Faculty of Resource Science and Technology

Tree Species Composition of Mixed Dipterocarp and Intermediate Kerangas-Alluvial Forest: A Case Study at Mount Jagoi, Bau, Sarawak

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This dissertation is submitted in partial fulfillment of the requirements for The Degree of Bachelor of Science with Honors in Plant Resource Science and Management

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DECLARATION

I declare that no portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

……………………………………..

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List of Abbreviations

cm- centimeter

d.b.h- diameter breast height

GPS- Global Positioning System

ha. - hectare

km- kilometer

m- meter

MDF- Mixed Dipterocarp Forest

No. – Number

yr- year

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ABSTRACT

Three different forests of Jagoi were involved in this study. These are the undisturbed forest of Jagoi, Pinungan, at 235 – 281 m altitude, the logged-over dipterocarp forest, Dorod Spolup, at 198 – 205 m altitude, and the heath forest, Dorod Po Aup, at 35 – 65 m altitude. Po Aup was also represented by alluvial riparian forest. *Dipterocarpus rigidus*, *Artocarpus odoratissimus*, and *Hevea brasiliensis* dominated at respective locality. Species diversity was greatest at Spolup as expected of a disturbed forest. Though lacking in volume, Spolup achieved decent regeneration in 20 years but comparison with the conditions prior to logging cannot be done due to lack of pre-logging documentation of the area. The strata between Pinungan and Spolup have similarities. In addition, the heath forest of Po Aup also depicted similar strata to both of the dipterocarp forest studied. The complexity of Po Aup heath forest can be distinguished by the number of individual, its volume, species composition and its variation from typical heath forest. Reasons for this is unknown and finding out would require a bigger plot size to fully examine all attributes of Po Aup heath forest.

Keywords: undisturbed, logged-over, heath, species diversity

ABSTRAK

Tiga jenis hutan berlainan di Jagoi terlibat dalam kajian ini; hutan dipterocarp tidak terganggu Jagoi, Pinungan, yang berada pada ketinggian 235 – 281 m, hutan dipterocarp yang telah dibalak, Dorod Spolup, pada ketinggian 198 – 205 m, dan hutan kerangas, Dorod Po Aup, pada ketinggian 35 -65 m. Po Aup juga melibatkan hutan aluvium. Dipterocarpus rigidus, Artocarpus odoratissimus, and Hevea brasiliensis mendominasi di kawasan hutan-hutan berikut. Kepelbagaian spesies terbanyak di Spolup adalah seperti yang dijangka dari hutan yang telah ditebang. Walaupun kekurangan dari segi isipadu, Spolup mampu mencapai tahap regenerasi yang memberangsangkan dalam masa 20 tahun namun pembandingan dengan keadaan sebelum pembalakkan tidak dapat dilakukan kerana ketiadaan dokumentasi sebelum pembalakkan dilakukan di kawasan tersebut. Strata antara Pinungan dan Spolup mempunyai persamaan. Hutan kerangas Po Aup mempunyai persamaan dari segi strata dengan kedua-dua jenis hutan dipterocarp yang dikaji. Kerumitan hutan kerangas Po Aup boleh dikenalpasti dari jumlah individu, isipadunya, komposisi spesies, dan variasi dari hutan kerangas yang tipikal. Sebab bagi kerumitan belum dikenalpasti dan kajian untuk menentukannya akan memerlukan saiz plot yang lebih besar bagi mengenalpasti sifat-sifat hutan kerangas Po Aup secara menyeluruh.

Kata kunci: tidak terganggu, dibalak, kerangas, kepelbagaian spesies

Introduction

Five types of natural forest are recognized in Sarawak (Sarawak Forestry, 2002). These are Hill Mixed Dipterocarp Forest, Peat Swamp Forest and Mangrove. Heath and Montane Forest are less prominent due to the total land area. Heath forest is estimated to cover 3% of Sarawak's total land mass. Katagiri *et al.* (1991) highlighted that while unique vegetation occupies the heath forest, little is known about the relationship between soil and vegetation. In addition to that, the relationship between the floristic and structural peculiarities of heath forest is still unclear. Ashton *et al.* (2004) stated that the most widespread lowland rain forest in Borneo is Mixed Dipterocarp Forest (MDF). The name in itself implies that the dominant species in this forest is the family Dipterocarpaceae. Depending heavily on the succession stages, species composition of a forest is often very unique to the forest itself.

