UNIVERSITI PUTRA MALAYSIA

ANALYZING THE SPATIAL PATTERN OF POTENTIAL MOTHER TREES IN SISFEC BY USING GIS-BASED PATTERN ANALYSIS

SITI AISYAH BINTI YAACOB

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By

SITI AISYAH BINTI YAACOB

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DEDICATION

Specially dedicated to my lovely and beloved parent,

Yaacob bin Karim and Saripah binti Adnan (al-fatihah)

Who always never endlessly supported me throughout producing this thesis and always give me infinite love to boost up my spirit and courage while producing this thesis.

My brother,

Muhammad Hairi bin Yaacob

Who always supports me to complete this study successfully.

My supervisor,

Dr. Norizah binti Kamarudin

For always giving me advices and tips throughout producing this thesis.

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ABSTRACT

Mother tree is the parent tree that produces seedlings and saplings to ensure the sustainability of a forest production in an area. The sustainability of timber trees with good traits is important to ensure the quality of timbers. Generally, the distribution and pattern of mother trees are recorded aspatially without consisting the spatial information and tabular data of the mother trees. Therefore, this study was conducted in order to assess the distribution and pattern of the potential mother trees existed in Sultan Idris Shah Forestry Education Centre (SISFEC) by using Geographical Information System (GIS) technology. This study had been conducted in SISFEC, located in Puchong. The purposes of this study are to identify the potential mother trees in SISFEC based on phenology observation and to analyse the spatial distribution of mother trees in SISFEC by using spatial pattern analysis of GIS. Existing mother trees in SISFEC are searched and identified using the phenology observation and the location of the mother trees are marked with Global Positioning System (GPS). The scientific name, local name, diameter breast height (DBH), tree height and canopy percentage are recorded into the mother tree form made. The data are then analysed with average nearest neighbour of spatial analysis. The mother tree patterns that existed in SISFEC are dispersed and random pattern. Dispersed pattern are vastly found in flat area meanwhile the random pattern is available at the slope and steep area. There are four familia of mother trees identified in SISFEC which are Dipterocarpaceae, Apocynaceae, Thymelaeaceae and Sterculiaceae. The total number of mother trees recorded in this study is 171 with 19 species. As for conclusion, the most abundant species of mother trees recorded during this study is from Dipterocarpaceae family with the total of 163 trees. Meanwhile, the least species of mother tree in this study is from Apocynaceae with only 1 standing mother tree.

ABSTRAK

Pokok ibu adalah pokok induk dengan ciri-ciri yang baik yang menghasilkan anak benih dan juga anak pokok bagi memastikan kemampanan sesebuah pengeluaran hutan. Kemampanan pokok kayu dengan ciri yang baik adalah penting bagi memastikan kualiti kayu tersebut. Secara umumnya, taburan dan corak bagi pokok ibu direkodkan secara *aspatial* tanpa merangkumi maklumat spatial dan data berjadual pokok ibu tersebut. Oleh itu, kajian ini dijalankan bagi menilai tabuan dan corak pokok ibu yang berpotensi yang terdapat di *Sultan Idris Shah Forestry Education Centre* (SISFEC) dengan menggunakan *Geographical Information System* (GIS). Sebuah kajian telah dijalankan di SISFEC, yng terletak di Puchong. Tujuan kajian ini dijalankan adalah untuk mengenalpasti pokok ibu yang berpotensi di SISFEC berdasarkan pemerhatian fenologi dan untuk menganalisa taburan spatial pokok ibu di SISFEC dengan menggunakan *spatial pattern analysis* dalam GIS. Pokok ibu yang sedia ada di SISFEC dicari dan dikenalpasti menggunakan pemerhatian fenologi dan lokasi pokok ibu tersebut ditanda menggunakan *Global Positioning System* (GPS). Nama saintifik, nama tempatan, *diameter breast height* (DBH), tinggi pokok dan peratusan kanopi direkodkan di dalam borang pokok ibu yang telah dihasilkan. Maklumat tersebut kemudiannya dianalisa menggunakan *average nearest neighbor*. Terdapat tiga jenis corak secara umumnya dan corak bagi pokok ibu yang terdapat di SISFEC adalah corak teratur dan rawak. Corak teratur banyak dijumpai di kawasan yang rata serta landai manakala corak rawak dijumpai di kawan yang bercerun atau curam. Terdapat empat famili pokok ibu yang dikenalpasti semasa kajian ini iaitu Dipterocarpaceae, Apocynaceae, Thymelaeaeceae dan Sterculiaceae. Jumlah keseluruhan pokok ibu yang direkodkan sepanjang kajian ini adalah sebanyak 171 pokok terdiri daripada 19 spesies. Kesimpulannya, spesies yang paling banyak didapati sepanjang kajian ini adalah dari famili Dipterocarpaceae dengan keseluruhannya ialah 163 dirian pokok. Manakala, spesies pokok ibu yang paling sedikit yang direkodkan sepanjang kajian ini adalah dari family Apocynaceae dengan hanya 1 bilangan dirian pokok ibu.

