



UNIVERSITI PUTRA MALAYSIA

***QUANTITATIVE ASSESSMENT OF THREE SHOREA SPP FOR SUNGAI
MENYALA VIRGIN JUNGLE RESERVE, NEGERI SEMBILAN***

Muhammad Amirul Asyraf Bin Hashim

FH 2016 78

**QUANTITATIVE ASSESSMENT OF THREE *SHOREA* SPP FOR SUNGAI
MENYALA VIRGIN JUNGLE RESERVE, NEGERI SEMBILAN**

By

**Muhammad Amirul Asyraf Bin Hashim
(173241)**

**A Project Report Submitted in Partial Fulfillment of the Requirements
For the Degree of Bachelor of Forestry Science in the
Faculty of Forestry
Universiti Putra Malaysia**

2016

ABSTRACT

In Peninsular Malaysia, Virgin Jungle Reserve (VJR) has been established since the 1950's and are initially known as Permanent Forest Reserve. Due to its status as a Permanent Forest Reserve, the forest has been spared from timber exploitation from the gazetting to the status since 1950. Since then, this forest area changed naturally and this condition is called a Virgin Jungle, meaning it has not been developed or exploited for commercial purposes. This study made use of the abundant tree stands from the family Dipterocarpaceae, genus *Shorea* present inside the forest reserve. The study was focused on three *Shorea* species, which all *Shorea parvifolia*, *Shorea acuminata* and *Shorea leprosula*. The objective of this study were to determine the abundance and distribution of these three species and to investigate the difference in basal area and volume of the three *Shorea* species. The primary data for each species were collected from a belt-transect plot sited at compartment 6 of the forest reserve with covering 2.0 ha. The population density of these three *Shorea* species, has an average population density for *Shorea leprosula* of 17.5 trees per hectare, for *Shorea parvifolia*, 14 trees per hectare and for *Shorea acuminata* 13.5 trees per hectare. The distribution of trees indicates the adverse characteristic of De iocourt's factor procedure (reverse J distribution) where stems frequencies increase with the increase in DBH. The growth stage distribution has a growth stage distribution of 3.5% small trees, 37.8% medium trees, 58.7% large trees. From the results for each species in this study, it can be concluded that the study area has a high number of medium sized trees as its main forest structure with *Shorea parvifolia* being the dominant stand with the biggest number of individuals among the other two but with *Shorea leprosula* having the biggest volume and basal area, followed by *Shorea parvifolia* and *Shorea acuminata*. This study will give a guideline for relevant authority on forest inventory and stand structure determination of Sg.Menyala Permanent Forest Reserve.

