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

by

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DECLARATION

I declare that this thesis entitled "The Distribution of Genus *Hopea* 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 : ....

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APPROVAL

I hereby declare that I 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 Science) with Honors

Signature : …………………………….........
Name of Supervisor : ……………………………….
Date : ………………………………..

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The Distribution of Genus *Hopea* in Bukit Bakar Forest Eco Park, Machang, Kelantan.

ABSTRACT

This study was conducted in a tropical rainforest in Bukit Bakar Forest Eco Park, Machang, Kelantan. The objective is to identify species from genus *Hopea* and to determine the aboveground biomass of genus *Hopea* with diameter at breast height (dbh) of less than 5 cm in Bukit Bakar Forest Eco Park. From the result of the distribution, the abundance and aboveground biomass of the *Hopea spp.* were calculated. A total of 5 sampling plots with measurement of 20 m x 20 m have been conducted in the study area. The entire *Hopea spp.* found in the study plot with diameter at breast height (dbh) of less than 5cm were identified. The abundance and aboveground biomass were also estimated. The total of 46 individuals from genus *Hopea* with diameter at breast height (dbh) less than 5cm were recorded and 7 species were identified. The *Hopea spp.* in the study area showed moderate diversity with Shannon Wiener Index, H' value is 1.90, Shannon Evenness Index 0.95 and Simpson Index value is 0.86. The total aboveground biomass value for *Hopea spp.* in the study area is 44.90t/ha. The data of this study will update the baseline data information in Bukit Bakar Forest Eco Park Machang, Kelantan. This finding shows that it is important to conserve valuable trees of *Hopea spp.* for future sustainability.

Taburan Genus *Hopea* di Hutan Rekreasi Bukit Bakar, Machang, Kelantan.

ABSTRAK

Kajian ini telah dijalankan di hutan hujan tropika di Hutan Rekreasi Bukit Bakar, Machang, Kelantan untuk menentukan taburan genus *Hopea* di kawasan tersebut. Tujuan kajian ini dijalankan adalah untuk mengenalpasti spesies daripada genus *Hopea* dan bagi menentukan biojisim atas tanah untuk genus *Hopea* dengan diameter pada paras dada (dbh) 5 cm dan kebawah. Keseluruhan spesies *Hopea* yang dijumpai dengan diameter pada paras dada (dbh) kurang dari 5 cm telah dikenal pasti dan kelimpahan dan biojisim atas tanah telah dianggarkan. Sebanyak 5 plot kajian berukuran 20m x 20m telah dibina di kawasan kajian. Sebanyak 46 jumlah individu dari genus *Hopea* yang mempunyai diameter pada paras dada pokok kurang daripada 5 cm telah direkodkan dan 7 spesies telah dikenalpasti. Spesies *Hopea* yang ditemui menunjukkan kepelbagaian sederhana dengan bacaan Indeks Shannon-Wiener, H' ialah 1.90, Indeks kesederhanaan Shannon ialah 0.95 dan Indeks Simpson ialah 0.86. Jumlah biojisim atas tanah untuk spesies *Hopea* yang ditemui ialah 44.90t/ha. Data bagi kajian ini akan mengemas kini maklumat data asas di Hutan Rekreasi Bukit Bakar, Machang, Kelantan. Penemuan ini menekankan tentang kepentingan spesies Hopea yang berharga bagi kemampanan masa hadapan.

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LIST OF ABBREVIATIONS

Cm	Centimeter
CR	Critically Endangered
DBH	Diameter Breast Height
DD	Data Deficient
EN	Endangered
EX	Extinct
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature
IV*i*	Important Value Index
Kg	Kilogram
LC	Least Concern
M	Meter
Mm	Millimeter
NT	Near Threatened
UMK	Universiti Malaysia Kelantan
VU	Vulnerable
AGB	Aboveground Biomass
GIS	Geographic Information System
t/m	Tonne per meter

LIST OF SYMBOLS

%	Percentage
°C	Degree Celsius
÷	Division
×	Multiply
+	Addition
( )	Parentheses
Σ	Total

CHAPTER 1

INTRODUCTION

1.1 Background of study

Tropical rainforest is the most complex ecosystem existed, and has a higher diversity of animal and plant life than the other vegetation type. These forests have their own unique characteristics since it is been evolved in millions of years. Tropical rainforest plays vital roles in maintaining human life by providing water resources, natural protection, medicine, oxygen and also absorb the carbon dioxide in the atmosphere which can reduce the amount of pollution that can effects in global warming, thus disturbing our biodiversity in the forest (Yadvinder & John, 2000). It is very crucial to maintain the diversity contain in our forest but they are now becoming smaller and fragmented due to human activities such as uncontrollable logging and shifting cultivation which leads to forest degradation thus, bring to the loss of habitat for flora and fauna.

Recently, biodiversity is a term that always used for discussing the every questions arises by human connections with natural environments and other species, between systems of ecological and social (Béla, 2013). Due to technological progress and demand to fill the new expanse to meet the needs of rapidly growing humankind, population is affecting natural environments and the diversity of living resources to an unexpected degree. It is important to execute the ways for conservation so as to preserve the natural patrimony as the heritage of future generations (Béla, 2013).

Genus *Hopea* is from the family of Dipterocarpaceae in the major group Angiosperms which are flowering plants. Genus *Hopea* is widely distributed in the tropical rainforest of Sumatra, Malaysia and up to the Andaman islands, and it is locally known as *merawan hitam* or *pengarawan* (Atun, Aznam, Arianingrum, Takaya, & Masatake, 2008). Genus *Hopea* and *Shorea* are quite similar but can be differentiated by their characteristics which genus Hopea has two long and three short fruit calyx wings, while genus *Shorea* has three long and two short wings on the fruit (Yulita, Bayer, & West, 2005) . However, information of Dipterocarpaceae on the patterns of *Hopea* species is very limited. In this study, Genus of *Hopea* in Bukit Bakar Forest Eco Park, Machang Kelantan will be discovered.

1.2 Problem Statement

Generally, Bukit Bakar Forest Eco Park contains various species of trees with high content of aboveground biomass. However, there is less scientific research about the tree species diversity in this area. Therefore, this study is important to add more research data in Bukit Bakar Forest Eco Park. There is less data available on genus *Hopea* and it make for people hard to refer for other studies. Other than that, the species composition of genus *Hopea* found which can estimate the species richness and evenness in the study area. This study will update the baseline data information of Bukit Bakar Forest Eco Park, Machang, Kelantan.

1.3 Objectives

The purposes of the study are:

1. To identify species from genus *Hopea* in Bukit Bakar Forest Eco Park.
2. To determine the aboveground biomass of genus *Hopea* with diameter at breast height (dbh) of less than 5 cm in Bukit Bakar Forest Eco Park.

1.4 Scope of Study

This study was conducted in Bukit Bakar Forest Eco Park, Machang, Kelantan with five random sampling plots of 20 m x 20 m. In this study, tree species of genus *Hopea* with diameter breast height (dbh) less than 5 cm were collected as voucher specimens for species identification. The locations of all species were mapped by using GPS. Furthermore, all the *Hopea spp.* found in the plots will be identified and the important value index and aboveground biomass will be calculated.

