# TREE SPECIES COMPOSITION WITH A DIAMETER BREAST HEIGHT LESS THAN 5 CM AT GUNUNG STONG STATE PARK (GSSP), KELANTAN

by

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**DECLARATION**

I declare that the thesis entitled Composition of Tree Species with a Breast Height of Less than 5 Cm in Gunung Stong State Park (GSSP), Kelantan is the result of my ownresearch except as stated in the reference. The thesis is not accepted for any degree andis not submitted concurrently in candidacy for any other degree.

Signature : 

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Date : 7/8/2024

## ACKNOWLEDGEMENT

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**Tree Species Composition with a Diameter Breast Height Less Than 5 cm at Gunung Stong State Park (GSSP), Kelantan**



## ABSTRACT

A study was conducted to determine tree species composition, diversity and estimatedbiomass in Gunung Stong State Park (GSSP), Dabong in Kelantan. Five plots of 20 mx 20 m with a total of 0.2 ha with different heights for each plot namely the first plot 452 a.s.l, the second plot 454 a.s.l, the third plot 456 a.s.l, the fourth plot 458 a.s.l and the last plot 460 a.s.l were established and all trees with diameter at breast height (DBH) ≤ 5 cm iscalculated. A total of 273 individual trees were counted and identified into 40 families,67 genera and 88 species. Lauraceae is the largest family consisting of 3 genera and 4 species. The total basal area is 1.0253064 $m^2$/ha. *Garcinia morella* is the main contributorin this study because the number of diameters is larger, affecting the number of biomasses on the ground, which is 0.03093 t/ha. Overall, the Shannon-Weiner Diversity Index (H') showed a value of 3.6. The total biomass of trees on the ground is estimatedat 0.61892904 t/ha. This study shows that there are species listed as vulnerable by the IUCNRed Data Book. Therefore, these species must be carefully observed so that their habitats will not become extinct.

**Komposisi Spesies Pokok Dengan Diameter Paras Dada Kurang 5 cm Di Taman Negeri Gunung Stong (GSSP), Kelantan**



## ABSTRAK

Kajian telah dijalankan untuk menentukan komposisi spesies pokok, kepelbagaian dan anggaran biojisim di Taman Negeri Gunung Stong (GSSP), Dabong di Kelantan. Lima petak 20 m x 20 m (0.2 ha) dengan ketinggian berbeza bagi setiap petak iaitu plot pertama 452 m a.s.l, plot kedua 454 m a.s.l, plot ketiga 456 m a.s.l, plot keempat 458 m a.s.l dan plot terakhir 460 a.s.l telah diwujudkan dan semua pokok berdiameter pada ketinggian payudara (DBH) ≤ 5cm dikira. Sebanyak 273 pokok individu telah dikira dan dikenal pasti kepada 40 famili, 67 genera dan 88 spesies. Lauraceae merupakan famili terbesar yang terdiri daripada 3 genera dan 4 spesies. Jumlah kawasan basal ialah 1.025306$m^2$/ha. *Garcinia morella* merupakan sumbangan utama dalam kajian ini kerana bilangan diameter lebih besar yang mempengaruhi bilangan biojisim di tanah iaitu 0.03093 t/ha. Secara keseluruhannya, Indeks Kepelbagaian Shannon-Weiner (H') menunjukkan nilai 3.6. Jumlah biojisim pokok di atas tanah dianggarkan sebanyak 0.619 t/ha. Kajian ini menunjukkan bahawa terdapat spesies yang disenaraikan sebagai terdedah oleh BukuData Merah IUCN. Oleh itu, spesies ini mesti diperhatikan dengan teliti supaya habitatnya tidak pupus.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| GSSP | Gunung Stong State Park |
| DBH | Diameter At Breast Height |
| LiDAR | Light Detection and Ranging |
| RMSE | Metrics Like Root Mean Square Error |
| R2 | Coefficient Of Determination |
| AGB | Above Ground Biomass |
| BA | Basal Area |
| COz | Carbon Dioxide |
| IUCN | International Union for Conservation of Nature |
| N/A | Not Applicable |

## LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| cm | Centimetre |
| M | Meter |
| ° | Degrees |
| ≥ | Greater than and equal to |
| x | Multiply |
| t/ha | Tonnes per Hectares |
| m/ha | Meter per Hectares |
| cm/ha | Centimetre per Hectares |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

One of the world's richest ecosystems, tropical forests are crucial for controlling the climate. Woods, the most widespread kind of forest in Malaysia, is the tropical rainforest, which makes up around 60% of Peninsular Malaysia and 75% of Sabah andSarawak. Usually, this forest may be found in regions that are no higher than 1000 metres. Features The key characteristics of the Equatorial Forest are its evergreen woods, closely spaced trees, roots that are deep, straight, and so forth (Siti Meriam Hassan, 2024).

In addition, this forest has a higher diversity of flora and fauna than other forests;in fact, given that this forest formed millions of years ago, even the dominant flora andfauna species have distinctive qualities of their own. Although there are many kinds oftropical rainforests in Malaysia, the hill dipterocarp forest at Gunung Stong State Park(GSSP), which is situated near Dabong, Kelantan, is one of the most well-known. This mountainous forest is home to several endemic species that are unique to it, as well asa rich and diversified ecology that includes valuable types of wood trees.

Planning sustainable forest management and implementing the best forest conservation strategies requires knowledge of the species variety and community structure of the forest. This information is crucial for better managing the

resources found in the forest and ensuring that these natural treasures are enjoyed by future generations. It also reinforces the database of forest flora in this country by providinginformation on the types of forest trees that are consistently found there.

## 1.2 Problem Statement

The purpose of this study was to examine and record the general species composition of trees at different forest levels, with a focus on mature trees with a diameter of less than 5 cm. Gaining an overview of the variety, composition, and abundance of these mature tree species in the chosen region is the primary goal of thisresearch. Such data is important for managing, conserving, and implementing sustainable forestry techniques in the environment under study.

Additionally, this study was carried out to update and enhance previously collected data for future use. The diversity of tree species presents in the Gunung StongState Park (GSSP) region has not received enough attention or investigation; thus, thisstudy was also carried out to broaden understanding in this area.

## 1.3 Objectives

The objectives are mainly:

1. To identify tree species with less than 5 cm diameter breast height and moreat Gunung Stong State Park (GSSP).
2. To enumerate species diversity and richness with less than 5 cm diameterbreast height and more at Gunung Stong State Park (GSSP).

## 1.4 Scope of Study

The scope of this research study is to assess the diversity, composition, and species richness of trees with a breast height diameter of less than 5 cm. This aspect focuseson identifying the species composition of trees with a diameter breast height of less than 5 cm in Gunung Stong State Park. The second objective is to calculate the diversity and richness of species with a diameter breast height of less than 5 cm in Gunung Stong State Park.

The study was conducted in Gunung Stong State Park (GSSP) in five random sampling plots with different elevations. Therefore, the study tree with a diameter ofless than 5 cm breast height was measured manually using a 1.3-diameter tape from the ground. Then, all tree samples from each plot were collected as voucher specimensfor that species. To achieve these two goals, five plots of 20 m x 20 m were constructed according to a carefully defined method. This research lasted for six daysbefore detailed data analysis of the tree species that had been recorded was done. Significantly, the investigation limited its search only to woody tree species becauseit ensured a specific approach to these criteria.

## 1.5 Significant of Study

The significance of this study lies in the fact that it is the first to determine the taxonomy of each tree and examine trees in Gunung Stong State Park (GSSP) with a diameter at breast height (DBH) of less than 5 cm. The species that are found in the research region have undergone changes in species diversity, which might be attributedto several variables such as anthropogenic activity, soil composition, climate, or biogeography.

Furthermore, this research contributes significantly to updating previously utilised data for future usage and enhancing any current data. In the end, this study

seeks to achieve this goal by assisting in filling in fundamental knowledge gaps and creating a strong, contemporary reference basis for ongoing research on the incrediblyvaried tree species found in Gunung Stong State Park (GSSP).

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Tree height and diameter at breast height (DBH) are the two most important factors in surveys, production, and management of forest resources, and research on forest ecosystems (Lei et al., 2009). They are usually used to calculate the volume, site index, forest growth, and yield (Leduc & Goelz, 2009) and to estimate forest volume,biomass, and carbon stock (Yan Qiong Li et al., 2015). Precise tree height and DBHare essential for assessing biomass and are crucial for studying forest growth modelsgrounded in physiological ecology (Mu et al., 2017).

Diameter at Breast Height, or DBH, is a crucial indicator for carbon sequestration and forest management (Fu et al., 2023). Because it is often measured by hand, which is labor-intensive, researchers are looking at alternate techniques likeLiDAR and Structure from Motion photogrammetry to obtain more precise and efficient measurements (Wang et al., 2022). Studies have shown the possibility of techniques like binocular vision, iPad LiDAR sensors, and automated DBH estimatepipelines, which provide accurate and affordable DBH estimation. Metrics like Root Mean Square Error (RMSE), coefficient of determination (R2), and mean relative error are used to assess the accuracy of this approach, demonstrating its efficacy in the inventory and management of forests.

## 2.2 Tropical Rainforest

One location that must be protected and conserved is the tropical rainforest. There areonly twelve countries in the world where biological diversity can be found as a habitat,and Malaysia is one of those countries. Furthermore, it is believed that Malaysia has more than 12,500 species of vascular plants, which includes 40% of all vascular plantspecies in the Malaysian region and 5% of the estimated 250,000 species worldwide (Latiff, 1997). After that, the largest quantity of those species is categorized as endemicspecies, meaning they are unique to the planet. About 26% of tree species in 52 familiesare native to Peninsular Malaysia.

Forests in Malaysia can be classified according to two factors, namely edaphiccharacteristics, and climatic climax. The tropical rainforest in Malaysia is divided intoten main types which are (Wyatt-Smith, 1963 and Fox, 1978):

i. Lowland dipterocarp forest
ii. Hill dipterocarp forest
iii. Upper dipterocarp forest
iv. Low mountain forest
v. Upper mountain forest
vi. Dry forest or swamp
vii. Freshwater swamp forest
viii. Peat swamp forest
ix. Riparian forest
x. Mangrove forest or sea swamp

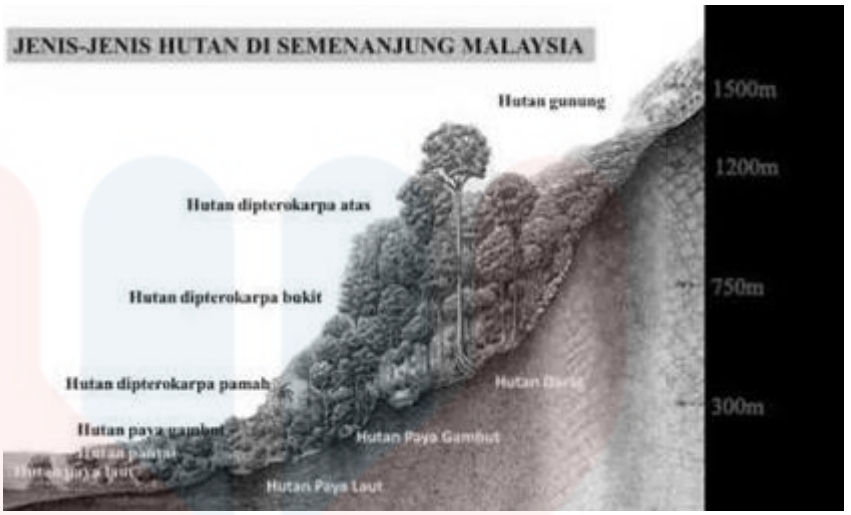


**Figure 2.1:** Types of forest in peninsular Malaysia (Source: Forest Department Peninsular Malaysia.

## 2.3 Tropical Rainforest in Malaysia

A total of 20.20 million hectares, or 61% of Malaysia's geographical area of around 33.03 million hectares are wooded regions, according (Kementerian PerusahaanUtama Malaysia 2002). Due to its location between 1º and 7° North and longitude between 100° and 119º East, Malaysia is classified as a tropical nation with a complexwooded region, a wide variety of flora, and abundant natural resources.

As a result, Malaysia has been named one of the world's twelve denizens, witha mega-diversity region exceedingly rich in diverse species and habitats (Medway, 1978). In addition to containing 60–70% of the world's biological variety, Malaysia is one of the Asian nations with the greatest concentration of indigenous trees (Latiff and Faridah Hanum 1997).

## 2.4 Forest Stratification

The canopy, understory, forest floor, and canopy are the four layers that make up mostrainforests. Because of variations in water content, solar exposure, and air movement,each layer has distinct properties of its own. Despite their differences,

each layer is a part of an interconnected system where species and processes in one layer have an impact on those in other layers.

The emergent layer is the uppermost layer of the rainforest. Trees reaching heights of up to 60 meters (200 feet) rule the skyline here. On tree trunks, foliage is frequently sparse; nevertheless, as trees reach the sunlit top layer, where they photosynthesize sunlight, the foliage expands extensively. In protracted droughts or dry seasons, trees in the emergent layer benefit from small, waxy leaves that help themhold onto water. Strong winds carry light seeds away from the parent tree (Rainforest,2023). Nonetheless, based on (Rainforest Layers, 2015). These typically vary in heightfrom 35 to 65 meters, depending on the region. When the emergent layer is taken intoconsideration, the lowland dipterocarp rainforests of Malaysia (the region that comprises Malaysia and Indonesia) often have the highest rainforests in the world. However, these emergent trees can occasionally develop to be considerably taller (70–80 meters). These young trees loom taller than most others, giving the impression thatthey are "islands" in a sea of treetops. The second layer is called the canopy and is made up of trees that are between 18 and 46 meters tall. The flat crown of these trees refers to the upper portion of the tree, which creates a dense environment that is hometo most of the indigenous plant and animal species found in tropical rainforests. Only two to five percent of sunlight can get through the canopy and reach the forest floor, therefore this layer also acts as a natural sunscreen for the rainforest.

