DISTRIBUTION OF GENUS SHOREA IN BUKIT BAKAR FOREST ECO PARK, MACHANG, KELANTAN

by

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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Natural Resources Science) with Honours

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DECLARATION

I declare that this thesis entitled "Distribution of Genus *Shorea* in Bukit Bakar Forest Eco Park, Machang, 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 :…….

Name :…….

Date :…….

APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources Sciences) with Honors"

Signature : …….....

Name of Supervisor I :

Date : ……..

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The Distribution of genus *Shorea* in Bukit Bakar Forest Eco Park, Machang, Kelantan.

ABSTRACT

A study to determine the distribution of genus *Shorea spp.* and estimate the above ground biomass for *Shorea spp,* in Bukit Bakar Forest Eco Park. Bukit Bakar Forest Eco Park contains of various tree species that have a high economic value which are expected to have high biomass content. This is important to conduct as there is less scientific data on the distribution of genus *Shorea* that exist in Bukit Bakar Forest Eco Park, Machang, Kelantan. The objectives aimed in this study were to measure the diversity and abundance of genus *Shorea* in this study area. Five plots of 20 m x 20 m were randomly plotted. There are 120 individuals from genus *Shorea* were found which are represented by 14 species of genus *Shorea* with the diameter at breast height (DBH) less than 5 cm. The *Shorea spp.* shows high diversity with Shannon-Wiener Index, H' value 2.50, Shannon Evenness Index, E is 0.95 and Simpson's Index with 0.91. The total above ground biomass value of *Shorea spp*. in Bukit Bakar Forest Eco Park is estimated at 72.48 t/ha. *Shorea macroptera* dominate the distribution of *Shorea spp*. in this study area as this species are found with total number is 23. The result of this study will update the information and data in Bukit Bakar Forest Eco Park Machang, Kelantan. For the future sustainability to maintain this valuable species, it is important for Forestry Department of Kelantan to conserve and sustain this species for stabilising carbon content in atmosphere.

Taburan genus *Shorea* di Hutan Rekreasi Bukit Bakar, Machang, Kelantan.

ABSTRAK

Satu kajian untuk menentukan komposisi, kepelbagaian spesies dan biojisim atas tanah untuk *Shorea spp*. telah dijalankan di Hutan Rekreasi Bukit Bakar yang mengandungi pelbagai spesies pokok yang mempunyai nilai ekonomi dan dijangkakan mengandungi kandungan biojisim di atas tanah yang tinggi. Kajian ini amat penting untuk dijalankan kerana terdapat kekurangan data saintifik mengenai pengedaran genus *Shorea* yang wujud di Hutan Rekreasi Bukit Bakar, Machang, Kelantan. Objektif kajian ini berfokuskan untuk mengukur kepelbagaian dan kelimpahan genus *Shorea* di kawasan kajian ini. Lima plot 20 m x 20 m telah ditubuhkan secara rawak. Terdapat 120 individu dari genus Shorea yang ditemui yang mewakili 14 spesies genus *Shorea* dengan garis pusat pada ketinggian dada (DBH) kurang dari 5cm. *Shorea spp.* menunjukkan kepelbagaian tinggi dengan Indeks Shannon-Wiener, dengan nilai H' ialah 2.50, nilai Indeks Shannon Evenness, E adalah 0.95 dan Indeks Simpson dengan nilai 0.91. Jumlah nilai biojisim di atas tanah bagi *Shorea spp*. di Hutan Rekreasi Bukit Bakar adalah 72.48 t/ha. *Shorea macroptera* menguasai pengedaran *Shorea spp.* di kawasan kajian ini kerana spesies ini ditemui dengan bilangan individu sebanyak 23 individu. Hasil kajian ini dilakukan untuk mengemaskini maklumat dan data di Hutan Rekreasi Bukit Bakar Machang, Kelantan. Bagi kelestarian masa depan untuk mengekalkan spesies yang berharga ini, adalah penting bagi Jabatan Perhutanan Kelantan untuk memulihara dan mengekalkan spesies ini untuk masa depan yang lebih baik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AGB	Above Ground Biomass
a.s.l	Above Sea Level
BA	Basal Area
CO_2	Carbon Dioxide
DBH	Diameter Breast Height
EN	Endangered
GPS	Global Positioning System
IUCN	International Union For Conservation of Nature
IVi	Important Value Index
LC	Least Concern
NRE	Ministry of Natural Resources and Environment
NT	Near Threatened
VU	Vulnerable

LIST OF SYMBOLS

cm	Centimetre
ºC	Degree Celsius
ft	Feet
≥	Greater than and equal to
ln	log base
m	Metre
−	Minus
×	Multiply
%	Percentage
π	3.1416
t/ha	Tonne per hectare

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is one of country that has the most complex ecosystem of their tropical rainforest in the world because it has their own attraction of the uniqueness and the variety of biodiversity of flora and fauna species, consists of complex vegetation structure, specificity in biological relationships and high taxonomic diversity (Zailani, 2000).

Tropical rainforest provide many ecosystem services such as providing natural medicines, natural protection, supporting the life and also purifying the atmosphere are the role played by tropical rainforest in supporting life (Zailani, 2000). Besides, ecosystem services also in climate regulation, maintaining biodiversity, carbon storage, water supply and regulation, pollination and cultural values (MEA, 2005). This ecosystem service is goods and services give benefits that human derive whether directly or indirectly.

The causal links between environmental change and human health are complex because they are often indirect, displaced in space and time and dependent on a number of modifying forces. Human health ultimately depends upon ecosystem products and services such as availability of fresh water, food and fuel sources which are requisite for good human health and productive livelihoods. Significant direct

human health impacts can occur if ecosystem services are no longer adequate to meet social needs.

Indirectly, changes in ecosystem services affect livelihoods, income, local migration and on occasion, may even cause political conflict. The resultant impacts on economic and physical security, freedom, choice and social relations have wide-ranging impacts on well-being and health, and the availability and access to health services and medicines.

A forest reserve is a designating forest and other natural area, to sustain their flora and fauna, which enjoy judicial and constitutional protection under the legal system or legal law of many countries. In Kelantan, 60% of land area is covered under natural forest compared to other states in Peninsular Malaysia.

Bukit Bakar Forest Eco Park is one of the forest reserved that is monitored by Kelantan State Forestry Department. The vegetation type of Bukit Bakar Forest Eco Park is mainly lowland and hill dipterocarp forest with elevation between 300 m a.s.l and 900 m a.s.l.

Among the most abundant constituents of the lowland rainforest in Malaysia is dipterocarps (Chua, 2010). The decreasing of the populations of dipterocarps is resulting on the harvesting and land use changes. In Bukit Bakar Forest Eco Park, it is also covered with family trees of Dipterocarpaceae.

One of the genus that can be found in Bukit Bakar Forest Eco Park is genus *Shorea.* Genus *Shorea* is a plant species from the family of Dipterocarpaceae. It can be found in Borneo, Sumatra and also Peninsular Malaysia and some of the species in genus *Shorea* are listed as endangered species which is threatened by habitat loss. Genus *Shorea* are mostly flowering (Ashton et al, 2004). It is an event in which

nearly all dipterocarp species with other species families will bloom heavily which is occur at irregular interval of 3-10 years. Local name for genus *Shorea* is known as "Meranti".

1.2 Problem Statement

This study is necessary as the distribution data of genus *Shorea* is difficult to access in Kelantan especially because there is lack number of research doing on this genus. Besides, A number of environmental problems is arises because of logging (Daniel & Kulaisingam, 1974). In addition, a lot of illegal activities occur in Forest nowadays. Forest logging in Peninsular Malaysia is now confined to the hills area such as the hill dipterocarp forests. For example, excessive illegal logging, deforestation and over exploitation especially for the species of plant that have high economic value such as genus *Shorea*. Thus, this study is necessary to protect and conserved genus *Shorea* so that this economic values species can be maintain for subsequent years.

