RESEARCH ARTICLE

MEDIA KONSERVASI
SCIENTIFIC JOURNAL IN CONSERVATION OF NATURAL RESOURCES AND ENVIRONMENT

Exploring the Vegetation Characteristics of Karst Landscapes: A Study of Community Forest in Tubokarto Village, Wonogiri, Indonesia

Sukma Hari Prabowo, Rissa Rahmadwiati and Malihatun Nufus

Study program of Forest Management, Faculty of Agriculture, University of Sebelas Maret, Surakarta 57126, Indonesia

Article Info:
Received 11 March 2024
Revised 14 July 2024
Accepted 7 August 2024

Corresponding Author:
Rissa Rahmadwiati
Study Program of Forest Management
University of Sebelas Maret
E-mail:
rahmadwiati.r@staff.uns.ac.id

Abstract

Karst landscapes are characterized by unique relief and drainage patterns, which influence the types of vegetation that can inhabit these environments. Vegetation in karst ecosystems plays a crucial role in groundwater filtration. Plant species diversity within these communities contributes to structural variations across different habitats. This study evaluates the potential of vegetation in community forests in Tubokarto Village, Wonogiri Regency, by analyzing species composition and vegetation. Using a purposive sampling method, we selected areas with polyculture planting patterns and agroforestry, applying a sampling intensity of 2.2% with 20 × 100 m strip plots. The results showed that the species composition at the location consisted of 18 species in 7 families. The stand density for trees is 221 ind ha^{-1}, poles 436 ind ha^{-1}, saplings 1,144 ind ha^{-1}, and seedlings 2,650 ind ha^{-1}. *Tectona grandis* emerged as the dominant species, with the highest Importance Value Index (IVI) values: 142.79 at the tree level, 212.48 for poles, 197.84 for saplings, and 122.29 for seedlings. Species diversity indices were 1.53 for trees, 0.97 for poles, 1.36 for saplings, and 1.21 for seedlings. The species richness index showed values of 2.79 for trees, 1.49 for poles, 1.21 for saplings, and 1.80 for seedlings, while the species evenness index ranged from 0.43 to 0.76. The vegetation structure of Tubokarto Village spans strata B and C, with tree diameter class distribution resembling that of natural forests. Environmental factors, including climate and soil composition, are likely influencing species growth patterns.

Keywords: karst ecosystem, vegetation structure, vegetation composition, *Tectona grandis*

1. Introduction

Wood is a natural product widely used in almost all fields to support human life. The advantage of wood is that it is easily processed into various products such as paper, textiles, furniture, and so on [1]. However, in recent years, there has been a decrease in the supply of raw materials for the timber industry originating from natural forests. This is shown by data in 2015 of 8.3 million m^3 to 5.7 million m^3 in 2018. Meanwhile, the supply from community forests increased from 4.8 million m^3 in 2015 to 6.2 million m^3 in 2018 [2]. These data show the importance of community forests as part of the timber supply chain in Indonesia, so it is necessary to manage vegetation to produce good quality wood. It can reduce dependence on wood from natural forests.

Vegetation in an area positively influences ecosystem balance [3]. This influence is closely related to the structure and composition of vegetation that grows in an ecosystem [4]. According to Kadir [5], land that does not have or experiences vegetation damage has the potential to increase surface flow and erosion, which can further increase the criticality of the land. This is because vegetation is a major factor in determining the level of land criticality [6]. Based on this description, vegetation management is important to produce good vegetation and has implications for the best quality wood products. In addition, vegetation management is part of community forest development to improve critical land and reduce land criticality in an area [7].

Community forest development is directed to restore/increase the productivity of critical land, land conservation, forest protection, and poverty alleviation through management efforts [8]. One of the critical landforms is the karst ecosystem. Karst is a typical hill composed of limestone. Its formation is influenced by karstification, which is singly or in groups affected by the process of dissolution and erosion at a higher level than other regions [9]. In general, karst ecosystem regulations in various countries are designed to maintain the ability of karst landscapes in the form of forests to regenerate healthily and productively after harvest [10]. According to Amalia et al. [11], the development of future community forest management requires understanding the structure and composition of trees as a constituent of community forest stands to describe the condition of a stand and know the ongoing succession process in a community.

Research on transforming degraded land into productive community forests is essential to ensure that both economic and ecological benefits are realized. The aim of this study is to examine the structure and composition of vegetation in the karst landscape of Tubokarto Village's community forest. This research is intended to provide insights into the potential of wood resources from community forest vegetation and offer guidance on selecting species suitable for growth in karst environments. Additionally, it aims to contribute to scientific knowledge and serve as a reference for future studies on the structure and composition of vegetation in similar areas

2. Materials and Methods

2.1. Study site

This study has been conducted from January to September 2023. The research location is in Tubokarto Village, Pracimantoro District, Wonogiri Regency (Figure 1). Pracimantoro District is the largest sub-district in Wonogiri Regency, with an area of 14,214 ha, and part of the area is located in the limestone or karst area. Wonogiri has a karst area of 338.74 km^2. This means 18.6% of the Wonogiri area. The karst area in Wonogiri is spread across five sub-districts in the southern part of Wonogiri, namely the entire Paranggupito District, parts of Pracimantoro, Giritontoro, Giriwoyo, and Eromoko Districts [12].

Pracimantoro District is geographically located in the southern part of Wonogiri Regency, with an altitude of 253 m above sea level. It is a limestone folding hill area with a soil structure dominated by acid-brown latosol and grumosol soil association. In several parts, the topography of Tubokarto Village comprises karst hills planted with teak plants. Land use in Tubokarto Village is divided into two types: yards of 152.51 ha and land use for plantations or moors of 237.21 ha [13]. The community forest in Tubukarto Village is located on community-owned moors that are mostly planted Tectona grandis trees with an average age of 12 years and many commercial tree species such as *Acacia auriculiformis* and *Swietenia macrophylla*. The community forest area in Tuborkato Village is 91 ha [14].

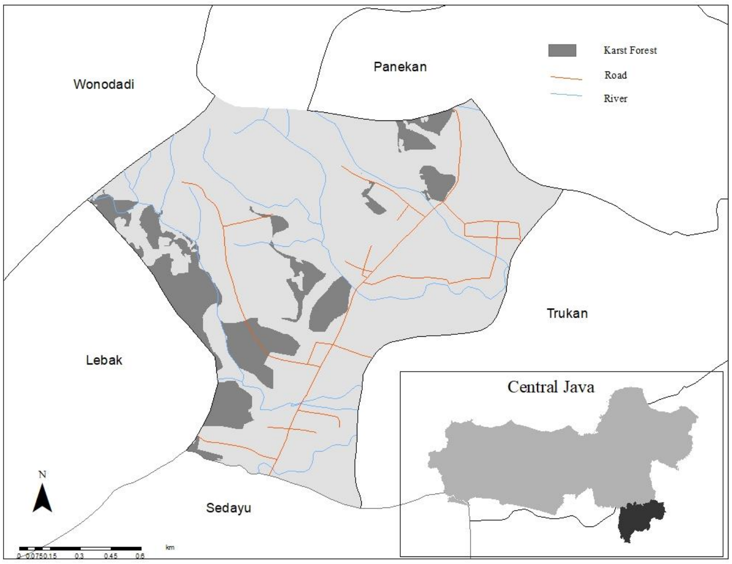


Figure 1. The research location is Tubokarto Village, Wonogiri Regency. The research was conducted in a community forest in a karst area.