1.5 Significant of Study

This study was done to study the distribution of genus *Hopea* with dbh less than 5cm in Bukit Bakar Forest Eco Park, Machang, Kelantan. This study is important because there is lack of scientific research conducted in Bukit Bakar Forest Eco Park, Machang, Kelantan on genus *Hopea*. This data can be useful for management of the forest in future and also will be helpful for ecological study in Bukit Bakar Forest Eco Park, Machang, Kelantan area. This data need to be updated also due to the tremendously increased of request for this tropical hardwood in over last twenty years which affect in highly forest degradation due to over-logging thus, affecting the tree regeneration of the tropical forest. Forest harvesting for timber disrupts the interaction between the various communities. Thus, it is very important to conserve the valuable group of trees like this as they will become carbon sink in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Tropical Rainforest

Tropical rainforest is described as the lung of the earth. The process of photosynthesis carried out by the tropical plants takes out the carbon dioxide from the atmosphere and replace it with oxygen. The tropical rainforest has an extremely complex ecosystem of flora and fauna by the food web and also by pollination of flowers and the dispersal of seeds which helps in maintaining the forest (Manokaran, 1992).

The most complex ecosystems in the world is Malaysia Tropical Rainforest because it contains biodiversity and its uniqueness that has evolved for millions years. Malaysia's tropical rainforest consists of at least 8000 species of flowering plants and 2500 of trees species and it is the most diverse because of their topographic variations (Zailani, 2000). The rainforest of Malaysia includes the peat swamp forest, mangrove forest and lowland and highland rainforests.

2.1.1 Forest Strata

According to Drinnen (2000), the tropical rain forests are stratified into few vertical layers which are emergent, canopy, understory and forest floor. All the stratum describing the terms of plant life but the animal life can also described in that way. Figure 2.1 shows the strata of the tropical rainforest.

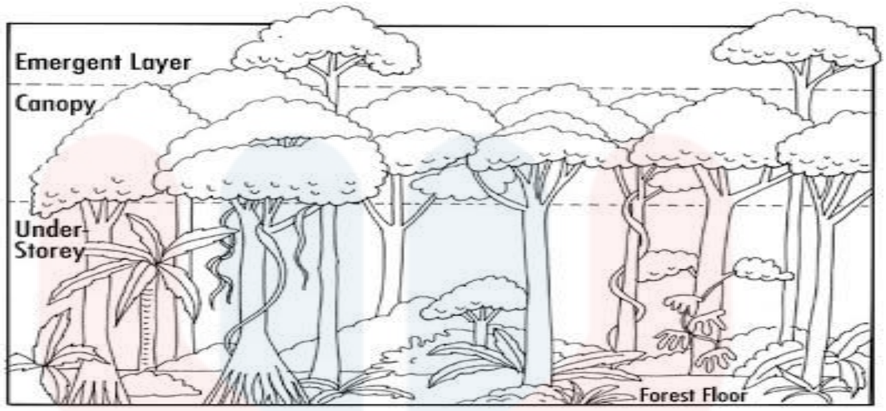


Figure 2.1: The layers of tropical rainforest

(Sources: Retrieved April 7,2018 from "Characteristics Of Tropical Rainforest - BV 1N6 2011 Geography Page,")

The top layer of tropical rainforest is the emergent layer which contains gigantic trees from 46 m to 76 m which appear from the canopy show an umbrella like layer. Most of the trees at emergent layer has broad-leaved and hardwood evergreens. The second layer, after the emergent layer is the canopy. It is formed by trees that grow around 18 m to 46 m (Drinnen, 2000). This layer consists of compact habitats that maintain a lot of plant and animal life available in tropical rainforest. Most of the trees here have an oval and smooth leaves

The layer below the canopy is called understory, which contains trees of small sized from about 9m to 18m in height (Drinnen, 2000). Some of them form part of the canopy eventually while others will remain in the understory. The examples of plants that available in this layer are orchids, Lianas and bromeliad. The final layer is called forest floor which usually 18 m below the canopy (Drinnen, 2000). It is very dark in this area and there is almost no plant in this area. Things in this layer will begin to decay quickly as it is hardly to receive sun. A leaf that estimated to decompose within a year during regular climate will took only just six weeks to disappear. This layer contains mostly seedlings, herbs, and ferns.

2.2 Diversity of Species

According to Rosenzweig (1995), diversity of species is generally the evaluation of number and abundance of species at a specific point in space and time. Biodiversity and diversity of species are largely used terms in natural resource management and ecology. Diversity of species can affect functions in ecosystem, such as the stability and productivity of a production. Ecologist had essentially concerned about the diversity of species as it is normally used as a representative of ecological diversity. Diversity and diversity size of tree species mixed the quality of particular advantages to forestry. The width of niche and habitat diversity is also the key components for diversity of ecology.

The fundamental definition for index of diversity is to acquire a quantitative estimation of variability of biological that useful to distinguish biological entities, discrete components composition, in time or space. For practice, however, indices of diversity were used generally for collections or communities of species or other taxonomic units. For these cases, two parameters are usually used to contribute to the concept of the diversity of community. The two parameter or concepts are the species richness and species evenness (Help, Herman & Soetaert, 1998)

2.2.1 Species Richness and Evenness

The richness of species refers to the overall quantity of species that is accessible in specific area or sample while diversity is how it is allocate between those species for example is the abundance of species frequency (Aslam, 2009). It is the simplest idea for distinguishing the community of diversity which is pointed on the estimation of the species richness based on local community. In fact, about all the quantitative measures of diversity turn outs it turns out being some mixed of two concept which are species richness and evenness, where evenness illustrated the way individuals balancing are conveyed among the species. The species number in each sample is an estimation of richness. The higher species pointed in a sample describes the higher the species richness.

In evenness of species is expresses the frequency the individuals in the community are distributed over the different species. The evenness of species or the similarity in abundance of species relative in a community gives another aspect of diversity by deciding diversity as a standardized index for abundance of relative species (Zhang et al., 2012)

2.3 Family of Dipterocarpaceae

Dipterocarpaceae or dipterocarps are derived from few Greek words which mean two-winged fruits. It refers to the typical structure of the Dipterocarpus's (a genus of Dipterocarpaceae) fruit. Dipterocarpaceae is under kingdom of Plantae and is one of the most familiar tree families in the tropical zones for its valuable species of timber. It is a family of tree that standing tall and become one of the magnificent formation of forest in the biosphere (Appanah & Turnbull, 1998). It has been distributed all over tropical Asia, which traverse numerous geographic regions and climatic zones. The dipterocarps also initiate the major timber for domestic needs in seasonal evergreen forests of Asia.

Furthermore, the forest are sources of a variation of minor products on which plentiful forest residents are directly rely on their endurance (Huy et al., 2016).

