

Vegetation Analysis Using the Square Transect Method in the Bodogol Nature Conservation Education Center

Risti Mulyani Nur 'Kauthsar¹, Putri Amelia Agustin¹, Irgi Indrawan¹,
Intan Dwi Yulianti¹, Revinda Janiar Andika¹, Suhendar^{1*},
Gina Nuranti¹

¹Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Muhammadiyah Sukabumi, Jl. R. Syamsudin, S.H. No. 50, Sukabumi City, 43113, Indonesia.

*Corresponding Author: suhendar@ummi.ac.id

Abstract. *Bodogol Nature Conservation Education Center is part of Gunung Gede Pangrango National Park and represents lower montane forest vegetation that is still relatively well preserved. This study aimed to describe the structure and composition of the plant community and relate it to soil edaphic conditions. A descriptive-quantitative approach was applied using the square transect method with random sampling on three transects equipped with nested plots of 20 × 20 m, 10 × 10 m, 5 × 5 m, and 2 × 2 m. All plant species found in the plots were recorded, and the number of individuals per species was used to calculate density, frequency, dominance, the Importance Value Index (IVI), as well as the Shannon-Wiener diversity index (H'), evenness (E), and species richness (R). A total of 36 species were recorded with a few dominant species, particularly *Schima wallichii* and *Vernonia amygdalina*, while most other species showed low IVI values. The H', E, and R values indicate low diversity, evenness, and species richness, with a community dominated by a small number of adaptive species. Edaphic conditions characterized by sandy soils with near-neutral pH, relatively stable soil temperature, and decreasing soil moisture with depth help shape this dominance pattern. These findings provide baseline information on community structure and edaphic conditions to support vegetation management and conservation planning in the Bodogol area.*

Keywords: *Vegetation, Bodogol, Diversity, Index, Edaphic*

1. Introduction

The Bodogol Nature Conservation Education Center (PPKA Bodogol) is part of the Gunung Gede Pangrango National Park (TNGGP), which lies within the Cibodas Biosphere Reserve and covers approximately 24,270 hectares. The area hosts a high diversity of vegetation and serves as an important conservation zone for maintaining the ecological balance of the lower montane forest ecosystem in West Java (Kartawinata & Sudarmonowati, 2022). Topographically, Bodogol consists of hilly terrain with slopes ranging from 10° to 70°, characterized by mixed forest formations that include natural forest as well as restoration areas (Sadili, Salamah, Mirmanto, & Kartawinata, 2023).

Vegetation is a fundamental component of ecosystems, contributing to environmental stability through ecological processes such as nutrient cycling, carbon sequestration, and interactions with other organisms (Sinapoy, 2018; Ufiza et al., 2018). Analyses of vegetation structure and composition are essential for understanding ecosystem dynamics and assessing the stability of plant communities within a given area (Safe'i et al, 2021). Vegetation studies can also be used to evaluate regeneration status, species dominance, and species diversity, key indicators of forest ecosystem health (Ismail, 2024).

Previous research in the Bodogol area indicates that restoration forests are still

dominated by a few particular species and exhibit relatively low diversity, suggesting that natural succession is ongoing (Sadili et al, 2023). Research by Rozak et al, (2016) on tree species richness across different elevation zones in Gunung Gede Pangrango National Park found that relatively undisturbed submontane forests have the highest species diversity compared to montane and subalpine zones. Meanwhile, Kusumo et al, (2016) reported that vegetation degradation in Tesso Nilo National Park led to a decline in species numbers and diversity values across all growth stages. These findings demonstrate that analyses of vegetation structure and composition can effectively reflect ecosystem stability and provide a scientific basis for conservation management, particularly in areas such as Bodogol, where mixed forest conditions and ongoing successional processes are present.

However, most previous studies have focused solely on species observations or vegetation structure without examining their relationship to soil conditions. Edaphic factors such as soil texture, pH, and organic matter content play an important role in determining the distribution, growth, and dominance of plant species (Holilullah et al., 2015; Zuhaida, 2018).

Until now, studies integrating vegetation analysis with edaphic characteristics in the Bodogol area remain limited, particularly those applying quantitative approaches based on field data and secondary data. Therefore, this study aims to analyze the vegetation structure and composition in the PPKA Bodogol area and relate them to soil edaphic conditions. The findings are expected to provide baseline information that will support vegetation management and conservation planning in the Bodogol forest conservation area.

