E-ISSN. 2809-9346
Journal of Global Forest and Environmental Science Vol. 2, No. 2 June 2022

Tree diversity and forest structure of tropical forest in Mount Geulis, Cianjur

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ABSTRACT

This study attempted to describe tree diversity and forest structure in Mount Geulis forest, Cianjur. We placed sixty nested quadrat plots for each category: 20 m x 20 m for trees (>35 cm dbh), 10 m x 10 m for poles (10-35 cm dbh), 5 m x 5 m for saplings (<10 cm dbh), and 2 m x 2 m for seedlings (h<1.5 m) in zone I and zone II (<1000 and >1000 asl). We recorded 195 species of woody plants from 60 families. The diameter class showed the inverse J-shape indicating that the forest succession is taking place. The diversity index (Ĥ) in both zones was slightly different indicating the abundant distinction in the growth categories between the zones. The tree, pole, sapling, and seedling were dominated by species indicating lowland forest in zone I, e.g., Moraceae and Euphorbiaceae, and sub-montane in zone II, e.g., Lauraceae and Fagaceae. While the rest of the dominant species were native to the forest, the dominance of *Calliandra calothyrsus* as an introduced species as part of the administrator's rehabilitation effort may show that human disturbance was high in this forest. Nevertheless, we concluded that this forest is valuable in terms of tree and wildlife diversity. Further biodiversity conservation effort needs to be carefully addressed despite its size and category as a remnant forest.

Keywords: *Floristic composition, diameter class, diversity index, mountain forest, Mount Geulis*

INTRODUCTION

Forests have a variety of ecological functions, such as maintaining biodiversity and habitat for wildlife (Muhamad et al., 2013). However, land conversion, large-scale deforestation, and illegal logging are among the main causes and resulted in a serious threat to the existence of plant species. Changes in plant species eventually lead to changes in the composition and vegetation structure in a forest (Monge-González et al., 2020).

Mount Geulis natural forest in Cianjur is one of the most interesting forests in West Java even though relatively seems to have little attention. Although it is not a conservation area and covers small areas, the forest serves as a habitat for several endemic wildlife protected by the Indonesia government regulation No. 7/1999 including the Javan leopard *(Panthera pardus)*, leopard cat *(Felis bengalensis)*, Javan hawk-eagle *(Nisaetus bartelsi)*, silvery gibbon *(Hylobates moloch)* and Javan surili *(Presbytis comata)* (Muhamad et al., 2013).

Moreover, it is a supporting area for the villagers who live nearby. Various direct and indirect benefits can be obtained from this forest. Some of the direct benefits are the use of timber for firewood and the raw material of charcoal. The indirect benefits are a means of cultural values and the other general benefits of natural forest, e.g., stabilizing the hydrological functions, soil protection, carbon sequestration, and ecosystem integrity (Muhamad et al., 2014). Furthermore, Mount Geulis has an important and strategic role as a part of the national strategic area ruled by Government Regulation No. 26/2008 about spatial planning of Jabodetabekpunjur as a water catchment area to maintain hydrological function.

On the other hand, land-use change has also been accelerating as an inevitable impact of rural and economic development, thus, obtaining the forest diversity data in the study area is important to dealing with sustainable land use planning. However, there is a lack of such information in this area. Therefore, this study attempts to provide the structure and composition of the forest as a database served for further appropriate management.

MATERIALS AND METHODS

Study site

The study site is located in Mount Geulis forest, Cianjur, and geographically situated at 6°45'28" - 6°47'01" latitude and 107°04'28" – 107°05'32" longitude as shown in Figure 1. The forest is considered as a quasi-natural remnant forest considering that it has been influenced by human activities while functioning as a native forest reflected by the presence of the numbers of primates and big mammals that most of them are protected by the Indonesian government regulation No. 7/1999 (Muhamad et al., 2013).

The forest is under the management of Forest Management Unit (*KPH*) of Cianjur, Perum Perhutani Unit III West Java and Banten. It is located around 7 – 9 km from Cianjur city capital and at an elevation of 800 – 1200 meters above sea level (asl). The mean daily temperature is about 22°C and the daily maximum temperature ranges from 25° to 30°C. The annual precipitation is approximately 2,000 mm, with a rainy season (October–June) and a short dry season (July–September).

