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Tree Species Growing on Pinus merkusii Stands at Karangsari Research Station, Gunung Ciremai National Park, West Java

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Abstract. The presence of alien species in conservation areas has attracted a lot of attention. Pinus merkusii is one of the alien species in Gunung Ciremai National Park and dominates the lower part of the area because it previously functioned as a production forest. Pines in conservation areas should not be replaced through logging so that one possible effort is enrichment. However, not all local species are able to grow on pine stands because pine produces allelopathy. The aim of the study was to identify local tree species capable of growing in pine stands. Research using the Gentry method has recorded as many as 23 species of trees, consisting of 15 species at the seedling, 15 species at the sapling, and 3 species at the pole. The study did not record tree-level individuals in the sample plots. The most dominant species at the seedling to pole level is the *Trevesia sundaica*. Other species that can grow to the level of the pole are *Ficus fistulosa* and *Ficus ribes*. This study shows that the three types of plants can be considered in the enrichment of pine forests in conservation areas in the form of mountain ecosystems. Keywords: Alien species, Gunung Ciremai, invasif, national park, *Pinus merkusii*.

Keywords: Tree Species; Pines Conservation; Plant

1 Introduction

Information on local tree species capable of growing in *Pinus merkusii* stands is very helpful in species enrichment activities. The species for its survival will release a compound into the environment, called allelopathy [1]-[2]. These compounds are detrimental to other plant species because they are toxic [3]. Allelopathy belongs to a group of terpenoid compounds, namely monoterpenes α-pinene and β-pinene [4]-[1]. Allelopathy released by pine can inhibit the growth of other plant species in the vicinity [5]. Allelopathy by plants is excreted through roots, stems, leaves, and organ debris, as well as through leaching from external organs [6]-[7].

There are many studies that have conducted studies related to the plants species that can grow under pine stands. However, these studies generally examine understorey species, for example the research at Kalirajut RPH and Baturaden RPH Central Java [8], Gama Giri Mandiri forest, Yogyakarta [9], the pine forest of Mount Slamet Barat BKPH [10], and the pine forest of North Tapanuli Regency [11]-[12]. Research [13] in the pine stands of the Petungkriyono forest, Pekalongan Regency, Central Java is also limited to ferns species. Meanwhile, research on the trees species that can grow in pine stands has not been done much.

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Several researchers who have done this include Alhamd & Rahajoe [14] in Gunung Gede Pangrango National Park, Natalia et al. [15] in a pine forest in the Gedong Songo Temple Area, Semarang Regency. The limitations of this study result in limited information regarding the types of trees capable of growing in pine stands.

Gunung Ciremai National Park (TNGC) is one of the conservation forest areas in which there are stands of *Pinus merkusii* [16] Pines that grow in TNGC are the result of planting. This species was planted when Gunung Ciremai was still functioning as a production forest managed by Perum Perhutani, the Kuningan Forest Management Unit (KPH). Pines in TNGC are classified as foreign tree species, in contrast to pine in Sumatra which are classified as natural species [17]. Even though they are classified as foreign species, pine trees in TNGC cannot be replaced by logging because they are in a conservation area. Therefore, a more feasible effort is enrichment activities.

This study aims to identify tree species that can grow in pine stands in TNGC. Information on the tree species obtained from this research activity is expected to be a recommendation for species selection in pine stands enrichment in conservation areas, both in TNGC and in other conservation areas that have pine stands, such as in Gunung Gede Pangrango National Park [14].

2 Methodology

2.1. Study Site

The research was conducted around Karangsari Research Station, Gunung Ciremai National Park. Based on government administration, the research location is in Karangsari Village, Darma District, Kuningan Regency. Land cover in the form of old pine stands [18]. The bottom is overgrown with shrubs, including Calliandra. Around 2004, the lower part of this pine stand was managed intensively by the local community by planting secondary crops and vegetables such as corn, green onions, cabbage, and potatoes.

2.2. Vegetation Survey

The parameters collected in this study were the name of the species and the number of individuals of each species for the seedling and sapling levels, the name of the species and the diameter of the stem for the pole level. Data was collected using the Gentry [19] method, in which the sample plots were 2 m wide and 50 m long. Sample plots were made continuously on a 2 km long line so that the total number of sample plots were 40 sample plots. The number of lanes made to place the sample plots were 2 lanes, with a length of 1 km/lane. Data was collected by means of researchers tracing sample plots and recording all trees species found in each sample plot. Plants at the seedling, sapling, and pole levels were recorded in the same sample plot size.

