Vegetation Analysis Of Stand Trees Composition of Natural Forest Of Merapi Volcano National Park

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Abstract. Forest is an ecosystem that is yielded from the interaction of biotic and abiotic factors which all the included abundant capital natural resources is the grant from the God both to be preserved and utilized at the longlasting basis. Tropical rain forest compiled of highly kind varieties of plants and plays a very important role in hydrology and land protection. The purposes of this research to find out the native stand trees composition, to know the native stand trees kind abundance, and to know the species association types. This research was conducted at the natural forest of the Merapi Volcano National Park that is administratively located in Hargobinangun Village of Pakem Subdistrict of Sleman Regency of Yogyakarta Special Region Province from May until June 2014. Plot method was applied for the vegetation measurement which was in the various plot size based on the stand tree level with 2.5 percents sampling intensity towarded all the stand trees in the natural forest of Merapi Volcano National Park. The Importance Value Index, species variety, and species association calculation was included. The results of this study showed that there were 20 tree types and 20 tree families in the Merapi Volcano National Park. The Damar (Agathis damara) species has the highest importance value index at the tree level while the lowest went to Sandalwood (Santalum album) species. The vegetation community as the composer of the natural forest of Merapi Volcano National Park had a low level of species variety caused by a small number National Park of Mountain of and only had a few dominant species at the tree level.

1. Introduction
Currently, the condition of forests in Indonesia has undergone many changes so it is susceptible to damage. Tropical rain forest ecosystem is the specific characteristic of Indonesian forest that has fragile ecosystem, to be utilized in accordance with its ability required knowledge about the properties owned[1]. Tropical rain forest is a source of germplasm that can not be ignored. Indonesia has tropical climate that causes the soil to be fertile, so many species of plants can grow. In a plant community, its constituent species interact with each other and form an association. This association is the principal
unity of plant communities that have a particular floristic composition, uniformity of physiognomy and grow in uniform habitat conditions[2].

The forest in Mount Merapi has been designated as a protected area since 1931 for water source protection, river and buffer life system of Yogyakarta City and Sleman Regency, Klaten Regency, Boyolali Regency and Magelang Regency. Before being designated as a national park, the forest area belonging to the Special Province of Yogyakarta consists of protected forest ± 1.041,38 Ha, Plawangan Nature Preserve ±146,16 Ha; and Plawangan Turgo Nature Tourism Park ± 96,45 Ha. Forest areas belonging to the province of Central Java are protected forests ± 5.126 Ha[3].

Natural forest of Merapi Volcano National Park has high diversity of plant species and potential for protection and conservation. Problems encountered in forest protection and conservation activities can be resolved if there is information about the state of the forest. This information can be used as a consideration to determine management policies. One way to get that information is by vegetation analysis. Vegetation analysis can be approached in various ways such as based on vegetation floristic composition[4]. This is done in order to see the composition of the species of standing structure at the height of the tree. The data are collected by vegetation analysis. The object of this study is the original forest stands of Merapi Volcano National Park trees precisely in Plawangan Turgo Nature Preserve.

2. Methodology

2.1. Data collecting method
This research was conducted in Plawangan Nature Preserve of Merapi Volcano National Park. This study was conducted during early April to early May 2014. Materials needed were all species in the area of Plawangan Turgo Nature Preserve, Merapi Volcano National Park with an area of 50 ha which has a diameter at breast height (1.30 m) of 10 cm or more[5]. Data were collected using quadrant method and systematic sampling (IS 2,5%). The selection of plots was done systematically. This selection was intended to allow the data to be represented from the entire area under study[7], the sampling of vegetation was done by using multiple sample plots that are spread evenly.

2.2. Data Analysis Method
Vegetation analysis for tree species used Point Centered Method, observed tree species were recorded, determined, and identified, plant samples were made of herbarium, but also recorded growing places. A number of herbarium specimens were taken for further identification using reference books: Backer and Bakhuizen van den Brink (1963, 1965, 1968).