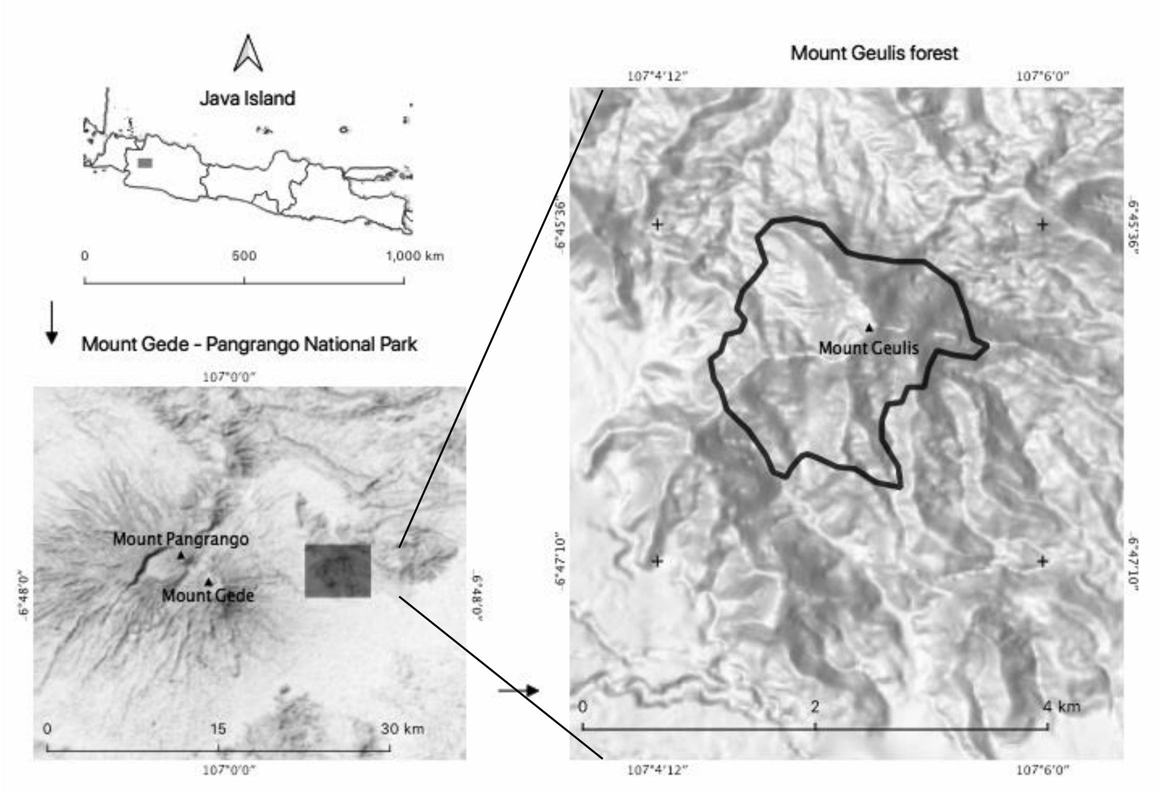

Figure 1. Map of study site

Data sampling

The sampling technique used was a combination of nested quadrat and line transect methods (Mueller-Dombois & Ellenberg, 2016). Sampling location was determined based on the representation of vegetation characteristics and altitude ranges. The number of line transects used was three lines and the length of each line was 1000 meters and placed across over the contour lines. Thus, it could collect representative data as a whole study site covering each vegetation characteristic and corresponding elevation.

There were four different stages namely 20x20 m for trees (dbh >35 cm), 10x10 m for poles (dbh =10-35 cm), 5x5 m for saplings (dbh <10 cm and height (h) >1.5 m), and 2x2 meters for seedlings (H <1.5 m) in each plot (Hadi et al., 2009; Ibanez et al., 2014). These plots were placed alternately on the right and left of the line transect with intervals of 50 meters on every point. The number of plots on each line transect was 20, so the entire number was 60 plots.