Despite the rich vegetation diversity in Bodogol, most previous studies have either focused on individual species observations or structural analysis without considering the relationship between vegetation and soil conditions. This study aims to fill that gap by integrating both aspects in a quantitative manner to better inform conservation efforts.

2. Method

This study was conducted in the Bodogol Nature Conservation Education Center (PPKA Bodogol), located within the Gunung Gede Pangrango National Park (TNGGP) in West Java. The Bodogol area lies at an elevation of approximately 750–1,500 meters above sea level and is characterized by hilly topography dominated by lower montane forest types (Anwari, Sutjihati, & Munarti, 2021).

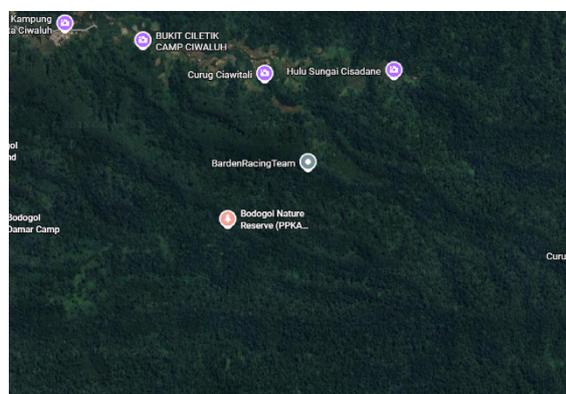


Figure 1. Map of the PPKA Bodogol Area

A descriptive–quantitative approach was employed to characterize vegetation structure and composition based on ecological index calculations. Vegetation analysis

was conducted using the square transect method with a random sampling technique (Goasyah, Purnama, & Rammang, 2021)

Transects were established using random sampling along three lines placed in locations considered representative of the general vegetation conditions within the study area, taking into account relative uniformity in terms of topography and canopy cover. Along each transect, square sample plots of four different sizes were arranged as follows:

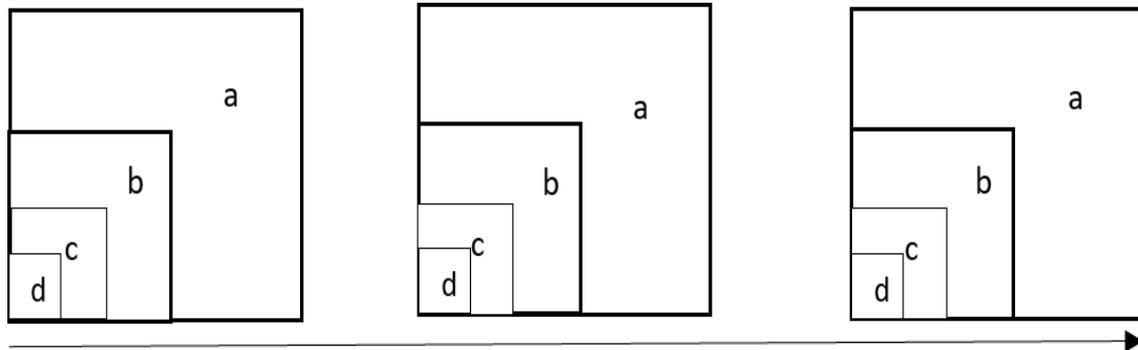


Figure 2. Layout of the square transect

Description:

a = 20 × 20 m plot

b = 10 × 10 m plot

c = 5 × 5 m plot

d = 2 × 2 m plot

The calculation of vegetation parameters followed standard formulas for density, frequency, and dominance (Indriyanto, 2006) as described (Table 1).