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APPROVAL SHEET

I certify that this research project report entitled “Analyzing the Spatial Pattern of Potential Mother Trees in SISFEC by Using GIS-Based Pattern Analysis” by Siti Aisyah binti Yaacob has been examined and approved as a partial fulfilment of the requirements for the degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

Approved by:

_____
Dr. Norizah binti Kamarudin
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

_____
Prof. Dr. Mohamed Zakaria bin Hussin
Dean
Faculty of Forestry
Universiti Putra Malaysia

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LIST OF ABBREVIATIONS

AHFR	Ayer Hitam Forest Reserve
DBH	Diameter Breast Height
ESRI	Environmental Systems Research Institute
FAO	Food and Agriculture Organization
FDPM	Forest Department Peninsular Malaysia
GIS	Geographic Information System
GPS	Global Positioning System
HDF	Hill Dipterocarp Forest
LDF	Lowland Dipterocarp Forest
MTC	Malaysian Timber Council
R&D	Research & Development
RSO	Rectified skewed orthomorphic
SFM	Sustainable Forest Management
SISFEC	Sultan Idris Shah Forestry Education Centre
WGS	World Geodetic System

CHAPTER ONE

INTRODUCTION

1.1 General Background

With about 61 per cent of its land area under natural forest, Malaysia is home for over 2,650 tree species. Continued research and development (R&D) in all aspects of forestry and forest products such as suitable management and silvicultural system in forestry has enabled Malaysia's Permanent Reserved Forests to be managed well, and certified as sustainable, to ensure its perpetuity (Chiew, 2009). The timber industry in Malaysia is one of long-standing prominence, garnering much attention as one of the economy's core components of growth (Timber of Sabah, 2014).

Forests provide a wide variety of goods, services and processes needed by society including wood and fibre, non-timber products, clean water and air, wildlife and fish habitat, recreation, aesthetics and preservation of biodiversity (Thomas, 2000). Major forest types in Malaysia are mangrove forest, peat swamp forest, lowland dipterocarp forest (LDF), hill dipterocarp forest (HDF), upper hill dipterocarp forest, oak-laurel forest and montane ericaceous forest (Pengurusan Kayu Kayan Terengganu, 2008). In addition, there are also smaller areas of freshwater swamp forest, heath forest, forest on limestone and forest on quartz ridges.

The forests in Malaysia are mostly dominated by trees from Dipterocarpaceae family; hence the term 'dipterocarp forest' is used for the

forest area that is largely covered by them. This term is used due to the appearance and morphology of the fruit that have seed with two wings (di = two; ptero = wing; carp = seed) (WWF, 2016).

LDF occurs up to an elevation of 300m. Together with HDF, it constitutes the main forest type in Malaysia. Primary LDF consists of dominant and co-dominant strata reaching 45m in height with emergent trees reaching 60m in height. An intermediate stratum of trees forms a canopy between 23m and 30m, below which grows suppressed vegetation. Where emergent trees are rare, the forest forms a three-layered stand. Ground vegetation is of moderate density. About half of the upper-story trees belong to the Dipterocarpaceae family. In Sarawak, no distinction is made between LDF and HDF (Lee et al., 2002). They are generally referred to as mixed dipterocarp forest, and occupy an area from the inland limit of the freshwater peat swamps to the lower limit of the montane forests.

