Species Composition and Stand Structure in sub-montane Forest of Mount Galunggung, Tasikmalaya, West Java

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Abstract. Mount Galunggung is an active stratovolcano in Tasikmalaya, West Java, which shows the last major eruption in 1982-1983. This eruption caused the changes in forest vegetation, so this study aims to analyze species composition and stand structure in Mount Galunggung forest. This study conducted using a combination between transect and line plot methods. Based on the findings, there are 58 species of trees and its regeneration belonging to 24 families and 63 species of understorey belonging to 21 families. The highest species number of trees and its regeneration comes from Theaceae (7 species), Lauraceae (7 species), Moraceae (5 species), and Myrtaceae family (4 species). Furthermore, the highest species number of understorey comes from Urticaceae (4 species), Rubiaceae (3 species), and Orchidaceae (3 species) family. The species composition of trees and its regeneration dominated by pioneer species such as Homalanthus populneus, Ficus spp., and Schima wallichii, and climax species such as Castanopsis javanica, C. tungurrut, and Macropanax dispernum. Besides that, understorey dominated by Begonia robusta, Pilea melastomoides, and Athyrium sorgonense. Diameter distribution of the trees forming inverted J-curve that was dominated by 10-20 cm diameter class. Stratification of the trees canopy dominated by C stratum (4-20 m).

1. Introduction

Based on several characteristics (climate, edaphic, and plant composition, and forest stands factors), Indonesia's forests classified as a tropical rainforest. This forest type found in areas with a climate that is always wet (climate types A and B), located far from the coast, forest stands dominated by evergreen trees, and not shedding leaves [1, 2]. Mountain forest is one of the tropical rain forest formations found in the mountainous region at altitudes between 1000 to 2400 m asl [3].

One of the mountain forests in West Java is Mount Galunggung forest, which has an altitude of 2168 m asl. Galunggung Mountain is a volcano located in Tasikmalaya, West Java, protected forest based on Minister of Agriculture Decree No. 837 /Kpts/UM/II/1980, November 24, 1980. Mount Galunggung has experienced four eruptions in 1822, 1894, 1918, and 1982. Mountain eruptions caused changes in vegetation and environmental conditions.

Before the eruption, 85 species of trees found in the Galunggung Mountain forest. However, after the eruption, only found six species of trees and dominated by pioneer species such as Schima wallichii, Parasponia parviflora, Ficus toxicaria, Eugenia cuprea, Glochidion arborescens, and Eugenia operculata. At least, the plant species that live in the location are thought to be caused by...
conditions of growing areas that are dominated by sandy parent material and clay rocks with depths reaching one meter [4].

This research is essential to analyze the composition of species and stands structure in Mount Galunggung forest. Then, by knowing the composition of species and structure of a forest stand, it can also be known as the potential of biological natural resources in Mount Galunggung. This data collection is also one of the steps that can be undertaken as a material consideration, and reference in managing the Mount Galunggung protected the forest.

2. Method

2.1. Study site
This research was conducted in January-February 2017 in Mount Galunggung forest at plot 23 RPH Cisayong, BKPH Tasikmalaya, KPH Tasikmalaya.

2.2. Procedure
Data collected in this research are the name of species and the number of individuals (for understorey, seedling, sapling, pole, and tree), diameter a breast-high (dbh), and total high (for pole and tree). In this research, the sampling unit for vegetation analysis used a combination of transect and line plot method. Sample plots made to cut contour lines or contours perpendicular to the placement of sample plots at three locations, which have different altitudes, namely 1300 m asl, 1400 m asl, and 1600 m asl. The sample plot design used can be seen in Figure 1. Besides that, soil texture, pH, C-organic, CEC, Total N, P, and K analyzed at Soil Science Laboratory, IPB University.

