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Tree Vegetation Structure at the Realolo Village Bantimurung Bulusaraung National Park Maros District

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***Abstract*— This paper reports on tree vegetation structure at the Realolo village, Bantimurung Bulusaraung National Park. Data were collected from 15 transects with the size of each transect was 100 x 10 m at Region I, Region II, and Region III that successively farther away from the settlements. The results showed there were 49 species and belong to 30 families. Family with the highest number of species is Myrtaceae. In the Region, I and II, species with the highest Important Value Index (IVI) belonged to *Gastoniaserratifolia*, and at Region III belong to *Litsea* sp. Species with the lowest IVI Region I belonged to *Phaleriacapitata*, at Region II belonged to *Pittosporummolucanum*, and at Region III was belong to *Bischoviajavanica*. The class interval of density and frequency showed more rare species than widespread species. Soil's temperature and pH have a negative relation with trees' frequency and density. More species distribute the lowest stem class diameter. The highest value of Shannon Wiener's diversity index, Richness Index and Pielou's evenness index was in Region II, and the lowest value of these indexes was in Region I.This study provides a baseline for the management of Bantimurung Bulusaraung National Park.**

***Keywords*— tree vegetation structure; Realolo village; Bantimurung Bulusaraung National Park; important value index.**

I. INTRODUCTION

Sulawesi is the largest island and has high biodiversity in the area of Wallacea, in Indonesia [1]. As part of the tropical rainforest region of Southeast Asia, the region suffered severe degradation and damage [2]and led to losses of biodiversity [3]. Biodiversity on the Sulawesi Islands is now mainly under threat of extinction mainly by deforestation [1]. Clearing for agriculture leads to reduced of forest area, and logging [4], resulting in 80% loss of primary forest [1]. These conditions resulted in mountain regions and protected areas into the last bastions of biodiversity on the Sulawesi islands [5].

The Bantimurung Bulusaraung National Park (The Babul NP) with an area of ± 43,750 ha is one of the protected areas in Province of South Sulawesi. This National Park is a natural conservation area that has a native ecosystem, managed with a zoning system and utilized for research, science, education, aquaculture, tourism, and recreation purposes [6].

This area has an ecosystem that mostly composed of karst, endemic flora, and fauna, among others, are Ebony (*Diospyros celebica*) and Black macaques (*Macaca Maura*). Until 2008, The Babul NP has registered 356 species of wild animals. The list of wildlife species is compiled from reliable sources and results from type identification activities conducted by the Babul NP itself. This area also functions as protection of water system from several large and small rivers in the Province of South Sulawesi [6].

The Bantimurung Bulusaraung National Park has seven resorts among them are, Mallawa, Pattunuang-Karaenta, Bantimurung-Leangleang, Camba, Balocci, Minasa Tene and Tondong Tallasa Resort. Mallawa Resort, i.e., in Mallawa sub-district, Maros District and is the largest resort compared to other resorts in the area. The Mallawa has an area as much as 25.09% of the Babul NP with an area of ± 10,981.1 ha covering Karst ecosystem type, Non-Dipterocarpaceae Low land Tropical rain forest ecosystem type, and also Lower Mountain Rain Forest ecosystem type [7].

The Realolo Village is one of the villages that located in Mallawa Resort. As other forests in the province of South Sulawesi, forests in this village have also disturbed resulting in the reduced forest area. Some of the causes for the decline in forest area in the Mallawa district are forest fires, illegal logging, and forest encroachment [7]. As a field for protection and conservation of biodiversity, and given the importance of The Babul NP area as a regional water

management system for the vicinity, therefore the Babul NP must be preserved.

Information about the tree vegetation that associated with the ecological conditions in the Realolo Village Mallawa Resort is still lacking. One of the things that need to be done in the Babul NP in an attempt to preserve the natural resources are the species inventory and monitoring [7]. The difficulties in the application of natural resource management in Indonesia, one of which is caused by the lack of ecological data [8]. Forest area management requires an understanding of the forest constituent component. Trees are among the components of forest ecosystems [9]. Knowledge of species richness is essential in prioritizing the planning and controlling activities of protected areas [10]. The first step that can be done is to understand the ecological conditions of vegetation, in particular for the trees that found in the Realolo Village, Mallawa Resort, Babul NP. This study aims to determine the structure of tree vegetation and its relation to the environmental factor in the Realolo Village, Mallawa Resort, Babul NP, Maros District.

