BIODIVERSITAS
Volume 26, Number 8, August 2025
Pages: 3927-3939

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d260823

Vegetation structure and species composition of agarwood (*Aquilaria* spp.) habitats in natural and planted forests in Buru Island, Indonesia

NINGSIE INDAHSUARY UAR[1,2,♥], LINA KARLINASARI[3], ISKANDAR Z. SIREGAR[4], SETYO PERTIWI[5]
[1]Dapertement of Natural Resources and Environmental Management, Graduate School, Institut Pertanian Bogor. Jl. Raya Darmaga Kampus IPB, Babakan, Dramaga, Bogor 16680, West Java, Indonesia. Tel./fax.: +62-251-8628448, ♥email: indahsuaryneng78@gmail.com
[2]Dapertemen of forestry, Faculty Agriculture and Forestry, Universitas Iqra Buru. Jl. Universitas, Namlea, Buru 97571, Maluku, Indonesia
[3]Department of Forest Products Technology, Faculty of Forestry and Environment, Institut Pertanian Bogor. Jl. Lingkar Akademik Kampus IPB, Dramaga, Babakan, Bogor 16680, West Java, Indonesia
[4]Department of Silviculture, Faculty of Forestry and Environment, Institut Pertanian Bogor. Jl. Lingkar Akademik Kampus IPB, Dramaga, Babakan, Bogor 16680, West Java, Indonesia
[5]Department of Mechanical and Bio-System Engineering, Institut Pertanian Bogor. Jl. Raya Darmaga Kampus IPB, Babakan, Dramaga, Bogor 16680, West Java, Indonesia

Manuscript received: 29 April 2025. Revision accepted: 15 August 2025.

Abstract. *Uar NI, Karlinasari L, Siregar IZ, Pertiwi S. 2025. Vegetation structure and species composition of agarwood (*Aquilaria *spp.) habitats in natural and planted forests in Buru Island, Indonesia. Biodiversitas 26: 3927-3939.* *Aquilaria* is a genus of agarwood-producing trees that grow almost throughout Indonesia. Buru Island is one of the areas with the presence of *Aquilaria* spp. species. Currently, information related to the structure and composition of tree species in the habitats of agarwood plants is still limited. This study aimed to describe the structure and composition of tree species in the natural habitat and cultivated area of agarwood plants in three locations in Buru Island, namely Airbuaya, Fena Leisela, and Batabual Sub-districts. Vegetation analysis was carried out by field surveys using a combination of line transect and square plot methods to document plant species and number of individuals at seedling, sapling, pole and tree levels. The results showed that the stand structure of vegetation community at the research location formed an inverted "J" curve. The species composition in the three locations for natural and cultivated habitats were composed by agarwood-producing plants and non-agarwood plants. The Diversity Index in the natural habitat was moderate to high, with a value of 1.08-3.35, while in the cultivated areas had a high Diversity Index, with a value of 2.08-3.57. Both natural and cultivated habitats had an even distribution of species. The species richness index at both natural and cultivated habitats was moderate to high, with a value of 3.60-7.54. The results of the study indicate that both natural forests and cultivated forests in Buru Island have high potential to support the growth of agarwood-producing trees, as evidenced by healthy stand structures and moderate to high diversity and species richness indices. Therefore, sustainable management strategies are necessary, including the conservation of natural forests, the development of agroforestry-based cultivation models, and the optimization of natural regeneration processes.

Keywords: Agarwood-associated species, Diversity Index, habitat suitability, Moluccas flora

INTRODUCTION

The utilization of Non-Timber Forest Products (NTFPs) has become a key focus in forest management in recent years since timber as the primary product of forest has been depleted due to extensive logging, declining the quantity and quality of forests. While all forest areas have the potential for NTFPs, information regarding their potential and utilization remains outdated and insufficiently documented. Agarwood-producing trees are among the most economically valuable NTFPs. These trees are distributed across almost all regions of Indonesia, both growing naturally and through cultivation. According to the Master Plan for Agarwood Development, there are approximately 27 species of naturally occurring agarwood-producing trees which are classified into three main families: Thymelaeaceae, Leguminosae, and Euphorbiaceae. Several agarwood-producing species have been cultivated by local communities, farmer groups, private enterprises, and government institutions, including *Aquilaria malaccensis*, *A. microcarpa*, *A. filaria, A. crasna* and *Gyrinops* spp. (Lee et al. 2022).

Agarwood is one of the most popular non-timber forest products in Indonesia that has high economic and social value. Agarwood also plays an important role in the ecological system of forest (Putra et al. 2020). The Convention on International Trade in Endangered Species (CITES) reported that Indonesia is the world's leading exporter of agarwood (CITES 2017). However, Indonesia's agarwood exports declined from 1,000 tons in 2010 to 736 tons in 2017. Agarwood exports include various forms of material such as flakes, powder, oil, and others. Despite the overall decline in exports from 2010 to 2017, the demand for agarwood chips in Saudi Arabia, Indonesia's primary export destination, increased by 73% during this period (CITES 2017)

Agarwood-producing trees contain resin as a result of infection process, either mechanically or through microbial infestation. The resin contains aromatic substances with fragrant smell and has a certain shape and color (Azah et al.

2013; Liu et al. 2019). The presence of fragrant compounds with high economic value makes agarwood-producing trees highly sought after by agarwood hunters.

There have been various studies on agarwood-producing plants that grow naturally or cultivated in several regions in Indonesia (Vantompan et al. 2015; Rachmawaty et al. 2021). Besides Kalimantan and Sumatra, Maluku Province is also the main area that produces agarwood from the *Aquilaria* and *Gyrinops* genera (Lee et al. 2022). Information on the presence and potential of agarwood-producing tree species in Maluku Province, particularly on Buru Island, remains very limited, especially for *Aquilaria* spp. and *Gyrinops* spp. The potential for agarwood development in Buru Island is becoming increasingly relevant, considering the region is home to various species of *Aquilaria* and *Gyrinops*, both naturally growing and cultivated. Therefore, understanding on the structure and composition of forest vegetation where agarwood-producing trees occur in Buru Island can serve as a basis for developing management and conservation strategies to prevent a decline in the natural population.

Species diversity in forests can be observed through their structure and composition. Tree species diversity serves as an indicator of forest health, as it is highly sensitive to changes, acting as an indicator of ecological systems and trophic, temporal, and spatial heterogeneity. Meanwhile, biodiversity is significantly influenced by environmental factors, interactions among living organisms, and interactions between organisms and their environment (Safe'i et al. 2018). Recent studies on floristic parameters in the Wallacea Region, particularly in Papua, indicate that sustainable management is crucial for conserving *Aquilaria* spp. as a highly valuable biological resource (Destri et al. 2020). Meanwhile, Mannan et al. (2024) highlights that biodiversity degradation in Wallacea is becoming increasingly alarming due to intense exploitation and changes in land cover. The main ecological challenges include habitat fragmentation, declining populations of endemic species, and the loss of ecosystem functions. Excessive exploitation of agarwood-producing and other plant species, without adequate ecological data, exacerbates the vulnerability of Wallacea's ecosystems. So that, data on the structure and composition of forest on the habitat of agarwood-producing species in Buru Island still need to be updated. Therefore, this study aims to investigate the spatial distribution of agarwood-producing trees in Buru Island and provide information on the structure and composition of vegetation on natural forest and cultivated forest where the agarwood trees found. The findings are expected to offer accurate and reliable information on the potential of agarwood-producing trees in the region.

MATERIALS AND METHODS

Study area and period

This study was conducted in Airbuaya, Fena Leisela, and Batabual Sub-districts, Buru District, Maluku Province, Indonesia (Figure 1) (Uar et al. 2024). Buru Island has biophysical conditions characterized by elevations ranging from 450 to 650 m asl, volcanic and alluvial soil types, an average annual rainfall of 1,757.5 mm, and temperatures ranging between 21.6°C and 32.8°C. The island features diverse vegetation types. In general, land use on Buru Island includes intensive agricultural lands (mainly paddy field), agroforestry, horticulture lands, area for livestock farming, and protected areas. Data collection was done in sites with occurrence of cultivated and naturally grow agarwood-producing trees.