![Diagram of sampling unit combination between transect and line plot method](image)

A plot: 2 m x 2 m subplots for seedling and understorey inventory
B plot: 5 m x 5 m subplots for sapling inventory
C plot: 10 m x 10 m subplots for pole inventory
D plot: 20 m x 20 m subplots for tree inventory

**Figure 1.** Design of sampling unit combination between transect and line plot method [5]

2.3. Data analysis

2.3.1. Important Value Index (IVI)
The important value of vegetation calculated with the following formulae:

\[
IVI = RD + RF \quad (\text{for understorey, seedling and sapling stage})
\]

\[
IVI = RD + RF + RDo \quad (\text{for pole and tree stage})
\]
2.3.2. *Species Diversity Index*

1. Shannon-Wieners Indeks of Diversity formula ($H'$) [6]:
\[ H' = - \sum (p_i \ln p_i) \]

2. Pielou index of Evenness (Pielou 1975 in [6]):
\[ E = \frac{H'}{\ln(S)} \]

3. Index of Richness (R) using the Margallef formula (Clifford and Stephenson 1975 in [6]) as follows:
\[ R = \frac{S - 1}{\ln(N)} \]

2.3.3. *Dominance Index*

To find out the dominance index, the following formula is used [7]:
\[ ID = \sum \left( \frac{n_i}{N} \right)^2 \]

3. Result and discussion

3.1. *Species Composition*

Based on the analysis vegetation results, the species number found varies at each growth stage at various altitudes. In the research area, there are 46 species of seedling, 41 species of the sapling, 41 species of the pole, 56 species of tree, and 63 species of understorey. The number of plant species in the research study can be seen in Table 1.

| Altitude  | Species number at each growth stage at each altitude |
|-----------|------------------------------------------------------|
|           | Seedling | Sapling | Pole | Tree | Understorey |
| 1300 m asl| 25       | 29      | 22   | 27   | 27          |
| 1400 m asl| 27       | 27      | 25   | 39   | 26          |
| 1600 m asl| 13       | 18      | 23   | 33   | 25          |

The species number of understorey, trees, and regeneration tends to decrease with increasing the altitude. Generally, number of species at an altitude of 1600 m asl is lower than at an altitude 1300 and 1400 m asl. This is consistent with Rozak and Gunawan [8] that increased altitude significantly declining the trees species. Besides that, the highest number of understorey species found at an altitude of 1300 m asl. The understorey is greatly influenced by sunlight entering the forest floor. Abundant sunlight will trigger the growth and development of intolerant understorey [9, 10].

3.2. *Dominant Species*

Vegetation analysis results are used to calculate the Important Value Index of each species found at each growth stage. The five dominant species based on the Important Value Index presented in Table 2. Based on Table 2, species dominant at a growth stage do not always dominate at the next growth stage, there are some species of plants that are only found at a certain growth stage. This is consistent with Dendang and Handayani [11], which states that not all species of vegetation found at every stage of growth. The disturbance could affect the regeneration process, causing changes in the composition of species that occupy at each growth stage.
At the research location, species of pioneers such as Homalanthus populneus, Ficus spp., and Schima wallichii are still commonly found. The species of climax such as Castanopsis javanica, Castanopsis turgurut, and Macropanax dispensum have also dominated at a certain altitude. This result shows that those species can grow well and adaptive to environmental conditions (soil and topography) in research location.

Homalanthus populneus dominates at the seedling stage at an altitude of 1300 m asl and the pole stage at an altitude of 1 600 m asl. This is caused by more open canopy cover so that more sunlight enters the forest floor and then encourages seeds of that type to grow. Homalanthus sp. is a pioneer species and dominates in secondary succession areas in mountain forests [12] [van Valkenburg and Ketner 1994 in [13]. Besides that, Schima wallichii pionir species found in the rainforest, in the pamah to the mountains at an altitude of > 700 m asl. This species can regenerate well in disturbed forests [3]. This species was spread out and commonly found in sub-montane forest especially in west Java, such as in sub-montane forest of Mount Endut, Banten [14], Wornoojiwo forest area, Cibodas Botanical Garden [15], sub-montana forest at Gede Pangrango Mountain National Park [16], secondary forest at Mount Papandayan [17], etc.

