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Research Article

Tree Architecture Models of the *Syzigium* Genus Collection at the Purwodadi Botanical Gardens

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ABSTRACT
There are many species of plants in the genus *Syzygium*. This genus is distinguished by its strong root system, evergreen, sprawling and complex tree crowns and a powerful branching system on the trunk. The vertical structure of *Syzygium* trees is distinguished by branching a large crown. Based on its characteristics, the genus *Syzygium* has a great potential in supporting the sustainability of ecosystem balance. The diversity of tree architecture possessed by the genus *Syzygium* allows *Syzygium* species to play an active role in soil and water conservation efforts. The aim of this study is to identify various architectural models of trees *Syzygium* species in the collection of Purwodadi Botanical Garden in order to assess their role in the ecosystem. The method used in this study was to measure the physical characteristics of trees, such as tree height, trunk diameter, and crown area, and to observe the shape of trees, such as stem growth patterns, branching patterns, and direction of branch development. As the result, of the 17 *Syzygium* tree species selected and in accordance with the research criteria, 7 of them have the Stone model, 3 species have the Scarrone model, 2 species have the Attims model, 2 species have the Petit model, and 1 species each has the Koriba, Massart, and Troll models. Each variation of tree architecture model has different functions to the ecosystem.

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INTRODUCTION

Forest has an important role in the water cycle regulation, the carbon cycle role, and the habitat for world terrestrial biodiversity (Indrajaya et al. 2022). One of the botanical gardens in Indonesia that illustrates artificial dry lowland forest habitat is Purwodadi Botanical Garden (PBG) located in East Java. The genus *Syzygium*, a member of the Myrtaceae family, is one of the most abundant collections in the Purwodadi Botanical Garden (PBG), it grows naturally and can be found in both ex situ and in situ habitats surrounding the garden (Beech et al. 2017). PBG has an ecosystem that is still preserved. The abundance of tree collections and the similarity of tree conditions as in their natural habitat make Purwodadi Botanical Garden an optimal place for research.

Syzygium plays various roles in life (Aung et al. 2020, 2023; Ilham et al. 2022; Kristanti et al. 2022). *Syzygium* trees are characterised by varying heights, extensive branching systems, complex and shady crowns, the nature of roots that can withstand the river flow, as well as hold up or slows down the rate of river flow. Root systems jon strong pedestal stems (Mudiana 2016; Yasin et al. 2022). In stratum C of the tropical forest ecosystem, *Syzygium* trees have a vertical structure that has quite a lot of branching and crowns (Utami & Putra 2020). Thus, the *Syzygium* species will create various models of tree architecture, thus potentially conserving soil and water for the benefit of the ecosystem, *Syzygium* have an important role in the stabilisation of the region along the banks of the river (Mudiana 2016). Preliminary research shows that there is no significant difference between the physical characteristics of *Syzygium* trees in their natural habitat, dry lowland forest in Gunung Baung Nature Tourism Park (TWA), and *Syzygium* trees collected in Purwodadi Botanical Garden (*ex situ*), so *Syzygium* research should be conducted at PBG.

Tree crowns in the *Syzygium* tree architecture model can clarify the rainfall-mitigating and time-lagging effect during rainfall, and thereby helps to control peak flow, flood, and erosion (Li et al. 2016). Tree felling makes tree architecture dose not function optimally and puts water at risk of causing landslides and floods. Therefore, the ecological function of each species of *Syzygium* tree can be known by analysing architecture model. Tree architectural can describe those trees' ability to conserve the soil surface. Their model is a tree building model as a result of plant growth controlled by meris (Agung & Abban 2017).

The branching pattern of a tree derived from the morphological description of the crown at a certain stage of the tree is a model of tree architecture. According to Joye (2019), tree architecture describes the plant structure that occurs in all members of the same species. Environmental factors and growing sites also have an impact on the architectural state of each tree species. This results in different branching patterns, trunk shapes, and branching angles (Echereme et al. 2015). There are 23 widely recognised tree architecture models (Joye 2019).

Mudiana (2016) in his research on the *Syzygium* genus diversity in Pasuruan Regency, showed the results that this genus naturally grows in the forest of Mount Baung Pasuruan and along the river (Welang watershed). However, the researchers only collected data on *Syzygium* species. While Arlianty (2020) conducted research on tree architecture with various tree species on public senior high school, the results showed that there were 10 tree architecture models, Scarrone, Corner, Attims, Troll, Roux, Leeuwenberg, Koriba, Rauh, Aubreville and Stone. The tree architecture model that dominated the schools was the Troll model (35.7 %) with 15 species.

The innovative aspect of this research is the identification of *Syzygium* tree architecture models in the Purwodadi Botanical Garden collection as one of the plant genera that has strong, extensive, and complex crown branching in several tree architecture models. It is very important to analyse the tree architecture model as a first step to find out how each species of *Syzygium* tree contributes to the ecosystem. The purpose of this study is to determine the various architectural models of *Syzygium* trees in the Purwodadi Botanical Garden collection and their services or functions to the ecosystem.

MATERIALS AND METHODS

Study Area

In the vicinity of the Purwodadi Botanical Garden (Figure 1), this study was carried out in December 2022. The purposeful sampling strategy was used to pick the trees. Through exploration and observation, measurements of physical characteristics of trees and examinations of the shapes of *Syzygium* genus trees in the Purwodadi Botanical Garden collection were used to gather data for tree architecture models.

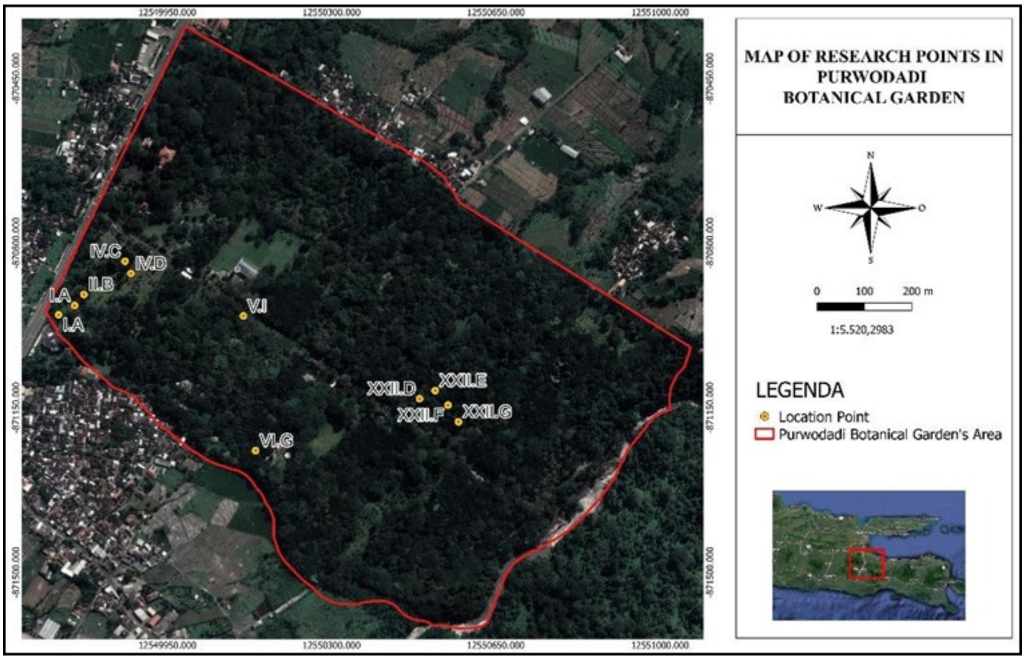

Figure 1. Map of research location points in Purwodadi Botanical Garden area.