Procedures

Spatial analysis

Spatial analysis was conducted using interpreted aerial imagery data, including land cover and land use system data obtained from the Indonesian Ministry of Environment and Forestry (KLHK), as well as *Rupa Bumi Indonesia* (RBI) data obtained from the Geospatial Information Agency (*Badan Informasi Geospasial*). These datasets were overlaid by combining multiple spatial data layers of land cover and land use system. The potential areas with occurrence of agarwood-producing trees were analyzed based on predetermined criteria (e.g., elevation, soil type, rainfall). The distribution pattern was analyzed using spatial statistical techniques, such as hot spot analysis, to determine the presence of agarwood-producing trees. This was done by processing Global Positioning System data, which identified the exact locations of agarwood-producing trees within the study area (Figure 2). In addition, information on the presence of agarwood-producing trees was also obtained through direct interviews with local agarwood collectors, as well as gathered from the Maluku Provincial Forestry and Environment Agency (*Dinas Kehutanan dan Lingkungan Hidup Provinsi Maluku*), the Regional Development Planning Agency (BAPPEDA) of Buru District, and the Buru District Agriculture Department.

Vegetation analysis

Vegetation analysis was carried out through field surveys using a combination of transect line and square plot methods (Figure 3). Transect lines were established then square plots were created to record vegetation across various levels of regeneration with total of 32 plots for each sub-district. Tree level vegetation was documented using plots measuring 20x20 m^2, while poles, saplings and seedlings were inventoried using plots measuring 10x10 m^2, 5x5 m^2, and 2x2 m^2 respectively (Indriyanto 2008).

Data analysis

Vegetation structure, composition and diversity were analyzed using various parameters, including the Important Value Index (IVI), Shannon-Wiener Diversity Index, Margalef Species Richness Index (RI), and species Evenness Index (E) (Istomo and Ferliana 2024).

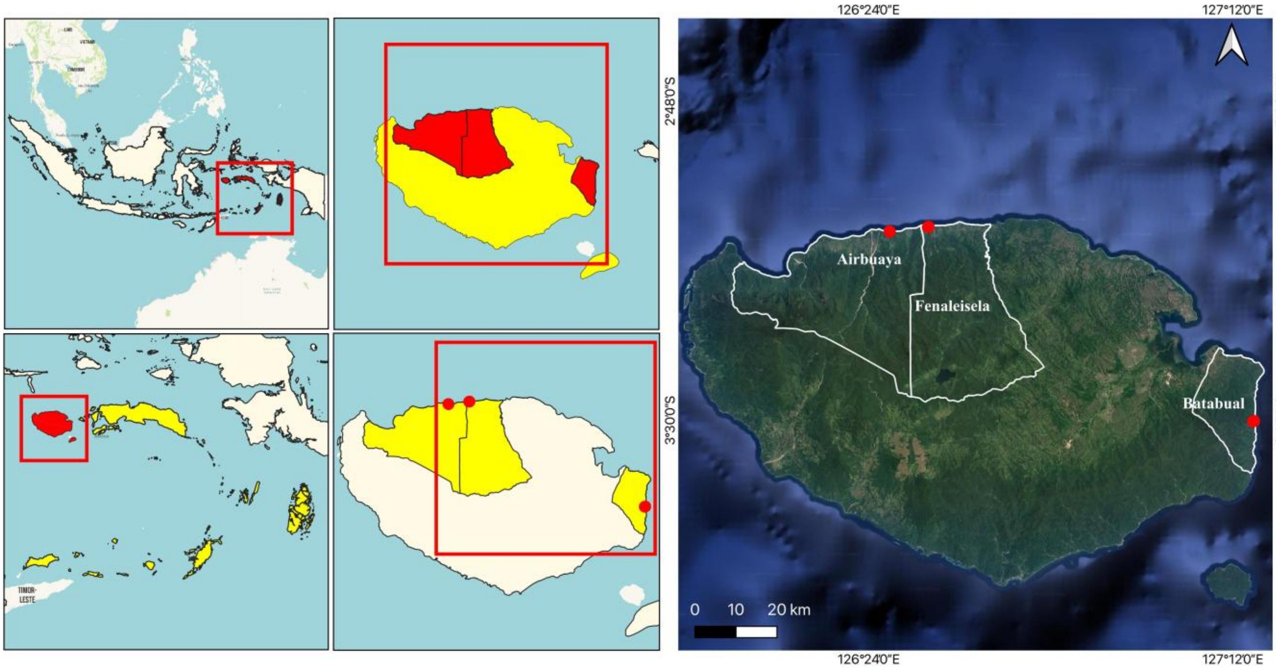

Figure 1. Map of research location in Aibuaya, Fena Leisela, and Batabual sub-districts, Buru Island, Maluku Province, Indonesia (126°23'47.832″E, 3°5'23.075″S to 127°14'12.23″E, 3°30'35.971″S)

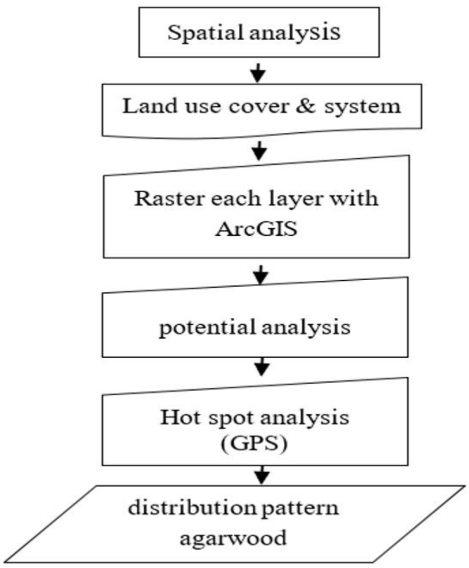

Figure 2. Flow chart of spatial analysis to identify the potential areas of the presence of agarwood-producing trees

Important Value Index (IVI)

Vegetation composition analysis was done by calculating the Important Value Index (IVI), which consisted of Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo).

$$\text{Density of species} = \frac{\text{The number of individuals of a species}}{\text{Observation plot area}}$$

$$\text{Relative Density (RD)} = \frac{\text{The number of individuals of a species}}{\text{Observation plot area}} x\ 100\%$$

$$\text{Frequency of species} = \frac{\text{Number of plots found of a species}}{\text{Observation plot area}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Number of plots found of a species}}{\text{Observation plot area}} x\ 100\%$$

$$\text{Dominance of species} = \frac{\text{Dominance of a species}}{\text{Observation plot area}}$$

$$\text{Relative Dominance (RDo)} = \frac{\text{The number of individuals of a species}}{\text{Observation plot area}} x\ 100\%$$

IVI (%) = RD+RF+RDo

Shannon-Wiener Diversity Index (H')

Shannon-Wiener Diversity Index (H') was calculated using the formula:

$$H' = -\sum(pi\ In\ Pi)$$

$$pi = ni/N$$

Where, H': Shannon-Wiener Diversity Index, n: Number of species, ni: Number of individuals of a species, and N: The total number of individuals of the entire species.

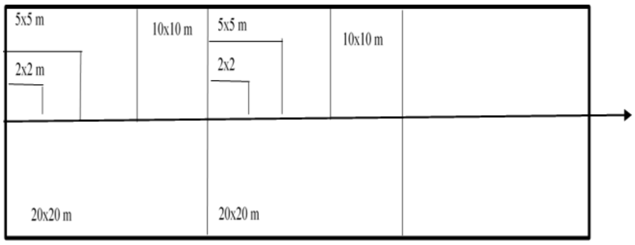

Figure 3. Vegetation analysis sample plot design

Margalef Species Richness Index (RI)

Margalef Species Richness Index was calculated as follow:

$$R1 = s - \frac{1}{In(N)}$$

Where, RI: Margalef Species Richness Index, S: Number of species, N: Total number of individuals.

Species Evenness Index (E)

Species Evenness Index was computed using the equation below:

$$E = \frac{H'}{In(S)}$$

Where, E: Species Evenness Index, H': Shannon-Wiener Diversity Index, and S: Number of species found.

RESULTS AND DISCUSSION

Spatial analysis

The spatial analysis conducted in the study area indicates that agarwood-producing trees on Buru Island are distributed across the three sub-districts (Airbuaya, Fena Leisela, and Batabual) that serve as the focus of this research (Figure 4). The presence of agarwood-producing trees in Buru Island shows promising potential, particularly those growing naturally in forests. Meanwhile, cultivated agarwood trees have been planted by certain community members who are aware of their economic value. The presence of cultivated agarwood-producing trees in Buru Island provide opportunity for further development as a multi-purpose tree species under agroforestry system. The extent of cultivated agarwood-producing trees in the three sub-districts covered 6 to 8 hectares in Air Buaya, 6 hectares in Fena Leisela and 5.6 hectares in Batabual. These plantations are privately owned and have been cultivated since 2010. In addition to agarwood-producing trees, these cultivated areas contain horticultural crops and other forest tree species.