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sunlight can get through the canopy and reach the forest floor, therefore this layer also acts as a natural sunscreen for the rainforest.

The third layer, known as the understory, is found under the canopy, and is madeup of little trees that grow to a height of nine to eighteen meters. Eventually, some of these trees will join the canopy, while others will stay in the lower section.

Since the forest floor is the lowest and darkest stratum in the rainforest, plant growth is extremely challenging there. Fallen leaves soon begin to decompose on the forest floor. Generally, the trees that exist in this layer have a height of more than 18 meters and the temperature in this layer is quite cold compared to the canopy layer because the amount of sunlight is less received even though only small plant species such as herbs, saplings, and ferns inhabit this layer (Drinnen, 2000). On the forest floor, decomposers including termites, snails, scorpions, worms, and fungus flourish. Whenorganic material falls from plants and trees, these creatures convert the decomposing material into nutrition. These nutrients are absorbed by the shallow roots of rainforest plants, while the decomposers are devoured by hundreds of predators.

**Figure 2.2:** Forest layer of the rainforest (Source: Google Map)

## 2.5 Composition and Diversity of Tree Species in Gunung Stong State Park(GSSP)

Tropical rainforest species richness varies widely from location to location, mostly because of changes in biogeography, habitat, disturbance, and biogeography. (Whitmore, 1998). Chua et al. (2022) claim that Malaysia is a megadiverse nation in terms of plant species. Although there is still much to learn about the variety of plant species in Malaysia, the Flora of Sabah and Sarawak and Flora of Peninsular Malaysiaprograms have greatly increased our understanding of it. Since 1995, there has been the addition of more than 400 new plant species, comprising at least 14 new genera. Anthropogenic activity or natural causes can also cause disturbances. Activities like deforestation, excessive logging, forest fires, and landslides can disrupt tree species and result in habitat loss. However, when a forest is disturbed—which can happen dueto changes in forest blocks or topography—biogeography has the power to alter the kinds of trees found there.

Jusoff (2013) reported that the predominant species in Gunung Stong are members of the Dipterocarpaceae family (*Shorea sp.),* followed by members of the Euphorbiaceae family (*Aporusa sp*.), Sapotaceae family (*Palaquium sp*.), and Myrtaceae family (*Syzygium sp*.) (Chee et al., 2005). Table 2.1 has a list of everyspecies.

**Table 2.1:** List species identification in Gunung State Park (GSSP)

| **Family/species** | **Scientifie Name** | **Common Name** | Author/ Years |
|---|---|---|---|
| Dipterocarpaceae (*Shorea sp.)* | *Shorea curtisii*<br>*Shorea roxburghii*<br>*Shorea parvifolia*<br>*Shorea platyclados* | Seraya<br>Meranti<br>Meranti Sarang<br>Punai<br>Meranti bukit | Jusoff, 2013;<br>Chee at al. 2005 |

| | | | |
|---|---|---|---|
| Euphorbiaceae *(Aporusa sp.)* | *Aporusa spp.* | Sebasah | Jusoff, 2013 Chee at al.,2005 |
| Sapotaceae *(Palaquium sp.)* | *Sapotacea spp.* | Nyatoh Minyak | Jusoff, 2013 Chee at al.,2005 |
| Myrtaceae *(Syzygium sp.)* | *Syzygium spp.* | Kelat | Jusoff, 2013 Chee at al.,2005 |

One of the biggest forest reserves in Peninsular Malaysia, Gunung Stong ForestReserve, has undergone a preliminary inventory of plant species, according to (Chee Beng Jin 2005) of the Forestry Research Institute of Malaysia. The purpose of this study was to catalogue the variety of plants in the region and to identify any endemic species. A total of 406 plant species—including subspecies and varieties—from 84 families and 254 genera have been identified by the researchers. The checklist highlights the distinctive biodiversity of the area by including species that are only found in Peninsular Malaysia and the Gunung Stong Forest Reserve. From this study,it was found that the most diverse families recorded were Orchidaceae, Rubiaceae, and Melastomataceae. Meanwhile, the most diverse genera are Begonia, Impatiens, and Ficus. several endemic species, including *Begonia stongensis*, named after the GunungStong Forest Reserve.

This study involved fieldwork, where researchers conducted surveys and collected plant specimens from different locations within the forest reserve. Collectedspecimens were then identified and classified using taxonomic keys and in consultation with botanists. These researchers recorded information about the families, genera, species, subspecies, and types of plants they encountered. They also recorded the distribution and habitat of each species. This study aims to document the diversity of plant life in the area and identify any endemic species. These findings provide valuableinsight into the botanical composition of Gunung Stong Forest Reserve and contributeto conservation efforts in preserving the rich

flora.

Research has been done on the floristic composition, diversity, richness, and homogeneity of the mixed lowland dipterocarp forest in Gunung Stong State Park, Kelantan. An analysis was conducted on 172 stems, which encompassed 28 families, 54 genera, and 72 species. Up to the species level, stems taller than five metres have been identified. According to the evaluation of species diversity, richness, evenness, and important value of tree species (Iv = 36.17), *Dyera costulata* is the dominant species in Gunung Stong State Park. However, when it comes to the number of species,genera, and individuals present in the research plot, the Dipterocarpaceae family predominates i Gunung Stong State Park (Muhammad Asyraf Hanafi, 2024).

## 2.6 Dimeter Breast Height (DBH) and Forest Structure

Diameter-at-chest height (DBH), is a common way to measure tree size that is reliable across time, between plots, and amongst data collectors. DBH stands for "breast height," which is 1.35 metres above the highest point of the ground at the tree's base. This measurement is used to determine each tree's diameter. To find out more about the link between DBH and biomass, see Understanding Allometry. According to the geometry lesson, a diameter is a line that ends on the circle's edge and runs through the centre of the circle. Measure the tree's circumferenceand use equation 1 to get its diameter. Occasionally, use this calculation to determine the diameter using a calibrated or caliper The tape in question is known as DBH tape. While gathering field data for the GLOBE Carbon Cycle (TeacherGuide 1 of 7 How Do Scientists Measure Trees, n.d.).

Circumference = π*diameter (where π = 3.14) or Diameter = Circumference/ π [equation 1]

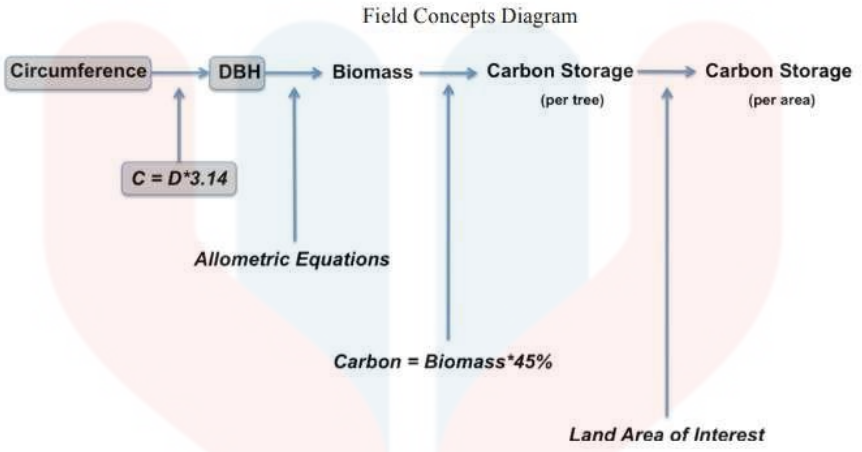


**Figure 2.3:** Forest layer of the Field Concepts Diagram

Gehring et al. (2008) state that a set of allometric equations for estimating biomass in tropical forests has been created. These equations may be used in primary and secondary forests (Araújo et al., 1999; Chave et al., 2005; Overmann et al., 1994;Brown et al., 1995). Diameter at Breast Height (DBH) is one of the allometric equations that is highly recommended and frequently used in biomass research to determine the diameter of trees. A common technique for expressing the diameter of standing trees is to measure the diameter at the trunk of the tree and use the diameter at breast height (DBH). As an alternative, a preliminary investigation reveals that thisallometric equation is computed by assuming that y = ax, where x is either DBH (cm)or H (m), and that a and b are coefficients derived using regression (Syafinie & Ainuddin, 2015).

However, because these plants lack a trunk and some of them are not even in a standing position, this measurement is inappropriate for tiny and medium-sized plantslike lianas, bushy vegetation, and woody undergrowth. According to Nizam et al. (2006), a diameter tape of 1.3 meters is typically utilised for this purpose, and

it is intended to measure tree trunks beginning above ground.

Small trees in forest ecosystems play a crucial role by representing the future composition and structure of the forest through their smooth and dynamic growth patterns, allowing for accurate predictions of the forest's future state. Additionally, small trees significantly contribute to forest biomass and carbon storage, making precise measurements of their biomass essential for assessing the total forest biomass. They also serve as sensitive indicators of environmental changes, as small trees respond more quickly to changes within the forest ecosystem, providing early warnings of disturbances. This rapid response helps in identifying and addressing disturbances or threats to the forest more effectively and swift

## 2.7 High Conservation Value Forest

High Conservation Value Forests (HCVFs) are places where ecosystem services andbiodiversity are very important. They are important in conservation efforts but are often threatened by various anthropogenic pressures. The Forest Stewardship Council(FSC) created the HCVF concept to designate forests with outstanding biodiversity, rare ecosystems, important natural services, important areas for local communities, and important for cultural identity (Subodh Kumar Maiti, 2012). These forests play an important role in maintaining valuable ecosystems and species, their identificationand protection is essential to achieving conservation goals and sustainable forest management practices. Various certification schemes, such as those by the FSC and the Roundtable for Sustainable Palm Oil, combine HCVFs to promote environmentally and socially sound practices in forest management, by setting long- term monitoring requirements and data sharing provided to ensure sustainable conservation

strategies. Effective High Conservation Value Forests (HCVFs) are classified into six types based on their environmental and social values. These types are defined by the Forest Stewardship Council (FSC) and include (Jennings, 2003):

1. HCV1: Forest areas that contain concentrations of globally, regionally, or

   nationally significant biodiversity values. This type includes areas with high concentrations of endangered species, endemic species, or protected areas.
2. HCV2: Forest areas containing large forests of global, regional, or national significance. These areas have renewable populations of most species that naturally exist in their natural patterns of distribution and abundance.
3. HCV3: Forest areas found in or containing rare, threatened, or endangered ecosystems. This type includes areas with rare or threatened ecosystems, suchas segments of regionally rare types of freshwater swamp forest.
4. HCV4: Forest areas that provide basic nature services are in critical condition.

   These areas provide important ecosystem services such as water resource protection, erosion control, or landslide risk management.
5. HCV5: Forest areas that are important to meet the basic needs of local communities. This type includes areas that are important for the basic needs of the local community such as survival, health, or other basic needs.
6. HCV6: Forest areas important to the traditional cultural identity of local communities. These areas have significant cultural value to

local communitiesand may include sacred areas, traditional areas for hunting or gathering food,or culturally, ecologically, economically, or religiously important sites.

Gunung Stong State Park (GSSP) in Kelantan holds significant conservation value, as evidenced by various studies. The park serves as an essential ecotourism destination, contributing to the socio-cultural, economic, and environmental sustainability of the area (Hassin et al., 2019). Additionally, GSSP plays a crucial role in providing income through sustainable tourism for local communities, enhancing infrastructure, and improving quality of life (Nurul Ihsan Fauzi et al., 2020). Furthermore, the park is home to diverse small mammal species, including some listed as Vulnerable, emphasizing its importance as a conservation area (Sarguna D.S et al., 2017).

Remote sensing technology has been utilized to manage forest resources effectively in GSSP, aiding in the identification and classification of various tree species for sustainable forest management (Vijaya Kumaran Jayaraj et al., 2012). These findings collectively highlight the high conservation value of Gunung Stong State Park in Kelantan, emphasizing the need for continued conservation efforts to preserve its biodiversity and ecological significance.

# CHAPTER 3

# MATERIALS AND METHOD

## 3.1 Study Area

This study was conducted in a forest area in the Jeli colony, which was part ofGunung Stong State Park (GSSP). Mount Stong, one of the highest mountains in Kelantan, stood at a height of 1,442 meters. Mount Stong was situated in the Dabong Forest Reserve, Kelantan. Gunung Stong provided an interesting and exciting forest full of natural treasures, wildlife, and more.

Gunung Stong State Park was a forest area surrounded by many mountain peaks, including Gunung Ayam, Gunung Tera, Gunung Saji, and others. Gunung StongState Park was located at approximately 5.3396N latitude and 101.9749E longitude (Figure 3.1). Covering an area of over 20,000 hectares, Gunung Stong State Park encompasses mountain peaks, rivers, and caves. This study was conducted in several areas within Gunung Stong State Park, with various designated plot sizes represented.

