FLORISTIC COMPOSITION AND ABOVE GROUND BIOMASS OF TREE SPECIES AT GUNUNG STONG STATE PARK (GSSP), DABONG, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "Floristic Composition and Above Ground Biomass of Tree Species at Gunung Stong State Park (GSSP), Dabong, Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature:

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Date: 7/8/2024

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Floristic Composition and Above Ground Biomass of Tree Species at Gunung Stong State Park (GSSP), Dabong, Kelantan.

ABSTRACT

A study to determine the composition, species diversity, and estimate the aboveground biomass of tree species was conducted in Gunung Stong State Park. Five plots were set up with 20 m by 20 m each with an area of 0.2 ha in this study and all trees with a diameter at breast level (DBH) of 10 cm and above were measured and recorded. A total of 131 trees, representing 25 species and 19 genera from 13 families, were surveyed in a 0.2 ha plot. The largest family in the study area is Dipterocarpceae, which is represented by 3 genera and 6 species, followed by the Myrtaceae family, which is represented by 1 genus and 3 species. The value of the Shannon-Wiener Diversity Index (H) in the study area is high, which is 2.90 (H'_{max} = 2.68). Shorea genus from the Dipterocarpaceae family has the highest basal area of 32.485 m/ha, followed by the Horsfieldia genus from the Myristicaceae family with an area of 10.232 m/ha. *Shorea platyclados* has the highest basal area of 8.389 m2/ha, followed by *Shorea parvifolia* with an area of 5.598 m2/ha. The above-ground biomass value estimated for the entire study plot is 298.762 t/ha. The genera that contribute the highest biomass in the study plot are the Shorea genera, with an estimated biomass of 182.709 t/ha, followed by the Horsfielda genera, with an estimated biomass of 29.206 t/ha. The species that contributed the highest biomass was *Shorea platyclados* (Dipterocarpaceae), with an estimated biomass of 95.170 t/ha, followed by *Shorea spp.* (Dipterocarpaceae), with an estimated biomass of 34.429 t/ha.

Komposisi Tumbuhan dan Biojisim Atas Tanah Spesies Pokok di Taman Negeri Gunung Stong (GSSP), Dabong, Kelantan.

ABSTRAK

Satu kajian untuk menentukan komposisi, kepelbagaian spesies, dan menganggarkan biojisim spesies pokok di atas tanah telah dijalankan di Taman Negeri Gunung Stong. Lima petak telah didirikan dengan keluasan 20 m x 20 m setiap satu dengan keluasan 0.2 ha dalam kajian ini dan semua pokok berdiameter paras payudara (DBH) 10 cm dan ke atas telah diukur dan direkodkan. Sebanyak 131 pokok, mewakili 25 spesies dan 19 genera daripada 13 keluarga, telah ditinjau dalam plot seluas 0.2 ha. Famili terbesar di kawasan kajian ialah Dipterocarpceae yang diwakili oleh 3 genera dan 6 spesies, diikuti oleh keluarga Myrtaceae yang diwakili oleh 1 genus dan 3 spesies. Nilai Indeks Kepelbagaian (H) Shannon-Wiener di kawasan kajian adalah tinggi iaitu 2.90 (H'_{max} = 2.68). Genus Shorea daripada keluarga Dipterocarpaceae mempunyai keluasan basal tertinggi iaitu 32.485 m/ha, diikuti oleh genus Horsfieldia daripada keluarga Myristicaceae dengan keluasan 10.232 m/ha. *Shorea platyclados* mempunyai keluasan basal tertinggi iaitu 8.389 m2/ha, diikuti oleh *Shorea parvifolia* dengan keluasan 5.598 m2/ha. Nilai biojisim di atas tanah yang dianggarkan untuk keseluruhan plot kajian ialah 298.762 t/ha. Genera yang menyumbang biojisim tertinggi dalam plot kajian ialah genera Shorea, dengan anggaran biojisim 182.709 t/ha, diikuti oleh genera Horsfielda, dengan anggaran biojisim 29.206 t/ha. Spesies yang menyumbang biojisim tertinggi ialah *Shorea platyclados* (Dipterocarpaceae), dengan anggaran biojisim 95.170 t/ha, diikuti oleh *Shorea spp.* (Dipterocarpaceae), dengan anggaran biojisim 34.429 t/ha.

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LIST OF ABBREVIATIONS

AGB	Above Ground Biomass
BA	Basal Area
DBH/D	Diameter Breast Height
GPS	Global Positioning System
H	Height
ha	Hectare
IUCN Red List	International Union for Conservation of Nature
List	IUCN Red List
N	Total Number of individuals in the sample
n	Total number of individuals in study area
H’	Shannon- wiener Diversity Index
D	Simpson Diversity Index
J	Evenness Index
FSC	Forest Stewardship Council
HCVF	High Conservation Value Forest
GSSP	Gunung Stong State Park
UAS	unmanned aerial systems
WD	Wood Density
SAR	Synthetic Aperture Radar

LIST OF SYMBOLS

%	Percentage
Σ	Summation
>	Highest than
<	Lowest than
C	Celsius
Kg	Kilogram
m	Meter
cm	Centimeter
m/ha	Meter per hectare
Mg ha-1	Megagram per hectare
t/ha	Ton per hectare

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Tropical forests are the subject of several studies to better understand the role they could play in sustainable development, climate change, and floristic biodiversity (Lewis et al., 2009). Numerous products and ecosystem services are offered by tropical forests, including preventing soil erosion and maintaining animal and plant habitats. Regarding the diversity of species, tropical rainforests differ significantly from temperate forests. In contrast to temperate forests, which are often dominated by six or fewer tree species, tropical species have evolved to occupy small niches in relatively stable environments, leading to huge diversity (Butler, 2001). The tree species composition in tropical areas varies greatly from one place to another mainly due to variations in biogeography, habitat, and disturbance (Mohd Nazip Suratman, 2012).

The common way to express the diameter of a tree or the trunk of a standing tree is as diameter at breast height, or DBH. One of the most popular dendrometric metrics in use today is DBH. One of the most significant markers of tree characteristics in a forest survey is the diameter at breast height (DBH) of individual trees (Georges Künstler et al., 2015). Accurate and efficient measurement of the diameter at breast height (DBH) of individual trees is essential for forest inventories, ecological management, and carbon budget estimation. However, traditional diameter tapes are still the most widely used dendrometers in forest surveys, which makes DBH measurement time-consuming and labor-intensive (Song et al., 2021).

The quantity of distinct species found in a population or area, as impacted by variables including speciation, extinction, climate, location, and human activity, is referred to as species diversity (Ge, 2017). It is measured using a variety of techniques, such as diversity indexes, and is expressed in terms of species richness and evenness (Jonathan & Upham, 2012). Because of the great diversity of species, the idea of species diversity is complicated, and universal species conceptions for all creatures are difficult to develop (Meelis Pärtel, 2014). Furthermore, although it is more controversial to derive ecologically oriented diversity estimates from the fossil record, it does help to comprehend past diversity, particularly in terms of taxonomic richness (Vasilevich, 2009). Plant communities with intermediate levels of productivity and disturbance are frequently home to high species variety, demonstrating a positive association between species richness and evenness but not necessarily stability. Understanding and preserving species diversity is crucial for maintaining the intricate balance of ecosystems and the services they provide.

The whole amount of live vegetation, including both woody and herbaceous plant material, above the soil's surface is referred to as above-ground biomass. This covers the branches, stems, stumps, bark, seeds, and leaves. It is an essential part of the carbon cycle and is frequently used to gauge changes in the environment or the effects of interventions on reducing carbon emissions and other ecological advantages. Above-ground biomass is typically measured in units of mass per unit area, such as megagrams per hectare (Mg ha-1). It can be estimated using various methods, including the "plot method" (“Methods for Estimating Above-Ground Biomass,” 2008).

1.2 Problem Statement

This study was conducted to investigate and document the overall composition of tree species at specific forest levels, with particular emphasis on mature trees with a diameter of 10 cm or more. The main objective of this research is to get an overview of the diversity, composition, and abundance of these mature tree species in the selected area. Such information is valuable to inform conservation, management, and sustainable forestry practices in the studied ecosystem.

This study was also conducted to improve existing data and update previous data for future reference. This study was also conducted to increase knowledge because of the lack of information about and research on the diversity of tree species found in the Gunung Stong State Park (GSSP)

1.3 Objectives

The objectives are mainly:

1. To identify tree species with 10 cm diameter breast height and more at Gunung Stong State Park (GSSP)

2. To estimate aboveground biomass of tree species with 10 cm diameter breast height and more at Gunung Stong State Park (GSSP)

1.4 Scope of Study

The scope of this research study is to evaluate the diversity, composition, and species richness of trees with a diameter breast height of 10 cm and more. This aspect focuses on identifying tree species composition with 10 cm diameter breast height and more at Gunung Stong State Park (GSSP). The second objective is to calculate species diversity and aboveground biomass tree species with 10 cm diameter breast height and more at Gunung Stong State Park (GSSP).

The study area is limited to the area around Kem Baha at Gunung Stong State Park (GSSP) and focuses comprehensively on all woody tree species that measure more than 10 cm in diameter at breast height (DBH). To achieve these two goals, five plots of 20 m x 20 m were constructed according to a carefully defined method. This research took place for five days before a detailed data analysis of the tree species that had been recorded was done. Significantly, the investigation limited its search only to woody tree species as it ensured a specific approach to these criteria. In this dimension, the methodology used in the research aims to provide a detailed understanding of the diversity of woody tree species found around Gunung Stong State Park (GSSP).

1.5 Significant of Study

This research provides a better knowledge of important phases in the ecology of forests, assesses how they are responding to climate change, and sheds light on the sustainability and health of ecosystems. Furthermore, the collected data is used as a standard for long-term studies to plan conservation and restoration projects strategically and make educated decisions about sustainable forest management. The focus on older trees highlights the significance of these records in fully comprehending forest dynamics, as well as the function these trees play in carbon sequestration, habitat complexity, and overall ecosystem health.

In addition, this research plays an important complementary role in improving any existing data and updating previously used data for future use. The stark contrast between Gunung Stong State Park (GSSP), which is an area with a very limited environment and knowledge about it, and realistic published literature that describes information about the diversity of tree species in this park has encouraged to hide this gap. In this ecological environment, increasing the level of knowledge is even more important because it not only strengthens the understanding of local biodiversity but also lays the premises for informed conservation initiatives. This study aims to do so by helping to address basic information gaps and building a solid modern reference base in current studies of the highly diverse tree species of 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. Precise tree height and DBH are essential for assessing biomass and are crucial for studying forest growth models grounded in physiological ecology (Mu et al., 2017).

