ZONATION DRIVES THE ABUNDANCE OF UNDERSTORY EXOTIC PLANT SPECIES IN IR. DJUANDA FOREST PARK, WEST JAVA

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Received : May 15, 2020 Accepted : May 6, 2021 Published : June 30, 2021

Abstract: The understory is an important component in the tropical forests, particularly to contribute to ecosystem services function and playing on succession. However, the study on their existence related to the zonation effect in an ex-situ conservation is still lacking. This study aimed to compare the structure and composition of the understory in the two blocks of Ir. Djuanda Forest Park, Bandung. Data collection was carried out through vegetation analysis using plot methods (sampling plots). A total of 40 sampling plots of 5m x 5m were made in two observation blocks. The Importance Value Index (IVI) for each species was calculated based on their relative density and relative frequency. Seventy-three species of understory from 38 families were found in the observation plots, dominated by Araceae and Moraceae families. The composition of the protected block has higher species richness than the utilization block due to the differences in microclimates conditions. *Calliandra calothyrsus*, known as an invasive species, has the highest IVI indicating high adaptability to open habitats in the utilization block, while two native species, *Plectranthus* sp. and *Chlorathus elatior*, dominate in the protection block. Based on these findings, we showed that forest zonation drives exotic and native species abundance in the ex situ conservation area.

Keywords: *Calliandra calothyrsus*, *ex-situ conservation, flora of Java*, *forest management*, *importance value index*

Abstrak: Tumbuhan bawah merupakan salah satu komponen penting dalam vegetasi hutan tropis, terutama dalam pelayanan ekosistem dan berperan dalam proses suksesi. Namun, penelitian mengenai keberadaannya dikaitkan dengan pengaruh zonasi di kawasan konservasi secara ex situ masih jarang. Tujuan penelitian ini untuk membandingkan struktur dan komposisi tumbuhan bawah pada dua blok yang berbeda di kawasan Taman Hutan Raya Ir. Djuanda, Bandung. Pengambilan sampel menggunakan analisis vegetasi dengan metode plot (petak contoh). Sebanyak 40 plot kecil berukuran 5mx5m di kedua blok pengamatan. Indeks nilai penting (INP) setiap jenis dihitung berdasarkan kerapatan relatif dan frekuensi relatifnya. Sebanyak 73 jenis dalam 38 suku tumbuhan didata di dalam pengamatan, yang didominasi dari suku Araceae dan Moraceae. Berdasarkan jumlah jenis tumbuhan penyusunnya, blok perlindungan memiliki jenis yang lebih banyak dibandingkan dengan blok pemanfaatan berkaitan dengan berkaitan dengan perbedaan kondisi iklim mikro di kedua blok tersebut. Jenis *Calliandra calothyrsus*, dikenal sebagai tumbuhan invasif, memiliki nilai INP tertinggi menunjukkan kemampuan adaptasi yang tinggi pada habitat terbuka di blok pemanfaatan, sedangkan tumbuhan asli pegunungan jawa, *Plectranthus* sp. dan *Chloranthus elatior* mendominasi pada blok perlindungan. Berdasarkan hasil temuan ini, kita menyarankan bahwa zonasi mempengaruhi kelimpahan tumbuhan eksotik dan asli di kawasan konservasi tumbuhan secara eksitu.

Kata kunci: *Calliandra calothyrsus*, konservasi eksitu, tumbuhan Jawa, indek nilai penting, pengelolaan hutan.

Recommended APA Citation :

Cahyanto, T., Yuni, B. N., & Efendi, M. (2021). Zonation Drives The Abundance of Understory Exotic Plant Species in Ir. Djuanda Forest Park, West Java. *Elkawnie*, *7*(1), 156-171. https://doi.org/10.22373/ekw.v7i1.6950

Introduction

Forest Park (FP) is a nature conservation area aiming at conserving flora and fauna, both exotic and native species. This collection is used for some purposes, such as research, environmental education, horticulture, social-culture, and nature-based tourism (Pedoman Penyusunan Rencana Pengelolaan Taman Hutan Raya, 2009). Ecologically, FP has an important role in ecosystem services, such as water reservoirs, soil fertility and erosion regulation, and microclimate maintenance (Balvanera et al., 2017; Kusliansjah et al., 2015; Sekercioglu, 2010). In an urban area, the presence of FP provides a green-public space area, oxygen supply, and water catchment areas (Sekercioglu, 2010).

Ir. Djuanda FP is one of the FP located in the north of Bandung. The park is divided into three main blocks, i.e., collection block, utilization block, and protection block (Dinas Kehutanan Provinsi Jawa Barat, 2007). The division of the FP area is carried out based on their function and topography. Moreover, some parts of Ir. Djuanda FP are forest areas, particularly in the utilization block and the protection block (Peraturan Menteri Lingkungan Hidup dan Kehutanan, 2015).

The understory is an important component of the floor-forest community (Willinghofer et al., 2012) to keep their microclimate condition (Tsvuura et al., 2010). The presence of the understory layer contributes as a thermal insulator and protects the soil from erosion (Nicholls, 2000). The abundance of exotic understory species is an indicator for vegetation succession, as reported by Grant & Loneragan (2001). At the sapling level, the understory woody-form can be used to predict the stand regeneration (Afrianto et al., 2016; Cahyanto et al., 2019; de Carvalho et al., 2017; Irfani, 2016; Rasnovi, 2006; Susanti, 2014).

The zonation effect on vegetation in an in situ conservation area has been reported by other studies (Aiba & Kitayama (1999), Fujii et al. (2006), Mutaqien et al. (2008), Nishimura et al. (2006), Rozak and Gunawan (2015), Willinghofer et al. (2012)). However, the study on the zonation effects in an ex situ conservation area, particularly in Ir. Djuanda FP is not available. Zonation can be used for early detection of forest destruction (Guirado et al., 2006) and the spread of invasive species, as reported in Cibodas Botanic Gardens (Junaedi, 2014; Mutaqien, 2011; Zuhri & Mutaqien, 2013). Therefore, this study aimed to compare the floristic composition and structure of understory species in the forest area of the protection block and the utilization block, Ir. Djuanda Forest Park, Bandung West Java.