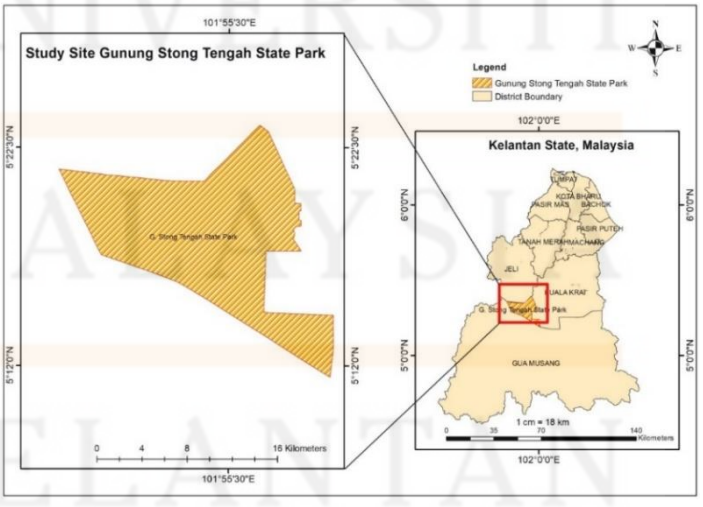


**Figure 3.1:** Location of study area located within Gunung Stong Tengah State Park, Kelantan.

## 3.2 Materials

Before the sampling is conducted, the material that used in this study is presented inTable 3.1 below:

**Table 3.1:** List materials and functions of materials that have been used while in Gunung StongState Park, Kelantan.

| **Materials** | **Function** |
|---|---|
| DBH tape | Use to measure the diameter breastheight (DBH) of trees, typically at 1.3 meters above ground level. |
| Distometer digital | Use to measure the height of a tree |
| Rope | Use to build 5 plots measuring 20 x 20 meters for each plot |
| Binokular | Used to see leaves on high tree species |
| Smartphone camera | Use to identify the types of trees that have been marked |
| Tagging | Use to be marked for each tree that has been counted |
| Pen and book | Use to record the trees that had been counted and been identify |
| Airtight Polythene | Used to store collected specimens for use in identifying specific species |
| Handheld GPS | Used to see the location and position of the plot and specific tree species |
| Caliper | a measuring tool used to measure the distance between two sides of an object with great precision. |

## 3.3 Method

### 3.3.1 Build a Sampling Plot

Plots were constructed systematically using a systematic sampling method with fiveplots set along the route. Each plot is constructed, each measuring 20

meters x 20 meters. Each plot is constructed using raffia rope and wooden stakes marked at eachcorner. Using a tape measure, measurement accuracy is ensured by ensuring accuratemeasurements for each plot. The calculated distance between plots is constant at 50meters which creates a systematic and orderly layout for the study area. This structured arrangement increases the accuracy of data collection in each 20-meter x20-meter plot, which can strengthen the overall validity of the research.

### 3.3.2 Measurement of Tree Diameter at Breast Height

Measurement of the diameter breast height for each tree with a diameter of 10 cm and above is done using DBH tape. Trees whose diameters have been measured aremarked with tagging to prevent the same tree from being measured repeatedly.

The measurement of tree diameter for each tree is different based on the position of the tree on flat or sloping land. for flat land with trees with straight trunks without buttress or with roots less than one meter deep, the DBH measurement is done by measuring the girth at 1.3 meters from the ground level.

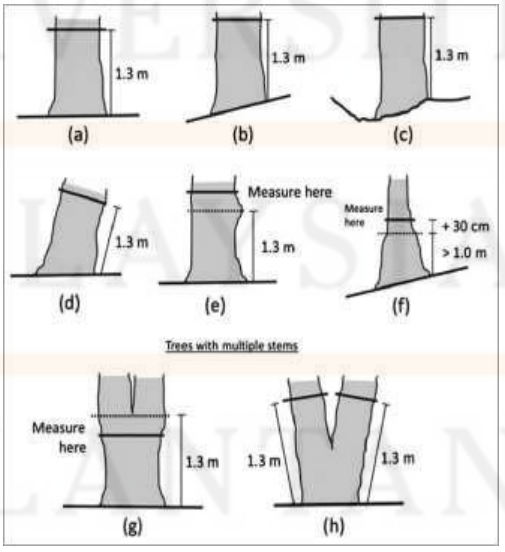


**Figure 3.2:** Diameter of breast Height measurement (Husch et al. 2003)

### 3.3.3 Collecting Specimen and Identify Species

All tree leaf samples less than 5 cm DBH and above in the study plot are taken to determine the name of the species. Specimen collection is done based on the selection of structural parts that need to be taken such as leaves, twigs, flowers, or fruit to facilitate the process of identifying tree species. for trees that are too tall,and it is difficult to get fresh specimens, dry leaves are taken to be used as a referenceto identify the tree species.

In addition, the process of identifying tree species is also done with the helpof plant experts who are experienced in recognizing tree species. To know the nameof the species and to know the tree species more clearly, a book titled "Pocket CheckList of Timber Trees" is used as a side reference.

## 3.4 Data Analysis

**a) Shannon Diversity Index**

The Shannon Diversity Index is an Index related to the concept ofuncertainty. The formula for the Shannon Diversity Index is:

$$H' = -\sum_{i=1}^{S}(pi)\ln(pi) \qquad \text{(Equation 3.1)}$$

Where:

H’ = Shannon diversity index

Pi = fraction of the entire population made up

of species iS = the number of species

$\sum$ = sum of species 1 to species

**b) Simpson Diversity Index**

The Simpson Index is a measure of biodiversity and species richness in each

ecological community or habitat. The formula for the Simpson Index is:

$$D = 1 - \sum \frac{n - (n - 1)}{N - (N - 1)} \qquad \text{(Equation 3.2)}$$

Where:

Ds = Simpson Diversity Index
N = Total number of all individuals
n = Number of individuals for each species

**c) Evenness Index**

Evenness Index refers to the distance between the number of each species in the environment. The formula for the Evenness Index is:

$$J = \frac{H}{Hmax} \qquad \text{(Equation 3.3)}$$

J'= the evenness index.

H'= the Shannon-Weiner index, which measures species diversity in a community (as explained earlier.

$H_{max}$ = the maximum possible value of the Shannon-Weiner index when all species are equally abundant, and it is calculated as ln(S), where S is the total number of species in the community.

**d) Basal Area**

The Basal Area Formula is a simplified version used to calculate the basal area of a tree trunk, where D is the diameter at breast height (DBH) of the tree. The formula for the Basal Area is:

$$Basal\ Area = 0.7857\ \times D^2 \qquad \text{(Equation 3.4)}$$

**e) Above Ground Biomass**

Above Ground Biomass, AGB refers to the total mass of all living matter found above the soil surface in a forest ecosystem. This includes stems, branches, leaves, and other parts of trees or plants that grow above ground. AGB is usually measured in units such as kilograms per tree or tons per hectare (t/ha) (Lamonica, 2023).

$$AGB = 0.0673 \times (WD \times H \times D^2)^{0.976} \qquad \text{(Equation 3.5)}$$

WD = Woode DensityH = Height of tree

D = Diameter Breast Height of tree

**f) Wood Density**

Wood density is a critical plant trait that is influenced by various factors such as tree growth strategy, environmental conditions, and hydraulic conductivity (Yanget al., 2023). It plays an important role in ecological processes such as tree growth,resistance to disturbance, and carbon stock assessment (Mallqui et al., 2022). Most Wood Density Values are obtained from the Global Database of Wood Densitywritten by Ignacio Larco Roca in 2017.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Diameter at Breast Height (DBH) Measurement

Diameter at breast height (DBH) is one of the important and standard measurementsused to measure the diameter of tree trunks for trees standing in forest areas.Therefore, this measurement is the most appropriate to use in the five study plots in Gunung Stong State Park (GSSP) to measure the diameter of trees between less than5 cm.

Figure 4.1 shows most trees present in this research plot fall into the DBH class between 1.0 cm - 1.9 cm. Therefore, the smaller diameter found by the trees growing in this plot, shows that most of the trees in this forest are still in the regeneration phase since there are more young trees found around this site.

Table 4.1 displays that *Antidesma montanum, Cinnamomum* iners, and *Garcinia morella* have the biggest diameters, measuring 5cm at DBH. However, mostof the earlier research carried out in this area was primarily concerned with trees larger than 5 cm in diameter. Jusoff and Skidmore (2009), for instance, used the AISAUPM-APSB airborne hyperspectral imaging technology system to study biomass in this forest at a different site and discovered that *Shorea bracteolate* (Meranti bukit), a member of the Dipterocarpaceae family, had a maximum diameter of 200 cm DBH and a height of 26 m.

Furthermore, this species is categorised as one of the uncommon species present in this forest. The two data obtained indicate that the diameter of the tree trunk has an impact on the tree's height. Accordingly, the tree will grow higher and

have thelargest biomass content in the research region the bigger its trunk diameter.

Figure 4.2 to 4.6 shows the DBH rate for the five plots that have been run. for the plot found (Figure 4.2) shows that DBH measuring 1.0 cm to 1.9 cm reacheda high number of 35 species. As for the second plot (Figure 4.2) it is also the same DBH which is the most, measuring 1.0 cm to 1.9 cm and 2.0 cm to 2.9 cm which hasthe same number of species as much as 21 species.

Next, for the third plot (Figure 4.2) shows that the graph does not reach GraphJ Curve. this is said to be so because in this third plot area there are many large and dead trees. This big tree lying dead trees is likely to be caused by being attackedby a disease, struck by lightning or the tree is too old. with the occurrence of such a thing, this fallen tree has hit the small trees that are under it, causing many small treesthat are under it to die and not be able to live again (Figure 4.3). As for the fifth plot(Figure 4.2) it shows the number of trees measuring 5.0 recorded as many as three species namely *Antidesma montanum*, *Cinnamomum iners* and *Garcinia morella*.

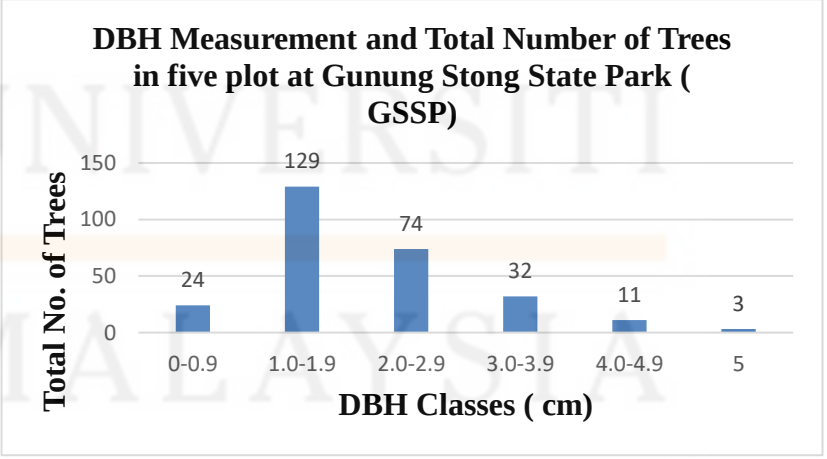


**Figure 4.1:** DBH Measurement and Total Number of Trees in five plots at Gunung StongState Park (GSSP)

**Table 4.1:** List of the highest species according to DBH measurement.

| Species Name | DBH (cm) |
|---|---|
| *Antidesma montanum* | 5 |
| *Cinnamomum iners* | 5 |
| *Garcinia morella* | 5 |
| *Ochanostachys bancana Valeton* | 4.9 |
| *Arthrophyllum diversifolium* | 4.9 |
| *Calophyllum rufigemmatum* | 4.8 |
| *Syzygium zeylanicum* | 4.8 |
| *Syzygium polyanthum* | 4.6 |
| *Gluta/ melanorrhoea spp.* | 4.5 |
| *Lindera lucida* | 4 |
| *Canarium pilosum* | 4 |
| *Melanochyla sp.* | 4 |
| *Syzgium scortechinii* | 4 |
| *Shorea parvifolia Dyer* | 4 |

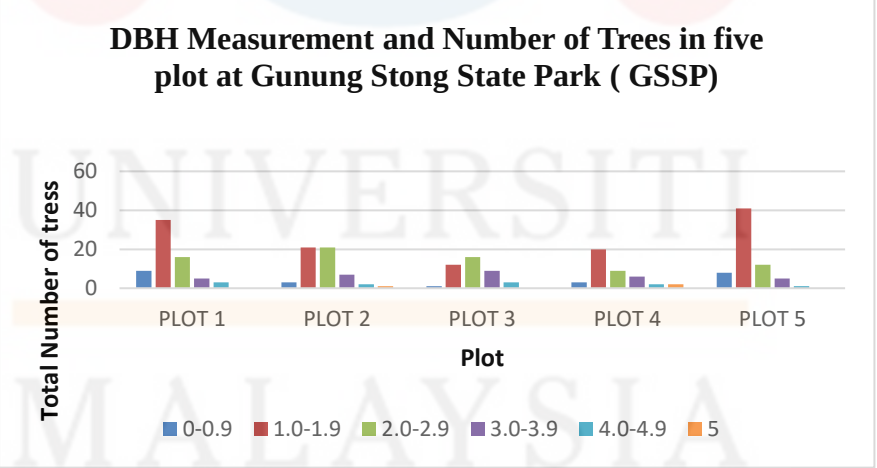


**Figure 4.2:** DBH Measurement and Number of Trees between five plots at Gunung StongState Park (GSSP)

**Figure 4.3:** Standing death tree and lying dead tree at Gunung Stong State Park (GSSP).

## 4.2 Trees Species Composition

Gunung Stong State Park (GSSP) is a hill dipterocarp forest that was cut down in the 1960s to 1980s (Maseri, 2009). Although logging was completely stopped in the 1990s(Maseri, 2009) but past logging can still be seen in lowlands (below 1000m) such as in this study plot where there are more young trees found during this study. This also shows that this forest is still in the regeneration phase. A total of 273 trees representing85 species, 74 genera and 43 families were recorded in these five plots.

The largest family found in these five plots is the Lauraceae family with 46 trees representing 4 species and 3 genera. The second largest family is Anacardiaceaebelongs to 27 families and consists of 5 species while Mytaceae is in the third largest family with 20 trees and consists of 6 species. Table 4.2 lists the largest familiesin the five parcels at this study site.

The species most frequently found in these five plots is *Cinnamomum iners* with 35 trees followed by *Ochanostachys bancana Valeton* with 13 trees and *Gluta/ melanorrhoea spp*. is the third most frequently found species with 11 trees as listed in Table 4.3.

