UNIVERSITI PUTRA MALAYSIA

STEM DISTRIBUTIONS AND INCREMENTAL VALUES OF SELECTED DIPTEROCARP AND NON-DIPTEROCARP SPECIES WITHIN THE 50-HECTARE PLOT OF THE PASOH FOREST RESERVE, NEGERI SEMBILAN, PENINSULAR MALAYSIA

MICHAEL VICTOR GALANTE

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MICHAEL VICTOR GALANTE

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DEDICATION

The following report is dedicated to the people in my life whom I have come across, in guidance and consultation, and who's perseverance and strength to show me the correct way, was not in vain as is proven here. If there were anyway that I could repay those kind words, helping hands, or friendly gestures, I would not hesitate, for it would be the one decision in which there would be no bias.

ACKNOWLEDGMENTS

This thesis was several long, laborious months in the making. Since its inception in August 2001, it has undergone substantial changes. I am grateful to the anonymous reader, for pointing out the significance of growth and yield studies in contemporary forestry, as the need to showcase the forest's development should always be a major concern when making resource and land-use decisions. Furthermore, understanding the full implications of management decisions towards our natural resources are decisions that do not come by chance, and should be exercised with the most extreme caution and consideration.

This thesis has been inspired by the growing environmental influences, which are constantly displayed, but perhaps overlooked, in our day-to-day lives. Recycling, reusing, and conserving; these are not new terms, but ones that have yet to reach their target in society. Only now, in unison with the 2002 World Summit held in Johannesburg, is the fragility of the world's forests and ecosystems starting to make an impact on people's lives, resulting in a strengthened respect for our natural environment. The concern does not lie within the context of losing our forests; forest cover will always be there. This issue stems from the composition of the forest, its genetic makeup, and the biodiversity held within. Carrying capacity, conservation and the adaptation potential to a changing environment, outside of the forest. These are the key issues that foresters are trying to gain insight into. Something I like to say, in retrospect to this problem is, "This is not a forestry problem, rather, a social problem". Other researchers like to call this 'counter-discourse'.

As forestry has been, and still is, subject to rich debates regarding "sustainability" in academia, the rationale that stems from this dilemma, is the realization of the inevitability, that neither man nor animal can avoid. I would like to thank my supervisor, Associate Professor Ashari Muktar, for his unending patience in answering my grueling and sometimes misunderstood questions from various points of view. Unknowingly possessing the ability to generate thought, he always prompted me to deepen my thinking towards new and inspiring ideas. Furthermore, I would also like to thank Dr. Awang, for his seemingly inexhaustible strive for excellence, and his lasting influence towards the cognitive processes in which I was unaware. I would also like to recognize his "reality teaching approach", which always found their target when explanations were required.

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LIST OF ABBREVIATIONS

n	Stem number
G	Basal Area per hectare (G/*ha*)
ASEAN	Association of Southeast Asian Nations
A.S.L.	Above Sea Level
CO_2	Carbon Dioxide
CIFOR	Centre for International Forestry Research (CGIAR)
C & I	Criteria & Indicators for Sustainable Forest Management
DBH	Diameter at Breast Height
EFGM	Empirical Forest Growth Model
FAO	Food and Agriculture Organization of the United Nations
FMU	Forest Management Unit
FT	Feet (1 foot = 12 inches)
GEF	Global Environment Facility
GCL	Girdling and Cutting of Lianas
Ha/ha	Hectare = 10,000 square meters
IBP	International Biological Programme
ITTO	International Tropical Timber Organization
MAB	Man and the Biosphere Programme
MAI	Mean Annual Increment
MOU	Memorandum of Understanding
MTH	Mixed Tropical Hardwood

NFP	National Forest Programme
NGO	Non-Governmental Organization
NTFP	Non-Timber Forest Products
NWFP	Non-Wood Forest Products
PAI	Periodic Annual Increment
PFE	Permanent Forest Plots
PSP	Permanent Sample Plots
R&D	Research and Development
RFP	Regional Forest Program
STFI	Smithsonian Tropical Forest Institute
SFD	Sustainable Forestry Development
SFM	Sustainable Forest Management
UN	United Nations