2.2 Tropical Rainforest in General

Southeast Asia, Australia, the island of New Guinea, western and central Africa, western India, and Central and South America are all home to tropical rainforests. With some having endured in their current state for at least 70 million years, they are the oldest ecosystems still in existence on Earth. Though they only make up 6% of the planet's surface, these rainforests are extraordinarily complex and diverse, supporting nearly half of all plant and animal species. The typical daily temperature in the tropical rainforest biome is between 20°C and 25°C, and it receives between 2,000 and 10,000 millimeters of rain per year. The biome is warm all year round and cannot experience frost (Butler, 2001).

The emergent layer, the main canopy, the understory, and the dark forest floor are the four main layers that make up the rainforest canopy. Giant trees that reach heights of 75 meters or more are found in the upper layer, or canopy, which blocks most sunlight from falling on the ground. With about half of all species found there, tropical rainforests are the most ecologically diverse terrestrial ecosystems on the planet. With an estimated 40 to 100 or more different types of trees present in each hectare, these rainforests are renowned for their dense canopies of vegetation that form three distinct layers. Unsustainable industrial and agricultural development has severely degraded the health of the world's rainforests, but citizens, governments, intergovernmental organizations, and conservation groups are working together to protect these invaluable but fragile ecosystems (Butler, 2001).

2.3 Tropical Rainforest in Malaysia

Malaysia is a country rich in natural resources and has been listed as one of the 12 mega biodiversity countries in the world. This is because Malaysia has tropical forests that are the habitat of various species of fauna. Forests are the most extensive and important area in Malaysia covering 70% of the forest area in Malaysia; 46% in Sarawak, 31% in Peninsular Malaysia, and 23% in Sabah (Saiful Bahari, 2021). This forest is evergreen, where the trees do not drop all their leaves at the same time, the vegetation is compact and dense, the temperature is stable, there is a high rate of rainfall, and there are two seasons, which are rainy and hot (Abrams & Abrams, 2019). There are four different layers to the formation of a tropical forest, namely the canopy or raised layer (>40 meters), the canopy layer also known as the silara layer (20-40 meters), the middle layer (10-20 meters), and the lower layer or floor (<10 meters). Each layer has its characteristics and is inhabited by flora and fauna according to the specifications and suitability of the habitat (Mohamad Pauzi Zakaria 2016).

The Malay Peninsula and its islands make up the Peninsular Malaysian rainforests, an ecoregion marked by rich biodiversity and a tropical and subtropical wet broadleaf forest biome. This ecoregion stretches south to Singapore, the Riau Archipelago, the Lingga Islands, and east to the Anamba Islands. It includes much of the southern Malay Peninsula in Malaysia and southern Thailand. The emergent layer, the main canopy, the understorey, and the dark forest floor are the several layers that make up the forests. Parts of the Peninsular Malaysian montane rain forests and this ecoregion are found in the Taman Negara National Park and Royal Belum State Park.

The huge logging, oil palm, and rubber concessions, along with the rapid economic expansion and infrastructure dispersion, pose a threat to the rainforests of Peninsular Malaysia. The montane rainforests of Peninsular Malaysia, which are thought to have escaped logging and other human influences, are still little understood physiologically and may hold the key to unlocking further biological secrets. These rainforests are representative of the montane forests found in central Peninsular Malaysia. To guarantee their survival and the conservation of their distinctive biodiversity, these rainforests are essential ecosystems that need to be protected (Peninsular Malaysian Rainforests One Earth, 2023).

2.4 Forest Layers

The vertical layering of a forest environment, which comprises the forest floor, the understory, and the canopy, is referred to as "forest layering" or "stratification." Above the canopy, there is also an emergent layer in tropical rainforests. Different groups of plants and animals are supported by each stratum according to variables including sunlight, moisture content, and the availability of food. The distribution of plant species richness and the amount of biomass produced by a forest is significantly influenced by the stratification of the forest. The existence of several layers in a forest canopy can affect the forecasting of forest characteristics like biomass and timber volume, emphasizing the significance of taking the multi-layer canopy structure into account while managing and creating new forests (Augusto & Antra Boča, 2022).

The various plant strata that make up a forest's layers are organized vertically to create a complex ecology. The forest floor, understory, canopy, and emergent layer are the four basic layers of a forest. Various groups of plants and animals can be found in each layer of the forest, based on elements like sunlight, wetness, and the availability of food. Forest structure refers to the three-dimensional organization of trees and other plants as well as inanimate spatial elements including soils, slopes, and hydrology. Comprehending the strata of a forest is imperative for overseeing and conserving the forest ecosystem, in addition to researching the distribution of plant species richness and the output of forest biomass.

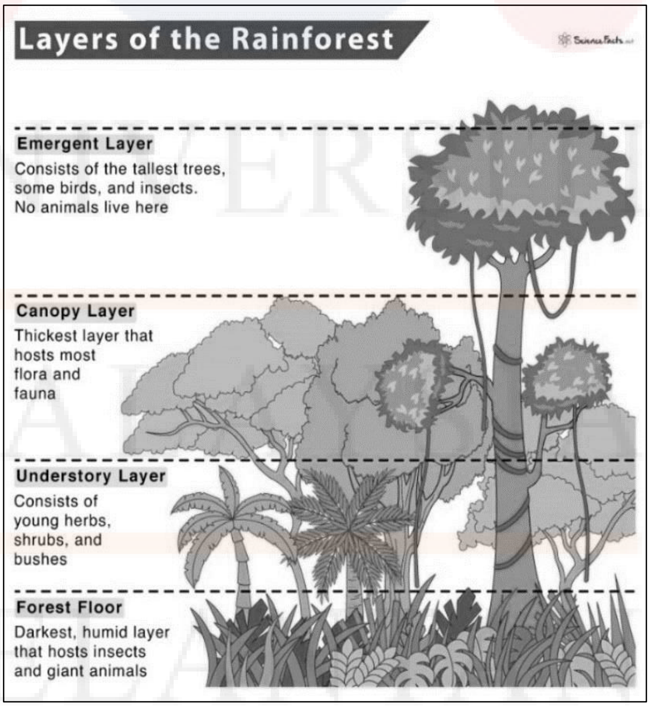

Figure 2.1 layers of the rainforest

2.4.1 Forest Floor

The lowest part of a forest is called the forest floor, and because of the intense darkness produced by the canopy above, it is largely devoid of plants. It is made up of soil and organic materials that have decomposed—leaf, grass, moss, and lichen—that are necessary for the breakdown process. One of the main locations for decomposition, which is essential to the survival of the forest, is the forest floor. Thousands of plants and animals can be found there as well, supporting the trees that create the canopy. The forest floor has several important features, including being the lowest layer of the forest and the wettest due to receiving only 0.5–5% of the light that reaches the main forest. The humid air and the shade make it an ideal environment for the growth of mosses, lichens, and liverworts. The forest floor is the region of the forest that was first explored and has been the most intensively studied. It is the layer where most of the forest floor species live and where many forests floor animals forage and reproduce. The forest floor is also the site of important interactions and complex relationships, such as predator-prey, parasite-host, and mutualistic interactions between plants and animals (Butler, 2001).

2.4.2 Understory

The deepest part of the forest, located above the forest floor and beneath the canopy, is known as the understory. It is made up of shrubs, soft-stemmed plants, young trees, and short trees. The understory is distinguished by several features, including being a warm, humid, and shielded layer due to the canopy above it. Because the canopy covers out most of the sunlight, the ground floor barely receives 5–10% of it. Because of the environment's adaptation to these circumstances, plants have big leaves to absorb the little available light. To draw pollinators, flowers at the base of the plant tend to be big, pale, and stinky since they must be visible and reachable in low light. In addition, the understory plants show signs of adaptation to environmental shifts, including increasing CO_2 levels and changes in root morphological characteristics and fine root biomass to improve nutrient uptake. A thorough understanding of the understory layer's dynamics is necessary to forecast how tropical rainforest ecosystems will react to changes in their surroundings (Bader et al., 2022).

Insects, which include most of the understory population, include bees, wood insects, bullet ants, beetles, and butterflies as examples of animals found in the understory. Because of the high humidity below ground, tree frogs and salamanders can survive and prevent their skin from drying out. The lower stratum is also home to over 150 different species of butterflies. Apart from these creatures, the understory is defined by restricted plant development, such as small trees, low shrubs, ferns, and other plants that normally do not reach a height of more than 12 feet (3.6 meters) (*Rainforest Understory Adaptations | California State University Stanislaus*, 2013).

2.4.3 Canopy

The heaviest covering of leaves, vines, and trees in a rainforest is called the canopy layer, sometimes known as the "roof of the rainforest." The overlapping branches and leaves of rainforest trees make up this structure, which can be found at elevations of more than 100 feet (30 meters). Because the canopy layer is where heat, water vapor, and atmospheric gases are primarily exchanged, it is essential for controlling both regional and global climate. It also preserves the moisture of the forest below by protecting the understory from intense sunshine, arid winds, and downpours (Butler, 2001).

The canopy layer has several important features, the first of which is height.

The next highest trees in the rainforest constitute the canopy layer, which can reach a thickness of up to 20 feet. The second factor is sunshine. The plants and trees in the canopy layer absorb over 80% of it, leaving the plants and trees that are found in the lower reaches of the rainforest with little light. Then there is moisture; tropical rains fall mostly into the canopy, which adds to the high humidity and the growth of different plant species. Finally, there is adaptation. Canopy trees have leaves with sharp "drip tips" and a glossy, hairless surface that makes it easier for water to flow off. These traits help the trees adjust to the high levels of humidity.

Mammals, birds, reptiles, insects, and other diverse plant and animal life can all be found in the canopy layer. Animals must be able to hop, jump, or fly to move between trees in the canopy. To learn more about this unusual environment, researchers use specialized facilities that include rope bridges, ladders, and towers to observe the canopy.

2.4.4 Emergent Layer

The upper layer of the rainforest, where trees as tall as 60 meters (200 feet) dominate the skyline, is the layer that appears in the tropical rainforest. Among the special characteristics of this layer are foliage, water and sunlight, wind, and animals. On tree trunks, foliage is frequently sparse; nevertheless, when trees reach the sunlit upper layer, where they photosynthesize sunlight, the foliage expands widely. The second factor is water and sunlight. The elevated layer receives a lot of rain and intense sunlight, which is ideal for hardwood trees with waxy leaves like mahogany and teak. Strong winds can transfer light seeds from the parent tree to the developing layer. A variety of animals, such as birds, bats, gliders, and butterflies, call the elevated layer home. Furthermore, the existence and distribution of emergent trees in tropical rainforests are crucial for comprehending the dynamics of forest growth and loss, particularly in light of the biostability between savanna and forest states brought about by feedback between fire and vegetation as well as potential tipping points that could result in widespread forest dieback (Marsden, 2012).

The Kapok Tree, Brazil Nut Tree, Orchid, and Grape Tree are a few of the plants that are frequently found in the emergent layers of the tropical rainforest. Emergent layers support a wide variety of species and contribute to the general equilibrium and health of the rainforest, making them an essential component of the ecosystem (*Twinkl*, 2023).

