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Analysis of Forest Vegetation Structure Using the Point Centered Quarter Method

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Abstract

Pananjung Pangandaran Nature Reserve is a conservation area characterized by high forest vegetation diversity and an important ecological role in maintaining ecosystem stability. Quantitative information on forest vegetation structure is essential as a scientific basis for conservation management. The Point Centered Quarter Method (PCQM) is a widely used vegetation sampling technique for assessing species composition, distribution, and ecological importance in forest communities. This study aimed to analyze the structure and composition of forest vegetation in the Pananjung Pangandaran Nature Reserve using the PCQM. The research was conducted using systematic sampling at ten observation points. At each point, the nearest tree in four quadrants was recorded, resulting in 40 sampled individuals. The collected data were analyzed to calculate Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), and the Important Value Index (IVI). The results showed that the forest vegetation consisted of 11 tree species. The species with the highest ecological dominance was *Syzygium lateata*, exhibiting a high RD, a moderately high RF, a high RDo, and a very high IVI. These values indicate that *S. lateata* plays a dominant ecological role in the forest community. Furthermore, the identified vegetation structure reflects a relatively uneven species distribution, highlighting the importance of monitoring dominant species to maintain ecosystem balance. This study provides essential ecological information to support conservation planning and sustainable forest management in protected areas.

Keywords: conservation management; diversity; forest; Pangandaran; vegetation analysis

INTRODUCTION

Forests play a crucial ecological role in maintaining environmental balance by regulating the water cycle, storing carbon, and providing habitats for diverse flora and fauna. In conservation areas, vegetation structure and composition are key indicators of ecosystem stability because changes in these attributes may reflect environmental disturbances and anthropogenic pressures. Therefore, vegetation analysis is essential for assessing species composition, dominance, regeneration patterns, ecosystem stability, and biodiversity, while also providing baseline information for sustainable forest management and conservation planning (Arisandy & Triyanti, 2018; Sutrisna *et al.*, 2018; Kawung *et al.*, 2020). Previous studies in Indonesia have demonstrated its application in evaluating post-disturbance and conservation forests, while vegetation characteristics have also been recognized as important indicators of carbon storage, environmental quality, and ecological restoration success (Ikriwas *et al.*, 2016; Kartini *et al.*, 2016; Setiawan & Syaufina, 2016; Chairul & Arwin, 2023; Nurlita *et al.*, 2025).

The structure and composition of forest vegetation are influenced by interactions between biotic and abiotic factors, including soil conditions, climate, topography, and interspecific competition. These factors affect species distribution, dominance patterns, vegetation diversity, and community structure across forest ecosystems. Therefore, vegetation analysis is essential for understanding ecosystem conditions (Diartika *et al.,* 2018; Sutrisna *et al.*, 2018). Several studies in Indonesia have shown that environmental conditions significantly influence vegetation composition, regeneration patterns, and ecosystem stability (Ikriwas *et al.,* 2016; Kartini *et al.,* 2016; Adnan *et al*., 2023). Site characteristics such as soil fertility, light intensity, and moisture availability also contribute to vegetation stratification and community dynamics. These characteristics serve as important indicators of ecosystem health and support sustainable forest management (Setiawan & Syaufina, 2016; Chairul & Arwin, 2023).

Forest vegetation analysis is generally conducted using a quantitative approach through the measurement of ecological parameters such as Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), and the Important Value Index (IVI). The IVI is used to determine species dominance and its contribution to vegetation community structure, while high IVI values indicate good adaptability to environmental conditions and the presence of individuals at different growth stages reflects vegetation stability and regeneration potential (Ananda *et al.*, 2018; Arisandy & Triyanti, 2018; Sulfayanti *et al.,* 2023). Vegetation analysis has been widely applied in Indonesian forest ecosystems to evaluate species composition, dominance, and ecological stability. Measurements of RD, RF, RDo provide a comprehensive overview of vegetation structure and species ecological roles, whereas IVI is useful for identifying dominant species and assessing vegetation dynamics in both natural and disturbed ecosystems (Imtiyaz *et al.*, 2019; Kawung *et al*., 2020; Ruseno *et al*., 2024). In addition, vegetation analysis can reveal succession processes and biodiversity levels, which are important indicators of ecosystem recovery and sustainability (Sutrisna *et al*., 2018; Budi *et al*., 2023).

