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Structure and composition of trees in Mount Tilu Nature Reserve, West Java, Indonesia

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Abstract. *Cahyanto T, Efendi M, Ramdan DM. 2020. Structure and composition of trees in Mount Tilu Nature Reserve, West Java, Indonesia. Biodiversitas 21: 2674-2680.* An understanding of the structure and composition of stands in a conservation area is needed to support sustainable management strategy. However, this information in the Mount Tilu Nature Reserve, Bandung District, West Java area is still lacking. This research was aimed to analyze the structure and composition of tree species in the block of Malagembol forest, Mt. Tilu NR. Data collection was carried out through vegetation analysis using sampling plot method with size of 10x100 m^2 at three-level altitudes of 1530 m, 1745 m, and 1950 m asl. Observation parameters included species names, number of individuals, and diameter at breast height (dbh). Data were analyzed to determine the floristic composition, species structure based on their diameter class, relative basal area, diversity indices, and analysis of the importance of the main components of trees species through Principal Component Analysis (PCA). A total of 32 tree species from 23 families was found in the observation plots which was dominated by Fagaceae, Lauraceae, and Myrtaceae families. Some pioneer plants covered the gap in vegetation due to minor disturbance and residual damage in the past. Nonetheless, the dominance of stands with small diameters indicated good regeneration status following such disturbance. Based on these findings, we recommend protecting the vegetation in Mt. Tilu NR by limiting community activities that can disturb the forest.

Keywords: Biodiversity, mountain forest, species richness, tree density, tree basal area

INTRODUCTION

Mount Tilu Nature Reserve (Mt. Tilu NR) is located in two subdistricts, namely Pasirjambu Subdistrict and Pangalengan Subdistrict, Bandung District, West Java Province, Indonesia. It is the second-largest nature reserve in West Java after Mt. Simpang NR, which is directly adjacent to the area. Initially, the area covered 8,000 ha based on the Minister of Agriculture Decree No. 68/Kpts/U/2/1978 dated 7 February 1978. In its development, based on the Minister of Forestry Decree No. SK.1873/Menhut-VII/KUH/2014 dated 25 March 2014, the area has been reduced to 7,479.80 ha.

Ecologically, Mt. Tilu NR plays an important role in the hydrological cycle of Bandung District and its surrounding areas. In addition, Mt. Tilu NR is a habitat for Javanese endemic primates, such as Javan Gibbon (*Hylobates moloch*), Lutung (*Trachypithecus auratus*) and Javan Surili (*Presbytis comata*), as well as important places to conserve the flora of mountain forests of Java, such as *Castanopsis argentea*, *Lithocarpus sundaicus*, *Litsea javanica* and *Schima wallichii* (Susilo 2018).

Similar with other mountain forest ecosystems in Java, the forest ecosystem in Mt. Tilu NR is threatened by environmental damage (Purwaningsih et al. 2017; Rosleine 2014; Sulistyawati et al. 2018; Cahyanto et al. 2019). The location of the forest is directly adjacent to plantation and community forest, allowing a unique mix of vegetation composition in the area, as found in the Cibodas Biosphere Reserve forest (Mutaqien and Zuhri 2011). However, because of this position, there is a risk of alien plant species invasion which has the potential to change the composition and structure of the natural forest vegetation (Zuhri and Mutaqien 2013; Junaedi and Dodo 2014).

Understanding the structure and composition of tree vegetation is one of the parameters that must be considered in the management of conservation forest areas (Laumonier et al. 2010; Kusmana 2011; Zhu et al. 2015). This is particularly important for several reasons. First, some tree species have important economic value which makes them under pressure due to over-exploitation, leaving them vulnerable to population extinction in their natural habitat (Budiharta et al. 2011). Second, information about tree structure can provide insight on regenerative ability of the stand in a forest area, both in present time and in the future (Laumonier et al. 2010; Mongabay 2013; Prawiroatmodjo and Kartawinata 2014; Ifo et al. 2016; de Carvalho et al. 2017; Henry et al. 2017; Manral et al. 2018; Siregar and Undaharta 2018; Salvana et al. 2019). Third, tree community is the largest contributor of above-ground biomass in tropical forests (Slik et al. 2010; Feldpausch et al. 2012). Forth, tree vegetation also provides various ecosystem services (Sekercioglu 2010; Lindenmayer et al. 2012), habitat of biodiversity (Myers et al. 2000; Hrdina and Romportl 2017) and potential use for bioprospecting

(Harvey and Gericke 2011; Senthilkumar and Murugesan 2012).

