VOLUME 7 No 1
JULY 2022

E-ISSN: 2622-3384
P-ISSN: 2527-9939

JURNAL MEdu Mangifera Edu

Association of dominant tree species in lowland forest of Mount Ciremai National Park

Yayan Hendrayana*, Deni Deni, Ade Muhammad Irsyad Habibi
Department of forestry, Faculty of forestry, Universitas Kuningan
Jl. Cut Nyak Dhien No. 36A Kuningan, West Java, Indonesia,
*Corresponding author: yayan.hendrayana@uniku.ac.id

ABSTRACT

The vegetation of the Karangsari rehabilitation zone of Mount Ciremai National Park vegetation consists of several trees that grow together and interact with each other. This study aims to determine species diversity and dominant tree associations in the rehabilitation zone of Karangsari Block, Mount Ciremai National Park. Field data collection using the checkered line method on a predetermined number of sampling plots. Furthermore, it was analyzed using the Important Value Index (IVI) to determine the dominant tree species and to determine the association relationship using a 2 x 2 contingency table. The study found 22 tree species with a diversity index value of 1.4. The dominant trees found in the study area were tusam (*Pinus merkusii*), saninten (*Castanopsis argantea*), anggrit (*Nauclea sp*), and avocado (*Persea americana*). There are six pairs of association relationships between dominant trees four pairs are positive and two are negative. This information is essential for future management of the use zone.

ARTICLE INFO

Keywords
Conservation, Lowland, Rehabilitation, Vegetation

Received
April 01, 2022

Revised
June 01, 2022

Accepted
June 04, 2022

Published
July 31, 2022

How to cite
Hendrayana, Y., Deni, D., & Habibi, A. M. I. (2022). Association of dominant tree species in lowland forest of Mount Ciremai National Park. *Jurnal Mangifera Edu*, *7*(1), 46-56. https://doi.org/10.31943/mangiferaedu.v7i1.142

INTRODUCTION

The Mount Ciremai area was designated as Mount Ciremai National Park (MCNP) in 2004 through the Decree of the Minister of Forestry Number: 424/Menhut-II/2004 dated October 19, 2004 (Balai TNGC, 2017). Before becoming a national park, this area was a protected forest and production forest managed by Perum Perhutani (Fajrul'Aini, 2021). This area has high biodiversity, both flora and fauna, even some of which are categorized as rare and critical species (Yogaswara et al., 2017). Besides that, it is a water catchment area for the area below, namely Majalengka, Kuningan, Cirebon, Indramayu and Brebes regencies (Rismunandar, 2016). According to Yuniarsih et al. (2014) MCNP area is a natural forest ecosystem with the classification of the lower zone (< 1,400 m asl), the middle zone (1,400 – 2,400 m asl,) and the peak zone (> 2,400 m asl). As much as 50.19% of the total area of the MCNP area, especially in the lower zone, must be immediately restored because it has been degraded due to illegal encroachment (Gunawan & Subiandono, 2014).

The forest area at the research site is included in the lower zone, the rehabilitation zone of the Karangsari Block, including the lowland forest, which has its uniqueness, namely the two main characteristics that distinguish lowland forest from other terrestrial biomes (Clark et al., 2019). In a forest plant community, interactions occur between species of population members (Kraft & Ackerly, 2014). For example, plant species must live on other plants to live, so they can grow side by side to form a forest community. Various types of plants found in a community will interact with other existing plants and their environment (Trivedi et al., 2020). This relationship of interest to grow together is known as an association (Susilo, 2018). Furthermore, according to Strain & Bazzaz (2019), vegetation is formed by the presence and interaction of several types of plants in it. One form of interaction between these types is association. Association is a typical type of community, found under the same conditions and repeated in several locations. The association is characterized by similar floristic composition, a uniform physiognomy, and a distinctive habitat.

Studies conducted in this area are generally related to animal or plant research, but studies on dominant tree associations in this area have not been carried out. Interact, especially in lowland forests, and the basis for enrichment activities at similar locations. This study aims to obtain information about the diversity and associations of plants in the Karangsari Darma block rehabilitation zone, Mount Ciremai National Park.

METHOD

This research was conducted for two months in the rehabilitation zone of Karangsari Block, Mount Ciremai National Park, which has an area of 30 ha. The research location includes Karangsari Village, Darma District, Kuningan Regency. The research tools and materials used are: Tools (stationery, Global Position System (GPS) to save geographic points/locations of plots or trees, machetes, digital cameras, meters, tallysheets, mines, measuring tapes and computer equipment). In contrast, the material used is vegetation in the rehabilitation zone of the Karangsari MCNP block.