**Table 4.2:** List ten of highest families according to highest individual number Of trees in five study plots at Gunung Stong State Park (GSSP).

| Family | No. of Species | No. of Genera | No. of Individual |
|---|---|---|---|
| Lauraceae | 4 | 3 | 46 |
| Anacardiaceae | 5 | 5 | 27 |
| Myrtaceae | 6 | 1 | 20 |
| Dipterocarpaceae | 6 | 4 | 17 |
| Moraceae | 5 | 4 | 17 |
| Ebenaceae | 3 | 1 | 16 |
| Annonaceae | 4 | 2 | 10 |
| Rubiaceae | 5 | 5 | 10 |

| | | | |
|---|---|---|---|
| Araliaceae | 2 | 2 | 9 |
| Apocynaceae | 4 | 3 | 8 |

**Table 4.3:** List of highest species that found in these five studies plots.

| Name | Family | No of Trees |
|---|---|---|
| *Cinnamomum iners* | Lauraceae | 35 |
| *Ochanostachys bancan Valeton* | Ochnaceae | 13 |
| *Melanorrhoea spp* | Anacardiaceae | 11 |
| *Diospyros paniculata* | Ebenaceae | 10 |
| *Arthrophyllum diversifolium* | Araliaceae | 8 |
| *Melanochyla sp* | Anacardiaceae | 8 |
| *Streblus elongatus* | Moraceae | 8 |
| *Stelechocarpus cauliflorus* | Annonaceae | 7 |
| *Syzygium polyanthum* | Myrtaceae | 7 |
| *Eurycoma longifolia* | Simaroubaceae | 6 |

## 4.3 Basal Area (BA)

When referring to the overall cross-sectional area of a standing tree, the phrase "basalarea" is sometimes used. This measurement is often made at the diameter at breast height (DBH) and is given as a percentage of the land area. Utilising this metric to characterise the structure of forests is also crucial. These five plots have a combined basal area of 0.02 $m^2$/ha.

Based on Table 4.4, *Garcinia morella*, *Cinnamomum iners*, and *Antidesma montanum* have the same base area, which is 0.00982 $m^2$/ha, indicating that these three species have an equivalent density and distribution in the measured forest area. Meanwhile, *Arthrophyllum diversifolium* and *Ochanostachys bancana Valeton* have a basal area of 0.00943 $m^2$/ha, slightly lower compared to the first three species, which indicates their slightly lower dominance in the forest. *Calophyllum rufigemmatum* and *Syzygium zeylanicum* each have a basal area of 0.00905 $m^2$/ha, showing a slightly lower dominance compared to the species at the top. *Syzygium polyanthum* with a base area of 0.00831 $m^2$/ha shows a lower distribution and density than the other species mentioned previously. *Melanorrhoea spp*. has a base area of 0.00796 $m^2$/ha, indicating that this species has fewer or smaller stems in the same area. Finally, *Canarium pilosum* has the lowest basal area, which is 0.00629 $m^2$/ha, showing the smallest density or stem size among all the species measured in the forest area. The total basal area for all species measured in these five plots is 1.0253064 $m^2$/ha. Basal area is an important measure in forest ecology because it provides an overview of the number and size of trees in an area, which influences the structure and function of the forest ecosystem. Higher numbers usually reflect the dominance or success of certain species in controlling space and resources in the habitat.

Put differently, basal area, which represents the cross-sectional area of tree stems at breast height and indicates the productivity and structure of the forest, is an important measure in the ecology and management of forests. Research has demonstrated that basal area and tree species density are critical factors in evaluating the health of forests and resource management (Canisius et al., 2022). According to the explanation provided, the basal region area varies depending on the kind of tree because of several aspects such as growth rates, tree size and form, species richness, interspecies competition, environmental factors, and tree age. bigger basal areas are typically seen in trees with faster growth rates, bigger trunks, and greater suitability for certain soil, water, and sunshine conditions. The basal area of each variety of treeis influenced by competition for resources, soil quality, water availability, climate, andtree age.

Table 4.5 shows Lauraceae has the highest basal area, which is 0.105352 $m^2$/ha, which shows significant dominance and density in the measured forest area. Olacaceae and Dipterocarpaceae followed with a basal area of 0.040864 $m^2$/ha and 0.036597 $m^2$/ha respectively, showing a lower but still important density and distribution. Anacardiaceae has a basal area of 0.031926 $m^2$/ha, while Ebenaceae and Araliaceae recorded a basal area of 0.027021 $m^2$/ha and 0.023202 $m^2$/ha, which shows their role in forest structure. Myrtaceae and Moraceae have a basal area of 0.021153 $m^2$/ha and 0.020056 $m^2$/ha, respectively, indicating a relatively lower density. Fagaceae was recorded with a base area of 0.011345 $m^2$/ha, while Burseraceae had the lowest base area, which was 0.002754 $m^2$/ha, which indicates a smaller number or size of stems. This basal area is an important indicator in forest ecology because it describes the number and size of trees in an area, which contributes to the understanding of the structure and function of forest ecosystems.

Higher numbers usually reflect the dominance or success of a family in controlling resources and space in the habitat.

In turn due to several variables, including species composition, tree density, and environmental influences. Basal area estimates may also be affected by the basal area factor (BAF) of the sample method (Taiwo et al., 2020).

**Table 4.4:** List of ten species with the largest basal area for five plots.

| No. | Species | Basal area ($m^2$/ha) |
|---|---|---|
| 1. | *Garcinia morella* | 0.00982 |
| 2. | *Cinnamomum iners* | 0.00982 |
| 3. | *Antidesma montanum* | 0.00982 |
| 4. | *Arthrophyllum diversifolium* | 0.00943 |
| 5. | *Ochanostachys bancana Valeton* | 0.00943 |
| 6. | *Calophyllum rufigemmatum* | 0.00905 |
| 7. | *Syzygium zeylanicum* | 0.00905 |
| 8. | *Syzygium polyanthum* | 0.00831 |
| 9. | *Melanorrhoea spp.* | 0.00796 |
| 10 | *Canarium pilosum* | 0.00629 |

**Table 4.5:** Lists of ten families with the largest basal area for plot five.

| Family | Basal area ($m^2$/ha) |
|---|---|
| Lauraceae | 0.105352 |
| Myrtaceae | 0.021153 |
| Anacardiaceae | 0.031926 |
| Olacaceae | 0.040864 |
| Dipterocarpaceae | 0.036597 |
| Moraceae | 0.020056 |
| Ebenaceae | 0.027021 |
| Araliaceae | 0.023202 |
| Fagaceae | 0.011345 |
| Burseraceae | 0.002754 |

## 4.4 Species Diversity

Using the Shannon-Wiener diversity index, the species diversity index was also derived from these five plots. A value of 3.975 is found for the species diversity throughout the five plots in this investigation. This demonstrates the continued diversity of species in these five plots. However, 3.455 ($H_{max}$ = 3.455) is the largest species diversity found in this study. The forest was cleared more than 30 years ago, so the value of the moderate species diversity is rather high. As a result, most of the various species in this plot may be regarded as not fully recovered because the majorityof the study site's trees are young, smaller-diameter trees (Table 4.6).

Additonally, the Shannon-Wierner index value also consists of two importantcomponents which are species richness and species evenness (Magurran, 1988). Plot1 Shannon-Wiener index recorded the greatest value of 3.455, while Plot 3 recordedthe lowest value of 2.51, indicating a disparity in species richness, according to a study of the five plots. Plot 1 exhibits a greater diversity of species and a more optimal distribution of individuals within each species, likely attributable to improved environmental conditions, less disturbance, and accelerated development. Plot 3 on the other hand would see more disturbance and intense competition amongst dominant species, which would lead to a decline in the variety of species and ecological diversity. Significant variations in the Shannon-Wiener index valuesbetween the two plots are caused by these causes (Table 4.7).

Higher values indicate greater diversity. The Simpson Diversity Index is usedto calculate the probability that two randomly picked individuals from a given location are of different species (Zhou et al., 2020). The region has a very high

speciesvariey, as evidenced by the Simpson variety Index reading of 0.971 for each of thefive plots. The fact that this score is nearly at its maximum of one suggests that nearlyevery individual in the plots belongs to a separate species. This reading depicts a verydiverse environment in which several species may dwell in harmony and no one species has an overwhelming amount of dominance.

The Simpson Diversity Index then showed a considerable difference in species diversity between the plots, with Plot 1 recording the greatest value of 0.99 and Plot 3 recording the lowest value of 0.91. Nearly all the individuals in Plot 1, which has an index of around 1, are from distinct species, indicating a highly diverseand well-balanced ecosystem. Conversely, Plot 3's value of 0.91 denotes a lesser levelof variety, meaning that there is a greater likelihood of two randomly chosen individuals belonging to the same species. This discrepancy can be attributed to Plot1's superior environmental circumstances, less disturbance, and more developed stageof growth than Plot 3, which might be subject to greater disturbance or have a dominating species that reduces the variety of other species (Table 4.7).

Finally, about the Evenness Index (J). The degree to which the number of individuals in a plot is equally distributed among species is determined by the Evenness Index (J). Plot 1 has the greatest Evenness Index (J) value of 1.0 out of the five plots, meaning that all the species presents are perfectly and evenly distributed across the people in this plot. Plots 2 through 4 all showed a somewhat high level of evenness, but not as high as Plot 1, with values of 0.95, 0.94, and 0.85, respectively. Plot 3 on the other hand had the lowest. With a 0.73 Evenness Index score, it is more likely that certain species are more dominant than others and that there is a larger imbalance in the distribution of people across species.

**Table 4.6:** List of diversity indices used in these five study plots.

| Indices | Values |
|---|---|
| Shannon-Wiener diversity index (H) | 3.455 |
| Simpson Diversity Index | 0.971 |

**Table 4.7:** List of Shannon-Wiener indices, Simpsons and Evenness index that used in these five studiesplots.

| | Index | | |
|---|---|---|---|
| **Plot** | **Shannon-Wiener** | **Simpson** | **Evenness Index (J)** |
| Plot 1 | 3.455 | 0.99 | 1.0 |
| Plot 2 | 3.294 | 0.97 | 0.95 |
| Plot 3 | 2.510 | 0.91 | 0.73 |
| Plot 4 | 2.954 | 0.95 | 0.85 |
| Plot 5 | 3.247 | 0.96 | 0.94 |

## 4.5 Above Ground Biomass (AGB)

Above Ground Biomass (AGB) is a critical metric for assessing forest carbon storage,measured in tonnes per hectare (t/ha). The data in table 4.8 shows the Above-Ground Biomass (AGB) value of ten tree species measured in tons per hectare (t/ha). *Garcinia morella* has the highest AGB with 0.03093 t/ha, indicating that this species has a larger biomass mass than other species in the list. *Calophyllum rufigemmatum* and *Syzygium zeylanicum* follow with AGB values of 0.028855 t/ha and 0.027676 t/ha, respectively, indicating a significant biomass density. *Ochanostachys bancana Valeton* and *Arthrophyllum diversifolium* each have AGBs of 0.026939 t/ha and 0.022608 t/ha, showing their contribution to the total forest biomass. *Lithocarpus cantleyanus* has an AGB of 0.01482 t/ha, followed by *Cinnamomum iners* with 0.013951 t/ha and *Antidesma montanum* with 0.013454 t/ha. *Streblus elongatus* and *Agathis atropurpurea* have the lowest AGB values, at 0.011581 t/ha and 0.011252 t/ha, respectively. The total AGB for these ten species is 0.61892904 t/ha. This AGB value is important for understanding the contribution of tree species to the total forest biomass, which plays a critical role in carbon storage and nutrient cycling within the forest ecosystem. Higher AGB values indicate a greater potential for carbon storage, which is crucial in the context of climate change mitigation and forest conservation. These measurements reflect the density and carbon sequestration potential of the forest vegetation, with higher values indicating more substantial biomass and greater carbon storage capacity.

It can clearly be stated that *Garcinia morella* dominates with a much higher AGB value than other species, indicating that it may be larger or more abundant in this study area. Factors such as fast growth rate, large stem size, and high populationdensity can contribute to high AGB values *Calophyllum rufigemmatum*

and *Syzygium zeylanicum* also showed significant AGB values, which may indicate theiradaptation to the environmental conditions in Gunung Stong State Park. The otherspecies on this list, despite having lower AGB values, still contribute to a significantamount of biomass in the area. This variation in AGB values can also be influenced by factors such as forest structure, competition between species, and the history of forest disturbance such as logging or fire. Next, the distribution of trees also plays animportant role in estimating the biomass on the ground because trees act as carbon absorbers in the forest by storing carbon dioxide (COz) through the process of photosynthesis and the amount of this carbon will affect the amount of biomass on the ground in the forest because if more trees are present in the forest area, then morecarbon can be absorbed and can directly increase the amount of biomass on the ground in the forest. For example, certain plots in this study were established in sloping areas and showed an uneven distribution of trees which caused the number of trees found in these plots to decrease. Therefore, the amount of above ground biomassobtained is lower than other previous studies.

Table 4.8 provides details on the Above Ground Biomass (AGB) values for various plant families within Gunung Stong State Park. The Lauraceae family has the highest AGB at 0.112741 t/ha, indicating a significant contribution to biomass and playing a crucial role in carbon storage, nutrient cycling, and habitat provision. Olacaceae follows with an AGB of 0.07586 t/ha, showing a substantial contribution as well. Dipterocarpaceae, with an AGB of 0.054113 t/ha, also makes a significant impact, while Myrtaceae has an AGB of 0.0192973 t/ha, reflecting a smaller presence compared to the top contributors. Moraceae and Anacardiaceae have similar AGB values at 0.02248394 t/ha and 0.0223532 t/ha,

respectively, indicating comparable contributions. Araliaceae contributes moderately with an AGB of 0.021952 t/ha. Fagaceae has a lower AGB of 0.012592 t/ha, showing a smaller role. Clusiaceae and Calophyllaceae have the lowest AGB values at 0.003033 t/ha and 0.000784 t/ha, respectively, indicating minimal contribution to the overall biomass. These AGB values illustrate the varying contributions of each plant family to the park's biomass, with higher AGB values reflecting greater roles in carbon sequestration and ecosystem functions.