2.5 High Conservation Value Forest (HCVF)

High Conservation Value Forests (HCVFs) are places where ecosystem services and biodiversity are exceptionally important. They are vital to conservation efforts, but they are frequently under danger due to a variety of anthropogenic stressors. The Forest Stewardship Council (FSC) created the idea of HCVFs to designate forests with notable concentrations of biodiversity, uncommon ecosystems, vital environmental services, regions crucial for nearby communities, and those necessary for cultural identity (Subodh Kumar Maiti, 2012). These forests play a vital role in maintaining valuable ecosystems and species, and their identification and protection are integral to achieving conservation goals and sustainable forest management practices. Various certification schemes, such as those by the FSC and Roundtable for Sustainable Palm Oil, incorporate HCVFs to promote environmentally and socially sustainable practices in forest management, emphasizing the need for long-term monitoring and transparent data-sharing to ensure effective conservation strategies.

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 containing globally, regionally or nationally significant concentrations of biodiversity values. This type includes areas with high concentrations of endangered species, endemic species, or refugia.
2. HCV2: Forest areas containing globally, regionally or nationally significant large landscape-level forests. These areas have viable populations of most naturally occurring species in their natural patterns of distribution and abundance.
3. HCV3: Forest areas that are in or contain rare, threatened or endangered ecosystems. This type includes areas with rare or endangered ecosystems, such as patches of a regionally rare type of freshwater swamp forest.
4. HCV4: Forest areas provide basic services of nature in critical situations. These areas provide critical ecosystem services like watershed protection, erosion control, or avalanche risk management.
5. HCV5: Forest areas fundamental to meeting basic needs of local communities. This type includes areas that are essential for subsistence, health, or other basic needs of local communities.
6. HCV6: Forest areas critical to local communities' traditional cultural identity. These areas are culturally significant to local communities and may include sacred burial grounds, traditional hunting or foraging areas, or other sites of cultural, ecological, economic, or religious importance.

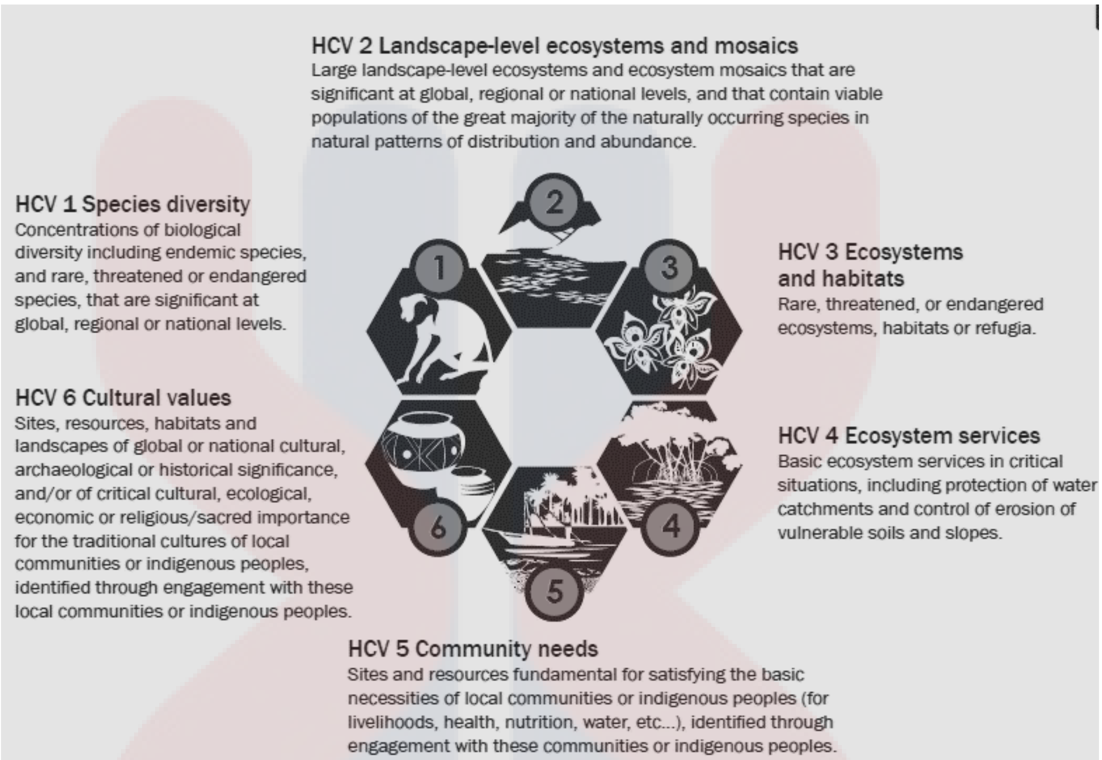

Figure 2.2 types of High Conservation Value Forest based on Forest Stewardship Council (FSC)

2.6 Tree Species Diversity in Peninsular Malaysia

According to Chua et al., (2022), Malaysia is a megadiverse country for plant species. Knowledge of Malaysian plant species diversity is incomplete but has been significantly expanded by the Flora of Sabah and Sarawak and Flora of Peninsular Malaysia projects. More than 400 new plant species, including at least 14 new genera, have been added since 1995. Between 1973 and 2015, Malaysia lost an estimated 29.4% of its natural forest cover; conserving plant species that are at immediate risk of extinction will help reduce future loss of natural forests and biodiversity. With 9.2% of the world's tree species living in Malaysia, of which 29.8% are endemic, species risk assessment is an important conservation planning tool for Malaysian flora. Through the GlobalTree Assessment project, Malaysia confirmed that approximately 24% of tree diversity is exposed to various threats from deforestation and forest degradation to poaching and the invasion of invasive alien species. According to him also the level and type of extinction risk faced by several major tree families, namely, Dipterocarpaceae, and tree genera Myristicaceae and Sapotaceae, whose wood remains of high value. It can be summarized that the nature and goals of the program drive the national conservation agenda for endangered plant species and describe some specific targets for Peninsular Malaysia, Sabah and Sarawak. They also focus an effort to improve in situ conservation and understanding of population dynamics. Programs that enable and support key agendas, such as institutional capacity building and awareness of the importance of biodiversity.

2.7 Tree Species Diversity in Gunung Stong State Park

According to Chee Beng Jin, (2005) the Forestry Research Institute of Malaysia has conducted a preliminary checklist of plant species in Gunung Stong Forest Reserve, one of the largest forest reserves in Peninsular Malaysia. This study was conducted to document the diversity of plant life in the area and identify any endemic species. The researchers have managed to record a total of 406 plant species, including subspecies and varieties, from 84 families and 254 genera. The checklist includes species exclusive to Peninsular Malaysia and the Gunung Stong Forest Reserve, highlighting the region's unique biodiversity.

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. The researchers have also identified several endemic species, including Begonia stongensis, which is named after the Gunung Stong Forest Reserve. The checklist provides valuable information for conservation efforts in preserving the flora richness of the area.

This study involved fieldwork, where researchers conducted surveys and collected plant specimens from different locations within the forest reserve. Collected specimens 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 valuable insight into the botanical composition of Gunung Stong Forest Reserve and contribute to conservation efforts in preserving the rich flora.

The floristic composition, diversity, richness, and evenness of a lowland mixed dipterocarp forest in Gunung Stong State Park, Kelantan, have all been studied. A total of 172 stems, spanning 28 families, 54 genera, and 72 species, were analysed. The stems with heights greater than 5 m were recognised to the species level. Dyera costulata is the leading species in Gunung Stong State Park, according to an evaluation of the species diversity, richness, evenness, and important value of the tree species (Iv = 36.17). In contrast, the family Dipterocarpaceae dominates Gunung Stong State Park in terms of the quantity of species, genera, and individuals discovered in the study plots (Hanafi, 2013).

In conclusion, this study has shed light on the botanical diversity of Gunung Stong Forest Reserve. Documentation of endemic species emphasizes the importance of preserving these natural habitats. These findings can be used to develop sustainable conservation practices for the area and promote biodiversity conservation in Peninsular Malaysia.

2.8 Ecological Factor Influencing Tree Species Composition

According to Nandera Juma Lolila et al., (2023) state that tree species composition is influenced by a combination of environmental and disturbance factors, with environmental factors explaining more variation in species composition than disturbance factors such as elevation, temperature, and soil nutrients, as well as anthropogenic disturbance. From what I can gather from the article, the focus of this study is to examine the relationship between tree species composition and environmental gradients and disturbances in tropical sub-montane forests in Tanzania. This study aims to determine how environmental factors such as altitude, temperature, and soil nutrients, as well as anthropogenic disturbances, affect forest composition. These findings may provide insight into site-specific environmental properties for biodiversity conservation and minimizing human disturbance in forest ecosystems.

However, Thakur et al. (2022) reported in a different study that topography, soil, and climate influence the species composition of trees in four distinct types of communities. This study aims to understand the relationship between species diversity and composition in the Western Himalayas of India and anthropogenic and environmental causes. After examining the altitude gradient between 700 and 4000 meters above sea level, the researchers found that 51 tree species from 28 families were present in this area. In addition, the diversity index was examined in this study, and the distribution of the data showed a hump in the height range. Non-metric dimensional scaling allowed for the identification of four distinct community kinds.

Based on Guo et al., (2021) this study aims to comprehend the effects of environmental conditions on tree species richness, abundance, and dispersion in subtropical forests. In a 15-ha patch in central China, the researchers carefully investigated how soil nutrients and topographical features like slope and convexity affected the patterns of variety. According to the study, species richness was significantly impacted negatively by soil nutrients, i.e., lower species richness was correlated with higher soil nutrient levels. Nonetheless, all metrics of the species abundance distribution were positively impacted by soil nutrients, suggesting that higher nutrient levels were linked to a higher relative abundance of tree species.

Patterns of diversity were also shaped by topographical features. Areas with higher convexity also had higher species richness, as convexity had a strong beneficial effect on species richness. Convexity, on the other hand, negatively impacted every metric used to measure the distribution of species abundance, indicating that regions with higher convexity also had lower relative abundances of tree species. The indices of species evenness and dominance, skewness and the Berger-Parker index were significantly impacted negatively by slope.

2.9 Above Ground Biomass (AGB)

In many ecosystems, estimating above-ground biomass (AGB) is essential, and new research has shown how important it is to use cutting-edge tools like unmanned aerial systems (UASs) (Aliasghar Bazrafkan et al., 2023). These systems provide a consistent approach for estimating AGB, with flight altitudes customized to vegetation characteristics and sensor selection based on vegetation type. Furthermore, the accuracy of AGB estimation in certain forest types is improved by the construction of biomass models for individual tree species, such as *Rhus ruspolii*, *Ekebergia capensis*, and *Nuxia congesta* (Muhammad Abdul Qirom et al., 2023). Integrating these technological advancements and modeling approaches can significantly improve the efficiency and accuracy of AGB estimation across diverse ecosystems, aiding in sustainable forest management and carbon stock quantification.