Species composition of a forest describes the number of different species that make up the forest stand community (Campbell *et al.*, 2008). A better understanding of the forest's development can be established by taking into consideration the three fundamental components defining the species composition of the forest. For example, when considering timber species composition of a forest, the first component is the number of individuals; in this case, the individuals being considered here are trees. Second is the basal area of the trees and third is the volume of the trees.

Timber harvesting is a widespread phenomenon happening throughout the tropical forests of Sarawak. The forests in Sarawak are home to an estimated 2500 tree species, most of which are categorized as hardwood species (Husin & Pek, 2002). Often, while most commercial logging sites are implementing sustainable forest management, the demand for timber produce is seemingly ever increasing such that these available commercial logging sites cannot cope with the demand and frequently resort to finding new sites for harvesting. Logging process drastically changes the canopy structure of the forest as well as the composition of the forest stand (Silva *et al.*, 1995). Primack and Tieh (1994) stated that, Sarawak was one of the world's leading suppliers of tropical hard woods in the 90s. A study by the International Tropical Timber Organization (ITTO) (1990), had shown that the timber industry in Sarawak provided approximately half of the state's revenues and 60,000 jobs in the rural economy. Many of Sarawak's forests then were primary forest and later were converted, almost rapidly, into secondary forest.

Secondary forests are defined as those formed as a consequence of human impact on the forest lands (Brown & Lugo, 1990). This definition then, excluded causes from natural disturbance. It is important to emphasize ample attention towards secondary forest as the number of this forest type is likely to increase due to rapid human development; particularly towards industrialization and urbanization.

The problem comes in the form of continuous streams of accusation laid onto the island of Borneo in relation to the protocols implemented to manage its tropical forests. The concern is mainly on the most important single characteristic of tropical rain forests, which is, their astonishing diversity of plant and animal species (Richards, 1996). Tackling this issue in the future would require an adequate understanding of tropical forests. This study will emphasize on species composition in two different conditions. One is the comparison between logged and undisturbed mixed dipterocarp forest. Another is to monitor and examine the state of the heath forest of Jagoi. Hence, the objectives of this thesis are:-

1. To obtain the species composition of timber for undisturbed MDF and logged-over MDF.
2. To distinguish the structure and timber volume content between MDF and heath forest.
3. In relation to timber, to identify the variations of undisturbed MDF, logged-over MDF and heath forest in terms of basic parameters; height, d.b.h, volume and species diversity.

Literature Review

2.1 Estimating Species Composition

Species composition is one of the two fundamental parameters of species diversity. Species diversity represents the variety of organisms that make up the community. Species composition or richness represents the number of different species. The other parameter is the relative abundance of the different species. Species composition alone is not enough to understand the forest stand dynamics. The study of forest stand dynamics is important when disturbed forest is taken into account as one of the parameters to be studied. Assessment of forest stand dynamics requires individual trees to be measured (Young & Giese, 1990). Development of a fundamental prescription of a given forest land, requires standing tree measurements such as the diameter breast height (d.b.h) and height of the trees as prerequisites towards understanding the forest development.

Diameter breast height (d.b.h) is the most useful data to acquire on site when estimating volume and mass of the tree. The diameter tape or d.b.h tape is the tool used, calibrated to calculate the diameter of the tree rather than its circumference at 4.5 feet, or 1.3 meters above ground. Basal area is a derived parameter. Young and Giese (1990) described that d.b.h measurement is frequently converted to basal area which refers to the area of the cross section of a tree at breast height. There are various categories of tree height. Two of the most useful are the total tree height and merchantable height. Total height is the height of the tree, measured from ground level up till the highest point. When timber volume is taken into consideration, merchantable height is the right category required for the data analysis. Merchantable height refers to the height of the tree, measured from ground level up till the first branch or the crown point. Form factor of a tree is the ratio of its volume to the volume of a specific geometric solid of similar basal diameter and height (Brack & Ward, 1998). Often, the form factor of tree is based on cylinder. The product of tree basal area, tree height and form factor would give the volume.