In the vegetation analysis the following parameters were calculated: species name, number of individuals, number of points, stem diameter to calculate the broad base area, and the height of the tree. Determination of dominant species was based on an Important Value Index (IVI)[8] which refers to the relative density (KR), relative frequency (FR), and relative dominance (DR) values of each species. Quantitatively, the diversity of species could be measured based on the diversity index, the richness index, and the similarity index that denotes the equitable division of individuals between species[9]. Furthermore, the Shannon-Weiner’s diversity index (H) and Simpson’s diversity index (λ) were determined by the following formula:

\[ H' = -\sum n_i/N \ln(n_i/N) \]

Where:
- \( H' \) : Shannon-Weiner’s diversity index
- \( n_i \) : Number of individuals of each type
- \( N \) : Total number of individuals observed

\[ \lambda = \sum_{i=1}^{s} p_i^2 \]

Where:
- \( \lambda \) : Simpson’s diversity index
- \( p_i \) : ni/N
\( n_i \) : Number of individuals of each type
\( N \) : Total number of individuals observed
\( i \) : 1,2,3 …etc

The determination of the Richness Index using the formulation proposed by Margalef (1958) and Menhinick (1964), using the formulation filed by the following:

\[
R1 = \frac{s-1}{\ln(n)}
\]

\[
R2 = \frac{s}{\sqrt{n}}
\]

Where:
\( R1 \): Margalef’s richness index
\( R2 \): Menhinick’s richness index
\( s \) : Total number of species observed
\( n \) : Total number of individuals observed

While to determine the index of similarity (Evenness Index) used the following formula:

\[
E = \frac{H'}{H_{max}}
\]

Where:
\( E \) : Evenness index (0 - 1)
\( H' \) : Shannon-Weiner’s diversity index
\( H_{max} \) : Shannon-Weiner’s maximum diversity index

2.3. Species association
The calculation of species associations was done by taking 7 tree species that had the highest important value index in the measuring plot. Then the value was compared with the value of the table and determined the species association which was positive or negative. The association analysis was done on the main constituent species that had an important value index \( \geq 10\% \) using 2x2 contingency table [10].

**Table** 1. 2x2 contingency association table

| Species B | Present | Absent | Total |
|-----------|---------|--------|-------|
| Species A | Present | A \( a \) | B \( b \) | \( a+b \) |
|           | Absent  | C \( c \) | D \( d \) | \( c+d \) |
| Total     | \( a+c \) | \( b+d \) | \( N=a+b+c+d \) |

Where:
\( A \) : The number of sampling units where both species, species A and species B
\( B \) : The number of sampling units where species A occurs, but not B
\( C \) : The number of sampling units where species B occurs, but not A
\( D \) : The number of sampling units where neither A nor B are found
\( N \) : the total number of sampling units

There are two types of associations. Determination of types of association is achieved by using association coefficient [9]:

\[
E(a) = \frac{(a+b)(a+c)}{N}
\]
With the following conditions
a. Positive – if observed \( a > E(a) \)
b. Negative – if observed \( a < E(a) \)

3. Result and Discussion

3.1. Composition Of Stand Trees
The results of observation and research in the Plawangan Nature Forest, Merapi Volcano National Park show that there are 20 species of trees consisting of 20 families. Plawangan Nature Forest, Merapi Volcano National Park consists of a mixed vegetation, and there are several species of plants that are more dominant than other types. Based on the results of calculation of relative density, relative dominance, and relative frequency can be sought or calculated into Importance Value Index (IVI) with summing the results of relative density, relative frequency, relative dominance of each species.

Table 2. Recapitulation of important value index of stand trees in Plawangan Nature Forest