Research on forest vegetation structure has thus far focused more on tree strata as the main canopy component, while studies on lower strata vegetation such as shrubs and herbs remain relatively limited. Nevertheless, the dominance and composition of shrub and herb vegetation can determine habitat types and play an important role in forest ecosystem dynamics. Vegetation analysis using the line intercept method can identify quantitative parameters such as the IVI, Shannon–Wiener diversity index, and species richness index, which are important indicators for describing vegetation community structure. Similar analytical approaches can also be applied in other vegetation analysis methods that use comparable sampling principles (Diartika *et al.*, 2018; Handayani *et al*., 2020). The PCQM method is an effective non-plot sampling method for describing the structure of vegetation communities with relatively random individual distribution patterns. This method allows for the quantitative estimation of vegetation parameters with time and labour efficiency, making it suitable for application in both natural forest areas and conservation areas (Kasim, 2022; Surbakti *et al*., 2025; Francioni *et al*., 2026).

Pananjung Pangandaran Nature Reserve is a lowland forest conservation area with high biodiversity, but it is influenced by human activities, particularly tourism. However, quantitative information on forest vegetation structure and composition in this area, especially using the PCQM and IVI approach, remains limited. Previous studies in this reserve have mainly focused on biodiversity inventories and tourism impacts rather than detailed vegetation structure analysis, although similar studies in tropical forest ecosystems are relatively common. Therefore, updated quantitative data are needed to support conservation management and ecological monitoring in this protected area. This study provides such data using a plotless sampling approach to strengthen ecological information for conservation purposes. Accordingly, this study aimed to analyze the structure and composition of forest vegetation in Pananjung Pangandaran Nature Reserve using the PCQM.

METHOD

This research was conducted in Pananjung Pangandaran Nature Reserve, Pangandaran Regency, West Java, Indonesia, a lowland tropical forest within a protected conservation area. The distribution of the ten observation stations is shown in Figure 1. To reduce spatial sampling bias and capture variation in vegetation conditions, observation points were systematically distributed across the study area. The method was used PCQM (Cottam & Curtis, 1956; Bryant *et al*., 2005).

Figure 1. Research location in the Pananjung Pangandaran Nature Reserve,
West Java, Indonesia. The yellow polygon indicates the study area where
vegetation sampling using the PCQM was conducted.

The PCQM method was applied to efficiently assess species spatial distribution, density, and dominance, providing a representative description of vegetation structure in heterogeneous forest ecosystems. Previous studies have shown that the PCQM can provide reliable estimates of vegetation structure even with a relatively limited number of sampling points when vegetation distribution is relatively homogeneous (Mitchell & Colleges, 2023). The distribution of observation points is shown in Figure 1. At each observation point, the PCQM was applied by dividing the sampling area into four quadrants based on cardinal directions (north, south, east, and west). The nearest tree individual in each quadrant was identified and the distance from the center point to the tree was measured. A total of 40 tree individuals were recorded from ten sampling points. The PCQM sampling design used in this study is illustrated in Figure 2.