II. Materials and Methods

A. Study Area

The research was conducted at the Realolo village, Mallawa Resort, Bantimurung Bulusaraung National Park (Babul NP), Maros District, South Sulawesi Province (04^0 49.256 ' S- 119 ^{0} 50. 361' E) in February-March 2015. The sampling was conducted in three areas: Regions I, II, and III with the distance of 1.5 km, 1.90 km, and 2.55 km successively from the residential area of Realolo village. This location is located ± 10 km from the capital of the Mallawa District, the distance from the capital of the regency is less than 90 km, and the distance to the capital of the province is 110 km.

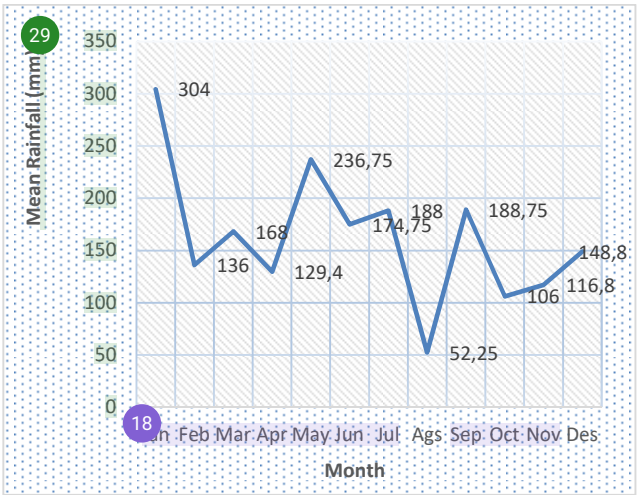

Fig. 1. Mean Rainfall month^{-1} (mm), the year of 2010-2014 at Maros Regency. Source: Meteorology Climatology and Geophysics Agency of Maros Regency.

Data of the average rainfall monthly in Maros Regency from 2010 to 2014 can be seen in Fig. 1. The highest rainfall average is in January, and the lowest is in August. This research was conducted in February and March with the average of rainfall successively was 136 mm month-1 and 168 mm month-1.

B. Sampling and Data Analysis

We randomly placed five transects with the size of 100 x 10 m in each of the three regions. Each transect consisted of ten plots with the size of 10 x 10 m. Thus in each region, the area observed is 0.5 ha. The total number of transects in the study area was 15, composed of 150 observation plots. Each tree in the plots was measured its diameter at stem breast height (130 cm above the ground surface) and identified to the species level. Voucher specimens of each plant were collected. Data of environmental variable from each plot was also collected as follow: the geographic coordinate, the slope, altitude, slope direction, soil pH, soil moisture, and litter thick. Species identification was made in the field, and unknown plants names were identified through voucher specimens [11], [12]. We also made consultation with the officers of Babul NP.

Basal area of trees was calculated as,

$$ba = \left(\frac{1}{2} d\right)^2 \pi(1) \quad (1)$$

where: ba = basal area; d = diameter at breast height;π = 3.142875. Basal area was use as dominance value.

Important value index (IVI) was obtained by the summation of relative density, relative dominance, and relative frequency [13]. Interval class of density distribution and stem diameter of trees were determined using Sturge's formula [14]. The interval class of frequency distribution was determined by assigning five class distributions, given the fixed number of plots which are 50 plots in each observation area. In each region we calculated in the following equations the value of the Shannon Wiener Diversity Index (H '):

$$H' = -\sum pi \ln pi \quad (2)$$

with the following formula:

$$pi = \frac{n_i}{N} \quad (3)$$

where: H' = Shannon Wiener Diversity Index, n_i= important value index of speciesi, N = Total Important Value Index with the Pielou's Evenness Index (J) [15]:

$$J = \frac{H'}{\ln n} \quad (4)$$

where: E = the Pielou's Evenness Index (J), H' = Shannon Wiener Diversity Index, n = number of individuals