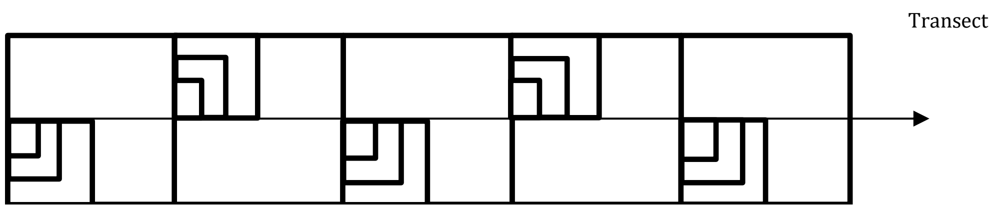
2.2. Tools and Materials

The tools used for vegetation analysis were diameter measuring tape, mine, raffia rope, tally sheet, labels, stationery, Haga hypsometer, newsprint, 70% alcohol scales, herbarium paper, ruler, and scissors/knives. The material used is a forest stand in Tubokarto Village, Wonogiri Regency.

Soil chemical analysis tools and materials include pH meters and H_2O (for pH H_20 analysis), analytical balance, spectrophotometer, measuring flask, sulfuric acid (H_2SO_4), potassium dichromate ($K_2Cr_2O_7$), glucose, and standard solutions (for organic C analysis), anhydrous $CuSO_4$, Na_2SO_4, H_3BO_3, NaOH (for Kjeldahl analysis). Materials for P analysis include $NaHCO_3$, $(NH_4)_6 Mo_7O_{24}.4H_2O$, H_2SO_4, H_2O $(SbO)C_4H_4O_6$, and PO_4.

2.3. Data Collection

Determination of the location of plot collection is carried out using purposive sampling techniques, such as taking the location of community forests, polyculture planting patterns, and agroforestry. In this study, the sampling intensity was set at 2.2%, which was determined based on accuracy, cost, and capability [15]. Based on the community forest area of 90 ha, it was determined that 50 plots were made in 10 lanes spread across five hamlets, each with a length of 20 x 100 m. The observation plot design is shown in Figure 2.



(a) 2 x 2 m plot to observe seedlings, (b) 5 x 5 m plot to observe saplings, (c) 10 x 10 m plot to observe poles, (d) 20 x 20 m plot to observe trees.

Figure 2. Observation plot design [16]. Line transect method with nested plots.

2.4. Species Identification

We collected 18 plant leaf samples in the field, made herbarium, and identified them. In this study, the method used for identification was the study literature and opinions from experts. Plant species at the study site were identified through a traditional herbarium method. Plant specimens, primarily leaves, were collected, dried, and then compared to reference materials such as classification books and journals.

2.5. Soil Analysis

The research location in the karst area still has thin soil solum in several places, which is then taken for lab testing. Soil samples were taken on threaded soil at a depth of 20 cm in five hamlets, namely Tubokarto, Selorejo, Bendungan, Jeruk, and Mlangseh Lor, with each hamlet one soil sample of approximately 200 gr then carried out laboratory tests.

The parameters analyzed include soil chemical properties, including CEC and exchange cations (K, Ca, Na, and Mg), C-organic N-total, pH, and P. The soil analysis carried out included the chemical properties of the soil, including CEC using the Kjeldahl distillation method and for exchange cations (K, Ca, Na, and Mg) using the Atomic Absorption Spectrophotometry method, C-organic with the UV-Vis Spectrophotometry method, N- total using the Kjeldahl method, pH using the electrometric method, namely with a pH meter, and P using the P-available Olsen method.

2.6. Vegetation Analysis

The vegetation analysis includes the stand's structure and the species composition. Stand structure analysis through a depiction of horizontal and vertical tree structures by creating a tree height distribution diagram using Sexi FS software. Stand species composition data was processed using quantitative analysis of vegetation as follows [4]:

2.6.1. Density

$$\text{Density (D)} = \frac{\text{Number of Individuals}}{\text{Area Plot Examples}} \quad (1)$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a Species}}{\text{Density of All Species}} \times 100\% \quad (2)$$

$$\text{Frequency (F)} = \frac{\text{Number of Plots Found Species}}{\text{Number of All Species}} \quad (3)$$

$$\text{Frequency (F)} = \frac{\text{Number of Plots Found Species}}{\text{Number of All Species}} \quad (4)$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a Species}}{\text{Frequency of All Species}} \times 100\% \quad (5)$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Dominance of a Breed}}{\text{Dominance of All Species}} \times 100\% \quad (6)$$

2.6.2. Important value index (IVI)

$$\text{IVI} = \text{RD} + \text{RF} + \text{RDo} \quad (7)$$

Where IVI = Important value index, RD = Relative density, RF = Relative frequency, and Rdo = Relative dominance.

2.6.3. Diversity index (H')

$$\text{H'} = -\sum \left(\frac{ni}{N}\right) In \left(\frac{ni}{N}\right) \quad (8)$$

Where H' = Shannon-Wiener diversity index, ni= Number of individuals of a breed, and N = Total number of individuals of the whole breed.

2.6.4. Evenness index (E)

$$\text{E} = \frac{\text{H}'}{\ln \text{S}} \quad (9)$$

Where E = Evenness index, H' = Diversity index, and S = Number of breeds found.

2.6.5. Richness index (R)

$$\text{Richness index} = \frac{(\text{S}-1)}{\ln\text{ (N)}} \quad (10)$$

Where R = Richness index, S = Number of breeds found, and N = The sum of all individuals.

2.7. Influence of Biotic and Abiotic Factors

Observations were conducted using the purposive sampling method with the same sample plot as vegetation analysis of biotic factors of pest attacks and climate factors that influence plant growth, and they were then presented in an observation table.

2.8. Tree Profile Diagram

Core tree data were taken using a vegetation analysis plot, which included tree coordinates, diameter, height, and harder width. The data was used to create a tree profile diagram on each research path using Sexi-FS software.

3. Results and Discussion

3.1. Results

The resulting identification revealed 18 species distributed across seven families: Lamiaceae, Meliaceae, Fabaceae, Myrtaceae, Anacardiaceae, Moraceae, and Gnetaceae. The identified species are then used to determine the composition and structure of vegetation in the

Tubokarto Village community forest. Figure 3 presents herbarium samples of the identified species.

(A) (B) (C) (D)

Figure 3. Herbarium specimen (A) sonokeling, (B) eucalyptus, (C) jackfruit, and (D) big leaf mahogany. Four of 18 species are found in Tubokarto Village.

Based on the research, several species were found at the research location, which are described in Table 1. Table 1 provides a detailed list of the identified species. The most found spesies is *Tectona grandis*.