2.2 Mixed Dipterocarp and Heath Forest

Lowland tropical rain forest is considered to be among the most diverse forest in the world (Richards, 1996). Mixed dipterocarp forest and heath forest are both types of lowland rain forest and occur under similar climate conditions but on different types of soil.

Mixed dipterocarp forest has wide range in terms of types of soil that this forest develops itself. Sarawak has a total land area of 12.3 million hectares. Approximately 10 million hectares or 80% of the total is covered with forest (Sarawak Forestry, 2002). Mixed dipterocarp forest (MDF) populates 7 million hectares of Sarawak's forest. Richards (1996) found that the mixed dipterocarp forest near Gunung Dulit developed on sticky red and yellow loams (kaolisols). Kaolisol is a soil type that is formed under the heat and heavy rainfall of the tropics. An analysis by Ashton and Hall (1992) found that mixed dipterocarp forests over the broad class of red-yellow podzolic soils have profound variation in terms of structures and floristic composition in relation to variation in topography, drainage and soil nutrients.

Heath or kerangas forest is common in Borneo (Richards, 1957). In Sarawak, kerangas forests are minimal in size. Particular vegetation populates the kerangas forests of Sarawak. Katagiri *et al.* (1991) described the formation of kerangas forest on podzolized siliceous sand (spodosols) drained by characteristic blackwater streams. Spodosol is one of the 12 soil orders in the U.S. Soil Taxonomy. The soil type is described as ashy grey, acidic soil with a strongly leached surface layer. Kerangas forest is often confined to sandy soils. The term 'kerangas' is an Iban word which means 'land on which rice cannot be grown' (Richards, 1996). Well-defined features easily distinguish kerangas forests from other forest types; density of the undergrowth as well as absence of strongly buttressed trees and large lianas (Richards, 1996).

2.3 Features for Secondary Forest

Tropical rainforests are converted into pastures and cropland, and later develop into secondary forest, at an alarming rate (Kessler *et al*., 2005). Due to variation in age, many published works concentrate heavily on secondary forests that are less than 60-80 yr-old (Brown & Lugo, 1990). Forests older than this are difficult to distinguish from primary forests. Most secondary forests created by logging as reported by Brown and Lugo (1990) are located in tropical Asia (47%) followed by tropical America (32%) and tropical Africa (21%).

Richards (1996) described some characteristics that are considered "typical" of secondary forests. One distinguishing feature is the scarcity of large trees. In addition, height of trees in secondary forests is less compared to primary forests on similar soils. The canopy of the forest is also more homogenous; the trees relatively have similar height. Richards (1996) also described the canopy of secondary forests is generally much even than that of primary forests. When describing the species inhabiting the secondary forest, Richards (1996) listed out fast-growing species such as *Macaranga, Malotus* and *Adinandra*. These species are light-demanding and short-lived. When they die, a compilation of less fast-growing, shade tolerant and longer-lived trees replaces the generation.

Brown and Lugo (1990) found that secondary forests have the capacity to accumulate woody plant at a more rapid rate partly due to the higher production of litter fall that contributed to higher fraction of the net productivity than stem wood biomass production. Other factors that help enhance the rapid regeneration of secondary forest are the stem coppicing and root sprouting as well as recovery by seed availability.

2.4 Tree Species in Different Forest Types

Sidiyasa (2001) highlighted the various tree species occupying different forest types found in the Kalimantan. There are nine genera of Dipterocarpaceae that are found in the Kalimantan, namely, *Shorea, Anisoptera, Parashorea, Diptercarpus, Cotylelobium, Dryobalanops, Hopea, Vatica,* and *Upuna.* From the 10 genera of the Malaysian Dipterocarps, only Neobalanocarpus has not been recorded from Borneo so far.

Other common and important tree species in lowland primary forests in Kalimantan are *Koompasia excelsa, Pometia pinnata, Dialium spp., Durio spp., Artocarpus spp.,* and *Dracontomelon dao.* Except for *Koompasia excelsa*, these species are important and well-known because of their edible fruits. *Sindora spp*., and *Palaquium spp*., are known for their timber quality.