To support carbon storage assessments and sustainable forest management, the above-ground biomass formula is essential for precisely calculating the biomass of forests. Models for estimating above-ground biomass have been established by numerous research employing various factors, including wood density (WD), total height (TH), diameter at breast height (DBH), and other tree features. For example, models have been developed for certain species of trees found in Dry Afromontane forests, such *as Rhus ruspolii, Ekebergia capensis*, and *Nuxia congesta* (Tamiru Lemi et al., 2023). Furthermore, above-ground biomass in forests like as the Colo-ISuva Forest Park has been estimated using allometric models based on DBH, tree height (H), and wood density (Atanas Pipite, 2022). Furthermore, regression models utilizing height (H) and branch diameters (D) have been used to predict above-ground biomass in shrubs like *Caragana korshinskii* and *Sophora viciifolia* in the Loess Plateau (Dou et al., 2019). These models play a vital role in accurately quantifying forest carbon stocks and aiding in global carbon cycle assessments (Panday et al., 2019).

Tropical forests are crucial components of the global carbon cycle, acting as significant carbon sinks by capturing and storing carbon in their biomass. The majority of carbon in tropical ecosystems is stored in aboveground vegetation, making accurate estimation of aboveground carbon stocks essential for understanding carbon sequestration dynamics. The results of this study make a substantial contribution to the body of knowledge already available on carbon sequestration in tropical forests. The work highlights the significance of precise carbon stock assessments for successful climate change mitigation measures and sustainable forest management practices by offering insights into aboveground biomass and carbon stock estimation in logged-over lowland tropical forests (Majid & Nurudin, 2015).

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

My research was conducted in the forest area within the Jeli colony, which is Gunung Stong State Park. Gunung Stong State Park is a forest area, surrounded by many mountain peaks in the background, including Gunung Ayam, Gunung Tera, Gunung Saji and etcetera. Gunung Stong State Park is located at approximately 5.3396N latitude and 101.9749E longitude (figure 3.1). Gunung Stong State Park covers an area of over 20,000 hectares, surrounding mountain peaks, rivers, and caves. This study was carried out in several areas within the Gunung Stong State Park with several designated plots represented.

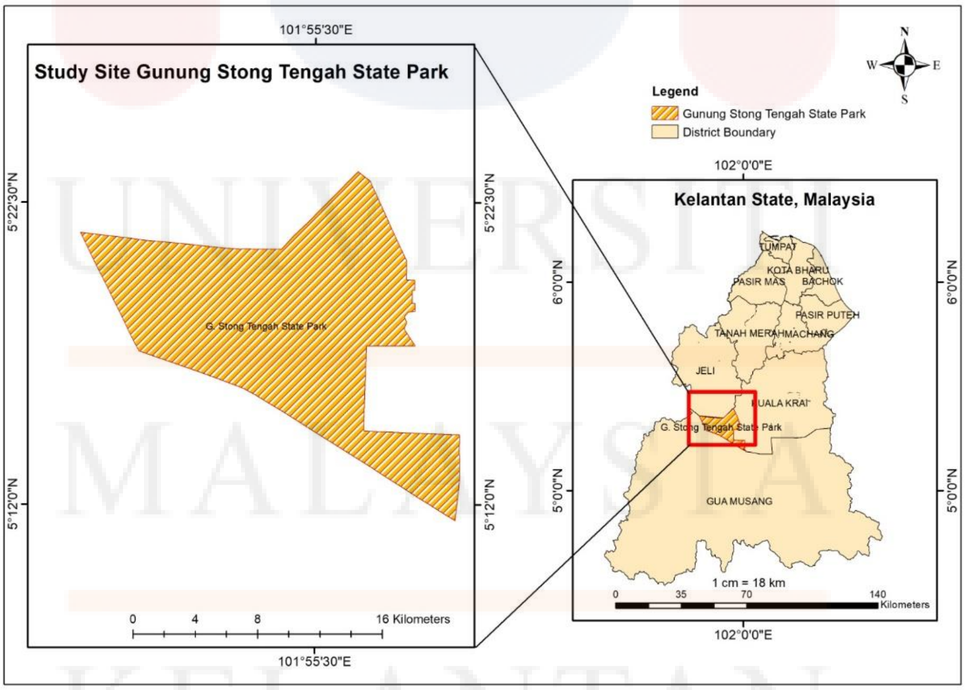

Figure 3.1 Study area at Gunung Stong State Park

3.2 Materials

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

Table 3.1 Materials and functions of materials that have been used while in Gunung Stong State Park, Kelantan.

Materials	Function
DBH tape	Use to measure the diameter breast height (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 12 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

3.3 Method

3.3.1 Build a Sampling Plot

Plots were constructed systematically using a systematic sampling method with five plots 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 each corner. Using a tape measure, measurement accuracy is ensured by ensuring accurate measurements for each plot. The calculated distance between plots is constant at 50 meters which creates a systematic and orderly layout for the study area. This structured arrangement increases the accuracy of data collection in each 20-meter x 20-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 are marked 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 banir 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.

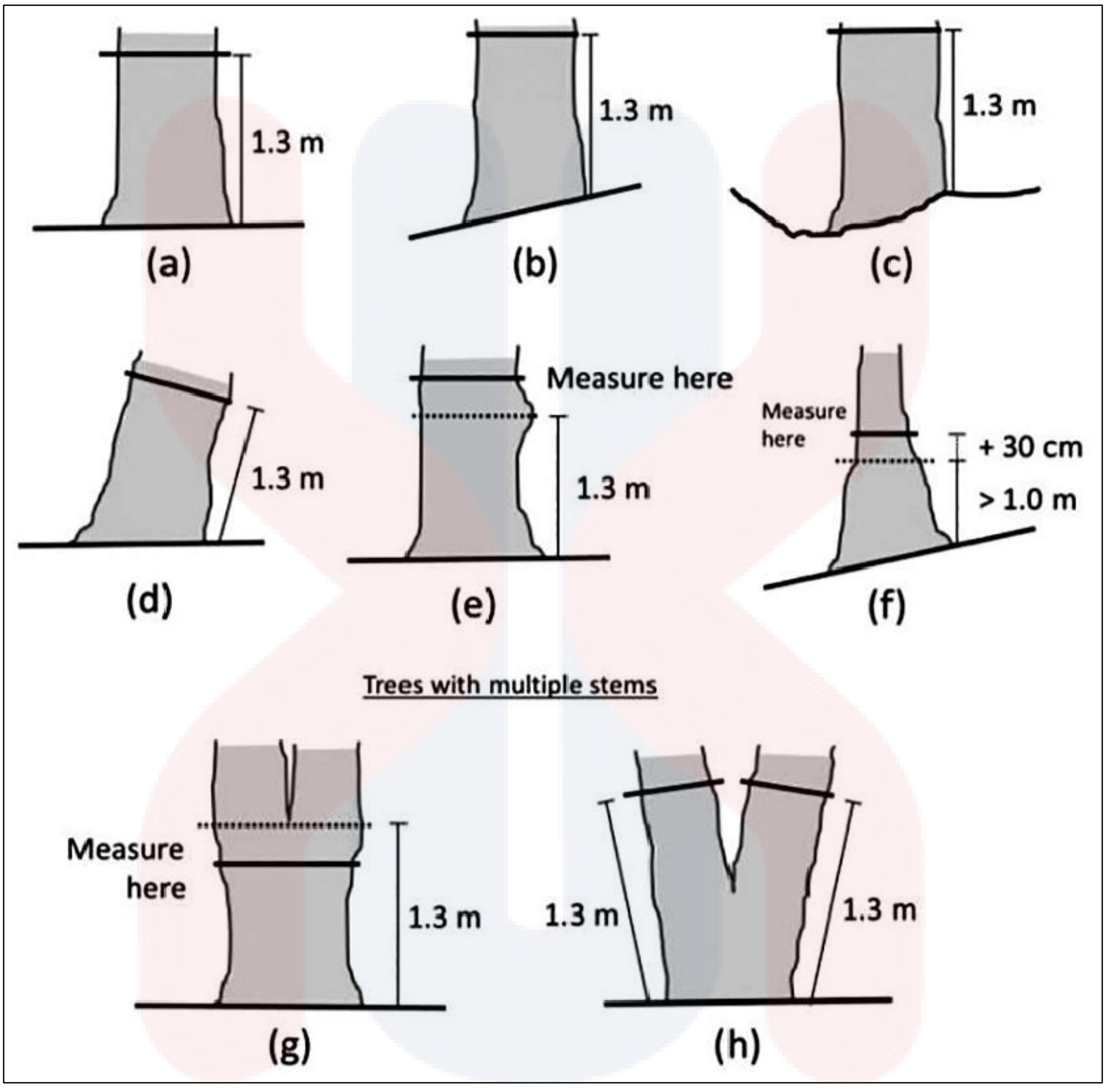

Figure 3.2 Diameter of breast Height measurement (Husch et al. 2003)

3.3.3 Collecting Specimen and Identify Species.

All tree leaf samples that are 10 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 reference to identify the tree species.

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

3.4 Data Analysis

a) Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index, also known as the Shannon Diversity Index, is a measure used to quantify the diversity of species within a community. The formula for the Shannon Wiener Diversity Index is:

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

Where:

H’ = Shannon diversity index

Pi = fraction of the entire population made up of species i

S = the number of species

∑ = sum of species 1 to species s

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:

$$D_s = 1 - \sum\left(\frac{n(n-1)}{N(N-1)}\right) \qquad \text{(Equation 2)}$$

Where:

Ds = Simpson Diversity Index

N = Total number of all individuals

n = Number of individuals for each species

c) Evenness Index

$$J = \frac{H}{Hmax} \qquad \text{(Equation 3)}$$

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:

$$Basal\ Area = 0.7857\ \times D^2 \qquad \text{(Equation 4)}$$

e) Above Ground Biomass

$$AGB = 0.0673 \times (WD \times H \times D^2)^{0.976} \qquad \text{(Equation 5)}$$

i. WD = Wood Density
ii. H = Height of tree
iii. D = Diameter Breast Height of tree

f) Important Value Index

The Importance Value Index (IVI), which measures a species' importance in the environment, is a vital tool in phytosociological investigations. IVI is typically calculated using a variety of techniques, including density, dominance, and frequency; however, they may not adequately account for the hierarchical significance of species at low densities (Xie et al., 2023).

$$IVI = Rf + Rd + RD \quad \text{(Equation 6)}$$

Rf = Relative frequency

Rd = Relative density

RD = Relative Dominance

g) Wood Density

Wood density values vary significantly depending on factors such as tree species, age, state of decomposition, and water content. Research has shown that wood density plays a crucial role in backwater formation in rivers, with values ranging from 250 kg/m³ to over 900 kg/m³ (Mallqui et al., 2022). Wood Density Value was got from Global Database Wood Density write by Ignacio Larco Roca in 2017.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Tree Species Composition

The total number of trees with a diameter at breast height (DBH) of 10 cm and above at the study site around forest Gunung Stong State Park in five plots of 0.02 ha was recorded. All specimens with a total of 131 trees, representing 13 families, 19 genera and 25 species have been identified. In addition, the number of species and the number of families that exist because of the selected studies have been listed in Table 4.1. Based on Table 4.2 shows the list of the top ten species according to the number of the highest tree individuals in the five study plots and the list of the highest families according to the number of the highest tree individuals in the five study plots in Gunung Stong National Park (GSSP).