Methods

Study site and periods

Ir. Djuanda FP is located in three regencies in West Java, i.e., Bandung City, West Bandung Regency, and Bandung Regency and covered an area of 528,393 ha (Dinas Kehutanan Provinsi Jawa Barat, 2007). This study was conducted in the south site of Ir. Djuanda FP within Bandung City focused on the two main blocks, i.e., the protection block and the utilization block (**Figure 1**). The two blocks were chosen because they both have a natural forest. Utilization block (UB), up to 169.827 ha, is a mixed forest used for tourism activity and education. Pinus dominate the stand of UB *merkusii*, *Switenia macrophylla*, *Khaya anthotheca*, *Calliandra calothyrsus*, *Pterocarpus indicus,* and some pioneer species such as *Macaranga* spp., *Claoxylon longifolium*, *Dendrocnide* spp. and *Ficus fistulosa*. A protection block (PB) is a natural forest designated to protect representative biodiversity and its ecosystem. The stand of PB is dominated by *Acronychia trifoliolata, Aglaia argentea*, *Dendrocnide stimulans,* and *Macaranga* spp. The area reaches an area up to 312.772 ha. (Peraturan Menteri Lingkungan Hidup dan Kehutanan, 2015).

The topography of the study site is rather flat and uphill with slopes up to 75° (Dinas Kehutanan Provinsi Jawa Barat, 2007). The data collection was done from August to September 2019. Environment conditions were recorded during the fieldwork (**Table 1**).

Table 1. Environmental conditions in two blocks of Ir. Djuanda Forest Park

Block	Soil pH	Soil humidity (%)	Light density (lux)	Air temperature (°C)	Air humidity (%)
Utilization block	6.79±0.11	26±16.88	3883±612.32	29.27±1.24	54.85±4.91
Protection block	6.83±0.14	34.52±8.78	1916±305.5	28.60±1.68	57.42±5.61

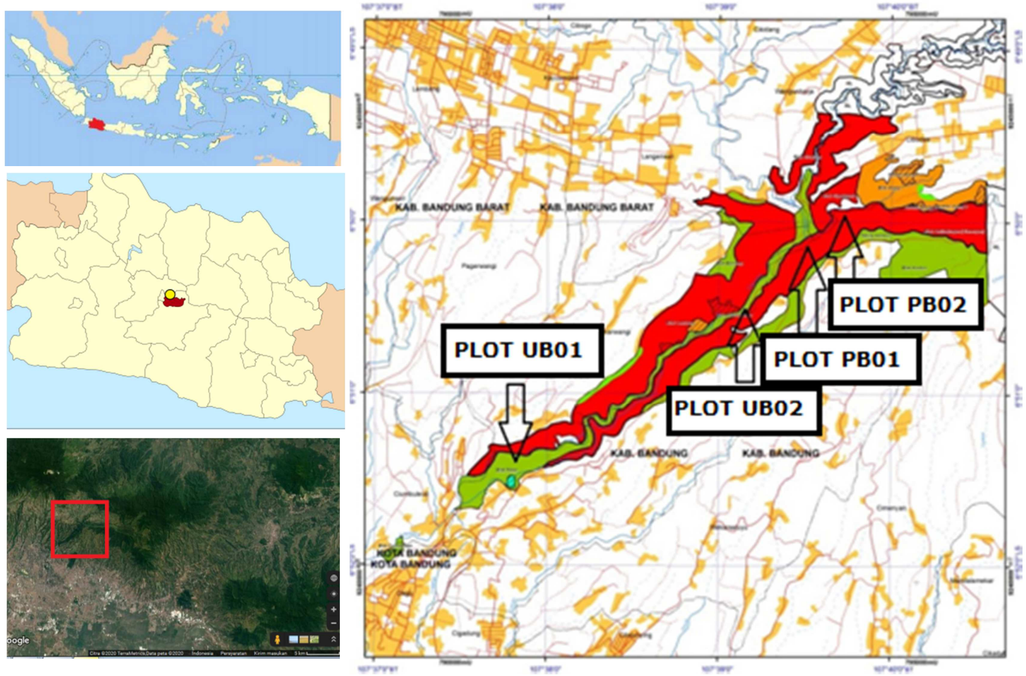

Figure 1. Study site at the utilization block (UB) and protection block (PB) in Ir. Djuanda FP, Bandung.

Data Collection

Data collection was carried out using a sampling plot method in the UB and PB. Four main plots are measuring 10 x 100 m^2 were made in two blocks to investigate the understory. Each plot was divided into 10 subplots of 5 x 5 m^2, alternate position, and the distance between plots is 5 m. (**Figure 2**). In this research, we defined understory as a seed plant that occupies the vegetation layers below the canopy of taller trees, including (i) herbs, (ii) woody-life form, and/or (iii) small tree less than 1.5 m height (Wagner et al., 2011). Observation parameters include scientific names, local names, family, and individual numbers.

Plant identification refers to the *Flora of Java* (Backer & van den Brink Jr, 1963, 1965, 1968). Renewal of scientific names and taxa grouping refers to the Angiosperm Phylogeny Group classification (The Angiosperm Phylogeny Group, 2016).

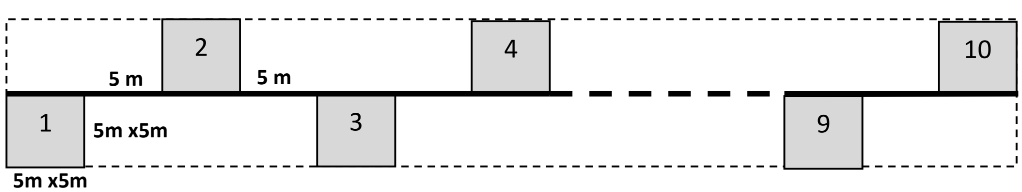

Figure 2. Plot design of sampling plot to understory analysis.

Data analysis

Data of vegetation were analyzed using importance value (IV), i.e., the sums of relative density and relative frequency (Muller-Dombois & Ellenberg 1974). Relative density is defined as the presentation of the number of individuals in each unit area. In contrast, relative frequency refers to the proportion of times a species occurs in subplots in the plot and is expressed as a percentage of the total number of subplots (Purwaningsih et al., 2017). The similarity index of species composition among observation plots was analyzed using *Unweight Pair Group With Aritmethical Average* (UPGMA) at NTSys version 2.1 programs (Rohlf, 1998).