For kerangas forest, which refers to forest growing on very acid soils that usually consist of white sands, the most common tree species that occur are *Shorea balangeran, Cratoxylum glaucum*, and *Eugenia spp*. Some species of *Lithocarpus* and *Buchania arborescens* also occur here. *Casuarina nobilis* and *Calophyllum incrassatum* were recorded in Sarawak. Sidiyasa (2001) also highlighted the fact that for kerangas forest, *Shorea balangeran* and *Cratoxylum glaucum* are the most common for his study sites in the Kalimantan.

2.5 Tropical Soil

Soils in the humid tropics are prone to weathering. Frequent and heavy rainfall drenches the soil thoroughly, with a surplus to penetrate to the ground water (Burnham, 1975). Thus, leaching occurs; a situation whereby the constituents which can be carried in solution are continually removed.

Burnham (1975) described the temperature and water content of a water-drained tropical soil help enhance the levels of biological activity. This includes the continuous production of organic matter by the vegetation and its rapid decomposition by microbes in and on the soil. Burnham (1975) then concluded that these three parameters, high levels of weathering, leaching and biological activity orchestrate the properties of tropical soil.

Red-yellow podzolic soils or ultisols is the ‘argilic’ or ‘textural B’ (B_t) horizon in the sub-soil (Burnham, 1975). Ultisols are considered soils of warm, humid regions (Coyne & Thompson, 1987). Base cycling for this soil type is less significant because of the severe weathering and leaching as well as parent material that has less limestone. Malaysia, which is considered to be the much wetter part of South East Asia has brightly coloured ultisols compared to pale, greyish colours of profiles from Burma or Thailand (Burnham, 1975).

Podzols (spodosols) are soils on coarse siliceous deposits. Parent materials are predominantly consisting of quartz. Quartz is low in clay as well as in bases. Burnham (1975) identified this soil type as readily permeable and well-drained though tendency of waterlogged is likely due to the influence of ground water. Heath or kerangas forest is one of the characteristic vegetation of lowland podzols.

Methodology

3.1 Study Sites

Figure 1 shows the study sites localities. The study sites were located in close proximity with Mount Jagoi (01°20.68’ N, 110°1.45’E), located at the Bau district, approximately 35 km from Kuching city. The site for plot set up for mixed dipterocarp forest was at Spolup Hill for logged-over area and Pinungan for undisturbed mixed dipterocarp forest. Plot set up for kerangas and alluvial forest was at Mount Po area.