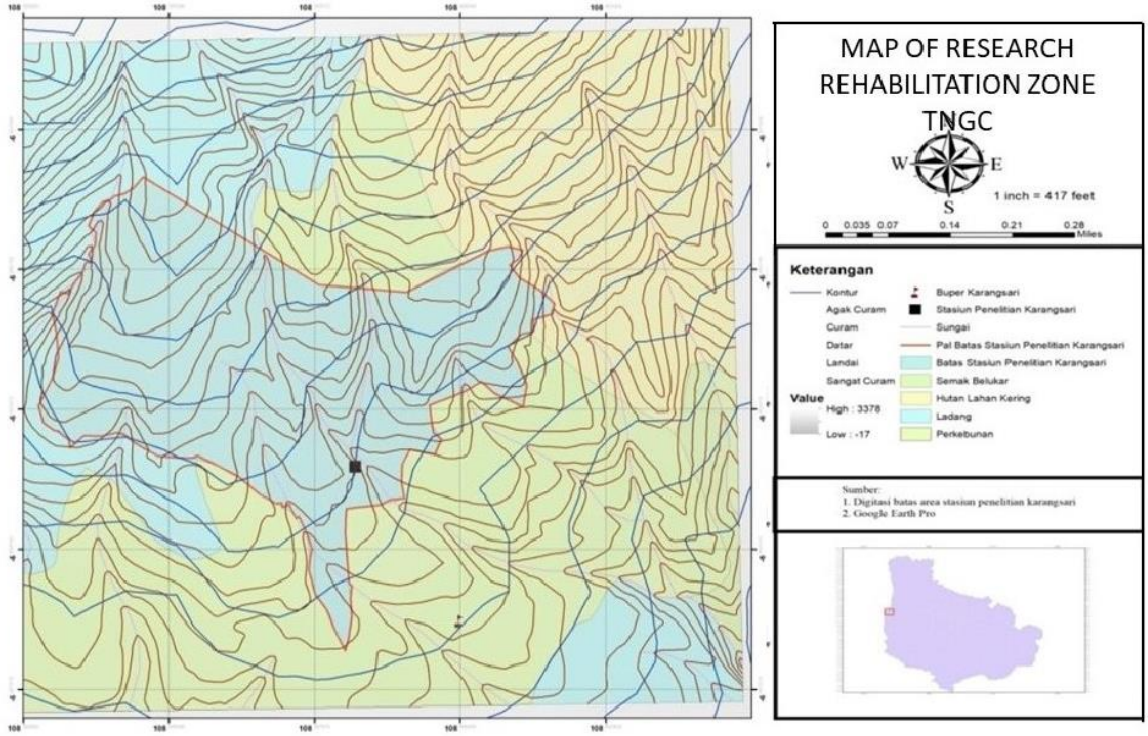


Figure 1. Research location for Karangsari MCNP block rehabilitation zone

In this study, two types of data are used. Namely primary and secondary data, including: primary data obtained from observations/divisions in the field, namely the diversity of plant species in vegetation analysis. In contrast, secondary data is data that already exists in the form of reports. Library books, information on research objects in tree associations, maps of research areas, and profiles of research objects. For forest groups with an area of 1,000 ha or more, the sampling intensity should be 2%. In comparison while if it is less than 1,000 ha, the sampling intensity should be 5%-10% (Boon & Tideman 1950, Soerianegara & Indrawan, 1978). Based on the above provisions, a sampling intensity of 10% is used because the area is 30 ha.

Field data retrieval was carried out using vegetation analysis techniques with the nested quadratic transect method (nested sampling) by determining the research location by purposive sampling consisting of three observation points (stations) (Hayati et al., 2021). The size of the transect is adjusted to the data conditions required, namely the tree level (20 m x 20 m) (Rahayu et al., 2017). Tree growth is characterized by having a diameter of 20 cm. Each plant species' diameter, height, the names of the species and the number of individuals in each plot were noted. Species identification was carried out by taking samples from the research location and then matching them with the Tjiptrosoepomo Plant Morphology Book (2005), or directly query the professionals.

Vegetation analysis was carried out after obtaining data from the research location with the analyzed parameters, including:

1. Important Value Index (IVI)

The important value index on the tree growth rate is calculated using the formula

$$IVI = RD + RCC + RF \quad (1)$$

Where RD is relative density, RCC is relative canopy cover, and RF is relative frequency.

