, tetapi juga manfaat lingkungan, dan sosial. Vegetasi riparian berfungsi untuk mendukung peningkatan fungsi perlindungan lingkungan di hutan produksi. Vegetasi riparian menawarkan sejumlah manfaat lingkungan terkait dengan kualitas air, stabilisasi tebing sungai, dan habitat. Penelitian ini bertujuan untuk mempelajari potensi vegetasi riparian (yaitu komposisi spesies, keragaman spesies dan kesamaan komposisi spesies) di sungai Cemoro-Modang. Penelitian ini dilakukan di KHDTK Cemoro-Modang, Kabupaten Blora, Provinsi Jawa Tengah, yang terletak pada wilayah kerja BKPH Pasarsore dan BKPH Cabak, KPH Cepu, Perum Perhutani Unit I. Inventarisasi jenis dilakukan melalui survei dengan cara membuat transek menyusuri sungai Cemoro dan Modang dengan membuat plot-plot ukur berukuran 20 mx20 m untuk vegetasi tingkat pohon, 10 mx10 m untuk tingkat tiang, 5 mx5 m untuk tingkat pancang, 2 mx2 m untuk tingkat semai dan 1 mx1 m untuk tumbuhan bawah. Hasil survei dianalisis menggunakan metode analisis vegetasi, berupa: indeks nilai penting (INP), keanekaragaman jenis, indeks kesamaan komposisi jenis (indeks similaritas). Hasil studi menunjukkan 114 spesies yang menyusun vegetasi di sempadan sungai Cemoro dan Modang. Vegetasi tingkat pohon, tiang, pancang, semai, dan tumbuhan bawah berturut-turut disusun oleh 6 spesies, 2 spesies, 20 spesies, 16 spesies, dan 85 spesies. Vegetasi riparian didominasi oleh jenis jati (Tectona grandis). Keanekaragaman jenis untuk vegetasi tingkat pohon dan tiang termasuk rendah, tingkat pancang dan semai kategori sedang, dan tumbuhan bawah termasuk tinggi. Indeks kesamaan komposisi jenis antara sungai Cemoro dan sungai Modang tergolong rendah yaitu hanya sebesar 40,4%.

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I. INTRODUCTION

Production forest is defined as a forest area that is set by the government to carry out basic functions of producing forest products. Production forest management is aimed at achieving not only economic benefit, but also environmental and social benefit (Republik Indonesia, 1999). The riparian zones in the production forests were designated as protected area that are part of the local protected area (Republik Indonesia, 2008). Riparian zones are lands adjacent to a stream, river or other waterbodies. These lands affect and are affected by the stream or water bodies. Undisturbed and less disturbed vegetation in the riparian zones maintains high quality of water and healthy aquatic communities (Cunningham *et al.*, 2009).

Diverse vegetation that grows along the streams acts as a protective buffer riparian zone. Riparian buffers are the grasses, grass-like, forbs, shrubs, trees or other vegetation growing along streams. Riparian vegetation could be an indicator of riparian condition (Macfarlane *et al.*, 2017). Riparian vegetation supports the improvement of environmental protection functions in production forest. Riparian vegetation offers a number of important ecological functions related to streambanks stabilization, water quality, terrestrial and aquatic habitat (Alemu *et al.*, 2018). Riparian vegetation can improve water quality by trapping and filtering pollutants such as sediments, nutrients, pesticides, herbicides, road salts, and heavy metals. The root systems of riparian vegetation help to stabilize streambanks by holding the soil in place. Leaves and twigs serve as a food source for aquatic bugs. Riparian vegetation can provide birds and animals with fruits and nuts as well as cover (Agouridis *et al.*, 2010). Riparian canopy can regulate of instream temperatures and able to reduce water temperature by 1 to 2 ^{0}C (Ryan & Kelly-Quinn, 2016; Trimmel *et al.*, 2018).

The function of riparian zone is affected by vegetation, buffer width, buffer slope, soil texture, flow of runoff, and rainfall intensity (Liu *et al.*, 2008). The encroachment of riparian vegetation encourages riparian degradation. Anthropogenic use has removed the majority of riparian habitat available to wildlife and people and reduced the ability of rivers and floodplains to provide river services (Griggs, 2009). Damaged riparian vegetation changes the hydraulic characteristics of the river channels and destroys fish habitats (Rivaes *et al.*, 2017).

The efficacy of riparian vegetation depends on the structure and composition of vegetation (Arrijani, 2008). The way to know the structure and composition of plants is by conducting vegetation analysis (Naidu & Kumar, 2016). The quantitative parameter of vegetation such as: relative density, relative frequency, relative dominance, importance value index can be described by vegetation analysis. The objective of this paper is to study the structure and composition of riparian vegetation observed along Cemoro and Modang river. Results of studies on diversity riparian vegetation can be used as a reference program for rehabilitation and enrichment of riparian areas in production forests.