1.3 Objectives

The aims of this study were focused on these objectives:

1. To identify the genus *Shorea* at Bukit Bakar Forest Eco Park, Machang, Kelantan.
2. To measure the diversity and abundance of genus *Shorea* at Bukit Bakar Forest Eco Park, Machang, Kelantan.
3. To measure the above ground biomass of genus *Shorea* with DBH less than 5 cm at Bukit Bakar Forest Eco Park.

1.4 Scope of Study

The study was conducted at Bukit Bakar Forest Eco Park at five randomly sampling plots with different altitudes. In this study, all the genus *Shorea* with diameter breast height (DBH), ≤ 5cm that exists in the sampling plot were be tagged and set the GPS for mapping process. The sample were collected as a voucher specimen for species identification. The biodiversity index of genus *Shorea* was calculated to estimate the frequency, relative frequency, density, relative density, abundance and relative abundance.

1.5 Significant of Study

This study is important to conduct as there is less scientific data on the genus *Shorea* that exist is Bukit Bakar Forest Eco Park, Machang, Kelantan. Therefore, it is very important to conduct the research in determining the genus *Shorea* at Bukit Bakar Forest Eco Park in Machang, Kelantan. As it is one of the species that being listed as endangered species which is threatened by habitat loss, it is important to carry this study to conserve and protect this species from being loss in the future. By carrying this research, the population of genus *Shorea* can be predict and this population can be managed well if there is specific data collected for the distribution of this genus.

CHAPTER 2

LITERATURE REVIEW

2.1 Tropical Rainforest

Tropical rainforest contain most diverse range and greatest diversity of flora and fauna. Tropical rainforests are a world like none other and their importance to the global ecosystem and human existence is paramount. Unparalleled in terms of their biological diversity, tropical rainforests are a natural reservoir of genetic diversity which offers a rich source of medicinal plants, high-yield foods, and a myriad of other useful forest products (Rhett, 2014).

There are three tropical rainforest areas around the world. The most extensive area of tropical rainforest is American rainforest in amazon basin, while the second rainforest area that is broad over the world is Tropical Rainforest in Indo-Malaya and the third is Tropical Rainforest in Africa (Pringle, 1969; Saatchi et al, 2011). Figure 2.1 shows the region of tropical rainforest over the world.

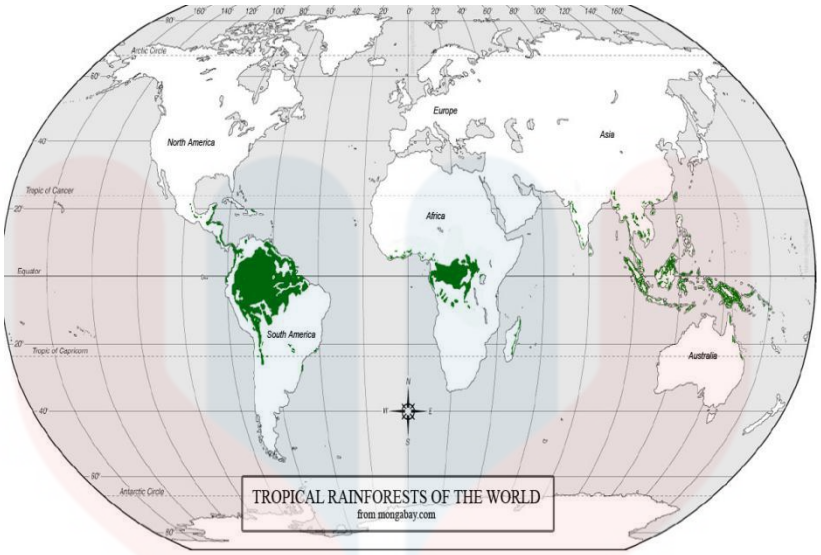


Figure 2.1 Region of Tropical Rainforest over the world.

(**Sources**: Retrieved August 20, 2008 from https://saferenvironment.wordpress.com /2008/08/20/ rainforest-conservation -%E2%80%93-challenges-of-addressing-deforestation-issues/)

American rainforest is the world's largest tropical rainforest, also known as Amazonia or Amazon Jungle. It has an area of 5,500 000 Km^2 and covers most of the Amazon Basin of South America and runs through Brazil, Peru, Colombia, Venezuela, Ecuador, Bolivia, Guyana, Suriname, and French Guiana. The Amazon River also runs through the forest. About 60 percent of the forest is contained in Brazil (Rhett, 2014).

The second biggest rainforest is in Indo-Malaya. The forest is found in Asia covering Indonesia, Laos, Cambodia, and the Malay Peninsula. The forest is home to many rare birds, mammals, amphibians, and reptiles.

Tropical rainforest is a biome with a high rainfall and constant temperature. It is generally found near the equator and the average temperature is between 20 ºC and 34 ºC, with the average between 125 cm to 660 cm of rainfall annually. Tropical

rainforests is allied between the Tropic of Capricorn and the Tropic of Cancer (23.5^{o} S and 23.5^{o} N) (Partha, 2008). The combination of rainfall and warmth creates a very humid environment. Malaysian forest has continuously become to be great economic importance for its development.

Almost 57 % of Malaysia's land is covered by tropical rain forests, especially in highlands and mountains. The tropical rain forests of Malaysia constitute the core of biodiversity in Malaysia. It is prove when the timber from the forests had become a predominant income earner in Malaysia and played a vital role in Malaysia's economic development (NRE, 2006).

2.1.1 Layers of Tropical Rainforest

The tropical rainforests are mainly consists of evergreen woody vegetation which is forming a thick canopy. All aboveground vegetation such as the biota, the trunks and crowns of its tree and its ecological processes are called as forest canopy. As well as a vertical structure, each forest has a horizontal organization which is depending on the maximum height of plant and trees.

Tropical rainforest have four main layers which are forest floor, understory, canopy and emergent as shown in Figure 2.2. Every layer plays their important role in supporting the different life form and the different of environment. The forest stratification is differ. It is different in many ways such as the wetness of environment, the types of life living, the temperature and also the amount of light penetrate (Partha, 2008). In Figures 2.2, it shown the stratification of tropical rainforest.

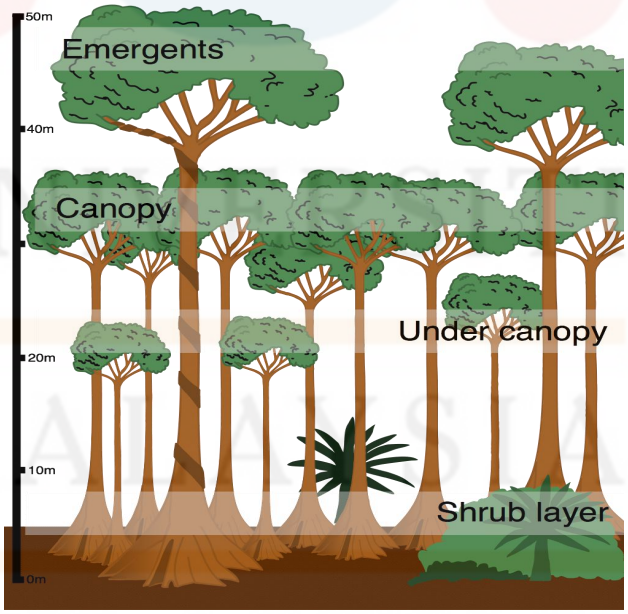


Figure 2.2 The Stratification of Tropical Rainforest

(**Sources**: Retrieved August 20, 2008 from https://saferenvironment.wordpress.com /2008/08/20/ rainforest-conservation -%E2%80%93-challenges-of-addressing-deforestation-issues/)

The emergent layer is the highest layer of the rainforest which at an altitude of more than 50 m from ground level and consists of the tops of the tallest trees in which ranging up to 50 m. This causes the forest floor cannot get the penetration of sun's ray. This layer is a home to many birds such as eagles and insects. In this editorial also found the plants that climb and attached to the branches of the tree such as orchids, rattan and fern types.