Procedure

Measurement the physical factor of *Syzygium* tree

Measurements of tree physical factors include tree height, trunk diameter, and crown area (Figure 2). Tree height measurements were made using the *smartmeasure* application by reading the scale on the tool. Trunk diameter is measured using a measuring tape wrapped around the trunk with a height of 1.3 meters to get the circumference of the tree, then the circumference data is used for stem diameter analysis using the formula ($d = K/\pi$). Measurement of crown area was carried out by projecting the ends of the crown, from west to east and north to south on the ground [(D1 = West + East)] + [(D2 = North + South)]. The average length of these lines divided by 4 is considered the crown diameter (D=D1+D2/4). Furthermore, the diameter of the existing crown can be used to determine the crown area (Crown area = D=D1+D2/4) (Pretzsch et al. 2015).

Observation the Branching of Tree *Syzygium* Canopy

The architecture is the result of its adaptation to environment, branching architecture density is a highly variable, changing with age, position in canopy, access to light, plant vigour, disease, and water stress (Charles-Dominique et al. 2017). The architecture of trees can be approached from many viewpoints, according to the vertical and horizontal characteristic (Seidel et al. 2019). Tree growth patterns, branching patterns, and the direction of branch growth points can all be observed (Figure 3). According to McGarry et al. (2016), there are three different types of stem growth patterns: dichotomy (main stem is divided into two equal sections), sympodial (main stem cannot be distinguished from branches), and monopodial (the axis of growth continues from a single point) (Figure 3a). Orthotropic stems grow vertically, while plagiotropic ones grow horizontally, over or below the soil surface (Gambino et al. 2016, Figure 3b). The angle produced between the main stem and the branch can be used to classify the direction of branch growth point: fastigiated, patens, horizontal, and declinatus (Nurdiana 2020, Figure 3c). Eachspecies of *Syzygium* spp. is characterized by the data collected, which are then utilised to examine the tree architectural model.

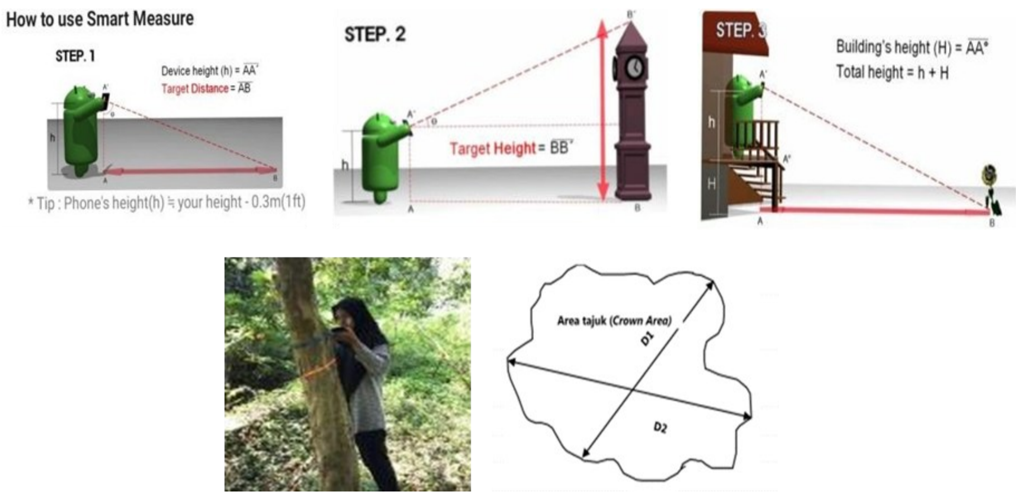

Figure 2. Measurement of physical factors of *Syzygium* trees. (a) Illustration of tree height measurement using *smartmeasure* . (b) Measurement of tree diameter. (c) Illustration of crown area measurement (Hematang et al. 2021).

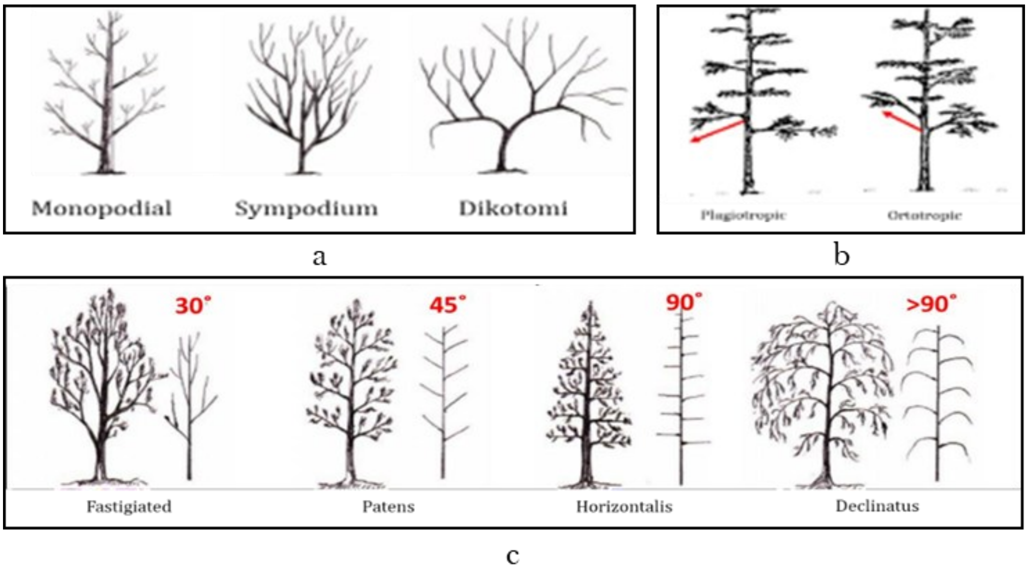

Figure 3. Variety of stem growth and branching models. (a) Trunk growth pattern. (b)Branching pattern. (c) Branch growth point direction (angle).

Tree Architecture Model Type Analysis

The analysis stage is carried out by documenting the image of each tree, then drawing illustrations through manual sketches, and also using artificial intelligence (AI) through the Dreamina Ai website to visualise the tree architecture model that has been observed.