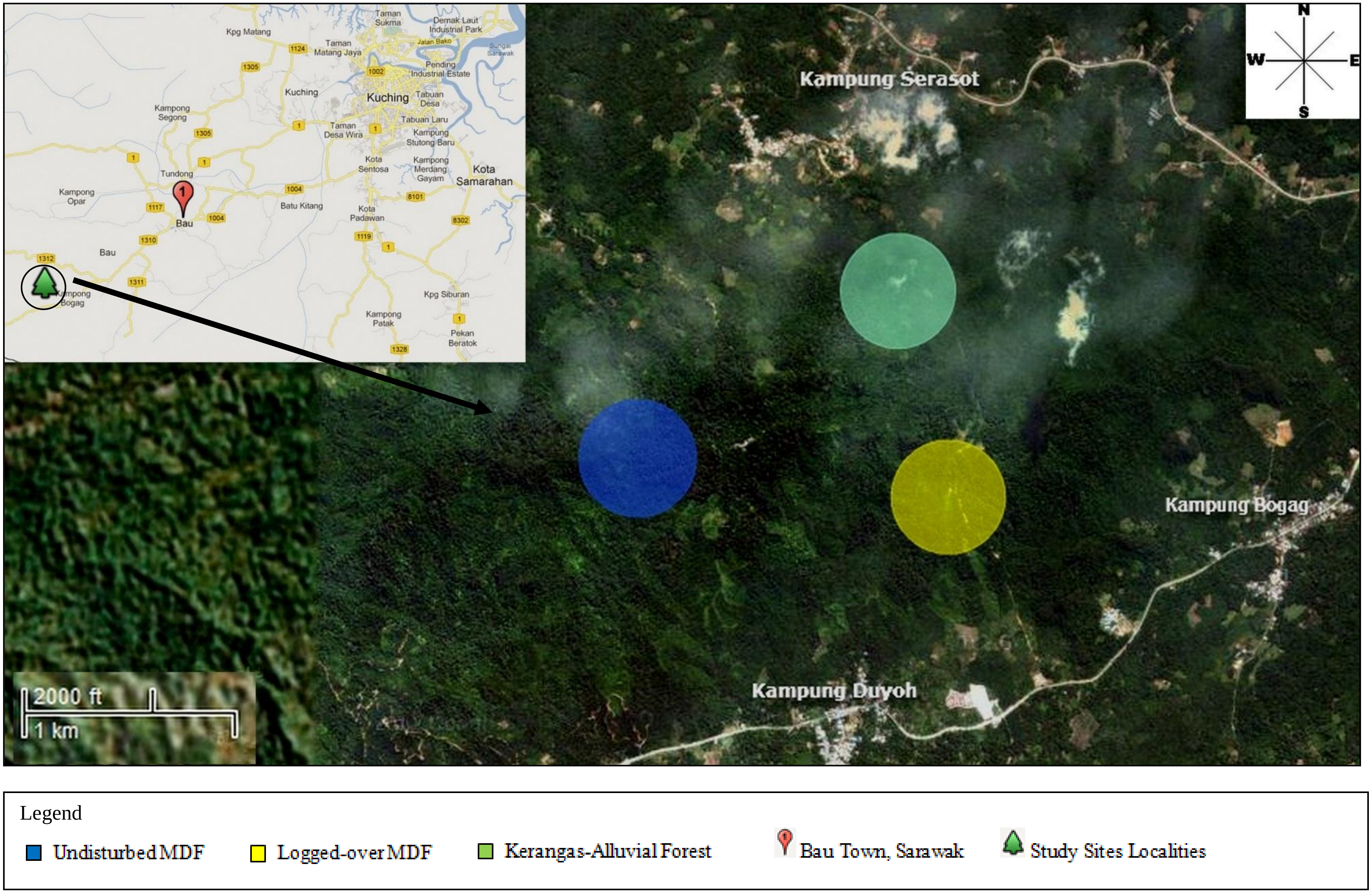

Figure 1: An overview of the study sites localities

3.2 Plot Design

For both forest types, the same plot design and set up was implemented. Systematic line sampling was employed in this study. A total of six sampling plots were established for each forest types. Six plots were added for mixed dipterocarp forest to collect data for logged area of the forest. The main plot was designed to be 20 m x 20 m which included four 10 m x 10 m subplots inside this main plot (Figure 2).