In the study area, the composition of the tree species with the highest number of trees is the tree species *Horsfieldia superba*, *Palaquium clarkeanum* and *Shorea spp* with the number of individuals as many as 13 trees each of the ten species that recorded the highest number of individuals, followed by the species *Shorea leprosula* with the total number individuals as many as 12 trees. In addition, the results show that the lowest number of individuals is the *Shorea parvifolia* species, which is 6 of the ten species that recorded the highest number of individuals.

Based on Table 4.3 in Gunung Stong State Park (GSSP), the highest family found in these five plots is the Dipterocarpaceae family with 40 trees representing 6 species and 3 genera. Among the species found in this family are *Shorea leprosula*, *Shorea spp*, *Shorea parvifolia*, *Shorea platyclados*, *Hopea odorata* and *Dipterocarpus bourdilnolli*. The second highest family is Myrtaceae which belongs to 16 trees representing 3 species and 1 genus namely *syzygium scortechinii*, *syzygium polyanthum* and *Sygyzium spp*. This result also recorded the family Aristolochiaceae as the lowest with the number of trees of 1 tree represent 1 species and 1 genus. The only species recorded under the Aristolochiaceae family is *Thottea piperiformis*.

Table 4.1 List of species names and lists of families in five study plots at Gunung Strong State Park (GSSP).

Species Name	Family
Campnosperma auriculatum *Melanorrhoea spp.* *Mangifera quadrifida*	Anacardiaceae
Arthrophyllum diversifolium	Araliaceae
Thottea piperiformis	Aristolochiaceae
Dipterocarpus bourdillnolli *Hopea odorata* *Shorea leprosula* *Shorea parvifolia* *Shorea platyclados* *Shorea spp*	Dipterocarpaceae
Diospyros buxifolia *Diospyros paniculata*	Ebenaceae
Lithocarpus cantleyanus	Fagaceae

Cinnamomum iners *Litsea lancifolia*	Lauraceae
Ficus vasculosa *Streblus elongatus*	Moraceae
Horsfieldia superba	Myristicaceae
Sygyzium spp *Syzygium polyanthum* *Syzygium scortechinii*	Myrtaceae
Pellacalyx saccardianus	Rhizophoraceae
Ixora congesta	Rubiaceae
Palaquium clarkeanum	Sapotaceae

Table 4.2 Lists of the ten highest species according to the highest individual number of trees in five study plots at Gunung Strong State Park (GSSP).

Species Name	**Individuals**
Horsfieldia superba	13
Palaquium clarkeanum	13
Shorea spp	13
Shorea leprosula	12
Diospyros paniculata	10
Syzgium scortechinii	10
Cinnamomum iners	7
Pellacalyx saccardianus	7
Streblus elongatus	7
Shorea parvifolia	6

Table 4.3 Lists of highest Families according to the highest individual number of trees in five study plots at Gunung Strong State Park (GSSP).

Family	No.of Species	No. of Genera	No. of Individual
Dipterocarpaceae	6	3	40
Myrtaceae	3	1	16
Ebenaceae	2	1	13
Myristicaceae	1	1	13
Sapotaceae	1	1	13
Lauraceae	2	2	8
Moraceae	2	2	8
Rhizophoraceae	1	1	7
Anacardiaceae	3	3	5
Rubiaceae	1	1	3
Araliaceae	1	1	2
Fagaceae	1	1	2
Aristolochiaceae	1	1	1
Total	**25**	**19**	**131**

4.2 Diameter at Breast Height (DBH) Measurement

The most appropriate measurement to use in the five plots of Gunung Stong State Park (GSSP) to determine the diameter of trees between 10 cm and more is the diameter at breast height (DBH), which is one of the significant and standard measurements used to determine the diameter of tree stumps for trees standing in forest areas.

The most densely populated tree category in Figure 4.1 is represented by trees with a diameter at breast height (DBH) of 10.0 to 19.9. There are a lot of trees in this size range up to 61 trees in this size range. This indicates that significant numbers of the forest's trees are smaller or younger. On the other hand, just one huge tree was found in each of the DBH ranges 70.0 to 79.9, 80.0 to 89.9, and 110.0 to 119.9. This indicates that the forest lacked many large trees. The absence of larger trees in this forest may mean that larger trees are less abundant there, or it could mean that large trees die and fall because of natural disturbance, making way for smaller ones.

It was apparent from examining the tree size distribution in the five plots of the surveyed forest that neither plot 1 nor plot 3 did not follow the usual J-curve pattern that is frequently seen in natural forest ecosystems. The data seen in this plot ranges from the usual pattern, even though the J-curve distribution normally displays a greater number of smaller trees with diameter at breast height (DBH) followed by a gradual decrease in frequency as tree size increases.

Plot 1 (Figure 4.2) shows a curious trend when there are more trees in the DBH range of 30.0 to 39.9 than there are in the range of 20.0 to 29.9. In the present situation, eight trees were found in the first group and just seven in the second. Plot 3(Figure 4.4) also showed comparable departures from the predicted distribution, with seven trees falling between 30.0 and 39.9 DBH, exceeding two trees recorded between 20.0 and 29.9. The observed difference from the expected J-curve pattern caused a more thorough investigation of the possible variables impacting the distribution of trees in this plot. Plot 3 showed significant indications of tree death upon closer inspection, most likely due to environmental factors like lightning strikes or die due to disease and old age, which resulted in the death and falling of multiple trees. Because there are less larger trees in the measured area because of this disturbance, the expected distribution is changed. Plot 3's absence of a J curve is thus explained by how environmental disturbances affect the dynamics of trees in forest ecosystems (Figure 4.7).

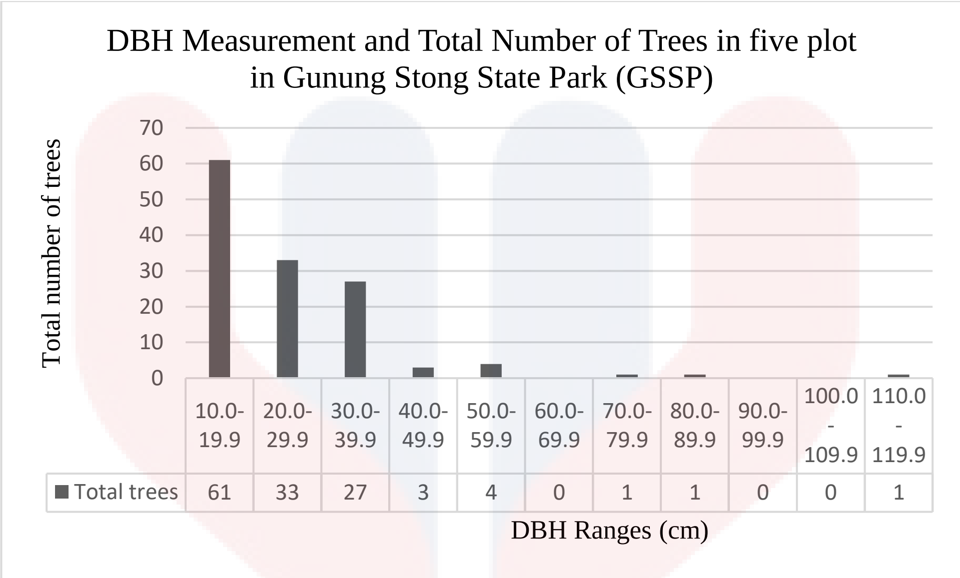

Figure 4.1 shows DBH Measurement and Total Number of Trees in five plots in Gunung Stong State Park (GSSP).

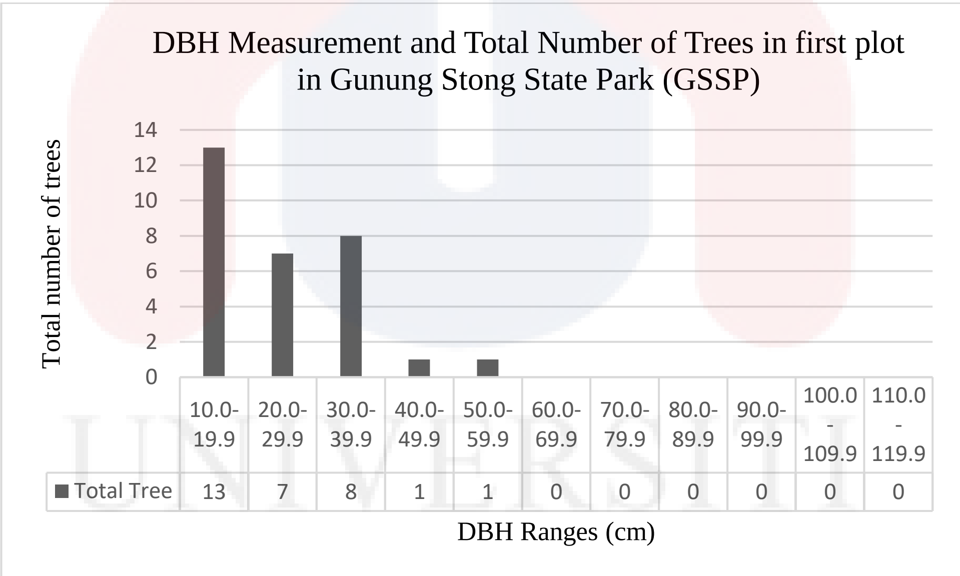

Figure 4.2 Shows DBH Measurement and Total Number of Trees in the first plot in Gunung Stong State Park (GSSP).