The data collected were the plant species name, frequency, density, and plant coverage in each plot. For trees, poles, and saplings stages, the basal area of each species was calculated by measuring of diameter breast high (Mueller-Dombois & Ellenberg, 2016) using diameter tape while plant coverage in the seedlings was calculated by the percentage of coverage. Most plant species were identified in the field by naming their vernacular names in advance before being brought to the Herbarium of Cibodas Botanical Garden, Cianjur to identify. To keep updated with the nomenclature and taxonomy of the plants that have been updated based on APG IV (Angiosperm Phylogeny Group IV), the scientific names of each plant species that have been identified then were verified on the site of the International Plant Name Index (IPNI), i.e. *http://www.ipni.org/* and the website of The Plant List, i.e. *http://www.theplantlist.org/*.

Data analysis

The analysis technique used was descriptive analysis. The floristic data measured was analyzed by grouping into families and diameter class. The Importance Value Index (IVI) of each plant species and the diversity index (Ĥ) was also calculated. The Importance Value Index is a quantitative parameter that is used to express the degree of dominance of a species in the plant community. It ranges from 0-300%, which is calculated by the formula:

$$\mathrm{IVI} = \mathrm{RF} + \mathrm{RDe} + \mathrm{RDo}$$

where *RF* is relative frequency, *RDe* is relative density, *RDo* is relative dominance.

The diversity index is a relative comparison between the individual numbers of a species with an individual number of all species. The species diversity index was determined using Shannon-Wienner formula (Magurran, 2004), namely:

$$\hat{\mathrm{H}} = -\sum_{i=1}^{s}\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)$$

where Ĥ is Shannon-Wienner diversity index, *ni* is an individual number of species *i*, and *N* is individual number of all species.

RESULTS AND DISCUSSION

Floristic diversity and species richness

The results showed that 195 woody species from 60 families were observed in Mount Geulis natural forest. In terms of floristic composition, Rubiaceae, Moraceae, Euphorbiaceae, Lauraceae, Meliaceae, Myrtaceae, and Fagaceae were the families having a large number of species more than eight species as described in Figure 2. The species from mixed families that are commonly encountered in lowland forest and montane forest zone may give an idea that this forest covers both zones and may explain the high floristic diversity in this small forest.

However, the presence of Euphorbiaceae as the third-highest family of having species numbers, such as *mara* (*Macaranga tanarius*), *calik angin* (*Mallotus paniculatus*), and *kareumbi* (*Homalanthus populneus*), indicate that this forest is experienced anthropogenic disturbance. These species are widely known as the pioneer group to grow in the cleared and disturbed forests. The discontinued forest canopy caused by the logging or clearance activities makes the way for the sunlight to reach the understorey layer and forest floor where these species could thrive, thus, resulting in their abundance in the forest that is then considered as a secondary forest.