The forest canopy is a structurally complex and ecologically critical sub-system of the forests (NRE, 2006). The canopy consists of upper part of the tree with ranging about 20 m to 40 m high. Most of animal habitat's live in the rainforest canopy such as birds, bats and certain primates.

The next layer is understory layer which is located in between the forest floor (below) and the canopy (upper). In this understory layer, it is composed of the trees that depressed growth, young trees and also comprised of other types of shade-tolerant trees. The understory layer is a home for animals such as jaguars, leopard, snake and also home for insects and birds.

The last layer of forest canopy is called as forest floor. The plants that live in this forest floor layer usually little plant and shade-tolerant because it is completely hidden from sunlight. Lack of light penetration cause the things rot and decay quickly. It is a home for kind of life such as fungi, molds and decomposing organisms alive and thriving which do not require light. In this situation, to break down dead organic matter, heat and moisture play important role to increase decay rate and the decomposed organic matter then were being absorb by trees root. This can contribute to below ground biomass.

2.2 Family Dipterocarpaceae

According to Whitmore (1988), for the groups of tree species in Tropical Rain Forest (TRF), there are two qualitatively distinct groups which are pioneer and climax and or non-pioneer species. For the tree species which their seeds can only germinate in gaps of the forest canopy open to the sky and can reach the sunlight for at least part of the day is called as pioneer. Meanwhile for non-pioneer, is for the tree species those seed can germinate under forest shade.

Dipterocarpaceae is a family of large tree species that is widely distributed in the tropical rain forests of Southeast Asia especially in Borneo and Peninsular Malaysia. The family Dipterocarpaceae consists of 17 genera and 500 species (Ashton, 1982).

Dipterocarpaceae consists of dipterocarps timber trees such as genus *Hopea* and genus *Shorea.* These tree species are large until exceeding 50 m height and 1 m its diameter. In addition, trees in family Dipterocarpaceae spread large and dense canopies over the jungle which can cause the forest very dark because of the thick canopy layer. The family of Dipterocarpaceae are found in wide-ranging habitat types from the sea to the hills of the tropics at altitudes below 1,800 m (Chua, 2010).

The population of dipterocarps in Malaysia are decreasing according to the harvesting activities and land use changes. Table 2.1 shows the number of genera in Dipterocarpaceae in Peninsular Malaysia under respective IUCN categories.

Table 2.1: The number of genus in Dipterocarpaceae in Peninsular Malaysia under respective IUCN categories.

Genus	EX	CR	EN	VU	NT	LC	DD	TOTAL
Anisoptera	0	0	1	4	0	1	0	6
Cotylelobium	0	0	1	0	1	0	0	2
Dipterocarpus	0	3	7	10	7	4	1	32
Dryobalanops	0	0	1	0	1	1	0	3
Hopea	0	4	6	11	9	3	0	33
Neobalanocarpus	0	0	0	0	1	0	0	1
Parashorea	0	1	0	0	1	1	0	3
Shorea	1	5	12	12	19	12	1	62
Vatica	0	2	7	5	7	1	0	22
Total	**1**	**15**	**35**	**42**	**46**	**23**	**2**	**164**

(Sources : Chua et al, 2010)

2.3 Groups in genus *Shorea*

Shorea is one of a genus that is belong to family of Dipterocarpaceae, consists of 360 species of tall South Asian evergreen trees that their timber is extremely valuable. Malaysia tropical rainforest, which is well-known with its beautiful and uniqueness of their flora and fauna, rich with its biodiversity, also consists of a huge number of *Shorea* species, which has a high market trade for its timber.

According to Noraini (2008), *Shorea* is divided into the four wood groups based on their wood anatomy which are Balau, Red Meranti, Meranti Pa'ang and Meranti Damar Hitam.

One of the species of *Shorea* known as Meranti Daun Besar or scientific name is *Shorea hemsleyana* is in red meranti group of Dipterocarpaceae from the swamp forest. Usually, the girth of tree is as large as 2.5 m but some may reach less than 2 m. The shape of this species' leaf is elliptic-oblong to obovate-oblong, covered by rough with hairs which split up at the ends (Norsham, 2013). *Shorea hemsleyana* can also be found in Sumantra and Thailand, besides in Peninsular Malaysia. This species is being listed as "Critically Endangered" species in conservation status by International Union for Conservation of Nature (IUCN).

Next is *Shorea resinosa* or locally known as Meranti Belang. According to Norsiha et al. (2013), *Shorea resinosa* is an "emergent storey" tree species and the distribution was recorded for west Sarawak, central Sumatra and Peninsular Malaysia from Perak and Kelantan to Johor and it is usually found on undulating land or hills up to 500 m above sea level. This species has being grouped under "white meranti" and commonly utilised for a worldwide product such as flooring strip, plywood and

veneer. *Shorea resinosa* is listed by habitat conversion and the conservation status is vulnerable for Malaysia which is in category of critically endangered.

The type of species of *Shorea* which is locally known as Meranti Sengkawang Merah. It is belong to the Red Meranti Group of Dipterocarpaceae. Meranti Sengkawang Merah or the scientific name is S*horea singkawang*, can be found in Penisular Thailand, Peninsular Malaysia and Sumatra. The habitat of *Shorea singkawang*, especially in Peninsular Malaysia, is includes damp soil near streams and lowland dipterocarp forests, usually on well-drained, bumpy land up to 400 m above sea level (Norsham, 2012).

Next is *Shorea sumantrana* that is a large-sized timber tree which is belonging to family Dipterocarpaceae. This forest tree species widely distributed across Sumantra, Thailand and Peninsular Malaysia especially in the region of east coast (Naimah, 2014). *Shorea sumantrana* look beautiful with small fragrant flowers with its pink base and its yellow petals. The wood is heavy hardwood and it is used for heavy construction, such as bridges and housing poles.

Figure 2.3 : *Shorea sumantrana*

(Source : https://www.flickr.com/photos/adaduitokla/12359101283)

2.4 Characters of the groups of *Shorea*

Morphological features, such as wood color, the presence of axial resin canals, vestured pits, silica grain, and crystals in tissue of *Shorea* species, provide information that can be used for identification to the wood group level (Desch 1941; Ogata et al. 2008). For example, Balau shows some characters of its botanical. They are usually well-shaped trees that has irregularly cracking or scaly bark, and close-textured, hard wood and its buttresses are sharp.

Balau is usually large in the form and well-shaped trees. The outer bark usually comparatively thin, inner bark is rarely more than 1cm thick, yellow, brown, pink or red. The sapwood is very closed in texture and hard in which it is usually shining on the cut tangential surface and sticky resin.