ABSTRAK

Di Semenanjung Malaysia, Hutan Simpanan Dara (VJR) telah ditubuhkan sejak tahun 1950an dan pada awalnya dikenali sebagai Hutan Simpan Kekal. Oleh kerana statusnya sebagai Hutan Simpan Kekal, hutan ini telah terselamat daripada eksploitasi kayu semenjak pewartaanya sebagai Hutan Simpan Kekal pada tahun 1950. Sejak itu, kawasan hutan ini berubah secara semula jadi dan sekarang dipanggil sebagai Hutan Dara, bermakna ia belum dibangunkan atau dieksploitasi untuk tujuan komersial. Kajian ini dibuat menggunakan dirian pokok dari family Dipterocarpaceae, genus *Shorea* yang ada di dalam hutan ini, member tumpuan kepada tiga spesies *Shorea*, *Shorea parvifolia*, *Shorea acuminata* dan *Shorea leprosula* bertujuan untuk menentukan jumlah dan kesebaran ketiga-tiga spesies ini dan untuk menyiasat perbezaan dalam kawasan pangkal dan isipadu spesies *Shorea* di kawasan kajian. Data primer bagi setiap spesies ini dikumpulkan menggunakan plot "belt-transect" bertapak di kompartmen 6 hutan ini dengan jumlah kawasan meliputi 2.0 ha. Kepadatan penduduk ketiga-tiga spesies *Shorea*, mempunyai kepadatan penduduk purata untuk *Shorea leprosula* 17.5 pokok sehektar, untuk *Shorea parvifolia*, 14 pokok sehektar dan untuk *Shorea acuminata* 13.5 pokok sehektar. Taburan pokok menunjukkan ciri-ciri buruk prosedur faktor De iocourt itu (terbalik pengedaran J) di mana batang frekuensi meningkat dengan peningkatan dalam DBH. Pengagihan peringkat pertumbuhan mempunyai taburan peringkat pertumbuhan pokok-pokok kecil 3.5%, 37.8% pokok sederhana, 58.7% pokok-pokok besar. Daripada keputusan bagi setiap spesies dalam kajian ini, dapat disimpulkan bahawa kawasan kajian mempunyai bilangan yang tinggi pokok bersaiz sederhana sebagai struktur hutan utama dengan *Shorea parvifolia* menjadi pendirian dominan dengan jumlah terbesar individu antara dua yang lain tetapi dengan *Shorea leprosula* mempunyai jumlah terbesar dan kawasan basal, diikuti oleh *Shorea parvifolia* dan *Shorea acuminata*. Mengikut keputusan yang didapati bagi setiap spesies dalam kajian ini, ia dapat disimpulkan bahawa kawasan kajian ini mempunyai bilangan yang pokok bersaiz sederhana yang tinggi sebagai struktur hutan utama dengan *Shorea parvifolia* menjadi dirian dominan dengan jumlah terbesar individu dibandingkan dengan dua spesies yang lain tetapi dengan *Shorea leprosula* mempunyai jumlah isi padu dan kawasan pangkal terbesar, diikuti oleh *Shorea parvifolia* dan *Shorea acuminata*. Kajian ini dijangka dapat member panduan kepada pihak berkuasa yang berkenaan dalam kerja-kerja inventori hutan dan menentukan struktur dirian di dalam Hutan Simpanan Kekal Sungai Menyala, Negeri Sembilan.

ACKNOWLEDGEMENT

I would like to extend my gratitude to my supervisor, Associate Professor Dr. Mohamad Azani Alias for his guidance and constructive criticisms during the preparation of this thesis. This acknowledgement is also intended for the academic and non-academic staffs of the Faculty of Forestry, Universiti Putra Malaysia in giving their cooperation for completing this thesis either directly or indirectly.

I would also like to thank Mr. Nor Zaidi Bin Jusoh from Negeri Sembilan Forest Department for allowing me to use the data and plots in the Sungai Menyala Forest Reserve, Negeri Sembilan Malaysia as my thesis data.

Lastly, I would like to take this opportunity to acknowledge my family and friends for their support and cooperation during the course of this project.

APPROVAL SHEET

I certify that this research project report entitled “Quantitative Assessment Of Three *Shorea* Spp For Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan” by Muhammad Amirul Asyraf Bin Hashim has been examined and approved as a partial fulfillment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Univeristi Putra Malaysia.

Approved by:

Dr. Mohamad Azani Alias
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

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

Date: 26 May 2016



TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	iii
ACKNOWLEDGEMENTS	iv
APPROVAL SHEET	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS	xi
CHAPTER	
1 INTRODUCTION	1
1.1 Background	1
1.1.1 Tropical Rain Forest in Malaysia	2
1.1.2 Virgin Jungle Reserve of Peninsular Malaysia.	3
1.2 Problem Statement	5
1.3 Objectives	6
2 LITERATURE REVIEW	7
2.1 State of Malaysian Tropical Rainforest.	7
2.1.1 Virgin Jungle Reserve of Peninsular Malaysia.	8
2.2 The General Information of Three Dipterocarp Species	9
3 METHODOLOGY	14
3.1 Study Site Background	14
3.2 Data Collection	15
3.3 Data Analysis	17
3.4 Basal Area	18
3.5 Tree Volume	19
3.6 Statistical Analysis	19
4 RESULTS	20
4.1 Distribution and population density of <i>Shorea</i> spp.	20
4.2 Stand Structure	23
4.3 Species Distribution	28
4.4 Basal Area	29
4.5 Total Volume	30
4.6 Statistical Analysis	32
5 DISCUSSION	37
6 CONCLUSION AND RECOMMENDATION	44
6.1 Conclusion	44
6.2 Recommendation	45
REFERENCES	46
APPENDICES	52