RESULTS AND DISCUSSION

Syzygium Tree Collection of Purwodadi Botanical Garden

Trees are tall, bulky plants with a primary trunk that is at least 20 cm in diameter with the height of activity hole was 5.1 m (Pakkala et al. 2018). Trees also play key ecological and ecosystem roles, having major influences on hydrological cycles, nutrient cycles, disturbance regimes, and the distribution and abundance of populations of their own and other species (Lindenmayer & Laurance 2016). Table 1 lists 25 different *Syzygium* trees species, 17 of which visually resemble tree-level plants. Thus, one tree from each of the 17 species was selected, assessed for its physical characteristics, and its shape recorded to determine the tree architecture model.

Table 1. List of *Syzygium* spp. trees collection of Purwodadi Botanical Garden.

No.	Scientific Name	Total	Location/Vac.
1	*S. javanicum* Miq.	4	I A, IV D, V I, XXII D
2	*S. cumini* (L.) Skeels	2	II B, V I
3	*S. acuminatisimum* (Blume) DC.	2	IV C, XXII D
4	*S. pycnanthum* Merr. & L.M.Perry	2	XXII E, XXII F
5	*S. discophorum* (Koord & Valeton) Amshoff	2	XXII E, XXII F
6	*S. polycephalum* (Miq.) Merr. & L.M.Perry	1	V I
7	*S. jambos* (L). Alston	1	VI G
8	*S. lineatum* (DC.) Merr. & L.M.Perry	1	XXII D
9	*S. racemosum* (Blume) DC.	1	XXII D
10	*S. polyanthum* (Wight) Walp.	1	XXII D
11	*S. formosum* (Wall.) Masam.	1	XXII D
12	*S. nervosum* A.Cunn. ex DC.	1	XXII D
13	*S. sexangulatum* (Miq.) Amshoff	1	XXII D
14	*S. malaccense* (L.) Merr. & L.M.Perry	1	XXII E
15	*S. creaghii* (Ridl.) Merr. & L.M.Perry	1	XXII E
16	*S. aqueum* (Burm.f.) Alston	1	XXII F
17	*S. garcinifolium* (King) Merr. & L.M.Perry	1	XXII G
	Total	25	

Physical Factors of *Syzygium* spp. trees in Purwodadi Botanical Garden Collection

Measuring tree characteristics, such as height, trunk diameter, and crown area, is very important for determining the habitat or physical factors that influence each individual tree (Sirami & Manuhua 2022). The physical properties of each species of *Syzygium* are listed in Table 2, and they will be used to analyse the type under the "tree or pole" category. Tree height typically ranges from 6 to 21 meters. The diameter of the trunk then varies from 16 to 73.3 cm. While the diameter of the tree's crown varies from 4.6 to 57 meters.

Lowland forests are characterised by many dense tree-climbing plants, large buttressed trees, and many trees with tall. In the lowland forest, many tree species belong to the family Dipterocarpaceae, Lauraceae, Myrtaceae, Miristicaceae, and Ebenaceae (Nugraha & Kusmana 2022). According to Baker and Harper (2022) trees can be classified ecologically based on their stage of growth. The trunk diameter of young trees (poles) ranges from 10 to 20 cm, whereas the diameter of the tree category is greater than 20 cm. According to this idea, Table 2 results from measuring the *Syzygium* spp. tree's diameter indicate that the Purwodadi Botanical Garden's *Syzygium* tree collection falls under the umbrella of poles (young trees) and trees. According to their height, trees can be categorized into four groups: young small size, old small size, young big size, and old big size (Ali & Wang 2021). All of the *Syzygium* tree species now in existence are included in the three categories, according to the findings of this theory. Crown base height, diameter at breast height (usually measured at 1.3 m above ground), tree height, and crown radius are some examples of tree-based measurement (Seidel et al. 2019).

Table 2. Data on physical factors of 17 *Syzygium* spp. tree species in Purwodadi Botanical Garden collection.

No.	Scientific Name	Measurement of Tree Physical Factors		
		Tree Height (m)	Stem Diameter (cm)	Tree crown area (m)
1	*S. acuminatisimum*	9	20.7	2.8
2	*S. aqueum*	7	17.5	7
3	*S. creaghii*	10	17.2	6.9
4	*S. cumini*	10	57.4	57
5	*S. discophorum*	8	20.7	2.5
6	*S. formosum*	8	16	4.6
7	*S. garcinifolium*	13	41	7.72
8	*S. jambos*	6	27	9
9	*S. javanicum*	11	29	14.2
10	*S. lineatum*	11	37.9	10.4
11	*S. malaccense*	8	26.8	6.4
12	*S. nervosum*	13	30.3	6.7
13	*S. polyanthum*	21	42	11.5
14	*S. polycephalum*	20	73.3	10.53
15	*S. pycnanthum*	9	25.5	6
16	*S. racemosum*	14	34.4	20
17	*S. sexangulatum*	12	29	17

Shape of *Syzygium* spp. tree in Purwodadi Botanical Garden Collection

There are several considerations in determining the architectural model of a tree, a handful of morphological characters, such as the position of sexual structures or the orientation of axis growth (Chomicki et al. 2017). *Syzygium* tree observations include branching patterns, branch growth points, and stem growth patterns. In general, the stem growth pattern of the *Syzygium* species is sympodial, with up to 8 species, and monopodial, with up to 8 species. There is one form of tree with a dichotomous stem growth pattern. These findings are shown in Table 3. Then, there are up to 14 different forms of orthotropic branching and up to 3 different plagiotropic branching patterns that make up the branching pattern of *Syzygium* trees species. In terms of branch development points, the *Syzygium* species typically has branch growth points of patterns, which can have up to 9 types, fastigiated, which can have up to 3, horizontal, which can have up to 4, and declinatus, which can have up to 1 type (Table 3).

Plant branching patterns will create a tree architectural model, according to Shipunov (2023), there are three types of stem growth patterns: monopodial, sympodial, and dichotomous. According to Klimešová et al. (2019), monopodial branching occurs when the main stem is consistently visible, sympodial branching occurs when the main stem and branches cannot be distinguished, and according to Spencer et al. (2023), that dichotomy branching occurs when the branching divides into two equal portions (Shipunov 2018). There are two categories of branching patterns: orthotropic and plagiotropic. Plagiotropic is a branching pattern with a horizontal branch direction, whereas orthotropic is an upright branching pattern toward the vertical direction (Gambino et al. 2016). There are four types of branch growth points: patens, fastigiated, horizontal, and declinatus. With respect to the main stem, fastigiated is created with an angle of less than 30 degrees, patens with a 45-degree angle, a 90-degree horizontally, and declinatus with an angle greater than 90 degrees or drooping (Nurdiana 2020). To study the tree architecture model in each type of *Syzygium* tree, all patterns were applied.

Table 3. Observation data of 17 *Syzygium* spp. tree species in Purwodadi Botanical Garden collection.