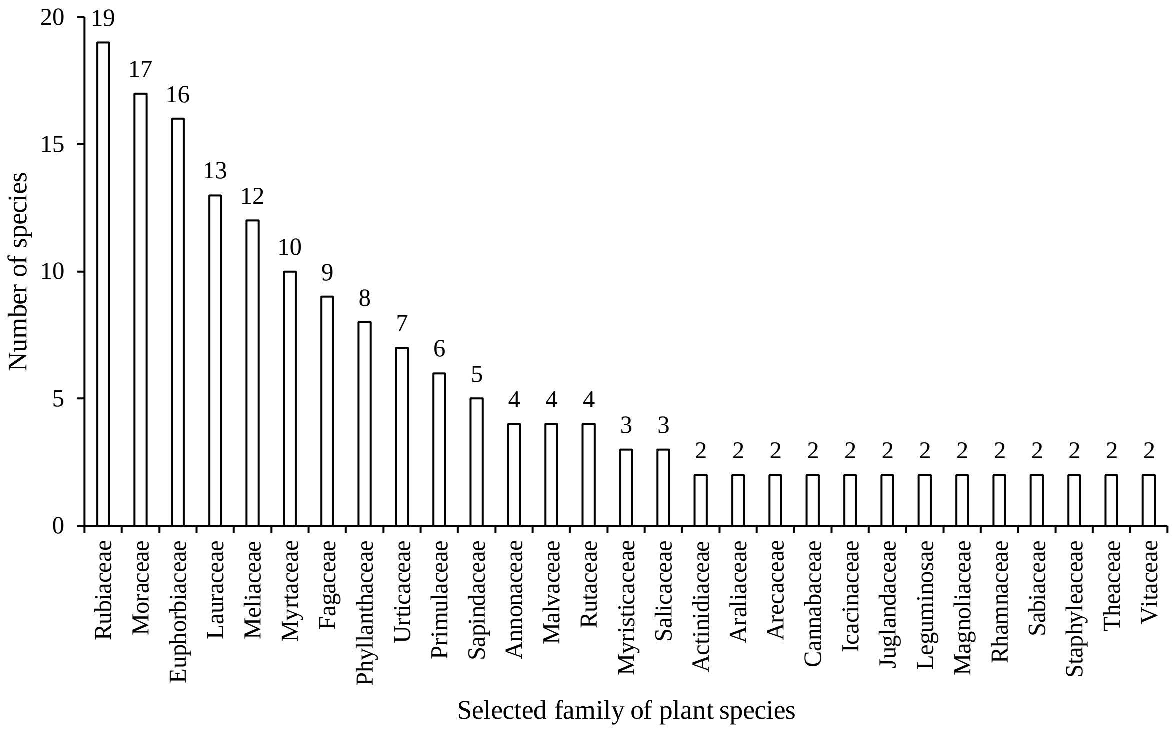

Figure 2. Species composition based on families in study site

It is also interesting to note that several rare species were observed but not presented in Figure 2 above as they were the single species recorded in their families. The species of *sempur* (*Dillenia excelsa*), *palahlar* (*Dipterocarpus hasseltii*), and *burahol* (*Stelechocarpus burahol*) were spotted in zone I of lowland forest and *jamuju* (*Dacrycarpus imbricatus*) was recorded in zone II of the sub-montane forest as depicted in Figure 3. The two former and the latter species have been known as the high-quality wood for construction and their population may suffer from the anthropogenic disturbance in the past by the big trees harvesting and leaving the seedling that could not compete well with the fast-growing tree species such as *Macaranga*, *Mallotus*, and *Homalanthus*. As of now, the species of *D. hasselltii* has been categorized as endangered species globally by IUCN while the rest are rarely to be found in the wild.

According to the local people, there has been logging activity in the past when timber production was at its peak in this area. The narrow trail called "jalur mindi" was once the track with five-meters width used to deliver the harvested wood from the forest to the city by horse-drawn carriage. While the target species for harvesting might be the cultivated trees, e.g., rasamala, African tulip, and pines in the plantation forest that occupies area next to the natural forest, the tree species from this forest might also be inappropriately cut down. The track is now used to explore the middle elevation of the forest also known as "jalur tengah".

Sempur (*Dillenia excelsa*)

Palahlar (*Dipterocarpus hasseltii*)

Burahol (*Stelechocarpus burahol*)

Jamuju (*Dacrycarpus imbricatus*)

Figure 3. Several rare species observed in study site

The floristic composition in zone I and II is relatively different as shown by the several dominant families in Figure 4. The species numbers of Moraceae, Euphorbiaceae, and Meliaceae are decreased from zone I to zone II while the contrast is happened for Rubiaceae, Lauraceae, and Fagaceae. It emphasizes the previous assumption that Mount Geulis forest is comprised of lowland and sub-montane flora resulting in diverse wildlife such as birds, mammals, and insects.