Until now, information on the condition of vegetation in Mt. Tilu NR is still lacking. Previously, Susilo (2018) conducted research on the association of some species in the Mt. Tilu, and Cahyanto et al. (2018) investigated trees that host orchids in the block of Gambung. Therefore, this research was focused on the vegetation in the block of Malagembol, which was not included in the previous studies. The aims of the study were to identify the diversity, floristic composition, and structure of trees species in the block of Malagembol, Mt. Tilu NR. The results of this study can serve as baseline information when developing conservation strategies and management of the nature reserve.

MATERIALS AND METHODS

Study area and period

The study was conducted along the climbing route in the block of Malagembol, Mt. Tilu NR, Bandung District, West Java Province at the altitude of 1500 to 2100 meters above sea level (m asl.) (**Figure 1**). The research location has hilly terrain with slope reaching 75^o and temperature of 20.2-26.8°C, air humidity up to 90%, soil pH 6.0-7.2, and light intensity of 75-4490 lux (field data). Data collection period lasted for two months, from April 2019 to May 2019.

Data collection

Data collection on the structure and composition of trees was carried out through vegetation analysis using sampling plot method. A plot with size of 10x100 m^2 was made at each level altitudes, i.e. 1530 m asl, 1745 m asl, and 1950 m asl. Each plot was divided into 10 subplots of 10x10 m^2 to record all trees within the plot. We defined tree as woody plant with a single stem with diameter at breast height (dbh) of more than 10 cm and minimum of two meters in height, excluding tree fern, bamboo, and palm (Beech et al. 2017). Observation parameters, i.e. scientific names, local names, number of individuals, and dbh, were recorded. The scientific name and taxa group referred to the Angiosperm Phylogeny Group classification (The Angiosperm Phylogeny Group 2016), the Plantlist database (http://www.theplantlist.org/) and the Powo science (http://www. plantsoftheworldonline.org/).

Data analysis

Data were analyzed to determine the floristic composition and structure including relative basal area, species richness, and tree diversity indices. The following statistical analyses were conducted using *R* programme (*R* Core Team 2017). Multivariate analysis through Principal Component Analysis (PCA) was used to analyze the importance of the tree in the forest community using the package of “FactoMineR” (Lê et al. 2008) and “factoextra” (Kassambra and Mundt 2017). Tree diversity indices, i.e. rarefied richness, Shannon-Wiener and Simpsons, were computed using “vegan” package (Oksanen et al. 2017).