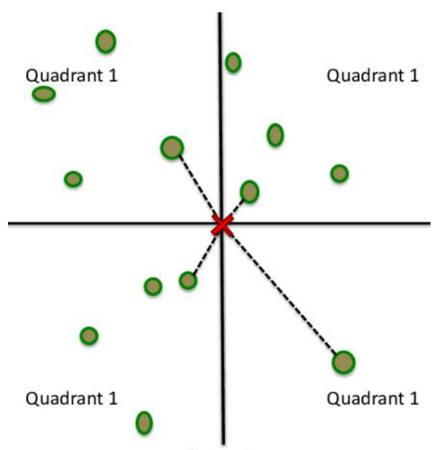

Figure 2. PCQM illustrating four sampling quadrants and
distance measurements from the center point

The equipment used in this study included a measuring tape for distance and diameter measurement, a compass to determine quadrant directions, and tally sheets for recording vegetation data. Vegetation documentation was carried out using a 50-megapixel camera. The research objects consisted of tree level vegetation within the study area. Plant species identification was conducted using Flora of Java by Backer & Bakhuizen van den Brink Jr., (1965) as the main taxonomic reference. Vegetation data collection was carried out at ten observation points that were systematically determined and evenly distributed across the study area to represent variations in forest vegetation conditions. These ten observation stations were considered sufficient to represent the vegetation structure of the study area while maintaining sampling efficiency.

Diameter at Breast Height (DBH) was measured as the basis for calculating basal area, with measurements taken at approximately 1.3 m above ground level. The measurement procedure varied depending on tree form and field conditions. For straight trees, diameter was measured horizontally at DBH. For leaning trees, measurements followed the stem axis to ensure accuracy. For buttressed, damaged, or irregular trees, diameter was measured above the buttress or irregular stem section to avoid measurement bias. All measurements were conducted carefully using a diameter tape to ensure consistency and reduce potential field errors. This standardized protocol ensures data comparability across different tree forms and supports the reliability and validity of the vegetation structure analysis.

The collected data were analyzed quantitatively to determine vegetation structure parameters, including RD, RF, RDo, and IVI. These parameters describe the ecological role, distribution pattern, and dominance of each species within the study area. The RD represents the proportion of individuals of a species relative to the total number of individuals of all species, RF describes species distribution across sampling points, and RDo reflects species contribution based on basal area. The IVI integrates RD, RF, and RDo to determine the overall ecological importance of each species within the vegetation community (Crawley, 1996; Brower & Zar, 1998). The formulas used were: RD = (number of individuals of a species / total number of individuals of all species) × 100%, RF = (frequency of a species / total frequency of all species) × 100%, RDo = (basal area of a species / total basal area of all species) × 100%, and IVI = RD + RF + RDo. Basal area was calculated from tree diameter measurements at breast height to represent the structural contribution of each species. IVI is widely used to identify dominant species and characterize forest vegetation structure and composition.

RESULT AND DISCUSSION

Forest vegetation analysis using the PCQM in the Pananjung Pangandaran Nature Reserve identified 11 tree species with varying values of RD, RF, and RDo. These parameters provide information on species distribution, abundance, and structural contribution within the study area. The vegetation structure parameters of each recorded species are presented in Table 1.

Table 1. The RD,RF, and RDo value of tree level vegetation in the Pananjung Pangandaran Nature Reserve

No	Plant Species	RD (%)	RF (%)	RDo (%)
1	*Syzygium lateata*	57.50	34.70	41.15
2	*Tectona grandis*	10.00	17.30	45.36
3	*Dillenia excelsa*	7.50	8.69	3.35
4	*Arenga obtusifolia*	5.00	4.34	3.18
5	*Pilea trinervia*	2.50	4.34	3.02
6	*Antidesma bunius*	2.50	4.34	2.80
7	*Salacca zalacca*	5.00	8.69	0.45
8	*Flacourtia rukem*	2.50	4.34	0.20
9	*Syzygium zollingerianum*	2.50	4.34	0.41
10	*Diospyros polyalthioides*	2.50	4.34	0.07
11	*Swietenia macrophylla*	2.50	4.34	0.02

The IVI, calculated from the combined values of RD, RF, and RDo, was used to evaluate the ecological importance and dominance of each species within the vegetation community. The IVI values for all recorded species are presented in Figure 3.