Table 1. Species found at the community forest stand of Tubokarto Village

No	Species	Local Name	Family
1	*Anacardium occidentale*	Cashew	Anacardiaceae
2	*Mangifera indica*	Mango	Anacardiaceae
3	*Acacia auriculiformis*	Acacia	Fabaceae
4	*Cassia siamea*	Black wood casia	Fabaceae
5	*Dalbergia latifolia*	Sonokeling	Fabaceae
6	*Falcataria moluccana*	Silk tree	Fabaceae
7	*Leucaena leucocephala*	Lamtoro	Fabaceae
8	*Samanea saman*	Saman tree	Fabaceae
9	*Gnetum gnemon*	Melinjo	Gnetaceae
10	*Gmelina arborea*	Gmelina	Lamiaceae
11	*Tectona grandis*	Teak	Lamiaceae
12	*Swietenia mahagoni*	Small leaf mahogany	Meliaceae
13	*Swietenia macrophylla*	Big leaf mahogany	Meliaceae
14	*Artocarpus camansi*	Breadnut	Moraceae
15	*Artocarpus heterophyllus*	Jackfruit	Moraceae
16	*Ficus septica*	Awar-awar	Moraceae
17	*Eucalyptus alba*	Eucalyptus	Myrtaceae
18	*Syzygium cumini*	Malabar plum	Myrtaceae

Forest vegetation analysis aims to determine the balance of forest communities, explain interactions within and between species, and predict future trends in stand composition [17]. For this reason, vegetation analysis was carried out at the research site to determine the state of the structure and composition of the stand. At the location, farmer intervention was found in selecting species in the form of commercial species. So, the species that grow at the location are commercial plants that can adapt to karst environments, such as teak, mahogany, and acacia. Based on observations of vegetation composition, the number of species for each growth phases are shown in Figure 3.

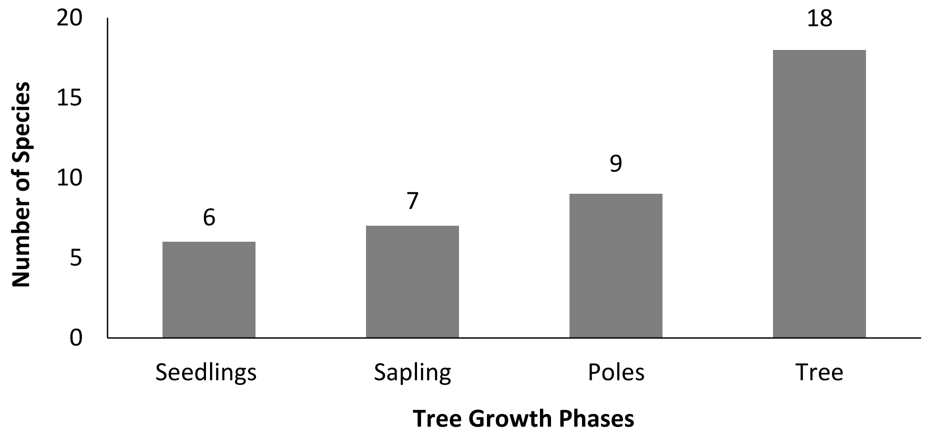


Figure 4. Number of species at seedlings, saplings, poles, and trees in community forest Tubokarto Village. There is an increase in the number of species at each growth phases. The tree phase has the greatest number of species.

The results of the tree-level IVI calculation are presented in Table 2. Tectona grandis has the highest IVI, with a value of 142.79%. The lowest IVI is *Leucaena leucocephala*, with a value of 1.13%.

Table 2. Important Value Index on tree growth phases in Tubokarto Village community forest

No	Species	Basal area	RD (%)	RF (%)	RDo (%)	IVI (%)
1	*Tectona grandis*	10.52	56.11	36.36	50.32	142.79
2	*Swietenia mahagoni*	4.70	19.46	15.15	22.49	57.10
3	*Acacia auriculiformis*	1.71	7.69	14.39	8.19	30.27
4	*Swietenia macrophylla*	0.65	3.62	7.58	3.11	14.30
5	*Gmelina arborea*	1.15	3.85	3.03	5.50	12.38
6	*Anacardium occidentale*	0.32	1.36	3.03	1.54	5.92
7	*Falcataria moluccana*	0.35	1.13	3.03	169	5.86
8	*Eucalyptus alba*	0.24	1.58	3.03	1.14	5.76
9	*Cassia siamea*	0.24	0.90	3.03	1.14	5.07
10	*Syzygium cumini*	0.22	0.90	2.27	1.04	4.22
11	*Artocarpus heterophyllus*	0.13	0.68	2.27	0.60	3.55
12	*Mangifera indica*	0.09	0.45	1.52	0.44	2.40
13	*Ficus septica*	0.08	0.45	1.52	0.38	2.34
14	*Gnetum gnemon*	0.11	0.68	0.76	0.52	1.96
15	*Artocarpus camansi*	0.18	0.23	0.76	0.87	1.85
16	*Dalbergia latifolia*	0.12	0.45	0.76	0.57	1.78
17	*Samanea saman*	0.07	0.23	0.76	0.32	1.30
18	*Leucaena leucocephala*	0.03	0.23	0.76	0.15	1.13
	Total	20.91	100	100	100	300

The results of the calculation of species diversity (H'), species richness (R), and species evenness (E) at the observation location are shown in Table 3. The highest density is the seedling phase with a value of 2,650 ind ha^{-1}. And the lowest density is the tree phase with a value of 221 ind ha^{-1}. The highest diversity and richness values are in the tree phase, with values of 1.53 and 2.79, respectively. The highest evenness is the seedling phase, with a value of 0.76.

Table 3. Diversity (H'), Richness (R), and Evenness (E) of every growth phase of vegetation

No	Growth phases	Density (ind ha^{-1})	H’	R	E
1	Tree	221	1.53	2.79	0.53
2	Poles	436	0.94	1.49	0.43
3	Sapling	1,144	0.97	1.21	0.50
4	Seedling	2,650	1.36	1.80	0.76

Soil analysis was conducted to determine the content of P-available elements, C/N ratio, pH, CEC, Ca, Mg, K, and Na in the soil at the study site. These measured parameters are essential soil properties that influence plant growth. The soil analysis results under Tubokarto Village stands are shown in Table 3.

Table 4. The condition of the soil under the community forest stands of Tubokarto Village

Parameters	Range of values	Unit	Criterion
P-Available Olsen	5.02–7.84	ppm per 100 g	Low
C/N-ratio	2.38–8.45	-	Low
N	0.07–0.39	%	Moderate
C	0.49–2.15	%	Low
pH	7.56–8.03	-	Somewhat alkaline
CEC	31.97–41.94	me per 100 g	Very High
Ca	29.43–137.16	me per 100 g	Very High
Mg	36.66–59.75	me per 100 g	Very High
K	0.11–0.50	me per 100 g	Low
Na	0.09–0.56	me per 100 g	Low

The classification of trees by header height is shown in Figure 5, it is known that the stratum at the research location consists of stratum B (20–30 m) and stratum C (4–20 m) if classified based on Indriyanto [4]. Stratum C is very dominating, with the number of trees in stratum C as many as 218 individuals ha^{-1} compared to stratum B, with as many as 6 individuals per ha^{-1}, and no stratum A stands found at the research location.