No.	Scientific Name	Shape Observation			Tree Architecture Model
		Stem Growth Pattern	Branching	Branch Growth Point	
1	*S. acuminatisimum*	Monopodial	Orthotropic	Patens	Scarrone
2	*S. aqueum*	Sympodial	Orthotropic	Fastigiated	Stone
3	*S. creaghii*	Monopodial	Orthotropic	Fastigiated	Attims
4	*S. cumini*	Dichotomy	Orthotropic	Horizontalis	Koriba
5	*S. discophorum*	Monopodial	Plagiotropic	Horizontalis	Petit
6	*S. formosum*	Monopodial	Orthotropic	Patens	Scarrone
7	*S. garcinifolium*	Sympodial	Orthotropic	Patens	Stone
8	*S. jambos*	Sympodial	Orthotropic	Patens	Stone
9	*S. javanicum*	Sympodial	Orthotropic	Patens	Stone
10	*S. lineatum*	Sympodial	Orthotropic	Patens	Stone
11	*S. malaccense*	Monopodial	Plagiotropic	Declinatus	Massart
12	*S. nervosum*	Monopodial	Plagiotropic	Horizontalis	Petit
13	*S. polyanthum*	Monopodial	Orthotropic	Patens	Scarrone
14	*S. polycephalum*	Monopodial	Orthotropic	Patens	Attims
15	*S. pycnanthum*	Sympodial	Orthotropic	Patens	Stone
16	*S. racemosum*	Sympodial	Orthotropic	Fastigiated	Stone
17	*S. sexangulatum*	Sympodial	Orthotropic	Horizontalis	Troll

Architectural model of *Syzygium* spp. tree in Purwodadi Botanical Garden (PBG) collection

Purwodadi Botanical Garden has an ecosystem resembling a lowland forest with a dry climate that forms a landscape resembling a tropical forest. Tropical forests are full of trees with diverse trunk and canopy structures (tree architecture model) very similar to those in temperate climates (Heydari et al. 2020). Table 4 displays tree architecture models that were created using information from physical factor data analysis and branching pattern observations. Purwodadi Botanical Garden's *Syzygium* tree architecture collection has seven models, according to the data. Scarrone, Stone, Attims, Petit, Koriba, Massart, and Troll are a few of these models. Based on the available information, it is known that *Syzygium* trees own the Stone model the most, with a total of 7 different types of trees. The Attims model has two varieties of trees, the Petit model has two types of trees, the Scarrone model has three species of trees, the Koriba, Massart, and Troll models each have one type of tree (Table 4).

Based on the publication Tropical Trees and Forests by Helle et al. (1978) in Shipunov (2023), there are 23 models of tree architecture that are widely used. Two categories can be made up of the numerous tree architecture models. 1) Trees that are monocausal or have no branches, using the Holltum and Corner models. 2) The Tomlinson, Schoute, Chamberlain, McClure, Leeuwenberg, Koriba, Prevost, Fagerlind, Petit, Nozcran, Aubreville, Massart, Roux, Cook, Scarrone, Stone, Rauh, Attims, Mangenot, Champagnat, and Troll models are polyaxial trees, or trees having more than one branch. Each tree architecture model has a unique characteristic that is represented by the branching structure and trunk expansion. Although there was significant intraspecific variance in response to canopy variety in architectural traits is related to the functional (Loubota Panzou et al. 2018).

Table 4. Architectural model of 17 *Syzygium* spp. tree collection of Purwodadi Botanical Garden collection.

Tree Architecture Model	Scientific Name
Scarrone	*Syzygium acuminatisimum* *Syzygium formosum* *Syzygium polyanthum*
Stone	*Syzygium aqueum* *Syzygium garcinifolium* *Syzygium jambos* *Syzygium javanicum* *Syzygium lineatum* *Syzygium pycnanthum* *Syzygium racemosum*
Attims	*Syzygium creaghii* *Syzygium polycephalum*
Petit	*Syzygium discophorum* *Syzygium nervosum*
Koriba	*Syzygium cumini*
Massart	*Syzygium malaccense*
Troll	*Syzygium sexangulatum*

Scarrone Model

Syzygium. acuminatisimum, *Syzygium. polyanthum*, and *Syzygium. formosum*, trees which is presented in (Figure 4) feature a Scarrone tree architectural model with a monopodial trunk, orthotropic branching, and the growth point of the patens branch producing an angle of roughly 45°, according to data in Table 3. Scarrone is a tree architectural model with a sympodial or monopodial trunk, according to Shipunov (2023). The branching of the Scarrone model tree is all orthotropic. When the branch and main stem establish a about 45° angle, patens begin to grow (Nurdiana 2020).

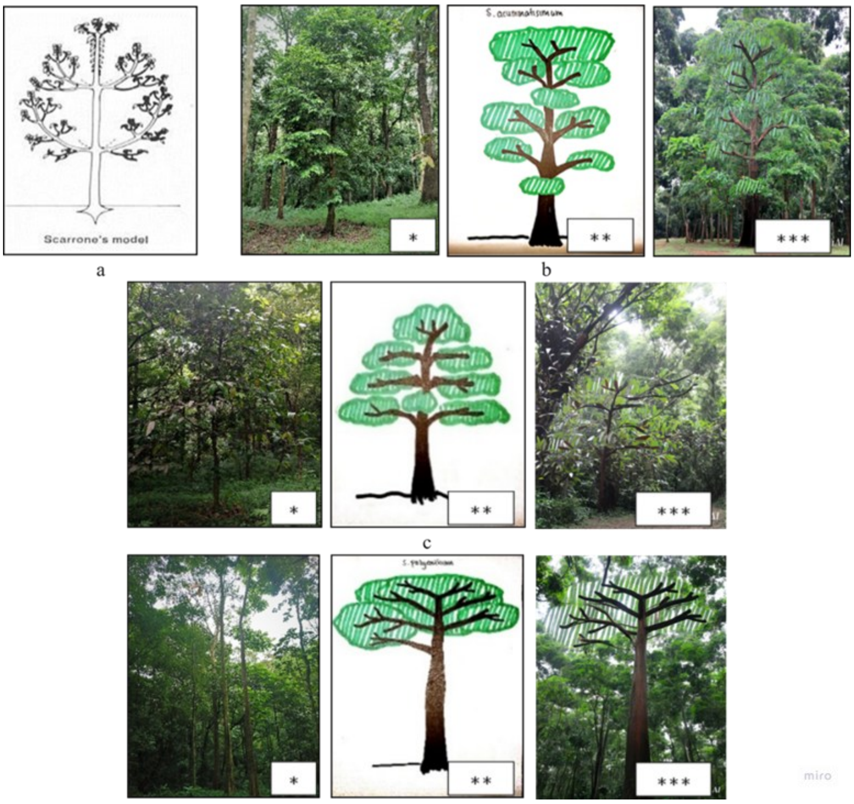

Figure 4. (a) Scarrone model (Tomlinson 1983), (b) *Syzygium acuminatisimum*, (c) *Syzygium formosum*, (d) *Syzygium polyanthum*. Description: * original picture, **manual illustration, ***AI illustration.