Appendix A
Appendix B
Appendix C
Appendix D

52
52
53
54



© COPYRIGHT UPM

LIST OF TABLES

TABLE		PAGE
2.1	Estimation of carbon stock in Malaysia	7
2.2	Summary on the timber type, shade tolerance, growth types and growth increment off the three <i>Shorea spp</i>	9
3.1	DBH class used for the study of quantitative assessment of three <i>Shorea spp</i> for Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan	18
3.2	Height class used for the study of quantitative assessment of three <i>Shorea spp</i> for Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan	18
4.1	List of total basal area for <i>Shorea spp.</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	30
4.2	Statistical analysis data of <i>Shorea acuminata</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	33
4.3	Statistical analysis data of <i>Shorea leprosula</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	33
4.4	Statistical analysis data of <i>Shorea parvifolia</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	33
4.5	Summary of the linear regression result of the three <i>Shorea spp</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan	36
5.1	Average diameter and height of <i>Shorea spp.</i> taken <i>spp</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan	39
5.2	Comparison between growth rate of <i>Shorea acuminata</i> in Sg. Menyala and other sites	42
5.3	Comparison between growth rate of <i>Shorea parvifolia</i> in Sg. Menyala and other sites	42
5.4	Comparison between growth rate of <i>Shorea leprosula</i> in Sg. Menyala and other sites	43

LIST OF FIGURES

FIGURE		PAGE
3.1	Map of Compartments of Sungai Menyala Virgin Jungle Reserve (VJR), Negeri Sembilan.	14
3.2	Belt transect block design, for the study of quantitative assessment of three <i>Shorea</i> spp for Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan	16
4.1	Distribution of <i>Shorea leprosula</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	22
4.2	Distribution of <i>Shorea parvifolia</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	22
4.3	Distribution of <i>Shorea acuminata</i> in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	23
4.4	Diameter class distribution of <i>Shorea</i> spp in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	26
4.5	Height class distribution of <i>Shorea</i> spp in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	26
4.6	Total distribution of <i>Shorea</i> spp in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	28
4.7	Total volume distribution of <i>Shorea</i> spp. in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	31
4.8	Total tree volume for each <i>Shorea</i> spp. In Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	32
4.9	Diameter analysis graph of <i>Shorea</i> spp. in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	34
4.10	Height analysis graph of <i>Shorea</i> spp. in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	34
4.11	Basal area analysis graph of <i>Shorea</i> spp. in Compartment 6 of Sungai Menyala VJR, Negeri Sembilan.	35



LIST OF ABBREVIATIONS

BA	Basal Area
DBH	Diameter at Breast Height
FRIM	Forest Research Institute Malaysia
SPSS	Statistical Package for the Social Sciences



CHAPTER 1

INTRODUCTION

1.1 Background

The family of Dipterocarpaceae consists of 16 genera, 3 subfamilies and more than 500 species, Dipterocarpaceae is the main species of tropical rain forest in Indonesia, Malaysia, Brunei and the Phillipines and it ranges eastwards as far as eastern New Guinea. *Shorea* is one of the genus of Dipterocarpaceae family, with its species numbering near to 200 spread all across South East Asia, and so far away as the Philippine Islands and the Indian Subcontinent, and it dominated the forest canopies of where it is native to *Shorea spp* (Appanah, 1998).

In Malaysia, the species of Dipterocarpaceae was dominant in Peninsular Malaysia and Borneo Island. Dipterocarpaceae in the forest was harvested to produce wood product because the wood was categorized as fancy wood. The timber of dipterocarps (roundwood logs) was 25% from total global consumption of tropical hardwood. While for the *Shorea spp* due to their high quality timber and resin, were highly sought after as valuable commodity for building wood based products. And as such, these genus have been heavily exploited and in danger of extinction as for the moment, one hundred and forty eight species of *Shorea* has been listed as critically endangered in the IUCN list. Recently, the quality and quantity of tropical rain forest were decreasing because of land conversion become forest plantation; illegal logging and shifting cultivation activity. They will increase the loss of biodiversity in both

species and genetic levels. On the other hand, the forest function such as carbon sink, hydrology and non-wood product will disappear.