2. Density (ind/ha)

$$K_i = \frac{Number\ of\ individual\ i}{observation\ area\ (ha)} \quad (2)$$

$$KR_i = \frac{Density\ of\ type{-}i}{Total\ density} x100\% \quad (3)$$

Where K_i is density of the type –i, and KR_i is the relative density of the -i type

3. Frequency/F

$$F_i = \frac{number\ of\ total\ plot\ for\ spsecies\ type{-}i}{Number\ of\ plot\ observation} \quad (4)$$

$$FR_i = \frac{frequency\ sof\ attendance\ of\ type{-}i}{Frequency\ total} \quad (5)$$

Where F_i is frequency of attendance of type I, and FR_i is relative frequency of type i

4. Dominance/D (m^2/ha)

$$D_i = \frac{Base\ plane\ area\ of\ i\ (m2)}{Observation\ plot\ area\ (ha)} \quad (6)$$

$$DR_i = \frac{Dominance\ type{-}i}{Dominance\ total} x100\% \quad (7)$$

Where D_i is dominance type-I, DR_i is relative dominance type-i

5. The species diversity index

The species diversity index is used to indicate the stability and complexity of a community, calculated by the formula Magurran (1988)

$$H' = -\sum_{i=1}^{s}(p_i \ln p_i) \quad (8)$$

Where H' is diversity index of Shannon Wiener's type, and p_i is value obtained by using the formula:

$$P_i = \frac{number\ of\ individuals\ from\ 1st\ species}{total\ individual\ from\ all\ species} \quad (9)$$

A total of 75 plots were made sequentially in one row without using the distance between the plots. The plots were made to cut the contour lines so that changes in the composition of plant species could be observed (Shukla & Chandel, 1996). Vegetation analysis was obtained by calculating the values of Density (K), Frequency (F), and Dominance (D). Furthermore, the Importance Value Index (IVI) of each species was obtained from the Relative Density (RD), Relative Frequency (RF), and Relative Dominance (DR).

Association analysis was based on the presence and absence of dominant species in a subsequent sampling plot using a 2 x 2 Contingency table (Greig-Smith, 1983). Contingency tables form 2 x 2 for two types are compared as follows.

Tabel 1. Contingency 2 x 2 for 2 types

		Species B		
		Yes	No	Amount
	Yes	a	b	a + b
Species A	No	c	d	c + d
	Amount	a + c	b + d	N= a + b + c + d

Information: a : number of sample units containing species A and species B, b : number of sample units containing only species A, B not present, c : number of sample units containing only species B, A absent, d : number of sample units which does not contain species A and species B, N : the number of observational sample units.

To determine whether there is a tendency to associate or not, the Chi-square Test was used with the following formulation:

$$\textit{Chi-square}\ \text{value} = \frac{(ad-bc)^2\, n}{(a+b)\,(a+c)\,(c+d)\,(b+d)}$$

a = Number of observation points containing type A and type B, b = Number of observation points containing only type A, c = Number of observation points containing only type B, d = Number of observation points that do not contain type A and type B, N = Number of observation points.

The calculated Chi-square value is then compared with the Chi-square table value at degrees of freedom = 1, at the 5% test level (value 1.678). The association is accurate if the Chi-square value Count > the table Chi-square value. If the calculated Chi-square value < Chi-square table value, then the association is insignificant (Ludwig & Reynold, 1988). Furthermore, to determine the level of strength of the association, the following formula is used:

$$E\ (a) = \frac{(a+b)(a+c)}{N} \quad (10)$$

The notation used has the same meaning as the previous formulation. Based on this formula, there are two associations, (1) positive, if the value of a > E (a) means that pairs of species occur together more often than expected (2) negative association, if the value of a < E (a) means sex pairs occur together less frequently than expected.