The Menhinick'sRichness Index (R) [13]:

$$R = \frac{5}{\sqrt{n}} \quad (5)$$

where R = the Menhinick's Richness Index, S= Number of species, n: number of individual

We used regression and correlation statistics to investigate the relationship between the environmental factors and tree vegetation structures. Parametric regression and Pearson correlation were applied when parametric assumptions of data were fulfilled. While if not, nonparametric permutation regression and Rank Spearman correlation were used [14]. The statistic test was performed using R programming software [15].

III. RESULT AND DISCUSSION

There were 49 species from 30 families of trees vegetation that found at Realolo village, Mallawa Resort Babul NP. Three of the species found have not been identified.The Family with the most numbers of species was *Myrtaceae*, as much as five species, followed by Moraceae four species, Lauraceae three species, family *Apocynaceae*, *Elaeocarpaceae*, *Euphorbiaceae*, *Leguminosae*, *Myristicaceae*, *Rubiaceae*, *Lamiaceae*, and *Rutaceae* each has two species, while the others only have one (Table 1).

TABLE I
TREE SPECIES AT REALOLO VILLAGE

Family	**Species**
Actinidiaceae	*Sauarauia* sp.
Anacardiaceae	*Dracontomelon dao* (Blanco) Merr. & Rolfe
Annonaceae	*Xylopia* sp.
Apocynaceae	*Alstonia scholaris*
Apocynaceae	*Rauvolfia serpentine*
Araliaceae	*Gastonia serratifolia* (Miq.) Philipson
Arecaceae	*Areca catechu* L.
Cyatheaceae	*Cyathea celebica* Bl.
Dilleniaceae	*Dillenia serrata* Thunb.
Elaeocarpaceae	*Elaeocarpus* sp.
Elaeocarpaceae	*Elaeocarpus teijsmanni*
Euphorbiaceae	*Aleurites moluccana* (L.) Wild.
Euphorbiaceae	*Actephila* sp.
Fagaceae	*Lithocarpus celebicus* (Miq.) Rehder
Icacinaceae	*Phytocrene macrophylla*
Lamiaceae	*Vitex cofassus* Reinw. Ex Blume
Lamiaceae	*Tectona grandis* L. f.
Lauraceae	*Litsea* sp.
Lauraceae	*Actynodaphne* sp.
Lauraceae	*Actynodaphne* sp. 1
Leguminosae	*Albizia* sp.
Leguminosae	*Erythrina subumbrans*
Magnoliaceae	*Magnolia candolli* (Bume) H. Keng
Moraceae	*Ficus callosa*
Moraceae	*Ficus fistulosa* Reinw. ex Bl.
Moraceae	*Ficus gul*
Moraceae	*Ficus* sp.
Myristicaceae	*Myristica fatua* Houtt.
Myristicaceae	*Myristica fragrans* Houtt.
Myrtaceae	*Euginea cuminii* Merr
Myrtaceae	*Memecylon paniculatum*
Myrtaceae	*Psidium guajava* L.
Myrtaceae	*Syzygium lineatum* (DC.) Merr. & L.M. Perry
Myrtaceae	*Syzygium littorale* (Blume) Amshoff
Phyllanthaceae	*Bischofia javanica* Blume
Pittosporaceae	*Pittosporum molucanum*
Rubiaceae	*Canthium confertum* Korth.
Rubiaceae	*Fagraea racenosa*
Rutaceae	*Melicope lunu-ankenda* (Gaertn.) Hartley
Rutaceae	*Melicope* sp.
Salicaceae	*Pangium edule*
Sterculiaceae	*Pterospermum diversifolium* Blume
Thymelaeaceae	*Phaleria capitata* Jack
Ulmaceae	*Celtis philippinensis* Blanco
Urticaceae	*Laportea stimulant*
Vitaceae	*Leea angulata* Korth. Ex Miq.
-	Galingkang (not identified)
-	Linre (not identified)
-	Kayu Putih (not identified)

Most species have interval class of species density distribution at the lowest class interval, which was consecutively from Region III to Region I, as much as 67.86%; 79.49 %; and 65.52% (Fig. 2), suggesting that every region has more than 50 % of rare species.