Stone Model

The observational data in Table 3 demonstrates that the Stone architectural model is the most prevalent of all models in the Purwodadi Botanical Garden's collection of *Syzygium* trees species. Sympodial stems with orthotropic branching patterns and stem development points ranging from fastigiated to patens are hallmarks of the Stone model in the data (Figure 5). According to the Stone model Shipunov (2023). The orthotopic branching and stems continue to develop sympodially. All trees have growing points that form an angle between 30 and 45 degrees, hence these points are fastigiated and rounded (Nurdiana 2020).

Attims Model

Observational data in Table 3 demonstrates that *Syzygium* trees species using the Attims model exhibit a distinctive monopodial stem growth pattern with fastigiated and patens branch growth points. Both species have an orthotropic pattern of branching (Figure 6). According to Shipunov (2023). The Attims model exhibits continuous growth, a monopodial trunk, and always orthotropic branching. Because the developing point in the Attims model forms an angle between 30° and 45°, it is patens and fastigiated (Nurdiana 2020).

Petit model

Observation data in Table 3, shows that *Syzygium discophorum* and *Syzygium nervosum* trees have *Petit's* architectural model. The stem growth pattern of both species ismonopodial with plagiotropic branching and *horizontal* branch growth points (Figure 7). The *Petit* model has continuous growth with monopodial stems and orthotropic or plagiotropic branching (Shipunov 2023). The *horizontal* growth point indicates that thedistance between the branch and the stem forms a 90° angle (Nurdiana 2020).

Koriba Model

The observation data in Table 3 shows that *Syzygium cumini* trees species have a *Koriba* architectural model characterised by dichotomous stem growth patterns, orthotropic branching patterns and horizontal branch growth points (Figure 8). *The Koriba* model hasa stem that continues to develop sympodially with orthotopic branching (Shipunov 2023). The tree's growing point forms a 90° angle, which accounts for the horizontal growth point (Nurdiana 2020).

Massart Model

The characteristics of the *Massart* model owned by *Syzygium* trees species presented in Table 3 showed that the stem growth pattern is monopodial with plagiotropic branching patterns and *declinatus* branch growth points (Figure 9). *The Massart* model has a monopodial stem with branching that is always plagiotropic or orthotropic (Shipunov 2023). While the *declinatus* growing point is because the tree has a growing point that forms an angle >90° (Nurdiana 2020).

Troll model

The characteristics of the Troll model in *Syzygium sexangulatum* trees species presented in Table 3, show that the stem growth pattern is sympodial with orthotropic branching and *horizontal* branch growth points (Figure 10). The Troll model has a sympodial stem with plagiotropic or orthotropic branches (Shipunov 2023). The stem axis is *horizontal* (Nurdiana 2020).

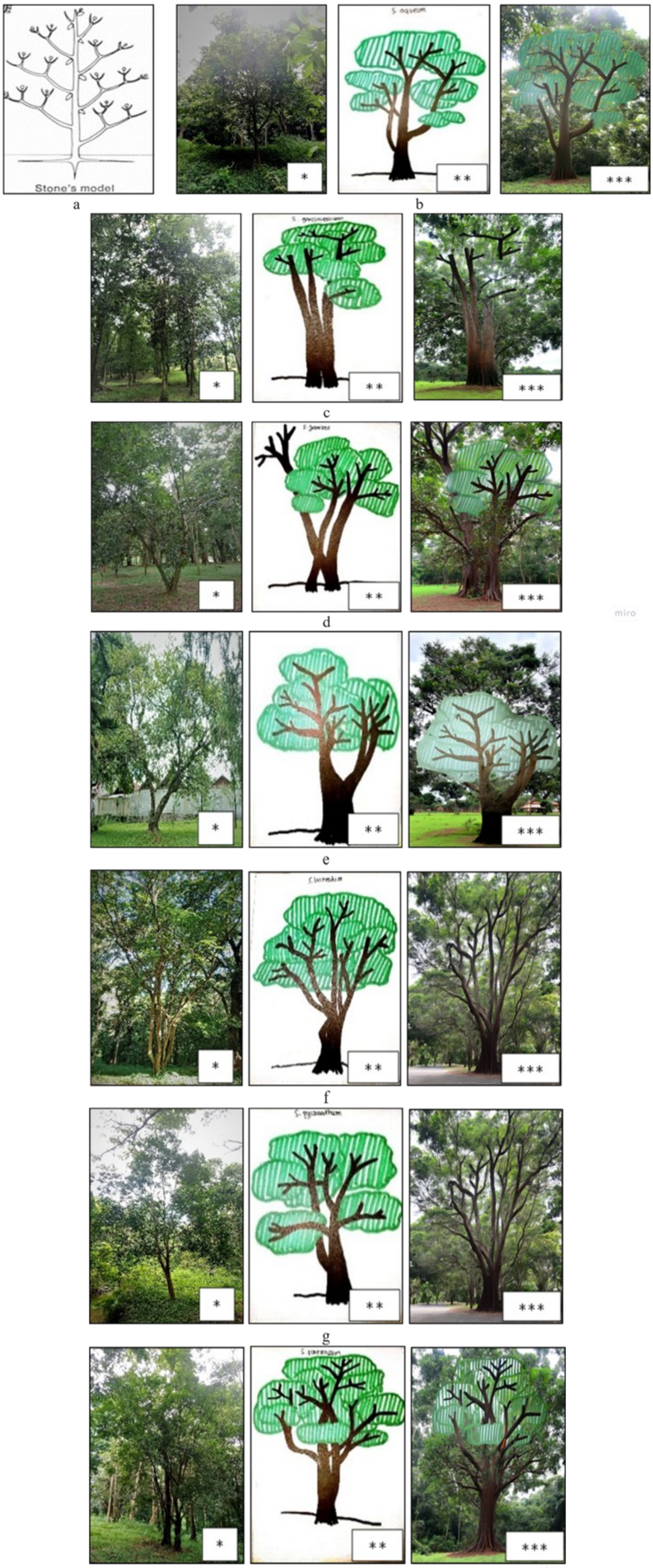

Figure 5. (a) Stone model (Tomlinson 1983), (b) *Syzygium aqueum*, (c) *Syzygium garcinifolium*, (d) *Syzygium jambos*, (e) *Syzygium javanicum*, (f) *Syzigium lineatum*, (g) *Syzygium pycnanthum*, (h) *Syzygium racemosum*.