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By

MICHAEL VICTOR GALANTE

SEPTEMBER, 2002

The objective of this study is to comparatively evaluate the distribution and growth increments of selected Dipterocarp and Non-Dipterocarp species occurring in the natural forest area of the 50-*ha* Plot, Pasoh Forest Reserve, Negeri Sembilan. The trees selected from the Dipterocarpaceae family are: *Shorea leprosula* Miq., *Shorea macroptera* Dyer., and *Shorea parvifolia* Dyer., and the trees from the Non-Dipterocarpaceae family are: *Cynometra malaccensis* Meewen. (Leguminoseae family), *Koompassia malaccensis* Benth. (Leguminoseae), and *Quercus argentata* Korth. (Fagaceae family). For each of these species within the years 1987, 1990, and 1995, the calculation of the stand density, periodic mean annual diameter increment, average annual basal area increment, mortality, and volume was conducted. Data enhancement by plotting the spatial distributions and conducting tests for correlation (linear regression) were conducted for precision.

The results showed that the stand density of *Shorea leprosula* Miq., *Shorea macroptera* Dyer., *Shorea parvifolia* Dyer., *Cynometra malaccensis* Meewen., *Koompassia malaccensis* Benth. and *Quercus argentata* Korth., for all trees ≥ 1 *cm* dbh in the 50-*ha* plot averaged 2643.67 ha^{-1}, 1555.33 ha^{-1}, 1469.33 ha^{-1}, 1192.33 ha^{-1}, 654.33 ha^{-1}, and 981 trees ha^{-1} respectively. Whereas, the mean basal area per hectare was found at 52.32 m^2, 13.77 m^2, 25.00 m^2, 16.49 m^2, 31.96 m^2, and 18.23 m^2 for all trees ≥ 10 *cm* dbh respectively. Dipterocarp average annual diameter increment for the 1987-1990 and 1990-1995 periods ranged from 0.37-0.57 $cm\ ha^{-1}\ yr^{-1}$ and 0.41-0.72 $cm\ ha^{-1}\ yr^{-1}$ respectively. The Non-dipterocarp species average annual growth increments for the same periods ranged from 0.37-0.52 $cm\ ha^{-1}\ yr^{-1}$ and 0.26-0.65 $cm\ ha^{-1}\ yr^{-1}$ respectively to the order previously stated. The Dipterocarp mortality rate for the 1987-1990 and 1990-1995 periods ranged from 1.24-1.64% and 1.24-2.95% respectively. Non-Dipterocarp mortality for the same periods ranged from 0.86-1.75% and 0.65-2.56% respectively. Average volumes for the years 1987, 1990 and 1995 for the Dipterocarp species were found to be 8.95 $m^3\ ha^{-1}$, 1.58 $m^3\ ha^{-1}$ and 3.24 $m^3\ ha^{-1}$ respectively. Non-Dipterocarp species averaged volumes of 2.14 $m^3\ ha^{-1}$, 5.87 $m^3\ ha^{-1}$, and 2.49 $m^3\ ha^{-1}$ respectively. All volume calculations were found for all trees ≥ 30 *cm* dbh. Strong positive correlations with tree densities, basal areas and volumes were found present in the stand.

Results showed that the dipterocarp species maintained a higher representation when compared to the non-dipterocarp species, with all species showing relatively dense populations at the seedling level, and sparse in emergent trees. *Shorea leprosula* maintained the most abundant and widespread distribution and this trend was followed in basal area, growth increment and volume results. Mortality was consistent with national tabulations and previous studies with the dipterocarp species maintaining their dominance throughout the 50-*ha*. Spatial distributions followed documented species characteristics with the phenological influences stemming from soil, water, and elevation.