Results and Discussion

The utilization block compared to protection block: A species composition

Seventy-three species belonging to 38 families were found within the plot, dominated by Araceae and Moraceae families (**Table 2 and Table 3**). Araceae and Moraceae were the largest families in angiosperms, which have widely distributed from lowland up to montane forest (Backer & van den Brink Jr, 1965, 1968; Berg & Corner, 2005), particularly in secondary forest (e.g., Cahyanto et al., 2019; Mutaqien et al., 2008; Widodo & Wibowo, 2012). Compared to other FP in Java and Sumatera, Ir. Djuanda FP has the highest species richness (Maisyaroh, 2010; Tranggono, 2013; Erwin et al., 2017; Nursanti & Adriadi, 2019).

The protection block was more diverse than that of the utilization block (**Table 2 and Table 3**). We suggest the protection block has been relatively well protected from anthropogenic influences. A jogging track contributes to the microclimate variations, especially the forests-edge of the utilization block (Fardila & Sutomo, 2011; Zuhri & Mutaqien, 2013). Another cause of species decline in the utilization blocks is differences in the tree canopy (Guirado et al., 2006; Marialigeti et al., 2016; Mestre et al., 2017).

The proportion of native species was higher than the exotic species, both in the observation block (Figure 3). Similar results have been reported in several ex-situ conservation areas, such as in the remnant forest of Cibodas Botanic Gardens (Junaedi, 2014) and R. Soeryo FP of Malang (Tranggono, 2013). Despite the low proportion, exotic invasive species in a natural forest to be needed are noticed (Hejda et al., 2009; Wijesundara, 2010; Zulharman, 2017) due to negative impact on the ecosystem (Zuhri & Mutaqien, 2011, 2013). The establishment of buffer zones around protected areas is often included in forest destruction (Guirado et al., 2006) and the management strategy of plant invasions (Junaedi & Dodo, 2014).

The similarity index among plots indicating a highly diverse species composition in Ir. Djuanda FP (**Figure 4**). The dendrogram tree of similarity index formed two main groups. The first group consisted of only one plot, UB01, with a similarity index value of 0.39. The second group consists of UB02, PB01, and PB02, with a similarity index range from 53% to 58%. Sub-group IIA consisted of UB02 and PB01, separated into sub-group IIB (PB02). It was supported by a similarity index value of 58%. This result indicated that sub-group IIA is a transition zone between utilization block and protected block, although more similar to protected block. The transition zone usually has the highest species number and unique composition of flora, as reported by Mutaqien and Zuhri (2011) and Zuhri et al. (2018) in Mt. Gede Pangrango NP.

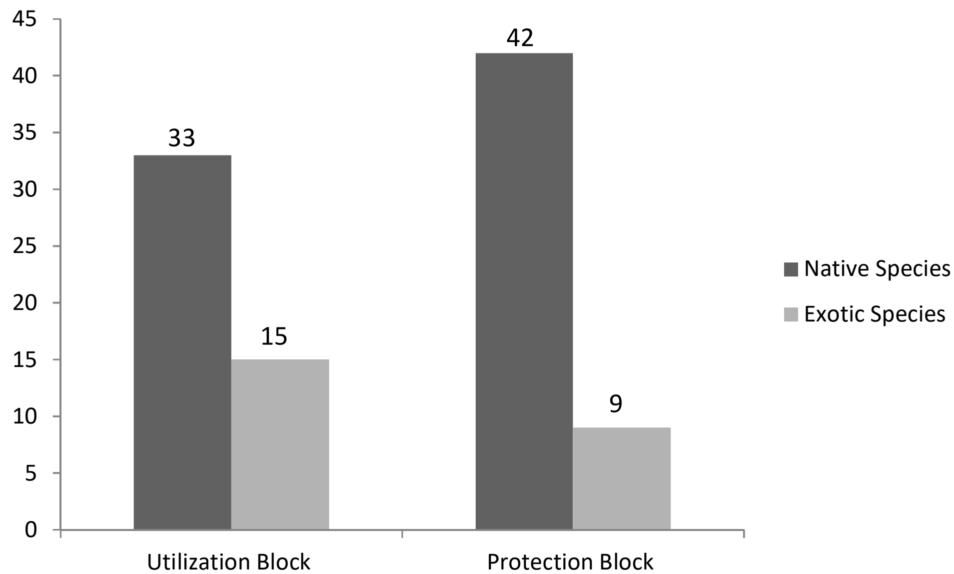

Figure 3. Composition of native and exotic species both in observation block

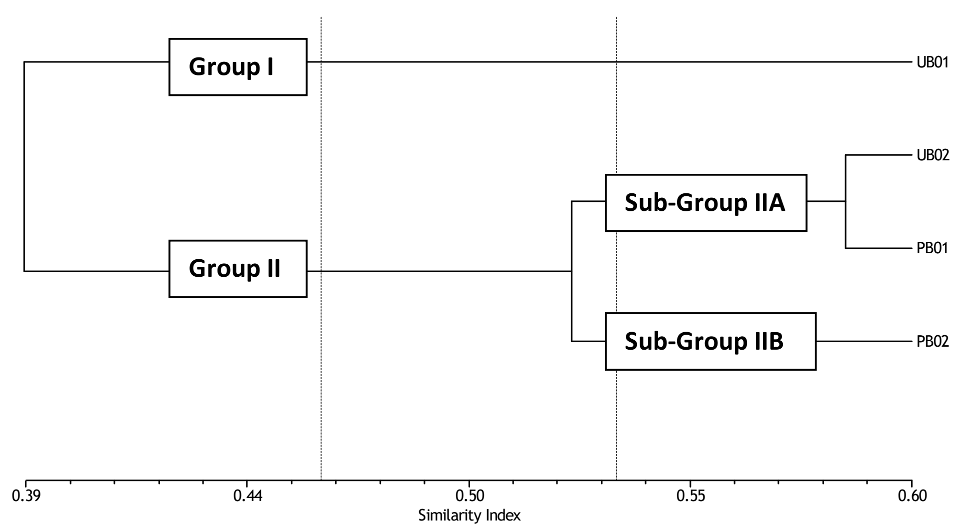

Figure 4. Similarity index of species composition in the observation plots, UB= Utilization Block, PB= Protection Block

The dominance of exotic versus native species based on their importance value

Calliandra callothyrsus, known as an invasive species, has the highest importance value (IV) in the utilization block (**Table 2**). Two main reasons, i.e., their high seed production and recalcitrant seed type supporting their good regeneration in the plots (Martin et al., 2014), are cited. Some invasive species, such as *Brugmansia suaveolens*, *diversifolia*, *Clidemia hirta* and *P. aduncum* (Tjitrosoedirdjo et al., 2016), and other exotic species (such as *Piper aduncum*, *Cestrum nocturnum,* and *Coffea canephora*) indicated a major disturbance in most of the utilization blocks, due to the high frequency of human activity.