II. RESEARCH METHODS

A. Time and Place

This study was conducted from May 2011 to November 2012 in riparian zone of forest for special purposes (KHDTK) Cemoro-Modang, Sambongrejo Village, Sambong District, Blora Regency, Central Java Province between 111^{0}30'39"-111^{0}33'43" E and 07^{0}2'23"-07^{0}05'06" S. The study area is located in production forest at BKPH Pasarsore and BKPH Cabak, KPH Cepu, Perum Perhutani Unit I. The two study sites were selected in riparian zone at Cemoro river and Modang river (Figure 1).

This site is distributed between 75 to 187.5 m elevations. The soil type is dominated by grumusol, mediteran, and lithosol. The rainfall average (1985-2006) of 1,663 mm year^{-1} and temperatures daily ranging between 19 to 32^{0}C. Based on Schmidt & Ferguson classification, the region's climate is included in D type (Balai Penelitian Kehutanan Solo, 2007).

B. Materials and Equipment

Material used in this study is a map of the forest area.Tools used in this study are global positioning system (GPS), haga altimeter, compass, altimeter, gauge, roll meter, diameter tape, plastic samples, old newspaper, alcohol, label, tallysheet, paper, pen, ink, paper plotter.

C. Riparian Vegetation Sampling and Parameters Observed

Inventory of riparian vegetation conducted by line plots method by making transects along the river combined with sample plots. The plot selection was done by systematic sampling. The sampling intensities used are 2% and 4% for Cemoro (5.65 km length) and Modang (3.94 km length) river respectively. Total sample plots are 36 (i.e. 21 plots from Cemoro river and 15 plots from Modang river. All plots were located 25 meters away from stream bank along the river (Figure 2).

The stages of vegetation observed and measured include understory vegetation to trees. The size of observation plot is 20 mx20 m for trees, 10 mx10 m for poles, 5 mx5 m for saplings, 2 mx2 m for seedlings and 1 mx1 m for understory

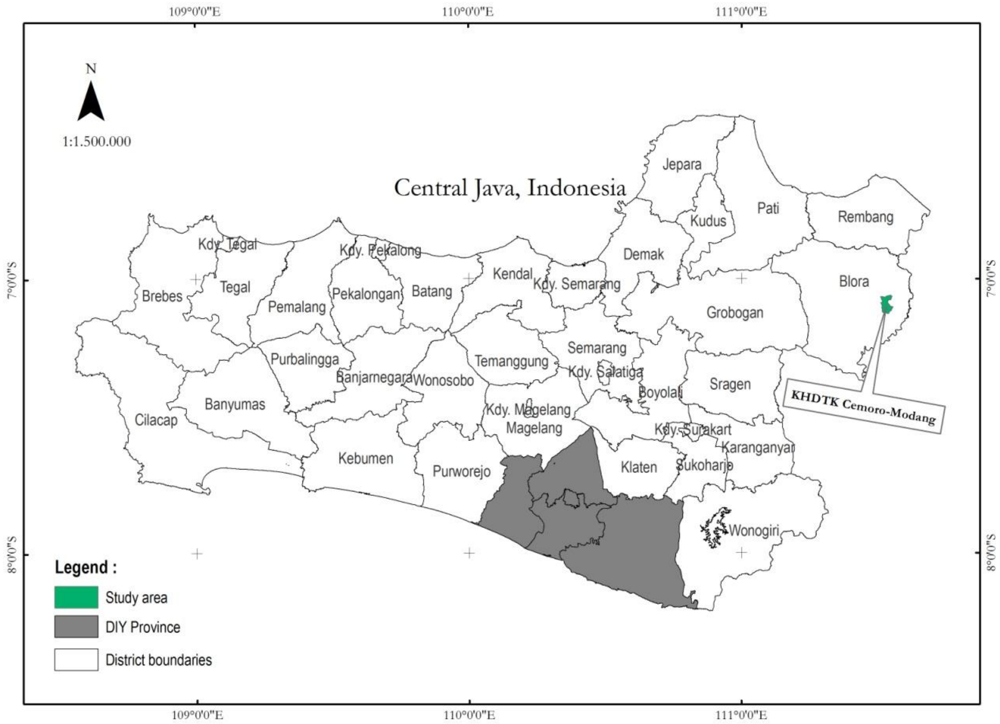

Figure 1. *Location of the study*
Gambar 1. *Lokasi penelitian*

vegetation (Figure 3). The measurement of ecological parameters includes the density, frequency, dominance, and importance value index (IVI) of each tree life stages.