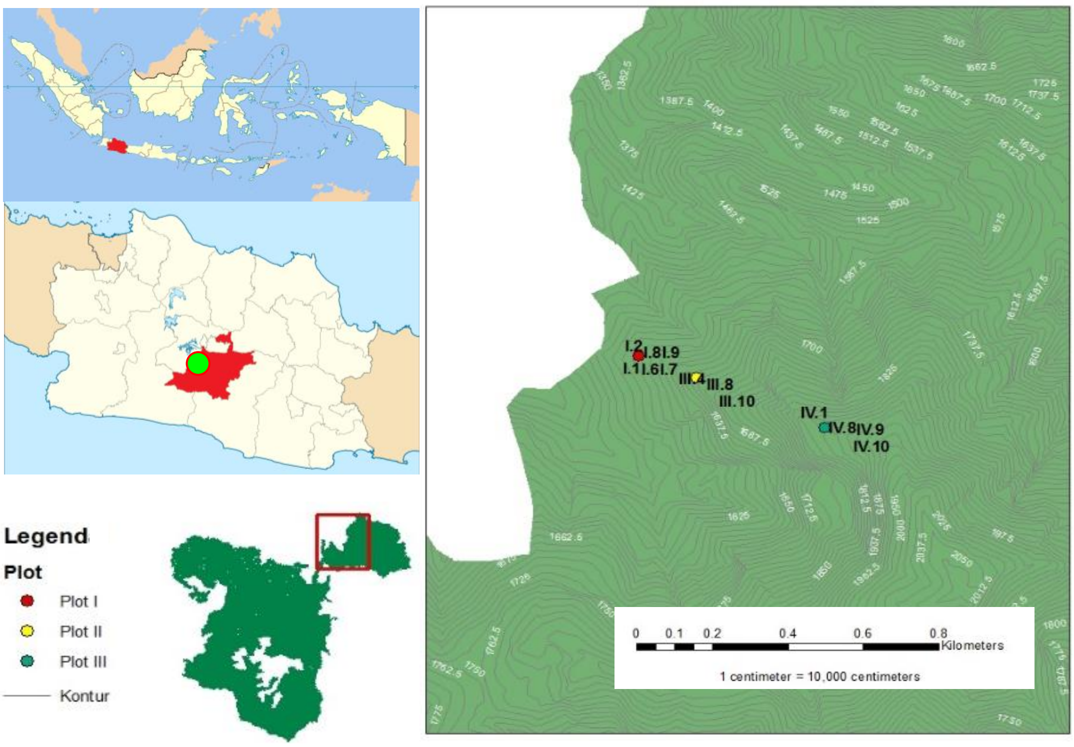

Figure 1. Research location at the block of Malagembol, Mt. Tilu Nature Reserve, Bandung, West Java, Indonesia

RESULTS AND DISCUSSION

The dominance of Fagaceae in the block of Malagembol

A total of 32 species of trees belonging to 23 families was successfully identified in the study area. *Castanopsis javanica* and *Quercus gemelliflora* were the most abundant species across all plots (Figure 2). Other mountain trees species, i.e. *Syzygium acuminatissimum*, *Schima wallichii*, *Lithocarpus pseudomoluccus*, and *Elaeocarpus angustifolius*, were also found in the area. One species of gymnosperms, i.e. *Podocarpus neriifolius*, was found at an altitude of 1950 m asl. The list of the species recorded were angiosperm trees widely distributed in Java (Junaedi and Mutaqien 2010; Rozak et al. 2016; Purwaningsih et al. 2017). Although the composition at species level differs from Susilo (2018), similar trend in the dominance of Fagaceae-Lauraceae was found in both studies.

The composition of trees from the Fagaceae, Myrtaceae, and Lauraceae families is one of the characteristics of mountain rain forests. These plant species formations dominate forest vegetation, especially in the submontane to montane zones (Culmsee et al. 2010; Culmsee et al. 2011; Sadili et al. 2018). Two species of Fagaceae, i.e. *C. javanica* and *Q. gemelliflora*, were found to have a wide distribution from lowland to an altitude of 2000 m asl (Fujii et al. 2006). Particularly *C. javanica*, the species is able to grow on various types of vegetation in Mt. Gede Pangrango National Park (Rozak et al. 2016) and is the dominant species in Mt. Patuha forest (Junaedi and Mutaqien 2010).

The number of tree species in the block of Malagembol is higher than that in the study by Susilo (2018) which was done in a permanent plot with size 100x100 m^2 in Mt. Tilu NR (Table 1). Four species, i.e. *Altingia excelsa*, *Q. gemelliflora*, *Schima wallichii*, and *Neolitsea javanica*, were found in both studies (Susilo (2018). Furthermore, *Lithocarpus pallidus*, *Ficus fistulosa*, *Phobea grandis*, *Castanopsis cuspidata*, and *Trema amboinensis*, were reported by Cahyanto et al. (2018). Floristic compositions are thought to be related to habitat conditions, soil conditions, topography, distance between locations, altitude, and the number of samples and the sampling techniques used (Coomes and Allen 2007; Baraloto et al. 2013; Rozak and Gunawan 2015; Chian et al. 2016; Salvana et al. 2019).

Pioneer tree species were also found in the study area including *Macaranga rhizinoides*, *Schima wallichii*, *Ostodes paniculata*, and *Viburnum sambucinum*. These plant species covered the gaps in the forest due to fallen trees, landslides, and windstorms. These species are more tolerant of light compared to the native species (Mutaqien and Zuhri 2011; Goodale et al. 2012; Rosleine et al. 2014; Mulyana and Kusmana 2017).

Good regeneration status of trees in the block of Malagembol

The average tree density reached 450 trees/ha and tended to increase along with the increase in altitude of the location, namely plot 1, plot 2, and plot 3 reached 340, 490 and 520 trees/ha, respectively. Conversely, tree size tended to decrease with increasing altitude which is in line with the other studies as reported by Culmsee et al. (2010), Reddy et al. (2010), and Coomes and Allen (2007). In addition to altitude (Rozak and Gunawan 2015), light competition and nutrient composition influence tree density (Coomes and Allen 2007; Wagner et al. 2011). Besides the higher density, the species composition at higher altitudes was also more homogeneous, especially in Plot 3. This shows the ability of adaptation of plant species to the environment is very limited (Arrijani 2008).