To ensure the survival of this genus, and *Shorea spp* in particular, a lot of In situ and ex situ conservation programmes has been carried out for that sole purpose. One of the conservation programmes was by transferring some of the seedlings far from mother trees to spread out the species. One of these programmes was carried out in Sungai Menyala and Kenaboi Forest Reserves, whereby seedlings from three species of *Shorea*, which were *Shorea leprosula*, *Shorea acuminata* and *Shorea parviflora*, the species from Sungai Menyala Forest Reserves were collected from due to the high quality and progeny from the area to be collected elsewhere, most notably in the Kenaboi Forest Reserve.

1.1.1 Tropical Rain Forest in Malaysia

Tropical rain forest in Malaysia which lay along equatorial line is hot and humid throughout the year which annual rainfall was heavy at 2,500 mm (Smith, 1950). The complex diversity of the tropical forest indicates that Malaysian forest was rich in both Flora and Fauna. The dipterocarp forest was one of the main forests in Malaysia other than peat swamp and mangrove forest. Many species under the family Dipterocarpaceae has the utility for valuable timber and it increases our country's economic income. Due to its diversity, many researchers can be done for the species in our forest to bring more benefit for human being.

However, there is lack of information regarding the growth requirements for indigenous species in our forest. It has a distinct disadvantage in slow growth rate and purportedly uneconomic in capitalizing them. They were already adapted to the local conditions where the genetic base is easily accessible. Further researches are needed to be carried out to overcome the problem of inadequate collection of seeds based on its accessible genetic base (Ninomiya, 1999).

1.1.2 Virgin Jungle Reserve of Peninsular Malaysia.

In Peninsular Malaysia, Virgin Jungle Reserve (VJR) has been established since the 1950's and are initially known as Natural Forest Reserve (Smith, 1950). According to the Department of Forestry of Peninsular Malaysia, a number of 103 Virgin Jungles have been established in all states of Peninsular Malaysia that covers all types of forest as well as class functions of respective forests. There are more than 120 VJRs covering an area of about 111,800 ha in Peninsular Malaysia (Chan, 2002). Total area of Permanent Forest Reserve in Peninsular Malaysia are numbered approximately 13.19 million hectares. Thus Virgin Jungle Reserves had an area of only around 0.19%.

Ever since the Malaysian Independence in the year 1957, Peninsular Malaysia has experienced a very advanced socio-economic growth in order to develop the socio-economic structure of the people primarily for the poor in rural areas. As such a good number of Forest Reserve areas are converted into agricultural areas and especially, into oil palm plantations in accordance to infrastructure

development that correlates with the people's Relocation Plan and this phenomenon had expanded in an orderly and advanced fashion. In the following decades of 1960-1980 this nation was very dependent on the revenues from forestry and agricultural sectors in order to requisition foreign money exchanges for development projects. There were also forest areas that are changed in status in becoming new urban areas, light and medium industrial centers, dams, highways and other multitudes of infrastructures.

Due to the pressure from socio-economic developments and ever changing land use in all the states of Peninsular Malaysia, a few areas of Virgin Jungle Reserves had to be taken out for agricultural, industrial, infrastructure and many other land use purposes for the cause of socio-economic development of the states (Aitken, 1994). More than 30 years prior, Putz (1978) reported that a few Virgin Jungle Reserves was repurposed for the reasons mentioned previously and according to the report, the number of Virgin Jungle Reserves has shrunk to only 86 forests and with a smaller areas of less than 20,000 ha.

In light of this, ever since the establishment of Virgin Jungle Reserve on the year 1950 up until the present day, around 17 forests has been relinquished of its status as Virgin Jungle Reserve from a number of states with a decreased in area of 500 ha or 20% of the total area. Furthermore, efforts to increase the number of Virgin Jungle Reserves by requisitioning new forest areas are painfully slow.