In Peninsular Malaysia, Dipterocarpaceae consist about of 157 species (Appanah & Turnbull, 1998). Table 2.1 shows the number of genus that found in Peninsular Malaysia under respective IUCN categories (Chua, 2010). They have been the most important timber family in Malaysian forest and this family should be the subject of bigger scrutiny in relation to species conservation. However, because of the omnipresent of this family in Malaysia, they are assumed not to be threatened. According to test that has been done, the pattern of the distribution of this family in Peninsular Malaysia specified that over 57% of the species are limits to specific zones within the Peninsular. 30 species of the dipterocarps are endemic in Peninsular Malaysia which indicates that the conservation strategy of this species should be highlighted (Guan & Yen, 2000). Dipterocarps are restricted to climate of tropical with a mean of rainfall exceeding 1000 mm (Appanah & Turnbull, 1998).

Table 2.1: The number of Dipterocarpacea genus 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**

(Source:Chua, 2010)

2.3.1 The distribution of Dipterocarpaceae in Peninsular Malaysia

Although dipterocarp dominate the forest of Peninsular Malaysia, not all of the species distribute evenly in the country. This distribution is limited by few factors for example is the climatic factor. In Peninsular Malaysia, the influencer of the climate pattern is the pattern and amount of annual rainfall. Majority of the dipterocarps are limited to areas with the mean annual rainfall exceeds 2000 mm. The next influencer of the climate changes are from the increasing of the mountain's elevation.

According to Symington (1943), most of the dipterocarps are well-distributed within lowland dipterocarps to the hill dipterocarps forest below 830 m elevation. Outside from that elevation, it shows the decreasing of the dipterocarp species and there is none of the dipterocarp found over 1300 m elevation. There is also none of the dipterocarps species found in mangrove swamp.

There are large numbers of the dipterocarps in Peninsular Malaysia are local endemic which it is species or taxa that can just found within their distribution in Peninsular Malaysia. There are 30 species of them those endemics of Peninsular Malaysia which it is about 19.1% of the total species found (Guan & Yen, 2000). Besides, the rare and endemic species of dipterocarp also found and all of them are recorded in Table 2.3

Table 2.2: Endemic and rare species Dipterocarpaceae in Peninsular Malaysia

Genus	No. of species	Endemic species	Endemic and rare	Rare non-endemic	Endemic and rare non-endemic
Anisoptera	6	0	0	0	0
Cotylelobium	2	0	0	1	1
Dipterocarpus	31	3	2	6	9
Dryobalanops	2	0	0	0	0
Hopea	32	9	4	6	15
Neobalanocarpus	1	1	0	0	1
Parashorea	3	1	0	1	2
Shorea	59	7	4	18	25
Vatica	21	9	2	2	11
Total	**157**	**30**	**12**	**34**	**64**

Rare species are defined as having restricted range, found within one to three adjacent states.

(Source: Guan & Yen, 2000)

2.4 Genus *Hopea*

Hopea is one of the vital timber species in the lowland and hill dipterocarp forests in Malaysia just like in the other country such as Myanmar, Cambodia, and Laos and it is also commercially important in Malaysia. There is relatively few research on this genus compared to other genus of dipterocarp (Photidsat, 1998). The genus *Hopea* are distributed from India and Sri Lanka eastwards through to South China and Hainan and Southeast through Myanmar, Thailand, Laos, Cambodia and Vietnam and it's across the archipelago to the Philippines and Papua New Guinea (Symington, 1943).

In Peninsular Malaysia, *Hopea* is found in many districts which usually in a medium size. About 100 species have been collected, of which about 70 species have been botanically described. There are more than 30 described species that occur throughout the Lowland Forest from the sea level up to 1200 m. Some species are rather rare and sporadic while others, show a distinct gregarious tendency, and may be locally abundant (Symington, 1943).

2.4.1 Morphological Characters of Hopea

Genus *Hopea* is a larger genus of Dipterocarpaceae with size of small to medium or few large trees which up to 40 m to 60 m tall and 100 to 180 cm in diameter and its produces two distinct groups of timber which their standard Malayan name are Giam and Merawan. Giam is representing the heavier group while Merawan represent the lighter group. The density of Giam's hardwood is heavy about 865-1220 kg m^{-3} air dry. The sapwood is in yellow color and is hardly recognize from its heartwood, which is yellow with a greenish tinge when fresh sawn, turning deep red-brown on exposure. The sapwood is usually lighter in color than and is poorly defined from the heartwood, which is yellow when fresh, but darkens on exposure to light brown or red-brown (Wong, 2002). Genus *Hopea* and *Shorea* are quite similar but can be differentiated by their characteristics which genus *Hopea* has two long and three short fruit calyx wings, while genus *Shorea* has three long and two short wings on the fruit (Yulita, Bayer, & West, 2005) . Figure 2.2 shows the different of the calyx wings of *Shorea* and *Hopea*.

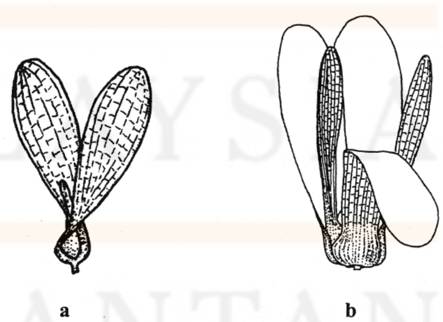


Figure 2.2: Fruit wings distinguishing Hopea (a) and Shorea (b)

(Source: Ashton 1982)

The trees of genus *Hopea* are in small to medium size with tapering boles, it is usually branching low with thin or few thick buttresses, with flying buttresses and stilt roots sometimes present. The canopies are monopodial and lanceolate. It has a lot or sometimes few horizontal pendent branching in small trees, becoming hemispherical with straight branchlets in large trees. For the bark, it variable for most species and dependent mostly on growth stage with smooth, chocolate and grey mottled, hoop-marked in early growth, remaining or becoming cracked and flaked or fissured. Their twigs are slender. The flower buds of *Hopea* usually small, ovoid and rarely globose. Next is the calyx lobes imbricate with 2 outer lobes ovate, obtuse or suborbicular and 3 inner lobes mucronate. The petal connate at the base and falling in a rosette. The ovary is glabrous or tomentose, ovoid, with or without stylopodium while stigma usually minute. The fruit have 2 outer calyx lobes which are longer than 3 inner ones, spatulate, thin, or with all lobes equal or sub-equal, thickened, saccate at base (Ashton, 1982).

2.5 Estimation of Aboveground Biomass

Biomass is the weight of live or dead organic matter. Trees biomass is commonly divided into above ground and below ground. According to Deo (2008), the above ground biomass (AGB) are all the living biomass above the soil while below ground biomass includes all biomass of live roots excluding fine roots which less than 2 mm diameter. It is very useful to quantify a forest since they can reflect the changes of the forest carbon stocks (Basuki et al., 2009) because vegetation biomass contains larger amount of global carbon than the atmosphere. The estimation of biomass helps in making future management decisions since biomass can be used in estimation of carbon, energy and nutrient contents (Agus, 2005).