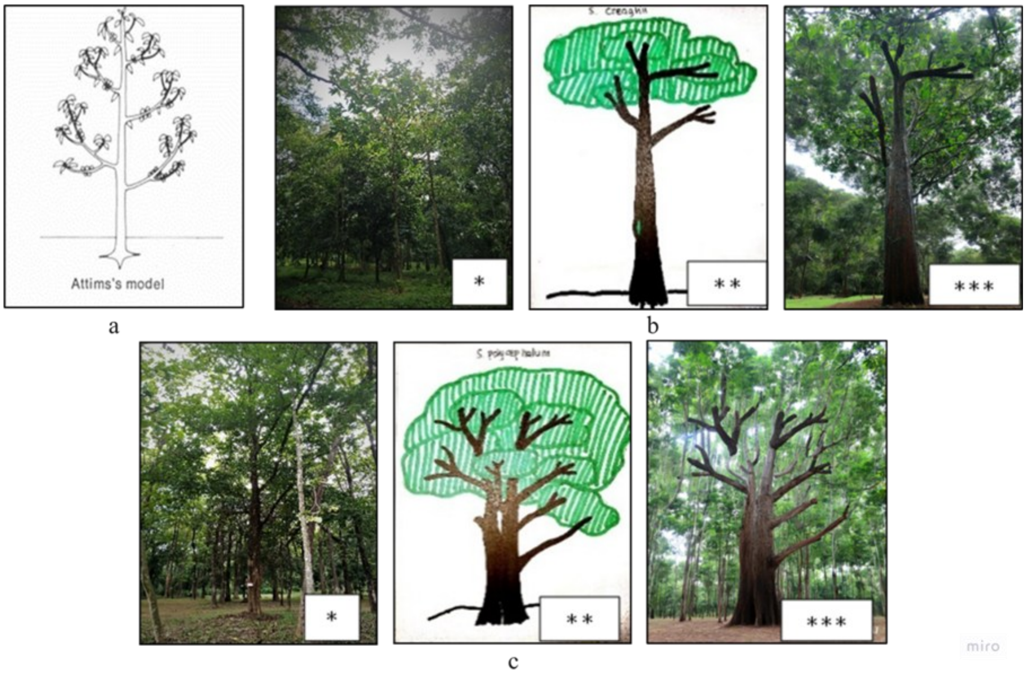

Figure 6. (a) Attims model (Tomlinson 1983), (b) *Syzygium creaghii*, (c) *Syzygium polycephalum*. Description: * original picture, **manual illustration, ***Ai illustration.

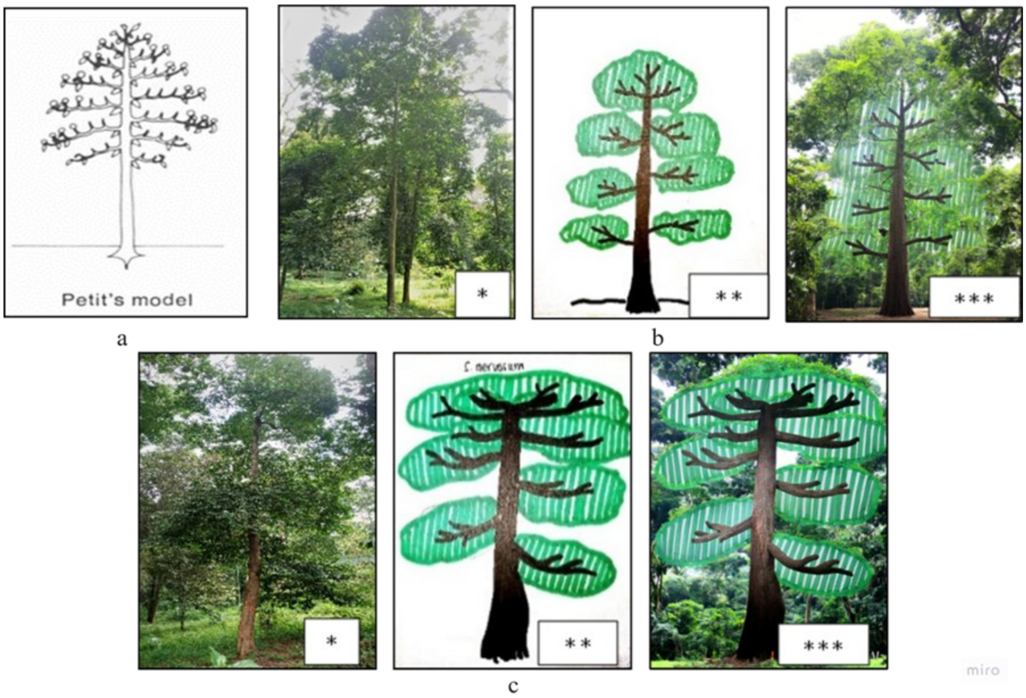

Figure 7. (a) Petit's model (Tomlinson 1983), (b) *Syzygium discophorum*, (c) *Syzygium nervosum*. Description: * original picture, **manual illustration, ***Ai illustration.

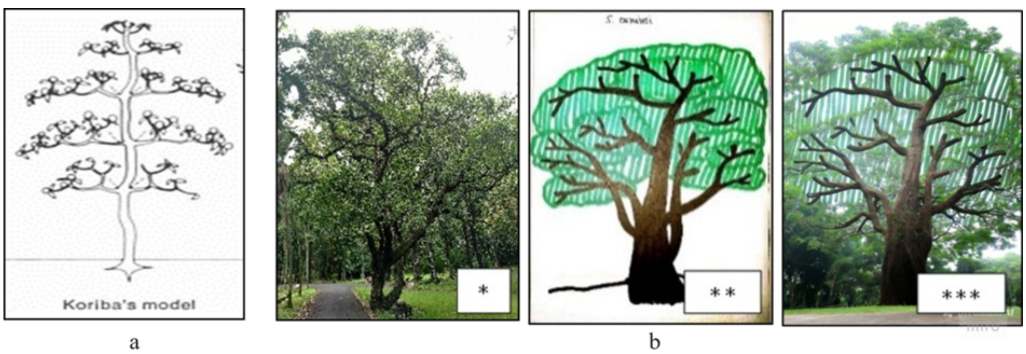

Figure 8. (a) Koriba model (Tomlinson 1983), (b) *Syzygium cumini*.

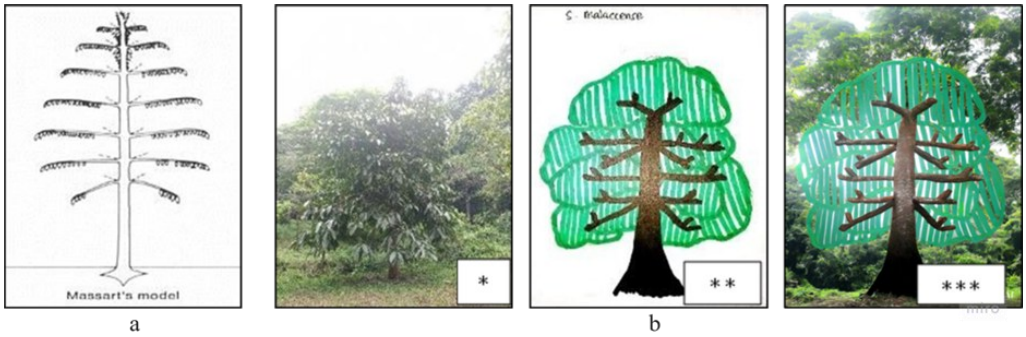

Figure 9. (a) Massart model (Tomlinson 1983), (b) *Syzygium malaccense.* Description: * original picture, **manual illustration, ***Ai illustration.