In Sabah, LDF is further divided into sub-types based on species dominance, such as *Parashorea malaanonan* forest and *Shorea/Eusideroxylon zwageri* forest (Lee et al., 2002). Lowland rainforest is far more threatened than montane forest because of its accessibility, more suitable soils for agriculture, and valuable hardwoods that can be used as timber. In many countries, virtually all lowland primary forest is gone, while montane forest still remains (Rhett, 2012).

The LDF is known as the most luxuriant of plant communities and amongst the finest dry land forest in the world (Whitmore, 1984). The typical characteristics of this forest type in Malaysia are having distinctive three layers of trees: emergent trees, main stratum (canopy) and smaller or shrubs trees; boles usually almost cylindrical, buttresses, cauliflory and ramiflory are common, frequently pinnate leaves, big woody climbers and bryophytes are rare (Jacobs & Kruk, 1988; Whitmore, 1990).

HDF occurs between elevations of 300m and 1300m. HDF are found on ultisols, oxisols and podzols with low agricultural potential (Lee et al., 2002). Ultisols (from Latin ultimus, "last") are strongly leached, acid forest soils with relatively low native fertility. They are found primarily in humid temperate and tropical areas of the world, typically on older, stable landscapes. Intense weathering of primary minerals has occurred, and much Calcium (Ca), Magnesium (Mg), and Potassium (K) have been leached from these soils.

Ultisols have a subsurface horizon in which clays have accumulated, often with strong yellowish or reddish colors resulting from the presence of Iron (Fe) oxides. The 'red clay' soils of the south-eastern United States are examples of Ultisols (University of Idaho, 2015). Oxisols (from French oxide, "oxide") are very highly weathered soils that are found primarily in the intertropical regions of the world. These soils contain few weatherable minerals and are often rich in Iron (Fe) and Aluminium (Al) oxide minerals. Most of these soils are characterized by extremely low native fertility, resulting from very low nutrient reserves, high phosphorus retention by oxide

minerals, and low cation exchange capacity (CEC). Most nutrients in Oxisol ecosystems are contained in the standing vegetation and decomposing plant material. Despite low fertility, Oxisols can be quite productive with inputs of lime and fertilizers (University of Idaho, 2015).

Podzols are soils with an ash-grey subsurface horizon, bleached by organic acids, on top of a dark accumulation horizon with brown or black illuviated humus and/or reddish iron compounds. Podzols occur in humid areas, in particular in the Boreal and Temperate Zones but locally also in the tropics. The name Podzol is used in most national and international soil classification systems; the USDA Soil Taxonomy refers to these soils as Spodosols (FAO, 2001). They currently form the bulk of the productive permanent forest estate. In Sabah, two sub-types of hill dipterocarp forest are distinguished: 1) *Shorea* forest (Selangan Batu forest) found on steeper and higher hills; and 2) *Dipterocarpus/Shorea* forest on sandstone escarpments along the east and north coast (Lee et al., 2002).

Upper hill or montane forest occurs above 1300m on brown earth and podzol soils. In Peninsular Malaysia this forest type contains few dipterocarp species. Common species found belong to Fagaceae (*Quercus, Lithocarpus* and *Castanopsis* spp.) and Lauraceae familia. Other species include *Agathis alba*, *Engelhardtia* spp. and *Podocarpus* spp. Ericaceous ('mossy') forests with few oaks occur above 1600m in the cloud belt (Lee et al., 2002). *Pteris ovalifolia*, *Rhododendron* spp. and *Vaccinium* spp. are common on acid peaty gley soils (Lee et al., 2002).

In Sabah, montane dipterocarp forests occur above the zone of hill dipterocarp forests in the Crocker Range and the central uplands. The main species here are *Shorea platyclados*, *Shorea venulosa* (on ultra-basic rocks), *Shorea monticola*, *Shorea laevis*, *Hopea montana*, *Hopea dyeri*, *Dipterocarpus ochraceus*, *Vatica dulitentis*, and *Vatica umbonata*. At higher elevations these forests become oak-chestnut forests and, at elevations over 2000m, they are replaced by mossy forests rich in conifers and Ericaceae (Lee et al., 2002).

Generally, the timber quality of native timber trees is superior to that of the common exotics, leading to a higher market value (Gregori, 2010). However, the scaling up of the domestication of native timber trees is constrained by the limited availability of planting materials and low quality germplasm (Tolentino et al., 2002; Gregorio et al., 2005). Timber, as the world's second largest industry after food provides a vast scope of employment opportunities and raw materials with further flexible functions.