Table 2. The understory species in the utilization block based on the importance value

Scientific Names	Family	Local Names	RD	RF	IV
Calliandra calothyrsus Meisn.	Fabaceae	Kaliandra	27.48	9.76	37.24
Lepisanthes montana Blume.	Sapindaceae	-	14.80	6.10	20.90
Unindentified	Poaceae	Rumput	13.54	3.66	17.20
Trevesia sundaica Miq.	Araliaceae	Papanggangan	2.91	10.98	13.89
Coffea canephora Pierre ex A Froehner	Rubiaceae	Kopi	6.46	5.49	11.94
Ficus cuspidata Reinw. ex Blume	Moraceae	Waringin	5.91	1.83	7.73
Piper sulcatum Blume	Piperaceae	Seureuh	2.05	5.49	7.54
Azadirachta excelsa (Jack) Kuntze	Meliaceae	Bintaran	2.76	4.27	7.02
Caryota rumphiana Mart.	Arecaceae	Bingbin	2.44	3.66	6.10
Clidemia hirta (L) D. Don	Melastomataceae	Harendong bulu	1.34	4.27	5.61
Elatostema strigosum Hassk.	Urticaceae	Ramoklia	2.83	1.22	4.05
Ficus sp.	Moraceae	Waringin	1.18	3.66	4.84
Pterygota horsfieldii (R.Br.) Kosterm.	Malvaceae	-	1.34	3.05	4.39
Ranunculus sundaicus (Backer) H.Eichler	Ranuculaceae	-	1.02	3.05	4.07
Raphidophora sp.	Araceae	Raphidophora	2.13	0.61	2.74
Cestrum nocturnum L.	Solanaceae	Cestrum	0.79	2.44	3.23
Litsea noronhae Blume	Lauraceae	Huru meuhmal	0.63	2.44	3.07
Baccaurea motleyana (Mull.Arg) Mull.Arg	Euphorbiaceae	Menteng negri	1.02	1.83	2.85
Pouteria campechiana (Kunth) Baehni	Sapotaceae	Campole	0.94	1.83	2.77
Piper aduncum L.	Piperaceae	Seuseureuhan	0.79	1.83	2.62
Carallia suffruticosa Ridl.	Rhizoporaceae	Ki kukuran	0.79	1.83	2.62
Calophyllum soulattri Burm.f	Clusiaceae	Bintangor	0.55	1.83	2.38
Oreocnide rubescens (Blume). Miq.	Urticaceae	-	1.34	0.61	1.95
Brugmansia suaveolen (Humb. & Bonpl, ex Wild) Bercht. & J.Presl	Solanaceae	Bunga terompet	0.47	1.22	1.69
Artocarpus elasticus Reinw. Ex Blume	Moraceae	Teureup	0.31	1.22	1.53

Scientific Names	**Family**	**Local Names**	**RD**	**RF**	**IV**
Arthrophyllum diversifolium Blume	Araliaceae	Jangkorang	0.24	1.22	1.46
Salacca zalacca (Gaertn.) Voss.	Arecaceae	Salak	0.24	1.22	1.46
Cinnamomum burmanni (Nees. & T.Nees) Blume	Lauraceae	Kayu manis	0.24	1.22	1.46
Schismatoglottis acuminatissima Schott.	Araceae	Taleus leuweung	0.39	0.61	1.00
Unidentified	Iridaceae	-	0.39	0.61	1.00
Bauhinia sp.	Fabaceae	Daun kupu-kupu	0.31	0.61	0.92
Curculigo capitulata (Lour.) Kuntze	Hypoxidaceae	Ki congkok	0.24	0.61	0.85
Maesopsis Eminii Engl.	Rhamnaceae	Kayu afrika	0.24	0.61	0.85
Acronychia trifoliolata Zoll. & Moritzi	Rutaceae	Jejerukan	0.24	0.61	0.85
Palaquium obovatum (Griff.) Engl.	Sapotaceae	Nyatuh	0.24	0.61	0.85
Tithonia diversifolia (Hemsl.) A.Gray	Asteraceae	Paitan	0.16	0.61	0.77
Pterocarpus indicus Wild.	Fabaceae	Angsana	0.16	0.61	0.77
Scutellaria discolor Benth.	Lamiaceae	Hamper lemah	0.16	0.61	0.77
Litsea mappacea Boerl.	Lauraceae	Huru koneng	0.16	0.61	0.77
Piper umbellatum L.	Piperaceae	Seureuh	0.16	0.61	0.77
Viburnum coriaceum Blume	Adoxaceae	Katumpang	0.08	0.61	0.69
Pinanga coronata Blume ex Mart.	Arecaceae	Bingbin	0.08	0.61	0.69
Claoxylon longifolium (Blume) Endl. ex Hask.	Euphorbiaceae	Ki uncal	0.08	0.61	0.69
Hibiscus macrophyllus Roxb. ex Hornem.	Malvaceae	Ki tisuk	0.08	0.61	0.69
Dysoxylum excelsum Blume	Meliaceae	Ki bawang	0.08	0.61	0.69
Ficus fistulosa Reinw. ex Blume	Moraceae	Beunying	0.08	0.61	0.69
Pittosporum molucanum Miq.	Pittosporaceae	Ki honje	0.08	0.61	0.69
Allophylus cobbe (L.) Reusch.	Sapindaceae	-	0.08	0.61	0.69

Description: RD = relative density, RF = relative frequency, IV = Importance value

The native species are more dominated in the protected block than exotic species, particularly small shrubs and non-woody herbs (**Table 3**). The native herbaceous species, namely *Plectranthus* sp., *Chloranthus elatior,* and *Elatostema* spp., have the highest IV due to their relative dominance in observation plots. The abundance of herbaceous species might be related to a suitable microclimate condition, particularly light density. The light density is a critical parameter that is one of the most significant limiting factors. The low to medium dense canopy may favor herb's plant regeneration, but the increase of light density and temperature decreases their herbs species richness (Montti et al., 2011; Wagner et al., 2011; Willinghofer et al., 2012).