| Number | Local name                | Scientific name               | Family      | IVI (%) |
|--------|---------------------------|-------------------------------|-------------|---------|
| 1      | Puspa                     | Schimawallichii              | Theaceae    | 60,79   |
| 2      | Pine                      | Pinemerkusii                 | Pinaceae    | 30,63   |
| 3      | Quinine                   | Cinchona ledgeriana          | Rubiaceae   | 20,35   |
| 4      | Rasamala                  | Altingia excels              | Hamamelidace| 17,79   |
| 5      | Sandalwood                | Santalum album              | Santalaceae | 10,90   |
| 6      | Dadap thorn               | Erythrina lithosperma       | Papilionaceae|14,17    |
| 7      | Bawangan                  | Zephyranthe sp               | Amarillidace| 7,02    |
| 8      | Kemadah                   | Laporte stimulans            | Urticaceae  | 7,84    |
| 9      | Flamboyan                 | Dalbergia latifolia         | Fabaceae    | 4,26    |
| 10     | Benda keboh               | Artocarpus elasticus        | Moraceae    | 6,38    |
| 11     | Tutupljo                  | Macarangajavanica           | Euphorbiace| 7,40    |
| 12     | Manijangan                | Cinnamomum burmani          | Lauraceae   | 6,79    |
| 13     | Delegan                   | Policias nodosa             | Araliaceae  | 5,14    |
| 14     | Klewer                    | Engelhardiaspicata         | Juglandaceae| 4,22    |
| 15     | Pulai                     | Alstonia scholaris          | Apocynaceae | 9,19    |
| 16     | Wolak-walik angin         | Mallotus paniculatus        | Euphorbiace | 4,65    |
| 17     | Acacia                    | Acacia mangium             | Mimosaceae  | 6,65    |
| 18     | Damar                     | Agathis damara             | Araucariace| 65,61   |
| 19     | Jamuju / muja-muju        | Podocarpus imbricartus      | Podocarpace| 6,89    |
| 20     | Sarangan                  | Castanopsis argentea        | Fagaceae    | 3,40    |
| Total  |                           |                               |             | 300     |

Source: Data processing in 2015

From the calculation of IVI 20 species of trees in the Plawangan Natural Forest area, there are 7 species with IVI above 10% consisting of Damar (Agathis damara) 65,61%; Pine (Pinemerkusii) 30,63%; Quinine (Cinchona ledgeriana) 20,35%; Rasamala (Altingia excelsa) 17,79%; Dadap thorn (Erythrina lithosperma) 14,17%; Sandalwood (Santalum album) 10,90% and Puspa (Schima wallichii) 60,79%.

3.2. Association Of Stand Trees
The association between the constituent species of vegetation can be used as a basis for the classification of vegetation [11]. Those 7 species of trees are combined into 21 pairs of combinations of tree species to be calculated using Chi Square (X²). After that, compares X² count and X² table (significance level \( \alpha = 5\% \)) amounted to 3,84. The results of association calculation or real relationship between Damar (Agathis damara) and Pine (Pinemerkusii) is 16,69; Damar (Agathis damara) and Quinine (Cinchona ledgeriana) 11,89; Damar (Agathis damara) and Rasamala (Altingia excelsa) 15,17; Damar (Agathis damara) and Dadap thorn (Erythrina lithosperma) 8,01; Damar (Agathis
This is supported by the broad form of association matrix obtained (Altingia excelsa), Damar (Erythrina lithosperma), and Quinine (Cinchona ledgeriana) with Dadap thorn (Erythrina lithosperma), 7,33. From the results can be found that the species with an association relationship is a high IVI species, because the high IVI species is the type that is often present in the observation plot, the number is relatively more and the spread is evenly distributed. The existence of several species commonly grown together due to 3 main reasons that are the spread of seeds in groups, environmental differences and also the interaction of several species[12]. To further clarify the association, the results of chi-square calculations are made an association matrix. Species that indicates the existence of associations either positive, or negative or not indicate an association relationship will be clearly displayed in the matrix of this association.

Table 3. Interspecies association matrix for tree level

| A  | B   | C   | D   | E   | F   | G   | H   |
|----|-----|-----|-----|-----|-----|-----|-----|
| A  | +   | -   | -   | -   | -   | -   | -   |
| B  | -   | -   | +   | -   | -   | -   | -   |
| C  | -   | +   | -   | -   | -   | -   | -   |
| D  | -   | -   | -   | -   | -   | -   | -   |
| E  | -   | -   | -   | -   | -   | -   | -   |
| F  | -   | -   | -   | -   | -   | -   | -   |
| G  | -   | -   | -   | -   | -   | -   | -   |
| H  | -   | -   | -   | -   | -   | -   | -   |

Source: Data processing in 2015

Where: A: Damar (Agathis damara) B: Pine (Pinus merkusii), C: Quinine (Cinchona ledgeriana), D: Rasamala (Altingia excelsa), E: Dadap thorn (Erythrina lithosperma), F: Sandalwood (Santalum album), G: Puspa (Schima wallichii).