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Oleh

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Kajian ini bertujuan untuk menilai perbandingan pertumbuhan antara spesis dipterocarp yang dipilih dan bukan-dipterocarp yang dipilih di Hutan Simpan Pasoh, Negeri Sembilan dalam plot seluas 50-*ha.* Pokok yang dipilih daripada spesies dipterokarp adalah seperti: *Shorea leprosula* Miq., *Shorea macroptera* Dyer., and *Shorea parvifolia* Dyer., dan pokok-pokok daripada spesies bukan-Dipterocarp: *Cynometra malaccensis* Meewen. (Leguminoseae), *Koompassia malaccensis* Benth. (Leguminoseae), dan *Quercus argentata* Korth. (Fagaceae). Bagi setiap spesies antara tempoh 1987, 1990, dan 1995 pengiraan bagi struktur pokok, min peningkatan diameter tahuanan, purata peningkatan keluasan basal tahunan kadar kematian dan isipadu volum telah dilakukan. Data-data dalam kajian ini telah diperkukuh dengan perwakilan dalam Taburan "Spatial", dan pengujian korelasi bagi ketepatan data-data tersebut.

Hasil kajian menunjukkan bahawa struktur bagi kesemua pokok ≥ 1 *cm* dbh di dalam kawasan plot 50-*ha* secara puratanya berukuran 2643.67 ha^{-1}, 1555.33 ha^{-1}, 1469.33 ha^{-1}, 1192.33 ha^{-1}, 654.33 ha^{-1}, dan 981 pokok ha^{-1} masing-masing. Min kawasan basal bagi kesemua pokok ≥ 10 *cm* dbh masing-masing berukuran 52.32 m^2, 13.77 m^2, 25.00 m^2, 16.49 m^2, 31.96 m^2, dan 18.23 m^2. Manakala purata peningkatan

pertumbuhan tahunan bagi dipterocarp untuk tahun 1987-1990, dan 1990-1995 adalah antara 0.37-0.57 $cm\ ha^{-1}\ yr^{-1}$ serta 0.41-0.72 $cm\ ha^{-1}\ yr^{-1}$.

Purata peningkatan pertumbuhan tahunan bukan-Dipterocarp bagi tempoh yang sama pula adalah antara 0.37-0.52 $cm\ ha^{-1}\ yr^{-1}$ dan 0.26-0.65 $cm\ ha^{-1}\ yr^{-1}$. Kadar kematian dipterocarp dalam tempoh 1987-1990, dan 1990-1995 masing-masing antara 1.24-1.64%, serta 1.24-2.95% manakala kadar kematian bagi bukan-Dipterocarp dalam tempoh yang sama pula adalah antara 0.86-1.75% dan 0.65-2.56% masing-masing. Purata isipadu bagi tiga tempoh masa tersebut ialah 8.95 $m^3\ ha^{-1}$, 1.58 $m^3\ ha^{-1}$, 3.24 $m^3\ ha^{-1}$, 2.14 $m^3\ ha^{-1}$, 5.87 $m^3\ ha^{-1}$, dan 2.49 $m^3\ ha^{-1}$ yang dilakukan pada kesemua pokok $\geq$ 30 *cm* dbh. Korelasi positif yang kukuh antara kepadatan pokok, kawasan basal dan isipadu ditunjukkan dalam kajian ini.

Hasil kajian menunjukkan bahawa spesies dipterocarp memperlihatkan perwakilan yang lebih tinggi berbanding dengan spesis bukan-dipterocarp . Dalam pada itu, kesemua spesis memperlihatkan kepadatan populasi yang tinggi pada anak-anak pokok dan kepadatan populasi yang rendah pada pokok-pokok yang tinggi. "*Shorea leprosula*" merupakan populasi spesis yang paling padat dan juga menunjukkan statistik yang paling tinggi dari segi hasil kajian kawasan basal, peningkatan pertumbuhan serta isipadu. Secara keseluruhannya, kadar kematian adalah konsisten dengan tabulasi kebangsaan dan kajian-kajian lepas. Kajian ini mendapati bahawa spesies dipterocarp mencatatkan kadar kematian yang dominan di dalam plot kajian 50-*ha* itu. Taburan "Spatial" (Spatial Distributions) memperlihatkan persamaan dengan ciri-ciri spesis dipterocarp yang pernah didokumentasikan dan juga pengaruh daripada tanah-tanih, air serta tahap ketinggian.