2.3. Data Analysis

Data were analyzed descriptively. The calculations used in this data analysis include frequency, relative frequency (%), density (ind/ha), relative density (%), dominance (m2/ha), relative dominance (%), and Important Value Index (%) for every species. The formula used for each of these calculations is as follows:

1) Frequency

   F = number of plots encountered species i/total plots

2) Density (ind/ha)
   K = number of individual species i/total area of sample plot (ha)
3) Dominance (m2/ha)
   D = base area of species i/total area of sample plot (ha)
4) Relative Frequency (%)
   FR = species frequency i/total frequency x 100%
5) Relative Density (%)
   KR = species density i/total density x 100%
6) Relative Dominance (%)
   DR = species dominance i/total dominance x 100%
7) The Important Value Index (%) for seedling and sapling levels is
   INP = FR + KR
8) The Important Value Index (%) for the stake level is
   INP = FR + KR + DR

3 Result and Discussion

3.1. Number of Species

The main hope of carrying out this research is to obtain information about the trees species that are able to grow in pine stands. Research using the Gentry method [19] has found plant species at the seedling, sapling, and pole levels. Meanwhile, tree growth rate was not found in this research plot. The total plant species recorded were 23 species of local trees, which came from 13 species for the seedling level, 15 species for the sapling level, and 3 species for the pole level (Table 1). In addition, the study also recorded 6 trees species that are often cultivated, namely *Maesopsis eminii*, avocado *Persea americana*, cempedak *Artocarpus integer*, mahogany *Swietenia macrophylla*, pakel *Mangifera feotida*, and rosewood *Dalbergia latifolia* (Table 1).

As a comparison, research by Alhamd and Rahajoe (2013) on the permanent plot of the Bodogol pine forest in Gunung Gede Pangrango National Park has recorded as many as 29 tree species, including the pine species itself. However, the study did not mention in detail these species, except for the first 15 species which had the largest important value index. When examining the 15 species presented, the species reported by Alhamd and Rahajoe include cultivated and invasive species, namely *Maesopsis eminii*, *Calliandra calothyrsus*, and *Piper aduncum*. Thus, the number of local tree species growing on pine stands, especially on permanent plots, in Gunung Gede Pangrango National Park is less than 29 species.

Research by previous researcher [15] in the pine forest of the Gedong Songo Temple Area, Semarang Regency, only two types of trees were found, namely pupsa *Schima walichii* and eucalyptus *Eucalyptus* sp. Based on the results of Pertiwi's research [20] in the education forest of Gunung Walat, Sukabumi, puspa has a very strong positive association with pine stands.

Table 1. List of Tree Species on Growth Rate from Seedling to Pole on Pine Stands in Mount Ciremai National Park

No			Familly	Observation (ind)		
	Local Name	**Scientific Name**		**Seedling**	**Sapling**	**Pole**
1	Afrika	*Maesopsis eminii*	Rhamnaceae	2		
2	Alpukat	*Persea americana*	Lauraceae		1	
3	Beunying	*Ficus fistulosa*	Moraceae	13	6	2
4	Cempedak	*Artocarpus integer*	Moraceae		1	
5	Hamberang	*Ficus* sp.	Moraceae		1	
6	Kareumbi	*Homalanthus populneus*	Euphorbiaceae	2		
7	Kijanitri	*Elaeocarpus* sp.	Elaeocarpaceae	1	2	
8	Kikeler	*Diospyros* sp.	Ebenaceae	1		
9	Kipare	*Glochidion zeylanicum*	Phyllanthaceae		1	
10	Kiteja	*Cinnamomum iners*	Lauraceae	1		
11	Kode 44.1	*Elaeocarpus stipularis*	Elaeocarpaceae	19	9	
12	Kode 47.1	*Memecylon myrsinoides*	Melastomataceae		1	
13	Kode 47.2	*Calophyllum soulattri*	Clusiaceae		5	
14	Kode 48.1	*Schima wallichii*	Theaceae	1		
15	Kode 49.2	*Engelhardia serrata*	Juglandaceae	1		
16	Kode 52.1			1		
17	Kode 61.1	*Canthium dicoccum*	Rubiaceae		1	
18	Kode 61.2	*Maesa ramentacea*	Primulaceae		1	
19	Kode 81.1	*Ficus* sp.	Moraceae		1	
20	Kode 82.1				1	
21	Mahoni	*Swietenia macrophylla*	Meliaceae		1	2
22	Pakel	*Mangifera foetida*	Anacardiaceae		1	
23	Peutag	*Syzygium* sp.	Myrtaceae	1		
24	Reunghas	*Gluta renghas*	Anacardiaceae	1		
25	Salam	*Syzygium polyanthum*	Myrtaceae		5	
26	Sanggabuana	*Trevesia sundaica*	Araliaceae	154	26	3
27	Sonokeling	*Dalbergia latifolia*	Fabaceae		1	
28	Walen	*Ficus ribes*	Moraceae	2	6	1
29	Wuni	*Antidesma bunius*	Euphorbiaceae		1	
	Total			**200**	**72**	**8**