According to Lu (2006), biomass can be assessed by using three approaches which are field measurement, remote sensing and GIS-based approach. The most accurate method for estimating aboveground biomass is by weighing tree biomass in the field but it is time consuming while destructive method is generally limited to small areas and small sample tree sizes (Quirine et al., 2001). Usually, allometric equation is widely used in tree biomass studies to extrapolate in situ and remotely sampled data to a larger area and deriving biomass from other variables.

There are more studies on aboveground biomass has been done all over the world. The example of the studies of aboveground biomass is by Terakunpisut et al. (2017). This study was conducted in Kanchanaburi Province, Thailand with three different forest types and the study conducted was for trees with dbh of more than 4.5cm. The value of aboveground biomass for that study is 275.46t/m for tropical rainforest.

2.6 Forest Threat

The tropical forests, specifically in Southeast Asia are dominated by Dipterocarps and have been exploited as important sources of hardwood in the world. The request for this tropical hardwood is tremendously increased in over last twenty years which affect in highly forest degradation due to over-logging thus, affecting the tree regeneration of the tropical forest. In general, the extent of tropical rain forest and especially, the Dipterocarp forests, has also decreased rapidly because of the extensively destruction by forest exploitation and conversion to other uses, and loss due to forest fire and shifting cultivation (Photidsat, 1998). Forest harvesting for timber disrupts the interaction between the various communities, the degree of disruption depending on the severity of logging.

The conservation of a valuable group like dipterocarp is very important as it would easily garner support for their conservation. The protection of this family in its natural ecosystems is also meant for the species protection around the area where the plant found. It is expected that the model developed for the family could at the later stage be lengthened to other plant species. The variety of dissimilar conservation required for the dipterocarps will probably be similar to that for most other tree species of Peninsular Malaysia. It is very important that the management agency of the forest for example is the Forest Department of Peninsular Malaysia which they can use such models and apply them for all plant species in the country (Guan & Yen, 2000).

CHAPTER 3

MATERIAL AND METHODS

3.1 Study Area

This study will be conducted at Bukit Bakar Forest Eco Park, which located in Machang, Kelantan. Bukit Bakar covers an area of 3.14 hectares, within the Ulu Sat Forest Reserve. The forest type of Bukit Bakar is hill dipterocarp forest which is usually found in areas of 500-700 m above sea level, contains less undergrowth and is one of the well-known beautiful forests in Malaysia that is rich in the flora and fauna. It is managed by the Kelantan State Forestry Department. Figure 1.1 shows the map of the study area which is in Machang, Kelantan.

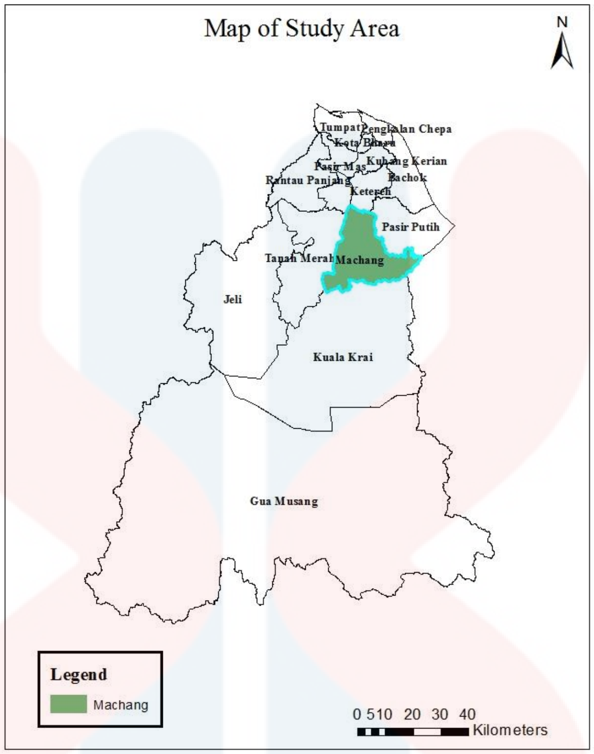


Figure 3.1: Map of Study Area

3.2 Sampling plots

According to Magurran (2004) and Bi et al. (2010), it is better to have numerous small plots than several larger one because it is easier to handle small plots and there will be less probability of inaccurate data.

There are five sampling plots of 20 m x 20 m were constructed in Bukit Bakar Forest Eco Park area according to plot establishment in Figure 3.2.

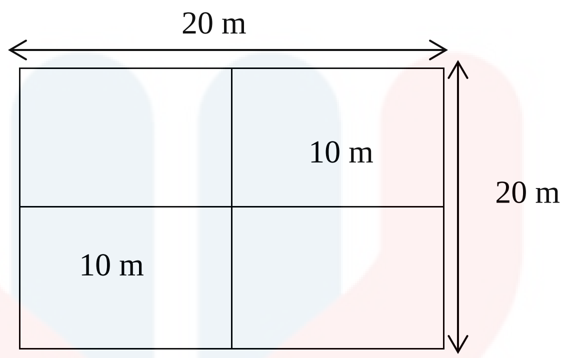


Figure 3.2: Plot establishment of 20 m x 20 m sampling plot

The entire plots selected were selected based on their contribution to species richness, density and basal area. It also considered the topography of the area. The locations of all the five plots have been mapped by the using of Garmin GPS.

3.3 Data Collection

3.3.1 Preservation and identification.

For data collection, specimens were collected for further identification species of the trees. All the genus *Hopea* species with dbh with less than 5cm found in the plots were collected for the identification. The locations of trees within each plot were recorded and the specimens were tagged and labeled with number for future assessment. In addition, the altitude, nature of the habitat, exact locality and the plant proper were also recorded accordingly.

Before species identification process, the specimens were spread out between the folds of old newspapers sheets to avoid overlapping of plant parts. Chemical treatment method has been used for the specimen collected. The 70% ethanol has been used to prevent fungal attack (Miller & Nyberg, 1990). All plants were preserved in airtight plastic bag with the addition of 70% of ethanol.

In UMK laboratory, the specimens were pressed in a standard plant press materials, which have a wooden frame functioning as rigidity, corrugated cardboard that act as ventilators that allow air to move through the press, and folded newspaper to place the plant material. The specimens were oven-dried in 45°c for 3 days. Continuous observation has been done during this process to avoid from specimen fragile or damage. Some of the herbarium specimen will be deposited in Natural Resources Museum in UMK Jeli Campus. Species identification has been referred to Tree Flora of Sabah Sarawak Volume 5 by Soepadmo et al. (2004), Malaysia Plant Red List by Chua et al. (2010) and by referred to few website in the internet.

3.5 Data Analysis

For the data analysis, some allometric equations will be used. The vegetation analysis are calculated to know the species dominance. The Shannon Wiener Index and Simpson Index are also used for species diversity calculation.

3.5.1 Vegetation Analysis

The vegetation analysis or Important Value Index (IV*i*) to show the dominance of any species collected with a single value. Its analyses include relative frequency, relative density and relative abundance. The formula below followed from article by (Zhigila, Sawa, Abdul, Abba, & Tela, 2015).