Table 1. Formulas for Vegetation Analysis Parameters

| Parameter | Formula | Description |
|--------------------------------------|--|--|
| Density (D) | $D = \frac{ni}{A}$ | ni = number of individuals of species i A = plot area (m ²) |
| Relative Density (RD) | $RD = \frac{ni}{\sum n} \times 100\%$ | $\sum n$ = total number of individuals of all species |
| Frequency (F) | $F = \frac{pi}{P}$ | pi = number of plots where species i occurs P = total number of plots |
| Relative Frequency (RF) | $RF = \frac{fi}{\sum F} \times 100\%$ | $\sum F$ = total frequency of all species |
| Dominance (Do) | $Do = \frac{\sum BA}{A}$ | BA = basal area (m ²); A = plot area |
| Relative Dominance (RDo) | $RDo = \frac{Di}{\sum D} \times 100\%$ | $\sum D$ = total dominance of all species |
| Importance Value Index (IVI) | $IVI = RD + RF + RDo$ | |
| Shannon-Weinner Diversity Index (H') | $H' = \sum (pi \ln pi)$ | pi = proportion of individuals of species i |

| Parameter | Formula | Description |
|----------------------------|-----------------------------|--|
| Evennes Index (E) | $E = \frac{H'}{\ln S}$ | S = total number of species |
| Species Richness Index (R) | $R = \frac{(S - 1)}{\ln N}$ | S = total number of species N = total individuals |

Edaphic data included soil pH, temperature, and moisture, which were measured using a soil tester and thermometer. Measurements were taken at the center of each plot at four depths: the soil surface and depths of 33, 66, and 99 cm, then recorded as the average value for each plot.

The calculated vegetation parameters and ecological indices were subsequently related to edaphic factors specifically soil pH and texture to examine the relationship between vegetation characteristics and soil conditions in the study area. The analysis was conducted descriptively to explain patterns of dominance and the level of vegetation diversity in Bodogol.

3. Results and Discussions

The results of the vegetation analysis in the PPKA Bodogol area revealed a variety of plant species distributed across all sampled plots (Table 2). The community was not dominated solely by tree species but also included shrubs, lianas, palms, herbs, and ferns, all of which collectively contribute to the vegetation structure along the observation transects.

Table 2. Vegetation structure parameters in the PPKA Bodogol area

| No | Species Name | Density (D) | Frequency (F) | Dominance (Do) | IVI |
|----|-------------------------------|-------------|---------------|----------------|-----|
| 1 | <i>Saurauia cauliflora</i> | 0,01 | 0,25 | 0,002 | 6 |
| 2 | <i>Pinanga coronata</i> | 0,005 | 0,5 | 0,011 | 6 |
| 3 | <i>Cyathea contaminans</i> | 0,003 | 0,25 | 0,010 | 3 |
| 4 | <i>Vernonia amygdalina</i> | 0,035 | 0,5 | 2,929 | 19 |
| 5 | <i>Huru sp</i> | 0,003 | 0,25 | 0,099 | 3 |
| 6 | <i>Schima wallichii</i> | 0,058 | 0,5 | 8,242 | 28 |
| 7 | <i>Castanopsis argenteae</i> | 0,008 | 0,25 | 2,817 | 5 |
| 8 | <i>Litsea codata</i> | 0,003 | 0,25 | 2,954 | 3 |
| 9 | <i>Caryota mitis</i> | 0,003 | 0,25 | 0,003 | 3 |
| 10 | <i>Calliandra calothyrcus</i> | 0,013 | 0,5 | 131,75 | 10 |
| 11 | <i>Tibouchina urvilleana</i> | 0,010 | 0,25 | 0,003 | 6 |
| 12 | <i>Plectocomia elongata</i> | 0,003 | 0,25 | 0,003 | 3 |
| 13 | <i>Selaginella plana</i> | 0,008 | 0,25 | 0,003 | 5 |
| 14 | <i>Nephrolepis cordifolia</i> | 0,005 | 0,25 | 0,003 | 4 |
| 15 | <i>Smilax leucophylla</i> | 0,005 | 0,25 | 0,003 | 4 |
| 16 | <i>Vernonia arborea</i> | 0,003 | 0,25 | 0,003 | 3 |
| 17 | <i>Gossypium hirsutum</i> | 0,005 | 0,5 | 553,750 | 8 |
| 18 | <i>Cyathea cooperi</i> | 0,010 | 0,25 | 0,003 | 6 |
| 19 | <i>Barringtonia asiatica</i> | 0,003 | 0,25 | 0,003 | 3 |
| 20 | <i>Tetrastigma glabratum</i> | 0,005 | 0,25 | 607,750 | 6 |
| 21 | <i>Swietenia mahagoni</i> | 0,003 | 0,25 | 173,250 | 4 |
| 22 | <i>Pandanus furcatus</i> | 0,003 | 0,25 | 166 | 4 |
| 23 | <i>Agathis dammara</i> | 0,005 | 0,25 | 255 | 4 |
| 24 | <i>Lithocarpus teysmanii</i> | 0,005 | 0,25 | 24530 | 65 |
| 25 | <i>Ficus virens</i> | 0,003 | 0,25 | 12685,750 | 35 |
| 26 | <i>Turpinia sphaerocarpa</i> | 0,003 | 0,25 | 1111,5 | 6 |