One of the species of Ficus spp. that dominates at each altitude is Ficus ribes. Ficus ribes also dominated in Wornoojiwo forest area, Cibodas Botanical Garden [15]. This species can grow up to 15 m in diameter reaching 30 cm, grows at an altitude of 100-1800 m asl, and is very common in mountain forests [18]. Macropanax dispensum dominates at the stage of seedlings and poles at an altitude of 1400 m asl because at that height is a suitable condition for its growth. According to Backer and van den Brink [19], Macropanax dispensum found in moist forests with a height of 1000-2300 m asl. Castanopsis javanica always found at every altitude. Castanopsis javanica can live at an altitude of 90-1650 m asl [18], in primary or sometimes in the secondary forest [17,20]. Hidayat [15] stated

![Table 2. Dominant species of understorey, tree, and its regeneration in research area based on Important Value Index (IVI)](table.png)
that the marga of Castanopsis was found dominance at 1300 m asl in Tanjung Tiga protected forest, Muara Enim.

3.3. Diversity of Plant Species
The Diversity Index is used to see the level of diversity of plant species in a forest community. Margalef (1972) in Magurran [6] states that diversity index values range between 1.5 and 3.5. Diversity index values of more than 4.5 are very rare. Based on the data in Table 3, it is known that the species diversity index obtained classified as moderate (2 < H < 3). The higher the diversity of species, the community will be more stable and have a higher ability to deal with forest disturbance [21]. Based on Fonge et al [22], diversity of species was affected by soil parameters such as organic carbon, nitrogen, calcium, and CEC.

Table 3. The species diversity index of understorey, tree, and its regeneration in the research area

| Altitude | Species Diversity Index |
|----------|-------------------------|
|          | Seedling | Sapling | Pole | Tree | Understorey |
| 1300 m asl | 2.93     | 2.91    | 2.74 | 2.89 | 2.64       |
| 1400 m asl | 2.80     | 2.77    | 2.84 | 2.85 | 2.77       |
| 1600 m asl | 2.01     | 2.56    | 2.81 | 2.91 | 2.53       |

Table 4. Richness index of understorey, tree, and its regeneration in the research area

| Altitude | Species Richness Index |
|----------|------------------------|
|          | Seedling | Sapling | Pole | Tree | Understorey |
| 1300 m asl | 5.97     | 5.60    | 4.68 | 4.80 | 4.44       |
| 1400 m asl | 5.13     | 5.09    | 5.15 | 6.92 | 4.22       |
| 1600 m asl | 2.45     | 3.45    | 4.95 | 5.56 | 3.93       |

Richness index is used to determine the species richness in a community. Based on Table 4, it is known that the richness index value is low (<3.5) to high (R > 5.0). The value of species richness index is directly proportional to the number of plant species in a community. The higher the species number found, the higher the value of the richness index. In general, the richness index decreases with increasing altitude. Magurran [6] explains that evenness index values range from 0-1. The evenness index value will reach a maximum (by 1) if all species have the same number of individuals. Based on Table 5, generally, the evenness index obtained tends to be close to 1. This indicates that almost all species at each growth stage and understorey at various altitudes have the same numbers of individuals.

Table 5. Evenness index of understorey, tree, and its regeneration in research area

|Altitude | Species Evenness Index |
|---------|------------------------|
|         | Seedling | Sapling | Pole | Tree | Understorey |
| 1300 m asl | 0.87     | 0.86    | 0.89 | 0.88 | 0.79       |
| 1400 m asl | 0.83     | 0.83    | 0.88 | 0.78 | 0.84       |
| 1600 m asl | 0.79     | 0.88    | 0.90 | 0.83 | 0.79       |

Table 6. Dominance index of understorey, tree, and its regeneration in research area

| Altitude | Dominance Index |
|---------|-----------------|
|         | Seedling | Sapling | Pole | Tree | Understorey |
| 1300 m asl | 0.064   | 0.075   | 0.084 | 0.071 | 0.095 |
| 1400 m asl | 0.081   | 0.086   | 0.092 | 0.092 | 0.076 |
| 1600 m asl | 0.195   | 0.101   | 0.075 | 0.079 | 0.129 |
The dominance index is a parameter that showed the level of mastery of species in a community [7]. Overall, the dominance index value obtained is relatively low because it tends to be close to zero (0) (Table 6). This shows that at each growth stage and understorey at various heights are not controlled by one plant species, but controlled by several plant species together [23].