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}} \quad (1)$$

$$\text{Relative Density}= \frac{\text{Number of individuals of one species}}{\text{Total number of all individual counted}} \times 100 \quad (2)$$

$$\text{Frequency}= \frac{\text{Number of quadrats in which the species occures}}{\text{Total number of duadrats sampled}} \quad (3)$$

$$\text{Relative Frequency}= \frac{\text{Frequency of one species}}{\text{Total frequency of all species}} \times 100 \quad (4)$$

$$\text{Abundance}= \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of duadrats in which the species occured}} \quad (5)$$

$$\text{Relative Abundance}= \frac{\text{The abundance of one species}}{\text{Total all species counted}} \times 100 \quad (6)$$

$$\text{IV}i=(\text{Relative Frequency} + \text{Relative Density} + \text{Relative Abundance}) \div 3 \quad (7)$$

3.5.2 Shannon-Wiener Diversity Index

For Shannon-Wiener Diversity Index (Shannon & Weaver, 1949), this formula will be used:

$$H' = \sum_{i=1}^{S} Pi \ln Pi \quad (8)$$

Where,

H'= the Shannon-Wiener index

Pi = the proportion of individuals belonging to species i

ln =the natural log

This index is affected by both the number of species and evenness. A larger number of species and a greater even distribution will increase diversity as measured by H'. The maximum diversity (Hmax) will happens when species are all equally abundant. The equation of Hmax is:

$$Hmax = \ln S \quad (9)$$

Where,

S = the total number of species.

The actual diversity can be compared to maximum possible values by calculating the evenness. The formula is as below:

$$E = H'/Hmax \quad (10)$$

3.5.3 Simpson's Index

Lastly, the Simpson's index for species evenness (Simpson, 1949) will be calculated using the following equation:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right) \quad (11)$$

Where,

D = the Simpson diversity

n = total no of individual in particular species

N = total number of individual of all species

3.5.4 Aboveground Biomass

The estimation of above ground biomass (AGB) for each species found was calculated using the equation by Kato et al. (1978). The equation to estimate AGB:

$$\text{Total AGB} = W_S + W_B + W_L \quad (12)$$

Where:

W_S = Weight of stems

W_B = Weight of branches

W_L = Weight of leaves

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Distribution of *Hopea spp.* in Bukit Bakar Forest Eco Park, Machang, Kelantan

Five sampling plot have been constructed and the entire coordinate have been mapped as shown in Table 4.1. The study recorded a total of 46 individuals representing 7 species under genus *Hopea* from the sampling site with dbh of less than 5 cm,

Table 4.1: Lists of coordinates of five sampling plots at Bukit Bakar Forest Eco Park, Machang, Kelantan.

Plot	Latitude	Longitude
1	05°43.203'	102°15.630'
2	05°43.009'	102°15.715'
3	05°43.030'	102°15.718'
4	05°43.038'	102°15.714'
5	05°42.666'	102°15.956'

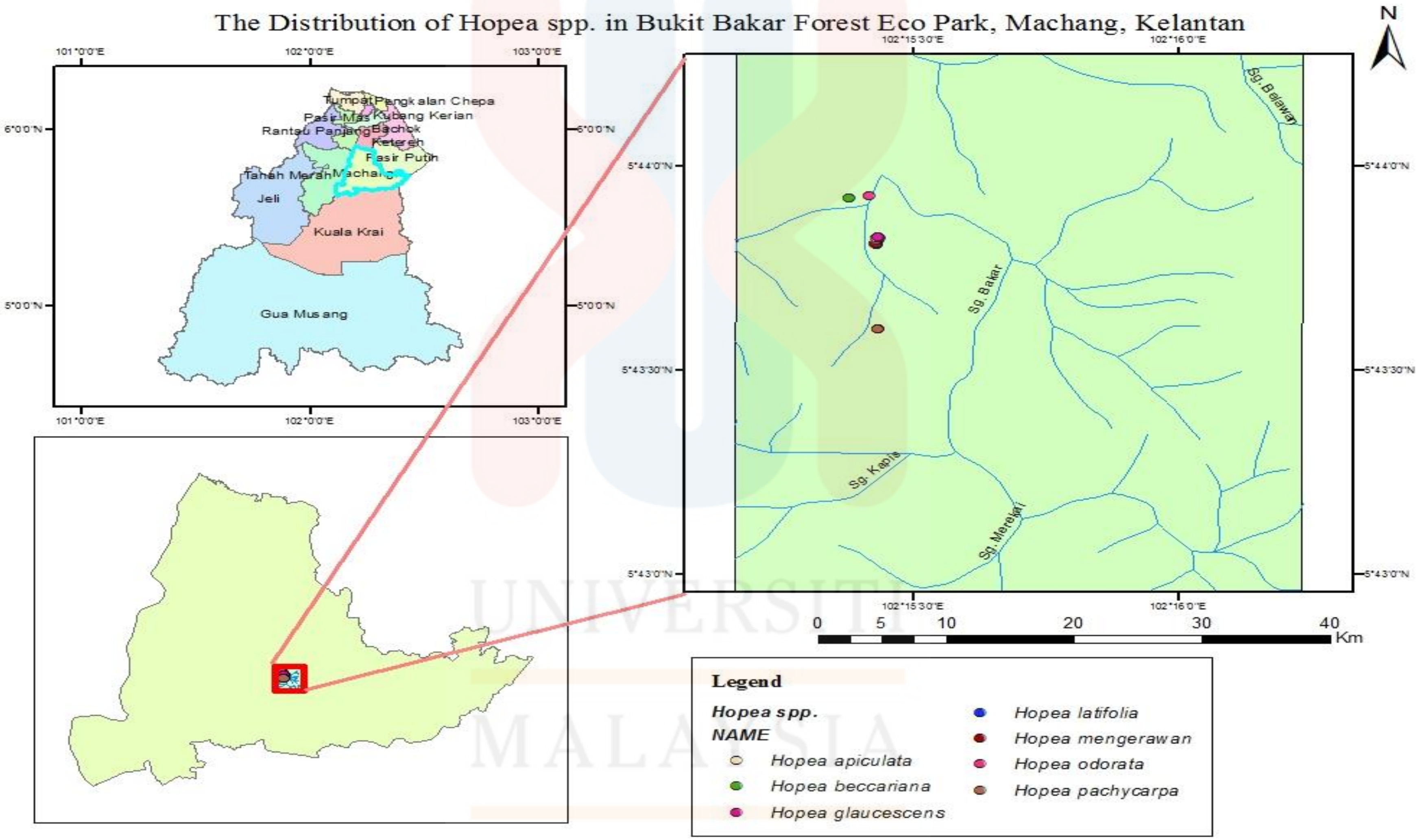
Table 4.2 presents the list of species under genus *Hopea* that were found in Bukit Bakar Forest Eco Park, Machang, Kelantan. The highest number of individuals is *Hopea latifolia* with 9 individual found. The lowest numbers of individual is *Hopea beccariana* which only present in one plot.

Table 4.2: Lists of *Hopea spp.* found in Bukit Bakar Forest Eco Park Machang, Kelantan according to the highest number of individual.