The species composition and plant diversity in forests depends on several environmental factors such as moisture, nutrition, sunlight, topography, source rocks, soil characteristics, canopy structures and land use histories[13]. The association matrix obtained by Damar (Agathis damara) with Pine (Pinus merkusii), and Quinine (Cinchona ledgeriana) with Dadap thorn (Erythrina lithosperma) shows that there is a positive association. It indicates that both pairs of species have mutual reciprocity or symbiotic mutualism, and thus the pairs indicate the tolerance of living together in the same area or there is a mutually beneficial relationship, especially in sharing living space. In addition to the influence of interaction on each other, each plant gives each other a place to live in an area and the same habitat[14]. While Damar (Agathis damara) and Quinine (Cinchona ledgeriana), Damar (Agathis damara) and Rasamala (Altingia excelsa), Damar (Agathis damara) and Dadap thorn (Erythrina lithosperma), Damar (Agathis damara) and Sandalwood (Santalum album), Puspa (Schima wallichii) and Dadap thorn (Erythrina lithosperma), Pine (Pinus merkusii) and Quinine (Cinchona ledgeriana), Pine (Pinus merkusii) and Rasamala (Altingia excelsa), Pine (Pinus merkusii) and Dadap thorn (Erythrina lithosperma), Pine (Pinus merkusii) and Sandalwood (Santalum album), show anegative associationso exterminating or destructive each other because of the occurrence of competition between these species. This competition is due to these species have the same life needs while the resources that support the needs of life in a limited state. This is supported by the broad form of morphological roots that can potentially be competitors in gaining nutrients and water[15].

3.3. Analysis Of Species Diversity

Analysis of species diversity is used to describe the diversity, richness and similarity of vegetation in an ecosystem.
Table 4. Analysis result of species diversity in Plawangan NatureForest

| Diversity Index | Richness Index | Evenness Index |
|-----------------|----------------|---------------|
| Shannon (H')    | Simpson (λ)    | Margelef (R1) | Menhinick (R2) | (E1) |
| 2.50            | 0.13           | 3.34          | 1.16           | 0.83 |

Source: Data Processing in 2015

Based on the results of the analysis of species diversity, it can be seen that the diversity of vegetation at tree level in Plawangan Natural Forest is classified in high levels. (H’=2>2.5>3). The Shannon-Wiener’s diversity index (H’) can illustrate species diversity, also can describe ecosystem productivity, ecosystem stress, and ecosystem stability. The high species diversity indicates that the function and process of ecology in the research location is still running normally or there is no physical pressure that can affect the stability of a community. With a high diversity value, the community is more stable so it can compete in gaining nutrients and indicates the stability of a community[16]. Simpson’s index in Plawangan Natural Forest is low with value of 0.13. The value of Simpson’s index is 0-1, if λ value close to zero then the diversity is low and will be high if the value λ close to 1[17].

The richness index shows the number of species in a community. The value of this richness index depends on the sample size (and time that needed to reach it). This is due to the relation between species richness index and total number of observed individuals that increases with increasing sample size[9]. Based on the results of Margalef’s richness index (R1) and Menhinick’s richness index (R2), Natural Forest of TurgohasR1: 3.34 and R2: 1.16. The evenness index shows the level of individual division that is evenly distributed among species. The value of evenness index is a measure of the balance between one community with others. This value is influenced by the number of species in a community[9]. The high value of species diversity in a habitat means that the balance of the community will be high too. The analysis shows Plawangan Natural Forest has the evenness index (E) of 0.83. E <0.3 indicates evenness of low class; E = 0.3 - 0.6, evenness type is moderate; and E > 0.6 [18], indicates high evenness. So that evenness species in Plawangan Natural Forest including high.

4. Conclusion

Based on the results of observation and analysis of the vegetation community in Plawangan Natural Forest, Merapi Volcano National Park can be drawn some conclusions as follows:

1. There are 20 species of trees composing Plawangan Natural Forest and there are 7 species with Important Value Index above 10% consisting of Damar (Agathis damara) 65.61%; Pine (Pinus merkusii) 30.63%; Quinine (Cinchona ledgeriana) 20.35%; Rasamala (Altingia excelsa) 17.79%; Dadap thorn (Erythrina lithosperma) 14.17%; Sandalwood (Santalum album) 10.90 and Puspa (Schima wallichii) 60.79%.