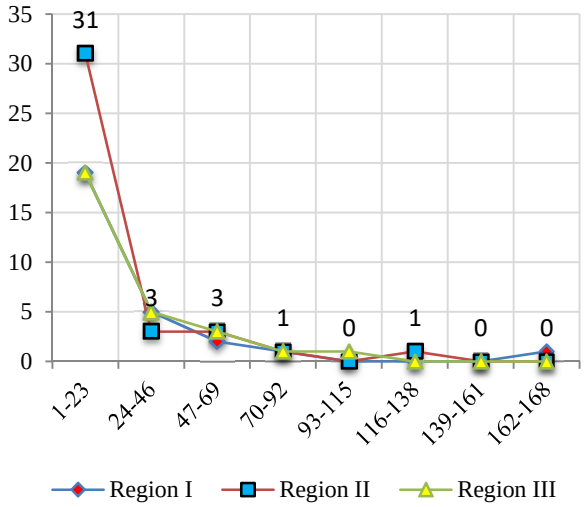

Fig. 2 Interval class of species density distribution of in 3 regions at Realolo Village, Mallawa Resort, Babul NP.

The highest density was found in Region II, with 708 individuals/0.5 ha and 39 species, followed by Region I, with 635 individuals/0.5 ha and 28 species, while the lowest was found in Region III, with 627 individuals/0.5 ha and 29 species. We consecutively found three, eight, and two number of species that only found at Region I, Region II, and Region III. These species were also included into the species with the lowest density. In each region, the percentage range of species that only have one individual was 20-23 %.

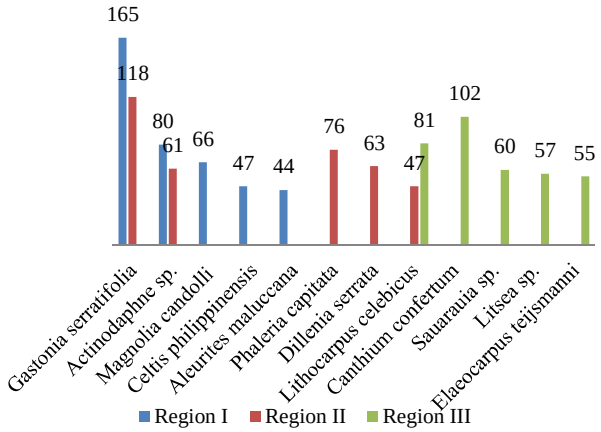

Fig 3. The species with density (0.5 ha) in the highest of five at Realolo Village, Mallawa Resort, Babul NP.

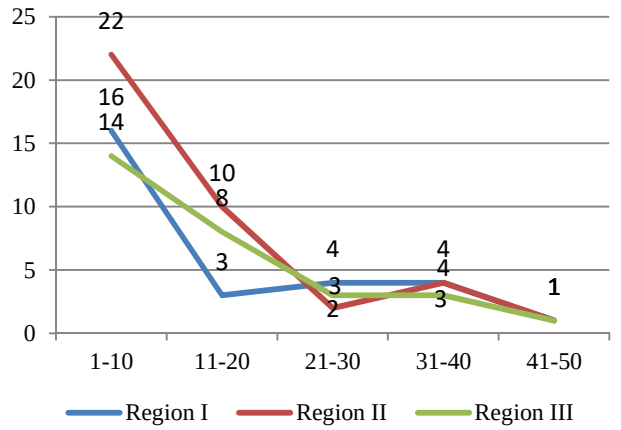

Fig. 4 Interval class of species frequency distribution in three regions at Realolo Village, Mallawa Resort, Babul NP

The density of tree was a decline as the pH soil increase. The nonparametric permutation regression showed Y= 13.13-2.403 X1. (F: 3.915., df1=1 and df2=148; R^2 = 0.026), with the Rank Spearman correlation = -0.174 (S= 660815.6; P<0.05).