Species	Number of Individual
Hopea latifolia	9
Hopea odorata	8
Hopea glaucescens	8
Hopea pachycarpa	7
Hopea apiculata	6
Hopea mengerawan	5
Hopea beccariana	3

According to Chua et al. (2010), the habitat of *Hopea latifolia* is lowland to hill dipterocarp which up to 400 m altitude. Therefore, this study also conducted in low land dipterocarp which this species have been found at plot number 1 and 2 with altitude between 90 m to 150 m. All the species found has been plotted in a map in Figure 4.1.

Figure 4.1: Map of distribution of *Hopea spp.* in Bukit Bakar Forest Eco Park, Machang Kelantan.



4.2 Diameter at Breast Height (DBH) Measurement

According to Mahmut (2004), diameter at breast height (dbh) is one of the important characteristics of tree and the measurement is easy. This measurement is the most important in this study because it was used to calculate the aboveground biomass calculation. For this study, all *Hopea spp.* with diameter at breast height (dbh) of 5 cm and below were recorded. Figure 4.2 shows the DBH ranges of *Hopea spp.* collected. Majority of the trees collected have diameter at breast height (dbh) of 1.0 cm to 1.9 cm with 22 individuals and the lowest trees diameter at breast height (dbh) is between 3.0 cm to 3.9 cm with 5 individuals. There is no individual with diameter at breast height (dbh) of 0.9 cm and below.

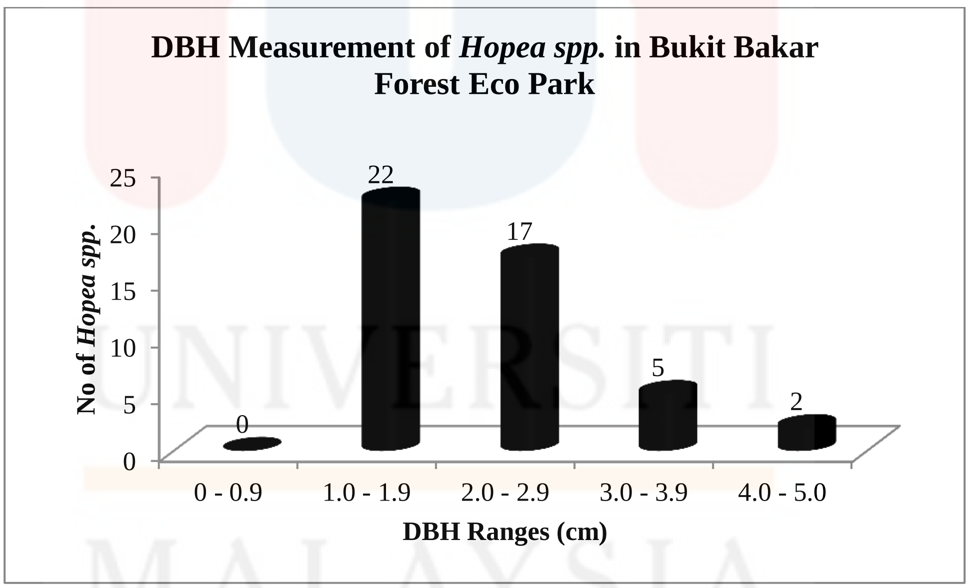


Figure 4.2: DBH ranges and number of *Hopea spp.* collected in Bukit Bakar Forest Eco Park, Machang Kelantan.

4.3 Vegetation Analysis

There are 69 individuals of *Hopea spp.* collected in the total of 5 plots in Bukit Bakar Forest Eco Park, Machang, Kelantan. The highest density and frequency is belongs to *Hopea latifolia* while the highest abundance belongs to *Hopea pachycarpa*. Table 4.3 shows the density, frequency and abundance of *Hopea spp.* respectively. These 3 parameters are essential in order to describe the structure of the forest (Nizam, 2006).

According to Faezah (2013), the highest frequency indicates the widespread distribution in the plots. Therefore, for this study, *Hopea latifolia* is the most widespread species among the others found.

Table 4.3: The percentage of density, frequency and abundance of *Hopea spp*. in Bukit Bakar Forest Eco Park, Machang, Kelantan.

Species	**Density (%)**	**Frequency (%)**	**Abundance (%)**
Hopea latifolia	19.57	22.22	12.40
Hopea odorata	17.39	18.52	13.22
Hopea glaucescens	17.39	14.81	16.53
Hopea pachycarpa	15.22	11.11	19.26
Hopea apiculata	13.04	14.81	12.40
Hopea mengerawan	10.87	11.11	13.80
Hopea beccariana	6.52	7.41	12.40

The Importance Value Index (IV*i*) is one of the importance calculations for this study. The IV*i* values indicate the species importance in the study plots (Nizam et al, 2006). The IV*i* value was calculated by total up the relative density (RD), frequency (RF) and relative Abundance (RA). Based on the result in Table 4.4, the most important species is *Hopea latifolia* with IV*i* of 26.79% and the least important species are *Hopea beccariana* with 11.13% of IV*i* values. From these values, *Hopea latifolia* can be considered to have absolute dominance among the community as it has the highest IV*i* value. This is because, according to Curtis and McIntosh (1951), species with IV*i* values high than 10% reflects as possess the absolute dominance in the studied community.

Table 4.4: The IV*i* values of *Hopea spp*. in Bukit Bakar Forest Eco Park Machang, Kelantan.

Species	**RD**	**RF**	**RA**	**IV*i* (%)**
Hopea latifolia	0.98	22.22	3.26	26.79
Hopea odorata	0.87	18.52	3.48	23.15
Hopea glaucescens	0.87	14.81	4.35	20.28
Hopea pachycarpa	0.76	11.11	5.07	17.15
Hopea apiculata	0.65	14.81	3.26	18.96
Hopea mengerawan	0.54	11.11	3.62	15.46
Hopea beccariana	0.33	7.41	3.26	11.13

4.4 Species Diversity

For species diversity, the Shannon-Wiener diversity index (H’) has been used to calculate the species richness. According to Magurran (1988), the Shannon Wiener Diversity index, H’ is the measure of two components which are species richness and species evenness. Usually H’ are value within 1.5 to 3.5 and the increasing value is small due to logarithmic element in the function, the value will exceed 4.5. A high value of H’ shows the high species number with comparable abundance thus, a low value indicate domination by a few species.

The values for all indices were calculated and the values are shown in Table 4.5. The value of Shannon-Wiener diversity index (H’) for this study is 1.90 with the Hmax value is 1.95. The values indicate that the *Hopea spp.* in this area has moderate species diversity. Therefore this values are in standard range as the typical values in most ecological studies are generally between 1.5 and 3.5 (Magurran, 2004). The value of for Shannon Evenness Index (E) is 0.95 which indicate that *Hopea spp*. in this area is quite even. The value for Simpson’s index is 0.86 where it shows the species richness of the study area is high. Apparently, both species richness and species evenness for this study can be considered as moderate species diversity.

Table 4.5: The values of diversity indices that used for *Hopea spp*. found in Bukit Bakar Forest Eco Park Machang, Kelantan.