The spatial information obtained from this study provides an overview of the potential distribution of agarwood-producing trees in the three study locations. This highlights that spatial analysis is a valuable tool for providing accurate and up-to-date field information based on the collected data. Spatial information is one of the key methods used to obtain spatial data, including both raster and vector data. Additionally, it enables wide-area coverage with high-frequency data acquisition. Furthermore, Geographic Information Systems (GIS) serve as a fundamental spatial tool with specialized capabilities for processing and analyzing spatial data. The information derived from GIS is obtained through data processing and analysis based on geographic information. This makes the information highly valuable, as it can display maps indicating the potential presence of agarwood-producing trees in the study area. Overall, this suggests that Buru Island holds promising potential for the development of agarwood-producing plants as a multipurpose crop.

The development of agarwood using the agroforestry system has been widely implemented in Indonesia. Agroforestry practices in cultivated agarwood plantations have been shown to influence the growth of agarwood-producing trees. Studies by Prastyaningsih et al. (2017) and Sulistiono et al. (2018) indicate that multiculture systems significantly impact tree diameter and height development. Therefore, in multiculture or agroforestry systems, it is essential to consider supporting factors, such as the optimal planting distance.

Agroforestry is fundamentally a land-use model that integrates agricultural crops and trees within a unified area. The recommended planting distance for agarwood in an agroforestry system is 5x5 m^2, as this spacing helps maintain adequate light exposure and nutrient competition, which significantly affects agarwood tree growth. In the study area, planting distances vary, ranging from 3x3 m^2 to 5x5 m^2, leading to variations in the growth of agarwood-producing trees, both in diameter and height. The diameter of cultivated agarwood trees ranges from 9 to 30 cm, while naturally growing trees are spaced at approximately 6x8 meters with irregular spacing.

Based on the potential data of agarwood-producing trees in Buru Island, particularly in the three sub-districts studied, these areas serve as a reference for the further development of agarwood plantations on Buru Island. Given that agarwood is a high-value commodity, its natural population is increasingly threatened. The growth characteristics of agarwood-producing trees significantly influence their development. Understanding these characteristics allows for the expansion and conservation of agarwood tree populations. The geographical and ecological factors of agarwood tree habitats provide valid insights into their growth potential.

Agarwood trees from *Aquilaria* spp. typically grow in type A tropical climates, with rainfall ranging from 97.9 mm to 260.44 mm. It thrives at altitudes between 700 and 1,000 meters above sea level and flourishes in lowland and swampy areas (Susilo et al. 2014; Rahmat and Nurlia 2015). Maluku Province has a humid tropical climate, characterized by high annual rainfall exceeding 2,000 mm, with rainy seasons lasting more than six months. However, some areas, including Southeast Maluku and Buru Island, experience drier conditions, with annual rainfall below 2,000 mm and rainy seasons lasting less than six months (BPS Maluku 2024). Given these climatic conditions, the distribution and growth potential of *Aquilaria* spp. in Buru Island are well-suited for expansion. This aligns with study findings indicating the presence of *Aquilaria filaria* and *Aquilaria* sp. in the research area. Efforts to develop agarwood cultivation should not be limited to farmers, local communities, or residential areas but should also extend to forest-adjacent areas. This approach supports the conservation of agarwood-producing trees, ensuring their long-term sustainability.

Recognizing the potential of agarwood as a flagship commodity in Buru Island can contribute to improving local community welfare. Therefore, a strategic development plan needs to be formulated, taking into account the biophysical, social, economic, and cultural conditions of the region. This will ensure that the cultivation and utilization of agarwood are carried out in a well-planned, focused, and sustainable manner.

Vegetation community around the habitat of agarwood-producing trees in Buru Island

Vegetation analysis conducted across 32 plots at each location, both at site with agarwood trees that naturally growing and cultivated areas, identified the presence of *Aquilaria* spp. along with other plant species. The presence of agarwood trees and the dominant species are presented in Figure 5. The stand structure of agarwood producing trees at the study location is presented in Figure 6. The stand structure showed that the highest density occurred on stand with the smallest diameter class (10-19 cm), then continued to decrease along with the increasing diameter class. The stand structure had an inverted "J" curve, showing a general diameter distribution class condition where higher diameter class tends to have less densely vegetation.

Vegetation diversity and stand structure continue to change and are influenced by biotic and abiotic environmental conditions. Plant communities live together and depend on each other in forest ecosystems. Different numbers of each plant species and formations of plant community structure indicate an association that occur in a forest ecosystem (Gedefaw and Soromessa 2014; Hilwan and Masyrafina 2015; Istomo and Hartarto 2019; Feldmann et al. 2020; Segura et al. 2021; Melesse 2024)

Changes in stand structure of vegetation community around naturally growing and cultivated agarwood plants showed a decreased density along with the increasing growth stage (Figure 7). The vegetation around the naturally growing agarwood plants had a density at the seedling level at 450.54 individuals/ha and reduced at the tree level at 167.62 individuals/ha. Similarly, in the cultivated agarwood habitat, the density reduced from 626.14 individuals/ha at the seedling level to 205.88 individuals/ha at the tree level. This indicates that species composition decreases at each growth stage within a forest area. Although the decline occurs, it remains relatively consistent following exponential pattern.

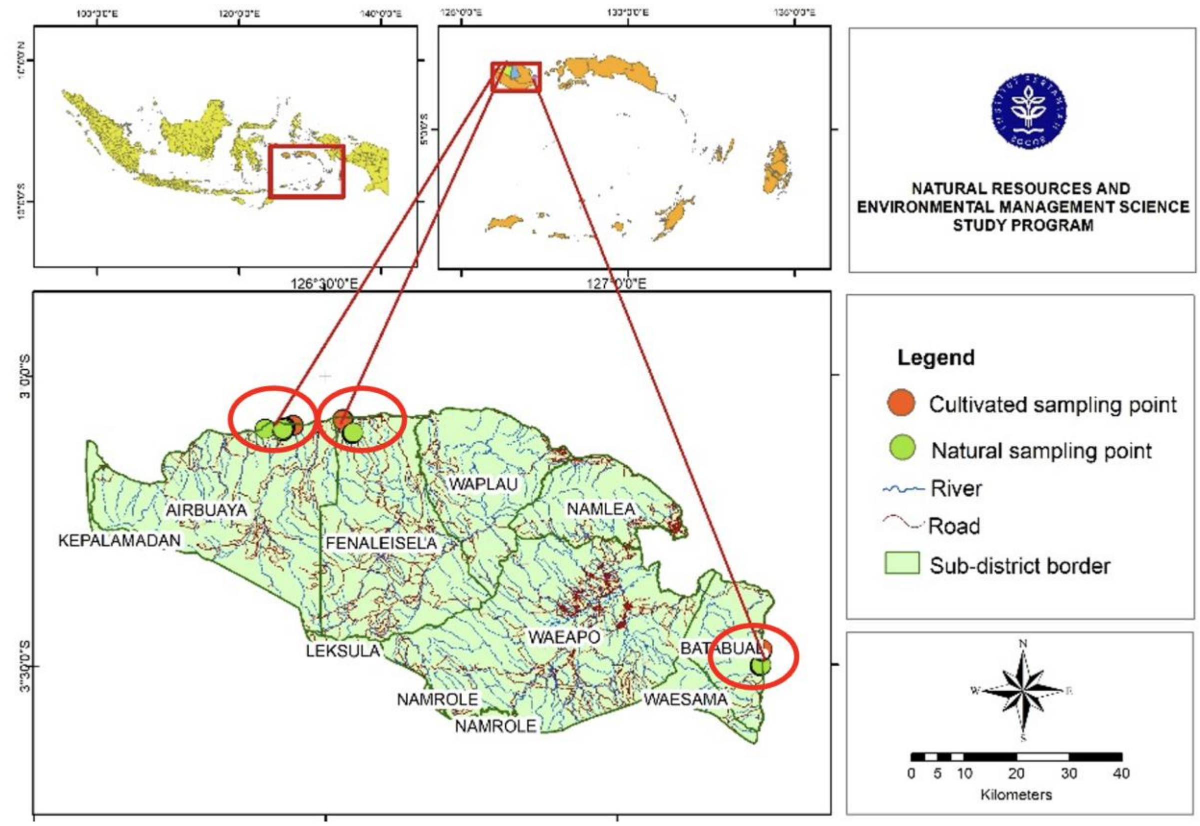

Figure 4. The spatial distribution of agarwood-producing trees in Buru Island, Maluku District, Indonesia