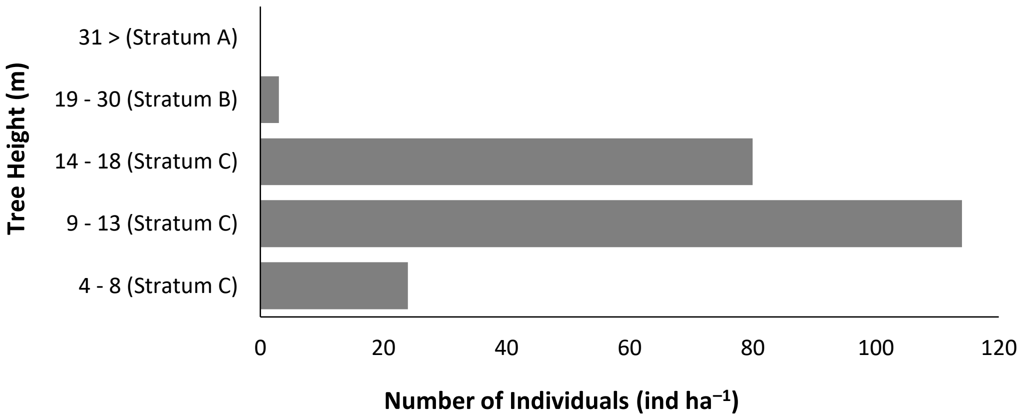
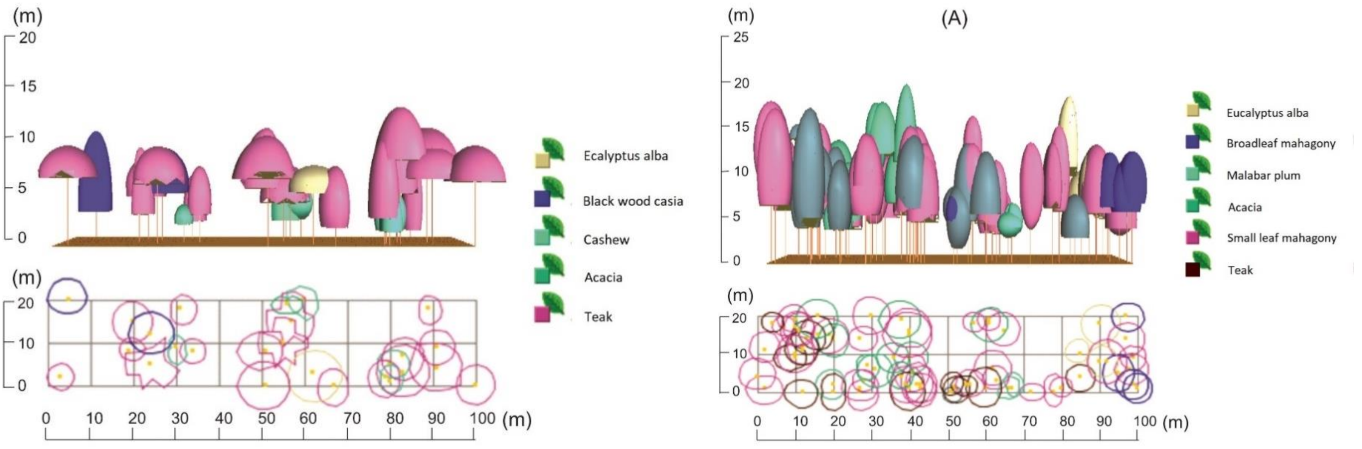


Figure 5. Stratification of tree stands canopy in Tubokarto Village Community Forest. The largest number of individuals is found in stratum C.

When the tree profile diagram at the research location was taken, two samples were considered to represent data: samples with medium density (line 2) and high density (line 6), shown in Figure 6. Medium density consists of 5 species, and high density consists of 6 species. At high density, the stratum looks more varied than at medium density.



(A) (B)

Figure 6. Projection of vertical and horizontal structure of medium density (A) and high density (B) in the Tubokarto Village. The tree profile diagram shows the stratification and relationship between tree species in the Tubokarto Village community forest.

3.2. Discussion

Fabaceae was the most abundant family, as shown in Table 1; identifying species means revealing or establishing a plant identity to obtain the correct name and place in the plant classification system [18]. The Fabaceae family was the most prevalent among the identified species. It offers numerous benefits to humans, such as food sources, animal feed, and ornamental plants. Additionally, some Fabaceae species possess medicinal properties. Notably, many members of this family can thrive in diverse soil conditions, including arid environments, due to their shallow root systems and valuable timber sources [20].

Soil conditions and land management systems are important in determining plant growth and yield in a place [21]. For this reason, it is necessary to test soil conditions, especially soil chemistry, to determine soil fertility and ensure that the species can grow and adapt to the research site. Although the research site is in the karst area, some places have a thin to medium soil solum. This part of the soil is then carried out for chemical analysis.

Based on Table 1, even though a karst area has low P and K main nutrients, there is a C/N ratio and CEC value suitable for plant growth. As in Hartawan et al. [22], the higher the C/N ratio on land, the longer the decomposition time will be. A low C/N ratio value at the site indicates a fast-composting process, indicating rapid organic matter formation. Soil CEC describes soil cations such as Ca, Mg, Na, and K that plant roots can exchange and absorb well [23]. So, based on soil analysis, the plant species that grows is a plant with high adaptive ability. Ca and Mg cation levels show high levels. According to Tini and Amri [24], calcium (Ca) is one of the nutrients absorbed in large quantities and determines the quality of teak.

Macronutrients such as nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), and sulfur (S) are needed, and CEC has a very close relationship with soil fertility. Soil with a high CEC can trap and provide nutrients better than soil with a low CEC. Soil with a high CEC value, if dominated by base cations Ca, Mg, K, and Na (high base saturation), can increase soil fertility [25]. *T. grandis* can grow in land conditions with CEC values > 16 cmol (medium), pH 5.5–7, organic C > 0.4% (very low), total N moderate (0.21–0.5%), P_2O_5 is moderate (26–45%), and K_2O is moderate (21–40%) [26]. The results of this research show that the soil conditions in Wonogiri contain nutrients that support *T. grandis*'s growth, making this species dominate at the research location. Thus, planting the *T. grandis* species at the location can be an effort to conserve karst land in Wonogiri.

The Important Value Index (IVI) is one of the indices calculated based on the amount obtained to determine the level of species dominance in a plant community [27]. Table 2 shows that the highest IVI is found in the teak species, with a value of 142.79%, and the lowest IVI is found in the *L. leucocephala* species, with a value of 1.13%. Based on the results of IVI calculations, *T. grandis* is the species that has the greatest role in the region. This follows Nurjaman et al. [28] that the species with the highest IVI has an important role in an area. As for the species of *L. leucocephala,* which has the lowest IVI, shows an insignificant role in the region. The influence of teak age on the highest INP is that the increase in tree age is directly proportional to the development of the tree, which is reflected in the increase in the width of the *T. grandis* stand, which is increasingly fertile, causing the intensity and temperature of sunlight to decrease and increase. The height of moist air received by the vegetation below.

The high IVI of teak is because people tend to plant a lot. After all, it has high economic value. In addition, *T. grandis* can grow in conditions of minimal nutrients, so *T. grandis* plants have an important role in the area [29]. In addition to *T. grandis*, other species, such as *S. macrophylla*, *A. auriculiformis*, and *S. mahagoni* respectively, also have a high IVI among other species. These species have almost the same characteristics as *T. grandis*, which can adapt to land with minimal nutrient conditions. As in Peniwidiyanti [30], who found species such as *A. auriculiformis*, *S. macrophylla*, and *T. grandis* were able to grow and adapt to the karst area. Based on this, community forests in Tubokarto Village can become wood producers, especially from commercial species of wood producers such as *T. grandis*, *A. auriculiformis*, and *S. mahogany*, so it can be an alternative producer of non-natural forest wood.