Every groups of *Shorea* have their own botanical and field characters. Table 2.4 shows the diagnostic characters of the groups of *Shorea.*

Table 2.4: Chief diagnostic characters of the groups of *Shorea*

	Group I (Balau)	Group II (Meranti Pa'ang)	Group III (Meranti Damar Hitam)	Group IV (Red Meranti)
Bole	Irregularly cracked or scaly, not regularly fissured	Usually irregular fissured, sometimes smooth	Scaly or irregularly cracked, but not regularly fissured	Usually regularly fissured, sometimes smooth or scaly
Cut	The inner bark usually brown or yellow, rarely pink or red	Inner bark usually rather thick, laminated, usually yellowish, rarely pink	Inner bark rather thin, dull light brown grading to greenish-yellow at the cambium, sapwood pale	Inner bark usually rather thick and fibrous, usually with a red or purple tinge, rarely yellow, sapwood soft to moderately hard

Dammar	Usually opaque, yellow, reddish and brown	Clear, pale yellow, or colourless	Opaque, dark brown to black, rarely yellow	Usually opaque, yellow brown, or reddish, rarely colourless
Flower	Anther 4-celled, appendage usually club-shaped, prominently barbate or ciliate	Anther oblong, 4-cell, appendage filiform, rather long, not prominently barbate or ciliate	Anther 2-cell, appendage filiform, rather long, prominently barbate or ciliate	Anther 4-cell, appendage filiform, or short, not prominently barbate or ciliate
Timber	A balau	White meranti or meranti pa'aang	A yellow meranti or meranti damar hitam	A red meranti, except *S. kunstleri* which is a damar laut merah

(Source: Ashton & Appanah, 2004)

2.5 Economic Value of Genus *Shorea*

Timber resource is usually undervalued economically and as a major component of tropical forest. *Shorea* is one of the tree species that has high economic values for its timber. The timber quality of *Shorea* cannot be denied as it has high demands and being sold under various trade name such as "Meranti", "Balau" and "Seraya". It is also commonly used for plywood, construction timber and furniture (Kazoa. et al. 2006).

The other product that can be produced from genus *Shorea* is including dammar. Dammar is a resin obtained from a variety of species and varies in colour. Traditionally, it is used for many uses such as adhesive, a medicine, as a fuel for torches and sometimes in foods. Dammar has many commercial applications, although many of these uses are least important nowadays due to the present of

synthetic materials. Commercially, it is an ingredient of oil paints, lacquers, inks, varnishes and is used as a glazing agent in foods.

2.6 Aboveground Biomass

Chave et al (2005) stated that tropical forests hold large stores of carbon, yet uncertainty remains regarding their quantitative contribution to the global carbon cycle. Based on the study by Brown (1997), above ground biomass is defined as the total amount of organic matter that is above ground in trees compartments such as stems, leaves and branch. The study that has been made by Syafinie et al (2015) shows that, the part of tree that has low carbon contents are branches and stem with 45 percent of carbon.

Plant biomass is an increasing in the net primary expenditure. The increase in production will go through the decomposition process and part of the decomposition will be preserved for long periods of time. Plants carried photosynthesis which absorbs carbon dioxide and removes oxygen. This is offset by breathing of plants and animals as well as decomposition activities that diffuse the use of oxygen and carbon dioxide emissions. This process is called carbonization. Tropical rainforests are unique because they have a high biomass value. According to Whitmore (1984), 40% from organic carbon is produced by tropical rain forest.

2.7 Species Richness

From the view of Tilman (1982 & 1986), species richness is enhanced by small scale heterogeneity and particularly determined as the abundance of physical resources. It is a biological type of species that can be found in the area. To measure the species richness, two different sample that record the numbers of species only can be compared if this two different species are being taken roughly in the same manner (Jonathan, 2010). The possibility of a high degree of species interaction occur when there is high species richness that indicates a complex community. Species richness is a total number of species presents in a given area or sample.

2.8 Species Evenness

Species evenness is communities that exhibit more even numbers of individuals within the total number of species present are thought to be closer to a state equilibrium than those in which the number individuals is less even. Species evenness is usually lower than maximum level in real communities (Huston 1997 & Grime 1998), with many species being rare and a few dominant species being relatively. Brian et al (2004) stated that, compared to species richness, species evenness shown to be an equally or more important component of small scale plant diversity.

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of Study Area

Kelantan is one of the state in Malaysia that experienced a good tropical climate in which their rainfall almost every year alternately in accordance with a particular month. Heavy rain will continue for a few days or for a few months. Usually, the most frequent rain fall is during the monsoon season which is in November, December and January. Figure 3.1 show the map of Kelantan which consists of 14 district including Machang.

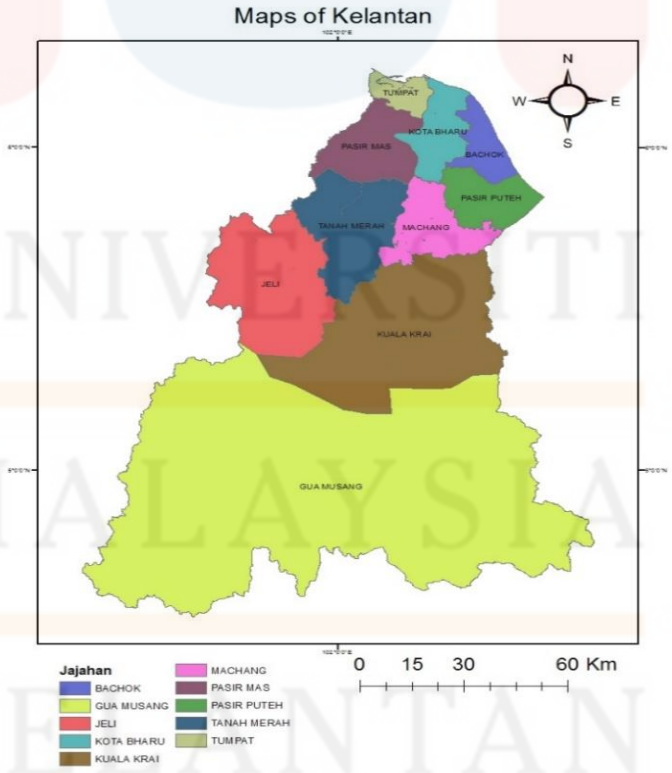


Figure 3.1: Maps of Kelantan

The study was conduct in Bukit Bakar Forest Eco Park, which is located in Machang, Kelantan. Bukit Bakar Forest Eco Park was opened in 1975 and this forest area is 3.14 hectares which is located in the reserve compartment 6 Ulu Sat Forest Reserve. The type of vegetation in Bukit Bakar Forest Eco Park is particularly lowland and hill dipterocarps forest is located within 530 m above sea level and 700 m above sea level. It is one of the forests that is well-known especially in Kelantan because of the richness in the flora and fauna that surrounded with a beautiful scenery. This area is monitored by Forestry Department of Kelantan state. Figure 3.1.1 shows the map of study area in Kelantan.

Figure 3.1.1: Map of study area.

(Source: Retrieved September 14, 2018 from "Map Carta")

3.2 Sampling Design

This study was conduct in Bukit Bakar Forest Eco Park area. Five systematic sampling plots which are about 20 m × 20 m of each plot, with subplot of 10 m × 10 m has been create by used the measuring tape. Each plot coordinates was marked using GPS for designing simple mapping of every plant. The process of collecting data become easier because the plot has no disturbance and it is static. Table 3.2 shows the coordinate of five sampling plot of study area in Bukit Bakar Forest Eco Park while Figure 3.2 shows the size of sampling plot with sub plot.

Table 3.2: List of coordinates for five plots which covered 0.2 ha of Bukit Bakar Forest Eco Park.