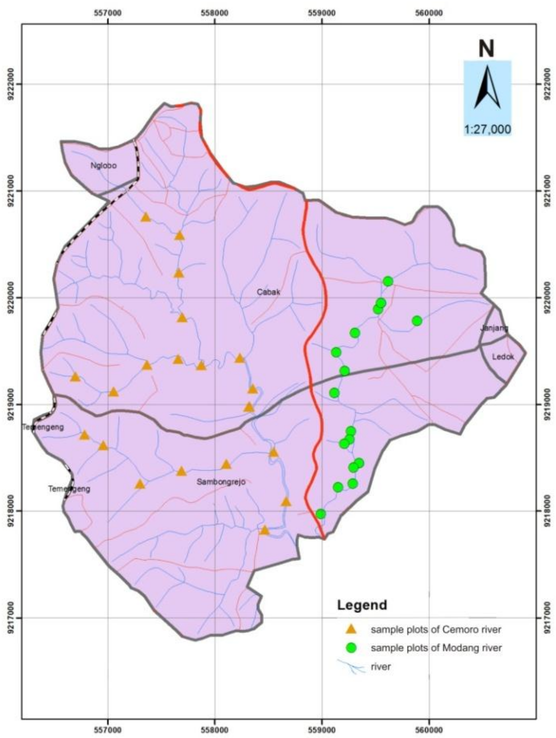

Figure 2. Sample plots of Cemoro and Modang river
Gambar 2. *Plot sampel di sungai Cemoro dan Modang*

D. Data Analysis

The data obtained were analyzed in order to clarify the vegetation community parameters such as: density, relative density, frequency, relative frequency, dominance, relative dominance, and IVI for each tree life stage. Frequency was calculated based on data of species, while density was calculated based on data of trees number.

1. Species Composition

Species composition for every tree life stage were clarified by IVI which calculated by using of the following formula (Indriyanto, 2008):

IVI = RD + Rf + RC (for trees and poles) (1)

IVI = RD + Rf (for saplings and seedlings) (2)

Remarks:

Density (D) = Number of individuals/total area sampled

Relative density (RD) = (Number of individuals of a species/total area sampled) x 100%

Frequency (f) = Number of plots in which a species occurs/total number of plots sampled.

Relative frequency (Rf) = (Frequency of species/total frequency of all species) x 100%

Coverage (C) = Basal area of each tree of a species from all plots/total area of all plots

Relative coverage (RC) = (Total basal area of a species/basal area of all species) x 100%

2. Species Diversity

Species diversity was clarified by the Shannon-Wiener index and calculated based on of

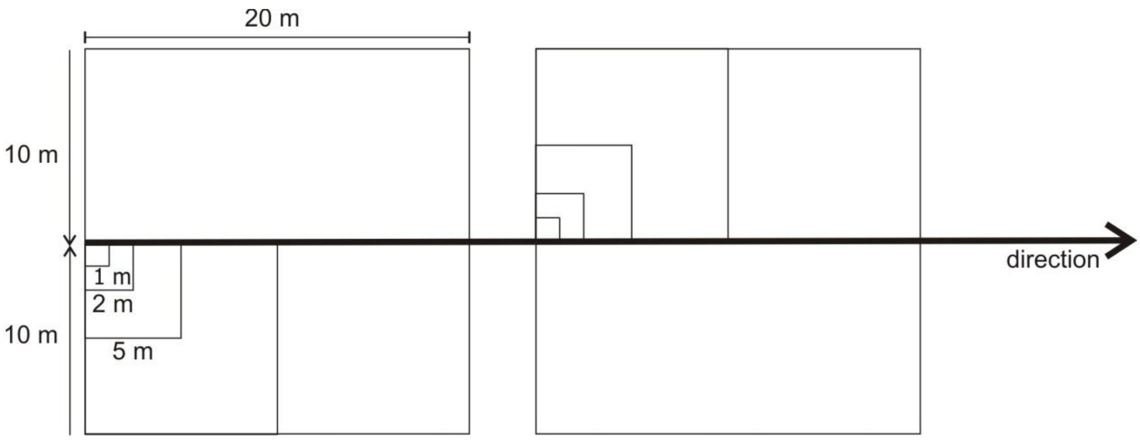

Figure 3. Design of line plot method
***Gambar 3.** Desain metode garis berpetak*

the following formula (Odum, 1971):

$$H' = \sum_{i=1}^{i=n} p_i \ln p_i \quad (3)$$

where:
H'H’ = Species diversity index
$p_i$pi = Number of the individual species$i$-i/number of individuals of all species

The value $H' < 1$H '<1 means the vegetation communities has less stable environmental conditions; $1 \le H' \le 2$ H' 1 means vegetation community has stable environmental conditions; and H'>2 means vegetation community has very stable environmental conditions (Mawazin & Subiakto, 2013).

3. Similarity Index

The similarity indices of species composition in two samples were clarified by the Jaccard coefficient (Kent & Coker, 1992) and calculated based on the following formula:

$$JS = \frac{A}{A+B+C} \quad (4)$$

where:
JSJS= Jaccard similarity coefficient
AA = Number of species found in the two samples compared
BB = Number of species in sample-1
CC = Number of species in sample-2

III. RESULTS AND DISCUSSIONS

A. Species Composition

Vegetation analysis is a way of studying the arrangement (species composition) and shape (structure) of vegetation or plant communities. In forest ecology, unit observed is a stand, which is a concrete association. A total of 114 species of vegetation was recorded from the riparian zone along Cemoro and Modang river. There were 6, 2, 20, 16, and 85 species of vegetation for trees, poles, saplings, seedlings and understory vegetation, respectively (Appendix and Table 1).The number of regeneration for seedling and sapling is abundant at 92 and 179 (Table 1).