Indices	**Values**
Shannon-Wiener Diversity Index (H')	1.90
Shannon- Wiener Maximum Index (Hmax)	1.95
Shannon Evenness Index (E)	0.95
Simpson's Index (D)	0.86

4.5 Aboveground Biomass

Aboveground biomass estimation is also important in scientific study and management of forest. Furthermore, it is a key variable in the annual and long term changes in the global terrestrial carbon cycle and other earth system interactions (Terakunpisut, Gajaseni & Ruankawe, 2016). The aboveground biomass was determined by calculating the sum of the biomass of the stem, branch and leaf. Total biomass was calculated as the sum of aboveground biomass and root biomass. The total biomass in each species was calculated from the summed biomass of all trees in each species.

The highest estimation for aboveground biomass in the study area holds by *Hopea glaucescens* with 12.57 t/ha which hold 28% of aboveground biomass total in this area. The lowest aboveground biomass is in *Hopea beccariana* with 0.71t/ha which hold just 1.58% of the total aboveground biomass in that area. The total aboveground biomass value for the total seven species found is 44.90 t/ha. The values of aboveground biomass of each species are shown in Table 4.6. The value of aboveground biomass for this study is quite low as compared to the study by Fauzi et al. (2017). In that study, their total aboveground biomass for lower altitude is 446.25 t/ha. This may because of this study focused on tree species with dbh of less than 5cm and under one genus which is genus *Hopea*.

Based on this result, it is estimated that this trees will holds moderate amount of carbon. However, it is estimated that all the trees may grows and contribute to higher carbon sequestration in future. The conservation of this valuable species will be long term benefit as these trees will become carbon sink and can absorb lots of carbon in the future. Thus, this forest can play major role in reduction of carbon dioxide.

Table 4.6: The values of aboveground biomass of *Hopea spp*. found in Bukit Bakar Forest Eco Park Machang, Kelantan.

Species	Aboveground biomass	
	t/ha	%
Hopea latifolia	4.35	9.68
Hopea odorata	2.98	6.64
Hopea glaucescens	12.57	28.00
Hopea pachycarpa	8.28	18.44
Hopea apiculata	10.70	28.38
Hopea mengerawan	5.31	11.83
Hopea beccariana	0.71	1.58
Total AGB	**44.90**	

4.6 Conservation Status

For this study, the IUCN red list data are used to gives information about the conservation status for *Hopea spp.* found in study area. Based on Table 4.7, 4 species are vulnerable, 2 species are endangered the rest 1 species is under least concern. The status shows that all the trees found are important as they are mostly vulnerable and endangered.

The conservation of a valuable group like the dipterocarp is of utmost importance, as it would easily garner support for their conservation. In the protection of this family in its natural ecosystems, this would also meant protection of other plant species that are found within such areas. It is hoped that the model developed for the family could at the later stage be extended to other plant species. The range of different conservation needs for the dipterocarps will probably be similar to that for most other tree species of Peninsular Malaysia.

Table 4.7: IUCN status for *Hopea spp*. found in Bukit Bakar Forest Eco Park, Machang Kelantan.

Species	**IUCN Status**
Hopea latifolia Symington	Vulnerable
Hopea odorata Roxb.	Vulnerable
Hopea glaucescens Symington	Vulnerable
Hopea pachycarpa (F.Heim) Symington	Endangered
Hopea apiculata Symington	Endangered
Hopea mengerawan Miq.	Vulnerable
Hopea beccariana Burck	Least Concern

CHAPTER 5

CONCLUSION AND RECOMMENDATION

As a conclusion, the objectives of this study have been successfully accomplished. The 46 individuals of *Hopea spp.* with 7 species found shows that this genus is quite diverse in Bukit Bakar Forest Eco Park, Machang, Kelantan. The result in this study proved that it is important to conserve this valuable group of trees for future sustainability. The estimation of aboveground biomass of the *Hopea spp.* found shows that this valuable group of species will be useful as they will become carbon sink in Bukit Bakar Forest Eco Park, Machang, Kelantan. The data of this study can be useful for management of the forest in future and also will be helpful for ecological study in Bukit Bakar Forest Eco Park, Machang, Kelantan area. Therefore, the appropriate conservation and practices of management for this valuable tree species will be long- term benefit for future generation. Thus, it is very important to conserve the valuable group of trees like this.

Forestry Department should take steps to persistently conserve this forest even it will be challenging to preserve and managing the forest because it is important to develop the sustainable forest ecosystem. Furthermore, more study should be conducted in this area in future so that this area will gain more attention to be conserved.

REFERENCES

Agus, H. 2005. Biomass estimation, carbon storage and energy content of three virgin jungle reserves in Peninsular Malaysia. Media Konservasi Vol X, No. 2 Disember 2005: 1–8.

Appanah, S., & Turnbull, J. M. (1998). *A Review of Dipterocarps: Taxonomy, ecology and silviculture*. Bogor, Indonesia: CIFOR.

Ashton P. S. 1982. Dipterocarpaceae. *Flora Malesiana Series I-Spermatophyta Flowering Plants* 9(2): 237 - 552.

Aslam, M. (2009). Diversity, species richness and evenness of moth fauna of Peshawar. *Pak. Entomol.*, *31*(2), 99–102.

Atun, S., Aznam, N., Arianingrum, R., Takaya, Y., & Masatake, N. (2008). Resveratrol derivatives from stem bark of Hopea and their biological activity test. *Journal of Physical Science*, *19*(2), 7–21.

Basuki, T.M., Van Laake, P.E., Skidmore, A.K. & Hussin, Y.A. 2009. Allometric equations for estimating the above-ground biomass in tropical lowland dipterocarp forests. Forest Ecology and Management 257: 1684–1694.

Béla, T. (2013). Dr. Tóthmérész Béla. *Diversity*, 298.

Bi, V., Aimé, T., Yao, A., Yves, C., Djaha, K., 'da, N., … Edouard, K. (2010). Diversités Floristique et Structurale sur le Site d'une Réserve Naturelle Volontaire à Azaguié, Sud-est de la Côte d'Ivoire. *European Journal of Scientific Research*, *45*(3), 1450–216.

Chua, L. S. L., & Institut Penyelidikan Perhutanan Malaysia. (2010). *Malaysia plant red list : Peninsula Malaysian Dipterocarpaceae*. Forest Research Institute Malaysia.

Curtis JT, McIntosh RP (1951) An Upland Forest Continuum in the Prairie-Forest Border Region of Wisconsin. Ecology 32 (3):476-496.

Deo, R.K. 2008. Modelling and Mapping of Above - ground Biomass and Carbon Sequestration in the Cool Temperate Forest of North-east China. Enschede, ITC, 2008.

Drinnen, K. (2000). Education Department Curriculum. *Tropical Rainforests, 3rd editio*, 85.

Faezah, P., Asmida, I., Siti Khairiyah, M. H., Norrizah, J. S., & Nuraini, C. A.