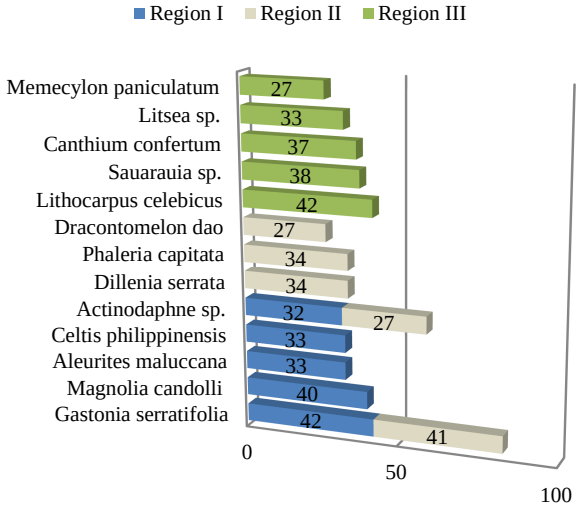

Fig. 5 The species with frequency in the highest of five at Realolo Village, Mallawa Resort, Babul NP.

Gastonia serratifolia (*Araliaceae* Family) was the species with the highest density at Region I and II, while *Canthium confertum* (*Rubiaceae* Family) at Region III. The percentage of species with the highest density at Region I, II, and III consecutively composing 25.98 %, 16.66 %, and 16.26 % of all densities in every region (Fig 5)

The family that has species with density in the highest of five in all regions is *Lauraceae* with *Actinodaphne* sp., in the region I, and II. These species compose 12.60 % density of species at Region I and 8.62 % at Region II, while *Litsea sp.* at Region III and composes 9.09 % density of species at Region III (Fig. 4).

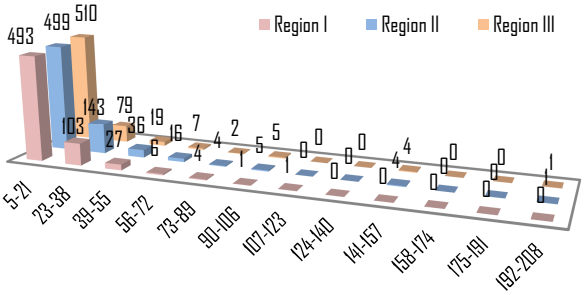

Fig. 4 Stem Class Diameter Distribution of Tree species individuals on three regions atRealolo Village, Mallawa Resort, Babul NP.

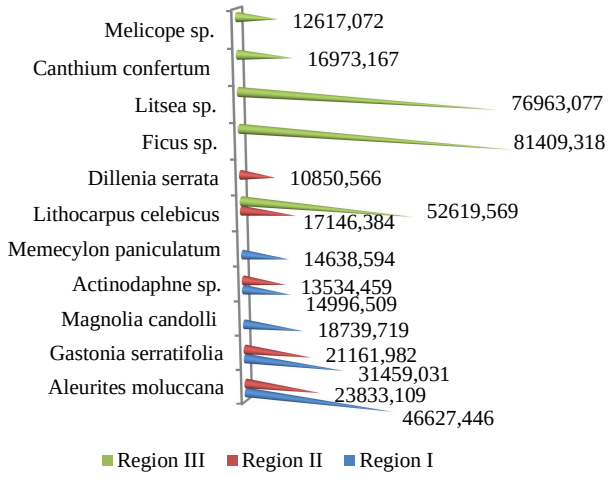

Fig. 5. The species with dominance in the highest of five at Realolo Village, Mallawa Resort, Babul NP.

Most species have interval class of species frequency distribution at the lowest class, which are 57.14 % at Region I, 56.41 % at Region II, and 48.28 % at Region III. This is indicating that more species were clumped than the spread distribution in the research area (Fig. 3).