Density is the main indicator in determining the production level to be obtained in natural forests and production in the next cycle to affect the quality of wood produced [32]. The density at the study site shows that the seedling growth phase is high at 2,650 ind ha^{-1}, while the tree growth phases have the lowest density at the study site, 221 ind ha^{-1} (Table 4). The density of the stand affects plant growth. As in Riyanto et al. [33], stand density is one of the environmental factors affecting macrofauna formation through the amount of litter production. The presence of soil macrofauna can be used as an indicator in determining soil fertility quickly [34].

Based on the analysis of the composition of stands that have been carried out, it shows that in the community forest of Tubokarto Village, there are 18 species, among which several species have potential for the timber industry. These species are *T. grandis, A. auriculiformis, S. mahogani, S. macrophylla, D. latifolia,* and others for wood [35]. In addition to the commercial species used for wood, there are fruit-producing plants. Fruit plants are grown because they contain vitamins and proteins used as food and complement other needs [36]. Other species of fruit plants found at the location are *G. gnemon*, *A. occidentale, M. indica,* and *S. cumini,* Others are planted by the community to be used for their fruit. Furthermore, species such as *L. leucocephala* and *F. septica* can function as soil conservation. The results of the calculation of species diversity (H'), species richness (R), and species evenness (E) at the observation location are shown in Table 3.

The diversity index compares the number of individuals of each species with those found at the study site [37]. Table 4. shows a diversity index at moderate tree growth phases (H' 1.5–3.5) while at a low growth phase of poles, saplings, and seedlings (H' < 1.5). This shows that some species of tree growth phases are no longer found at lower growth phases, so tree levels have an H' greater than pole, sapling, and seedling levels. If a conclusion is drawn, this shows that the youth's ability is naturally still lacking. Waskitaningtyas et al. [38], said rejuvenation occurs when plants can regenerate continuously, starting from the growth phases of seedlings, poles, saplings, and trees so that these species of plants are always found at each growth level. This also indicates that the research site is not yet at the stage of approaching natural forests. If logging is done, certain species can be lost due to the absence of youth or the need for assistance/control from farmers to plant certain species.

The species richness index shows that the growth phases of trees, poles, saplings, and seedlings is low (R < 3.5). The wealth index in a community will tend to be high if it has many species and each species is represented by one individual [39]. The low species richness at the research site indicates that the community only grows certain species (commercial), so the species found still need to be discovered. The site can also influence it, as in the soil analysis results (Table 2), which show that low nutrients affect the selection of species to be planted, such as the species that can grow in low nutrient conditions, resulting in low species wealth. Soil nutrient content tend to support a higher plant species diversity. Adequate nutrition helps the development of various types of plants, increases the availability of food and resources for other species, and strengthens ecosystem stability. Research shows that vegetation with sustainable nutrient cycles and diverse composition, such as in agroforestry and secondary forests, supports plant regeneration more effectively than land with limited nutrients [40].

The evenness index shows the degree of evenness of individual abundance between species [37]. The species evenness index in seedling growth phases is high (E > 0.6), while the growth phases of trees, poles, and saplings is medium (E 0.3–0.6). This gives an idea of the growth phases of seedlings of high species distribution, as evidenced by the almost complete discovery of seedlings in each observation plot. In addition, there is good header transparency at the location, and seedlings well receive sunlight, so the distribution is high.

Table 5. Comparison of diversity index (H'), Richness index (R), and Evenness index (E) species for similar studies

Comparison	Karst protected forest Widiyanti (2013)[a]	Community forest Hastuti and Sufiadi (2017)[b]	Research location (2023)[c]
Richness Index (R)			
Tree	2.40	2.73	2.79
Poles	0.39	3.00	1.49
Sapling	5.15	2.49	1.21
Seedling	4.81	5.06	1.80
Evenness Index (E)			
Tree	0.93	1.89	0.53
Poles	0.39	0.06	0.43
Sapling	0.67	0.06	0.50
Seedling	0.72	0.02	0.76
Diversity Index (H’)			
Tree	1.67	2.07	1.53
Poles	0.27	0.12	0.94
Sapling	2.35	0.12	0.97
Seedling	2.45	0.03	1.36

Source: (a) Results of Widiyanti [30], (b) Results of Hastuti and Sufiadi [31], and (c) Data processing results

Based on Table 5, it is known that species diversity at research sites located in community forests (b) and (c) tends to have a lower value than diversity in protected forests (a) even though it is in karst areas. The diversity of vegetation in community forests tends to be low because there are arrangements of economically beneficial species planted by the community. Meanwhile, protected forest function more as a life and water management buffer. So that, its ecosystem is still maintained and overgrown with various species of plants. In addition. the management of protected forests is in the hands of the state and is intended for conservation purposes, so that all species in it are maintained and preserved. As in Damanik and Sahudra [41], biodiversity in protected forests is high because the state manages it, and the community is involved in it to monitor the forest.

Observation of stand structure was carried out to determine the condition of stands in the community forest of Tubokarto Village by taking samples on tree growth phases. Trees are the most dominant level at the study site. with the most number and the most varied species. and have the most dominant role. The stand's structure is analyzed by determining the tree's diameter and height classes. The division of diameter classes was carried out to examine the structure of stands horizontally [42]. Figure 6 shows the stand structure by diameter class.

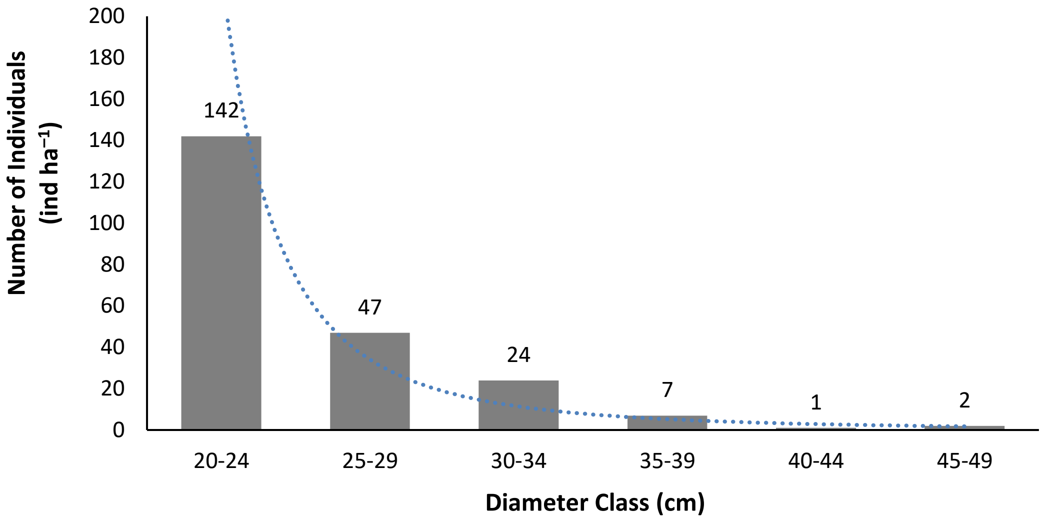


Figure 6. Distribution of tree diameter classes in People's Forest Tubokarto Village. The graph shows that the larger the diameter class. the fewer individuals there are.

Based on Figure 6, it is known that the distribution of tree diameter at the study site is dominated by the diameter class of 20–24 cm. In addition, when viewed based on the curve's shape. the curve of the tree diameter class shows a shape resembling an inverted "J." This illustrates the condition of stands that are fewer in number as the tree's diameter increases. The shape of the inverted "J" curve indicates that this condition resembles the condition in natural forests, where the small diameter class dominates the forest area and decreases in the diameter class above it [43]. This is due to harvesting activities carried out by farmers in adult stands. Such structural conditions indicate the ability to maintain the existence of the population in the long term because it has individuals at each growth level, especially those related to population regeneration [44].