Good regeneration is related to wide growing space that sunlight can reach the forest floor. Although teak is a dominant tree, teak is a deciduous tree and planted in wide spacing. In addition, the disturbance caused by the anthropogenic activities is relatively small. After the teak stands were set as a local protection area, all teak plants in the riparian zone were prohibited to be harvested. The analysis results for 5 (five) species with high IVIs at various tree life stages are presented in Table 2. The diversity of IVIs shows the influence of growing environment such as humidity, temperature and competition to get nutrients, sunlight and growing space with other species that affects tree growth.

Table 1 shows that the riparian vegetation is dominated by teak (*Tectona grandis*) plantation. The presence of teak in the riparian zone are at all life stages (i.e. trees, poles, saplings, and seedlings). This is reasonable because in the past, riparian zone is a production area that planted teak. The presence of dominant species at the research site becomes an indicator that this species is more likely to maintain the growth and sustainability of its species (Mawazin & Subiakto, 2013). Teak has

Table 1. Number of individual and species of tree, pole, sapling, and seedling at all plots
***Tabel 1.** Jumlah individu dan jenis tingkat pohon, tiang, pancang dan semai pada semua plot*

Parameters *(Parameter)*	Tree *(Pohon)*	Pole *(Tiang)*	Sapling *(Pancang)*	Seedling *(Semai)*
Number of individual *(Jumlah individu)*	162	37	179	92
Number of species *(Jumlah spesies)*	6	2	20	16

Table 2. Five dominant species based on IVI
***Tabel 2.** Lima spesies dominan berdasarkan indeks nilai penting*

Tree life stages *(Tingkat hidup pohon)*	**Species *(Spesies)***	**IVI *(Indeks nilai penting)***
Trees *(Pohon)*	Jati (*Tectona grandis*)	274.07
	Ipik (*Ficus retusa*)	7.89
	Johar (*Casia siamea*)	4.87
	Trembesi (*Samanea saman*)	4.66
	Ploso (*Butea monosperma*)	4.41
Poles *(Tiang)*	Jati (*Tectona grandis*)	201.95
	Johar (*Casia siamea*)	97.84
Saplings *(Pancang)*	Jati (*Tectona grandis*)	52.62
	Sonokeling (*Dalbergia latifolia*)	32.39
	Kaliandra (*Calliandra callothyrsus*)	29.42
	Kemlandingan (*Leucaena leucocephala*)	26,.18
	Sonokembang (*Dalbergia sisso*)	9.93
Seedlings *(Semai)*	Kemlandingan (*Leucaena leucocephala*)	46.28
	Jati (*Tectona grandis*)	43.48
	Walikukun (*Schoutenia ovata*)	34.54
	Jambu klampok (*Syzygium aqueum*)	20.65
	Sonokeling (*Dalbergia latifolia*)	6.96
Understory *(Tumbuhan bawah)*	Rumput (Poaceae)	26.22
	Kerinyu (*Eupatorium inolifolium*)	19.04
	Unidentified species	10.27
	Wedusan (*Derris polyphylla*)	10.18
	Uyah-uyahan (*Ficus quersifolia*)	8.47

evolved under local condition. Teak is a native plant on the islands of Java and Muna. Therefore, it can grow well on these sites. Teak at Muna has been domesticated because it has adapted to the environmental conditions of Muna Island (Adinugraha & Leksono, 2013). Teak was first introduced in Indonesia in the fourteenth and sixteenth centuries. The scientific community agrees that teak was naturalized in Java for several centuries, has been acclimatized to ecological conditions there, and has regenerated naturally throughout the area. The genetic origin of teak in Indonesian appeared to be very closely linked to Central Laos (Verhaegen *et al.*, 2010). Teak grows well up to 500 m above sea level, annual rainfall between 1,000-1,500 mm with flat topography (lowland forest) or slope of <20%. Teak prefers areas with a significant difference between dry and wet seasons (Asmayannur *et al.*, 2012).

Besides teak *(Tectona grandis)*, sono keling *(Dalbergia latifolia)* and sono kembang *(Dalbergia sisso)* are species developed by Perum Perhutani. Fast growing species like johar *(Casia siamea*) are used as rehabilitation and enriching plants. Native riparian vegetations such as ploso (*Butea monosperma)*, jambu klampok (*Syzygium aqueum),* trembesi *(Samanea saman)*, preh *(Ficus retusa)*, kepuh *(Sterculia foetida)* are also founded in the riparian zone, but in little quantities. This can be seen from low IVI. So if they are grouped, there are three vegetation groups of riparian zone namely: cultivation tree, riverbank tree, and rehabilitation/enrichment tree.