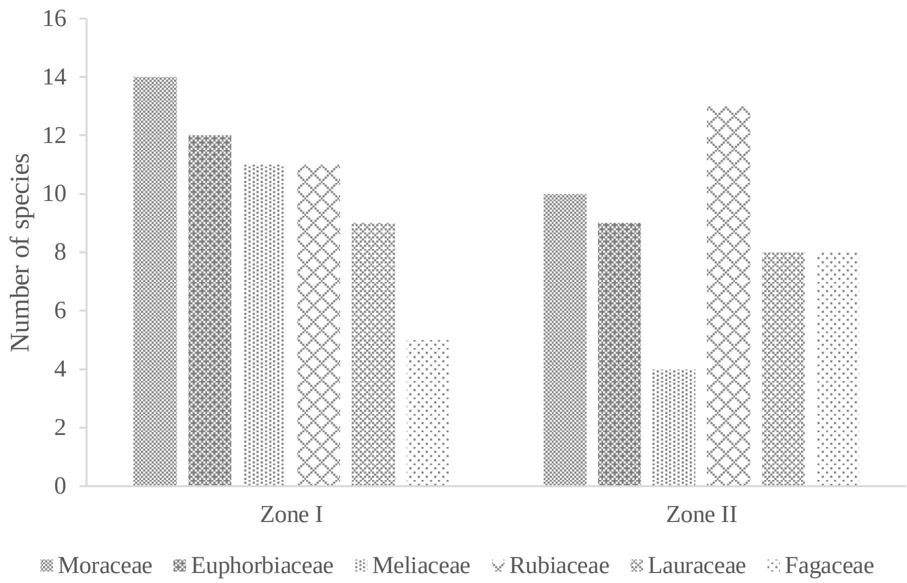

Figure 4. The species number of selected families in zone I and zone II

Vegetation structure

Vegetation structure is divided into three categories, namely vertical, horizontal, and quantitative structure (Mueller-Dombois & Ellenberg, 2016). In this study, vegetation structure scoped in quantitative structure depicting the diversity and abundance of each species and diameter class in vegetation community. The Important Value Index (IVI) is used as a quantitative parameter to determine abundancy and dominancy of each species. The IVI obtained from summary of the parameter of density, frequency, and dominancy relative of plant species in zone I and II of Mount Geulis natural forests is briefly shown in Table 1.

Table 1. Selected species for important value index in each category in zone I and II

Species names		RF [%]	RDe [%]	RDo [%]	IVI [%]
Scientific	Vernacular				
Zone I					
Tree					
Sterculia coccinea	Angrit	9.52	13.08	14.44	37.05
Dysoxylum sp.	Kibawang	7.62	8.46	9.96	26.04
Artocarpus elastica	Benda	8.57	6.92	7.86	23.35
Pole					
Oreocnide rubescens	Nangsi	8.15	12.31	10.13	30.59
Calliandra calothyrsus	Kaliandra merah	2.96	13.85	10.58	27.39
Laportea ardens	Pulus	5.19	7.69	6.62	19.50
Sapling					
Calliandra calothyrsus	Kaliandra merah	3.23	16.11	15.38	34.71
Oreocnide rubescens	Nangsi	6.45	7.22	7.21	20.88
Laportea ardens	Pulus	5.65	5.00	4.18	14.83
Seedling					
Pandanus fircatus	Pandan gunung	8.51	13.83	16.20	38.54
Laportea ardens	Pulus	8.51	8.51	8.38	25.40
Calliandra calothyrsus	Kaliandra merah	4.26	7.45	12.77	24.47

Zone II					
Tree					
Schima wallichii	Puspa	20.51	38.46	40.17	99.14
Castanopsis tungurrut	Tunggurut	10.26	7.69	8.43	26.38
Quercus sp.	Pasang	7.69	7.69	6.19	21.58
Pole					
Oreocnide rubescens	Nangsi	8.96	14.81	10.14	33.91
Schima wallichii	Puspa	8.96	11.11	13.32	33.39
Castanopsis javanica	Tungereup	7.46	6.17	6.12	19.76
Sapling					
Oreocnide rubescens	Nangsi	4.81	6.87	7.78	19.46
Neolitsea cassiifolia	Huru batu	4.81	6.11	5.96	16.88
Homalanthus populneus	Kareumbi	2.88	3.05	5.29	11.23
Seedling					
Psychotria angulata		4.55	13.71	32.58	50.84
Pandanus furcatus	Pandan gunung	9.09	4.03	16.29	29.41
Psychotria montana	Kicau	4.55	15.32	8.77	28.64

In general, Table 1 shows the difference of dominant species in zone I and II between lowland and sub-montane forests as previously mentioned. The tree category of zone I was dominated by lowland trees, such as *angrit* (*Sterculia coccinea*), *kibawang* (*Dysoxsylum* sp.), and *benda* (*Artocarpus elastica*), and zone II was inhabited by low-temperature tolerance trees, such as *puspa* (*Schima wallichii*), *tunggurut* (*Castanopsis tungurrut*), and *tungeureup* (*Castanopsis javanica*). While the three highest dominant and important species in zone I was not separated by a large number, the contrast was noticed in zone II. The IVI of *S. wallichii* was greatly higher than other tree species suggesting that this species reigns and plays an important role in this area, particularly in the sub-montane forest zone.