RESULTS AND DISCUSSION

Based on the results of the vegetation analysis, it can be seen that in the Karangsari rehabilitation zone, Mount Ciremai National Park, there are 22 tree species belonging to 13 families. The highest number of species was found in the family Meliaceae (four species), namely: hurupingku (*Dysoxylum excelsum*), kedoya (*Dysoxylum gaudichaudianum*), mahogany (*Swietenia mahagoni*), and suren (*Toona sureni*). This family has a habit of shrubs, shrubs and trees, and is often called the hamlet family because most of this family is used for its fruit. Susanto et al. (2021) confirmed that the Meliaceae family is also the third largest family after Euphorbiaceae and Moraceae. There was conducted in the Seda Block of Mount Ciremai National Park, which is located on the northern slope of Mount Ciremai, while the Karangsari Block is on the southern slope of MCNP. In addition, because this forest is directly adjacent to the community and was once one of the working areas of the Community Forest Management program, it is not uncommon to find cultivated plants such as coffee (*Coffea canephora*) and objects (*Artocarpus sp*). Saninten tree species (*Castanopsis argentea*), avocado (*Persea americana*) and anggrit (*Nauclea sp)* are trees that are commonly found in addition to pine trees (*Pinus merkusii*).

Table 2. Types of plants found in the research location

No	Local Name	Scientific Name	Family	Number of Individuals
1	Alpukat	*Persea americana*	Lauraceae	14
2	Anggrit	*Nauclea sp*	Rubiaceae	16
3	Aprika	*Maesopsis eminii*	Rhamnaceae	1
4	Bintinu	*Visenia umbellata*	Malvaceae	4
5	Hurupingku	*Dysoxylum excelsum*	Meliaceae	6
6	Jamuju	Dacrycarpus imbricatus	Podocarpaceae	13
7	Kaliandra	*Calliandra Calothyrsus*	Fabaceae	3
8	Kedoya	*Dysoxylum gaudhichaudianum*	Meliaceae	1
9	Beunying	*Ficus fistulosa*	Moraceae	1
10	Kicangkudu	*Tarenna incerta*	Rubiaceae	1
11	Hantap	*Sterculia oblongata*	Malvaceae	5
12	Kipare	*Glochidion arborescens*	Euphorbiacea	1
13	Kiciap	*Ficus septica*	Moraceae	3
14	Kuray	*Trema orientale*	Cannabaceae	11
15	Mahoni	*Swietenia mahagoni*	Meliaceae	2
16	Nangka	*Artocarpus heterophyllus*	Moraceae	1
17	Pasang	*Quercus sundaica*	Fagaceae	4
18	Pinus	*Pinus merkusii*	Pinaceae	311
19	Puspa	*Schima wallichii*	Theaceae	7
20	Saninten	*Castanopsis argentea*	Fagaceae	21
21	Suren	*Toona sureni*	Meliaceae	4
22	Tisuk	*Hibiscus macrophyllus*	Malvaceae	1

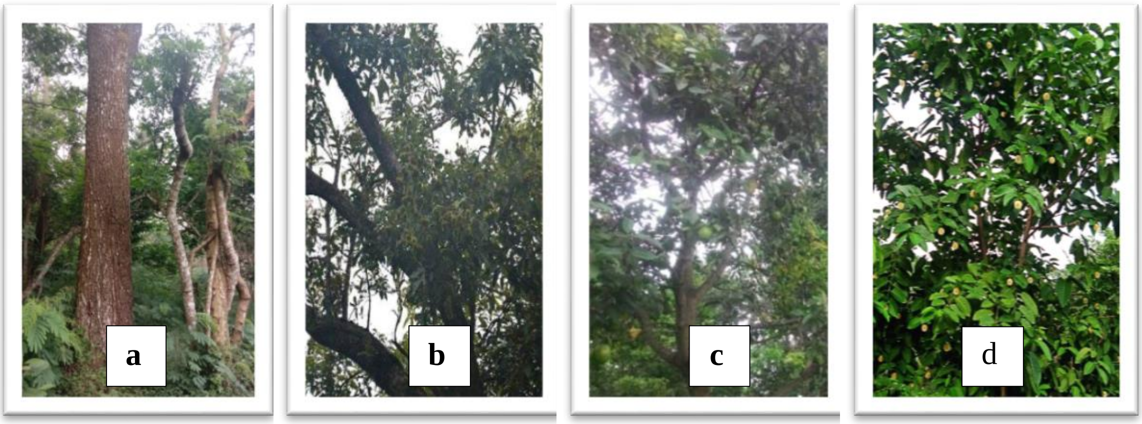
While the highest number of individuals at that location was tusam (*Pinus merkusii*) with a total of 311 individuals found. Many tusam individuals are at this location because the Karangsari rehabilitation zone area is a former production forest that cultivates tusam trees as the main production. Tusam (*Pinus merkusii*) is the dominant tree species in the rehabilitation zone of the Karangsari block.