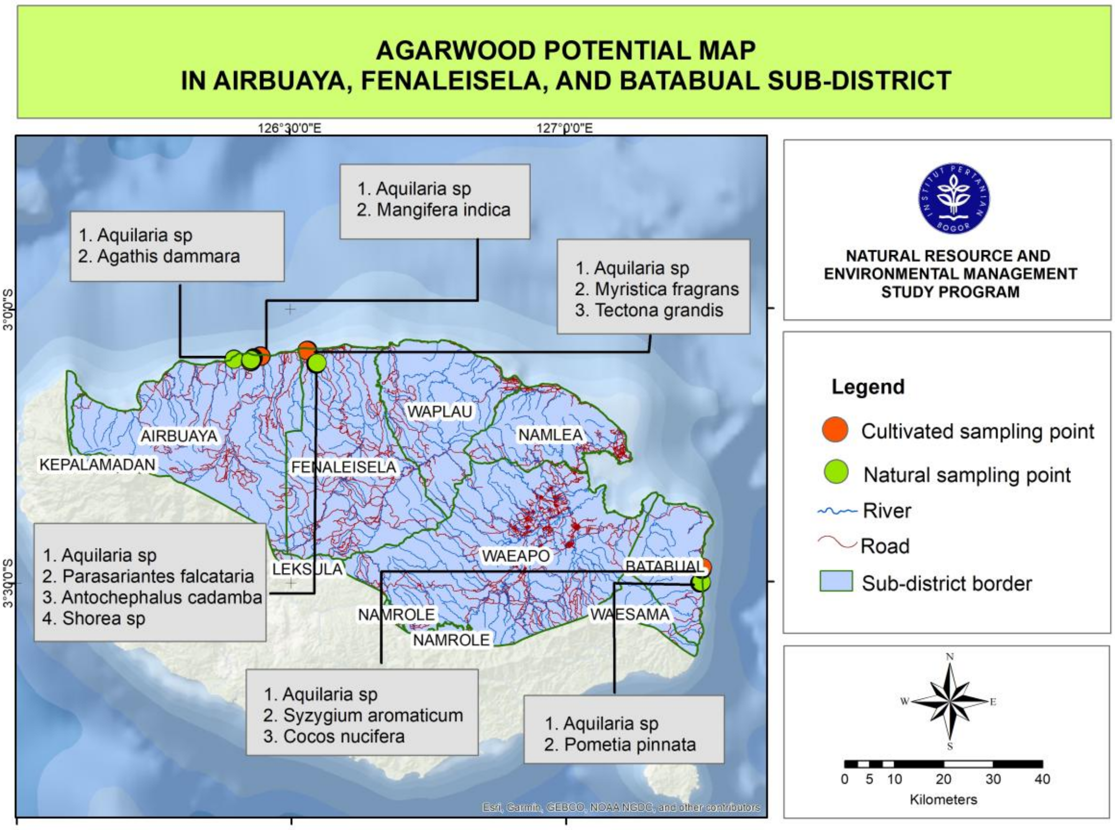

Figure 5. Map of agarwood-producing trees and dominant species in Buru Island, Maluku Province, Indonesia

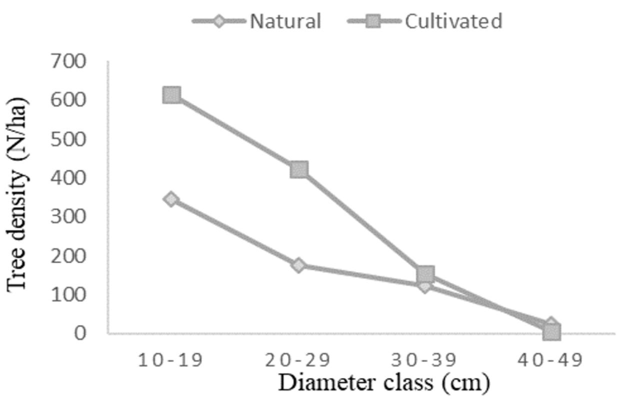

Figure 6. Natural and cultivated diameter class stand structure of agarwood-producing trees in Buru Island, Maluku Province, Indonesia

The species composition of vegetation around the habitat of naturally grow agarwood plants in the three study locations is presented in Figure 8. The Airbuaya location had the highest number of species with 161 species, and the lowest was obtained from in the Batabual with 139 species. Dendang and Wahyuni (2015) and Melesse 2024 mentioned that high abundance of certain species indicates the positive regeneration potential, because these species dominate the growth structure that presents a complete growth level.

The species composition of vegetation around the habitat of cultivated agarwood plants in the three study locations is presented in Figure 9. The Airbuaya location had the highest species number with 240 species while the lowest was in Batabual with 162 species. Species composition in cultivated areas is influenced by several factors, including species selection, management objectives, planting and maintenance methods, soil and environmental conditions, the influence of natural disturbances, and crop rotation cycles.

The lowest species composition in a forest area refers to the least species or the least frequently-found species in the ecosystem. This condition can provide an important picture of the ecological conditions, biodiversity, and factors that influence the survival of certain species in the forest area. Karmilasanti and Fajri (2020) stated that species composition indicates the number of species and the existence of species in a forest area including the level of influence of species in their community. The composition of species in an area is influenced by ecological conditions, species interactions, natural and human disturbances, climate factors, and forest management practices. These factors interact each other, resulting in a complex combination of ecological, biological, and anthropogenic factors (Gebeyehu et al. 2019; Larocque 2022; Nurfaeiza et al. 2022; Zhang et al. 2022; Mokennen et al. 2023).

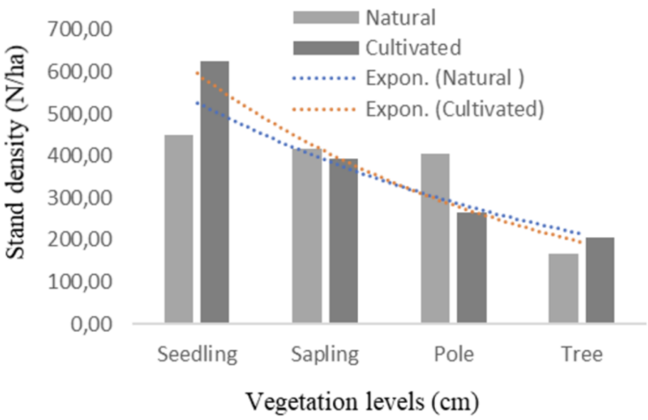

Figure 7. Stand density of vegetation at each growth stage in the habitat of naturally grow and cultivated agarwood trees in Buru Island, Maluku Province, Indonesia

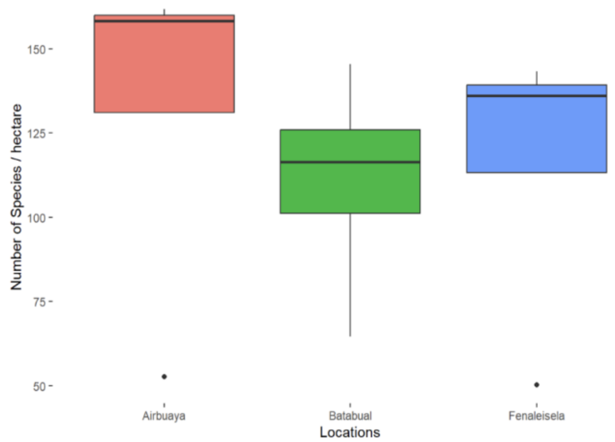

Figure 8. Number of species in the habitat of naturally grow agarwood plants in three study locations in Buru Island, Maluku Province, Indonesia

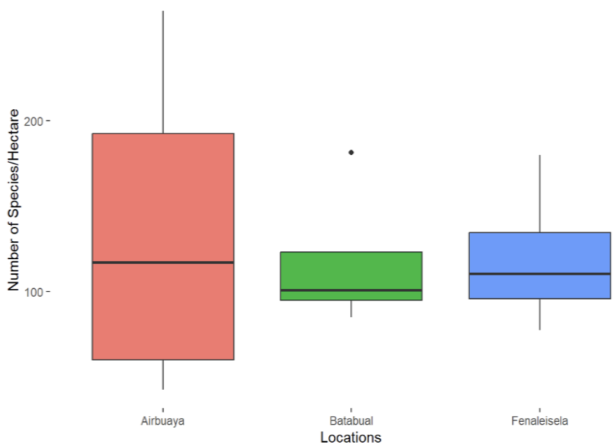

Figure 9. Number of species in the habitat of cultivated agarwood plants in three study locations in Buru Island, Maluku Province, Indonesia

In the habitat of naturally grow agarwood plant, the vegetation community was composed by 33% of agarwood-producing plants, 32% of other dominant species including *Paraserianthes falcataria*, *Anthocephalus cadamba*, *Agathis dammara*, *Shorea* sp. and *Pometia pinnata*, and the rest is other plant species. This shows that the *Aquilaria* sp. in its natural habitat is more dominant across the three study locations (Table 1). According to Karmilasanti and Fajri (2020), species composition presents the number of species, the existence of species, and the level of species control in the community.