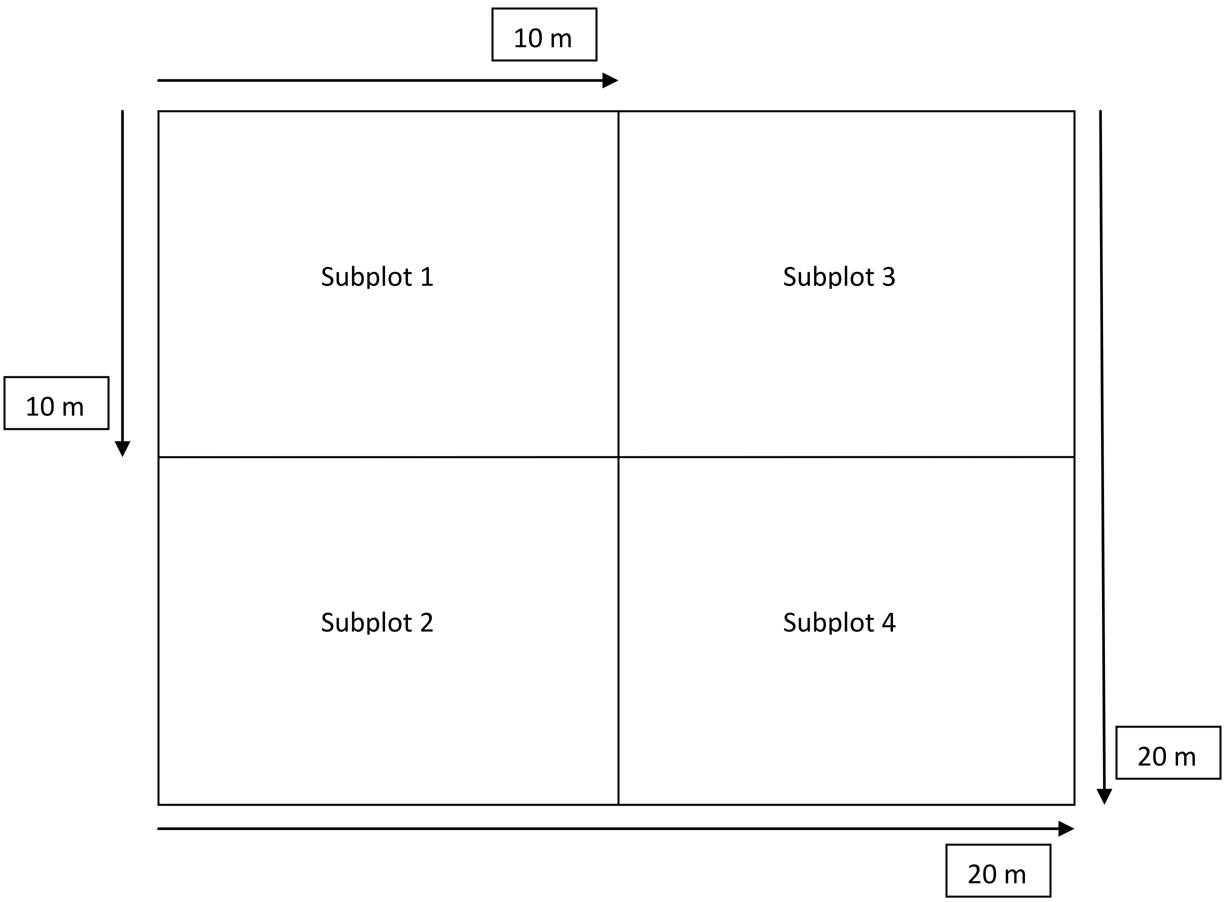

Figure 2: Plot design

3.3 Tools and Equipment

Tools and equipment used for the data collection were nylon ribbons, diameter tape, Suunto clinometer, measuring tape, data recording sheets, and Global Positioning System (GPS) device.

Visualization of the main plot was done using the nylon ribbon. Strips of the nylon ribbon were tied (above head height) to trees which marked the four corners of the main plot, half-way point of every sides of the main plot, as well as the center point of the main plot. Measurement of the diameter breast height was done using the diameter tape or d.b.h tape. Suunto clinometer was used to establish angle for height of trees. The angle then was used in the trigonometry principal to determine the height of trees (Philip, 2004). Measuring tape was used to measure the borderline for the establishment of the main plot. The GPS device was used for determining the coordinates for each plot.

3.4 Data Collection

After the plot set up, the diameter breast height was determined prior to estimating the height of all trees. Only trees that have d.b.h $\geq$ 5cm were included for the data. An informal source described that the smallest timber harvested and used by the local people has a diameter size much similar to the wrist size of an average adult male. The two different height categories determined for each individual tree were merchantable height and total height.

3.5 Data Analysis

3.5.1 Tree Volume Estimation

Standard timber measurement techniques were used to assess the volume of timber or biomass. The formula that was used for estimating tree volume is as shown below:-

$$V = 0.00007854 \text{ x } (\text{d.b.h})^2 \text{ x h x F}$$

Where, d.b.h = diameter breast height

h = merchantable height

F = form factor (0.65)

Volume per hectare was calculated using this formula

$$\text{Volume per ha.} = 10\,000 \text{ x } \frac{Timber\ volume\ per\ plot}{400\ sq.m}$$

Hence, the unit for V m^3/ha (volume per hectare); (*400 sq. m = 20 m x 20 m)

3.5.2 Measure of Species Diversity

For assessing the species diversity as well as species dominance, density and frequency, the approach used by Vasanthraj and Chandrashekar (2006) was applied. Shannon-Wiener index (H’) was used for estimating species diversity of trees in this study.

$$H' = - \Sigma p_i \ln p_i$$

Where p_i = Relative abundance for each individual species

ln = log / natural logarithm