Figure 10. (a) Troll model Shipunov (2023), (b) *Syzygium sexangulatum.* Description: * original picture, **manual illustration, ***Ai illustration.

Potential Ecosystem Functions of *Syzygium* spp. Tree Architecture Models

Tree plays a fundamental role on forest ecosystems to the integrity of biotic and abiotic environmental influences. The adaptation effects apparently show in trees characteristic, structures and growth habits (Lin et al. 2018). The characteristics of the *Syzygium* species, which have deep and strong roots that can grasp the soil and avoid landslides, have demonstrated the ability of *Syzygium* trees species to promote ecological equilibrium. Additionally, *Syzygium* has a broad and intricate crown branching structure, which supports transpiration while reducing erosion because rainwater is absorbed in the tree crown before reaching the ground. Tree architecture model can help identify one of the various types of tree that support ecosystem balance (Lin et al. 2018; Fachruddin et al. 2020).

With orthotropic or upward-facing branching characteristics away from the ground surface and fastigiated and patens branching angles that form an angle of less than 90, *Syzygium* trees species in the Purwodadi Botanical Garden collection with Stone, Sccarone, and Attims architectural models have upward-facing branching tendencies. The traits of architectural models with these traits allow them to transpire more effectively than other models because they can hold more rainwater. Rainwater that lands on the tree canopy evaporates as soon as it hits the surface because of this. According to Song et al. (2020), the benefit of vegetation canopy has demonstrated that interception loss could account for 10–50 % of total rainfall in various natural and plantation forests. Erosion risk is decreased as a result.

Plagiotropic or orthotropic branching can be seen in the Koriba, Petit, Massart, and Troll models of *Syzygium* trees species that were gathered for this study, but all of them contain Horizontalis and Declinatus branching angles more than 90 degrees. By dangling and sloping downward, this architectural design creates a crown that leans toward the ground. In forests, the canopy changed rainfall kinetic energy and thus, modifying raindrop size and velocity, usually used indicator to express the potential of rainfall erosivity and predict soil erosion rates (Li et al. 2019)

The results of research conducted by Rahmania et al. (2024) showed that *Syzygium polycephalum* species with attims tree architecture model and *Syzygium acuminatisimum* with sccarone tree architecture model had the highest interception value. Both have monopodial stems (distinguishable by branching), orthotropic branching (upward-facing branching), and patens stem growth direction (the distance between the main stem and branching forms a 45° angle). Trees with these characteristics have crowns that face upwards and away from the ground. This causes rainwater to evaporate immediately by the interception before falling to the ground. Interception is the rainwater on tree vegetation will be divided into two parts, some of which will evaporate and some will reach the ground through canopy escape and stem flow. So, it can support evaporation in the hydrological cycle in the ecosystem.

Although most species' architectural parameters overlapped and there was significant architectural variation within species, there was a clear correlation between a species' ranking in the probability distributions of architectural parameters and life history traits like adult stature and the amount of light needed for regeneration. According to these findings, architectural characteristics determines the level of productivity of a forest (Chantrain et al. 2018). The community structure of *Syzygium* in PBG is characterized by convergence and differentiation in tree design capable of supporting the hydrological cycle at the interception stage in the ecosystem.

CONCLUSION

There are 7 models of tree architecture in the *Syzygium* species collection of Purwodadi Botanical Garden. All *Syzygium* trees species have their own characteristics so that they can be grouped into tree architecture models. Of the 17 *Syzygium* tree species that met the selection criteria, 7 species have a Stone -model, 3 species have a Scarrone model, 2 species have Attims and Petit model, and 1 species each has Koriba, Massart, and Troll model. Each variation of tree architecture model has different functions to the ecosystem.

AUTHORS CONTRIBUTION

Rahmania, F. N., designed, supervised, conducted research sampling, analysed the research data, and drafted the research report, Prahardika, B. A., as a supervisor in the preparation of the design and discussion of research results, while Irawanto, R., as a field supervisor in sampling research data..

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CONFLICT OF INTEREST

There is no conflict of interest regarding the research or the research funding.

REFERENCES

Agung, S.D. & Abban, P.F., 2017. The canopy structure and its impact on hydrological performance of five local trees species grown in the Purwodadi Botanic Garden. *The journal of tropical life science*, 7(1), pp.40-47. doi: 10.11594/jtls.07.01.07.

Ali, A. & Wang, L.Q., 2021. Big-sized trees and forest functioning: Current knowledge and future perspectives. *Ecological Indicators*, 127, 107760. doi: 10.1016/j.ecolind.2021.107760.

Arlianty, D., 2020. The availability of open green space and tree architecture at public senior high schools. *Journal of Physics: Conference Series*, 1460, 012069. doi: 10.1088/1742-6596/1460/1/012069.

Aung, E.E. et al., 2020. Phytochemical constituents and bioactivities of *Syzygium* genus: *A review. Open Chemistry*, 18, pp.1256–1281. doi: 10.1515/chem-2020-0175.

Aung, E.E. et al., 2023. Phytochemicals constituents in medicinal plant *Syzygium aqueum* (Burm.) Alston (Myrtaceae*). Egyptian Journal of Chemistry*, 66(3), pp.301-308. doi: 10.21608/EJCHEM.2022.132251.5859.

Baker, P. & Harper, R., 2022. *A report on silvicultural guidelines for the 2024-2033 Forest Management Plan to the Western Australian Department of Biodiversity, Conservation and Attractions.* Government of Western Australia.

Beech, E. et al., 2017. The first complete global database of tree species and country distributions. *Journal of Sustainable Forestry*, 36(5), pp.454-489. doi: 10.1080/10549811.2017.1310049.

Chantrain, A. et al., 2018. *Forest stand structure, tree species architecture and carbon storage in the Maymbe forest.* Institut Nasional Pout L'etude Et La Recherche Agronomiques Africa.

Charles-Dominique, T. et al., 2017. The architectural design of trees protects them against large herbivores. *Functional Ecology*, 31(9), pp.1710-1717. doi: 10.1111/1365-2435.12876.

Chomicki, G., Coiro, M. & Renner, S.S., 2017. Evolution and ecology of plant architecture: integrating insights from the fossil record, extant morphology, developmental genetics and phylogenies. *Annals of Botany*, 120 (6), pp.855-891. doi: 10.1093/aob/mcx113.

Echereme, C.B., Mbaekwe, E.I. & Ekwealor, K.U., 2015. Tree Crown Architecture: Approach to Tree Form, Structure and Performance: A Review. *International Journal of Scientific and Research Publications*, 5(9). doi: 10.29322/IJSRP.