3.2. Dominant Species

The dominant species at the seedling, pole, and sapling levels are sanggabuana *Trevesia sundaica*. Other species that predominated were *Elaeocarpus stipularis* and *Ficus fistulosa* for the seedling level and *Elaeocarpus stipularis*, *Ficus ribes*, and *Ficus fistulosa* for the sapling level. From a total of 40 plots, sanggabuana was found in 24 plots for seedling level, 11 plots for sapling level, and 3 plots for pole level. *Elaeocarpus stipularis* was found in 12 plots for the seedling level, 4 plots for the sapling level (Table 2, Table 3, Table 4). *Treversia sundaica* which was only found in three plots for the pile level indicated that the species had an uneven distribution at that level. *Ficus fistulosa* which was able to grow to the level of the pole was

only found in 2 plots (Table 4). In the research of Supartono et al. [21], *Ficus fistulosa* is the only pioneer tree species growing on a single plot of soil seedbank.

Table 2. List of Important Value Index (IVI) of Seedling Growth Rate on Pine Stands in Gunung Ciremai National Park

No	Species	Obs. (ind)	Plots	D (ind/ha)	F	IVI (%)
1	*Trevesia sundaica*	154	24	385,00	0,60	118,38
2	*Elaeocarpus stipularis*	19	12	47,50	0,30	30,19
3	*Ficus fistulosa*	13	8	32,50	0,20	20,29
4	*Maesopsis eminii*	2	2	5,00	0,05	4,45
5	*Homalanthus populneus*	2	2	5,00	0,05	4,45
6	*Ficus ribes*	2	2	5,00	0,05	4,45
7	*Elaeocarpus* sp.	1	1	2,50	0,03	2,22
8	*Diospyros* sp.	1	1	2,50	0,03	2,22
9	*Cinnamomum iners*	1	1	2,50	0,03	2,22
10	*Schima wallichii*	1	1	2,50	0,03	2,22
11	*Engelhardia serrata*	1	1	2,50	0,03	2,22
12	Kode 52.1	1	1	2,50	0,03	2,22
13	*Syzygium* sp.	1	1	2,50	0,03	2,22
14	*Gluta renghas*	1	1	2,50	0,03	2,22
	Total	200	40	500,00	1,45	200,00

The results of this study differ from the results of research in the permanent plot of Bodogol pine stands, Gunung Gede Pangrango National Park [14]. The dominant species in the Bodogol pine forest was *Maesopsis eminii*, in addition to *Calliandra calothyrsus* and *Piper aduncum*. The last two types are classified as invasive species. Although the sanggabuana was found in the Bodogol permanent plot, it was not classified as the dominant species. In this study, *M. eminii* was only found at the seedling level in 2 plots, as many as 2 individuals, out of 40 plots.

Table 3. List of Important Value Indexes for Sapling Growth in Pine Stands in Mount Ciremai National Park

No	Nama Jenis	Observation (ind)	Plots	D (ind/ha)	F	IVI (%)
1	*Trevesia sundaica*	26	11	65,00	0,28	59,03
2	*Elaeocarpus stipularis*	9	4	22,50	0,10	20,83
3	*Ficus ribes*	6	6	15,00	0,15	20,83
4	*Ficus fistulosa*	6	5	15,00	0,13	18,75
5	*Calophyllum soulattri*	5	4	12,50	0,10	15,28
6	*Syzygium polyanthum*	5	4	12,50	0,10	15,28
7	*Elaeocarpus* sp.	2	1	5,00	0,03	4,86
8	*Persea americana*	1	1	2,50	0,03	3,47
9	*Artocarpus integer*	1	1	2,50	0,03	3,47
10	*Ficus* sp.	1	1	2,50	0,03	3,47
11	*Glochidion zeylanicum*	1	1	2,50	0,03	3,47
12	*Memecylon myrsinoides*	1	1	2,50	0,03	3,47
13	*Canthium dicoccum*	1	1	2,50	0,03	3,47
14	*Maesa ramentacea*	1	1	2,50	0,03	3,47
15	*Ficus* sp.	1	1	2,50	0,03	3,47
16	Kode 82.1	1	1	2,50	0,03	3,47
17	*Sweitenia macrophylla*	1	1	2,50	0,03	3,47