However, the presence of *nangsi* (*Oreocnide rubescens*) and *kareumbi* (*Homalanthus populneus*) in the dominant species in the pole and sapling category, although the rest were still the upland tree species, such as *S. wallichii*, *C. javanica*, and *huru batu* (*Neolitsea cassiifolia*), may indicate that several forest cover areas in zone II have been opened since these species need sufficient sunlight to grow. The opposite was also observed in zone I where *O. rubescens*, *kaliandra* (*Calliandra calothysrus*), and *pulus* (*Laportea ardens*) were the dominant species in the pole and sapling category. The highly distributed occurrence of *C. calothysrus* despite its low abundance may attest that this species has been planted in the forest surrounding confirming that there is high human intervention in this forest area.

Regarding the tree size distribution, Figure 4 below describes the diameter class for the tree stands at the study site. In general, it shows that the stem diameter from the smallest to the highest size is decreased in number forming the negative exponential curve or inverse J-shape. This curve shape is often referred to as an uneven-aged stand where the number of small trees per area is larger than the large trees (Kershaw Jr et al., 2016).

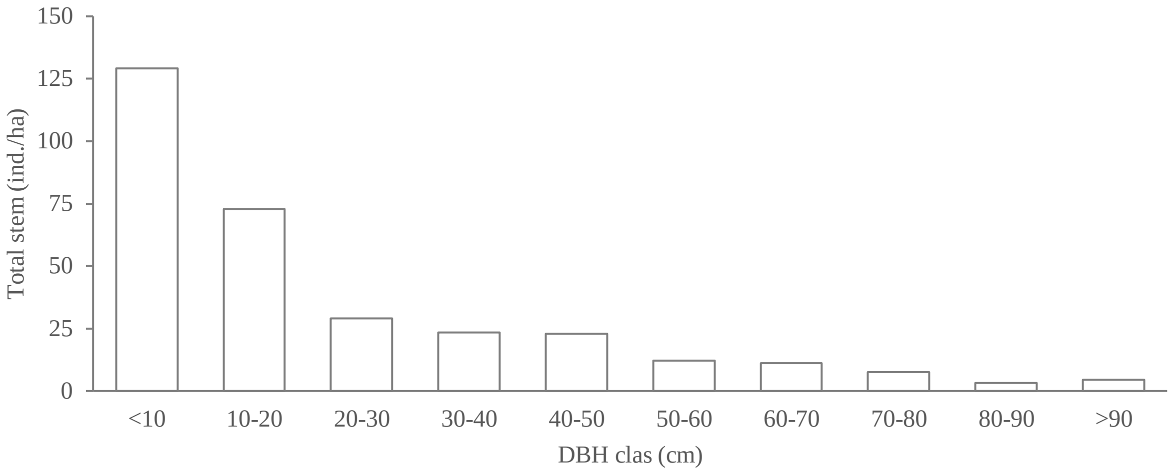

Figure 5. Diameter class of tree in study site

This inverse J-shape is also commonly observed in the forest that experiences selective logging through cutting management practices or past disturbance. Certain mature trees, usually for economic purposes, are harvested either individually or in small groups leaving smaller trees to have a large number in the stand (Figure 5). In turn, these trees that have been shaded by the canopy get more light to emerge as the successive process. Thus, it is also assumed that the inverse J-shape means that the regeneration or succession is taking place in the forest stand (Kershaw Jr et al., 2016).

Species diversity index

The diversity index is used to determine the comparison degree between species richness and its abundance in each growth category. The Shannon diversity index of tree vegetation community in Mount Geulis natural forest that we calculated here is shown in Figure 4.