From the results of the calculation of the diversity of Shannon Winner (H') it shows that the diversity of tree species in the rehabilitation zone of the Karangsari Block, Mount Ciremai National Park, is included in the moderate category. According to the Shannon Winner criteria if H' 1 indicates a low level of species diversity, if 1 < H' < 3 indicates a moderate level of diversity and if H' > 3 indicates a high level of species diversity (Nahlunnisa et al., 2016). So if it is associated with the criteria for the diversity of tree species above, the Karangsari area of Mount Ciremai National Park has moderate species diversity because it has an H value of 1.4, which is included in the medium category.

Species diversity tends to be low in physically controlled ecosystems and high in biologically regulated ecosystems. Conditions such as those above prove that forest areas that do not get a touch of cultivation activities can maintain a higher diversity of tree species than areas where cultivation activities are carried out (Wahyudi et al., 2014). The growth of trees in the rehabilitation zone of the Karangsari Block, Mount Ciremai National Park, which was originally a production forest, makes the diversity of trees in this area tend to enter the moderate category. The diversity index (H') value is related to species richness at a particular location, but is also influenced by the distribution of species abundance. The higher the H index value, the higher the species diversity, ecosystem productivity, and the stability of the existing ecosystem (Pelupessy & Arini, 2016).

The diversity index shows the relationship between the number of species and individuals that make up a community (Morris et al., 2014). The Karangsari rehabilitation zone, when managed by Perhutani, was a production forest area, so the diversity in this area tends to be moderate. However, in this zone, only a few years ago, land rehabilitation activities were carried out due to the shift in function from production forest to conservation forest. According to Cowles et al. (2016), diversity tends to increase in older communities and low in newly formed communities. According to Putra & Manurung (2019), the population of tree species in the Lho Pat Pun Pie Nature Reserve is relatively evenly distributed. Hence, getting disturbed and returning to its original state is not easy. This is because communities with high diversity will be more stable against the environmental l/climate changes.

Based on the Shannon Index approach, the value of Tree Species Diversity is included in the moderate criteria, namely with a value of 1.4. These results can be used as a basis for carrying out conservation and enrichment activities for various types of plants, after research. It can be seen in the current condition of trees in the educational forest, both from tree species, density, frequency, and land cover area. With the diversity of tree species can be better over time. Activities that can be carried out in conservation efforts are rehabilitation of damaged areas, species enrichment and captive breeding for the purposes of education and research, installation of prohibition signs in strategic places, and developing partnerships with surrounding communities in an effort to protect and secure the area. In this way, the forest will be maintained and used as a means of education or as an educational forest.



a. *Pinus merkusii* b. *Castanopsis argentea* c. *Persea americana* d. *Nauclema* sp

Figure 2. Several dominant tree species

1) Dominant Tree Association

Of the 22 tree species found at the research site, four types of trees were produced with IVI 10%. The highest IVI indicates the most common tree species in the research location. The pine tree is a type of tree that has the highest IVI value, with an IVI value of 208.4%. This tree can grow at various altitudes, but grows well at an altitude of 400-2,000 m above sea level. Pine trees planted at an altitude of fewer than 400 m above sea level will cause growth not optimal because the air temperature is too high. In addition, the growth of pine trees at more than 2,000 m above sea level showed non optimal growth due to the inhibition of the photosynthesis process (Sallata, 2013) When the air temperature increases, it will trigger the onset of photosynthesis in Korean pine (Wu et al., 2013). Pine trees have taproots with a root system that is deep and strong enough to grow in deep/thick soils with light to medium soil textures. In addition, pine trees' soil grow does not require high requirements because it can grow on various types of soil, even on soils with an acidic pH (Pietrzykowski, 2014).

Next in the second, third and fourth ranks are saninten tree (*Castanopsis argentea*) 12.15%, avocado (*Persea americana*) 12.06% and angrit (*Nauclema sp*) 11.68%. From the results of the IVI calculation, it can be seen that pine trees have the highest value, which means that this type has the most extensive role compared to other types. *Castanopsis argentea* is the second dominant species. This species is one of the indigenous species that plays an important role in the mountainous ecosystem with a broad canopy (Abe et al., 2018). *Castanopsis argentea* flowers in August-October with an intensity of once every 2 years (Hidayat, 2021). This tree is hard to find naturally due to its tiny population but is a place for wildlife, especially birds and mammals, to find food, rest, and nest.