Plot	Latitude	Longitude	Elevation (m)
Plot 1	05°43.203′	102°15.630′	92.4
Plot 2	05°43.009′	102°15.715′	137.2
Plot 3	05°43.030′	102°15.718′	143.1
Plot 4	05°43.038′	102°15.714′	132.7
Plot 5	05°42.666′	102°15.956′	235.1

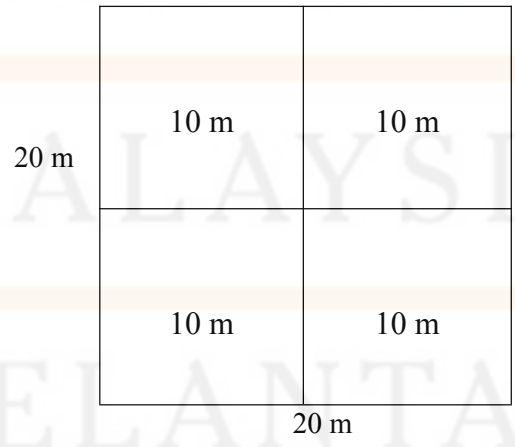
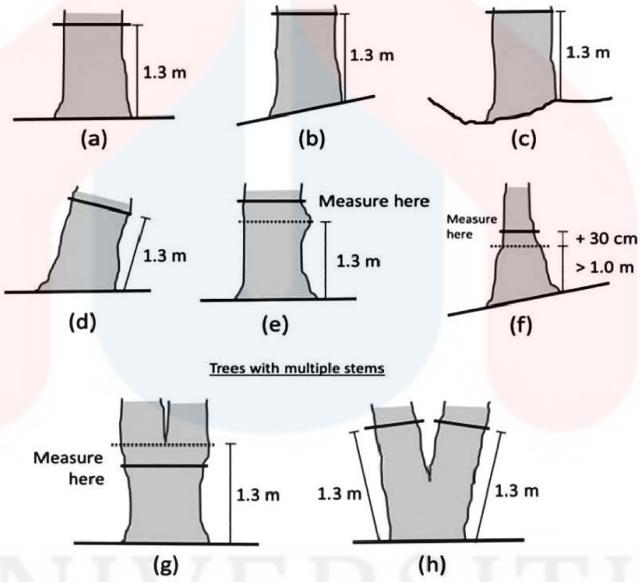


Figure 3.2: Size of sampling plot with sub plot.

3.3 Data Collection

All *Shorea* tree species with diameter at breast height (DBH) less than 5 cm in each plot were considered as a sample. The sample had been tagged and set the coordinate of each tree using GPS. This coordinate was very important while doing mapping to know the distribution of genus *Shorea* in Bukit Bakar Forest Eco Park. Besides, in order to make data more precise, the description of the physical characteristics and some factor that influenced the trees composition was recorded to make the process of identifying the species become easier.



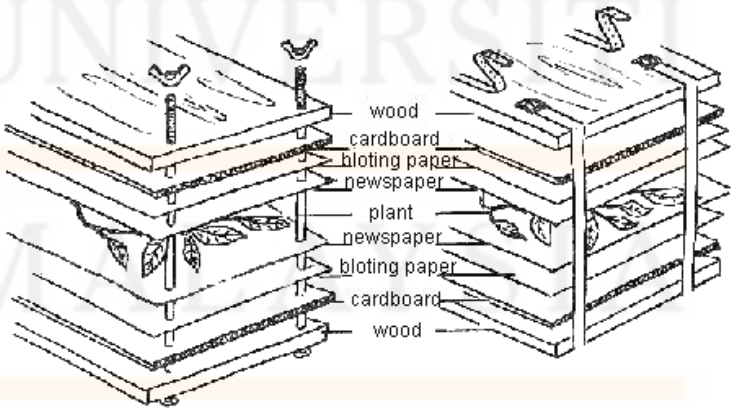
(Source: Kirsi, 2016)

Figure 3.3: Types of trees with different positions and different measurement methods

3.4 Preservation

The specimen that had be collected at the study area were tagged as a preparation for species identification. Thus, there are some methods used in this study to preserve the specimen from being damaged.

Herbarium process is one of the methods that can be used to preserve the sample collected. Firstly, for the species identification, the description of the sample characteristics must be wrote on the tag that has been tagging at the collected sample. Secondly, put the sample in the sealer plastic bag to prevent incoming air in order to evade the wilting rate of the sample going faster. Next, before the step of pressing, the sample need to be cleaned by brush up the soil to remove the moisture. After that, before bringing into the laboratory, all the specimens must be arranged on the newspaper as figure 3.4. Therefore, by put the wooden board, arrange it with making the layer and then the specimen will be bring to the laboratory for dying process in microwave with temperature 45 C. Finally, to avoid the sample texture from become fragile, the observation of the sample should often be done during the drying process.



(Source: American Museum of Natural History)

Figure 3.4: The Arrangement for Compressing the Specimen for Preservation

According to Miller et al,(1990), Schweinfurth method is another method that can be used to preserve the specimen. Helping to slow down the growth of fungi and maintaining three-dimension (3-D) shape of the specimen is one of the benefits of this method. This Scweinfurth method included using chemical treatment such as Industrial Methylated Spirit (IMS) solution or ethanol.

Malaysia tropical rainforest has high humidity, therefore, for preservation of plant specimen (Miller & Nyberg, 1990), IMS solution and ethanol is the best way to be used. By using this method, first, the collected specimens will be preserved in the airtight glass or plastic jar. Then, add about 0.5 ml to 1 L (60-70%) of diluted ethanol solution into the glass and leave it until properly dried. Finally, to ensure all the words on the label will retain and not fading, used archival ink to label the glass jar (Royal Botanic Garden Sydney, 2005).

3.5 Soil Sample

One of the technique to analysed the chemical elements that present is sample soils is by using Atomic Absorption Spectrometry (AAS) which is used by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The data of AAS analysis is a multi-step process, with the user having to select the correct method and wavelengths in order to obtain optimal results.

In this study, there are five parameters that have been used in determining soil composition. The parameter that have been used are Zinc (Zn), Calcium (Ca), Potassium (K), Magnesium (Mg), and Sodium (Na).

3.6 Data Analysis

As an ecological indicator, it is necessary in identify tropical rainforest in order to measure the species composition and diversity (Magurran, 1988; Nurun et al., 2015). Species richness and distribution of individuals among species can be considered as species diversity.

3.6.1. Shannon-Wiener Diversity Index (*H'*)

The species diversity has two separate components which are the number of species present which called species richness and the relative abundance which is species evenness or abundance. In addition, to identify the essential of species and species diversity of the study area, Shannon-Wiener Diversity Index (H') will be used in this study.

Thus, here is the formula how to measure the species diversity using the Shannon-Weiner Diversity Index (H')(Shannon & Weiner, 1949).

$$H' = -\sum_{i=1}^{s} = P_i \, ln \, P_i \qquad (3.1)$$

Where:

S = the number of species

P_i = the proportion of individuals or the abundance of the species express as a proportion of total abundance

ln= log base

3.6.2. Simpson's Index

According to Simpson (1949), Simpson's index is used to calculated the probability of any two individuals drawn at random from an indefinitely large community belonging to different species. The formula is as below.

$$D = \sum \frac{ni(ni-1)}{N(N-1)} \quad 3.2$$

Where,

ni= the number of individuals in the i^{th} species

N =the total number of individuals

3.6.3. Species Evenness

Using Whittaker index, the relative abundance of different species making up the richness of an area is measured by species evenness (Whittaker, 1972; Suratman, 2012).

$$E_w = \frac{s}{\ln Ni - \ln Ns} \quad (3.3)$$

Where,

E_w =the Whittaker's index of evenness

Ni =the abundance of most important species

Ns =the abundance of the least important species

3.7 Vegetation Analysis

Vegetation is one of the quantitative study which is called as phytosociology and it is aims to describe the vegetation, predict the pattern and classify it in a meaningful way. It also indicates the species diversity in which used to determine the distribution of individuals among the species in a specific habitat (Ilorkar and Khatri, 2003).

Vegetation data were analysed for the percentage of frequency (F), density (D) and abundance (A). The Importance Value Index (IVi) was calculated by adding values for relative frequency, relative density and relative dominance for all the trees. It is importance to rank the tree species which has highest importance value in the stand was considered as the dominant species.