CHAPTER I

INTRODUCTION

Overview of the Study

Prior to the undertaking of forest management, the pupil must accept the function that growth and yield is the basic understanding of the tropical forest environment. Indulging in its' sheer magnitude and unforgiving diversity creates life-long journeys through research and endless questions. Understanding the composition and relationships involved may prove to be an impossible task if the intention is to conclusively dissect and define the processes within. To understand the forest is to analyze its growth. From its growth, stems the degree of diversity within. Once this is realized, the researcher will understand its' structure, balance, and its phases of development. Furthermore, this value will also dictate the carrying capacity, which, indirectly, has the potential to determine the future of our existence.

As the Earth's ecosystem is constantly shifting, the quiet undertone of the realization that we, as a human race, must try to "undo" what has already begun; otherwise known as "Deforestation" (FAO, 2001). Species growth and environmental adaptability is constantly changing as a result of deforestation on the micro and macro levels, primarily due to the increasing external pressures of human intervention, and their need for forest resources (FAO, 2001). Therefore, continuous studies must be carried out to identify the trends of growth and adaptability of our natural forests against the hanging environment. Knowledge of these trends will increase the probability of tomorrow's managers and researchers to successfully implement new management strategies, which will not only satisfy biological carrying capacities, but will also provide the harmonious relationships of which all populations can coexist with the natural environment.

Studies in growth and yield are becoming increasingly important. Leading organizations such as the International Tropical Timber Organization (ITTO), the Global Environment Facility (GEF), and the Danish Cooperation for Environment and Development (DANCED) are allocating larger budgets for research and development within this field (Yaik, 2002_a). Furthermore, ongoing research is currently being carried out on the economic worth of the forests ecological values, including a joint project involving FRIM (Forest Research Institute Malaysia) and the NIES (National Institute for Environmental Studies of Japan (Chuen *et. al*, 2000).

Piecing together the various dynamics of the tropical rainforest is one of the underlying aspects of growth and yield studies. Understanding the physical environmental factors and the responding ecological compositions (phenology) is crucial for data analysis and interpretation. More importantly, the researcher must fully comprehend, with a willingness to learn and postulate, the forests ecophysiological behaviours and their correlated demographic features. This is under the assumption that evolution and species adaptation is highly influenced by the processes of forest dynamics (Bazzaz, 1983).

Issues relating to the study of growth and yield are vast and extensive. Examining the system as a whole, and concentrating on breaking the system down into smaller sub-units, increases the potential for a more exact analysis. As there are countless parameters involved, most researchers are deriving "models' to help understand and systematically place all variables within the context, into their respective categories. As stated by Kleine, (1997), the availability of growth and yield information where tropical forests are being managed is very limited, and perhaps non-existent. Therefore, the intention of these models is to describe mathematically; the ecological relationships based on the observations of the forest growth.

Problem Statement

Growth and yield data is complementary to forest management. The combination of forest ecological, economic, and social data can help researchers and managers to make sound, informed, and practical decisions. Knowingly, decisions are only as strong as the weakest link (with regards to information gathering and analysis). Therefore, growth and yield studies are comprehensive, exact, and can be carried out in a periodic, uniform, and systematic fashion. Reliable and exact information is of the utmost importance as any miscalculation or misinterpretation can have disastrous effects on management decisions, and the overall outcome of the study.

As forest owner's and manager's choices are severely limited to the options available to them (dictated by carrying capacities and economies), growth and yield studies are becoming increasingly recognized due to their specific nature, and reliability. This is summarized by Suhendang (2002, pp.10) "Forest management strategy should be developed based on the latest information of forest condition and growth and yield data". Internationally standardized growth and yield studies are becoming prominent in the planning process of future forest resources. Disregarding these studies is not an option as the future of the forest lies within.

Purpose of the Study

There have been numerous studies conducted on the subject of growth and yield within the Pasoh Forest Reserve in the past. Some have been ambitious and some have been relaxed. However, the intentions here are similar: to educate and further the understanding of tropical forest stand growth and their influencing characteristics in which researchers find unique, diverse, challenging, and intriguing. This paper is does not deviate from normal growth and yield studies. Rather, the intention is to correlate with existing research, and multiply this learning behavior by utilizing the cited literature to expand and amplify the findings logically, and idealistically within this new framework.