### 3.4. Individual Density of Understorey, Tree and its Regeneration

Based on Table 7, individual density decreases with increasing growth stage. The highest density at the seedling, sapling and pole stage found at an altitude of 1400 m asl with a density of seedling was 23500 ind ha\(^{-1}\), sapling was 3232 ind ha\(^{-1}\), and pole was 424 ind ha\(^{-1}\). Then, at the tree stage, there is an altitude of 1600 m asl of 315 ind ha\(^{-1}\).

| Altitude     | Seedling | Sapling | Pole   | Tree    | Understorey |
|--------------|----------|---------|--------|---------|-------------|
| 1300 m asl   | 10 900   | 2 832   | 356    | 224     | 47 300      |
| 1400 m asl   | 23 500   | 3 232   | 424    | 242     | 43 500      |
| 1600 m asl   | 13 500   | 2 208   | 340    | 315     | 44 700      |

These results also show that individuals at specific growth stages do not all grow to the next growth stages. This is caused by competition between individuals within the same species and competition between different species. This competition occurs in terms of obtaining light, groundwater, oxygen, nutrients, carbon dioxide, and space (Vickery 1984 in Indriyanto [7, 24]).

Individual density at each growth stage at an altitude of 1300 m asl is lower compared to an altitude of 1400 m asl. This caused by forest disturbance such as tree logging activities carried out by the community around the forest because the location of the forest at an altitude of 1300 m asl is more easily accessible by the community. Tree logging in Java strongly influenced by accessibility, such as topographical conditions. Tree logging is more common in flat locations and closes to the outer border of the forest. This is following Smiet [25] In addition, the location is a pathway to many tourist attractions traversed by the community, thus allowing disruption to the forest ecosystem. The existence of forest disturbance by humans causes damage to the forest ecosystem, resulting in a decrease of plant species in the area [21, 23, 25, 26].

However, tree logging that occurs does not significantly affect the ongoing regeneration process. This can be seen from the density of seedlings, saplings, poles, and trees at various altitude that still meet the criteria of Wyatt-Smith [27], where regeneration considered sufficient if there are 40% or 1000 seedlings ha\(^{-1}\) that are spread evenly, at the stage of sapling at least 60% or 240 saplings ha\(^{-1}\) that are spread evenly, at the pole stage of 75% or 75 poles ha\(^{-1}\) that spread evenly, and at the tree stage 100% or 25 trees ha\(^{-1}\) that are spread evenly. The availability of seedlings, saplings, and poles in a forest must be sufficient to ensure a natural regeneration process.

### 3.5. Forest Stand Structure

Horizontal stand structure can be seen from the relationship of tree density with the distribution of its diameter class. Based on Figure 2, the highest tree density at various altitudes found in the 10-20 cm diameter class, and the lowest tree density was in the > 60 cm diameter class. The number of trees distributed in the smallest diameter class and the number of trees decreases with increasing stem diameter [14, 28, 29]. The vertical stand structure can be seen from the relationship of tree density with canopy height. Based on Figure 3, it is known that trees in the 4-20 m high class (C stratum) have the highest density at various altitudes. Tree density decreases with increasing tree height.

Canopy stratification formed at various altitudes dominated by C stratum (4-20 m high). Trees in C stratum have a continuous canopy, low trees, small, and many branches [24]. Based on the results, it is known that the canopy stratification formed at an altitude of 1300 m asl and 1600 m asl consists of B and C stratum, while at an altitude of 1400 m asl consists of A, B, and C stratum. Yamada [30] states
that with increasing the altitude, tree height will decrease, and stratification of the canopy formed will be more straightforward. This canopy stratification occurs because of two important things experienced by plants in their alliance with other plants, namely the existence of competition between the plants and tolerance of tree species to the intensity of sunlight [7, 25].