Header stratification is a vertical arrangement of plants in a plant community or forest ecosystem [45]. The layers resulting from header stratification are called stratum or stratum. Stratification at the study site was carried out at the tree's growth phases because trees are the most dominant component in a forest [46].

The disparity in tree strata at the research site is primarily attributed to selective logging practices by the local community. Residents often harvest trees based on immediate needs, disregarding factors like age and height [47]. In Tubokarto Village, trees with diameters around 25 cm and heights between 15–18 m (stratum C) are commonly targeted for felling. This practice depletes the upper strata, as older, taller trees are removed. Similar findings were reported by Supriatna [48] in Karanglayung Village's community forest, where the absence of teak trees older than 12 years was linked to community harvesting. Additionally, the study revealed that 12-year-old teak trees typically reach heights of 9.38–12.19 m, placing them within stratum C.

At the research location, tree structures were depicted using vertical and horizontal structures with tree profile diagrams. This diagram illustrates the variation in the species of stand height on a predetermined line. Differences in the structure of forest stands occur due to differences in trees' ability to utilize solar energy, nutrients, and water and the influence of competition between trees. Therefore, the vegetation composition in forest stands will form a distribution of varying diameter classes [49].

Due to agroforestry activities under the stand. the tree profile shows a moderate density level. so loose gaps and a lot of growing space are available. This results in the tree canopy growing optimally and wider than the path with a high density. The density level is caused by the location of land used by the community in the form of agroforestry between *A. occidentale*, *T. grandis*, *C. siamea*, and *A. auriculiformis* with corn and peanut plants.

The canopy stratum formed in agroforestry systems has ecological and economic advantages. As in Wulandari [50], ecologically minimizes the incidence of runoff water because falling rainwater will hit the upper crown first, then to the medium crown and low header. Because the water that falls to the surface is only in the form of droplets, economically, it can increase income through crops. The canopy stratification system, regarding soil and water conservation, will have more impact on regulating water management, and rain does not directly affect the soil, which can prevent erosion [51].

At the research location. there is no use for agroforestry by the community. So that the community focuses more on forestry plants using a polyculture system for commercial species such as *T. grandis*, *S. mahogany*, *S. macrophyla, A. auriculiformis*, and *E. alba*. High density at the location affects tree growth. Nisar et al. [52] explain that high density can cause ecological pressure through competition for nutrients, growing space, and sunlight. As a result, the defeated tree will experience growth that could be more optimal. At the research location, several disturbances were found from biotic factors in the form of diseases against plants, such as the discovery of galls. perforation. and cancer in plants. Disturbances to plants at the study site are shown in Table 6.

Table 6. Disturbance of biotic factors in stands in the community forest of Tubokarto Village

No	Pests/Disease	Species	Line	Average attack (%)	Symptoms/Signs
1	Termite	*Tectona grandis* *Falcataria moluccana* *Swietenia macrophylla* *Swietenia mahogany*	1, 3, 4, 5, 7	8.12	The presence of a rattle resembling a path on the stem
2	Stem borer	*Tectona grandis* *Cassia siamea*	2, 8	13.04	There are holes in the trunk. and the surface has wood dust that pests used to eat.
3	Stem cancer	*Tectona grandis* *Acacia auriculiformis* *Falcataria moluccana*	1, 4, 8	6.89	There is decay in the stem. the presence of a gal. and there is a bulge/swelling

The productivity of each plant must be maintained to maintain product availability [53]. Disruption of crops can cause losses in both quantity and quality. Efforts can be made to reduce losses due to infection with plant diseases through control with the right targets and ways. Integrated pest control strategies can be carried out by striving for healthy plant growth, biological control activities, plant varieties resistant to pests and diseases, physical control activities. and semi-chemical control activities [54]. Disturbances in trees at the study site are presented in Figure 8.

(A) (B) (C)

Figure 8. Distribution of plants by biotic factors (A) cancer stems, (B) termites, and (C) rod hole. Tree disease that disrupts tree growth in Tubokarto Village.

In addition to pest and disease disorders. other factors affect plant growth. namely climatic factors. Stated that annual rainfall conditions in Wonogiri are included in the moderate category, with annual rainfall thickness reaching 2,000 mm [55]. Wet and dry months are classified as dry months when monthly rainfall is less than 60 mm and wet months when rainfall is more than 100 mm [56]. Based on rainfall data for the last two years, Wonogiri Regency shows high rainfall because the number of wet months is longer than dry months and categorized on type C Schmidt-Ferguson classification.

4. Conclusions

Tectona grandis is the most dominating species in the study area due to its strong adaptability to kars environment and it has the potential to be developed in such areas. The soil conditions in Wonogiri contain nutrients that support *Tectona grandis*'s growth, which contribute to its dominance at the research location. The existence of *Tectona grandis* in the karst ecosystem can be part of conservation efforts because it helps hold the soil from erosion. The composition of plant species in the karst ecosystem of Tubokarto Village consists of 18 species of trees. The density for the tree phase is 221 ind ha^{-1}, poles are 436 ind ha^{-1}, saplings are 1,144 ind ha^{-1}, and seedlings are 2,650 ind ha^{-1}. The tree species diversity index is medium, and the level of poles, saplings, and seedlings is low. The species richness index shows low levels at each growth phases. The species evenness index shows that seedlings are classified as high, while trees, poles, and saplings are classified as low. The vegetation structure in Tubokarto Village is in stratum B and stratum C. Environmental factors such as climate and soil content influence plant growth.

Author Contributions

SHP: Conceptualization. Methodology. Software. Investigation. Visualization. Writing – original draft; **RR**: Conceptualization. Methodology. Validation. Supervision. Writing – review & editing; **MN**: Conceptualization. Methodology. Supervision. Review.

Conflicts of Interest

There are no conflicts to declare.

Acknowledgments

Thanks to LPPM UNS through the UNS Non-APBN PNBP research fund for the HRG scheme. Research Group for Tropical Forest Management and Ecotourism. Forest Management Study Program. University of Sebelas Maret, the research team (Rifqi, Alya, and Nurul), colleagues from the Study Program of Forest Management, and Tubokarto Village officials.

References

1. Puspita, A.A.P.A.; Sachari, A.; Sriwarno, A.B. Dinamika Budaya Material pada Desain Furniture Kayu di Indonesia. *Panggung* **2016**, *26*, 247–260, doi:10.26742/panggung.v26i3.189.
2. Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia. Bangkitnya Industri Kayu Nasional Dari Jawa Tengah Untuk Indonesia. Available online: https://ppid.menlhk.go.id/berita/siaran-pers/4736/bangkitnya-industri-kayu-nasional-dari-jawa-tengah-untuk-indonesia (accessed on 1 January 2024).
3. Naharuddin. N. Komposisi dan Struktur Vegetasi dalam Potensinya sebagai Parameter Hidrologi dan Erosi. *Jurnal Hutan Tropis*, **2018**, *5*, 134–142, doi:10.20527/jht.v5i2.4367.
4. Indriyanto. *Ekologi Hutan*; Bumi Aksara: Jakarta, Indonesia, 2017.
5. Kadir, S. Pengelolaan Daerah Aliran Sungai untuk Pengendalian Banjir di Catchment Area Jaing Sub DAS Negara Provinsi Kalimantan Selatan. Dissertation, Brawijaya University, Malang, Indonesia, 2014.
6. Kadir, S.; Badaruddin, B. Pengayaan Vegetasi Penutupan Lahan untuk Pengendalian Tingkat Kekritisan DAS Satui Provinsi Kalimantan Selatan. *Jurnal Hutan Tropis* **2015**, 3, 145–152.