Significance of the Study

Understanding the methodology of growth and yield studies and the reasoning behind the chosen criteria for analysis will concisely express a greater understanding of the forest dynamics and its intricacies by the researcher. As this information highlights the research area, it is important to note that all growth and yield analyses are continuous, and should any problems arise during an enumeration, it can be carried over and/or corrected in the following enumeration.

Justification

Implementing proper forest management requires a full understanding of the forest and its biological make-up. This information can be generated by conducting a growth and yield study. Choosing the forest type to study is partly determined by market trends; however, personal preference cannot be ignored. Therefore, the author examines the chosen species for the following reasons: 1) all exhibit an above average representation within the 50-ha plot, 2) all are classified as 'tall-emergent' species.

The author has specifically included in the Non-Dipterocarp species listing, some species that are not commercial and of no particular interest to any parties (based on the literature). However, if the outlook of the reader is from an ecological standpoint, they will quickly realize the importance of these "non-important" species. Within the context of biology, everything in nature has a purpose and a function. The intention here is not to determine the function or role, but it to stimulate the reader to postulate their own questions as to why these species are present in such abundance, and what role(s) they play in the forest. The possibilities that present themselves will better prepare the managers and workers within the forest environment for tomorrow's issues and dilemma's.

Objective of the Study

The objective of this study is to comparatively evaluate the stand structure and growth increments of select Dipterocarp and Non-Dipterocarp species occurring in the natural forest area of the 50-*ha* Plot, Pasoh Forest Reserve, Negeri Sembilan. The species selected from the Dipterocarpaceae family are: *Shorea leprosula* Miq., *Shorea* *macroptera* Dyer., and *Shorea parvifolia* Dyer. The species selected for evaluation from the Non-Dipterocarpaceae group are: *Cynometra malaccensis* Meewen. (Leguminoseae), *Koompassia malaccensis* Benth. (Leguminoseae), and *Quercus argentata* Korth. (Fagaceae).

Within this context, the author intends to determine the following for each species within the time frames of 1987-1990, and 1990-1995: average annual diameter growth increment, average annual basal area increment, average annual volume increment and mortality. The author will enhance these findings by plotting the spatial distribution for each species within the 50-*ha* plot. Finally, light statistical analysis will be conducted using the basic regression technique to determine some correlations between variable groups.

Furthermore, factors such as sunlight, soil, water, canopy structure, and other physio-ecological factors which have a high influence in determining which species grows better in the natural forest environment will be highlighted along with the data by referencing previously published material. This will enable the author to study the situation in its entirety, and propose general inferences and trends.

Hypothesis

Physiological traits and forest type play important roles in species growth performance. It is in the author's opinion that trees within the Dipterocarpaceae family will produce a higher average growth increment than trees located outside this family (Non-Dipterocarpaceae family).

Assumptions

It is assumed that this data set, which consists of secondary data, is said to be true, and no alterations of any kind have occurred from the collecting agency, or the author.

Limitations

Within this context is the use of secondary data. Although this data has come from a trusted source, some variance and bias on the data collectors behalf may have occurred due to personal perception, judgement, lack of precision, general assumptions etc. There is no way to correct for this unless another full enumeration of the area is conducted.

Definitions

Accretion	material added to trees measured at both occasions (Kozlowski, 1962)
Enumeration	to determine the degree of accuracy attainable by the mathematical model employing the successive inventory technique for computing (i) tree movement, (ii) average diameter increment, and how it compares with more rigorous sample and increment plot techniques (Seth, 1974)
Gross Growth	total amount of material produced on an area (Kozlowski, 1962)
Ingrowth	trees that grow into the lowest recognized diameter limit in the timber stand during the specified growth period (ASEAN, 1990)
Merchantable Volume	something less than total volume by an amount that is unusable because of some kind of defect (Kozlowski, 1962)
Microclimate	the interactions between the structure of the stand (height, leaf area, foliage and branch density and distribution) and the prevailing weather (Landsberg, 1986)
Models	allow exploration of the consequences of varying the rates of various processes, and of exploring the sensitivity of the system to changes, uncertainties and variations in parameter values (Landsberg, 1986)
Mortality	the volume, at time of death, of trees that died during the period between measurements (Kozlowski, 1962)
Net Growth	the difference in volume at the two occasions and is usable as an observation for each sampling unit (Kozlowski, 1962)