2. The matrix of tree constituent composition of Plawangan Natural Forest obtained by Damar (Agathis damara) and Pine (Pinus merkusii), Quinine (Cinchona ledgeriana) and Dadap thorn (Erythrina lithosperma) shows positive associations of reciprocal and interrelated relationships between Damar (Agathis damara) and Quinine (Cinchona ledgeriana), Damar (Agathis damara) and Rasamala (Altingia excelsa), Damar (Agathis damara) and Dadap thorn (Erythrina lithosperma), Damar (Agathis damara) and Sandalwood (Santalum album) Puspa (Schima wallichii) and Dadap thorn (Erythrina lithosperma), Pine (Pinus merkusii) and Quinine (Cinchona ledgeriana), Pine (Pinus merkusii) and Rasamala (Altingia excelsa), Pine (Pinus merkusii) and Dadap duri (Erythrina lithosperma), Pine (Pinus merkusii) and Sandalwood (Santalum album) shows negative associationso as to exclude or destroy each other.

3. Species diversity in Plawangan Natural Forest with Margalef and Menhinick’s Richness Index each has value of R1 = 3.34 dan R2 = 1.16; Shannon-Wiener’s Diversity Index is high (H’ = 2>2.5>3) but on Simpson’ Index is low (λ = 0.13); Evenness Index (E) is classified as high (E = 0.83>0.6).
References

[1] D. and A. T. Marsono, “Ekosistem Hutan Hujan Tropika Humida,” Faculty of Forestry UGM, Yogyakarta, p. 1984, 1984.

[2] Ludwig, J A dan J. F. Reynold. Statistical Ecology. Jhon Wiley and Sons, 1988.

[3] Balai Taman Nasional Gunung Merapi, “Laporan Tahunan Balai Taman Nasional Gunung Merapi,” Yogyakarta, 2009.

[4] G. R. Tallo, “Analisis Vegetasi Hutan Adat Siat Desa Lutharato Kecamatan Lamaknen Selatan Kabupaten Belu Propinsi Nusa Tenggara Timur,” INSTIPER, 2013.

[5] L. Benson, Plant Classification. Boston: D.C. Heath, 1957.

[6] Indriyanto, Ekologi Hutan. I. Jakarta: Bumi Aksara, 2006.

[7] C. Kusmana, Metode Survey Vegetasi. Bogor: IPB Bogor, 1997.

[8] G. Cox, Laboratory Manual of General Ecology. New York: Brown Company Publisher, 1978.

[9] Ludwig, J. A. dan J. F. R. Ludwig, Statistical Ecology. New York: Jhon Wiley and Sons, 1988.

[10] P. 1971. Greig-Smith, “Analysis of Vegetation data : the user view-point.,” Statistical Ecol., vol. 3, pp. 146–166, 1971.

[11] K. Kershaw, “Association and co-variance Analysis of Plant Communities,” Ecology, vol. 49, pp. 643–655, 1973.

[12] R. Whittaker, Communities and Ecosystem. New York: Macmillan PublishingCo. Inco, 1975.

[13] S. S. and E. K. S. Hutchinson, T.F., R.E.J. Boerrner, L.R. Iverson, “Landscape patterns of understory composition and richness across a moisture and nitrogen mineralization gradient in Ohio (USA) Quercus forest,” Plant Ecol., vol. IV, pp. 177–189, 1999.

[14] M.-D. and E. H. Aims and Methods of Vegetation Ecology. New York: John Wiley & Sons, 1974.

[15] C. van Steenis, Flora untuk sekolah di Indonesia, vol. I. Jakarta: PT Pradnya Paramita, 1981.

[16] E. P. Odum, Dasar-dasar Ekologi. Gajah Mada University Press, 1998.

[17] Yazwiar, “Keanekaragaman Plankton dan Keterkaitan dengan Kualitas airdi Parapat Danau Toba,” Universitas Sumatra Utara, 2008.

[18] M. F. Fachrul, Metode Sampling Bioekologi. Jakarta: Bumi Aksara, 2007.