Native plants are used as riparian vegetation because they are suitable with soil, water flow dynamics, solar radiation, temperatures and other microclimates. In Siak river, local plant species is most appropriate for river bank protection in eco-engineering system (Sittadewi, 2010). Sittadewi (2010) recommended some local plants species for river bank protection, e.g.: rumput teki *(Cyperus rotundus),* rumput kumpai *(Hymenachne acutigluma),* rumput akar wangi *(Vetiveria zizanioides),* karangkunan *(Ipomea carnea),* bambu kuning *(Bambusa vulgaris),* pandan *(Pandanus* sp.*),* bintaro *(Cerbera manghas),* rengas *(Gluta renghas),* kempas *(Koompassia malaccensis),* jawi-jawi *(Ficus* sp.*), and* meranti *(Shorea* sp.*).* Using alien plants should be avoided because of alien plants are often an important agent of disturbance in ecosystem functioning in the riparian area (Richardson *et al.*, 2007).

B. Species Diversity Index

Species diversity is a useful tool in plant ecology and forestry to compare the composition of different species. The diversity of tree species differs from one location to another primarily due to variations in habitat, biogeography, and disturbance (Naidu & Kumar, 2016). The species diversity index can be used to determine the effect of disturbance to the environment or to know the succession and stability of the plant community in a location. Species diversity is influenced by the large number of stem ha^{-1}, the number of species and the spread of each species (Mawazin & Subiakto, 2013). In tropical regions, species diversity was significantly correlated with rainfall and average temperature, while forest structure was significantly correlated with rainfall. The species richness, stand structure, species dominance, basal area, and size class consistently decreased from high to low rainfall regions (Khaine *et al.*, 2017).

The results of species diversity index on each tree life stages in the riparian zone at Cemoro-Modang river ranged from 0.24 to 2.03 (Table 3). Species diversity index of trees and poles stage is low (0.24 to 0.65) which means vegetation communities have less stable environmental conditions. At this stage, the dominant vegetation species that arranged riparian zone are only a few namely: *Tectona grandis, Casia siamea*, and *Leucaena leucocephala*. A community is categorized as a low species diversity if the community is arranged by few species and if there are only a few dominant species (Indriyanto, 2008).

This is understandable because the riparian zone is a production forest that planted teak for a long time before it is designated as a local protected area. Maintenance activities, especially thinning, are still routinely done so that environmental conditions become less stable. Thinning is selective logging to widen the spacing in order to obtain more even growth of the trees so that the quality of the wood produced increases. This stand condition should become one of considerations for the forest manager in managing the riparian zone more effectively. The low species diversity should be increased by maintaining existing species at saplings and seedling stage, rehabilitating, and enriching species. In addition, the existing vegetation must be maintained and prevented from disturbance. Riparian vegetation change was predominantly caused by human land-use impacts (development and agriculture), or vegetation change (native riparian to invasive or upland vegetation types) that likely resulted from flow and disturbance regime alteration (Macfarlane, *et al.*, 2017) .

Table 3. Species diversity on tree life stages
Tabel 3*. Keanekaragaman jenis pada berbagai tingkat hidup pohon*

Tree life stages ***(Tingkat hidup pohon)***	**Species diversity index (H')) *(Indeks keanekaragaman jenis)***
Trees *(Pohon)*	0.24
Poles *(Tiang)*	0.65
Sapling *(Pancang)*	2.04
Seedlings *(Semai)*	2.03
Understory *(Tumbuhan bawah)*	3.28

Table 3 shows that understory has a high species diversity. Understory vegetation affects overstorey succession, productivity, nutrient cycling, accounts for the majority of diversity and wildlife habitat. Understory compositional stability is strongly influenced by harvesting activity (MacDonald *et al.*, 2015). Land cover vegetation (understory, litter, and tree) and physical conditions (slope) influence riparian effectiveness in sediment absorption. However, it should be noted that cover vegetation conditions are dynamic, whose values are influenced by the seasonal factor (rainfall), vegetation growth, and disturbance, boteh natural and human, such as fire and clearing. In riparian area of Cemoro and Modang river, the effectiveness of sediment absorption by the riparian vegetation is 16-85% (Riyanto & Nugroho, 2015). Buffer width and slope are twomajor factors influencing the efficacy of vegetated buffers on sediment trapping. A 10 m buffer and a 9% slope optimized the sediment trapping capability of vegetated buffers (Liu*, et al.*, 2008).

C. The Similarity of Species Composition

Similarity index of species composition is a method to determine the species composition similarity between two areas. The result of vegetation inventory on riparian zone along Cemoro-Modang river is presented in Table 4.

From Table 4, similarity index between Cemoro and Modang species composition can be obtained by calculating Jaccard similarity coefficient. Similarity index of species composition between Cemoro river and Modang river is presented in Table 5.