Species *G. serratifolia* has the highest frequency in Region I and II, while in Region III was *Lithocarpus celebicus* (*Fagaceae* Family). The family that has species with frequency in the highest of five in all regions is Lauraceae with *Actinodaphne sp.*, in the Region I and Region II, while *Litsea sp.*, in region III (Fig. 4). Species that found at one plot and one region comprise 3.57 % of total species at Region I, 7.69 % at Region II, and 6.90 % at Region III. The frequency of tree is decline as the soil temperature increase, with the simple linear regression as

follow Y= 13.305 – 0.2894X1.; (F: 4.197., df1=1 and df2=148; R^2 = 0.028), while the correlation = 0.16 (P> 0,05; t=-2.0487; df= 148).

More individuals distribute at the lowest interval class of Stem Class Diameter Distribution which consecutively from Region I to III were 77.64%, 70.48%, and 81.34%. There was only one individual tree that found at the highest interval class in Region II and III, while no species were found at the same interval class in Region I. Interval class of species frequency distribution from the three regions showed the inverse J model (Fig. 5).

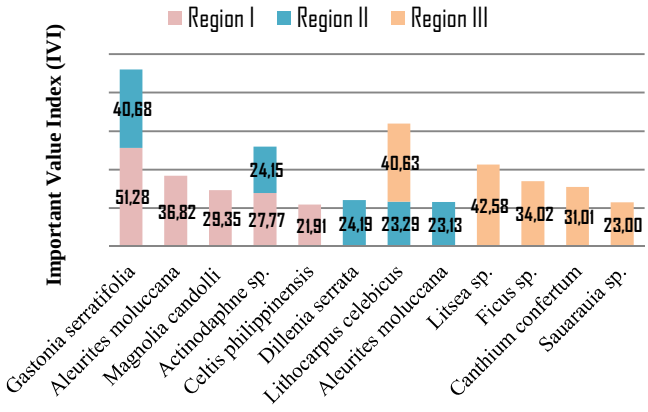

Fig. 6 The species with Important Value Index (IVI) in the highest of five at Realolo Village, Mallawa Resort, Babul NP.

Species with the highest dominance at Region I and II was *Aleurites moluccana* (L.) Wild. (*Euphorbiaceae* Family), while at Region III was *Ficus sp* (*Moraceae* Family). Probably this is an indication that dominance species are fewer in the area. The area with the highest vegetation dominance is Region III, and the lowest is Region II.

Phaleria capitata Jack (*Thymelaeaceae* Family) is the species with the lowest dominance value at Region I, and at Region II is *Pittosporum moluccanum* (*Lam.*) *Miq.* (*Pittosporaceae* Family) While at Region III is *Eugineacuminii* Merr (*Myrtaceae* Family). Regression analysis with permutation nonparametric could not be done between dominance and environmental factor.

Species *A. moluccana* and *G. serratifolia* are only the species that found to be included as species with dominance value in the highest of five at two regions and occur in the order of one and two. Both of these species in the Region III are in not include as species with dominance value in the highest of five (Fig. 6).

At the Region, I and Region II, species with the highest IVI belonged to *G. Serratifolia*, and at Region III was belong to *Litsea* sp (*Lauraceae* Family). *G. serratifolia* along with *A. moluccana* and *Actinodaphne* sp. were found to be the species that is included as the species with IVI in the highest of five, but not included in this group at Region III. The same is found for *L. celebicus*, but at a different area that is at Region II and Region III (Fig. 7).

Species with the lowest IVI at Region I belonged to *P. capitata*, at Region II belonged to *P. molucanum*, and at Region III was belong to *Bischovia javanica Blume* (*Phyllanthaceae* Family).

The highest value of Shannon Wiener's diversity index, Menhinick's richness index, and Pielou's evenness index was in Region II, and the lowest value of these indexes was in Region I. The value of Pielou's Evenness Index in all regions below 0.5 indicates that evenness of individual of species is relatively low. (Fig.7).