In the habitat of cultivated agarwood, the vegetation community was composed by agarwood-producing plants (33%) and non-agarwood plants (29%), including *Myristica fragrans*, *Syzygium aromaticum*, *Mangifera indica*, *Tectona grandis* and *Cocos nucifera* (Table 2).

Based on the result of this study, *Aquilaria* spp. are highly potential in both natural and cultivated habitat. The species composition shows the number of species and abundance in a forest area. The stand composition describes the number of plant species in an area and the stratification of all plant species, based on the height of various tree species and other plant combinations. The stand composition can change over time, depending on the environmental condition. Biodiversity is the number of differences in the amount of natural diversity, which includes the quantity and frequency of ecosystems, species, and genes in a site (Kusmana and Melyanti 2017). In a forest ecosystem, vegetation and its environmental conditions will be closely related to each other. The differences in the number and shape of the structure of each plant type indicate this relationship. The diversity pattern and forest stand structure are always changing and depend on biotic and abiotic environmental conditions.

In Table 3, the most dominant species in the habitat of naturally grow agarwood was *Aquilaria* sp. with an Important Value Index (IVI) of 161.85% at the seedling level and the lowest value was *Shorea* sp. with 50.33% at the tree level. The highest IVI was at the Airbuaya location, while the lowest IVI was at the Fena Leisela location. The dominant species in the habitat of cultivated agarwood in Airbuaya for both seedling and tree levels were *Aquilaria* sp. with the highest IVI of 264%, while the lowest was *M. indica* with 42.93%. The abundance of a species in an area reflects whether the species is dominant or not, indicating the extent of its role or influence within the ecosystem. Kusmana and Susanti (2015) explained that dominance in plant species is caused by high ability to utilize existing resources compared to other species. The magnitude of the IVI of a species indicates the species density value, relative frequency level, and relative dominance that influence each other. Dendang and Handayani (2015) stated that the importance value index of a species illustrates the stability of species existence or high opportunity to maintain the species growth.

Various IVI levels indicate the influence of environmental factors, including temperature, humidity, nutrient competition, sunlight, and growing space with other species, that greatly affect the diameter growth of the vegetation and human activities through the indirect contact with the forest. The magnitude of the IVI of a species indicates the role of a species in a community. High density and evenly distributed species throughout the area indicate a high importance value index (Oyelowo et al. 2012; Kusmana and Susanti 2015; Pamoengkas et al. 2019).

Kusmana and Susanti (2015) stated that the species concentration occurs when it is found in large number (high density), evenly distributed, discovered in almost all observation plots, and measured to have a larger diameter than other species. The control of a particular species in a community shows that the species is able to highly absorb most of the existing resources compared to other species. The higher IVI level of a species, the greater control over the community, and *vice versa* (Asmayanur 2012; Purnama et al. 2019). In addition, Kacholi (2014) stated that species with lower IVI level indicate that most of the species are difficult to adapt with the environmental condition of the habitat. At the tree and pole levels, a dominant species is indicated by IVI value greater than 15%, while at the sapling and seedling levels is characterized by IVI value greater than 1% (Wahyuni and Mokodompit 2016; Purnama et al. 2019). Thereby, high IVI value indicates a species concentration in the plant community (Purnama et al. 2019).

Diversity, evenness, and richness indices

The Diversity Index (H') of the vegetation community in the habitat of naturally grow and cultivated agarwood plants at the three study locations is presented in Table 4. The Diversity Index in the natural habitat ranged from 0.03 to 2.70, while in the habitat of cultivated plants, the Diversity Index ranged from 0.18 to 1.33. This indicates that the diversity of both natural and cultivated habitats falls within the low to moderate range.

Batabual had the highest bioDiversity Index in the natural habitat of agarwood plants, while the cultivated habitat had the lowest values. This indicates that the natural forest in Batabual is better preserved. Fena Leisela had the highest plant species richness in the natural habitat, suggesting that the location has great potential for hosting various plants, both for conservation and cultivation. Airbuaya showed the highest Diversity Index in both habitat types, indicating a more uniform distribution of individuals. However, the species richness was low, both in natural and cultivated sites, suggesting that there were only a few plant species at that location.

Table 1. Composition of agarwood and some dominant non-agarwood species in the habitat of naturally grow agarwood plants in three locations in Buru Island, Maluku Province, Indonesia

Species	Sub-district			Average
	Air Buaya	Fena Leisela	Bata-bual	
Agarwood				
Aquilaria spp.	48%	13%	38%	33%
Non agarwood				
Paraserianthes falcataria	-	14%	-	5%
Anthocephalus cadamba	-	14%	-	5%
Agathis dammara	53%	-	-	18%
Shorea sp.	-	5%	-	2%
Pometia pinnata	-	-	6%	2%

Table 2. Composition of agarwood and dominant non-agarwood species in the habitat of cultivated agarwood plants in three locations in Buru Island, Maluku Province, Indonesia

Species	Sub-district			Average
	Air Buaya	Fena Leisela	Bata-bual	
Agarwood				
Aquilaria spp.	50%	22%	28%	33%
Non agarwood				
Myristica fragrans	18%	-	-	6%
Syzygium aromaticum	-	10%	-	3%
Mangifera indica	43%	0	-	14%
Tectona grandis	-	8%	-	3%
Cocos nucifera	-	-	9	3%

Table 3. Importance value index of species in the habitat of naturally grow and cultivated agarwood trees in three study locations in Buru Island, Maluku Province, Indonesia

Growth stage / Location	Natural		Cultivated	
	Species name	IVI (%)	Species name	IVI (%)
Seedling				
Airbuaya	*Aquilaria* sp.	161.85	*Aquilaria* sp.	264.51
Fena Leisela	*Parasariantes falcataria*	143.29	*Myristica fragrans*	180.12
Batabual	*Aquilaria* sp.	145.40	*Aquilaria* sp.	181.50
Sapling				
Airbuaya	*Aquilaria* sp.	159.35	*Aquilaria* sp.	168.71
Fena Leisela	*Anthocephalus cadamba*	137.97	*Aquilaria* sp.	119.42
Batabual	*Aquilaria* sp.	119.42	*Syzygium aromaticum*	103.88
Ples				
Airbuaya	*Aquilaria* sp.	157.18	*Aquilaria* sp.	65.98
Fena Leisela	*Aquilaria* sp.	134.32	*Aquilaria* sp.	102.06
Batabual	*Aquilaria* sp.	113.43	*Aquilaria* sp.	98.17
Tree				
Airbuaya	*Agathis dammara*	52.71	*Mangifera indica*	42.93
Fena Leisela	*Shorea* sp.	50.33	*Tectona grandis*	77.72
Batabual	*Pometia pinnata*	64.58	*Cocos nucifera*	85.24

Table 5 shows the Evenness Index (E) values at the three study locations. The evenness values in the natural habitat of agarwood plants ranged from 0.12 to 0.84, while for cultivated habitat, it ranged from 0.11 to 0.80. This indicates that the distribution of species varies from uneven to even. The Richness Index (RI) in the natural and cultivated habitat of agarwood plants at the three study locations can be seen in Table 6. The richness index in the natural habitat ranged from 1.11 to 3.10, indicating a moderate level of species richness. Meanwhile, the richness index in the cultivated habitat ranged from 0.37 to 2.24, suggesting a low level of species richness.

The recapitulation of Diversity Index, evenness, and species richness is presented in Table 7. The calculation of the Diversity Index, evenness, and richness aims to understand the vegetation condition within a community. The Diversity Index ranges from 1.08 to 4.17. The species diversity values for the seedling level are 2.08 and 3.35, the sapling level is at 2.82 and 4.17, the pole level is at 1.30 and 3.53, and for the tree level is at 1.08 and 2.83. The Diversity Index values for naturally growing plants are moderate to high, while for cultivated plants are moderate. The high or low Diversity Index of a plant community depends on the number of species and individuals in all categories. High plant species diversity helps natural forests maintain ecological balance (Safe'i et al. 2018). Species diversity in a forest can be seen through its structure and composition. Tree species diversity is an indicator of forest health as it is highly sensitive to changes, an indicator of ecological systems, and an indicator of trophic, temporal, and spatial heterogeneity. Meanwhile, biodiversity is greatly influenced by environmental factors, and interactions between living organisms and their environment play a significant role (Safe'i et al. 2018). Biodiversity is reflected in the variation and characteristics of organisms and their traits at all levels of the life hierarchy, from molecular to ecosystem levels (Morris et al. 2014). The high or low diversity of species in an area is caused by certain factors. Soil types, including rocks/geology, climate, elevation variations, and protected areas, all influence the diversity of plant species in an area (Kusmana and Susanti 2015). Meanwhile, the growth and distribution of *Aquilaria* spp. are strongly influenced by soil characteristics such as texture, pH, and organic content, as well as high rainfall and humidity, with microclimatic factors also limiting natural regeneration.