AGB measures the total dry matter mass of trees above ground, important for understandingcarbon storage and forest ecosystem productivity. These genera contribute greatly to carbon storage, which helps mitigate climate change by absorbing CO2 from the atmosphere. They also play a role in maintaining the structure and function of ecosystems, supporting biodiversity, providing habitats for various species, andproviding valuable resources such as wood and medicinal products. The dominance of Myrtaceae shows the importance of this family in the ecosystem, while thecontribution of other family shows that each type of tree has a unique role inmaintaining the balance and health of the forest in Gunung Stong State Park.

**Table 4.8:** Ten species for the highest Above Ground Biomass value in all five plots in GunungStong State Park.

| No | Species | AGB (t/ha) |
|---|---|---|
| 1 | *Garcinia morella* | 0.03093 |
| 2 | *Calophyllum rufigemmatum* | 0.028855 |
| 3 | *Syzygium zeylanicum* | 0.027676 |
| 4 | *Ochanostachys bancana Valeton* | 0.026939 |
| 5 | *Arthrophyllum diversifolium* | 0.022608 |
| 6 | *Lithocarpus cantleyanus* | 0.01482 |
| 7 | *Cinnamomum iners* | 0.013951 |
| 8 | *Antidesma montanum* | 0.013454 |
| 9 | *Streblus elongatus* | 0.011581 |
| 10 | *Agathis atropurpurea* | 0.011252 |

**Table 4.9:** Ten families for the highest Above Ground Biomass value in all five plots in Gunung Stong State Park.

| Family | AGB(a/ha) |
|---|---|
| Myrtaceae | 0.0192973 |
| Lauraceae | 0.112741 |
| Olacaceae | 0.07586 |
| Anacardiaceae | 0.0223532 |
| Moraceae. | 0.02248394 |
| Araliaceae | 0.021952 |
| Clusiaceae | 0.003033 |
| Fagaceae | 0.012592 |
| Calophyllaceae | 0.000784 |
| Dipterocarpaceae | 0.054113 |

## 4.6 Important Value Index (IVI)

The Importance Value Index (IVI) is an important metric used to assess the importance of different species in ecosystems, particularly in the study of mangrove vegetation. IVI values help prioritize species based on their abundance and distribution, providing insight into the overall diversity and ecological importance of each species in an ecosystem. This index plays an important role in conservation efforts by highlighting key species that contribute significantly to ecosystem structure and function, helping in the formulation of effective management strategies to preserve biodiversity and ecosystem health.

The data provided lists the Species Important Value Index (SIVi) and their corresponding percentages for ten plant species across five plots. The *Antidesma montanum, Cinnamomum iners,* and *Garcinia morella* each have an SIVi of 1.14102%, indicating their equal importance in terms of their overall presence and role within the plots. These species share the highest index value, suggesting they are particularly significant in the ecosystem. Following closely are *Arthrophyllum diversifolium* and *Ochanostachys bancana Valeton*, both with an SIVi of 1.10309 %, highlighting their notable but slightly lesser importance compared to the top three species. *Calophyllum rufigemmatum* and *Syzygium zeylanicum* each have an SIVi of 1.06593%, reflecting their moderate significance. *Syzygium polyanthum* has a slightly lower SIVi of 0.99389%, and *Melanorrhoea spp*. stands at 0.95903%, showing a smaller but still relevant role. Finally, *Shorea parvifolia Dyer* has the lowest SIVi of 0.79619% among the listed species. The total SIVi across all five plots sums up to 100%, indicating that these values represent the relative importance of each species within the studied area. The SIVi helps in understanding the ecological significance and dominance of various species, which is crucial for conservation and management efforts.

Table 4.11 shows the Family Important Value Index (FIVi) for the top ten plant families across five plots in Gunung Stong State Park. Lauraceae has the highest FIVi at 18.70019%, indicating its significant role in the forest ecosystem. Anacardiaceae and Dipterocarpaceae follow with FIVi values of 8.05891% and 7.4416%, respectively, reflecting their notable but slightly lesser importance compared to Lauraceae. Olacaceae and Moraceae have FIVi values of 5.78523% and 5.06991%, showing a moderate importance within the ecosystem, while Ebenaceae has a FIVi of 5.5657%, also indicating substantial significance. Myrtaceae has an FIVi of 5.90941%, highlighting its important role. Araliaceae and Annonaceae have FIVi values of 3.91123% and 3.15298%, respectively, indicating a smaller but still relevant role. Lastly, Rubiaceae has the lowest FIVi among the ten families at 2.87137%, but still contributes to the forest structure. Overall, the data shows that Lauraceae is the dominant family, while other families like Anacardiaceae, Dipterocarpaceae, and Olacaceae also play important roles in the composition and functioning of the forest ecosystem in the park.

**Table 4.10:** List ten Species for the highest Important Value Index in all five plots in Gunung Stong State Park.

| No. | Species Important Value Index (SIVi) | SIVi (%) |
|---|---|---|
| 1. | *Antidesma montanum* | 1.14102 |
| 2. | *Cinnamomum iners* | 1.14102 |
| 3. | *Garcinia morella* | 1.14102 |
| 4. | *Arthrophyllum diversifolium* | 1.10309 |
| 5. | *Ochanostachys bancana Valeton* | 1.10309 |
| 6. | *Calophyllum rufigemmatum* | 1.06593 |
| 7. | *Syzygium zeylanicum* | 1.06593 |
| 8. | *Syzygium polyanthum* | 0.99389 |
| 9. | *Melanorrhoea spp.* | 0.95903 |
| 10 | *Shorea parvifolia Dyer* | 0.79619 |

**Table 4.11:** List ten families for the highest Important Value Index in all five plots in Gunung Stong State Park.

| Family Important Value Index (FIVi) | FIVi (%) |
|---|---|
| Lauraceae | 18.70019 |
| Myrtaceae | 5.90941 |
| Anacardiaceae | 8.05891 |
| Dipterocarpaceae | 7.4416 |
| Olacaceae | 5.78523 |
| Moraceae | 5.06991 |
| Ebenaceae | 5.5657 |
| Araliaceae | 3.91123 |
| Annonaceae | 3.15298 |
| Rubiaceae | 2.87137 |

## 4.7 Conservation Status

Table 4.12 lists ten tree species along with their conservation status according to the IUCN. The species included in the "Least Concern" category are *Syzygium claviflorum* from the Myrtaceae family, *Heptapleurum actinophyllum* from the Araliaceae family, G*lycosmis pentaphylla* from the Rutaceae family, and *Campnosperma squamatum* from the Anacardiaceae family, indicating that these species do not face a significant threat of extinction. *Shorea parvifolia* Dyer from the Dipterocarpaceae family and *Horsfieldia superba* from the Myristicaceae family are categorized as "Near Threatened", indicating that they are at risk of extinction if conservation action is not taken. The species *Vatica maingayi* from the family Dipterocarpaceae and *Aquilaria malaccensis* from the family Thymelaeaceae are classified as "Vulnerable", which indicates that they face a higher risk of extinction. Two species, *Ochanostachys bancana Valeton* from the family Ochnaceae and *Diospyros buxifolia* from the familyAnnonaceae, have no conservation status available (N/A), possibly due to a lack of sufficient data to assess their status.

Since this tree species is still not classified as endangered by the IUCN, the conservation status of this study indicates that the species identified in the GSSP are still safeguarded and protected by the Kelantan Forestry Department and other relevantorganisations.

Furthermore, several variables, including the introduction of new non-native species and modifications in the fragmentation of forests, may be to blame for the risksfaced by some endemic species (Mrinal, 2013). However, according to Ng and Low (1982), 27% of the tree species in Peninsular Malaysia are indigenous, and some of them are under danger.

**Table 4.12:** List ten families for the Conservation Status in all five plots in Gunung Stong State Park.

| Species | Family | IUCN/Status |
|---|---|---|
| *Syzygium claviflorum* | Myrtaceae | Least Concern |
| *Shorea parvifolia dyer* | Dipterocarpaceae | Near Threatened |
| *Vatica maingayi* | Dipterocarpaceae | Vulnerable |
| *Heptapleurum actonophyllum* | Araliaceae | Least Concern |
| *Horsfieldia superba* | Myristicaceae | Near Threatened |
| *Ochanostachys bancana valeton* | Ochnaceae | N/A |
| *Diospyros buxifolia* | Annonaceae | N/A |
| *Glycosmis pentaphylla* | Rutaceae | Least Concern |
| *Aquilaria malaccensis* | Thymelaeacaeae | Vulnerable |
| *Campnosperma squamatum* | Anacardiaceae | Least Concern |

# CHAPTER 5

## CONCLUSION AND RECOMMENDATIONS

In this study, it is shown that most of the frequent and dominant tree species in these four plots are *Cinnamomum iners* from the Lauraceae family. This is an indication thatGunung Stong State Park still contains very valuable tree species. A total of 273 tree trunks with a breast diameter of less than 5 cm and above were surveyed in a plot of 0.2 ha with a flora composition consisting of 43 families, 70 genera and 85 species.

The largest family from the entire study is the Lauraceae family with 35 species. The biomass value above ground for the five plots in this study was estimated as 9.3379 tons/ha. Plot 3 contributed to the highest biomass value of 0.5058 tons/ha while plot 1 contributed the lowest biomass with an estimated biomass of 0.0942.

Next, the Lauraceae family contributes to the highest biomass value of the family which is 7.2458 tons/ha while the second place is the *Ochanostachys BancanaValeton* species from the Ochanostachys family contributing biomass with anestimated biomass 0.7313 tons/ha. The Shannon-Wiener Diversity Index value fromthis study is 3.455 where this value is found to be high compared to some other studies.

Most of the trees recorded and marked in this plot are young and juvenile treeswhich may indicate that this forest is still in the process of regeneration due to loggingthat happened more than thirty years ago. Therefore, among the suggestions that can be made to improve or increase the amount of flora in Gunung Stong State

Park (GSSP)is to replant saplings or other tree species to increase the species population in the future and at the same time avoid us. Also, encourage more new studies. Carried out in this forest considering that this forest is quite large so more researchers withdifferential studies are needed to get more information especially about speciesdiversity, composition, carbon stock and biomass content. Thus, with the new data obtained, it can help the Kelantan Forestry Department to be more concerned about this forest and preserve this valuable resource. Finally, to increase the number of visitors in this forest, the responsible parties need to do some promotion or organize some challenging activities based on nature to attract more people to come and explorethis forest and at the same time can raise awareness about the importance of preservingand protecting the forest.

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## APPENDIX A

List of recorded families, genera and species in five study plots at Gunung Stong State Park (GSSP).

| Family | No. of Species | No. of Genera | No. of Individual |
|---|---|---|---|
| Lauraceae | 4 | 3 | 46 |
| Anacardiaceae | 5 | 5 | 27 |
| Myrtaceae | 6 | 1 | 21 |
| Dipterocarpaceae | 6 | 4 | 17 |
| Moraceae | 5 | 4 | 17 |
| Ebenaceae | 3 | 1 | 16 |
| Olacaceae | 1 | 1 | 14 |
| Annonaceae | 4 | 2 | 10 |
| Rubiaceae | 5 | 5 | 10 |
| Araliaceae | 2 | 2 | 9 |
| Apocynaceae | 4 | 3 | 8 |
| Myristicaceae | 2 | 2 | 7 |
| Simaroubaceae | 2 | 2 | 7 |
| Fagaceae | 3 | 1 | 6 |
| Caesalpinioideae | 1 | 1 | 5 |
| Rhizophoraceae | 2 | 2 | 5 |
| Chtysobalanaceae | 2 | 2 | 4 |
| Euphorbiaceae | 2 | 2 | 4 |
| Malvaceae | 1 | 1 | 4 |
| Sapindaceae | 2 | 2 | 4 |
| Araucariaceae | 1 | 1 | 3 |
| Burseraceae | 1 | 1 | 3 |
| Thymelaeaceae | 1 | 1 | 3 |
| Cannabaceae | 1 | 1 | 2 |
| Melastomataceae | 1 | 1 | 2 |
| Phyllanthaceae | 2 | 2 | 2 |
| Primulaceae | 1 | 1 | 2 |

| | | | |
|---|---|---|---|
| Rutaceae | 1 | 1 | 2 |
| Tetrameristaceae | 1 | 1 | 2 |
| Calophyllaceae | 1 | 1 | 1 |
| Clusiaceae | 1 | 1 | 1 |
| Fabaceae | 1 | 1 | 1 |
| Mytaceae | 6 | 1 | 1 |
| Ochnaceae | 1 | 1 | 1 |
| Pandaceae | 1 | 1 | 1 |
| Picramniaceae | 1 | 1 | 1 |
| Piperaceae | 1 | 1 | 1 |
| Polygalaceae | 1 | 1 | 1 |
| Ulmaceae | 1 | 1 | 1 |
| Violaceae | 1 | 1 | 1 |
| **Total** | **88** | **67** | **273** |

## APPENDIX B

List of species and individuals' number of tress found in five study plots at GunungStong State Park.