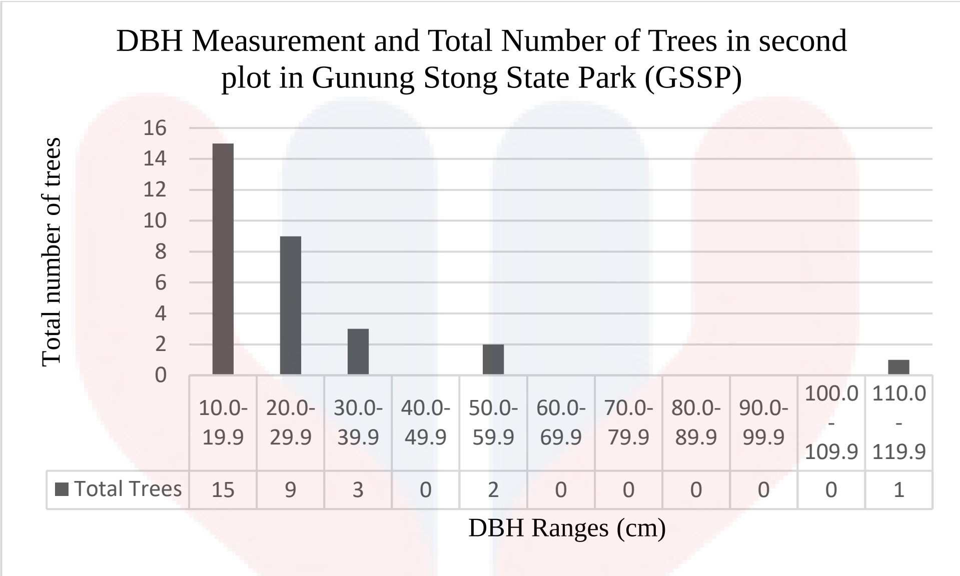

Figure 4.3 Shows DBH Measurement and Total Number of Trees in second plot in Gunung Stong State Park (GSSP)

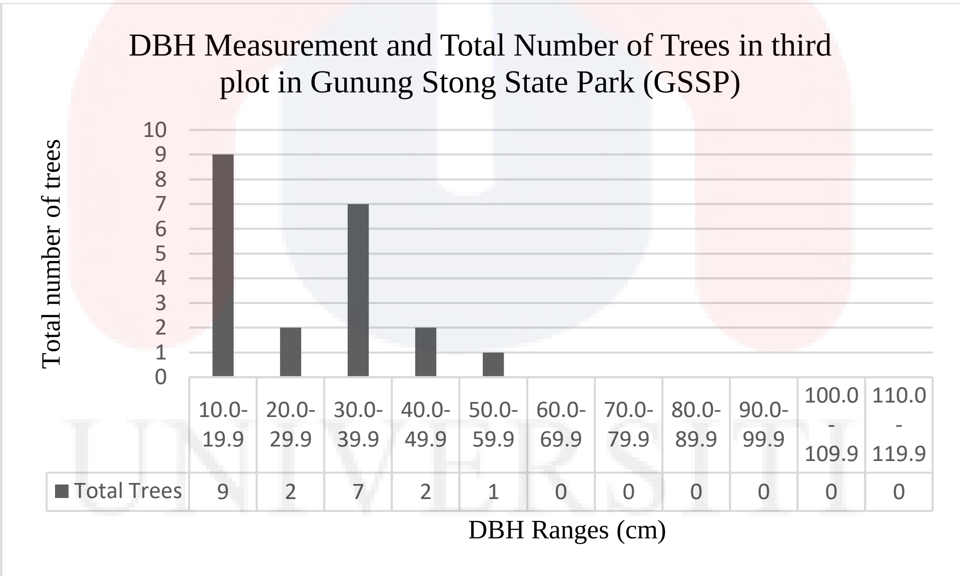

Figure 4.4 Shows DBH Measurement and Total Number of Trees in third plot in Gunung Stong State Park (GSSP)

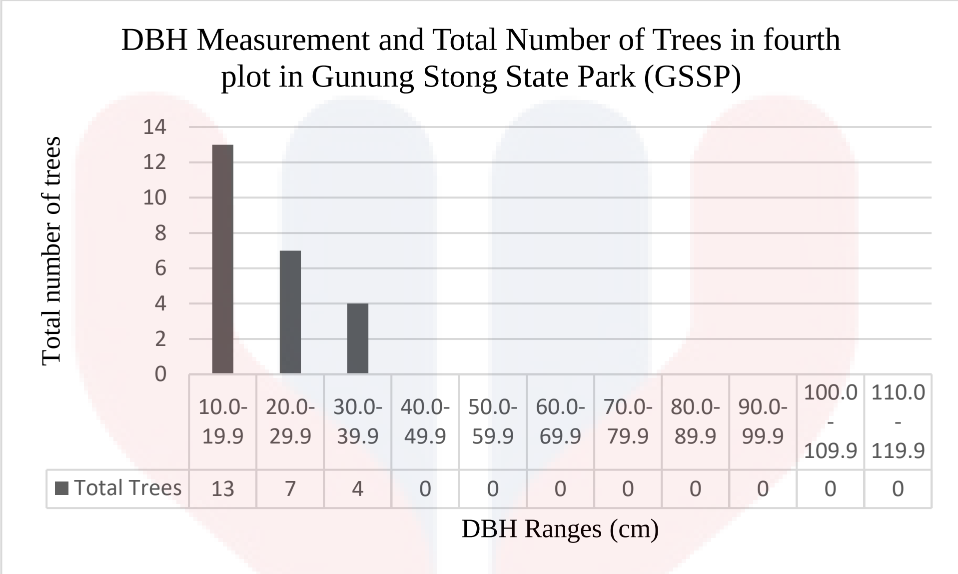

Figure 4.5 shows DBH Measurement and Total Number of Trees in fourth plot in Gunung Stong State Park (GSSP)

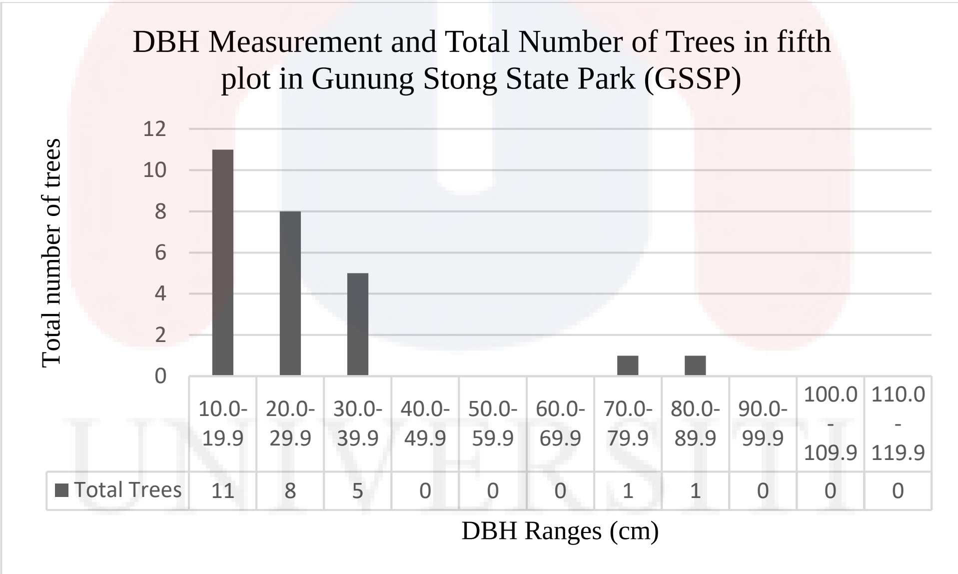

Figure 4.6 Shows DBH Measurement and Total Number of Trees in fifth plot in Gunung Stong State Park (GSSP)

Figure 4.7 The trees that died in Gunung Stong State Park (GSSP)

4.3 Species Diversity

The Shannon-Wiener diversity index (H') for a 0.02-hectare plot in Gunung Stong State Park (GSSP) (Table 4.4) is 2.90 and Simpson Diversity Index is 0.94. This result, which ranges between 1.5 and 3.5 on the usual range for Shannon-Wiener diversity index (H') and close to an index value of 1 for Simpson Diversity Index, indicates a high degree of species variety. A high index value highlights the ecological complexity and health of the forest ecosystem by showing a rich and balanced composition of tree species. Higher ecological resilience and stability are correlated with higher biodiversity. This value also emphasizes how successful conservation initiatives are at preserving species diversity, which is crucial for species survival and adaptation in the face of environmental change. As a result, the Gunung Stong State Park (GSSP) area is proven to be able to predict the diversity of species in the area by the Shannon-

Wiener index and Simpson Diversity Index value.

There were significant differences in the species diversity and distribution between all five plots when comparing the Shannon-Wiener Diversity Index (H') (Table 4.5). With an index value of 2.68, Plot 5 was found to have the highest species diversity across all plots. This points to a more diverse and evenly distributed tree species composition, which will strengthen and stabilize the ecology in this plot. Plot 2 was next, with an index value of 2.53, which was little lower than plot 5 but still indicated a significant species diversity. Plot 1, on the other hand, had the lowest index value (2.43), indicating a less equal distribution of tree species and comparatively low species diversity.

A comprehensive evaluation of the five plots using the Simpson Diversity Index revealed a high degree of species richness with little variation throughout the study area. Plot 5 has the highest index value for Simpson diversity index which is 0.96 (Table 4.6), suggesting that it contains the most species diversity and a similar distribution of individuals across various species. Plots 3 and 4, which also have an index value of 0.95 and exhibit similarly high levels of species diversity, come in close second to this. Plot 1 shows significant species diversity, but slightly less than the other plots, while having the lowest index value (0.93). Consistently high Simpson's index values across these plots highlight the overall ecological richness and stability of the area, indicating that the forest ecosystem within Gunung Stong State Park supports a balanced and diverse range of tree species.

The evenness index, which measures the distribution of species abundances within a community, is an essential diversity assessment indicator. There have been conceptual difficulties with traditional evenness measures; some have placed more emphasis on relative diversity than on true evenness (Zhang et al., 2021).

The Evenness index values for each of the five plots are compared in Table 4.7, with plot 5 having the highest index value of 1. This shows that the number of individual trees in plot 5 is evenly distributed across different species, indicating a perfectly equitable community with an equal representation of each species. The Evenness index values of the other four plots, on the other hand, are lower, indicating a less even distribution of individuals across species. Plot 5's similarity reveals a balanced ecosystem devoid of a single dominant species, signifying a stable and healthy forest ecosystem.

Table 4.4 Total value of Shannon-Wiener Diversity Index (H') and Simpson Diversity Index (D) for all plots

Index	**Value**
Shannon-Wiener Diversity Index (H')	2.90
Simpson Diversity Index (D)	0.942

Table 4.5 Differences total value of Shannon-Wiener Diversity Index (H') between all plots

Shannon-Wiener	**Value**
Plot 1	2.43
Plot 2	2.53
Plot 3	2.47
Plot 4	2.44
Plot 5	2.68

Table 4.6 Differences total value of Simpson Diversity Index (D) between all plots

Simpson Index	**Value**
Plot 1	0.93
Plot 2	0.94
Plot 3	0.95
Plot 4	0.95
Plot 5	0.96

Table 4.7 Differences total value of Evenness Index (J) between all plots

Evenness Index	Value
Plot 1	0.91
Plot 2	0.94
Plot 3	0.92
Plot 4	0.91
Plot 5	1.00

4.4 Basal Area (BA)

The cross-sectional area of tree stems at breast height is known as the basal area, and it is a critical metric in the ecology and management of forests. It is a measure of the productivity and structure of the forest. Research has indicated that basal area and tree species density are crucial factors in evaluating the health of forests and resource management (Canisius et al., 2022).