(2013). Diversity and tree species community at Bukit Nanas Forest Reserve, Kuala Lumpur. In *BEIAC 2013 - 2013 IEEE Business Engineering and Industrial Applications Colloquium* (pp. 846-850)

Fauzi N., Hambali K., Nawawi S. A., Busu I. & Yew S. K. (2017) Biomass and carbon stock estimation along different altitudinal gradients in tropical forest of Gunung Basor, Kelantan, Malaysia. Malayan Nature Journal 69(1):57-62

Guan, S. L., & Yen, S. Y. (2000). Conservation of Dipterocarpaceae in Peninsular Malaysia. *Journal of Tropical Forest Science*, *12*(3), 593–615.

Help, C. H. R., Herman, P. M. J., & Soetaert, K. (1998). Indices of diversity and evenness. *Oceanis*, *24*(4), 61–87.

Huy, B., Poudel, K. P., Kralicek, K., Hung, N. D., Khoa, P. Van, Phuong, V. T., & Temesgen, H. (2016). Allometric equations for estimating tree aboveground biomass in tropical dipterocarp forests of Vietnam. *Forests*, *7*(8), 1–19.

Kato, R., Tadaki, Y., Ogawa, H., 1978. Plant biomass and growth increment studies in Pasoh Forest. Malay. Nat. J. 30, 211–224.

Lu, D. 2006. The potential and challenge of remote sensing-based biomass estimation. International Journal of Remote Sensing 27(7-10): 1297–1328.

Mahmut D. Avsar , 2004. The Relationships between Diameter at Breast Height, Tree Height and Crown Diameter in Calabrian Pines (Pinus brutia Ten.) of Baskonus Mountain, Kahramanmaras, Turkey. Journal of Biological Sciences, 4: 437-440.

Magurran, A. E. (2004). A.E. (1998) Ecology Diversity and its measurement. Chapman & Hall, New York.19

Magurran, A. E. (2004). Measuring Biological Diversity Ch4. *Measuring Biological Diversity*, 256.

Manokaran, N. (1992). An overview of biodiversity in Malaysia. *Journal of Tropical Forest Science*, *5*(2), 271–290.

Miller, A. G., & Nyberg, J.A. (1990). Collecting herbarium voucher, 27,561-573

Nizam M.S., Fakharul M., Hatta and Latiff A. (2006) Diversity and tree species community in the Krau Wildlife Reserve, Pahang, Malaysia. Malays. Appl. Biol. 2006, 35 (2): 81-85

Photidsat, S. (1998). Some ecological studies on *Hopea Odorata* and *Hopea Pubescene* seedlings.

Quirine, M.K., Coe, R., Van Noordwijk, M., Ambagau, Y. & C.A. Palm. 2001.

Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests. Forest Ecology and Management 146: 199–209.

Rosenzweig, M. (1995). Species diversity in space and time. *Books.google.com*.

Simpson, E. H. (1949). Measurement of diversity. Nature, 163, 688.

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of information*. *Urbana University of Illinois Press* (Vol. 97).

Soepadmo, E., Saw, L.G. & Chung, R.C.K. (2004). Tree Flora of Sabah and Sarawak, Volume 5. Sabah Forestry Department, Forest Research Institute Malaysia (FRIM), Sarawak Forestry Department, Malaysia. pp. 528.

Symington, C. F. (1943). Foresters' Manual of Dipterocarps. Malayan Forest Record no. 16. Penerbit Universiti Malaya. 244p.

Terakunpisut J., Gajaseni N. & Ruankawe N. (2016) Carbon sequestration potential in aboveground biomass of Thong Pha Phum National Forest, Thailand. Applied Ecology and Environmental Research 5(2):93-102

Wong, T. M. (2002). A Dictionary of Malaysian Timbers. Malayan Forest Records No. 30. *Forest Research Institute Malaysia*, 115.

Yadvinder Malhi & John Grace. (2000). Tropical forests and atmospheric carbon dioxide. Trends in Ecology and Evolution. Volume 15, Issue 8, Pages 332-337.

Yulita, K. S., Bayer, R. J., & West, J. G. (2005). Molecular phylogenetic study of Hopea and Shorea (Dipterocarpaceae): Evidence from the trn L – trn F and internal transcribed spacer regions. *Plant Species Biology*, 167–182.

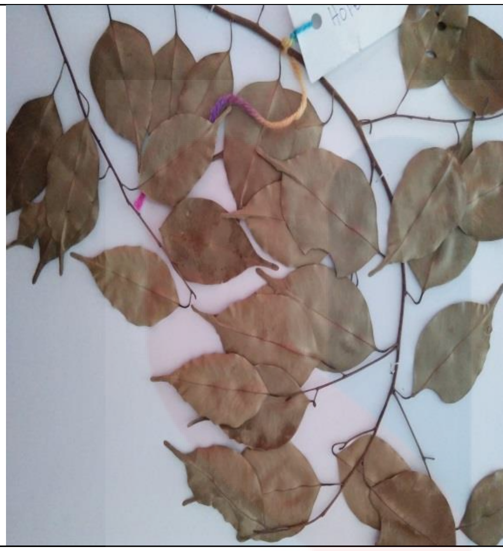
Zailani, K. (2000). Universiti Putra Malaysia Satellite Remote Sensisng Technology for Forest Type Classification and Inventory in Gunung Stong Forest Reserve, Kelantan, Malaysia.

Zhang, H., John, R., Peng, Z., Yuan, J., Chu, C., Du, G., & Zhou, S. (2012). The relationship between species richness and evenness in plant communities along a successional gradient: a study from sub-alpine meadows of the Eastern Qinghai-Tibetan Plateau, China. *PloS One*, *7*(11), e49024.

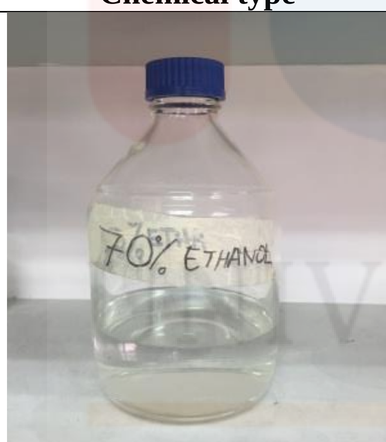
Zhigila, Daniel & F.B.J., Sawa & Abdul, S & M Abba, Halima & Tela, Murna. (2015). Diversity and Phytogeographic Investigation into Woody Plants of West Tangaza Forest Reserve, Sokoto State, Nigeria. International journal of plant research. 2015. 73-79.

APPENDIX A

Raw Materials	Description
	Materials that used during field work in the study site.
	Garmin GPS that used to locate the coordinates of sampling plots.
	Some fresh leaves pictures and specimen for species identification. The leaves have also been collected as a specimen to deposit in UMK's Natural Resources Museum.

	Oven dried leaves

APPENDIX B

Chemical type	Description
	The 70% ethanol that have been diluted from absolute ethanol. These have been used to preserve the plant specimen in the field.

APPENDIX C

Field Work Date	Days
31 July 2018 to 4 August 2018	5
6 October 2018 to 7 October 2018	1
Pictures	**Description**
	During field work in the sampling plot.
	Pressing samples before oven-dry process in the laboratory
	All the pressing samples were oven dried.