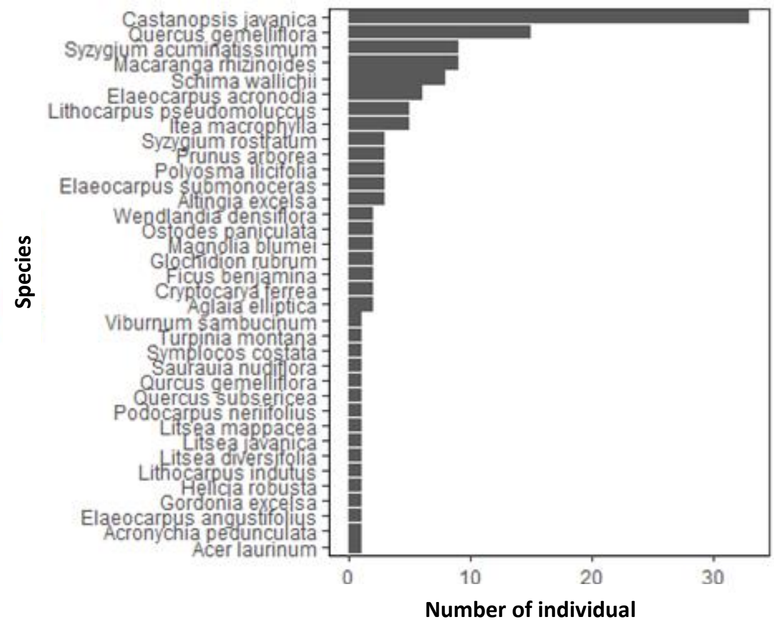

Figure 2. Species name and individual number of trees in the block of Malagembol forest, Mt. Tilu, Bandung, West Java, Indonesia

Table 1. Composition of trees in the Mt. Tilu NR forest, Bandung, West Java, Indonesia

Name of tree	Local name	Family	*This research*	Susilo (2018)
Acer laurinum Hassk.	Huru bodas	Sapindaceae	+	-
Acronychia pedunculata Zoll & Moritzi	Ki jeruk	Rutaceae	+	-
Aglaia elliptica (C.DC.) Blume	Tanglar	Meliaceae	+	-
Altingia excelsa Noronha	Rasamala	Altingiaceae	+	+
Antidesma montanum Blume.	Ki huut	Phyllanthaceae	-	+
Castanopsis acuminatissima (Blume) A.DC	Ki riyung	Fagaceae	-	+
Castanopsis argentea (Blume) A.DC	Saninten	Fagaceae	-	+
Castanopsis javanica (Bl.) A.DC	Ki hiur	Fagaceae	+	-
Cryptocarya ferrea Bl.	Huru mentek	Lauraceae	+	-
Elaeocarpus angustifolius Bl.	Janitri	Elaeocarpaceae	+	-
Elaeocarpus punctatus Wall. ex Mast.	Huru cangkring	Elaeocarpaceae	+	-
Ficus cf. *benjamina* L.	Beringin	Moraceae	+	-
Ficus hispida L.f.	Beunying	Moraceae	-	+
Ficus padana Burm.f.	Hamberang	Moraceae	-	+
Ficus vasculosa Wall. ex Miq.	Kuray	Moraceae	-	+
Glochidion rubrum Bl.	Ki pare	Phyllanthaceae	+	-
Gordonia excelsa (Blume) Blume	Ki sapi	Theaceae	+	-
Helicia robusta (Roxb.) R.Br. ex Blume	Kendung	Proteaceae	+	-
Itea macrophylla Wall.	Kanyere badak	Iteaceae	+	-
Lithocarpus pseudomoluccus (Blume) Rehder	Pasang jambe	Fagaceae	+	-
Lithocarpus sundaicus (Blume) Rehder	Pasang	Fagaceae	-	+
Litsea accedentoides Kood. & Valeton *	Huru	Lauraceae	-	+
Litsea diversifolia Bl.	Huru Kisereh	Lauraceae	+	-
Litsea mappacea Boerl.	-	Lauraceae	+	-
Macaranga rhizinoides (Bl.) Müll.Arg.	Manggong	Euphorbiaceae	+	-
*Magnolia sumatrana (*Miq.) Figlar & Noot.	Baros	Magnoliaceae	+	-
Neolitsea javanica (Blume) Backer	Huru batu	Lauraceae	+	+
Ostodes paniculata Bl.	Mumuncangan	Euphorbiaceae	+	-
Podocarpus neriifolius D.Don	Jamuju	Podocarpaceae	+	-
Polyosma illicifolia Bl.	Ki apu	Escalloniaceae	+	-
Prunus arborea (Bl.) Kalkman	Kawoyang	Rosaceae	+	-
Quercus gemelliflora Blume	Huru batu	Fagaceae	+	+
Quercus lineata Blume	Pang gebod	Fagaceae	-	+
Saurauia nudiflora A.DC	Ki leho	Actinidiaceae	+	-
Schefflera aromatica (Blume) Harms.	Manggong	Araliaceae	-	+
Schima wallichii Choissy	Puspa	Theaceae	+	+
Symplocos costata Choisy ex Zoll.	Jirak	Symplocaceae	+	-
Syzygium acuminatissimum (Bl.) A.DC	Ki tambaga	Myrtaceae	+	-
Syzygium rostratum (Bl.) A.DC	Ki heas	Myrtaceae	+	-
Syzygium sp.	Cerem	Myrtaceae	-	+
Turpinia montana (Blume) Kurz	Ki tulang	Staphyleaceae	+	-
Viburnum sambucinum Reinw. ex Blume	Benteur	Adoxaceae	+	-
Wendlandia densiflora (Bl.) A.DC	-	Rubiaceae	+	-