Excessive exploitation, forest fragmentation, and land conversion contribute to the decline of natural populations. *Aquilaria* tends to occupy narrow niches in secondary habitats, making conservation threats increasingly severe without strengthened community empowerment and data-based ecosystem management (Destri et al. 2020)

Table 4. Diversity Index (H') of the habitat of naturally grow and cultivated agarwood plants at various growth levels in three study locations in Buru Island, Maluku Province, Indonesia

Growth level	Natural			Cultivated		
	Air Buaya	Fena Leisela	Batabual	Air Buaya	Fena Leisela	Batabual
Seedling	1.17	0.88	0.03	1.33	0.72	1.29
Sapling	2.70	0.58	0.89	0.96	0.62	1.24
Poles	0.48	0.45	2.60	0.27	0.37	0.66
Tree	0.52	0.54	1.77	0.54	0.36	0.18
Average	1.22	0.61	1.32	0.78	0.52	0.84

Table 5. Evenness Index (E) of the habitat of naturally grow and cultivated agarwood plants at various growth levels in three study locations in Buru Island, Maluku Province, Indonesia

Growth level	Natural				Cultivated			
	Air Buaya	Fena Leisela	Batabual	Average	Air Buaya	Fena Leisela	Batabual	Average
Seedling	0.84	0.45	0.83	0.71	0.59	0.37	0.80	0.59
Sapling	0.57	0.23	0.31	0.37	0.69	0.23	0.28	0.40
Poles	0.21	0.18	0.12	0.17	0.11	0.16	0.54	0.27
Tree	0.19	0.19	0.46	0.28	0.49	0.16	0.09	0.25
Average	0.45	0.36	0.35	0.41	0.43	0.35	0.33	0.40

Table 6. Richness Index (RI) of the habitat of naturally grow and cultivated agarwood plants at various growth levels in three study locations in Buru Island, Maluku Province, Indonesia

Growth level	Natural			Cultivated		
	Air Buaya	Fena Leisela	Batabual	Air Buaya	Fena Leisela	Batabual
Seedling	1.25	1.91	1.41	0.37	1.88	1.36
Sapling	1.11	3.10	1.82	0.69	2.24	1.76
Poles	2.14	2.44	2.60	2.24	1.53	1.82
Tree	2.82	2.95	1.77	1.62	1.66	1.47
Average	1.83	2.60	1.90	1.23	1.83	1.60

The evenness values range from 0.17 to 0.59. The evenness values in the study indicate a range from 0 to close to 1, meaning that the species evenness at the study locations for both natural and cultivated sites is uneven, with the distribution of individuals within an area being either uneven or even. Species evenness at a location is considered uniform when the index value approaches 1, and the opposite is true when it is closer to 0. The high and low types of sub-diversity in an area are caused by certain factors. Soil types, including rocks/geological condition, climate, altitude variations, and protected areas influence the diversity of plant species in an area (Kusmana and Susanti 2015). Nahlunnisa et al. (2016) and Istomo and Hafazalah (2023) stated that species evenness in a location describes the balance between one species and another. High evenness indicates a stable and healthy ecosystem.

The species richness index range 3.60 to 7.54. The species richness value is at medium to high richness at all growth levels for both naturally grow and cultivated plants. The species richness value shows the relative dominance of a species in a community. The species richness value in an area can be used as a tool or indicator for environmental management and conservation. The species richness index value is positively correlated with the number of species in the community. Increased species population due to high opportunity of the species to be found can boost the richness index value (Oladoye et al. 2014).

The correlation between tree height and diameter at the three locations, for both natural and cultivated habitats, can be seen in Figure 10. The correlation between tree height and diameter shows a positive relationship between stem diameter and tree height. This means that the larger the stem diameter, the taller the plants found at the three locations. The regression line demonstrates a clearer linear trend, indicating that as stem diameter increases, tree height tends to increase as well. In other words, plants with larger stem diameters tend to also have greater height.

In general, with plant growth, larger or older plants tend to have a larger stem diameter and height. Although there is a general pattern showing a positive relationship, there is also considerable variation in each location category. This indicates that the stem diameter has an impact on plant height, but there are other factors influencing plant growth in the wild, such as soil conditions, weather, competition among plants, and water availability. This rapid growth may indicate increasingly favorable environmental factors, such as adequate rainfall, nutrient availability in the soil, and minimal disruption to the natural growth of trees (Safitri et al. 2020).

Table 7. The recapitulation of Diversity Index (H), Evenness Index (E), and species richness index (RI) on different vegetation levels across the three study locations

Location	Vegetation levels	H'	E	RI
Natural	Seedling	3.35	0.71	4.58
Cultivated		2.08	0.59	3.60
Natural	Sapling	2.82	0.37	6.03
Cultivated		4.17	0.40	4.70
Natural	Poles	1.30	0.17	7.17
Cultivated		3.53	0.27	5.59
Natural	Tree	1.08	0.49	7.54
Cultivated		2.83	0.25	4.75

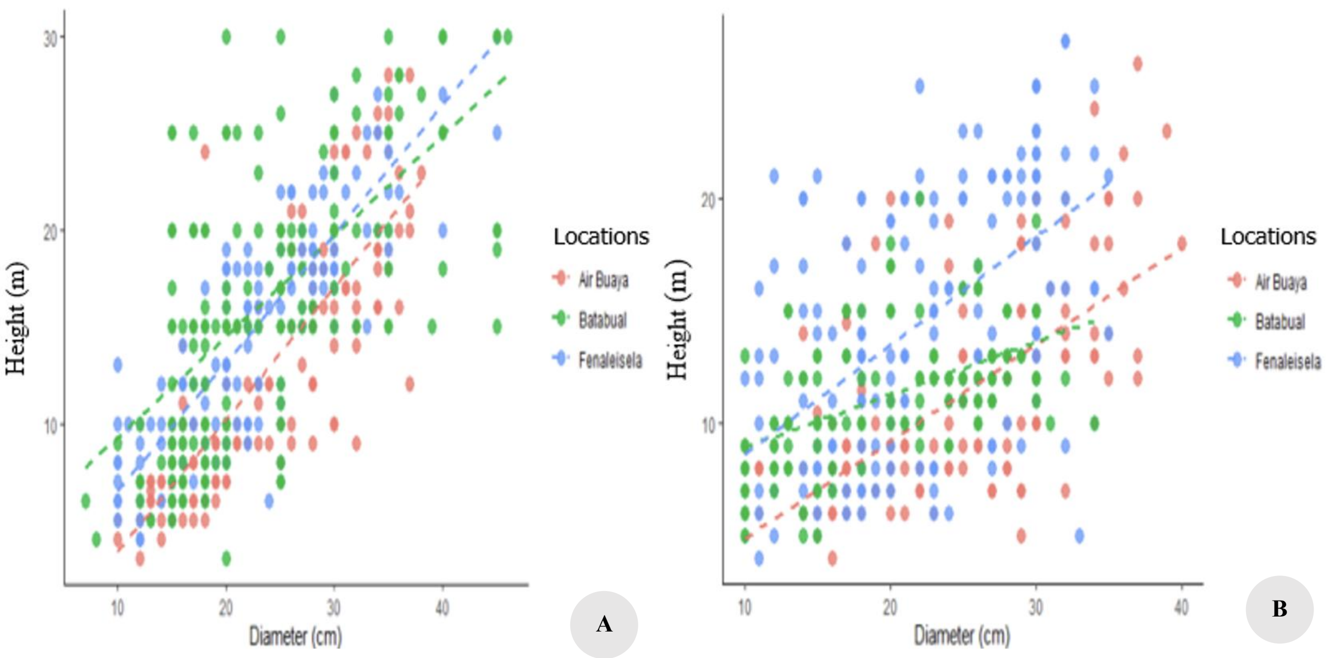

Figure 10. The correlation between tree height and diameter at three study locations in natural habitat (A), cultivated habitat (B) of agarwood plants in Buru Island, Maluku, Indonesia

The Air Buaya location, marked by a red gradient, tends to have a more dispersed pattern compared to the data points from Batabual (green) and Fena Leisela (blue). This indicates that the environmental conditions in Air Buaya are more variable for plant growth compared to the other two locations. The correlation for cultivated plants shows a positive relationship between tree diameter and height, with a similar trend. Although both graphs exhibit similar patterns, it is evident in the cultivated plants that there is a more structured or consistent variation compared to natural vegetation. This could be due to more controlled management factors at the cultivation sites, such as more organized plant maintenance.