| Name | Individual |
|---|---|
| *Agathis atropurpurea* | 3 |
| *Aidia densiflora* | 1 |
| *Alstonia angustiloba* | 2 |
| *Alstonia scholaris* | 1 |
| *Alyxia reinwardtii* | 1 |
| *Ampelocera edentula* | 1 |
| *Antidesma montanum* | 1 |
| *Aquilaria malaccensis* | 3 |
| *Archidendron hendersonii* | 5 |
| *Ardisia colorata* | 2 |
| *Arthrophyllum diversifolium* | 8 |
| *Baccaurea brevipes* | 1 |
| *Blepharistemma serratum* | 1 |
| *Brackenridgea hookeri (Planch.) A. Gray* | 1 |
| *Buchanania sessilifolia* | 5 |
| *Calophyllum rufigemmatum* | 1 |
| *Campnosperma squamatum* | 1 |
| *Canarium pilosum* | 3 |
| *Canthium coromandelicum* | 2 |
| *Chassalia corallioides* | 2 |
| *Cinnamomum iners* | 35 |
| *Desmos chinensis* | 1 |
| *Diospyros buxifolia* | 5 |

| | |
|---|---|
| *Diospyros diepenhorstii* | 1 |
| *Diospyros paniculata* | 10 |
| *Dipterocarpus bourdillnolli* | 1 |
| *Elaeocarpus petiolatus* | 1 |
| *Eonia glycycarpa* | 1 |
| *Eurycoma longifolia* | 6 |
| *Ficus subulata* | 1 |
| *Ficus vasculosa* | 1 |
| *Galearia fulva* | 1 |
| *Garcinia morella* | 1 |
| *Gironniera parvifolia* | 2 |
| *Gluta/ melanorrhoea spp.* | 11 |
| *Glycosmis pentaphylla* | 2 |
| *Guatteria punctata* | 1 |
| *Hancea penangensis* | 3 |
| *Heptapleurum actinophyllum* | 1 |
| *Heritiera javanica (blume) Kosterm.* | 4 |
| *Hirtella triandra* | 1 |
| *Hopea odorata* | 1 |
| *Horsfieldia superba* | 4 |
| *Ixora chinensis* | 2 |
| *Ixora condesta* | 1 |
| *Knema furfuracea* | 3 |
| *Koompassia malaccensis* | 1 |
| *Lindera lucida* | 5 |
| *Lithocarpus* | 2 |
| *Lithocarpus cantleyanus* | 3 |
| *Lithocarpus glaber* | 1 |
| *Litsea lancifolia* | 2 |

| | |
|---|---|
| *Litsea reticulata* | 4 |
| *Maclurodendron porteri* | 5 |
| *Mallotus leucoderrnis Hook.f.* | 1 |
| *Mangifera quadrifida* | 2 |
| *Maranthes corymbosa* | 3 |
| *Meiogyne Miq* | 1 |
| *Melanochyla sp.* | 8 |
| *Ochanostachys bancana Valeton* | 13 |
| *Paranephelium macrophyllum* | 3 |
| *Pellacalyx saccardianus Scort.* | 4 |
| *Perebea hispidula standl* | 2 |
| *Picramnia antidesma* | 1 |
| *Piper aduncum* | 1 |
| *Psychotria grandis* | 2 |
| *Pternandra echinata Jack* | 2 |
| *Shorea leprosula* | 6 |
| *Shorea parvifolia Dyer* | 3 |
| *Shorea spp* | 3 |
| *Stelechocarpus cauliflorus* | 7 |
| *Streblus elongatus* | 8 |
| *Strombosia ceylanica* | 1 |
| *Syzgium scortechinii* | 4 |
| *Syzygium claviflorum* | 1 |
| *Syzygium polyanthum* | 7 |
| *Syzygium pseudo formosum* | 4 |
| *Syzygium subcrenatum* | 1 |
| *Syzygium zeylanicum* | 4 |
| *Tabernaemontana undulata* | 4 |
| *Teimanniodendron smilacifolium (H.* | 1 |

| | |
|---|---|
| *Pearson) kosterm* | |
| *Tetramerista glabra Miq.* | 2 |
| *Vatica maingayi* | 3 |
| *Xanthophyllum sp.* | 1 |
| *Xerospermum noronhianum* | 1 |

## APPENDIX C

List of species and above ground biomass content in five plots at Gunung Stong StatePark, Kelantan.

| ***Name*** | **Family** | **AGB (t/ha)** |
|---|---|---|
| *Garcinia morella* | Clusiaceae | 0.03093 |
| *Calophyllum rufigemmatum* | Calophyllaceae | 0.028855 |
| *Syzygium zeylanicum* | Myrtaceae | 0.027676 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.026939 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.022608 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.01482 |
| *Cinnamomum iners* | Lauraceae | 0.013951 |
| *Antidesma montanum* | Phyllanthaceae | 0.013454 |
| *Streblus elongatus* | Moraceae | 0.011581 |
| *Agathis atropurpurea* | Araucariaceae | 0.011252 |
| *Syzgium scortechinii* | Myrtaceae | 0.011233 |
| *Streblus elongatus* | Moraceae | 0.010831 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.010451 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.010302 |
| *Syzygium polyanthum* | Myrtaceae | 0.009703 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.008103 |
| *Lithocarpus* | Fagaceae | 0.007355 |
| *Melanochyla sp.* | Anacardiaceae | 0.006969 |
| *Hancea penangensis* | Euphorbiaceae | 0.006884 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.006615 |
| *Syzgium scortechinii* | Myrtaceae | 0.006425 |
| *Eurycoma longifolia* | Simaroubaceae | 0.006301 |
| *Glycosmis pentaphylla* | Rutaceae | 0.006282 |
| *Tetramerista glabra Miq.* | Tetrameristaceae | 0.005866 |
| *Baccaurea brevipes* | Phyllanthaceae | 0.005455 |
| *Syzygium zeylanicum* | Myrtaceae | 0.005408 |
| *Lithocarpus* | Fagaceae | 0.005245 |
| *Campnosperma squamatum* | Anacardiaceae | 0.005195 |

| | | |
|---|---|---|
| *Cinnamomum iners* | Lauraceae | 0.004964 |
| *Ochanostachys bancana valeton* | Olacaceae | 0.004944 |
| *Cinnamomum iners* | Lauraceae | 0.004629 |
| *Cinnamomum iners* | Lauraceae | 0.00439 |
| *Streblus elongatus* | Moraceae | 0.004366 |
| *Alyxia reinwardtii* | Apocynaceae | 0.004137 |
| *Cinnamomum iners* | Lauraceae | 0.004128 |
| *Cinnamomum iners* | Lauraceae | 0.004118 |
| *Canarium pilosum* | Burseraceae | 0.00405 |
| *Syzygium polyanthum* | Myrtaceae | 0.003961 |
| *Canthium coromandelicum* | Rubiaceae | 0.003944 |
| *Cinnamomum iners* | Lauraceae | 0.003911 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.003895 |
| *Ixora chinensis* | Rubiaceae | 0.003796 |
| *Diospyros buxifolia* | Ebenaceae | 0.003717 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.003681 |
| *Diospyros diepenhorstii* | Ebenaceae | 0.00354 |
| *Lindera lucida* | Lauraceae | 0.003525 |
| *Heptapleurum actinophyllum* | Araliaceae | 0.003428 |
| *Agathis atropurpurea* | Araucariaceae | 0.003322 |
| *Cinnamomum iners* | Lauraceae | 0.003285 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.003176 |
| *Shorea spp* | Dipterocarpaceae. | 0.003111 |
| *Hancea penangensis* | Euphorbiaceae | 0.003068 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.003033 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.002972 |
| *Syzgium scortechinii* | Myrtaceae | 0.002902 |
| *Shorea spp* | Dipterocarpaceae. | 0.002895 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.002872 |
| *Diospyros paniculata* | Ebenaceae | 0.002863 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.002828 |
| *Diospyros paniculata* | Ebenaceae | 0.002799 |
| *Cinnamomum iners* | Lauraceae | 0.002779 |

| | | |
|---|---|---|
| *Guatteria punctata* | Annonaceae | 0.002669 |
| *Streblus elongatus* | Moraceae | 0.002642 |
| *Vatica maingayi* | Dipterocarpaceae | 0.002576 |
| *Canarium pilosum* | Burseraceae | 0.002538 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.002504 |
| *Pternandra echinata Jack* | Melastomataceae | 0.00229 |
| *Tetramerista glabra Miq.* | Tetrameristaceae | 0.002254 |
| *Syzygium polyanthum* | Myrtaceae | 0.002142 |
| *Cinnamomum iners* | Lauraceae | 0.002104 |
| *Elaeocarpus petiolatus* | Elaeocarpaceae | 0.002101 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00206 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.002017 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.002003 |
| *Cinnamomum iners* | Lauraceae | 0.001965 |
| *Mangifera quadrifida* | Anacardiaceae | 0.001957 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.001925 |
| *Hancea penangensis* | Euphorbiaceae | 0.001883 |
| *Agathis atropurpurea* | Araucariaceae | 0.001866 |
| *Hopea odorata* | Dipterocarpaceae | 0.001792 |
| *Diospyros paniculata* | Ebenaceae | 0.001779 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.001776 |
| *Horsfieldia superba* | Myristicaceae | 0.001749 |
| *Syzygium zeylanicum* | Myrtaceae | 0.001694 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.001674 |
| *Melanochyla sp.* | Anacardiaceae | 0.001595 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.001564 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.001541 |
| *Cinnamomum iners* | Lauraceae | 0.001529 |
| *Syzygium polyanthum* | Myrtaceae | 0.001522 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.001478 |
| *Cinnamomum iners* | Lauraceae | 0.00146 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.00145 |
| *Cinnamomum iners* | Lauraceae | 0.001442 |

| | | |
|---|---|---|
| *Aidia densiflora* | Rubiaceae | 0.001416 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.001402 |
| *Streblus elongatus* | Moraceae | 0.001391 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.001386 |
| *Dipterocarpus bourdillnolli* | Dipterocarpaceae | 0.001373 |
| *Shorea leprosula* | Dipterocarpaceae | 0.001369 |
| *Eurycoma longifolia* | Simaroubaceae | 0.001343 |
| *Mallotus leucoderrnis Hook.f.* | Euphorbiaceae | 0.001315 |
| *Vatica maingayi* | Dipterocarpaceae | 0.001311 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.001294 |
| *Eurycoma longifolia* | Simaroubaceae | 0.001286 |
| *Tabernaemontana undulata* | Apocynaceae | 0.001282 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.001272 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.001265 |
| *Tabernaemontana undulata* | Apocynaceae | 0.001237 |
| *Streblus elongatus* | Moraceae | 0.001229 |
| *Diospyros buxifolia* | Ebenaceae | 0.001215 |
| *Teimanniodendron smilacifolium (H. Pearson) kosterm* | Simaroubaceae | 0.001182 |
| *Psychotria grandis* | Rubiaceae | 0.001175 |
| *Desmos chinensis* | Annonaceae | 0.001172 |
| *Brackenridgea hookeri (Planch.) A. Gray* | Ochnaceae | 0.00117 |
| *Cinnamomum iners* | Lauraceae | 0.00115 |
| *Eurycoma longifolia* | Simaroubaceae | 0.001145 |
| *Maclurodendron porteri* | Moraceae. | 0.001144 |
| *Syzygium subcrenatum* | Myrtaceae | 0.001135 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.001123 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.001103 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.001102 |
| *Cinnamomum iners* | Lauraceae | 0.001083 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.001074 |
| *Blepharistemma serratum* | Rhizophoraceae | 0.001074 |
| *Canarium pilosum* | Burseraceae | 0.001064 |

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|---|---|---|
| *Strombosia ceylanica* | Olacaceae | 0.001043 |
| *Diospyros paniculata* | Ebenaceae | 0.001025 |
| *Knema furfuracea* | Myristicaceae | 0.001016 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.000988 |
| *Alstonia angustiloba* | Apocynaceae | 0.000987 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.000957 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.000952 |
| *Eurycoma longifolia* | Simaroubaceae | 0.000923 |
| *Melanochyla sp.* | Anacardiaceae | 0.000916 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.000912 |
| *Ampelocera edentula* | Ulmaceae | 0.000911 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.000886 |
| *Diospyros paniculata* | Ebenaceae | 0.000883 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00088 |
| *Picramnia antidesma* | Picramniaceae | 0.000876 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.000843 |
| *Maclurodendron porteri* | Moraceae. | 0.000837 |
| *Lithocarpus glaber* | Fagaceae | 0.000833 |
| *Ardisia colorata* | Primulaceae | 0.000828 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.000818 |
| *Cinnamomum iners* | Lauraceae | 0.00081 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.000789 |
| *Gironniera parvifolia* | Cannabaceae | 0.000784 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.000767 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.000763 |
| *Pternandra echinata Jack* | Melastomataceae | 0.000758 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00075 |
| *Syzygium claviflorum* | Mytaceae | 0.000723 |
| *Melanochyla sp.* | Anacardiaceae | 0.000708 |
| *Knema furfuracea* | Myristicaceae | 0.000691 |
| *Litsea reticulata* | Lauraceae | 0.000669 |
| *Shorea spp* | Dipterocarpaceae. | 0.000648 |
| *Eurycoma longifolia* | Simaroubaceae | 0.000642 |