3.7.1 Frequency

Frequency is one of the important quantitative parameter in analysis vegetation which is reflects the distribution of a species in a given area and given by percent. Frequency is the number of tree species that are occurs in a given number of quadrats. For example, if the distribution of species is uniformly in the study area given, there is a higher probability of its occurrence in all quadrant and would have greatest and maximum value of frequency. The percentage of frequency of each species in a given area is calculated by using the following formula:

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which species occur}}{\text{Total number of quadrats study}} \times 100 \qquad (3.4)$$

While, frequency count is a measure of the number of times that an event occurs. To measure the relative frequency, obtains the frequency count for the total

population and a frequency count for a subgroup population. Relative frequency can be calculated by using the following formula:

$$\text{Relative frequency} = \frac{\text{Number of quadrats in which species occured}}{\text{Total number of quadrat occupied by all species}} \times 100 \qquad (3.5)$$

The above equation express that the relative frequency as a proportion. It also can be expressed in the form of percentage. Thus, if a species that occurs in 5 out of 10 in the quadrants study, the relative frequency is 0.5 which is equivalent to 50%.

3.7.2 Density

Density is defined as the number of individuals of a specific species collection per unit area. The tree density shows how closely the trees are growing in the study area. Density value that obtained for each species was expressed as number of individuals per unit area.

$$\text{Density} = \frac{\text{Total number of individuals S of the species}}{\text{Total number of quadrats used in sampling}} \qquad (3.6)$$

The relative density is the study of numerical strength of a species in relation to total number of individuals of all species and was calculated by using the following formula:

$$\text{Relative density} = \frac{\text{Total number of individuals S of the species}}{\text{Sum of all individuals S of all species}} \times 100 \qquad (3.7)$$

3.7.3 Abundance

Only the quadrats of occurrence are taken into consideration and not all the study quadrats, it cause the abundance does not give total picture of numerical strength of a species. The formula that used for calculated the abundance.

$$\text{Abundance} = \frac{\text{Total number of individual S of the species}}{\text{Number of quadrats in which its occured}} \quad (3.8)$$

3.7.4 Important Value Index

This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959).

$$\text{IVI} = (\text{Relative frequency} + \text{Relative density} + \text{Relative abundance}) \div 3 \quad (3.9)$$

3.7.5 Above Ground Biomass

The above ground biomass is calculated by the total sum of weight of stem, weight of branch and leaf (Kato et al, 1978). The formula to calculate AGB is:

AGB = WS+ WB+ WL

AGB = above ground biomass

WS = weight of stem

WB = weight of branch

WL = weight of leaf

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The Distribution of *Shorea*

Bukit Bakar Forest Eco Park which is located in Machang, Kelantan is a lowland and hill dipterocarp forest which is fully monitored by Forestry Department of Kelantan State. There are a lots of trees family that can be found in this study area such as family of Dipterocarpaceae. The trees from Dipterocarpaceae family have their unique characteristic especially *Shorea* which have the high economic value of timber.

Table 4.1: List of number of individual of *Shorea spp.* in Bukit Bakar Forest Eco Park.

Species	No. of Individual
Shorea assamica	5
Shorea balanocarpoides	9
Shorea bracteolata	7
Shorea curtisii	6
Shorea hopeifolia	4
Shorea hypochra	6
Shorea leprosula	12
Shorea longisperma	5
Shorea macroptera	23
Shorea materialis	14
Shorea multiflora	5
Shorea ovalis	12
Shorea parvifolia	5
Shorea pauciflora	7

Table 4.1 shows that *Shorea macroptera* have the most frequent individual which is 23 individual found and followed by *Shorea materialis*, the second highest. The third highest number of individual is represented by *Shorea leprosula* and *Shorea ovalis* which is both have the same number of individual which is 12.

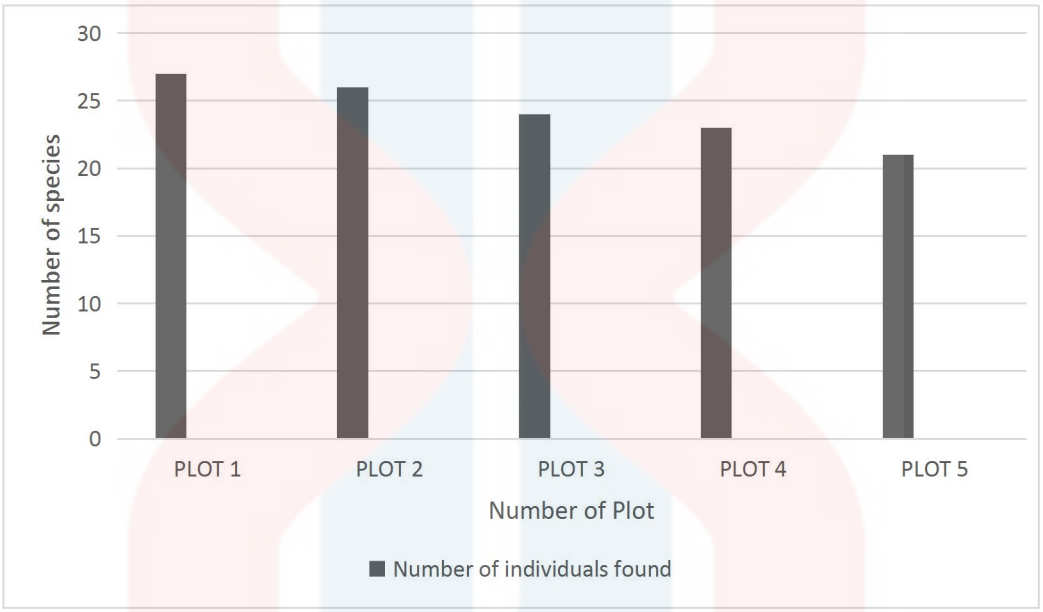


Figure 4.1: Number of individuals found in five different plots

From the result obtains based on Figure 4.1, it shows that genus *Shorea* mostly distributed in the lowland with the elevation less than 100 m. Plot 1 dominated the number of *Shorea* distribution as it is has low elevation compared to the other plot.

Based on the studied by Nazahatul (unpublish) at Pasir Raja Forest Reserved, Dungun, Terengganu, there are around 25 species of family *Dipterocrpaceae* that have been found in a plot of 0.2 ha. These shows that the number of species recorded in the Bukit Bakar Forest Eco Park can be compared to be relatively high compared to other areas in Malaysia with a total area of 0.2 ha only able to obtain 120 individuals of *Shorea*. This is an indicator shows that Bukit Bakar Forest Eco Park is still contained highly valuable timber tree species.

4.2 Diameter at Breast Height (DBH) measurement of *Shorea*

Diameter at breast height is the most common tree measurement that used to measure the diameter of standing trees. This diameter is measured over the outside bark at the point of breast height. Breast height is specifically defined as a point around the trunk at 1.3 m above the forest floor on the uphill side of the tree. In this study, the range of diameter trees that taken is from 0.1 cm to 5 cm so that, this method of measurement is convenient to apply.

Figure 4.2 shows the result of diameter at breast height of *Shorea spp*. in Bukit Bakar Forest Eco Park. From the graph, the trees with DBH ranges between 1.1 cm to 2.0 cm were the highest and the species that dominated in this range is *Shorea leprosula* with 10 individual of this species are includes in this range. According to Ashton and Appanah (2004), when matured, *Shorea leprosula* frequently exceeding 3m girth and their buttresses prominent but usually not very large.