The following species is *Persea americana*, which is the third dominant tree. This type is a fruiting tree whose existence result from planting in the rehabilitation zone. Generally, this plant can grow in the lowlands to the highlands of 5-1000 m above sea level. *Persea americana* is a primary tropical fruit originating in tropical America, including the eastern and central highlands of Mexico, Guatemala, Central America down to the northern parts of South America (Peru, Ecuador) (Ayala Silva & Ledesma, 2014). The tree spread (canopy spread) of the *Persea americana* trees studies ranged from 4.9 - 13.17 m with an average of 8.43 ± 0 .25 m. Most (92.4%) of the trees had canopy spreads between 6 and 12 m (Janice et al., 2018).

Table 3. Dominant trees in the Karangsari rehabilitation zone

No	Species name	Scientific name	Number of individuals	KR (%)	DR (%)	FR (%)	IVI (%)
1	Pinus	*Pinus merkusii*	311	70,84	98,96	38,60	208,40
2	Saninten	*Castanopsis argantea*	21	4,78	0,35	7,02	12,15
3	Alpukat	*Persea americana*	14	3,19	0,10	8,77	12,06
4	Anggrit	*Nauclea spp*	16	3,64	0,14	7,89	11,68

Association analysis was carried out on the main constituent species having IVI 10% using a 2 x 2 contingency table (Greig-Smith, 1983). In this study, referring to the literature sources above, only the main tree species (IVI 10%) were included in the contingency table analysis for the association between the two species

Calculating the association between the four types shows that the probability of a negative association is very small compared to the probability of a positive association. This probability is due to a large number of pairs of sex whose results are compared to the 5% test level. Thus, these results indicate that the dominant sex pairs in the study area tend to live together more than the sexes who do not have a tendency to live together. It can be said that the determination of species associated with the 2 x 2 Contingency table approach has already indicated of the degree of association. The results of the calculation positively associated pairs are the pair *Persea americana* with *Pinus merkusii, Nauclea sp* with *Pinus merkusii, Nauclea sp* with *Castanopsis argantea* and *Pinus merkusii* with *Castanopsis argantea* showing a positive association at degrees of freedom = 1 test level 5%. Thus, these four types of couples have the potential to live together in the same area or there is a mutually beneficial relationship, especially in the division of living space between the four couples.

Table 4. Association of dominant species in the use zone of Karangsari

Combination type	X^2t (5%)	X^2t	Association type	E(a)
Persea americana with *Nauclea* sp	1,678	2,118*	(-)	4,08
Persea americana with *Pinus merkusii*	1,678	4,174*	(+)	0,66
Persea americana with *Castanopsis argantea*	1,678	2,618*	(-)	1,5
Nauclea sp with *Pinus merkusii*	1,678	3,675*	(+)	0,70
Nauclea sp with *Castanopsis argantea*	1,678	3,064*	(+)	0,25
Pinus merkusii with *Castanopsis argantea*	1,678	2,683*	(+)	0,25

Information: $^+$ positive association, $^-$ negative asssociation, * Significantly different at the level of 5%

Wilson (2015), confirmed that the interaction affects a community; each plant gives each other a place to live in the same area and habitat.. This study found positive associations of pine species with *Castanopsis argantea, Persea americana* and *Nauclea sp*. The Karangsari research location was included in Mount Ciremai National Park management. Before being managed by

Mount Ciremai National Park, this area was managed by Perhutani which made this area a production forest. After changing the management of the area, Karangsari is included in the rehabilitation zone of Mount Ciremai National Park, this affects the type of Pinus merkusii that dominates this area, supported by the altitude factor, *Pinus merkusii* trees thrive in this area, the spread of *Pinus merkusii* in this area even reaches leading to natural forests, this was proven because several *Pinus merkusii* individuals were found in sample plots taken in natural forests, therefore it was assumed that pine was positively associated with *Castanopsis argantea*, *Persea americana,* and *Nauclea sp* because *Pinus merkusii* trees did not undergo regeneration and natural or intentionally planted spread. Therefore, the *Pinus merkusii* tree dominates the Karangsari Rehabilitation.

Table 4 shows that the combination of *Persea americana* with *Castanopsis argantea* and *Persea americana* with *Nauclea* sp has no significant or negative association at the 5% test level. This combination indicates that the co-occurrence between the sex pairs is smaller than expected (Körner, 2018). It may be that this pair excludes or negates each other, or the pair of types have different reactions to environmental differences. In addition, the tendency to exclude two types is assumed to be caused by the occurrence of competition between the two types, the emergence of this competition is because these species have the same necessities of life while the resources that support the necessities of life themselves are limited.