Table 3. The understory species in the protection block based on the importance value index

Scientific Names	Family	Local Names	RD	RF	IV
Plectranthus sp.	Lamiaceae	Hamperu lemah	18.46	3.33	21.79
Chloranthus elatior Link	Chloranthaceae	-	15.39	4.00	19.39
Elatostema strigosum Hassk.	Urticaceae	Ramoklia	14.03	4.00	18.03
Syngonium podophyllum Schott.	Araceae	Taleus leuweung	4.66	8.67	13.32
Ziziphus horsfieldii Miq.	Rhamnaceae	Widara	9.09	1.33	10.42
Trevesia sundaica Miq.	Araliaceae	Papanggangan	6.98	3.33	10.32
Schismatoglottis acuminatissima Schott.	Araceae	Taleus leuweung	4.54	3.33	7.88
Ficus cuspidata Reinw. Ex Blume	Moraceae	Beunying	2.33	5.33	7.66
Clidemia hirta (L) D. Don	Melastomataceae	Harendong bulu	4.83	2.67	7.49
Litsea noronhae Blume	Lauraceae	Huru bako	1.08	4.67	5.75
Dendrocnide cf *ardens* (Blume) Blume ex JJS.	Urticaceae	Pulus	1.14	3.33	4.47
Cyrtandra picta Blume	Gesneriaceae	Rendeu badak	0.85	3.33	4.19
Tetrastigma dichotomum Planch.	Vitaceae	Areuy kibarera	1.48	2.67	4.14
Arthrophyllum diversifolium Blume	Araliaceae	Jangkorang	2.10	2.00	4.10
Piper sulcatum Blume.	Piperaceae	Seureuh	0.80	2.67	3.46
Oreocnide rubescens (Blume). Miq.	Urticaceae	-	0.51	2.67	3.18
Elatostema paludosa Miq.	Urticaceae	Ramoklia	0.97	2.00	2.97
Pinanga coronata Blume ex Mart.	Arecaceae	Bingbin	1.36	1.33	2.70
Cestrum nocturnum L.	Solanaceae	Cestrum	0.62	2.00	2.62
Homalomena pendula (Blume) Bakh.f	Araceae	Hariang	0.57	2.00	2.57
Macropanax dispermus (Blume.) Kuntze.	Araliaceae	Panggang serem	0.45	2.00	2.45
Piper aduncum L.	Piperaceae	Seuseureuhan	0.45	2.00	2.45
Aglaia argenta Blume	Meliaceae	Tanglar gunung	0.40	2.00	2.40
Millettia cinerea Brnth	Fabaceae	-	0.34	2.00	2.34
Ficus hirta Vahl	Moraceae	Beunying	0.34	2.00	2.34
Ardisia fuliginosa Blume	Primulaceae	Ki ajag	0.17	2.00	2.17
Persicaria chinensis (L.) H .	Polygonaceae	Bungbrun	0.57	1.33	1.90
Commelina paludosa Blume.	Commelinaceae	Gewor	0.51	1.33	1.84
Ranunculus sundaicus (Backer) H.Eichler	Ranuculaceae	-	0.34	1.33	1.67
Litsea mappacea Boerl.	Lauraceae	Huru koneng	0.34	1.33	1.67
Acronychia trifoliolata Zoll. & Moritzi	Rutaceae	Jejerukan	0.28	1.33	1.62
Ficus fistulosa Reinw. Ex Blume	Moraceae	Beunying	0.23	1.33	1.56
Homalanthus giganteus Zoll. Moritzi.	Euphorbiaceae	Kareumbi	0.23	1.33	1.56
Paraphlomis oblongifolia (Blume) Prain	Lamiaceae	-	0.23	1.33	1.56
Coffea canephora Pierre ex A	Rubiaceae	Kopi	0.17	1.33	1.50

Scientific Names	Family	Local Names	RD	RF	IV
Froehner					
Cinnamomum burmanni (Nees. & T.Nees) Blume	Lauraceae	Kayu manis	0.74	0.67	1.40
Ficus variegata Blume	Moraceae	Kondang	0.74	0.67	1.40
Colocasia sp.	Araceae	Talas hutan	0.28	0.67	0.95
Saurauia pendula Blume	Actinidiaceae	Ki leho	0.23	0.67	0.89
Antidesma tetrandrum Blume.	Phyllanthaceae	Huni peucang	0.17	0.67	0.84
Bridelia insulana Hance	Phyllanthaceae	Kanyere	0.17	0.67	0.84
Lepisanthes montana (Blume.)	Lauraceae	-	0.17	0.67	0.84
Brugmansia suaveolen (Humb. & Bonpl, ex Wild) Bercht. & J.Presl	Solanaceae	Bunga terompet	0.11	0.67	0.78
Claoxylon longifolium (Blume) Endl. Ex Hask.	Euphorbiaceae	Ki uncal	0.11	0.67	0.78
Dysoxylum excelsum Blume	Meliaceae	Ki bawang	0.06	0.67	0.72
Stephania corymbosa Walp.	Menispermaceae	Areuy camcah minyak	0.06	0.67	0.72
Ficus sp.	Moraceae		0.06	0.67	0.72
Pittosporum molucanum Miq.	Pittosporaceae	Ki honje	0.06	0.67	0.72
Bambusa sp.	Poaceae	Awi	0.06	0.67	0.72
Allophylus cobbe (L.) Reusch.	Sapindaceae	-	0.06	0.67	0.72
Zingiber inflexum Blume	Zingiberaceae	Tongtak leutik	0.06	0.67	0.72

Description: RD = relative density, RF = relative frequency, IV = Importance value

Generally, the zonation system applied in Ir. Djuanda FP affects the abundance of exotic understory species. The abundance of herbaceous plants observed is influenced by the microclimate variations in the observation plots. Furthermore, the accessibility to the forest and human activity in utilization block increases the exotic number of species (Guirado et al., 2006), particularly in those nearest to the forest edge.