Fachruddin, P.A., Basir, M. & Pitopang, R., 2020. The Use of Tree Architecture Models on the Landscape Arrangement Pattern to Manage Micro Environment in Universitas Tadulako. *Tadulako Science and Technology Journal*, 1(1), pp.24-29.

Gambino, S., Ratto, F. & Bartoli, A., 2016. Architecture of the genus Gutierrezia (Asteraceae: Astereae, Solidagininae). *Boletín de la Sociedad Argentina de Botánica*, 51(4), pp.657-663. doi: 10.31055/1851.2372.v51.n4.16343.

Hematang. F., Murdjoko, A. & Hendri., 2021. Model Pendugaan Diameter Pohon Berbasis Citra Unmanned Aerial Vehicle (Uav) Pada Hutan Hujan Tropis Papua: Studi Di Pulau Mansinam Papua Barat. *Jurnal Penelitian Kehutanan Faloak*, 5(1), pp.16-30. doi: 10.20886/jpkf.2021.5.1.16-30.

Heydari, M. et al., 2020. Soil quality and mesofauna diversity relationship are modulated by woody species and seasonality in semiarid oak forest. *Forest Ecology and Managemen*t, 473, 118332. doi: 10.1016/j.foreco.2020.118332.

Ilham, M. et al., 2022. Morpho-anatomical characterization and DNA barcoding of *Achillea millefolium* L. *Biodiversitas*, 23(4), pp.1958-1969. doi: 10.13057/biodiv/d230430.

Indrajaya, Y. et al., 2022. Tropical forest landscape restoration in Indonesia: A review. *Land*, 11(3), 328. doi: 10.3390/land11030328.

Joye, T., 2019, 'Tom Joye - Tree Architecture', in *Ancient Tree Forum*, viewed 20 September 2024, from https://www.ancienttreeforum.org.uk/resources/summer-conference-papers/2018-hereford/tom-joye-tree-architecture/

Klimešová, J. et al., 2019. Handbook of standardized protocols for collecting plant modularity traits. *Perspectives in Plant Ecology, Evolution and Systematics*, 40, 125485. doi: 10.1016/j.ppees.2019.125485.

Kristanti, A.N. et al., 2022. Phytochemistry of *Syzygium polycephalum. Tropical Journal of Natural Product Research*, 6(5), pp.728-731. doi: 10.26538/tjnpr/v6i5.11.

Li, G. et al., 2019. Influence of canopy interception and rainfall kinetic energy on soil erosion under forests. *Forests*, 10(6), pp.509. doi: 10.3390/f10060509.

Li, X. et al., 2016. A study on crown interception with four dominant tree species: A direct measurement. *Hydrology Research*, 47(4), pp.857-868. doi: 10.2166/nh.2015.066.

Lin, Y. et al., 2018. Recruiting conventional tree architecture models into state-of-the-art LiDAR mapping for investigating tree growth habits in structure. *Frontiers in plant science*, 9, 220. doi: 10.3389/fpls.2018.00220.

Lindenmayer, D.B. & Laurance, W.F., 2016. The unique challenges of conserving large old trees. *Trends in Ecology & Evolution*, 31(6), pp.416-418. doi: 10.1016/j.tree.2016.03.003.

Loubota Panzou, G.J. et al., 2018. Architectural differences associated with functional traits among 45 coexisting tree species in Central Africa. *Functional Ecology*, 32(11), pp.2583-2593. doi: 10.1111/1365-2435.13198

McGarry, R.C. et al., 2016. Monopodial and sympodial branching architecture in cotton is differentially regulated by the Gossypium hirsutum Single Flower Truss and Self-Pruning orthologs. *New Phytologist*, 212 (1), pp.244-258. doi: 10.1111/nph.14037.

Mudiana, D., 2016. *Syzygium* diversity in Gunung Baung, East Java, Indonesia. *Biodiversitas*, 17(2), pp.733-740. doi: 10.13057/biodiv/d170248.

Nugraha, B.H. & Kusmana, C., 2022. Species composition and vegetation structure of lowland forest in Rambut Island Wildlife Reserve, Kepulauan Seribu, DKI Jakarta. *IOP Conference Series: Earth and Environmental Science*, 950, 012021. doi: 10.1088/1755-1315/950/1/012021.

Nurdiana, 2020. Morfologi Tumbuhan. Sanabil, Mataram.

Pakkala, T. et al., 2018. Nest tree characteristics of the old-growth specialist Three-toed Woodpecker Picoides tridactylus. *Ornis Fennica*, 95, pp.89-102.

Pretzsch, H. et al., 2015. Crown size and growing space requirement of common tree species in urban centres, parks, and forests. *Urban forestry & urban greening*, 14(3), pp.466-479. doi: 10.1016/j.ufug.2015.04.006.

Rahmania, F. N., Prahardika, B. A., & Irawanto, R., 2024. Study of interception, throughfall, and stemflow on seven types of Syzygium sp. tree collected by Purwodadi Botanical Garden. *IOP Conference Series: Earth and Environmental Science*, 1312, 012011. doi: 10.1088/1755-1315/1312/1/012011.

Seidel, D. et al., 2019. Identifying architectural characteristics that determine tree structural complexity. *Trees*, 33, pp.911-919. doi: 10.1007/s00468-019-01827-4.

Shipunov, A., 2018. *Introduction to botany.* Lecture notes, North Dakota.

Shipunov, A., 2023. *Key to the Diversity and History of Life.* Libre text, California.

Sirami, E.V. & Manuhua, D., 2022. Relationship between Biometric Factor of the Host and Giant Piper's Growth (*Piper decumanum* L.) *Jurnal Kehutanan Papuasia*, 8(1), pp.177-186. doi: 10.46703/jurnalpapuasia.Vol8.Iss1.302.

Song, P. et al., 2020. Hydrological effects of urban green space on stormwater runoff reduction in Luohe, China. *Sustainability*, 12(16), 6599. doi: 10.3390/su12166599.

Spencer, V.M.R., Bentall, L. & Harrison, C.J., 2023. Diverse branching forms regulated by a core auxin transport mechanism in plants. *Development*, 150(6), dev201209. doi: 10.1242/dev.201209.

Tomlinson, P.B., 1983. Tree architecture: new approaches help to define the elusive biological property of tree form. *American Scientist*, 71(2), pp.141-149.

Utami, I. & Putra, I.L.I., 2020. *Ekologi Kuantitatif; Metode Sampling dan Analisis Data Lapangan.* Yogyakarta: Penerbit K-Media.

Yasin, F.M., Zam, Z.Z. & Rakhman, K.A., 2022. Analysis of antioxidant content of anthocyanin in the lobi-lobi fruit (*Flacourtian inermis*) and jamblang fruit (*Syzygium cumini* L. Skeel) using the dpph method with spectrophotometry. *Jurnal Biosains Pascasarjana*, 24, pp.8-14. doi: 10.20473/jbp.v24i1.2022.8-14.