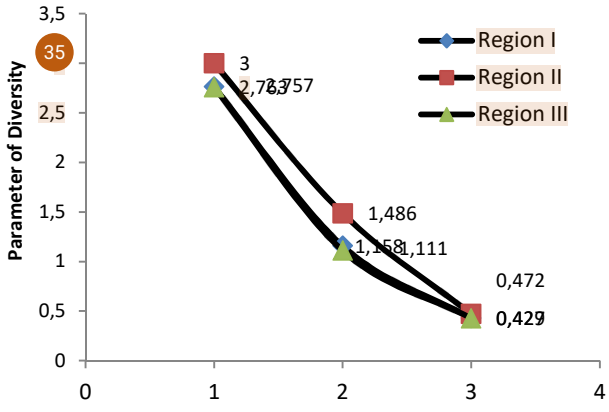

Fig. 7 Shannon Wiener Diversity Index (H '), the Pielou Evenness Index (J) and the Menhinick Richness Index (R)

Myrtaceae was the family with the highest number of species probably because of this family could see growth and adapted well in the tropic area with various abiotic and habitat factor at Realolo Village. The *Myrtaceae* are the ordinary families found in lowland tropical forests [16]. The *Myrtaceae* family could live in various habitat in Tropical Rainforest [17].The result of this study is very close to rainforest tree of the island of Tutuila, American Samoa where the most common families were *Myrtaceae* (five species) [18]. The tropical rainforest of Kibira, Burundi, Myrtaceae is second regarding plant families with the largest number of species [19].

In Pono Valley (alt.150 m) and the lower montane Bariri Forest (alt. 1 400 m) were found that the family of Lauraceae with a total of 19 species that is a family with the highest number of species, while *Myrtaceae* family has nine species. *Myrtaceae* has the second highest family importance value at lower montane forest [20]. The differences in the number of families and more species of these two forests than those found at the Realolo resorts are likely to be due to the higher locations that are hardly accessible to the population causing relatively undisturbed forest.

Species *G. serratifolia* was found growth well at the relatively open area with low soil moisture and rarely found at the higher altitude area. The research by Wawangningrum and Puspitaningtyas [21], found that this species grow well until the altitude at 1.200 m asl, also at the riverside, open area, and forest edge. *G. Serratifolia* grows and disperses in Sulawesi, Philippines, Borneo [12].

Species *C. confertum*, *L. celebicus*, *Litsea* sp., *Ficus* sp., were species that have good adaptation at high altitude. The seedling of *C. confertum* with the highest density at the location. Many *L. Celebicus* that found dispersed at highland areas in Mallempo Village, Resort Mallawa, Babul NP. Species *Litsea* sp. was found with low density in the same resort at lower area. In Malempo Village at average altitude 600 m asl, Mallawa Resort did not find any seedling of this species. On the other side, at a range of altitude 800-900 m,

asl found seedling with the same genus, which was *L. accedens* with the highest VI.

Ficus sp. is the species that could grow at lowland as well as at Highland. This plant was found with stem diameter 140 cm at an altitude 1,006 m asl at Bulusaraung mountain, Balloci Resort, Babul NP.This species can reach a large size and spread in various places.

High tolerance of *A. moluccana* toward tropical lowland tropic probably make this species grow well at lowland area in Realolo Village. Many *A. moluccana* found at the area with the tropical climate, like the light, and growth as tree pioneer at an open area [22]. *A.moluccana* also spreads throughout all the region in Indonesia.

Vitex cofassus Reinw. Ex Blume (*Lamiaceae* Family), *Pangium edule* Reinw. ex Blume (*Achariaceae* Family),*P. moluccanum*, and *B. javanica* were plants that have high economic value. Species *V. cofassus* is used as building material and *P. edule* as spices ingredients. (Babul NP' s officer, pers. comm.). At Ranupani Village *P. moluccanum*is used as firewood [23]. These conditions maybe make the species few and rare at Realolo Village.

B. javanica is species that its wood susceptible to disease [24] and found many at riverbank also with thick and fertile sandy soil [25]. *P. capitata* is a species with a low value of dominance and IVI probably due to environmental factors that are not suitable for these species to grow well. In contrast to research in the Malempo Village who found this species dominant regarding frequency.