Table 4. The result of vegetation inventory on riparian zone along Cemoro-Modang river
Tabel 4. *Hasil inventarisasi vegetasi di zona riparian sepanjang sungai Cemoro-Modang*

Tree life stages ***(Tingkat hidup pohon)***	**Number of species *(Jumlah spesies)***		
	Cemoro-Modang river *(Sungai Cemoro-Modang)*	**Cemoro river *(Sungai Cemoro)***	**Modang river *(Sungai Modang)***
Trees *(Pohon)*	6	3	4
Poles *(Tiang)*	2	2	1
Saplings *(Pancang)*	20	14	14
Seedlings *(Semai)*	16	13	7
Understory *(Tumbuhan bawah)*	85	67	61
All vegetation *(Total vegetasi)*	114	89	81

Table 5. Similarity index and dissimilarity index of Cemoro and Modang river
Tabel 5. *Indeks kesamaan dan ketidaksamaan sungai Cemoro-Modang*

Comparison of tree life stages between Cemoro-Modangriver *(Perbandingan tingkat hidup pohon antara sungai Cemoro-Modang)*	Similarity index *(Indeks kesamaan)*	Dissimilarity index *(Indeks ketidaksamaan)*
Trees *(Pohon)*	46.2%	53.8%
Poles *(Tiang)*	40%	60%
Saplings *(Pancang)*	41.7%	58.3%
Seedlings *(Semai)*	44.4%	55.6%
Understory *(Tumbuhan bawah)*	40%	60%
All vegetation *(Total vegetasi)*	40.4%	59.6%

Similarity index of species composition ranges from 0-100%. The higher of similarity index (close to 100%) indicates the higher similarity level between the two communities compared. It can also be interpreted that the higher of similarity index, means the different species composition are less (Mawazin & Subiakto, 2013). Table 5 shows that similarity index of Cemoro and Modang riverhas a low value of under 50%. This indicates that there are differences in composition and structure of vegetation at tree life stage significantly. It is possible because of the environmental differences between the two areas. Soil preparation, vegetation clearing, and burning for crops cultivation are activities that change the environment so that reduce land cover vegetation (Riyanto & Nugroho, 2015).

IV. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

Based on vegetation analysis results it can be concluded that: (1)There were 114 species recorded on riparian zone of Cemoro-Modang river, consisting of 6, 2, 20, 16 and 85 species of vegetation for trees, poles, saplings, seedlings and understory vegetation, respectively. The riparian vegetation was dominated by *Tectona grandis*, (2) Species diversity index especially for trees and poles stage were low, as the protection/conservation area means the area is in a hampered condition, (3) Similarity index between Cemoro and Modang river was low (40.4%), which means that both area are different in vegetation structure at tree life stage.

B. Suggestion

Rehabilitation and enrichment planting, by using of local (native riparian vegetation) species, should be considered in developing of riparian zone of Cemoro-Modang river. Among others, the recommended species are *Ficus* sp., *Bambusa* sp., *Inocarpus* sp., *Artocarpus* sp., *Samanea saman*, and *Sterculia foetida*.

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REFERENCES

Adinugraha, H. A., & Leksono, B. (2013). Kinerja jati asal Muna pada plot uji klon jati di empat lokasi. *Jurnal Penelitian Kehutanan Wallacea, 2*(2), 138-153.

Agouridis, C. T., Wightman, S. J., Barton, C. D., & Gumbert, A. A. (2010). Planting a riparian buffer. Lexington: University of Kentucky College of Agriculture.

Alemu, T., Weyuma, T., Alemayehu, E., & Ambelu, A. (2018). Identifying riparian vegetation as indicator of stream water quality in the Gilgel Gibe catchment, southwestern Ethiopia. *Ecohydrology, 11*(1), 1-9.

Arrijani. (2008). Vegetation structure and composition of the montane zone of Mount Gede Pangrango National Park. *Biodiversitas, 9*(2), 134-141.

Asmayannur, I., Chairul, & Syam, Z. (2012). Analisis vegetasi dasar di bawah tegakan jati emas (*Tectona grandis* L.) dan jati putih (*Gmelina arborea* Roxb.) di kampus Universitas Andalas. *Jurnal Biologi Universitas Andalas, 1*(2), 172-177.

Balai Penelitian Kehutanan Solo. (2007). *Grand design KHDTK Cemoro-Modang*. Surakarta.

Cunningham, K., Liechty, H., & Stuhlinger, C. (2009). Riparian buffers: functions and values. *Agriculture and Natural Resources*. Arkansas: University of Arkansas Division of Agriculture.

Griggs, F. T. (2009). *California riparian habitat restoration handbook*. California: River Partners.

Indriyanto. (2008). *Ekologi hutan*. Jakarta: PT Bumi Aksara.

Kent, M., & Coker, P. (1992). *Vegetation description and analysis : a practical approach* London: Belhaven press.

Khaine, I., Woo, S. Y., Kang, H., Kwak, M. J., Je, S. M., You, H., Lee, T., Jang, J., Lee, H. K., Lee, E., Yang, L., Kim, H., Lee, J. K., & Kim, J. (2017). Species diversity, stand structure, and species distribution across a precipitation gradient in tropical forests in Myanmar. *Forests, 8*(282), 1-5.

Liu, X., Zhang, X., & Zhang, M. (2008). Major factors influencing the efficacy of vegetated buffers on sediment trapping: a review and analysis. *Journal of Environmental Quality, 37*, 1667–1674.

MacDonald, R. L., Chen, H. Y. H., Bartels, S. F., Palik, B. J., & Prepas, E. E. (2015). Compositional stability of boreal understory vegetation after overstorey harvesting across a riparian ecotone. *Journal of Vegetation Science, 26*(733-741).