Note: (+) = found in observation area, (-) = not found in observation area

The horizontal structure of stands based on diameter class showed trees with small diameters tended to have higher density compared to the large trees (Figure 3.A). This reverse J-shaped diameter distribution indicates good regeneration status of tree species in the area which has similar condition with some mountain forests in Java, including Mt. Gede Pangrango (Arrijani 2008), Mt. Wilis (Purwaningsih et al. 2017) and Mt. Burangrang (Cahyanto et al. 2019). However, very large trees with dbh of more than 50 cm were not found in this study. The dominance of small trees in the block of Malagembol forest is likely due to illegal logging, farming activity, and natural disturbances (Kelman 2013; Tsujino et al. 2016; Austin et al. 2019).

Cumulatively, *C. javanica*, and *Q. gemelliflora* contributed the highest relative basal area due to the abundant number of individuals. However, it is different from *A. excelsa* in which despite the small number of individuals, it had a relatively high basal area due to the large size of the tree in terms of diameter. In the Cibodas mountain forest, the three species are categorized as emergent trees, having large diameter with tree height reaching 80 m and up to hundreds of years in age (Zuhri et al. 2018). The dominance of small trees (i.e. trees with dbh < 40 cm) in the block of Malagembol is an indication of primary succession, but it has not been climax yet (Arrijani 2008; Mansur et al. 2017).

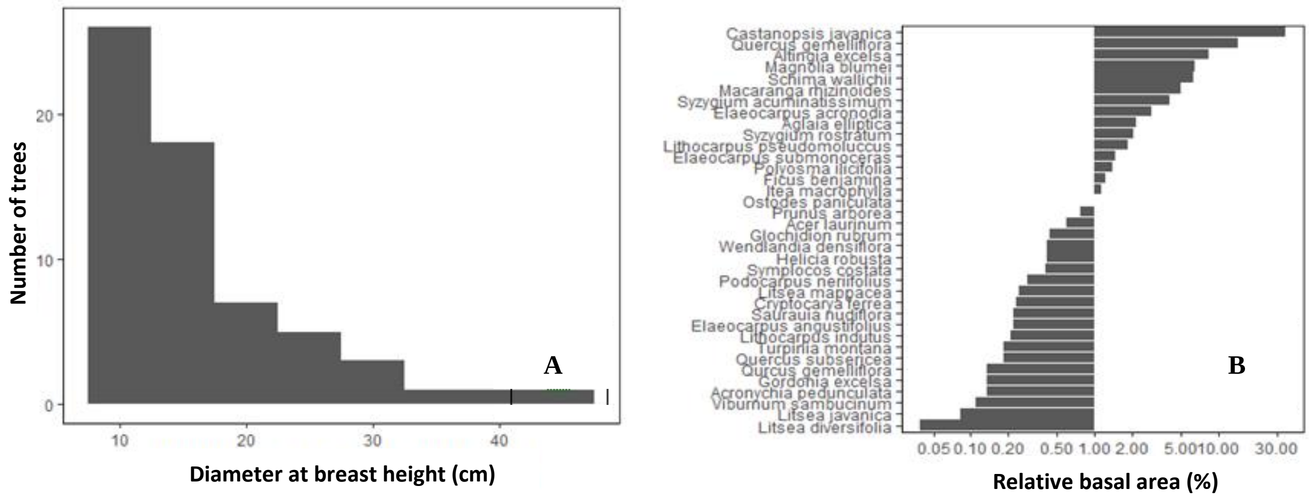

Figure 3. The structure of vegetation based on: A. dbh class; B. Relative basal area