7. Sudiana, E.; Hanani AR, N.; Yanuwiadi. B.; Soemarno. Pengelolaan Hutan Rakyat Berkelanjutan di Kabupaten Ciamis. *Jurnal Agritek* **2009**, *11*, 543–555.
8. Faid, N.E. Status Berkelanjutan Pengelolaan Hutan Rakyat Lestari di Kabupaten Gunungkidul Provinsi Daerah Istimewa Yogyakarta. Thesis, Diponegoro University, Semarang, Indonesia, 2019.
9. Suhendar, R. Kebijakan Pengelolaan Karst di Indonesia. *Geomagz (Majalah Geologi Populer)* **2015**, *5*, 18–19.
10. Widyaningsih, G.A. Permasalahan Hukum dalam Perlindungan Ekosistem Karst di Indonesia (Studi Kasus: Ekosistem Karst Sangkulirang–MangkaliHat, Provinsi Kalimantan Timur). *Jurnal Hukum Lingkungan Indonesia* **2017**, *3*, 73–95.
11. Amalia, E.R.; Setyaningsih, L.; Meiganati, K.B. Struktur. Komposisi Dan Potensi Kayu Di Hutan Rakyat Desa Katongan (Studi Kasus: Di Desa Katongan, Kecamatan Nglipar, Kabupaten Gunung Kidul, Yogyakarta). In The 5th Conference on Innovation and Application of Science and Technology (CIASTECH), Malang, Indonesia, 2022; pp. 325–334.
12. Pemerintah Kabupaten Wonogiri. Wonogiri Dalam Data 2019. Available online: https://humas.wonogirikab.go.id/2020/06/15/potensi-pertambangan-kabupaten-wonogiri-tahun-2019/ (acessed on 1 January 2024).
13. Badan Pusat Statistik Kabupaten Wonogiri. *Kabupaten Wonogiri dalam Angka 2021*; Badan Pusat Statistik Kabupaten Wonogiri: Wonogiri. Indonesia. 2021.
14. Badan Informasi Geospasial. Peta Rupa Bumi Indonesia Kabupaten Wonogiri. Aavailable online: https://tanahair.indonesia.go.id/portal-web (acessed on 1 January 2024).
15. Umroni, A. Metode Inventarisasi Model-Model Pengelolaan Hutan Rakyat di NTT. *Jurnal Warta Cendana* **2012**, *6*, 12–18.
16. Zulkarnain, L.O.; Razak, A. Analisis Vegetasi dan Visualisasi Profil Vegetasi Hutan di Ekosistem Hutan Tahura Nipa-Nipa Di Kelurahan Mangga Dua Kota Kendari. *Ecogreen* **2015**, *1*, 43–54.
17. Hamidun, M.S.; Baderan, D.W. *Struktur, Komposisi dan Pola Distribusi Vegetasi Pada Kawasan Hutan Lindung dan Hutan Produksi Terbatas*; Universitas Gorontalo: Gorontalo, Indonesia, 2013.
18. Tjitrosoepomo, G. *Dasar-Dasar Taksonomi Tumbuhan*; Gadjah Mada University Press: Sleman, Indonesia, 2013.
19. Putri, A.I.; Dharmono. Keanekaragaman Genus Tumbuhan dari Famili Fabaceae di Selatan. In Prosiding Seminar Nasional Lingkungan Lahan Basah, Banjarmasin, Indonesia, April 2018; pp. 209–213.
20. Septiasari, A.; Balgis, M.; Lathifah, M.N.; Hanugroho, P.D.; Setyawan, A.D. Identification and Potential of Vascular Plants in the Karst Ecosystem of Somopuro Cave.,Pacitan, East Java, Indonesia. *International Journal of Tropical Drylands* **2021**, *5*, 75–83, doi:10.13057/tropdrylands/t050204.
21. Prabowo, R.; Subantoro, R. Analisis Tanah sebagai Indikator Tingkat Kesuburan Lahan Budidaya Pertanian di Kota Semarang. *Cendekia Eksakta* **2018**, *2*, 59–64.
22. Hartawan, R.; Nengsih, Y.; Marwan, E. Pemanfaatan Serasah Kedelai sebagai Bahan Kompos. *Jurnal VokasI* **2017**, *1*, 74–78, doi:10.30811/vokasi.v1i2.681.
23. Soewandita, H. Studi Kesuburan Tanah dan Analisis Kesesuaian Lahan untuk Komoditas Tanaman Perkebunan di Kabupaten Bengkalis. *Jurnal Sains dan Teknologi Indonesia* **2008**, *10*, 128–133.
24. Tini, N.; Amri, K. *Mengebunkan Jati Unggul Pilihan Investasi Prospektif*; Agromedia Pustaka: Jakarta Selatan. Indonesia, 2002.
25. Sarah, S.; Sarah, S.; Burhanudin, A.B.; Bustan, B. Sebaran Nilai Kapasitas Tukar Kation (KTK) Dan Kemasaman (pH) Tanah Di Tanah Vertisol Kecamatan Sakra Kabupaten Lombok Timur. *Journal of Soil Quality and Management* **2024**, *3*, 1–6.
26. Djaenudin, D.; Marwan, H.; Subagjo, H.; Hidayat, A. Petunjuk Teknis Evaluasi Lahan Untuk Komoditas Pertanian. 2nd ed; Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian. Badan Penelitian dan Pengembangan Pertanian: Bogor, Indonesia, 2011.
27. Parmadi, E.H.; Dewiyanti, I.; Karina, S. Indeks Nilai Penting Vegetasi Mangrove Di Kawasan Kuala Idi, Kabupaten Aceh Timur. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah* **2016**, *1*, 82–95.
28. Nurjaman, D.; Kusmoro, J.; Santoso, P. Perbandingan Struktur dan Komposisi Vegetasi Kawasan Rajamantri dan Batumeja Cagar Alam Pananjung Pangandaran. Jawa Barat. *Jurnal Biodjati* **2017**, *2*, 167–179, doi:10.15575/biodjati.v2i2.1304.
29. Sumarna, Y. *Budidaya Jati*; PT. Penebar Swadaya: Jakarta Timur, Indonesia, 2003.