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|---|---|---|
| *Xerospermum noronhianum* | Sapindaceae | 0.000636 |
| *Streblus elongatus* | Moraceae | 0.000627 |
| *Diospyros paniculata* | Ebenaceae | 0.000608 |
| *Chassalia corallioides* | Rubiaceae | 0.000576 |
| *Cinnamomum iners* | Lauraceae | 0.000575 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.000567 |
| *Cinnamomum iners* | Lauraceae | 0.00056 |
| *Shorea leprosula* | Dipterocarpaceae | 0.000524 |
| *Diospyros paniculata* | Ebenaceae | 0.000523 |
| *Piper aduncum* | Piperaceae | 0.00052 |
| *Ficus vasculosa* | Moraceae | 0.000519 |
| *Cinnamomum iners* | Lauraceae | 0.000504 |
| *Xanthophyllum sp.* | Polygalaceae | 0.000499 |
| *Chassalia corallioides* | Rubiaceae | 0.000488 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00047 |
| *Cinnamomum iners* | Lauraceae | 0.000468 |
| *Cinnamomum iners* | Lauraceae | 0.000466 |
| *Maclurodendron porteri* | Moraceae. | 0.000454 |
| *Horsfieldia superba* | Myristicaceae | 0.000453 |
| *Cinnamomum iners* | Lauraceae | 0.000444 |
| *Streblus elongatus* | Moraceae | 0.000441 |
| *Maclurodendron porteri* | Moraceae. | 0.000441 |
| *Psychotria grandis* | Rubiaceae | 0.000436 |
| *Cinnamomum iners* | Lauraceae | 0.000427 |
| *Ixora condesta* | Rubiaceae | 0.00042 |
| *Cinnamomum iners* | Lauraceae | 0.000412 |
| *Knema furfuracea* | Myristicaceae | 0.000412 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.000406 |
| *Gironniera parvifolia* | Cannabaceae | 0.000405 |
| *Melanochyla sp.* | Anacardiaceae | 0.000402 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.000396 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.00039 |
| *Ardisia colorata* | Primulaceae | 0.00039 |

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|---|---|---|
| *Cinnamomum iners* | Lauraceae | 0.000375 |
| *Mangifera quadrifida* | Anacardiaceae | 0.000372 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.000365 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.000364 |
| *Canthium coromandelicum* | Rubiaceae | 0.000359 |
| *Glycosmis pentaphylla* | Rutaceae | 0.000359 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.000352 |
| *Diospyros buxifolia* | Ebenaceae | 0.000341 |
| *Shorea leprosula* | Dipterocarpaceae | 0.000339 |
| *Ixora chinensis* | Rubiaceae | 0.000338 |
| *Cinnamomum iners* | Lauraceae | 0.000332 |
| *Litsea lancifolia* | Lauraceae | 0.000327 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.000314 |
| *Diospyros paniculata* | Ebenaceae | 0.000314 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.000309 |
| *Ficus subulata* | Moraceae | 0.0003 |
| *Lindera lucida* | Lauraceae | 0.000285 |
| *Eonia glycycarpa* | Violaceae | 0.000285 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.000284 |
| *Tabernaemontana undulata* | Apocynaceae | 0.000284 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.00028 |
| *Cinnamomum iners* | Lauraceae | 0.000277 |
| *Melanochyla sp.* | Anacardiaceae | 0.000276 |
| *Koompassia malaccensis* | Fabaceae | 0.000266 |
| *Diospyros buxifolia* | Ebenaceae | 0.000265 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.000263 |
| *Melanochyla sp.* | Anacardiaceae | 0.000261 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.000259 |
| *Syzgium scortechinii* | Myrtaceae | 0.000259 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.000258 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00025 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.000248 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.000244 |

| | | |
|---|---|---|
| *Hirtella triandra* | Chrysobalanaceae. | 0.000244 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.000233 |
| *Meiogyne miq* | Annonaceae | 0.000227 |
| *Diospyros paniculata* | Ebenaceae | 0.000222 |
| *Lindera lucida* | Lauraceae | 0.000222 |
| *Horsfieldia superba* | Myristicaceae | 0.000221 |
| *Vatica maingayi* | Dipterocarpaceae | 0.000219 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.000208 |
| *Syzygium zeylanicum* | Myrtaceae | 0.000204 |
| *Perebea hispidula standl* | Moraceae. | 0.000202 |
| *Litsea reticulata* | Lauraceae | 0.000201 |
| *Syzygium polyanthum* | Myrtaceae | 0.000195 |
| *Alstonia angustiloba* | Apocynaceae. | 0.000194 |
| *Litsea reticulata* | Lauraceae | 0.000194 |
| *Lindera lucida* | Lauraceae | 0.00017 |
| *Cinnamomum iners* | Lauraceae | 0.000169 |
| *Diospyros paniculata* | Ebenaceae | 0.000167 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.000161 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00016 |
| *Cinnamomum iners* | Lauraceae | 0.000154 |
| *Tabernaemontana undulata* | Apocynaceae | 0.000153 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.000153 |
| *Diospyros buxifolia* | Ebenaceae | 0.00015 |
| *Horsfieldia superba* | Myristicaceae | 0.000134 |
| *Alstonia scholaris* | Apocynaceae | 0.00013 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.00013 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.000125 |
| *Shorea leprosula* | Dipterocarpaceae | 0.000123 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.000123 |
| *Shorea leprosula* | Dipterocarpaceae | 0.000121 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.000119 |
| *Lindera lucida* | Lauraceae | 0.000116 |
| *Litsea lancifolia* | Lauraceae | 0.000115 |

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|---|---|---|
| *Perebea hispidula standl* | Moraceae. | 0.0000974 |
| *Cinnamomum iners* | Lauraceae | 0.0000972 |
| *Galearia fulva* | Pandaceae | 0.0000971 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.0000962 |
| *Litsea reticulata* | Lauraceae | 0.0000951 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.0000846 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.0000846 |
| *Cinnamomum iners* | Lauraceae | 0.0000818 |
| *Syzygium polyanthum* | Myrtaceae | 0.0000793 |
| *Cinnamomum iners* | Lauraceae | 0.0000704 |
| *Maclurodendron porteri* | Moraceae. | 0.0000649 |
| *Melanochyla sp.* | Anacardiaceae | 0.0000420 |
| *Syzygium polyanthum* | Myrtaceae | 0.0000350 |
| *Cinnamomum iners* | Lauraceae | 0.0000193 |
| *Cinnamomum iners* | Lauraceae | 0.0000514 |
| **Total** | **-** | **0.61892904** |

## APPENDIX D

List of Basal Area content in five plots at Gunung Stong State Park, Kelantan.

| *Name* | Family | BA (t/ha) |
|---|---|---|
| *Agathis atropurpurea* | Araucariaceae | 0.00598 |
| *Agathis atropurpurea* | Araucariaceae | 0.00509 |
| *Agathis atropurpurea* | Araucariaceae | 0.00226 |
| *Aidia densiflora* | Rubiaceae | 0.00077 |
| *Alstonia angustiloba* | Apocynaceae | 0.00246 |
| *Alstonia angustiloba* | Apocynaceae. | 0.00057 |
| *Alstonia scholaris* | Apocynaceae | 0.00032 |
| *Alyxia reinwardtii* | Apocynaceae | 0.00286 |
| *Ampelocera edentula* | Ulmaceae | 0.00114 |
| *Antidesma montanum* | Phyllanthaceae | 0.00982 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.00266 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.0019 |
| *Aquilaria malaccensis* | Thymelaeaceae | 0.00039 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00428 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00142 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00077 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00057 |
| *Archidendron hendersonii* | Caesalpinioideae | 0.00048 |
| *Ardisia colorata* | Primulaceae | 0.00088 |
| *Ardisia colorata* | Primulaceae | 0.00088 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00943 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00308 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00246 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00157 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00066 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00057 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00039 |
| *Arthrophyllum diversifolium* | Araliaceae | 0.00039 |

| | | |
|---|---|---|
| *Baccaurea brevipes* | Phyllanthaceae | 0.00354 |
| *Blepharistemma serratum* | Rhizophoraceae | 0.00114 |
| *Brackenridgea hookeri (Planch.) A. Gray* | Ochnaceae | 0.00157 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00246 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00173 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00127 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00088 |
| *Buchanania sessilifolia* | Anacardiaceae | 0.00039 |
| *Calophyllum rufigemmatum* | Calophyllaceae | 0.00905 |
| *Campnosperma squamatum* | Anacardiaceae | 0.00354 |
| *Canarium pilosum* | Burseraceae | 0.00629 |
| *Canarium pilosum* | Burseraceae | 0.00481 |
| *Canarium pilosum* | Burseraceae | 0.00246 |
| *Canthium coromandelicum* | Rubiaceae | 0.00208 |
| *Canthium coromandelicum* | Rubiaceae | 0.00039 |
| *Chassalia corallioides* | Rubiaceae | 0.00088 |
| *Chassalia corallioides* | Rubiaceae | 0.00077 |
| *Cinnamomum iners* | Lauraceae | 0.00982 |
| *Cinnamomum iners* | Lauraceae | 0.00598 |
| *Cinnamomum iners* | Lauraceae | 0.00481 |
| *Cinnamomum iners* | Lauraceae | 0.00481 |
| *Cinnamomum iners* | Lauraceae | 0.00354 |
| *Cinnamomum iners* | Lauraceae | 0.00354 |
| *Cinnamomum iners* | Lauraceae | 0.00354 |
| *Cinnamomum iners* | Lauraceae | 0.00354 |
| *Cinnamomum iners* | Lauraceae | 0.00308 |
| *Cinnamomum iners* | Lauraceae | 0.00246 |
| *Cinnamomum iners* | Lauraceae | 0.00246 |
| *Cinnamomum iners* | Lauraceae | 0.00208 |
| *Cinnamomum iners* | Lauraceae | 0.0019 |
| *Cinnamomum iners* | Lauraceae | 0.00157 |
| *Cinnamomum iners* | Lauraceae | 0.00157 |

| | | |
|---|---|---|
| *Cinnamomum iners* | Lauraceae | 0.00157 |
| *Cinnamomum iners* | Lauraceae | 0.00157 |
| *Cinnamomum iners* | Lauraceae | 0.00142 |
| *Cinnamomum iners* | Lauraceae | 0.00142 |
| *Cinnamomum iners* | Lauraceae | 0.00088 |
| *Cinnamomum iners* | Lauraceae | 0.00088 |
| *Cinnamomum iners* | Lauraceae | 0.00088 |
| *Cinnamomum iners* | Lauraceae | 0.00088 |
| *Cinnamomum iners* | Lauraceae | 0.00077 |
| *Cinnamomum iners* | Lauraceae | 0.00066 |
| *Cinnamomum iners* | Lauraceae | 0.00057 |
| *Cinnamomum iners* | Lauraceae | 0.00048 |
| *Cinnamomum iners* | Lauraceae | 0.00048 |
| *Cinnamomum iners* | Lauraceae | 0.00039 |
| *Cinnamomum iners* | Lauraceae | 0.00032 |
| *Cinnamomum iners* | Lauraceae | 0.00032 |
| *Cinnamomum iners* | Lauraceae | 0.00032 |
| *Cinnamomum iners* | Lauraceae | 0.00032 |
| *Cinnamomum iners* | Lauraceae | 0.00014 |
| *Cinnamomum iners* | Lauraceae | 3.54E-05 |
| *Desmos chinensis* | Annonaceae | 0.00142 |
| *Diospyros buxifolia* | Ebenaceae | 0.00246 |
| *Diospyros buxifolia* | Ebenaceae | 0.00127 |
| *Diospyros buxifolia* | Ebenaceae | 0.00077 |
| *Diospyros buxifolia* | Ebenaceae | 0.00088 |
| *Diospyros buxifolia* | Ebenaceae | 0.00032 |
| *Diospyros diepenhorstii* | Ebenaceae | 0.00308 |
| *Diospyros paniculata* | Ebenaceae | 0.0033 |
| *Diospyros paniculata* | Ebenaceae | 0.00226 |
| *Diospyros paniculata* | Ebenaceae | 0.00157 |
| *Diospyros paniculata* | Ebenaceae | 0.00157 |
| *Diospyros paniculata* | Ebenaceae | 0.00127 |
| *Diospyros paniculata* | Ebenaceae | 0.00088 |

| | | |
|---|---|---|
| *Diospyros paniculata* | Ebenaceae | 0.00077 |
| *Diospyros paniculata* | Ebenaceae | 0.00039 |
| *Diospyros paniculata* | Ebenaceae | 0.00039 |
| *Diospyros paniculata* | Ebenaceae | 0.00032 |
| *Dipterocarpus bourdillnolli* | Dipterocarpaceae | 0.00157 |
| *Elaeocarpus petiolatus* | Elaeocarpaceae | 0.00226 |
| *Eonia glycycarpa* | Violaceae | 0.00066 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00481 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00173 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00157 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00101 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00066 |
| *Eurycoma longifolia* | Simaroubaceae | 0.00066 |
| *Ficus subulata* | Moraceae | 0.00088 |
| *Ficus vasculosa* | Moraceae | 0.00088 |
| *Galearia fulva* | Pandaceae | 0.00025 |
| *Garcinia morella* | Clusiaceae | 0.00982 |
| *Gironniera parvifolia* | Cannabaceae | 0.00114 |
| *Gironniera parvifolia* | Cannabaceae | 0.00088 |
| *Glycosmis pentaphylla* | Rutaceae | 0.00454 |
| *Glycosmis pentaphylla* | Rutaceae | 0.00088 |
| *Guatteria punctata* | Annonaceae | 0.00354 |
| *Hancea penangensis* | Euphorbiaceae | 0.00354 |
| *Hancea penangensis* | Euphorbiaceae | 0.00246 |
| *Hancea penangensis* | Euphorbiaceae | 0.00208 |
| *Heptapleurum actinophyllum* | Araliaceae | 0.00226 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.00246 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.00157 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.00157 |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | 0.00127 |
| *Hirtella triandra* | Chrysobalanaceae. | 0.00039 |
| *Hopea odorata* | Dipterocarpaceae | 0.00157 |
| *Horsfieldia superba* | Myristicaceae | 0.00157 |