Tree diversity in the block of Malagembol

Tree diversity in Plot 2 was much higher than that in Plots 1 and 3 (Table 2). While we found Plot 1 was more diverse than Plot 3 in terms of rarefied richness and Shannon-Wiener indices, we found the Simpson index of Plot 1 was slightly lower than Plot 3 (Table 2). The difference of those indices perhaps due to the limited number of plots as shown in the rarefaction curve (Figure 4). In general, the level of tree diversity in Mt. Tilu was lower than that in Mt. Wilis, East Java, which was conducted at an altitude of 1500 m asl (Purwaningsih et al. 2017). The differences in diversity indices among forests are thought to be related to habitat conditions and disturbance levels.

Based on the PCA, the variation of trees composition in the block of Malagembol only explains 45.1% of all variations composition in the dimension I and dimension II (Figure 5). The low contribution of factor to the variation in our study site is perhaps due to the limited number of the plot area. This is supported by the fact that species richness based on rarefaction curves is still increasing along with the number of sample sizes (i.e. not reach a steady-state) (Figure 4). This finding suggests that we need more plots in order to capture a more accurate result in the variation of the forests. Two species, i.e. *Castanopsis javanica* and *Q. gemelliflora*, have a high contribution in arranging stands, supported by the dominance of the number of individuals and their basal area (Figure 3.B).

Table 2. Tree diversity indices in the block of Malagembol, Mt. Tilu NR, West Java

	Plot 1	Plot 2	Plot 3
Rarefied richness	16	19	15
Shannon-Wiener	2.45	2.54	2.32
Simpson	0.87	0.89	0.88

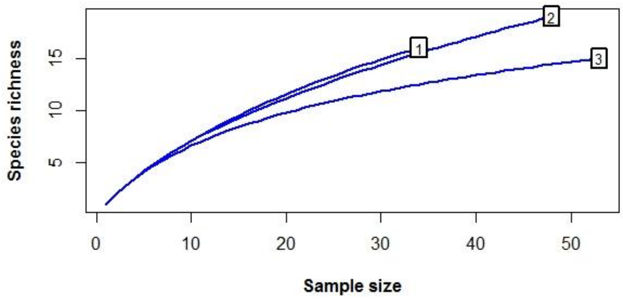

Figure 4. The curve of species richness based on rarefaction curve in the block of Malagembol, Mt. Tilu, Bandung, West Java, Indonesia

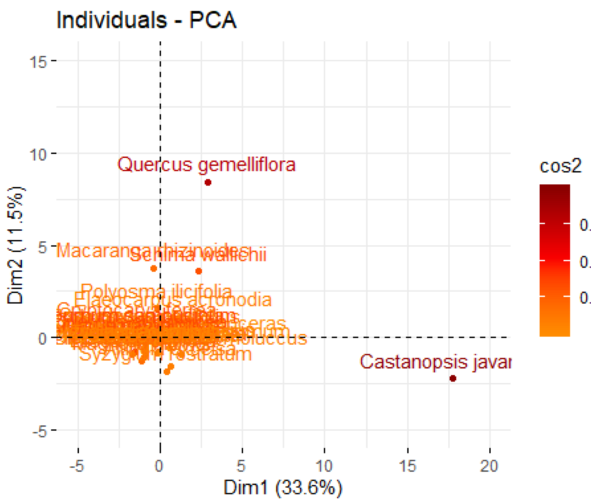

Figure 5. PCA analysis of the type of forest stand in Block Malagembol, Mt. Tilu, Bandung, West Java, Indonesia

In conclusion, the dominance of Fagaceae family in the block of Malagembol, Mt. Tilu NR is in accordance with the floristic composition of other mountain forests in Java. *Castanopsis javanica* and *Q. gemelliflora* have the highest contribution in arranging this formation, both in individual number and relative basal area. The presence of pioneer plants and the dominance of small trees showed good regeneration status in Mt. Tilu following previous vegetation disturbances, which are probably due to natural disturbance and illegal logging some decades ago.

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