The tree height characteristics at the three study locations can be seen in Figure 11. The tallest trees are in Air Buaya at the cultivation site, with a height of 23.8 meters, while the maximum height in Fena Leisela and Batubual is only 16.8 and 12.4 meters. Overall, tree diameter growth in all locations shows a positive trend, likely influenced by environmental factors such as water availability, soil fertility, and ecological conditions that support plant growth. Soil nutrient absorption supports photosynthesis and tissue formation, playing a crucial role in plant growth (Aldafiana and Murniyati 2021).

The bio-physical conditions show that agarwood plants on Buru Island grow at elevations ranging from 400 to 650 meters above sea level. The climate of Buru Island has relatively high rainfall, with an average annual rainfall of 1,757.5 mm, or approximately 146.5 mm per month. The soil types are mostly volcanic and alluvial. Buru Island has sufficient water availability, as well as genetic, species, and ecosystem diversity. Land conversion, deforestation, soil erosion, and pollution are present in the study locations. The characteristics of the growth environment for agarwood-producing trees, both geographically and ecologically, provide important information about the growth of agarwood plants (Table 8). *Aquilaria* spp. is a species that grows at elevations of 700 to 1000 meters above sea level (Mpapa and Lamusu 2014; Susilo et al. 2014; Rahmat and Nurlia 2015; Putra et al. 2020). It grows in various soil conditions, from fertile to moderate, and the availability of sufficient water strongly supports the growth of agarwood.

Buru Island has biophysical conditions that support the growth of agarwood plants, including suitable elevation, adequate rainfall, suitable soil types (volcanic and alluvial), and sufficient water availability. Biodiversity on Buru Island is also high, with good genetic variation and ecosystems. These factors provide a strong foundation for the development of agarwood in this area, which can produce high-quality agarwood and extend the productive lifespan of the trees, provided that environmental management, including land conversion and deforestation, is carefully considered.

Buru Island has a rich biodiversity, with variations and characteristics of organisms along with their traits reflecting the area's biodiversity (Morris et al. 2014). The development of agarwood on Buru Island will progress more effectively, producing high-quality agarwood and extending the productive lifespan of the trees when considering bio-physical conditions. Biophysical conditions are a crucial factor in agarwood development as they influence the growth of agarwood-producing trees, the quality of resin produced, and the potential for sustainable development. To ensure agarwood trees grow optimally and produce high-quality agarwood, these factors must be carefully considered in the development process on Buru Island (Table 8).

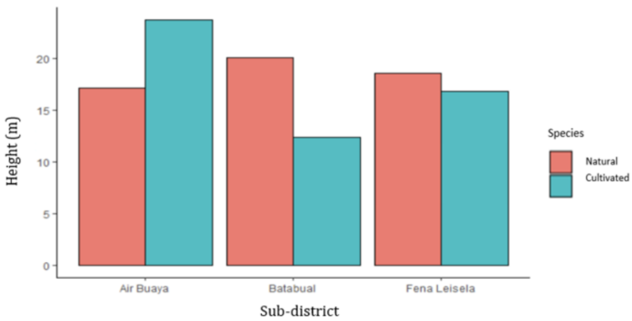

Figure 11. Tree height characteristics with a diameter greater than 10 cm at three locations

Table 8. Biophysical conditions at the habitats of agarwood plants in three study locations in Buru Island, Maluku Province, Indonesia

Biophysical aspect	Location		
	Air Buaya	Fena Leisela	Batabual
Elevation	400 to 450 m asl	400 to 450 m asl	650 m asl
Climate	Rainfall of 1,757.5 mm per year, or an average of 146.5 mm per month.	Rainfall of 1,757.5 mm per year, or an average of 146.5 mm per month.	Rainfall of 1,757.5 mm per year, or an average of 146.5 mm per month.
Soil types	Volcanic and alluvial	Volcanic and alluvial	Volcanic and alluvial
Water availability	Sufficient	Sufficient	Sufficient
Biological diversity	Genetics, species, and ecosystems	Genetics, species, and ecosystems	Genetics, species, and ecosystems
Land degradation	Pressure due to land conversion and deforestation	Pressure due to land conversion and deforestation	Pressure due to land conversion and deforestation
Pollution and environmental damage	Mining activities/other activities	Mining activities/other activities	Mining activities/other activities

In conclusion, the stand structure at the study location presents an inverted "J" curve form, which indicates a general diameter distribution class condition. The composition of natural and cultivated forest types consists of *Aquilaria* spp. and non-*Aquilaria*. Besides *Aquilaria*, the dominant species in the natural location are also commercial types, such as *P. falcataria*, *A. cadamba*, *A. dammara*, *Shorea* sp., and *P. pinnata*. The dominant types in cultivated plants are *M. fragrans*, *S. aromaticum*, *C. nucifera*, *T. grandis*, and *M. indica*. The Diversity Index at each growth level is characterized as moderate to high with an index value of H<2 and H>2. The study locations have an evenly-distributed species. A moderate-to-high richness index at the study locations is presented in all growing levels. The correlation between tree height and diameter shows a positive relationship between stem diameter and tree height. The abundance of agarwood-producing tree species on Buru Island reflects favorable biophysical and ecological environmental characteristics, indicating strong potential for agarwood development, particularly in terms of species composition, distribution, and optimal growth conditions.

ACKNOWLEDGEMENTS

Education Fund Management Institute (LPDP) Ministry of Finance of the Republic of Indonesia for dissertation research funds.

REFERENCES

Aldafiana S, Murniyati A. 2021. Growth in height, diameter, and volume of sengon (*Paraserianthes falcataria*) plants aged 10 years in Perdana Village, Kembang Janggut District, Kutai Kartanegara. Eboni J 3 (2): 73-78.

Azah Nor MA, Husni SS, Mailina J, Sahrim L, Abdul MJ, Faridz MZ. 2013. Classification of agarwood (agarwood) by resin content. J Trop For Sci 25 (2): 213-219. DOI: 10.11113/jt.v77.5986.

Badan Pusat Statistik. 2016. Forestry Production Statistics: Forestry Production Statistics. BPS, Indonesia. [Indonesian]

CITES. 2017. Appendices I, II and III the Convention on International Trade in Endangered Species of Wild Fauna and Flora. CITES. https://cites.org/sites/default/files/eng/app/2017/E-Appendices-2017-10-04.pdf.

Dendang B, Handayani W. 2015. Structure and composition of forest stands in Mount Gede Pangrango National Park, West Java. Prosiding Seminar Masyarakat Biodiversity Indonesia. Yogyakarta, 21 Maret 2015. [Indonesian]

Destri, Zaenal M, Rozak AH. 2020. Agarwood in the forest community and its potential depletion in West Papua. J Wallacea For Res 9 (1): 1-12. DOI: 10.18330/jwallacea.2020.vol9iss1pp1-12.

Feldmann E, Glatthorn J, Ammer C, Leuscher C. 2020. Regeneration dynamics following of understory gaps in a Slovakian Beech Virgin Forest. Forests 11 (5): 585. DOI: 10.3390/f11050585.

Gebeyehu G, Soromessa T, Bekele T, Teketay D. 2019. Species composition, stand structure, and regeneration status of tree species in dry afromontane forests of Awi Zone, Northwestern Ethiopia. Ecosyst Health Sustain 5 (1): 199-215. DOI: 10.1080/20964129.2019.1664938.

Gedefaw M, Soromessa T. 2014. Status and woody plant species diversity in Tara Gedam Forest, Northern Ethiopia. Science, Technol Arts Res J 3 (2): 113-118. DOI: 10.4314/star.v3i2.15.

Hilwan I, Masyrafina I. 2015. The diversity of undergrowth species in the eastern part of Papandayan mountain, Garut, West Java. Jurnal Silvikultur Tropika 6 (2): 119-125.

Indriyanto. 2008. Ekologi Hutan. PT Bumi Aksara, Jakarta. [Indonesian]

Istomo, Ferliana E. 2024. The composition and structure at Wan Abdul Rachman Park conservation area, Lampung. Jurnal Silvikultur Tropika 15 (1): 1-8. DOI: 10.29244/j-siltrop.15.01.1-8.