![Figure 2. Horizontal stand structure at each altitude](image)

![Figure 3. Vertical stand structure at each altitude](image)

3.6. Soil properties in the sub-montane forest of Mount Galunggung

Physical and chemical properties of soil affect plant vegetation in their habitat. Plant species that dominate at the research area show that these plant species can adapt and utilize nutrients that are available properly. Sambas et al. [31] state that each tree species has a specific preference for abiotic factors (soil and topography). Wiharto et al. [32] also stated that soil and topography factors influence vegetation alliance in forest ecosystems of Mount Salak, Bogor. The results of soil analysis can be seen in Table 8.

| Soil properties | Altitude          |
|-----------------|-------------------|
|                 | 1300 m asl | 1400 m asl | 1600 m asl |
| Texture         | Loamy sand | Loamy sand | Loamy sand |
| pH              | 5.15 - 5.28   | 4.97 - 5.11 | 4.84 - 5.44 |
| CEC             | 9.73 - 22.11  | 9.40 - 15.24 | 13.11 - 19.33 |
| Organic-C       | 4.08 - 6.36   | 1.47 - 2.79  | 3.68 - 5.53  |
| Total-N         | 0.22 - 0.32   | 0.17 - 0.25  | 0.29 - 0.33  |
| P               | 16.11 - 25.12 | 13.83 - 17.80 | 12.74 - 17.51 |
| K               | 22.55 - 71.29 | 12.88 - 26.56 | 17.78 - 28.05 |

Based on the results of the study, the soil texture at the study site was dominated by sand fractions (Loamy sand) at an altitude of 1300, 1400, and 1600 m asl. According to Gunawan et al. [33], the soil texture after the eruption was dominated by volcanic ash and sand, as found in the Mount Merapi National Park. Nandini and Narendra [34] also stated that soil texture was dominated by sand with a percentage of 82-94.5% in the area after the eruption of Mount Batur.

Soil pH at various altitudes classified as acidic. Acidic soil conditions also found in the sub-montane forest in Gunung Endut, Banten [14]. Soil pH determines whether or not plants absorb nutrients. In acid soils, P nutrients cannot be absorbed by plants because Al binds them. The Al element is also a poison for plants [35]. Fauzie et al. [36] explained that the pH could change with
time due to the growth of plants in the area. According to Dong et al. [37], pH has a positive correlation with CEC and the availability of nutrients such as C-organic, total N, P, and K.

The cation exchange capacity (CEC) shows the ability of the soil to hold and exchange cations. Cation exchange capacity is a chemical characteristic that is closely related to soil fertility. The CEC obtained classified as low to moderate. Land with a low CEC can absorb and has a lower nutrient storage power. CEC is also strongly influenced by the content of organic matter present in the soil [35]. Soils with high organic matter content will have a higher CEC. Soils at an altitude of 1300 and 1600 m asl contain C-organic, which is higher than 1400 m asl, causing an increase in CEC.

Organic C classified as moderate to high. The organic content of the soil influenced by the level of decomposition of organic material present on the forest floor. The decomposition of organic matter strongly influenced by temperature, humidity, soil air conditioning, soil treatment, pH, type of organic matter [35], and abundant litter [38]. Based on the results, total N is low to moderate, P content is low to moderate, and K is low to very high.

4. Conclusion
Species composition of the tree and its regeneration in Galunggung Mountain sub-montane forest still dominated by pioneer species such as Homalanthus populneus, Ficus ribes, Ficus septica, Ficus fistulosa, Ficus cuspidata, and Schima wallichii and climax species such as Castanopsis javanica, C. tungurut, and Macropanax dispernum. Besides that, species composition of understorey dominated by Begonia robusta, Pilea melastomoides, and Athyrium sorgonense. Diameter distribution of the trees forming invaded J-curve that was dominated by 10 to 20 cm diameter class. Stratification of the trees canopy dominated by C stratum (4-20 m).

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