Conclusion

The composition of understory species, native vs. exotic species, follows their zonation in Ir. Djuanda FP. The exotic understory species are more dominant in the utilization block than in the protected block due to differences in their microclimate and human activity. The dominance of native herbaceous plants, on the other hand, is well-known as a sign of a healthy natural forest.

Acknowledgements

We would like to thanks the Head of Ir. Djuanda FP, West Java, for granting permission in this study. Thank you also to Mr. Muslim (Cibodas Botanic Gardens, LIPI), who has assisted field sampling and helping in the identification of plants. The authors greatly appreciate our supervisor, Dr. Andes

Hamuraby Rozak (Research Centre for Plant Conservation and Botanic Gardens, LIPI), for his advice, guidance, and encouragement throughout this study.

Contributor statement

The authors have similar contributions in this paper as the **main contributor**.

References

Afrianto, W. F., Hikmat, A., & Widyatmoko, D. (2016). Komunitas Floristik dan Suksesi Vegetasi Setelah Erupsi 2010 di Gunung Merapi Jawa Tengah. *Jurnal Biologi Indonesia*, *12*(2), 265–276.

Aiba, S., & Kitayama, K. (1999). Structure, composition and species diversity in an altitude-substrate matrix of rain forest tree communities on Mount Kinabalu, Borneo. *Plant Ecology*, *140*(139–159), 19.

Backer, C. A., & van den Brink Jr, R. C. B. (1963). *Flora of Java (Spermatophytes only): Vol. I*. NVP Noordhoff.

Backer, C. A., & van den Brink Jr, R. C. B. (1965). *Flora of Java (Spermatophytes only): Vol. II*. NVP Noordhoff.

Backer, C. A., & van den Brink Jr, R. C. B. (1968). *Flora of Java (Spermatophytes only): Vol. III*. NVP Noordhoff.

Balvanera, P., Quijas, S., Karp, D. S., Neville, A., Bennett, E. M., Boumans, R., Brown, C., Chan, K. M. A., Chaplin-Kramer, R., Halpern, B. S., Honey-Rosés, J., Kim, C. K., Cramer, W., Martínez-Harms, M. J., Mooney, H., Mwampamba, T., Nel, J., Polasky, S., Reyers, B., … Walz, A. (2017). Ecosystem Services. In M. Walters & R. J. Scholes (Eds.), *The GEO Handbook on Biodiversity Observation Networks* (pp. 41–78). https://www.researchgate.net/publication/311406617_Ecosystem_Services

Berg, C. C., & Corner, E. J. H. (2005). *Flora Malesiana Series I - Seed Plants* (Vol. 17). The National Herbarium Netherlands.

Budiharta, S., Widyatmoko, D., Irawati, Wiriadinata, H., Rugayah, Partomihardjo, T., Ismail, Uji, T., keim, A. P., & Wilson, K. A. (2011). The processes that threaten Indonesian plants. *Oryx*, *45*(2), 172–179.

Cahyanto, T., Efendi, M., Shofara, R. M., Dzakiyyah, M., Nurlaela, & Satria, P. G. (2019). Floristic survey of vascular plant in the submontane forest of Mt. Burangrang Nature Reserve, West Java, Indonesia. *Biodiversitas*, *20*(8), 2197–2205.

Cain, M. L., Milligan, B. G., & Strand, A. E. (2000). Long-distance seed dispersal in plant populations. *American Journal of Botany*, *87*(9), 1217–1227. https://doi.org/10.2307/2656714

Chamberlain, J. R. (Ed.). (2001). *Calliandra calothyrsus: An agroforestry tree for the humid tropic*. Oxford University Press.

de Carvalho, A. L., d'Oliveira, M. V. N., Putz, F. E., & de Oliveira, L. C. (2017). Natural regeneration of trees in selectively logged forest in western Amazonia. *Forest Ecology and Management*, *392*(2017), 36–44. https://doi.org/10.1016/j.foreco.2017.02.049

Destaranti, N., Sulistiyani, & Yani, E. (2017). Struktur dan vegetasi tumbuhan bawah pada tegakan Pinus di RPH Kalirajut dan RPH Baturraden Banyumas. *Scripta Biologica*, *4*(3), 155–160. https://doi.org/doi.org/10.20884/1.SB.2017.4.3.407

Dinas Kehutanan Provinsi Jawa Barat. (2007). *Dinas Kehutanan Provinsi Jawa Barat*. http://www.dishut.jabarprov.go.id/index.php?mod=manageMenu&idMenuKiri=461&idMenu=468

Erwin, Bintoro, A., & Rusita. (2017). Keragaman vegetasi di Blok Pemanfaatan Hutan Pendidikan Konservasi Terpadu (HPKT) Tahura Wan Abdul Rachman Provinsi Lampung. *Jurnal Silva Lestari*, *5*(3), 1–11.

Fardila, D., & Sutomo. (2011). Efek tepi koridor jalan di hutan Bukit Pohen, Cagar Alam Batukahu, Bali. *Berk. Penel. Hayati*, *17*(2011), 9–13.

Fauziiah, R., Priyanti, & Aminudin, I. (2018). Komposisi dan Struktur Vegetasi di Resort Gunung Salak 2 Taman Nasional Gunung Halimun Salak (TNGHS). *Majalah Ilmiah Biologi Biosfera : A Scientific Journal*, *35*(3), 111–118. https://doi.org/10.20884/1.mib.2018.35.3.516

Fitriyana, D. (2016). Konflik manajemen antara pengelola dan masyarakat di Tahura Djuanda, Bandung, Jawa Barat. *JUMPA*, *2*(2), 111–123.