30. Widiyanti, P. Komposisi Jenis dan Struktur Vegetasi Pada Kawasan Karst Gunung Cibodas, Kecamatan Ciampea, Kabupaten Bogor. Undegraduate Thesis, Bogor Agricultural University, Bogor, Indonesia, 2014.
31. Hastuti, I.N.; Sufiadi, E. Studi Perbandingan Propil Tumbuhan Agroforestry Di Perum Perhutani Dengan Lahan Milik Di Kabupaten Sumedang. *PASPALUM* **2017**, *4*, 29–39, doi:10.35138/paspalum.v4i1.21.
32. Newton, P.F. Wood Quality Attribute Models and Their Utility when Integrated into Density Management Decision-Support Systems for Boreal Conifers. *Forest Ecology and Management* **2019**, *438*, 267–284, doi:10.1016/j.foreco.2019.01.053.
33. Riyanto; Indriyanto; Bintoro, A. Produksi Serasah pada Tegakan Hutan di Blok Penelitian dan Pendidikan Taman Hutan Raya Wan Abdul Rachman Provinsi Lampung. *Jurnal Sylva Lestari* **2019**, *1*, 1–8, doi:10.23960/jsl111-8.
34. Velasquez, E.; Lavelle, P. Soil Macrofauna as An Indicator for Evaluating Soil Based Ecosystem Services in Agricultural Landscapes. *Acta Oeco***19**, *100*, 1–18, doi:10.1016/j.actao.2019.103446.
35. Santoso, P. Potensi Kayu Sonokeling (*Dalbergia latifolia* Roxb) dan Jenis Kayu Lain di Hutan Rakyat Kecamatan Dlingo, Bantul Yogyakarta. *Journal of Forest Science Avicennia* **2021**, *4*, 1–14.
36. Ziraluo, Y.P.B.; Duha, M. Diversity Study of Fruit Producer Plant in Nias Islands. *Jurnal Inovasi Penelitian* **2020**, *1*, 683–694.
37. Nasrudin, A.; Parikesit. Vegetation Analysis of Karst in Padjadjaran University Campus Area Cintaratu, Pangandaran, West Java. *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia* **2020**, *6*, 493–500.
38. Waskitaningtyas, E.; Utami, S.; Wiryan,. E. Distribusi dan Regenerasi Jamuju (*Dacrycarpus imbricatus* (Blume) de Laub) di Cagar Alam Gebugan Kabupaten Semarang. *Jurnal Akademika Biologi* **2018**, *7*, 21–26, doi:10.14710/jbt.1.2.1-5.
39. Rau, A.R.; Kusen, J.D.; Paruntu, C.P. Struktur Komunitas Moluska di Vegetasi Mangrove Desa Kulu, Kecamatan Wori, Kabupaten Minahasa Utara. *Jurnal Pesisir dan Laut Tropis* **2013**, *1*, 44–50, doi:10.35800/jplt.1.2.2013.2123.
40. Hartoyo, A.P.P.; WiJayanto, N.; Olivita, E.; Rahmah, H.; Nurlatifah, A. Keanekaragaman Hayati Vegetasi pada Sistem Agroforestri di Desa Sungai Sekonyer, Kabupaten Kotawaringin Barat, Kalimantan Tengah. *Jurnal Silvikultur Tropika* **2019**, *10*, 100–107, doi:10.29244/j-siltrop.10.2.100-107.
41. Damanik, S.E.; Sahudra, T.M. *Manajemen Wilayah Hutan*. Penerbit K-Media: Yogyakarta, Indonesia, 2021.
42. Wiharto, M.; Kusmana, C.; Prasetyo, L.B.; Partomihardjo, T. Distribusi Kelas Diameter Pohon pada Berbagai Tipe Veget Asi di Gunung Salak. Bogor, Jawa Barat. *Jurnal Ilmu Pertanian Indonesia* **2008**, *13*, 95–102.
43. Suhartati, T.; Saputra, E. Distribusi Diameter Jati dan Mahoni di Hutan Rakyat Desa Semoyo Kecamatan Patuk Kabupaten Gunungkidul. *Jurnal Wana Tropika* **2022**, *12*, 63–69, doi:10.55180/jwt.v12i02.319.
44. Irwanto, I.; Tuhumury, A.l.; Sahupala, A. Analisis Penyebaran Lasa (*Castanopsis buruana* Miq) sebagai Pohon Penghasil Pangan Alternatif di Seram bagian Barat Maluku. *Jurnal Hutan Pulau-Pulau Kecil* **2018**, *2*, 149–164, doi:10.30598/jhppk.2018.2.2.149.
45. Kamaludin. Inventarisasi Pohon Penghasil Buah Pada Hutan Tembawang Ilik Desa Sepan Lebang. *PIPER* **2019**, *15*, 84–94, doi:10.51826/piper.v15i28.287.
46. Wahyudi, A.; Harianto, S.P.; Darmawan, A. Keanekaragaman Jenis Pohon di Hutan Pendidikan Konservasi Terpadu Tahura Wan Abdul Rachman. *Jurnal Sylva Lestari* **2014**, *2*, 1–10, doi:10.23960/jsl321-10.
47. Suprapto, E. Hutan Rakyat: Aspek Produksi, Ekologi dan Kelembagaan. In Seminar Nasional Kontribusi Pengurangan Emisi Karbon dari Kawasan Hutan yang Dikelola Masyarakat Secara Lestari dan Berkelanjutan FWI, Jakarta, Indonesia, 29 Juli 2010; pp. 1–8.
48. Supriatna, A.H. Pertumbuhan Tanaman Pokok Jati (*Tectona grandis* Linn F.) pada Hutan Rakyat di Kecamatan Conggeang, Kabupaten Sumedang. Undergraduate Thesis, Bogor Agricultural University, Bogor, Indonesia, 2011.
49. Kalima, T. Profil Keragaman dan Keberadaan Spesies dari Suku *Dipterocarpaeae* di Taman Nasional Meru Betiri, Jember. *Jurnal Penelitian Hutan* **2008**, *5*, 175–191.
50. Wulandari, C. Identifikasi Pola Agroforestri yang Diimplementasikan Masyarakat pada Lahan Marjinal di Lampung Utara. *Jurnal Ilmu Pertanian Indonesia* **2009**, *14*, 158–162.
51. Suraeni, I. Analisis Tingkat Kekeringan dan Arahan Mitigasi Di Daerah Aliran Sungai Jeneberang Hulu. Thesis, Hasanuddin Universit,. Makassar, Indonesia, 2022.
52. Nisar,M.;Malik,A.; Wahid, A. Studi Komposisi dan Potensi Vegetasi Hutan Produksi Di Wilayah KPHP Model Dampelas Tinombo Desa Lembah Mukti Kecamatan Dampelas Kabupaten Donggala. *Warta Rimba* **2016**, 65–73.

53. Prihatiningrum, C.; Nafi'udin, A.F.; Habibullah, M. Identifikasi Teknik Pengendalian Hama Penyakit Tanaman Cabai Di Desa Kebonlegi Kecamatan Kaliangkrik Kabupaten Magelang. *Jurnal Pertanian Cemara* **2021**, *18*, 19–24, doi:10.24929/fp.v18i1.1130.
54. Indiati, S.W.; Marwoto. Penerapan Pengendalian Hama Terpadu (PHT) pada Tanaman Kedelai. *Bulletin Palawija* **2017**, *15*, 87–100.
55. Wijayanti, P.; Noviani, R.; Tjahjono, G.A. Dampak Perubahan Iklim Terhadap Imbangan Air Secara Meteorologisdengan Menggunakan Metode Thornthwaite Mather Untuk Analisiskekritisan Air Di Karst Wonogiri. *Geo Media: Majalah Ilmiah dan Informasi Kegeografian* **2015**, *13*, 27–40, doi:10.21831/gm.v13i1.4475.
56. Schmidt, F.H.; Ferguson, J.H.A. *Rainfall Species Based on Wet and Dry Periode Rotation Indonesiawith WestenNew Guenca*; Kementerian Perhubungan Jawatan Meteorol0gi dan Geofisika: Jakarta, Indonesia, 1951.