Istomo, Hafazallah K. 2023. Plant diversity in protected area of IUPHHK-HT PT. Wana Hijau Pesaguan in Province West Kalimantan. Jurnal Silvikultur Tropika 14 (1): 30-38. DOI: 10.29244/j-siltrop.14.01.30-38.

Istomo, Hartarto W. 2019. Composition of types and structures establish various forest formations at Bama resort Baluran National Park, East Jawa. Jurnal Silvikultur Tropika 10 (2): 75-82. DOI: 10.29244/j-siltrop.10.2.75-82.

Kacholi DS. 2014. Analysis of structure and diversity of the Kilengwe Forest in the Morogoro Region, Tanzania. Intl J Biodivers 2024: 516840. DOI: 10.1155/2014/516840.

Karmilasanti, Fajri M. 2020. Structure and species composition of tree in secondary forest: A case study at KHDTK Labanan, East Borneo Province. Jurnal Penilitian Hutan Tanaman 17 (2): 69-85. DOI: 10.20886/jpht.2020.17.2.69-85.

Kusmana C, Melyanti R. 2017. Species Composition and vegetation structure of protected forest area using CBFM (Community Based Forest Management) in BKPH Tampomas, FMU (Forest Management Unit) Sumedang Perum Perhutani Regional Division of West Java and Banten Region. Jurnal Silvikultur Tropika 8 (2): 123-129. DOI: 10.29244/j-siltrop.8.2.123-129.

Kusmana C, Susanti S. 2015. Species composition and stand structure of natural forest in Hutan Pendidikan Gunung Walat, Sukabumi. Jurnal Silvikultur Tropika 5 (3): 210-217.

Larocque GR. 2022. Simulation models of dynamics of forest ecosystems. Forests 13 (5): 705. DOI: 10. 3390/f13050705.

Lee SY, Turjaman M, Chaveerach A, Subasinghe S, Fan Q, Liao W. 2022. Phylogenetik relationships of *Aquilaria* and *Gyrinops* (Thymelaeaceae) revisited: Evidence from complete plastid genomes. Bot J Linn Soc 200 (3): 344-359. DOI: 10.1093/botlinnean/boac014.

Liu J, Zhang X, Yang J, Zhou J, Yuan Y, Jiang C, Chi X, Huang L. 2019. Agarwood wound locations provide insight into the association between fungal diversity and volatile compounds in *Aquilaria* sinensis. Royal Soc Open Sci 6 (7): 190211. DOI: 10.1098/rsos.190211.

Mannan A, Malik A, Zhiddiq S. 2024. Degradasi biodiversitas wallacea; Tantangan ekologi dan kebutuhan ekonomi. J Environ Sci 6 (2): 36-53. DOI: 10.35580/jes.v6i2.60931. [Indonesian]

Melesse B. 2024. Structural analysis and woody plant species composition of Arba Minch Riverine Forest, Southern Ethiopia. Omo Intl J Sci 1 (1): 15-27.

Mokennen AB, Mohammed AS, Demissew A. 2023. Species diversity, structure, and regeneration status of woody plants in Saleda Yohans Church Forest, South Wollo, Ethiopia. Sci J 2023: 3853463. DOI: 10.1155/2023/3853463

Morris EK, Coruso T, Buscot F, Fisher M, Hancock C, Maier TS, Meiners T, Muller C, Obiemaeir E, Prati D, Socher SA, Sonnemann I, Waschke M, Wurst S, Rilig MC. 2014. Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. J Ecol Evol 4 (18): 3514-3524. DOI: 10.1002/ece3.1155.

Mpapa BL, Lamusu D. 2014. Growth rate of agarwood-producing plants of the *Aquilaria malaccensis* Species. Jurnal Agrohut 5 (2): 110-115. [Indonesian]

Nahlunnisa H, Zuhud EAM, Santosa Y. 2016. The diversity of plant species in high conservation value area of oil palm plantation in Riau Province. Media Konservasi 21 (1): 91-98. DOI: 10.29244/medkon.21.1.91-98.

Nurfaeiza SAR, Shamsul K, Wan Yuliana WA, Shukor MN. 2022. Tropical rainforest regeneration in an area devastated by dam impoundment in Hulu Terengganu, Malaysia. Malays For 85 (1): 96-108.

Oladoye AO, Aduradola AM, Adedire MO, Agboola DA. 2014. Composition and stand structure of regenerating tropical rainforest ecosystem in South-western Nigeria. Intl J Biodivers Conserv 6 (11): 765-776.

Oyelowo OJ, Aduradola AM, Ekpo EN, Ine I. 2012. Efloristic composition of a sacred grove in igbara-oke, ondo state, Nigeria. J For Res Manag 9: 83-92.

Pamoengkas P, Zamzam A, Dwisutono A. 2019. Vegetation recovery of logged-over dipterocarp forests in Central Kalimantan, Indonesia.

Journal Floresta Ambiente 26 (3): 1-11. DOI: 10.1590/2179-8087.123917.
Prastyaningsih SR, Ervayenri E, Azwin, A. 2015. Potential of cultivated agarwood-producing plants in Kampar Regency, Riau Province. Wahana Forestra 10 (2). DOI: 10.31849/forestra.v10i2.232.
Purnama A, Wasis B, Hilwan I. 2019. Vegetation characteristics in lowland natural forest, plantation forest, and post nickel mining land in Bombana District. Jurnal Silvikultur Tropika 10 (3): 140-145. DOI: 10.29244/j-siltrop.10.3.140-145.
Putra A, Prastiawan AD, Prihanto D. 2020. Exploring the Potential and problems of Agarwood Development (*Aquilaria* Spp) in Putat Lor Village. J Karinov 3 (2): 121-125.
Rachmawaty R, Ashar A, Ali A, Fagarra H, Hiola SF. 2021. Formation of Agarwood on the tree *Aquilaria malaccensis* Lamk., Using Inoculum *Fusarium* sp. J Sainsmat 10 (2): 178-188. DOI: 10.35580/sainsmat102262252021.
Rahmat M, Nurlia A. 2015. Conservation and development of agarwood-producing plant species in the Lakitan Forest Management Unit: Potential, challenges, and policy alternatives. Prosiding Workshop Penguatan Apresiasi dan Kesadaran Konservasi Jenis Kayu Lokal Sumatra Bernilai Tinggi. Pekanbaru, 23 April 2015. [Indonesian]
Safe'i R, Erly H, Wulandari C, Kaskoyo H. 2018. Analysis of tree diversity as an indicator of the health of conservation forests. J Perennial 14 (2): 32-36. DOI: 10.24259/.v14i2.5195.
Safitri B, Wahyudi, Christopheros. 2020. Distribusi diameter tanaman sengon (*Paraserianthes falcataria*) sebagai indikator pertumbuhan normal Jurnal Hutan Tropika 15 (1): 43-50. DOI: 10.36873/jht.v15i1.1713. [Indonesian]
Segura C, Jiménez MN, Fernández-Ondoño E, Navarro FB. 2021. Effects of afforestation on plant diversity and soil quality in Semiarid SE Spain. Forests 12 (12): 1730. DOI: 10.3390/f12121730.
Sulistiono N, Insusanty E, Azwin. 2018. Survey of agarwood potential with agroforestry system in the XIII Koto Kampar sub-district, Kampar district (case study: Pulau Gadang village and Koto Masjid village). Wahana For 13 (1): 12-21. DOI: 10.31849/forestra.v13i1.1280.
Susilo A, Kalima T, Santoso E. 2014. Introduction to Agarwood-Producing Plant Species *Aquilaria* spp. in Indonesia. Forest Conservation and Rehabilitation Research and Development Agency. Ministry of Forestry, International Tropical Timber Organization (ITTO), CITES Phase II Project Bogor, Indonesia
Uar NI, Karlinasari L, Siregar IZ, Pertiwi S. 2024. Chemical content of agarwood-producing trees from Buru Island, Maluku, Indonesia. Biodiversitas 25 (8): 2629-263. DOI: 10.13057/biodiv/d250835.
Vantompan WDP, Arreneuz S, Wibowo MA. 2015. Comparison fusarium sp inoculant using infusion and injection methods to get agarwood on *Aquilaria malaccensis* trees. J Equat Chem 4 (1): 34-37.
Wahyuni NI, Mokodompit HS. 2016. Structure, composition, and tree species diversity in the Inobonto Poigar I Production Forest, KPHP Poigar, North Sulawesi. Wasian J 3 (1): 45-50. DOI: 10.20886/jwas.v3i1.1174.
Zhang L, Feng H, Du M, Wang Y, Lai G, Guo J. 2022. Dynamic effects of structure-based forest management on stand structure in a *Platycladus orientalis* plantation. Forests 13 (6): 852. DOI: 10.3390/f13060852.