CONCLUSION

The conclusion that can be drawn is that 22 species of trees found in lowland forest in the rehabilitation zone of the Karangsari Block with a moderate diversity index value. The dominant trees found in the study area were tusam (*Pinus merkusii*), saninten (*Castanopsis argantea*), anggrit (*Nauclea sp*), and avocado (*Persea americana*). There are six pairs of association relationships between dominant trees, which are positive four pairs and negative two pairs. Some trees can coexist in *Pinus merkusii* stands even though they have allelopathic substances.

REFERENCES

Abe, T., Tanaka, N., & Shimizu, Y. (2018). Plant species diversity, community structure and invasion status in insular primary forests on the Sekimon uplifted limestone (Ogasawara Islands). *Journal of Plant Research*, *131*(6), 1001–1014. https://doi.org/10.1007/s10265-018-1062-5

Ayala Silva, T., & Ledesma, N. (2014). Avocado history, biodiversity and production. In *Sustainable horticultural systems* (pp. 157–205). Springer. https://doi.org/10.1007/978-3-319-06904-3_8

Balai TNGC. (2017). *Buku Informasi Keanekaragaman Hayati Taman Nasional Gunung Ciremai. Kuningan*. Kementerian Lingkungan Hidup dan Kehutanan, Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem.

Clark, D. B., Ferraz, A., Clark, D. A., Kellner, J. R., Letcher, S. G., & Saatchi, S. (2019). Diversity, distribution and dynamics of large trees across an old-growth lowland tropical rain forest landscape. *PloS One*, *14*(11), e0224896. https://doi.org/10.1371/journal.pone.0224896

Cowles, J. M., Wragg, P. D., Wright, A. J., Powers, J. S., & Tilman, D. (2016). Shifting grassland plant community structure drives positive interactive effects of warming and diversity on aboveground net primary productivity. *Global Change Biology*, *22*(2), 741–749.

https://doi.org/10.1111/gcb.13111

Fajrul'Aini, T. (2021). Dari Hutan Produksi ke Kawasan Konservasi: Kajian Tentang Kawasan Gunung Ciremai Tahun 1978-2014. *Historia*, *4*(1), 509–522.

Greig-Smith, P. (1983). *Quantitative plant ecology* (Vol. 9). Univ of California Press.

Gunawan, H., & Subiandono, E. (2014). Disain ruang restorasi ekosistem terdegradasi di Taman Nasional Gunung Ciremai, Jawa Barat. *Indonesian Forest Rehabilitation Journal*, *2*(1), 67–78. https://doi.org/10.9868/ifrj.2.1.67-78

Hayati, S. D., Bramasta, D., Kamala, N., & Basrowi, M. (2021). Floristic composition and vegetation structure in the edge forest, Mount Ciremai National Park, West Java. *Jurnal Sumberdaya HAYATI*, *7*(1), 17–24. https://doi.org/10.29244/jsdh.7.1.17-24

Hidayat, I. W. (2021). Reproductive phenology period of the five threatened species in Cibodas Botanic Gardens. *IOP Conference Series: Earth and Environmental Science*, *918*(1), 12005.

Janice, D. A., John, A., & Jemmy, F. T. (2018). Morphological characteristics of avocado (Persea americana Mill.) in Ghana. *African Journal of Plant Science*, *12*(4), 88–97. https://doi.org/10.5897/AJPS2017.1625

Körner, C. (2018). Concepts in empirical plant ecology. *Plant Ecology & Diversity*, *11*(4), 405–428.

Kraft, N. J. B., & Ackerly, D. D. (2014). Assembly of plant communities. *Ecology and the Environment*, *8*, 67–88. https://doi.org/10.1007/978-1-4614-7501-9_1

Ludwig, J. A., & Reynold, J. F. (1988). *Statistical Ecology*. John Wiley and Sons, New York, 377pp.

Magurran, A. E. (1988). *Ecological diversity and its measurement*. Princeton university press.

Morris, E. K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., Meiners, T., Müller, C., Obermaier, E., & Prati, D. (2014). Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. *Ecology and Evolution*, *4*(18), 3514–3524. https://doi.org/10.1002/ece3.1155

Nahlunnisa, H., Zuhud, E. A. M., & Santosa, Y. (2016). Keanekaragaman spesies tumbuhan di areal Nilai Konservasi Tinggi (NKT) perkebunan kelapa sawit Provinsi Riau. *Media Konservasi*, *21*(1), 91–98. https://doi.org/10.29244/medkon.21.1.91-98

Pelupessy, L., & Arini, I. (2016). Keseragaman jenis-jenis ikan pada komunitas mangrove Desa Waai Kecamatan Salahutu Kabupaten Maluku Tengah. *BIOPENDIX: Jurnal Biologi, Pendidikan Dan Terapan*, *3*(1), 1–8.