Fujii, S., Nishimura, S., & Yoneda, T. (2006). Altitudinal distribution of Fagaceae in West Sumatra. *Tropics*, *15*(2), 153–163. https://doi.org/10.3759/tropics.15.153

Grant, C. D., & Loneragan, W. A. (2001). The effects of burning on the understory composition of rehabilitated bauxite mines in Western Australia: Community changes and vegetation succession. *Forest Ecology and Management*, *145*(3), 255–279. https://doi.org/10.1016/S0378-1127(00)00441-2.

Guirado, M., Pino, J., & Roda, F. (2006). Understory plant species richness and composition in metropolitan forest archipelagos: effects of forest size, adjacent land use and distance to the edge. *Global Ecology and Biogeography*, *15*(2006), 50–62.

Harvey, A. L., & Gericke, N. (2011). Bioprospecting: Creating a Value for Biodiversity. In I. Pavlinov (Ed.), *Research in Biodiversity—Models and Applications* (p. 17). InTech. http://www.intechopen.com/books/research-in-biodiversity-models-and-applications/bioprospecting- creating-a-value-for-biodiversity

Hejda, M., Pyšek, P., & Jarošík, V. (2009). Impact of invasive plants on the species richness, diversity and composition of invaded communities.

Journal of Ecology, *97*(3), 393–403. https://doi.org/10.1111/j.1365-2745.2009.01480.x

Howe, H. F., & Smallwood, J. (1982). Ecology of Seed Dispersal. *Annual Review of Ecology and Systematics*, *13*(1), 201–228. https://doi.org/10.1146/annurev.es.13.110182.001221

Hughes, M., Girmansyah, D., & Ardi, W. H. (2015). Further discoveries in the ever-expanding genus Begonia (Begoniaceae): Fifteen new species from Sumatra. *European Journal of Taxonomy*, *0*(167). https://doi.org/10.5852/ejt.2015.167

Irfani, E. (2016). *Pola penyebaran dan regenerasi jenis Saninten (Castanopsis argentea Blume) di Resort Selabintana, Taman Nasional Gunung Gede Pangrango*. Institut Pertanian Bogor.

Junaedi, D. I. (2014). Exotic plants in the Cibodas Botanic Gardens remnant forest: Inventory and cluster analysis of several environmental factors. *Buletin Kebun Raya*, *17*(1), 1–8.

Junaedi, D.I. & Dodo. (2014). Exotic plants in Halimun Salak Corridor: Micro-environment, detection and risk analysis of invasive plants. *Biotropia, 21* (1), 38 - 52. https://doi.org/ 10.11598/btb.2014.21.1.4.

Pedoman Penyusunan Rencana Pengelolaan Taman Hutan Raya, Pub. L. No. P.10/Menhut-II/2009, 25 (2009).

Peraturan Menteri Lingkungan Hidup dan Kehutanan, Pub. L. No. P.76/Menlhk-Setjen/2015, 43 (2015).

Kusliansjah, Y. K., Widjaja, G. P., Amirani, R., & Priatna, K. (2015). *Kolam Pakar Tahura Ir. H. Djuanda sebagai Arena Ruang Publik Kota Bandung* (p. 54). Universitas Katolik Parahyangan.

Linares-Palomino, R., Cardona, V., Hennig, E. I., Hensen, I., Hoffmann, D., Lendzion, J., Soto, D., Herzog, S. K., & Kessler, M. (2009). Non-woody life-form contribution to vascular plant species richness in a tropical American forest. *Plant Ecology*, *201*(1), 87–99. https://doi.org/10.1007/s11258-008-9505-z

Maisyaroh, W. (2010). Struktur Komunitas Tumbuhan Penutup Tanah di Taman Hutan Raya R. Soerjo Cangar, Malang. *Jurnal Pembangunan dan Alam Lestari*, *1*(1), 1–9.

Marialigeti, S., Tinya, F., Bidlo, A. & Odor, P. (2016). Environmental drivers of the composition and diversity of the herb layer in mixed temperate forests in Hungary. *Plant Ecol*, *217*(2016), 549–563. https://doi.org/10.1007/s11258-016-0599-4

Martin, M. D., Zimmer, E. A., Olsen, M. T., Foote, A. D., Gilbert, M. T. P., & Brush, G. S. (2014). Herbarium specimens reveal a historical shift in phylogeographic structure of common ragweed during native range disturbance. *Molecular Ecology*, *23*(2014), 1701–1716.

Mestre, L., Toro-Manriques, M., Soler, R., Huertas-Herrera, A., Martínez-Pastur, G., & Lencinas, M.V. (2017). The influence of canopy-layer composition on understory plant diversity in southern temperate forests. *Forest Ecosystems*, *4*(6), 1-13.

Montti, L., Campanello, P. I., Gatti, M. G., Blundo, C., Austin, A. T., Sala, O. E., & Goldstein, G. (2011). Understory bamboo flowering provides a very narrow light window of opportunity for canopy-tree recruitment in a neotropical forest of Misiones, Argentina. *Forest Ecology and Management*, *262*(2011), 1360–1369. https://doi.org/10.1016/j.foreco.2011.06.029

Muller-Dombois, D., & Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. John Wiley and Sons.

Mulyana, D., & Kusmana, C. (2017). Species and Structure Composition of Nature Disturbed Forest Stand in Papandayan Mountain, West Java Indonesia. *International Journal of Sciences*, *31*(2), 286–296.

Mutaqien, Z. (2011). Establishing a long, term permanent plot in remnant forest of Cibodas Botanic Garden, West Java. *Biodiversitas, Journal of Biological Diversity*, *12*(4), 218–224. https://doi.org/10.13057/biodiv/d120406

Mutaqien, Z., Santoso, P., & Kusmoro, J. (2008). Studi vegetasi hutan hujan tropis pegunungan di Gunung Manglayang. *Widyariset 11 (22): 157-164.*, *11*(2), 157–164.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *NATURE*, *403*, 853–858.

Nahlunnisa, H., Zuhud, E. A. M., & Prasetyo, L. B. (2015). Penyebaran spasial keanekaragaman tumbuhan pangan dan obat di Kampung Nyungcung, Desa Malasari, Kecamatan Nanggung, Bogor. *Media Konservasi*, *20*(3), 187–196.