Macfarlane, W. W., Gilbert, J. T., Jensen, M. L., Gilbert, J. D., Hough-Snee, N., McHugh, P. A., Wheaton, J. M., & Bennett, S. N. (2017). Riparian vegetation as an indicator of riparian condition: Detecting departures from historic condition across the North American West. . *Journal of Environmental Management 202*(2), 447-460.

Mawazin, & Subiakto, A. (2013). Species diversity and composition of logged over peat swamp forest in Riau. *Indonesian Forest Rehabilitation Journal 1*(1), 59-73.

Naidu, M. T., & Kumar, O. A. (2016). Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *Journal of Asia-Pacific Biodiversity, 9*, 328-334.

Odum, E. P. (1971). *Fundamentals of ecology*: H B/Holt/Saunders.

Republik Indonesia. (1999). *Undang-Undang Republik Indonesia Nomor 41 Tahun 1999 Tentang Kehutanan*. Jakarta: Menteri Negara Sekretaris Negara Republik Indonesia.

Republik Indonesia. (2008). *Peraturan Pemerintah Republik Indonesia Nomor 26 Tahun 2008 Tentang Rencana Tata Ruang Wilayah Nasional*. Jakarta: Menteri Hukum dan Hak Asasi Manusia Republik Indonesia.

Richardson, D. M., Holmes, P. M., Esler, K. J., Galatowitsch, S. M., Stromberg, J. C., Kirkman, S. P., Pysek, P., & Hobbs, R. J. (2007). Riparian vegetation: degradation, alien plant invasions, and restoration prospects. *Diversity and Distributions, 13*, 126-139.

Rivaes, R., Boavida, I., Santos, J. M., Pinheiro, A. N., & Ferreira, T. (2017). Importance of considering riparian vegetation requirements for the long-term efficiency of environmental flows in aquatic microhabitats. *Hydrology and Earth System Sciences, 21*, 5763–5780.

Riyanto, H. D., & Nugroho, N. P. (2015). *The effectivity of protection riparian area for filtering the sediment on teak production forest.* Paper presented at the Restorasi DAS: Mencari keterpaduan di tengah isu perubahan iklim, Surakarta.

Ryan, D. K., & Kelly-Quinn, M. (2016). Riparian vegetation management for water temperature regulation: implications for the production of macroinvertebrate prey of salmonids. *Fisheries Management and Ecology, 23*, 519–530.

Sittadewi, E. H. (2010). Penentuan jenis vegetasi lokal untuk perlindungan tebing sungai Siak dengan desain eko-engineering tanpa turap. *Jurnal Teknik Lingkungan, 11*(2), 189-195.

Trimmel, H., Weihs, P., Leidinger, D., Formayer, H., Kalny, G., & Melcher, A. (2018). Can riparian vegetation shade mitigate the expected rise in stream temperatures due to climate change during heat waves in a human-impacted pre-alpine river? *Hydrol. Earth Syst. Sci., 22*, 437-461.

Verhaegen, D., Fofana, I. J., Logossa, Z. A., & Ofori, D. (2010). What is the genetic origin of teak (*Tectona grandis* L.) introduced in Africa and in Indonesia? *Tree Genetics & Genomes, 6*, 717-733.

Appendix: List of species in riparian zone along Cemoro and Modang river
Lampiran: *Daftar spesies zona riparian sepanjang sungai Cemoro dan Modang*

Tree life stages *(Tingkat hidup pohon)*	Species *(Spesies)*	Local name *(Nama lokal)*	IVI *(Indeks nilai penting)*
Trees *(Pohon)*	*Ficus retusa*	Ipik/preh	7.89
	Tectona grandis	Jati	274.07
	Casia siamea	Johar	4.87
	Butea monosperma	Ploso	4.41
	Gluta renghas	Rengas	4.09
	Samanea saman	Trembesi	4.66
Poles *(Tiang)*	*Tectona grandis*	Jati	201.95
	Casia siamea	Johar	97.84
Saplings *(Pancang)*		Grandru	2.17
	Syzygium aqueum	Jambuklampok	8.19
	Tectona grandis	Jati	52.62
	Casia siamea	Johar	4.34
	Calliandra callothyrus	Kaliandra	29.42
	Sapondias pinnata	Kedondonghutan	2.17
	Leucaena leucocephala	Kemlandingan	26.18
	Sterculia foetida	Kepuh	2.17
	Schleichera oleosa	Kesambi	4.34
	Artocarpus camansi	Kluwih	2.17
	Swietenia mahagoni	Mahoni	2.17
	Adenanthera microsperma	Saga	2.17
	Eugenia polyantha	Salam	2.17
		Sonogembuk	2.17
	Dalbergia latifolia	Sonokeling	32.39
	Dalbergia sisso	Sonokembang	9.93
	Annona squamosa	Srikaya	2.17
	Muntingia sp.	Taloklondo	4.34
		Trasekan	4.34
	Schoutenia ovata	Walikukun	4.34
Seedlings *(Semai)*	*Allophylus cobbe*	Cukilan	3.48
	Glyricidia sepium	Gliriside	3.48
	Psidium guajava	Jambubiji	4.56
	Syzygium malccense	Jambubol	4.56
	Syzygium aqueum	Jambuklampok	20.65
	Tectona grandis	Jati	43.48
	Casia siamea	Johar	3.48
	Calliandra callothyrus	Kaliandra	6.96
	Cassia mimosoides	Kedinding	3.48
	Terminalia edulis	Kelumpit	3.48
	Leucaena leucocephala	Kemlandingan	46.28
	Swietenia mahagoni	Mahoni	6.96
	Morinda citrifolia	Mengkudu	3.48
	Dalbergia latifolia	Sonokeling	6.96
	Casia fistula	Trengguli	4.56
	Schoutenia ovata	Walikukun	34.54
Understory		Adal-adal	2.99
(Tumbuhan bawah)	*Imperata cylindrica*	Alang-alang	1.59
	Ficus ampelas	Ampelas	0.33
	Antidesma ghaesembilla	Ande-ande	0.66
	Vitis sp.	Anggur-angguran	0.33
	Clerodendron capitatum	Apit/Kapitatum	0.38
	Ficus septica	Awar-awar	1.38
		Babing	7.45
		Barudin	1.51