| No | Species Name | Density (D) | Frequency (F) | Dominance (Do) | IVI |
|----|-------------------------------|-------------|---------------|----------------|-----|
| 27 | <i>Lannea coromandelica</i> | 0,003 | 0,25 | 4,537 | 3 |
| 28 | <i>Syzygium polyanthum</i> | 0,003 | 0,25 | 106,003 | 3 |
| 29 | <i>Quercus gemelliflora</i> | 0,003 | 1 | 0,420 | 10 |
| 30 | <i>Macaranga rhizinoides</i> | 0,003 | 0,25 | 2,233 | 3 |
| 31 | <i>Aleurites moluccana</i> | 0,003 | 0,25 | 1,948 | 3 |
| 32 | <i>Piper aduncum</i> | 0,003 | 0,25 | 0,303 | 3 |
| 33 | <i>Pandanus utilis</i> | 0,005 | 0,25 | 0,115 | 4 |
| 34 | <i>Selaginella wildenowii</i> | 0,005 | 0,25 | 4 | 4 |
| 35 | <i>Guettarda speciosa</i> | 0,003 | 0,25 | 2 | 3 |
| 36 | <i>Calamus sp.</i> | 0,005 | 0,5 | 4 | 6 |

Overall, the values of density (D), frequency (F), dominance (Do), and their corresponding relative measures show that several species contribute significantly more to the community than others. Among all recorded species, those with the highest Importance Value Index (IVI) were *Schima wallichii*, followed by *Vernonia amygdalina*. These two species appear repeatedly across multiple plots with relatively high numbers of individuals, making their roles particularly prominent in shaping the vegetation community structure in Bodogol.

Despite the rich vegetation diversity in Bodogol, most previous studies have either focused on individual species observations or structural analysis without considering the relationship between vegetation and soil conditions. This study aims to fill that gap by integrating both aspects in a quantitative manner to better inform conservation efforts.

Schima wallichii is commonly recognized as a canopy tree species in lower montane forests, known for its tolerance to sandy loam soils and near-neutral pH conditions. Its dominance in the sampled area indicates that this portion of the site still retains characteristics of natural forest, marked by the presence of large trees forming the primary canopy layer (Orwa et al., 2009). *Vernonia amygdalina*, on the other hand, typically occupies the lower strata and takes advantage of light gaps beneath the canopy. However, its relatively high abundance and IVI values suggest that this species also plays an important role in shaping the vegetation community, particularly in the understory layer (Orwa et al., 2009).

Other species such as *Tibouchina urvilleana*, *Calamus sp.*, *Cyathea cooperi*, *Cyathea contaminans*, *Castanopsis argentea*, *Lithocarpus teysmanii*, *Pinanga coronata*, as well as several fern and herb species, exhibited only moderate to low density and IVI values. Most of these species were recorded in only one or two plots with limited numbers of individuals. They function as associate species that contribute to community heterogeneity but are not abundant enough to shift the dominance of the primary species. This pattern is typical of tropical forest communities, where a few key species control much of the space and resources, while numerous others occur at low abundances (Marsandi et al., 2017).

Overall, the combination of species with high IVI values and the large number of species with low IVI values indicates that the vegetation community structure in the surveyed area is not entirely homogeneous. A few species act as key components that shape the stand structure, while others occupy narrower ecological niches. Understanding this pattern is important because changes in the populations of dominant species. For example, through logging or localized disturbance which have the potential to alter resource availability and ultimately influence the presence and persistence of other plant species in the community.