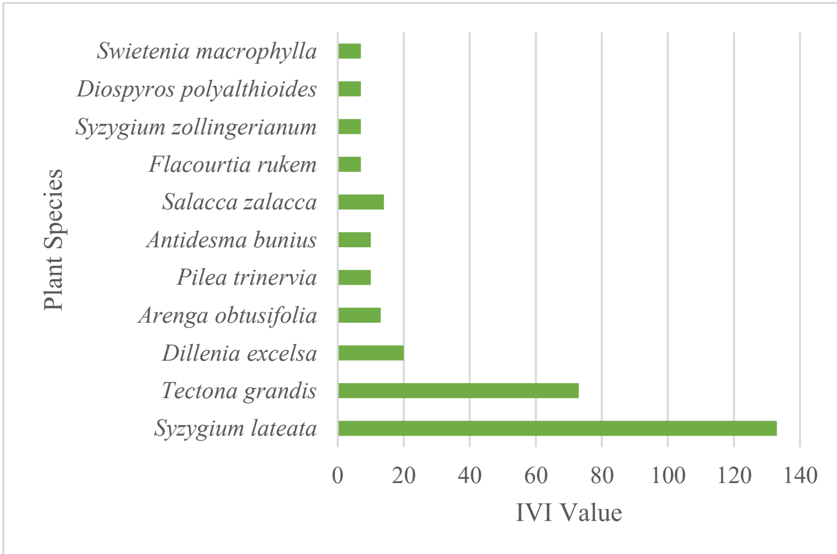

Figure 3. The IVI value of tree level vegetation in the Pananjung Pangandaran Nature Reserve

Based on Table 1 and Figure 3, *Syzygium lateata* exhibited the highest ecological importance with an IVI value of 133.35. This result was supported by its high RD (57.50%), RF (34.70%), and RDo (41.15%), indicating that the species was abundant, widely distributed, and structurally dominant within the study area. Such characteristics suggest that *S. lateata* plays a major role in shaping the vegetation structure and maintaining ecosystem processes in the Pananjung Pangandaran Nature Reserve. The dominance of the genus *Syzygium* in lowland tropical forests is consistent with previous studies reporting that members of the family Myrtaceae often become dominant components of forest communities due to their ecological adaptability and competitive ability in resource acquisition. Species with high IVI values generally exert strong influences on nutrient cycling, light interception, space occupancy, and overall community stability (Magurran, 2016; Salwanafi *et al*., 2023; Tarigan & Siregar, 2025).

The strong dominance of *S. lateata* may also be associated with its tolerance to environmental variations commonly found in lowland tropical forests, including differences in soil moisture, light availability, and competition intensity. Species with broad ecological tolerance often achieve greater abundance and distribution, allowing them to dominate vegetation communities and influence regeneration patterns of associated species (Diartika *et al.*, 2018; Nahlunnisa *et al.*, 2025). Furthermore, dominant canopy species can regulate microclimatic conditions beneath the canopy, thereby affecting understory composition and forest regeneration dynamics. These findings highlight the ecological importance of *S. lateata* in maintaining the structure and functioning of the forest ecosystem within the Pananjung Pangandaran Nature Reserve.

The second highest IVI value was recorded for *Tectona grandis* (72.66). Although its RD value (10.00%) was substantially lower than that of *S. lateata*, it exhibited the highest RDo value (45.36%), indicating a large contribution to stand basal area and forest structure. This finding suggests that the ecological importance of a species is determined not only by its abundance but also by its structural characteristics, particularly stem diameter and biomass accumulation (Mitchell & Colleges, 2023; Afrianti & Pakpahan, 2024). The substantial dominance of *T. grandis* may therefore contribute significantly to canopy formation, carbon storage, and habitat structure within the forest ecosystem. These characteristics emphasize the important ecological role of *T. grandis* in maintaining forest structural complexity and supporting overall ecosystem functioning.