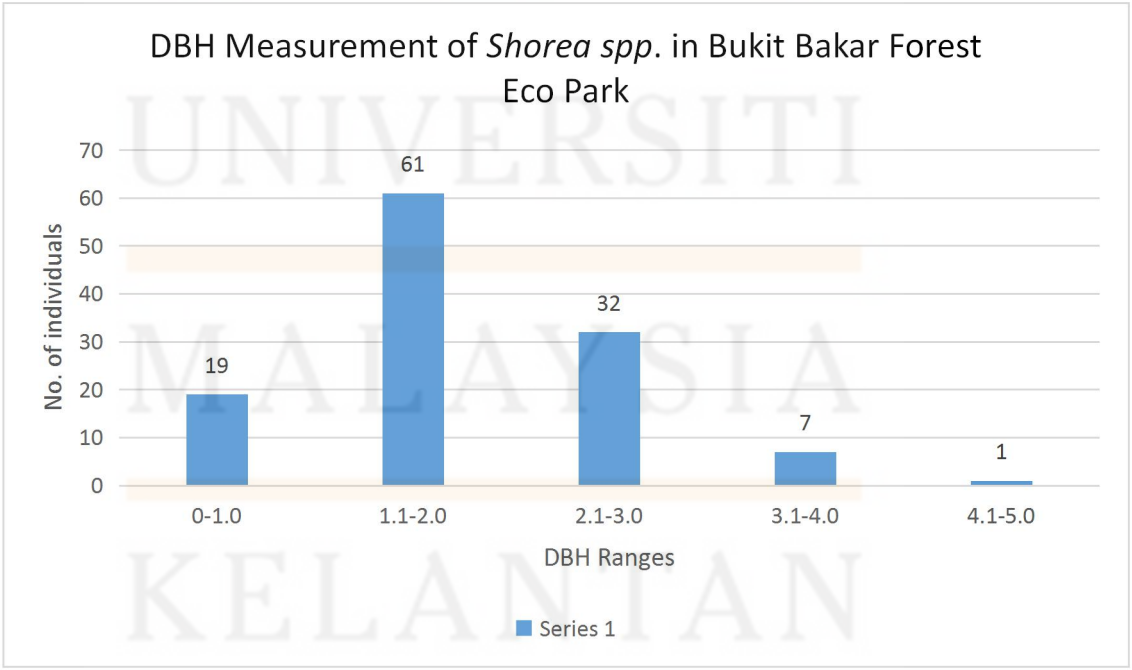


Figure 4.2: DBH measurement of *Shorea spp.* in Bukit Bakar Forest Eco Park.

Meanwhile, with the diameter at breast height at 4.6 cm, *Shorea parvifolia* shows the largest DBH among the other species (Table 4.2). Among the indigenous meranti species in the Malay Peninsula, *Shorea parvifolia* has the best growth rates and give benefit in economic as it is one of the main sources of light red meranti timber in peninsula (Desch, 1941).

Table 4.2: List of ten species that have highest Diameter at Breast Height in Bukit Bakar Forest Eco Park.

Species	DBH (cm)
Shorea parvifolia	4.6
Shorea multiflora	3.8
Shorea longisperma	3.7
Shorea bracteolata	3.4
Shorea macroptera	3.2
Shorea ovalis	3.2
Shorea materialis	3.1
Shorea macroptera	3.1
Shorea materialis	3.0
Shorea hypochra	3.0

4.3 Density

A forest is an area with high density of trees. As a general rule, forests dominated by angiosperms are more species rich than those dominated by gymnosperms. Forests sometimes contain many tree species within a small area such as in temperate deciduous forest and tropical rain forests, or relatively few species over large areas. The species that have higher number of individual will have higher density. Table 4.3 shows the density of the *Shorea spp*. in Bukit Bakar Forest Eco Park which is dominated by *Shorea macroptera* with the density of 19.17 %. This shows that *Shorea macroptera* conqured the number of individual that found in the five study plot in Bukit Bakar Forest Eco Park.

Table 4.3: List of density of species that found in these five study plots.

Species	Density values
S.ovalis	10.00
S.leprosula	10.00
S.materialis	11.67
S.parvifolia	4.17
S.macroptera	19.17
S.multiflora	4.17
S.balanocarpoides	7.50
S.assamica	4.17
S.hopeifolia	3.33
S.bracteolata	5.83
S.curtisii	5.00
S.pauciflora	5.83
S.hypochra	5.00
S.longisperma	4.17

4.4 Frequency

Frequency is the number of species occur in quadrants divided with the total number of duadrats sample. The highest value of frequency reflects a widespread distribution of the *Shorea spp*. in this five study plots. It means that each plot is inhabit the species. Table 4.4 show the frequency of species found in five study plots in Bukit Bakar Forest Eco Park.

Table 4.4: List of *Shorea spp*. and their frequency value in five plots at Bukit Bakar Forest Eco Park.

Species	Frequency
S.ovalis	11.77
S.leprosula	14.71
S.materialis	11.77
S.parvifolia	2.94
S.macroptera	11.77
S.multiflora	5.88
S.balanocarpoides	8.82
S.assamica	2.94
S.hopeifolia	2.94
S.bracteolata	5.88
S.curtisii	5.88
S.pauciflora	5.88
S.hypochra	2.94
S.longisperma	5.88

Based on the five study plots in Bukit Bakar Forest Eco Park, the species that more often to be found is *Shorea leprosula* which have frequency of 14.71%. The second species which have a highest frequency is obtained by three species that have same frequency of 11.77%. The species that share the second highest values of frequency are *Shorea ovalis, Shorea materialis*, and *Shorea macroptera*.

4.5 The Important Value Index (IVi)

This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density and relative abundance are summed up together and this value is designated as the Importance Value Index or IVi of the species (Curtis, 1959). Important value index is the important parameter that used in determining the economic value of a forest and their timber values (Lajuni & Latiff, 2013). Table 4.5 below shows lists of *Shorea spp.* with their important value index in five study plots at Bukit Bakar Forest Eco Park.

Table 4.5: Lists of *Shorea spp* with their Important value index.

Species	Relative density (%)	Relative frequency (%)	Relative abundance (%)	Important value index (%)
Shorea ovalis	10.00	11.77	8.08	9.95
Shorea leprosula	10.00	14.71	8.14	10.95
Shorea materialis	11.67	11.77	8.96	10.80
Shorea parvifolia	4.17	2.94	6.75	4.62
Shorea macroptera	19.17	11.77	12.98	14.64
Shorea multifflora	4.17	5.88	4.89	4.98
Shorea balanocarpoides	7.50	8.82	6.84	7.72
Shorea assamica	4.17	2.94	6.75	4.62
Shorea hopeifolia	3.33	2.94	5.55	3.94
Shorea bracteolata	5.83	5.88	6.29	6.00
Shorea curtisii	5.00	5.88	5.59	5.49
Shorea pauciflora	5.83	5.88	6.29	6.00
Shorea hypochra	5.00	2.94	7.99	5.31
Shorea longisperma	4.17	5.88	4.89	4.98

Table 4.5 shows ten species with highest important value index in five study plots at Bukit Bakar Forest Eco Park, Machang which shows that *Shorea macroptera* has the highest value of IVi which is 14.64% and followed by the second highest value of IVi which is *Shorea leprosula* with 10.95%. The third species that has highest values of IVi is *Shorea materialis* with the percentage of IVi is 10.80%.

4.6 Species Diversity

Species diversity is a measurement of biological diversity to be found in a specific ecological community. It represents the species richness or number of species found in an ecological community, the abundance (or number of individuals per species), and the distribution or evenness of species (Nurun et al, 2015).

Based on study by Shannon & Weiner (1949), to identify the essential of species and species diversity of the study area, Shannon-Wiener Diversity Index (H') will be used in this study. The value of H' is usually around 1.5 to 3.5, in which, the higher the value of H', the higher the species number of comparable abundance.