Table 3. Diversity index (H'), evenness (E), and species richness (R) values of vegetation in the PPKA Bodogol area

| Index | Value |
|-----------------------|-------|
| H' (Shannon Wiener) | 2,99 |
| E (Evenness) | 0,84 |
| R (Richness/Margalef) | 7,43 |

The Shannon–Wiener diversity index (H') obtained in this study was 2.99, indicating a moderate level of species diversity within the vegetation community of the Bodogol area. This value suggests that the community is composed of a relatively high number of species with a reasonably balanced distribution of individuals. The evenness index (E) of 0.84 further supports this interpretation, showing that individuals are distributed fairly evenly among the recorded species and that no single species overwhelmingly dominates the community in terms of abundance.

The species richness index (R) was 7.43, reflecting a relatively high number of species in relation to the total number of individuals recorded within the sampling area. This result indicates that, despite the dominance of several key species, many other species are present at lower abundances and contribute to overall community richness. Together, the values of H', E, and R demonstrate that the vegetation community in the PPKA Bodogol area exhibits a moderately diverse and relatively stable structure, although the presence of dominant species suggests that ecological interactions and resource availability are not distributed completely evenly across all species.

Table 4. Soil edaphic measurements in the PPKA Bodogol area

| Soil Abiotic Factors | Soil Depth (cm) | | | |
|-----------------------|-----------------|----------------|----------------|----------------|
| | 0 cm/a | 33 cm/b | 66 cm | 99 cm |
| Soil Texture | Tanah berpasir | Tanah berpasir | Tanah berpasir | Tanah berpasir |
| Soil pH | 6,5 | 7 | 7 | 7 |
| Soil Moisture (Rh %) | 80 | 51 | 51 | 20 |
| Soil Temperature (°C) | 23 | 23 | 23 | 23 |

The edaphic characteristics measured in the study area included soil texture, pH, soil temperature, and soil moisture at several depths (Table 4). Overall, the soil texture at the observation sites is classified as sandy with a near-neutral pH. Soil temperature remained relatively stable, while soil moisture showed a clear decline with increasing depth—being highest at the surface layer and decreasing in deeper layers.

These conditions indicate that soil water availability is greater near the surface, suggesting that the active root zone of vegetation is likely concentrated in the upper soil layers. This aligns with the dominance of species that tolerate sandy soils with good drainage and more fluctuating water availability in the upper horizon, such as *Schima wallichii* and several other species that emerged as dominant based on IVI calculations. Conversely, species that require more stable soil moisture or finer soil textures tend to be less prominent in this community.

4. Conclusions

Based on the vegetation analysis and edaphic conditions in the PPKA Bodogol area, vegetation structure and composition in Bodogol are dominated by several key species. Based on the Importance Value Index (IVI), *Lithocarpus teysmanii* recorded the highest

IVI value, followed by *Ficus virens*, *Schima wallichii*, and *Vernonia amygdalina*. This indicates that community structure is influenced not only by species abundance and frequency, but also by dominance in terms of space occupation and basal area contribution. Most other species exhibited relatively low IVI values, indicating their more limited roles in shaping the overall community structure.

The diversity ($H' = 2.99$), evenness ($E = 0.84$), and species richness ($R = 7.43$) values indicate that the vegetation community in the study area exhibits a moderate level of diversity with a relatively even distribution of individuals among species. Although several species show clear dominance patterns, the overall community structure can be considered relatively stable, with many species contributing to community composition at lower abundances.

Edaphic conditions, characterized by sandy soils with near-neutral pH, stable soil temperature, and a marked decrease in soil moisture with increasing depth, are associated with the dominance patterns of certain species, particularly canopy and sub-canopy species such as *Lithocarpus teysmanii* and *Schima wallichii*, as well as several understory species that are tolerant of well-drained soils and variable moisture conditions. From a management perspective, the findings provide essential baseline information for supporting conservation efforts in PPKA Bodogol. The presence of dominant species alongside numerous low-abundance species highlights the importance of monitoring regeneration processes and maintaining environmental conditions that prevent declines in species diversity. Edaphic characteristics may also serve as a reference for selecting plant species suitable for local soil conditions in conservation and restoration programs.

Limitations in the data, particularly the lack of separation by growth stage and plant habit, as well as the relatively small sampling intensity, mean that the relationship between soil factors and vegetation diversity can only be described descriptively. Further research that includes soil chemical analyses, broader sampling coverage, and data separation by growth stage is needed to clarify the mechanisms underlying species dominance patterns and vegetation community structure in the Bodogol area.

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