Tree life stages ***(Tingkat hidup pohon)***	**Species** ***(Spesies)***	**Local name** ***(Nama lokal)***	**IVI** ***(Indeks nilai penting)***
	Piper retrofractum	Cabe puyang	1.51
	Ruellia tuberosa	Ceplikan	0.33
	Cyclea barbata	Cincau	0.33
		Ciput	1.38
		Cirinting	1.59
	Allophylus cobbe	Cukilan/Asa-asa	0.33
		Epek/Rambatan	0.33
	Bridelia glauca	Gandri/Kandrikebo	5.11
	Gynura divaricata	Daundewa	0.38
	Corypha utan	Gebang	0.38
		Gembukan	0.72
	Leea aculeata	Girang	7.97
		Gloyor	0.66
	Tacca palmata	Iles-iles	1.82
		Jenar	0.38
	Centrosema pubescens	Kacang-kacangan	1.84
		Kalakgedang	1.19
	Anomianthus dulcis	Kalakucet	0.33
	Poliantha lateriflora	Kalakan	2.26
	Karrisa macrocarpa	Kare	2.47
	Cassia mimosoides	Kedinding	0.33
	Cyperuskyllingia	Kembangudel/wudelan	1.23
	Hernandia peltata	Kemiren	2.13
	Cordia dichotoma	Kendal	0.33
	Eupatorium inolifolium	Kerinyu	19.04
	Floribunda decaisne	Klayu	2.10
	Clibadium sp.	Klibadium	2.32
	Boesenbergia pandurata	Temukunci	4.85
	Caesalpinia bonduc	Kutuk	2.38
	Brucea javanica	Kuwalot	4.04
	Panicum repens	Lempuyang	2.99
	Billbergia nutans	Nanasan	0.33
		Opo-opo	3.87
	Bridelia glauca	Otokkebo/Kanyerebadak	5.14
		Pacingan	0.33
	Adiantum capillus	Suplir	0.33
	Momordica sp.	Pare alas	0.33
	Euphorbia hirta	Petikan	0.82
		Polodan	4.85
	Mimosa pudica	Putri malu	2.75
	Gigantochloa pruriens	Regen/rumput	1.31
		Rambatan	5.70
		Rauk	0.38
		Regil	0.98
	Ardisia elliptica	Rempeni/lampeni	2.26
	Mimosa sp.	Ri bandil	0.33
		Ri cuwut	0.33
		Ri kengkeng	0.77
	Mimosa invisa	Ri lanjargarut/Baret	0.87
		Ri wono	0.72
	Poaceae	Rumput	26.22
	Andrographis paniculata	Sambiroto	1.36
	Caesalpinia sappan	Secang	0.70
	Streblus asper	Serut	0.33
	Unidentified species		0.49
	Solanum torvum	Takokak/langkis	0.33

Tree life stages ***(Tingkat hidup pohon)***	**Species** ***(Spesies)***	**Local name** ***(Nama lokal)***	**IVI** ***(Indeks nilai penting)***
	Xanthosoma violaceum	Talas-talasan	1.68
	Muntingia sp.	Taloklondo	0.33
	Crotalaria jucae	Tatakkriak/sundukmentul	1.12
	Lantana camara	Tembelekan	1.05
	Curcuma sp.	Temu	0.38
	Casia fistula	Trengguli	0.33
	Clausena excavata	Tikusan	2.10
		Trombolan	0.65
	Milletia sericea	Tungkul/akar tuba	1.38
	Arengasp	Umbut	0.44
	Dioscorea olata	Uwi	1.43
	Ficus quersifolia	Uyah-uyahan	8.47
	Olax scandens	Wangon	0.77
	Derris polyphylla	Wedusan	10.18
	Ficus fistulosa	Wilodo	0.33
		Wilus	0.98
	Unidentified species 1		10.27
	Unidentified species 2		4.76
	Unidentified species 3		1.26
	Unidentified species 4		0.59