Important tree growth is seen across the research area in the entire basal area of the five plots, which totals 42.132 m²/ha and covers an area of 0.2 ha. Comparing the basal area of each family, Table 4.8 shows considerable variation. With a total basal area of 25.186 m2/ha, the family Dipterocarpceae had the largest basal area, suggesting that a dense population of trees with higher diameters is responsible for the big basal area overall. Family Myristicaceae the second-highest basal area for each family at 4.177 m²/ha, demonstrating a high concentration of trees as well. Family Aristolochiaceae, on the other hand, had the lowest total basal area of any of families at 0.055 m²/ha, suggesting either a sparser distribution of trees or smaller tree sizes overall. These variations highlight how the study site's forest structure and tree density range.

Table 4.9 presents an understanding of the differences between species, especially when compared to the basal area, where the top 10 species are listed. With a basal area of 8.389 m²/ha, *Shorea platyclados*. was found to be the species with the highest basal area, closely followed by *Shorea parvifolia* (5.598 m²/ha). Interestingly, these plants are members of the Dipterocarpaceae family, demonstrating their dominance in terms of the diameter of the entire breast height. This shows the significant role dipterocarps play in the biomass and general structure of forests. Conversely, among the top 10 species, *Hopea odorata*, still a member of the Dipterocarpaceae family, has the lowest basal area, measuring 1.118 m²/ha. These variations highlight the diversity of species distribution and composition in forest ecosystems, with certain families like the Dipterocarpaceae playing a significant influence in determining the dynamics and structure of the forest while others contribute less to the basal area.

Based on Table 4.10 in Gunung Stong State Park (GSSP), the five genera with the highest basal area are Shorea (23.501 m/ha), Horsfieldia (4.177 m/ha), Palaquium (2.980 m/ha), Syzygium (2.507 m/ha), and Diospyros (1.594 m/ha), showing significant dominance in the forest ecosystem. On the other hand, the genera with the lowest basal area are Thottea (0.055 m/ha), Mangifera (0.061 m/ha), Ficus (0.066 m/ha), Lithocarpus (0.258 m/ha), and Ixora (0.281 m/ha), indicating a very limited presence in study plot. These data show significant differences in ecological roles between dominant and less dominant genera in the GSSP.

Table 4.8 Basal area for all families in Gunung Stong State Park

Family	BA(t/ha)
Dipterocarpaceae	25.186
Myristicaceae	4.177
Sapotaceae	2.980
Myrtaceae	2.507
Anacardiaceae	1.595
Ebenaceae	1.594

Moraceae	1.133
Rhizophoraceae	0.989
Lauraceae	0.830
Araliaceae	0.479
Rubiaceae	0.281
Fagaceae	0.258
Aristolochiaceae	0.055

Table 4.9 Ten species for the highest basal area in all five plots in Gunung Stong State Park

Species name	**BA(t/ha)**
Shorea platyclados	8.389
Shorea parvifolia	5.598
Shorea spp	5.294
Shorea leprosula	4.219
Horsfieldia superba	4.177
Palaquium clarkeanum	2.980
Campnosperma auriculatum	1.232
Diospyros paniculata	1.201
Streblus elongatus	1.133
Hopea odorata	1.118

Table 4.10 List of Genera for the highest basal area in all five plots in Gunung Stong State Park

Genera	**BA(t/ha)**
Shorea	23.501
Horsfielda	4.177
Palaquium	2.980
Syzygium	2.507
Diospyros	1.594
Campnosperma	1.232
Streblus	1.133
Hopea	1.118
Pellacalyx	0.989
Dipterocarpus	0.567

Arthrophyllum	0.479
Cinnamomum	0.433
Litsea	0.397
Melanorrhoea	0.302
Ixora	0.281
Lithocarpus	0.258
Ficus	0.066
Mangifera	0.061
Thottea	0.055

4.5 Above Ground Biomass

According to a study completed at Gunung Stong State Park, the total biomass above ground in a 0.2 ha plot area was 298.762 t/ha, taking consideration of the number of species identified in each plot. The above ground biomass values for each of the families are listed in Table 4.11, which shows an interesting range. Family Dipterocarpceae had the largest aboveground biomass, with 193.747 t/ha, suggesting that biomass was largely generated by thick, mature tree populations. The family Aristolochiaceae, on the other hand, had the lowest value (0.216 t/ha), suggesting a smaller or less developed population of trees. These values draw attention to variations in biomass distribution and forest structure throughout the research region, offering vital information for comprehending the biological processes and potential carbon storage of the region.

With a focus on the 10 species with the highest biomass values, Table 4.12 presents a thorough overview of the biomass contributions made by the various species in the research area. *Shorea platyclados* has the greatest biomass value (95.170 t/ha), highlighting its remarkable ability to store carbon. These high results suggest that *Shorea platyclados* are important for forest carbon sequestration and have a major impact on the ecosystem's ecological health and carbon balance.

This is interesting to note that the list shows a pattern whereby the Dipterocarpaceae family represents nearly all the top species contributing to biomass. In addition to *Shorea spp.*, *Shorea leprosula*, *Shorea parvifolia*, *Shorea platyclados*, and *Hopea odorata* are further important members of this family. *Campnosperma auriculatum* has the lowest biomass value of these species, 6.695 t/ha, while being in the top ten. The dominance and significant ecological impact of Dipterocarpaceae species in this forest environment is highlighted by their predominance among the top contributors to biomass.

The dominance of Dipterocarpaceae species indicates that these trees are crucial for preventing climate change since they store carbon and contribute significantly to the structure of the forest. They are important actors in preserving the dynamics of forest carbon because of their capacity to amass substantial amounts of biomass. Thus, Table 4.11 data highlights how crucial it is to preserve these species to preserve ecological balance and improve forests' capacity to absorb carbon dioxide. To maintain biodiversity and maximize carbon sequestration in Gunung Stong State Park, forest management and conservation practices can benefit greatly from this concentration on Dipterocarpaceae species.

The five genera with the greatest biomass values are Shorea, Horsfieldia, Palaquium, Syzygium and Streblus (Table 4.13), which shows the Above Ground Biomass values for the genera in the five study plots in Gunung Stong State Park (GSSP). At 182.709 t/ha, Shorea had the highest biomass value, demonstrating its extraordinary dominance in the forest environment. Horsfielda came in second with 4.177 t/ha, and Palaquium third with 20.022 t/ha. At 15.232 t/ha, Syzygium has a higher biomass value than Streblus, which recorded 8.906 tan/ha. However, Ficus (0.066 t/ha), Mangifera (0.061 t/ha), Thottea (0.055 t/ha), Ixora (1.490 t/ha), and

Cinnamomum (1.519 t/ha) are the genera with the lowest biomass values, indicating a very limited presence and a modest contribution to the overall forest biomass. These data emphasize the significant difference in ecological dominance between dominant and less dominant genera in GSSP.

Table 4.11 Above Ground Biomass for all families in Gunung Stong State Park

Family	AGB(t/ha)
Dipterocarpaceae	193.747
Myristicaceae	29.206
Sapotaceae	20.022
Myrtaceae	15.232
Moraceae	9.070
Anacardiaceae	8.878
Ebenaceae	8.034
Lauraceae	4.636
Rhizophoraceae	4.442
Araliaceae	1.974
Fagaceae	1.814
Rubiaceae	1.490
Aristolochiaceae	0.216

Table 4.12 Ten species for the highest Above Ground Biomass value in all five plots in Gunung Stong State Park

Species name	AGB(t/ha)
Shorea platyclados	95.170
Shorea spp	34.429
Shorea parvifolia	31.814
Horsfieldia superba	29.206
Shorea leprosula	21.296
Palaquium clarkeanum	20.022
Streblus elongatus	8.906

Sygyzium spp	7.531
Hopea odorata	7.051
Campnosperma auriculatum	6.695

Table 4.13 List of Genera for the Above Ground Biomass value in all five plots in Gunung Stong State Park

Genera	AGB(t/ha)
Shorea	182.709
Horsfielda	29.206
Palaquium	20.022
Syzygium	15.232
Streblus	8.906
Diospyros	8.034
Hopea	7.051
Campnosperma	6.695
Pellacalyx	4.442
Dipterocarpus	3.987
Litsea	3.117
Melanorrhoea	1.994
Arthrophyllum	1.974
Lithocarpus	1.814
Cinnamomum	1.519
Ixora	1.490
Thottea	0.216
Mangifera	0.189
Ficus	0.165

4.6 Important Value Index (IVi)

According to a study completed at Gunung Stong State Park, the Important Value Index for each of the families is listed in Table 4.14, which shows an interesting range. Family Dipterocarpceae had the largest important value index, with 37.17, which indicates that these families Dipterocarpceae play a dominant and critical role in the ecosystem. The family Aristolochiaceae, on the other hand, had the lowest value (0.566). These values draw attention to the role of each family in forest structure and ecosystem throughout the research region, offering vital information for comprehending the biodiversity balance.

With a focus on the 10 species with the highest biomass values, Table 4.15 presents a thorough overview of the important value index made by the various species in the research area. The Dipterocarpaceae family member *Shorea spp.* has the greatest important value index (11.13), highlighting its remarkable play of the important role in forest ecosystem. While *Pellacalyx saccardianus* had the lowest value of the important value index which is 4.63.

The five genera with the greatest biomass values are Shorea, Horsfieldia, Palaquium, Syzygium and Diospyros (Table 4.16), which shows the Important Value Index for the genera in the five study plots in Gunung Stong State Park (GSSP). At 32.49, Shorea had the highest important value index, demonstrating its extraordinary dominance in the forest environment. Syzygium came in second with 10.69, and Horsfielda third with 10.23. However, Thottea (0.57), Mangifera (0.58), Ficus (0.58), Litsea (0.89), and Dipterocarpus (0.97) are the genera with the lowest important value index, indicating a very limited presence and a modest contribution to the overall forest ecosystem. These data emphasize the significant difference in ecological dominance between dominant and less dominant genera in GSSP.

Table 4.14 Important Value Index for all families in Gunung Stong State Park

Family	**IVi**
Dipterocarpaceae	37.171
Myrtaceae	10.687
Myristicaceae	10.232
Sapotaceae	9.587
Ebenaceae	8.447

Moraceae	5.348
Lauraceae	4.913
Rhizophoraceae	4.625
Anacardiaceae	3.704
Rubiaceae	1.867
Araliaceae	1.534
Fagaceae	1.319
Aristolochiaceae	0.566

Table 4.15 Ten species for the highest Important Value Index in all five plots in Gunung Stong State Park

Species Name	**IVi**
Shorea spp	11.133
Horsfieldia superba	10.232
Shorea leprosula	9.943
Palaquium clarkeanum	9.587
Shorea parvifolia	6.476
Diospyros paniculata	6.470
Syzygium scortechinii	6.171
Shorea platyclados	4.933
Streblus elongatus	4.764
Pellacalyx saccardianus	4.625

Table 4.16 List of Genera for the Important Value Index in all five plots in Gunung Stong State Park

Genera	**IVi**
Shorea	32.485
Syzygium	10.687
Horsfielda	10.232
Palaquium	9.587
Diospyros	8.447
Streblus	4.764
Pellacalyx	4.625
Cinnamomum	4.035

Hopea	3.712
Melanorrhoea	1.872
Ixora	1.867
Arthrophyllum	1.534
Lithocarpus	1.319
Campnosperma	1.255
Dipterocarpus	0.974
Litsea	0.878
Ficus	0.584
Mangifera	0.577
Thottea	0.566

4.7 Conservation Status

Information regarding the IUCN status of several tree species is displayed in Table 4.15. The groups Ebenaceae, Dipterocarpaceae, Moraceae, Anacardiaceae, Myristicaceae, and Myrtaceae are represented among the species listed.