Other species, including *Dillenia excelsa*, *Arenga obtusifolia*, *Pilea trinervia*, *Antidesma bunius*, *Salacca zalacca*, *Flacourtia rukem*, *Syzygium zollingerianum*, *Diospyros polyalthioides*, and *Swietenia macrophylla*, exhibited considerably lower RD, RF, RDo, and IVI values. These species contributed less to the overall community dominance but remained important components of forest biodiversity. Low IVI species generally occur at lower densities and frequencies, resulting in a smaller influence on vegetation structure (Kawung *et al.*, 2020; Sulfayanti *et al.*, 2023). Nevertheless, their presence increases species richness, functional diversity, and structural complexity, all of which are essential for maintaining ecosystem resilience and long-term ecological stability (Arisandy & Triyanti, 2018; Tarigan & Siregar, 2025).

Interestingly, *Salacca zalacca* showed moderate RD (5.00%) and RF (8.69%) values but a very low RDo value (0.45%). This pattern suggests that although the species occurred relatively frequently across the study area, it was represented primarily by smaller individuals that contributed little to stand basal area. Such characteristics are typical of understory or small stature vegetation occupying lower forest strata. In addition to their ecological roles, several recorded species possess socioeconomic importance. *Tectona grandis* and *Swietenia macrophylla* are valuable timber producing species, whereas *Salacca zalacca* and *Antidesma bunius* provide edible fruits with economic value. Therefore, the conservation of these species contributes not only to ecosystem functioning but also to the preservation of biological resources with potential socioeconomic benefits.

Variations in vegetation dominance and distribution are often influenced by environmental factors such as soil characteristics, humidity, temperature, and light availability. Although these factors were not directly measured in the present study, previous research has demonstrated that environmental gradients strongly affect species composition and vegetation structure in tropical forest ecosystems (Lumban-gaol & Mudita, 2023; Ruseno *et al*., 2024). Consequently, the dominance patterns observed in the Pananjung Pangandaran Nature Reserve likely reflect the interaction between species-specific ecological traits and local environmental conditions. Direct measurements of abiotic environmental variables would better explain the mechanisms underlying vegetation dominance and distribution patterns. Such an approach would provide a more comprehensive understanding of vegetation dynamics and support more effective conservation and management strategies for the Pananjung Pangandaran Nature Reserve.

Overall, the forest vegetation structure of the Pananjung Pangandaran Nature Reserve was strongly characterized by the dominance of *Syzygium lateata* and *Tectona grandis*. The exceptionally high IVI of *S. lateata* resulted from its abundance, broad distribution, and dominance within the community, whereas the ecological importance of *T. grandis* was primarily driven by its large basal area and structural contribution. This dominance pattern reflects a heterogeneous lowland tropical forest community in which a few species play major structural roles while numerous subordinate species contribute to biodiversity and ecosystem resilience. Such information is valuable for supporting conservation planning, biodiversity monitoring, and sustainable ecosystem management in protected forest areas (Budi *et al.*, 2023; Nurlita *et al*., 2025; Tarigan & Siregar, 2025).

CONCLUSION

Based on the forest vegetation analysis using the PCQM, the vegetation structure and composition of the Pananjung Pangandaran Nature Reserve were represented by 11 tree species with varying levels of ecological importance. *S. lateata* was identified as the most dominant species with the highest IVI of 133.35, followed by *Tectona grandis* with an IVI of 72.66, indicating that both species play major roles in shaping the forest community structure. Accordingly, the vegetation of the study area can be locally characterized as *Syzygium* and *Tectona* dominated forest. The findings provide baseline ecological information for long term vegetation monitoring and conservation management in the reserve. At the national level, this study contributes to the understanding of lowland tropical forest vegetation in Indonesia and may serve as a scientific reference for biodiversity conservation, ecosystem restoration, and sustainable forest management.

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