In order to produce a well-developed forest, the area of the forest must consist of several species of mother trees that can ensure the sustainability of commercial timber species at particular area. Mother tree should be the largest, healthiest, the most straight, large crown, and has most high survival rates. The survival of trees, growth performance, length of rotation and volume and quality of timber are greatly influenced by the quality of seedlings used. Seedling quality is described in terms of physical and genetic characteristics. Physical quality relates to silvicultural treatments applied to

seedlings in the nursery while genetic quality expresses the characteristics of mother trees that can be transferred to seedlings (Wightmann, 1999).

In Peninsular Malaysia, phenology observation is conducted in choosing the seeds from the entrusted and selected mother trees. Phenology means the study of the timing of recurring biological events in the plants, the causes of the timing with regards to biotic and abiotic forces and the interrelation among phases of the same or different species (Forestry Department Peninsular Malaysia (FDPM), 2014).

In order to balance the competing resource conservation and resource use, activities must be accommodated. Accessing the feasibility of these multiple uses is greatly enhanced by the use of Geographic Information System (GIS) techniques. Many governments, states, and private forestry organizations and agencies today utilize geospatial technology such as GIS and satellite imagery for various applications supporting analysis, assessment and management.

In North America, GIS is frequently applied to geographically oriented computer technology, integrated systems used in substantive applications and more recently, a new discipline which is generating massive interest worldwide (Maguire, 1991). GIS provides the power to fully utilize information and find the geographic relationships between data. Map data can be mined with database queries. Making advanced spatial queries is

another new way to extract meaning from data (Fountains America Inc., 2014).

Forest management planning involves making forecasts about what the future forest will look like relative to alternative management activities. This ability is crucial to nearly all aspects of management forecasting, particularly long-term wood and wildlife supply. GIS stores both the geographic and numerical structure of the forest stands and links that spatial database to the planning models. It allows the manager to effectively add both the important temporal and spatial dimensions to the management planning process. Within the limits of the inventory and model, the manager can then map what the forest will look like for example in 5, 10, 25, or 100 years in the future (Fountains America Inc., 2014).

Spatial forest modelling using GIS technology is essential to planning harvesting strategies. Spatial models use both the absolute and relative geographic positions of forest stands in developing and testing harvesting strategies (Schroeder et al., 2006). These strategies can help in producing a consistent and sustainable forest that is far from disturbance. Using individual stand locations allows the manager to produce harvest schedules and candidate harvest blocks that are easily translated into maps. Mapping different harvesting strategies lets the manager see the economic impact of the harvest and the impact on nearby wildlife (Alves et al., 2009).

Spatial Analysis extends the basic set of discrete map features of points, lines and polygons to surfaces that represent continuous geographic space as a set of contiguous grid cells. The consistency of this grid-based structuring provides a wealth of new analytical tools for characterizing contextual spatial relationships, such as effective distance, optimal paths, visual connectivity and micro-terrain analysis. In addition, it provides a mathematical/statistical framework by numerically representing geographic space.

Pattern analysis is the study of the spatial arrangements of point or polygon in two-dimensional space in the GIS. Pattern analysis uses distance measurement as inputs and statistics (spatial statistics) in describing the distribution pattern. As generally, a pattern analysis can reveal whether a point distribution pattern is random, dispersed, or clustered.

1.2 Justification

The sustainability of timber trees with good traits is important to ensure the quality of timbers. Hence, the distribution of mother trees is essential to be recorded to ease the collection of seeds and to ensure the variability of traits and origination is known. Generally, the distribution of mother trees are recorded aspatially. Delay in seed collection is possible when no locational information given for the distribution of mother trees. With spatial information and tabular data, seed collection could be more effective. Thus, this study

was conducted in order to assess the distribution and pattern of the potential mother trees existed in SISFEC by using GIS technology.

1.3 Objectives

The aim of this study is to spatially identify the distribution of potential mother trees in SISFEC. To be specific, the objectives are;

1. To identify the potential mother trees in Sultan Idris Shah Forestry Education Centre (SISFEC) based on phenology observation, and
2. To analyse the spatial distribution of mother trees in SISFEC by using spatial pattern analysis of GIS.

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