| | | |
|---|---|---|
| *Horsfieldia superba* | Myristicaceae | 0.00157 |
| *Horsfieldia superba* | Myristicaceae | 0.00039 |
| *Horsfieldia superba* | Myristicaceae | 0.00039 |
| *Ixora chinensis* | Rubiaceae | 0.00354 |
| *Ixora chinensis* | Rubiaceae | 0.00039 |
| *Ixora condesta* | Rubiaceae | 0.00057 |
| *Knema furfuracea* | Myristicaceae | 0.0019 |
| *Knema furfuracea* | Myristicaceae | 0.00101 |
| *Knema furfuracea* | Myristicaceae | 0.00088 |
| *Koompassia malaccensis* | Fabaceae | 0.00039 |
| *Lindera lucida* | Lauraceae | 0.00629 |
| *Lindera lucida* | Lauraceae | 0.00057 |
| *Lindera lucida* | Lauraceae | 0.00039 |
| *Lindera lucida* | Lauraceae | 0.00032 |
| *Lindera lucida* | Lauraceae | 0.00032 |
| *Lithocarpus* | Fagaceae | 0.00454 |
| *Lithocarpus* | Fagaceae | 0.00266 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.00481 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.00157 |
| *Lithocarpus cantleyanus* | Fagaceae | 0.00088 |
| *Lithocarpus glaber* | Fagaceae | 0.00127 |
| *Litsea lancifolia* | Lauraceae | 0.00088 |
| *Litsea lancifolia* | Lauraceae | 0.00039 |
| *Litsea reticulata* | Lauraceae | 0.00088 |
| *Litsea reticulata* | Lauraceae | 0.00057 |
| *Litsea reticulata* | Lauraceae | 0.00039 |
| *Litsea reticulata* | Lauraceae | 0.00032 |
| *Maclurodendron porteri* | Moraceae. | 0.00157 |
| *Maclurodendron porteri* | Moraceae. | 0.00157 |
| *Maclurodendron porteri* | Moraceae. | 0.00127 |
| *Maclurodendron porteri* | Moraceae. | 0.00114 |
| *Maclurodendron porteri* | Moraceae. | 0.00019 |
| *Mallotus leucoderrnis Hook.f.* | Euphorbiaceae | 0.00246 |

| | | |
|---|---|---|
| *Mangifera quadrifida* | Anacardiaceae | 0.00048 |
| *Mangifera quadrifida* | Anacardiaceae | 0.00039 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.00208 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.00039 |
| *Maranthes corymbosa* | Chrysobalanaceae | 0.00039 |
| *Meiogyne miq* | Annonaceae | 0.00039 |
| *Melanochyla sp.* | Anacardiaceae | 0.00629 |
| *Melanochyla sp.* | Anacardiaceae | 0.00157 |
| *Melanochyla sp.* | Anacardiaceae | 0.00127 |
| *Melanochyla sp.* | Anacardiaceae | 0.00066 |
| *Melanochyla sp.* | Anacardiaceae | 0.00039 |
| *Melanochyla sp.* | Anacardiaceae | 0.00039 |
| *Melanochyla sp.* | Anacardiaceae | 0.00025 |
| *Melanochyla sp.* | Anacardiaceae | 0.00014 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00796 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00286 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00266 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00173 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00088 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00077 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00066 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00039 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00039 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00032 |
| *Melanorrhoea spp.* | Anacardiaceae | 0.00032 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00943 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00481 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00354 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00246 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.0019 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00157 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00127 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00114 |

| | | |
|---|---|---|
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00088 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00088 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00088 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00039 |
| *Ochanostachys bancana Valeton* | Olacaceae | 0.00032 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.00481 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.00208 |
| *Paranephelium macrophyllum* | Sapindaceae | 0.00208 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.00509 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.0019 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.00066 |
| *Pellacalyx saccardianus Scort.* | Rhizophoraceae | 0.00025 |
| *Perebea hispidula standl* | Moraceae. | 0.00039 |
| *Perebea hispidula standl* | Moraceae. | 0.00025 |
| *Picramnia antidesma* | Picramniaceae | 0.00114 |
| *Piper aduncum* | Piperaceae | 0.00039 |
| *Psychotria grandis* | Rubiaceae | 0.00157 |
| *Psychotria grandis* | Rubiaceae | 0.00088 |
| *Pternandra echinata Jack* | Melastomataceae | 0.00308 |
| *Pternandra echinata Jack* | Melastomataceae | 0.00039 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00157 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00127 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00127 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00088 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00039 |
| *Shorea leprosula* | Dipterocarpaceae | 0.00039 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.00629 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.00266 |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | 0.00157 |
| *Shorea spp* | Dipterocarpaceae. | 0.00354 |
| *Shorea spp* | Dipterocarpaceae. | 0.00286 |
| *Shorea spp* | Dipterocarpaceae. | 0.00088 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00157 |

| | | |
|---|---|---|
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00157 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00127 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00114 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00088 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00088 |
| *Stelechocarpus cauliflorus* | Annonaceae | 0.00025 |
| *Streblus elongatus* | Moraceae | 0.00378 |
| *Streblus elongatus* | Moraceae | 0.00354 |
| *Streblus elongatus* | Moraceae | 0.00286 |
| *Streblus elongatus* | Moraceae | 0.00208 |
| *Streblus elongatus* | Moraceae | 0.00088 |
| *Streblus elongatus* | Moraceae | 0.00088 |
| *Streblus elongatus* | Moraceae | 0.00077 |
| *Streblus elongatus* | Moraceae | 0.00066 |
| *Strombosia ceylanica* | Olacaceae | 0.00142 |
| *Syzgium scortechinii* | Myrtaceae | 0.00629 |
| *Syzgium scortechinii* | Myrtaceae | 0.00567 |
| *Syzgium scortechinii* | Myrtaceae | 0.00246 |
| *Syzgium scortechinii* | Myrtaceae | 0.00048 |
| *Syzygium claviflorum* | Mytaceae | 0.00077 |
| *Syzygium polyanthum* | Myrtaceae | 0.00831 |
| *Syzygium polyanthum* | Myrtaceae | 0.00481 |
| *Syzygium polyanthum* | Myrtaceae | 0.00157 |
| *Syzygium polyanthum* | Myrtaceae | 0.00088 |
| *Syzygium polyanthum* | Myrtaceae | 0.00057 |
| *Syzygium polyanthum* | Myrtaceae | 0.00039 |
| *Syzygium polyanthum* | Myrtaceae | 0.00032 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.00127 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.00048 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.00048 |
| *Syzygium pseudo formosum* | Myrtaceae | 0.00039 |
| *Syzygium subcrenatum* | Myrtaceae | 0.00127 |
| *Syzygium zeylanicum* | Myrtaceae | 0.00905 |

| | | |
|---|---|---|
| *Syzygium zeylanicum* | Myrtaceae | 0.00567 |
| *Syzygium zeylanicum* | Myrtaceae | 0.00114 |
| *Syzygium zeylanicum* | Myrtaceae | 0.00032 |
| *Tabernaemontana undulata* | Apocynaceae | 0.00354 |
| *Tabernaemontana undulata* | Apocynaceae | 0.00157 |
| *Tabernaemontana undulata* | Apocynaceae | 0.00088 |
| *Tabernaemontana undulata* | Apocynaceae | 0.00039 |
| *Teimanniodendron smilacifolium (H. Pearson) kosterm* | Simaroubaceae | 0.00157 |
| *Tetramerista glabra Miq.* | Tetrameristaceae | 0.00402 |
| *Tetramerista glabra Miq.* | Tetrameristaceae | 0.0019 |
| *Vatica maingayi* | Dipterocarpaceae | 0.00246 |
| *Vatica maingayi* | Dipterocarpaceae | 0.00127 |
| *Vatica maingayi* | Dipterocarpaceae | 0.00039 |
| *Xanthophyllum sp.* | Polygalaceae | 0.00088 |
| *Xerospermum noronhianum* | Sapindaceae | 0.00066 |
| Total | - | 0.512645 |

## APPENDIX E

List of species, family and IUCN status for all trees that found in five plots atGunung Stong, State Park

| Name | Family | IUCN Status |
|---|---|---|
| *Agathis atropurpurea* | Araucariaceae | Near Threatened |
| *Aidia densiflora* | Rubiaceae | N/A |
| *Alstonia angustiloba* | Apocynaceae | N/A |
| *Alstonia scholaris* | Apocynaceae | Least Concern |
| *Alyxia reinwardtii* | Apocynaceae | N/A |
| *Ampelocera edentula* | Ulmaceae | Least Concern |
| *Antidesma montanum* | Phyllanthaceae | Least Concern |
| *Aquilaria malaccensis* | Thymelaeacaeae | Vulnerable |
| *Archidendron hendersonii* | Fabaceae | Least Concern |
| *Ardisia colorata* | Primulaceae | N/A |
| *Arthrophyllum diversifolium* | Araliaceae | Least Concern |
| *Baccaurea brevipes* | Phyllanthaceae | N/A |
| *Blepharistemma serratum* | Rhizophoraceae | N/A |
| *Brackenridgea hookeri (Planch.) A. Gray* | Ochnaceae | N/A |
| *Buchanania sessilifolia* | Anacardiaceae | N/A |
| *Calophyllum rufigemmatum* | Calophyllaceae | Least Concern |
| *Campnosperma squamatum* | Anacardiaceae | Least Concern |
| *Canarium pilosum* | Burseraceae | Least Concern |
| *Canthium coromandelicum* | Rubiaceae | N/A |
| *Chassalia corallioides* | Rubiaceae | N/A |
| *Cinnamomum iners* | Lauracaeae | Least Concern |
| *Desmos chinensis* | Annonaceae | N/A |
| *Diospyros buxifolia* | Ebenaceae | Least Concern |

| | | |
|---|---|---|
| *Diospyros diepenhorstii* | Ebenaceae | Least Concern |
| *Diospyros paniculata* | Ebenaceae | Vulnerable |
| *Dipterocarpus bourdillnolli* | Dipterocarpaceae | N/A |
| *Elaeocarpus petiolatus* | Elaeocarpaceae | Least Concern |
| *Eonia glycycarpa* | Violaceae | N/A |
| *Eurycoma longifolia* | Simaroubaceae | N/A |
| *Ficus subulata* | Moraceae | Least Concern |
| *Ficus vasculosa* | Moraceae | Least Concern |
| *Galearia fulva* | Pandaceae | N/A |
| *Garcinia morella* | Clusiaceae | Least Concern |
| *Gironniera parvifolia* | Cannabaceae | N/A |
| *Gluta/ melanorrhoea spp.* | Anacardiaceae | N/A |
| *Glycosmis pentaphylla* | Rutaceae | Least Concern |
| *Guatteria punctata* | Annonaceae | Least Concern |
| *Hancea penangensis* | Euphorbiaceae | Least Concern |
| *Heptapleurum actinophyllum* | Araliaceae | Least Concern |
| *Heritiera javanica (blume) Kosterm.* | Malvaceae | N/A |
| *Hirtella triandra* | Chrysobalanaceae | Least Concern |
| *Hopea odorata* | Dipterocarpaceae | Vulnerable |
| *Horsfieldia superba* | Myristicaceae | Near Threatened |
| *Ixora chinensis* | Rubiaceae | N/A |
| *Ixora condesta* | Rubiaceae | N/A |
| *Knema furfuracea* | Myristicaceae | Least Concern |
| *Koompassia malaccensis* | Fabaceae | Least Concern |
| *Lindera lucida* | Lauracaeae | Least Concern |
| *Lithocarpus* | Fagaceae | Least Concern |
| *Lithocarpus cantleyanus* | Fagaceae | N/A |
| *Lithocarpus glaber* | Fagaceae | Least Concern |

| | | |
|---|---|---|
| *Litsea lancifolia* | Lauracaeae | Least Concern |
| *Litsea reticulata* | Lauracaeae | Least Concern |
| *Maclurodendron porteri* | Moraceae | Least Concern |
| *Mallotus leucoderrnis Hook.f.* | Elaeocarpaceae | N/A |
| *Mangifera quadrifida* | Anacardiaceae | Least Concern |
| *Maranthes corymbosa* | Chrysobalanaceae | Least Concern |
| *Meiogyne Miq* | Annonaceae | N/A |
| *Melanochyla sp.* | Anacardiaceae | N/A |
| *Paranephelium macrophyllum* | Sapindaceae | N/A |
| *Pellacalyx saccardianus Scort* | Rhizophoraceae | N/A |
| *Perebea hispidula standl* | Moraceae | N/A |
| *Picramnia antidesma* | Picramniaceae | Least Concern |
| *Piper aduncum* | Piperaceae | Least Concern |
| *Psychotria grandis* | Rubiaceae | Least Concern |
| *Pternandra echinata Jack* | Melastomataceae | N/A |
| *Shorea leprosula* | Dipterocarpaceae | Near Threatened |
| *Shorea parvifolia Dyer* | Dipterocarpaceae | Least Concern |
| *Shorea spp* | Dipterocarpaceae | N/A |
| *Stelechocarpus cauliflorus* | Annonaceae | N/A |
| *Streblus elongatus* | Moraceae | N/A |
| *Strombosia ceylanica* | Olacaceae | N/A |
| *Syzgium scortechinii* | Myrtaceae | N/A |
| *Syzygium claviflorum* | Myrtaceae | Least Concern |
| *Syzygium polyanthum* | Myrtaceae | N/A |
| *Syzygium pseudo formosum* | Myrtaceae | N/A |
| *Syzygium subcrenatum* | Myrtaceae | N/A |
| *Syzygium zeylanicum* | Myrtaceae | N/A |
| *Tabernaemontana undulata* | Apocynaceae | Least Concern |
| *Teimanniodendron smilacifolium (H. Pearson) kosterm* | Simaroubaceae | N/A |

| | | |
|---|---|---|
| *Tetramerista glabra Miq.* | Tetrameristaceae | N/A |
| *Vatica maingayi* | Dipterocarpaceae | Vulnerable |
| *Xanthophyllum sp.* | Polygalacea | N/A |
| *Xerospermum noronhianum* | Sapindaceae | N/A |
| *Ochanostachys bancana Valeton* | Ochnaceae | N/A |