In Region II there are more species with one individual. This perhaps due to the high number of species in this area, which in turn results in a low number of individual of species in this area. The tropical rainforest of South Western Nigeria, the occurrence of many rare species in an area due to the abundance species that presence with low-frequency [26].

The class interval of density and frequency showed that more rare species than widespread species and pattern of species distribution tend to clump. The characteristic of lowland tropical rainforest was that most species were rare species [11]. Factors causing the presence of rare species are pathogens and predators [27]. If the trees seedling grows close to the parent, then the chances of survival are very low because predators will easily find it or attacked by pathogens. To survive, the seedlings must grow away from the parent so that opportunities found by predators and pathogens become low. Researcher [28] said that a species might be rare because of the following, the geographical range of the species is narrow, the range of the species habitat is narrow, and about the local population, even where it is found, is its size small or the species are non-dominant.

Stem class diameter distribution showed that more species have small stem diameter than species with big stem class diameter. At riverside forest, Rio Botucaraí, Southern Brazil the distribution of the diameter of the tree class shows the distribution where most individuals are found in the two smallest diameter classes and decrease in number in the largest diameter classes [29]. The trees' regeneration was going well, due to the occurrence of many individuals of the species at low stem class diameter [30]. The productivity of tree biomass decreases with increasing light gap [23]. Odum [23] also mentions that the dominant species have massive productivity. Dominance can express plant biomass.

A proper regeneration process is vital for protected areas in Sulawesi, especially in Babul NP because, in this area, the destruction of forests and the conversion of land to agriculture mainly resulted in changes in tropical forests at a rapid rate [31]. Protected areas are essential for biodiversity conservation because they are used as a refugee for species, to sustain ecological processes that cannot continue to exist on land or water areas that have undergone extensive management and serve as a reference to human understanding in its interaction with nature [32].

The highest value of Shanon Wiener's index of diversity, Menhinnick'sindex of Richness, and Pielou'sindex of evenness were in Region II. High diversity is supported by the highness of species richness and species evenness of every species. The high diversity in Region II is presumably because the area is relatively open allowing for species to grow well in the area. In Region II there are more species with a single individual, thus providing more space for other species to grow. The high species richness in this area resulted in high diversity, which in turn making the number of individual trees in this region are fewer than the other two regions

Also, the results of this research show that the low evenness value is low due to many species that do not spread evenly and there is a species that is very dominating. If certain species in an area are dominant, while other species are not dominant, or their density is lower than the evenness value, the area will be lower [33]. In two upper Amazonian forests, this condition is due to the increasing number of small trees [34]. The high biodiversity in more seasonal wet forests, probably due to stress caused by a disease that is a factor that sustaining competitively superior of tree species at lower densities [35]. The diversity of a community is a combination of species richness and evenness of that community [36]. The value of diversity index can be used to know the condition of the community.

Soil's temperature and pH have a negative relation with trees' frequency and density at Realolo Village. Low soil temperatures could decrease water, and nutrient absorption that could impair metabolic processes caused inhibition of growth, and root and crown development [37]. Vegetation health is very much depending on water. Furthermore, dominance has no relationship with the environmental factors of the research sites, but there is a tendency that pattern of crown cover and litter thickness similar to the pattern of dominance.

IV. Conclusion

The tree vegetation structures in regions I and II have the same species with the highest values regarding density, dominance, frequency, and IVI and are different from those in region III. The distribution model of the stem class diameter in each area is inverse J. The value of Shannon Wiener's diversity Index Value, Pielou's Evenness Index, and Richness Index is the highest at Region IIandand the lowest at the Region III. The value of Pielou's evenness index in all regions is low. The density of tree is affected by the soil pH, and the frequency of tree is affected by soil temperature. This research indicates that tree vegetation

structure at Realolo village Resort Mallawa, Babul NP has a good condition considering the stem diameter has an inverse J-shaped curve. This needs to be maintained in the conservation management of this area. On the other hand, the existence of many rare species within the protected area makes this area vulnerable. Relatively good vegetation structures in Babul NP are essential for biodiversity in the Wallacea region especially Sulawesi considering the disturbance to vegetation in this area.

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