18	*Mangifera feotida*	1	1	2,50	0,03	3,47
19	*Dalbergia latifolia*	1	1	2,50	0,03	3,47
20	*Antidesma bunius*	1	1	2,50	0,03	3,47
	Total	72	40	180	1,2	200

This study has provided information that of the 23 local tree species that grow on pine stands, only 3 species are able to grow to the pole level, namely *Treversia sundaica*, *Ficus fistulosa*, and *Ficus ribes* (Table 4). These results indicate that not all tree species that are able to live in pine stands are able to grow and develop relatively quickly. This study also shows that the three species are species that are quite capable of adapting to pine stands. In addition to these three types, there is actually one other species that is able to grow to the level of pole growth, namely mahagony *Swietenia macrophylla*. However, mahogany is classified as an exotic species [22] so it cannot be selected for enrichment in pine stands. Mahogany is a fast-growing species and has the potential to be an invasive species [23]. Because it is potentially invasive, mahogany is not recommended to be planted in areas adjacent to conservation areas [24]. Through the wind, the seeds of this species will be easily dispersed because they have wings [25].

However, the three species also actually have a limited distribution – when based on the number of plots they encounter – and a fairly low density (Table 3). *T. sundaica* was found in 24 plots for seedling level, 11 plots for sapling level, and 3 plots for pole level. *F. fistulosa* was found in 8 plots for seedling level, 5 plots for sapling level, and 2 plots for pole level. *F. ribes* was found in 2 plots for seedling level, 6 plots for sapling level, and 1 plot for pole level.

Table 4. List of Important Value Indices of Pole Growth Rate in Pine Stands in Gunung Ciremai National Park

No	Nama Jenis	Jumlah (ind)	Petak	K (ind/ha)	F	Dominance (m^2/ha)	IVI (%)
1	*Trevesia sundaica*	3	3	7,50	0,08	0,07	97,10
2	*Ficus fistulosa*	2	2	5,00	0,05	0,10	83,22
3	*Sweitenia macrophylla*	2	2	5,00	0,05	0,10	82,32
4	*Ficus ribes*	1	1	2,50	0,03	0,04	37,36
	Total	8		20	0,20	0,30	300

3.3. Conservation Implications

One of the main functions of a conservation area is the preservation of plant species diversity, especially local species. The function of preserving the biodiversity of a conservation area will be reduced when there are non-native ecosystems in it, such as pine stands as happened in TNGC. Pine stands are very helpful in absorbing carbon [26], but when they are in a conservation area, they cause problems. Pine is a type of tree that produces toxic substances (alelopathy) to the detriment of other plant species, but pine should not be cut down because it is in a conservation area. Therefore, the effort that can be done is enrichment.

This research was conducted to obtain information about local tree species capable of growing in pine stands. Research has obtained information that the types of plants that are able to grow up to the pole level are *T. sundaica*, *F. fistulosa*, and *F. ribes*. These three species can be recommended to be planted in enrichment in *Pinus merkusii* stands, even though the density is relatively low. Research by Hendrayana et al. [27] also showed that *F. fistulosa* was one of the most common species found in shrubs in Mount Ciremai National Park. In the research of Sutomo et al. [28], *Altingia excelsa* and *Schima walichii* were classified as species

that are able to grow together with pine stands. *A. excelsa* is a local species, native to the Gunung Gede Pangrango National Park [29]. Therefore, apart from the three species obtained from this study, *A. excelsa* and *S. walichii* can also be tested in the enrichment of pine stands in conservation areas. Seedlings for the five species can be obtained either through cuttings or plucking from other places. Other activities that need to be carried out related to the procurement of seeds are nursery development and research through experimental methods in procuring seeds from cuttings.

4 Conclusion

There are 23 trees species that can grow in pine stands. The species found were from the seedling level (13 species), sapling (15 species), and pole (3 species), but were not found at the tree level. Only three species were able to grow to the pole level, namely: *Trevesia sundaica*, *Ficus fistulosa*, and *Ficus ribes*. *T. sundaica* is the dominant species from seedling to pole level. Other species that are quite dominating are *Elaeocarpus stipularis* and *F. fistulosa* for the seedling level, *E. stipularis*, *F. ribes*, and *F. fistulosa* for the sapling level. The three species that are able to grow up to the pole level can be recommended for species enrichment in pine stands. More extensive research also needs to be carried out to obtain more complete information on the types that are able to grow in pine stands.

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