Pietrzykowski, M. (2014). Soil quality index as a tool for Scots pine (Pinus sylvestris) monoculture conversion planning on afforested, reclaimed mine land. *Journal of Forestry Research*, *25*(1), 63–74. https://doi.org/10.1007/s11676-013-0418-x

Putra, M. A., & Manurung, T. F. (2019). Keanekaragaman jenis vegetasi di Cagar Alam Lho Fat Pun Pie Kecamatan Monterado Kabupaten Bengkayang. *JURNAL HUTAN LESTARI*, *7*(1), 86–96. https://doi.org/10.26418/jhl.v7i1.31003

Rahayu, N., Hikmat, A., & Tjitrosoedirjo, S. (2017). Characteristics of Climbing Plants Community in Rambut Island Wildlife Reserve. *Media Konservasi*, *22*(1), 1–10. https://doi.org/10.29244/medkon.22.1.1-10

Rismunandar, R. (2016). Strategi kebijakan pemanfaatan jasa lingkungan air secara berkelanjutan di Taman Nasional Gunung Ciremai Kuningan-Jawa Barat. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *6*(2), 187. https://doi.org/10.29244/jpsl.6.2.187

Sallata, M. K. (2013). Pinus (Pinus merkusii Jungh et de Vriese) dan keberadaannya di Kabupaten Tana Toraja, Sulawesi Selatan. *Buletin Eboni*, *10*(2), 85–98. https://doi.org/10.20886/buleboni.5013

Shukla, R. S., & Chandel, P. S. (1996). *Plant ecology and soil science*. S. Chan and Company Ltd.

Soerianegara, I., & Indrawan, A. (1978). *Ekologi Hutan Indonesia*. Fakultas Kehutanan, IPB.

Strain, B. R., & Bazzaz, F. A. (2019). Terrestrial plant communities. In *CO2 and Plants* (pp. 177–

222). CRC Press.

Susanto, S. A., Putri, D. M., Rahmawati, I., & Sanjaya, M. A. (2021). Keragaman permudaan pohon di area sumber air blok seda, Taman Nasional Gunung Ciremai. *Jurnal Sumberdaya Hayati*, *7*(2), 62–70. https://doi.org/10.29244/jsdh.7.2.62-70

Susilo, A. (2018). Asosiasi jenis-jenis pohon dominan di Cagar Alam Gunung Tilu. *Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning*, *15*(1), 813–819.

Trivedi, P., Leach, J. E., Tringe, S. G., Sa, T., & Singh, B. K. (2020). Plant–microbiome interactions: from community assembly to plant health. *Nature Reviews Microbiology*, *18*(11), 607–621. https://doi.org/10.1038/s41579-020-00490-8

Wahyudi, A., Harianto, S. P., & Darmawan, A. (2014). Keanekaragaman jenis pohon di hutan pendidikan konservasi terpadu Tahura wan abdul rachman. *Jurnal Sylva Lestari*, *2*(3), 1–10.

Wilson, E. O. (2015). The diversity of life. In *Thinking About the Environment* (pp. 193–195). Routledge.

Wu, J., Guan, D., Yuan, F., Wang, A., & Jin, C. (2013). Soil temperature triggers the onset of photosynthesis in Korean pine. *PLoS One*, *8*(6), e65401. https://doi.org/10.1371/journal.pone.0065401

Yogaswara, N., Martono, E., & Marwasta, D. (2017). Optimalisasi peran rimbawan muda dalam pengelolaan Taman Nasional Gunung Ciremai dan implikasinya terhadap ketahanan wilayah (studi di Balai Taman Nasional Gunung Ciremai Kuningan, Jawa Barat). *Jurnal Ketahanan Nasional*, *23*(1), 49–67. https://doi.org/10.22146/jkn.18844

Yuniarsih, A., Marsono, D., Pudyatmoko, S., & Sadono, R. (2014). Zonasi taman nasional gunung ciremai berdasarkan sensitivitas kawasan dan aktivitas masyarakat. *Jurnal Penelitian Hutan Dan Konservasi Alam*, *11*(3), 239–259. https://doi.org/10.20886/jphka.2014.11.3.239-259