This subspecies does not now face a severe risk of extinction, as evidenced by the three species (*Diospyros buxifolia*, *Ficus vasculosa*, and *Syzygium scortechinii*) that are listed as Least Concern on the IUCN Red List. Two species, *Shorea platyclados* and *Horsefieldia superba*, are Near Threatened, which means they are on the verge of becoming endangered. There is a significant risk of extinction in the wild for two other species, *Diospyros paniculata* and *Hopea odorata*, which are both categorized as vulnerable. Aside from that, three species (*Dipterocarpus bourdilnolli*, *Melanorrhoea spp*., and *Shorea spp*.) are designated as N/A since there is insufficient information available to assess their conservation status.

The conservation status of this study shows that the species discovered in the GSSP are still protected and conserved by the Kelantan Forestry Department and other relevant organizations, as this tree species is still not listed as endangered by the IUCN.

Table 4.17 List of ten species according to conservation status

Species Name	Family	IUCN Red List (IUCN 2024
Diospyros buxifolia	Ebenaceae	Least Concern
Diospyros paniculata	Ebenaceae	Vulnerable
Dipterocarpus bourdillnolli	Dipterocarpaceae	N/A
Ficus vasculosa	Moraceae	Least Concern
Melanorrhoea spp.	Anacardiaceae	N/A
Hopea odorata	Dipterocarpaceae	Vulnerable
Horsfieldia superba	Myristicaceae	Near Threatened
Shorea platyclados	Dipterocarpaceae	Near Threatened
Shorea spp	Dipterocarpaceae	N/A
Syzygium scortechinii	Myrtaceae	Least Concern

CHAPTER 5

CONCLUSION AND RECOMMENDATION

A total of 131 trees with a diameter at breast height (DBH) of 10 cm or greater were recorded in a thorough survey carried out on a 0.2-hectare tract. With 13 different families, 19 genera, and 25 different species, this plot demonstrated a wide diversity of plants. With 3 genus and 6 species, the family Dipterocarpaceae was significant for being the largest family in the research area and for its ecological importance.

The study also estimated the trees' above-ground biomass, which came out to be a healthy 298.762 t/ha. The genus Shorea contributed the most biomass to this study, with a value of 182.709 t/ha. *Shorea platyclados*, a member of the Dipterocarpaceae family, contributed the greatest biomass of all the species, with an estimated 95.170 t/ha. This emphasizes the importance of Dipterocarpaceae, especially the Shorea species, in the forest's biomass composition.

Two indices were also used to quantify the plot's variety. A moderate to high diversity is indicated by a Shannon-Wiener diversity index of 2.9, which calculates species richness and evenness. There is a significant degree of species diversity and evenness within the plot, as indicated by the Simpson diversity index, which was 0.94 and considers the likelihood of two individuals belonging to the same species. These indices show that an ecosystem is in balance and that a wide range of species contribute to biodiversity.

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APPENDIX A

List of species and family found in five plot study at Gunung Stong State Park (GSSP), Dabong, Kelantan.

Species Name	Family
Campnosperma auriculatum	Anacardiaceae
Melanorrhoea spp.	
Mangifera quadrifida	
Arthrophyllum diversifolium	Araliaceae
Thottea piperiformis	Aristolochiaceae
Dipterocarpus bourdillnolli	Dipterocarpaceae
Hopea odorata	
Shorea leprosula	
Shorea parvifolia	
Shorea platyclados	
Shorea spp	
Diospyros buxifolia	Ebenaceae
Diospyros paniculata	
Lithocarpus cantleyanus	Fagaceae
Cinnamomum iners	Lauraceae
Litsea lancifolia	
Ficus vasculosa	Moraceae
Streblus elongatus	
Horsfieldia superba	Myristicaceae
Syzygium spp	Myrtaceae

Syzygium polyanthum	
Syzygium scortechinii	
Pellacalyx saccardianus Scort	Rhizophoraceae
Ixora congesta	Rubiaceae
Palaquium Clarkeanum	Sapotaceae

APPENDIX B

List of species and individuals' number of trees found in five study plots at Gunung Stong State Park (GSSP), Dabong, Kelantan.

Species name	**Individuals**
Arthrophyllum diversifolium	2
Campnosperma auriculatum	1
Cinnamomum iners	7
Diospyros buxifolia	3
Diospyros paniculata	10
Dipterocarpus bourdillnolli	1
Ficus vasculosa	1
Melanorrhoea spp.	3
Hopea odorata	5
Horsfieldia superba	13
Ixora condesta	3
Lithocarpus cantleyanus	2
Litsea lancifolia	1
Mangifera quadrifida	1
Palaquium Clarkeanum	13
Pellacalyx saccardianus Scort	7
Shorea leprosula	12
Shorea Parvifolia	6
Shorea Platyclados	3
Shorea Spp	13
Streblus elongatus	7
Sygyzium Spp	3
Syzgium scortechinii	10
Syzygium polyanthum	3
Thottea piperiformis	1

APPENDIX C

List of genera for basal area, above ground biomass and important value index content in five plots at Gunung Stong State Park, Kelantan.

Genera	BA(t/ha)	AGB(t/ha)	IVi
Shorea	23.501	182.709	32.485
Syzygium	2.507	15.232	10.687
Horsfielda	4.177	29.206	10.232
Palaquium	2.980	20.022	9.587
Diospyros	1.594	8.034	8.447
Streblus	1.133	8.906	4.764
Pellacalyx	0.989	4.442	4.625
Cinnamomum	0.433	1.519	4.035
Hopea	1.118	7.051	3.712
Melanorrhoea	0.302	1.994	1.872
Ixora	0.281	1.490	1.867
Arthrophyllum	0.479	1.974	1.534
Lithocarpus	0.258	1.814	1.319
Campnosperma	1.232	6.695	1.255
Dipterocarpus	0.567	3.987	0.974
Litsea	0.397	3.117	0.878
Ficus	0.066	0.165	0.584
Mangifera	0.061	0.189	0.577
Thottea	0.055	0.216	0.566

APPENDIX D

List of species for basal area, above ground biomass and important value index content in five plots at Gunung Stong State Park, Kelantan.

Species Name	BA(t/ha)	AGB(t/ha)	IVi
Shorea spp	5.294	34.429	11.133
Horsfieldia superba	4.177	29.206	10.232
Shorea leprosula	4.219	21.296	9.943
Palaquium clarkeanum	2.980	20.022	9.587
Shorea parvifolia	5.598	31.814	6.476
Diospyros paniculata	1.201	5.543	6.470
Syzygium scortechinii	1.066	5.358	6.171
Shorea platyclados	8.389	95.170	4.933
Streblus elongatus	1.133	8.906	4.764
Pellacalyx saccardianus Scort	0.989	4.442	4.625
Cinnamomum iners	0.433	1.519	4.035
Hopea odorata	1.118	7.051	3.712
Sygyzium spp	1.005	7.531	2.498
Syzygium polyanthum	0.437	2.175	2.019
Diospyros buxifolia	0.393	2.490	1.977
Melanorrhoea spp.	0.302	1.994	1.872
Ixora condesta	0.281	1.490	1.867
Arthrophyllum diversifolium	0.479	1.974	1.534
Lithocarpus cantleyanus	0.258	1.814	1.319
Campnosperma auriculatum	1.232	6.695	1.255
Dipterocarpus bourdillnolli	0.567	3.987	0.974
Litsea lancifolia	0.397	3.117	0.878
Ficus vasculosa	0.066	0.165	0.584
Mangifera quadrifida	0.061	0.189	0.577
Thottea piperiformis	0.055	0.216	0.566

APPENDIX F

List of species and wood density value (kg/m)

Species name	Wood Density (kg/m)
Arthrophyllum diversifolium	0.37
Campnosperma auriculatum	0.32
Cinnamomum iners	0.46
Diospyros buxifolia	0.72
Diospyros paniculata	0.63
Dipterocarpus bourdillnolli	0.58
Ficus vasculosa	0.3
Melanorrhoea spp.	0.67
Hopea odorata	0.68
Horsfieldia superba	0.56
Ixora condesta	0.64
Lithocarpus cantleyanus	0.653
Litsea lancifolia	0.595
Mangifera quadrifida	0.45
Palaquium Clarkeanum	0.66
Pellacalyx saccardianus Scort	0.47
Shorea leprosula	0.43
Shorea Parvifolia	0.36
Shorea Platyclados	0.54
Shorea Spp	0.55
Streblus elongatus	0.84
Sygyzium Spp	0.64
Syzygium polyanthum	0.56
Syzygium scortechinii	0.525
Thottea piperiformis	0.575

APPENDIX G

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

Species Name	**Family**	**IUCN Red List**
Arthrophyllum diversifolium	Araliaceae	Least Concern
Campnosperma auriculatum	Anacardiaceae	Least Concern
Cinnamomum iners	Lauraceae	Least Concern
Diospyros buxifolia	Ebenaceae	Least Concern
Diospyros paniculata	Ebenaceae	Vulnerable
Dipterocarpus bourdillnolli	Dipterocarpaceae	N/A
Ficus vasculosa	Moraceae	Least Concern
Melanorrhoea spp.	Anacardiaceae	N/A
Hopea odorata	Dipterocarpaceae	Vulnerable
Horsfieldia superba	Myristicaceae	Near Threatened
Ixora congesta	Rubiaceae	N/A
Lithocarpus cantleyanus	Fagaceae	N/A
Litsea lancifolia	Lauraceae	Least Concern
Mangifera quadrifida	Anacardiaceae	Least Concern
Palaquium clarkeanum	Sapotaceae	Vulnerable
Pellacalyx saccardianus Scort	Rhizophoraceae	N/A
Shorea leprosula	Dipterocarpaceae	Near Threatened
Shorea parvifolia	Dipterocarpaceae	Least Concern
Shorea platyclados	Dipterocarpaceae	Near Threatened
Shorea spp	Dipterocarpaceae	N/A
Streblus elongatus	Moraceae	N/A
Syzygium spp	Myrtaceae	N/A
Syzygium polyanthum	Myrtaceae	N/A
Syzygium scortechinii	Myrtaceae	Least Concern
Thottea piperiformis	Aristolochiaceae	N/A