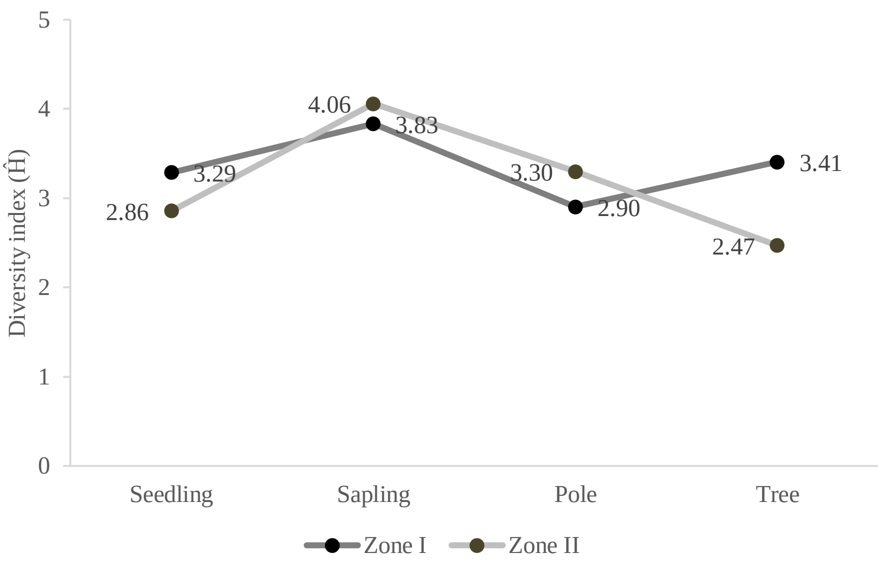

Figure 6. Species diversity index for each habitus and growth category in study site

Figure 4 shows that, in general, the diversity index of sapling growth in both zones of this forest is the highest than others while the tree growth is the lowest. Although being the lowest, it is still in the usual range of the Shannon value. In contrast, the sapling category was approximately at the 4 mark which is a rare occasion. While this index needs more justification and is difficult to interpret despite its popular use (Magurran, 2004), it may still give an idea how the proportion of the individual throughout the species encountered.

This Shannon index is in parallel with the diameter class and species number provided in the previous section. As for the sapling growth category, it was the highest Shannon index since it has the largest number of individuals as shown in Figure 5 that are relatively evenly distributed within species in this category. On the other hand, the tree category in zone II was the lowest because not only the species number shrank but also the individual proportion was dominated by certain species leaving a huge gap among others.

This Shannon-Wiener index could also imply that the more balanced the species individual proportion, the highest the species diversity index. Thus, it is suggested that the trees diversity index ($\hat{H}$) of Mount Geulis natural forest is high. It also may be hinted that the Mount Geulis natural forest vegetation has high complexity. According to Hadi et al. (2009), the high floristic forest diversity allows the native and protected wildlife aforementioned to inhabit the ecological niche in the area and also emphasizes the valuable contribution of this forest to the biodiversity in the local context despite its remnant and non-conservation forest status.

Conclusions

The vegetation in Mount Geulis natural forest is composed of 195 species from 60 families. The difference in dominant species composition and abundance in zone I and II indicates the forest type distinction of both zones. The abundance species of *A. elastica*, *S. coccinea*, and *O. rubescens* may represent the type of lowland forest in zone I, while *S. wallichii*, *C. tunguruut*, and *N. cassiifolia* indicate the sub-montane forest in zone II. The diameter class showed the inverse J-shape indicating the forest succession is taking place. This study showed the high floristic and structural diversity in the study site despite its small coverage and non-conservation status. Considering the importance of this forest, further appropriate management is needed to maintain the forest’s functions both for the wildlife habitat and the surrounding community.

Acknowledgements

We are grateful to Pak Unen and the BEST (Biodiversity and Ecosystem Services Team) research for their tremendous support in the fieldwork. We also thank Zainal Mutaqien and Rustandi (Cibodas Botanical Garden), Joko Kusmoro (Herbarium Jatinangoriense Universitas Padjadjaran) and Arifin Irsyam (Herbarium Bandungense ITB) for assisting plant identification.

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