Table 4.6: The values of diversity indices that used for *Shorea spp.* found in Bukit Bakar Forest Eco Park, Machang, Kelantan.

Indices	Values
Shannon- Wiener Diversity Index (H')	2.50
Shannon- Wiener Maximum Index (Hmax)	2.64
Shannon Evenness Index (E)	0.95
Simpson's Diversity Index (D)	0.91

From table 4.6, the value of Shannon-Wiener Index (H') for this study area is 2.50 with the maximum index (Hmax) value of 2.64. This value shows that *Shorea spp* has high species diversity in this study area. Besides, the reading for species evenness of *Shorea spp* in Bukit Bakar Forest Eco Park is 0.95.

4.7 Above Ground Biomass

The above ground biomass is calculated by the summation of weight of three different compartment of above ground biomass which are stems, branches and leaves Kato el al, (1978). Based on table 4.7, stems show highest above ground biomass content which are 56.78 t/ha or 78.34%, followed by branches with 7.95 t/ha or 10.97% and leaves with 7.75 t/ha or 10.69%.

Table 4.7: Total Above Ground Biomass for all trees in these five study plots at Bukit Bakar Forest Eco Park, Machang, Kelantan.

Tree Compartment	**Above Ground Biomass**	
	(t/ha)	**(%)**
Stems	56.78	78.34
Branches	7.95	10.97
Leaves	7.75	10.69
Total	72.48	

The highest above ground biomass reading for five study plots in Bukit Bakar is *Shorea macroptera* with 13.12 t/ha which hold 18% of total above ground biomass in the study area. The lowest above ground biomass is *Shorea hopeifolia* with 1.21 t/ha which is equal to 1.67% only. The total above ground biomass that obtained form these five study plots in Bukit Bakar Forest Eco Park was 72.48 t/ha that contributed by 120 trees with DBH is less than 5cm.

4.8 Soil Analysis

In this study, the soil sample was collected in each plots and their subplots to determine the quantity of element which affecting the distribution of *Shorea* spp in Bukit Bakar Forest Eco Park. This soil sample is analyse using the Atomic Absorption Spectroscopy (AAS) with five different elements being observed which are Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), and Zinc (Zn). Table 4.8 shows the average reading of five different elements in soil at five different plots study in Bukit Bakar Forest Eco Park.

Table 4.8: The average reading of five different elements of soil sample at five different plots study in Bukit Bakar Forest Eco Park.

	Average reading of elements(%)				
	Plot 1	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**
Ca	1.7738	1.3558	0.8762	1.4604	2.5386
K	7.6926	5.7452	4.5254	5.8156	4.9576
Mg	2.303	2.5902	1.8134	3.723	2.9934
Na	2.1028	2.5902	1.8134	3.723	2.9934
Zn	0.2492	0.1884	0.0922	0.1404	0.1064

From the table 4.8, the elements of Potassium (K) shows the highest reading in all five study plots. It can be seen that, in plot 1, the reading of Potassium is 7.6926% the highest element that can be found in soil sample for plot 1 and followed by Magnesium with the reading of 2.303%. In plot 2, Potassium still dominate the highest reading in soil sample and followed by Magnesium and Sodium where each has same value which is 2.5902.

Plants differ in their ability to take up K depending on several factors. The factors that affect availability of K in the soil and resulting plant uptake are soil factors, plant factors, and fertilizer and management practices.

Besides, calcium is a positively charged ion, it is adsorbed in the soil to the surface of clay and organic particles which are negatively charged. Positively charged ions adsorbed to soil particles are termed "exchangeable ions" because it can be exchanged by other ions present in the soil solution. Soil analysis determines the level of exchangeable calcium ions, and not the total calcium in soil, because the exchangeable calcium is the form which is available to the plant.

Calcium is an essential for plant nutrients and it has many roles such as Calcium participate in metabolic processes of other nutrients uptake. It also promote proper plant cell elongation and strengthen cell wall structure.

4.9 IUCN Red List

To evaluate the extinction risk of thousands of species and subspecies, IUCN red list has become the most comprehensive inventory of the global conservation status of biological species. Table 4.9 shows the list of IUCN red list of *Shorea spp*. in Bukit Bakar Forest Eco Park where 3 out of 14 species found are listed as critically endangered species which are *Shorea assamica*, *Shorea hopeifolia* and *Shorea materialis*.

Table 4.9: List of IUCN Red List of Shorea spp. in Bukit Bakar Forest Eco Park.

Species	**IUCN Status**
Shorea assamica	Critically Endangered (CR)
Shorea balanocarpoides	Endangered (EN)
Shorea bracteolata	Endangered (EN)
Shorea curtisii	Least Concern (LC)
Shorea hopeifolia	Critically Endangered (CR)
Shorea hypochra	Endangered (EN)
Shorea leprosula	Near Threatened (NT)
Shorea longisperma	Endangered (EN)
Shorea macroptera	Endangered (EN)
Shorea materialis	Critically Endangered (CR)
Shorea multiflora	Least Concern (LC)
Shorea ovalis	Least Concern (LC)
Shorea pauciflora	Endangered (EN)
Shorea parvifolia	Least Concern (LC)

According to International Union for Conservation Nature (IUCN) (1995), species are classified into nine groups which are Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

As the conclusion, from this study, the most dominant *Shorea spp.* that frequently can be found in these five study plots in Bukit Bakar Forest Eco Park, Machang is *Shorea macroptera* with 23 individuals. This has shown that, Bukit Bakar Forest Eco Park is maintaining and preserving their valuable timber trees species because the distribution of *dipterocarpaceae* especially for genus Shorea in this area is still under control because this place is monitored by Kelantan Forestry Department. The number of timber tree is increasing in this area about 5% compared to previous study that has been made in 2015.

In maintaining this sustainable ecosystem, Kelantan Forestry Department need to take a strict action in avoiding the excessive logging activities which can cause the disturbance towards the trees that have high economic values in the same time, strengthen the forestry law to control and monitor the excessive logging in Malaysia especially in Kelantan state which the surface is most covered with beautiful forest in Malaysia.

The other initiative that can be taken to sustain and protect the economic values of timber in forest is educated the student at early age such as student in primary school on how important of forest to human life. Besides, encourage the studies conducted in Bukit Bakar Forest Eco Park so that, more data and information can be gained in order to protect the mother nature. This updated data is necessary as it can help Kelantan Forestry Department for updating their data on the tree species in forest in the same time to conserve and preserve this valuable natural resources.

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APPENDIX A

Table of overall Weight of Stem, Weight of Branch and Weight of Leaves and Above Ground Biomass by species

Species	WS	WB	WL
Shorea ovalis	5.9521	0.7897	0.7840
Shorea leprosula	4.3884	0.5383	0.6112
Shorea materialis	5.4823	1.0446	1.0268
Shorea parvifolia	5.9345	0.8353	0.5919
Shorea macroptera	10.7896	1.2203	1.4022
Shorea multiflora	3.5128	0.4839	0.3858
Shorea balanocarpoides	4.6281	0.5961	0.5264
Shorea assamica	1.9751	0.2558	0.2797
Shorea hopeifolia	0.9666	0.1202	0.1482
Shorea bracteolata	3.5284	0.6209	0.5825
Shorea curtisii	1.9939	0.2373	0.2941
Shorea pauciflora	2.6792	0.3480	0.3797
Shorea hypochra	1.5714	0.4017	0.4024
Shorea longisperma	3.3767	0.4540	0.3398
TOTAL	56.78	7.95	7.75

APPENDIX B

Pictures	Description
	During field work for sampling
	Garmin GPS that used to locate the coordinate of sampling plot
	The equipment used during field work

APPENDIX C

Field work date	Days
31 July 2018 until 6 August 2018	7 days
6 October 2018 until 7 October 2018	2 days