Nishimura, S., Yoneda, T., Fujii, S., Mukhtar, E., Abe, H., Kubota, D., Tamin, R., & Watanbe, H. (2006). Altitudinal zonation of vegetation in the Padang region, West Sumatra, Indonesia. *Tropics*, *15*(2), 137–152. https://doi.org/10.3759/tropics.15.137

Nursanti, N., & Adriadi, A. (2019). Study of Basic Vegetation Composition in Sultan Thaha Saifuddin Grand Forest Park Area. *Media Konservasi*, *24*(1), 85–93. https://doi.org/10.29244/medkon.24.1.85-93

Nurtjahjaningsih, I. L. G., Sulistyawati, P., & Rimbawanto, A. (2016). Struktur Genetik Calliandra Calothyrsus di Indonesia Menggunakan Penanda Random Amplified Polymorphism DNA (RAPD). *Jurnal Pemuliaan Tanaman Hutan*, *10*(1), 31–38.

Purwaningsih, Polosakan, R., Yusuf, R., & Kartawinata, K. (2017). Phytosociological study of the montane forest on the south slope of Mt. Wilis, East Java, Indonesia. *Reinwardtia*, *16*(1), 31–45.

Rasnovi, S. (2006). *Ekologi Regenerasi Tumbuhan Berkayu pada Sistem Agroforest Karet*. Institut Pertanian Bogor.

Rohlf, F. J. (1998). *Numerical Taxonomy and Multivariate Analysis System version 2.0*. Applied Biostatistics Inc.

Rozak, A. H., & Gunawan, H. (2015). Altitudinal gradient effects on trees and stand attributes in Mount Ciremai National Park, West Java, Indonesia. *Jurnal Penelitian Kehutanan Wallacea*, *4*(2), 93. https://doi.org/10.18330/jwallacea.2015.vol4iss2pp93-99

Sekercioglu, C. H. (2010). Ecosystem functions and services. In N. S. Sodhi & P. R. Ehrlich (Eds.), *Conservation Biology for All* (p. 32). Oxford University Press. https://conbio.org/images/content_publications/Chapter3.pdf

Susanti, S. (2014). *Komposisi dan struktur tegakan regenerasi alami di Hutan Pendidikan Gunung Walat, Sukabumi*. Institut Pertanian Bogor.

Tallei, T. E., Nangoy, M. J., & Saroyo. (2016). Potensi biodiversitas tumbuhan di Taman Hutan Raya Gunung Tumpa sebagai basis ketahanan pangan masyarakat lokal. *Prosiding Seminar Nasional Pertanian 2016 IS Pengembangan Sumber Daya Untuk Menunjang Kemandirian Pangan*, 1–15.

The Angiosperm Phylogeny Group. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society*, *181*(1), 1–20. https://doi.org/10.1111/boj.12385

Tjitrosoedirdjo, S. S., Mawardi, I., & Tjitrosoedirdjo, S. (2016). *75 Important Invasive Plant species in Indonesia*. SEAMEO BIOTROP.

Tranggono, U. A. D. (2013). *Struktur komunitas tumbuhan bawah pada tegakan terbuka dan tertutup serta pemanfaatannya oleh masyarakat di Taman Hutan Raya (TAHURA) R. Soerjo Cangar Kota Batu*. Universitas Islam Negeri Maulana Malik Ibrahim.

Tsvuura, Z., Griffiths, M. E., Gunton, R. M., Franks, P. J., & Lawes, M. J. (2010). Ecological filtering by a dominant herb selects for shade tolerance in the tree seedling community of coastal dune forest. *Oecologia*, *164*(2010), 861–870. https://doi.org/10.1007/s00442-010-1711-4

Wagner, S., Fischer, H., & Huth, F. (2011). Canopy effects on vegetation caused by harvesting and regeneration treatments. *European Journal of Forest Research*, *130*(1), 17–40. https://doi.org/10.1007/s10342-010-0378-z

Widodo, P., & Wibowo, D. N. (2012). Araceae di Lereng Selatan Gunung Slamet. In *Ekologi Gunung Slamet: Geologi, Klimatologi, Biodiversitas, dan Dinamika Sosial* (pp. 89–92). Pusat Penelitian Biologi.

Widyatmoko, D. (2019). Strategi Dan Inovasi Konservasi Tumbuhan Indonesia Untuk Pemanfaatan Secara Berkelanjutan. *Isu-Isu Strategis Sains, Lingkungan, dan Inovasi Pembelajarannya*, 1–22.

Wijesundara, S. (2010). Defining Invasive Alien Species. In B. Marambe, P. Silva, S. Wijesundara, & N. Atapattu (Eds.), *Invasive Alien Species in Sri Lanka – Strengthening Capacity to Control Their Introduction and Spread* (pp. 1–6). Biodiversity Secretariat of the Ministry of Environment.

Willinghofer, S., Cicuzza, D., & Kessler, M. (2012). Elevational diversity of terrestrial rainforest herbs: When the whole is less than the sum of its parts. *Plant Ecol*, *213*(2012), 407–418. https://doi.org/10.1007/s11258-011-9986-z

Zuhri, M., & Mutaqien, Z. (2011). Perubahan komposisi vegetasi dan struktur pohon pada Plot Meijer (1959- 2009) di Gunung Gede, Jawa Barat. *Buletin Kebun Raya*, *14*(1).

Zuhri, M., & Mutaqien, Z. (2013). The Spread of Non-native Plant Species Collection of Cibodas Botanical Garden into Mt. Gede Pangrango National Park. *Journal of Tropical Life Science*, *3*(2), 74–82. https://doi.org/10.11594/jtls.03.02.01

Zuhri, M., Mutaqien, Z., Nurdiana, D. R., Destri, D., Nudin, N., & Djuanda, D. (2018). Vegetasi Tumbuhan pada Kawasan Tepi Hutan Taman Nasional Gunung Gede Pangrango yang Berbatasan dengan Kebun Raya Cibodas. *Biogenesis: Jurnal Ilmiah Biologi*, *6*(2), 105. https://doi.org/10.24252/bio.v6i2.5010

Zulharman. (2017). Analisis Vegetasi Tumbuhan Asing Invasif (Invasive Species) pada Kawasan Revitalisasi Hutan, Blok Argowulan, Taman Nasional Bromo Tengger Semeru. *Natural B*, *4*(1), 78–87.