1.2 Problem Statement

Quantitative analysis is conducted on *Shorea parvifolia*, *Shorea acuminata* and *Shorea leprosula* and this analysis will help the management to evaluate the regeneration of new individuals of seedlings to ensure the stock of the species within the forest are not threatened and to evaluate whether there are enough seedling population to enable another relocation of the seedling to other site. Hence, this will help the management in further planning or treatment if necessary.

Base data of the tree basal area for the particular timber species group for Sungai Menyala Forest Reserve are last taken by FRIM on the year 1998, that was 18 years ago, thus are now outdated., The information from the diameter increment models and on the basal area and height of trees will be the basis for further complex models development such as modelling site productivity for tropical forest

1.3 Objectives

The aim of this study was to assess the quantitative values of three *Shorea* species in Compartment 6 of Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan. Two specific objectives were designed to meet this aim which were:

- I. To determine the abundance and distribution of *Shorea leprosula*, *Shorea acuminata* and *Shorea parvifolia*. Which are planted in 1968 in Sungai Menyala Virgin Jungle Reserve, Negeri Sembilan
- II. To investigate the difference in basal area and volume of the three *Shorea* species throughout study area.

REFERENCES

- Abdul M. (1992). Application of Miyawaki's Forest Rehabilitation Technique towards a Uniquely Malaysian Landscape. International Symposium .On Rehabilitation of Tropical Rain Forest Ecosystems: Research and Development Priorities, 76-89.
- Affendi. (2010). Growth Increment of Indigenous Species Planted in Secondary Forest Area. *Academic Research Inc. Research Journal of Forestry*, 173-178.
- Aitken, S. (1994). Peninsular Malaysia protected area coverage, 1902-1992 - creation, rescission, excision and intrusion. *Environmental Conservation* 21, 49-56.
- Aiba, M. & Nakashizuka, T. (2007). Variation in juvenile survival and related physiological traits among dipterocarp species co-existing in a Bornean forest. *Journal of Vegetation Science*, 18(3), 379-388.
- Akta Perhutanan Negara. (2009). *Undang-Undang*. Malaysia: Pesuruhjaya Penyemak Undang-Undang, Malaysia, 20-30
- Aminah, (2005). Growth performance of some dipterocarps and non-dipterocarps planted from rooted cuttings. In *Proceedings of the Eight Round-table Conference on Dipterocarps*. Ho Chi Minh City, Vietnam.
- Appanah, S. & Weinland, G. (1993). Planting quality timber trees in Peninsular Malaysia: A review. Kuala Lumpur: Forest Research Institute Malaysia, 45-55.
- Appanah, S. & Weinland, G (1993). *Planting Quality Timber Trees in Peninsular Malaysia*. Kepong, Malaysia: FRIM, 65-70
- Appanah (1998). *A review of Dipterocarps; Taxonomy, ecology and Silviculture*. Bogor, Indonesia: Center For international Forestry Research. pp 55-115
- Ashton, P. (1964). *Manual of the Dipterocarp trees of Brunei State*. Singapore: The Straits Times Press, 30-60
- Ashton, P. S. (1968). A manual of the dipterocarp trees of Brunei State and of Sarawak-supplement. Kuching, Sarawak: Borneo Literature Bureau (for Sarawak Forest Department), 55-75.
- Ashton, P. O. (2003). *Pasoh Ecology of a Lowland Rain Forest in Southeast Asia*. In T.Okuda, N. Monokaran, Y Matsumoto, K.Niiyama, S.C Thomas, & P.S Ashton (Eds.). Pasoh: Tokyo,Japan: Springer, 60-120

Avsar, M. a. (2005) The Relationships between diameter at breast height, tree height and crown diameter in Lebanon Cedars of the Yavsan Mountain, Kahramanmaras, Turkey. *Pakistan Journal of Biological Science*, 66-128

Awang, K. (1985). Some Agroforestry Practices in Southeast Asia. Occasional Paper No.4. Faculty of Forestry, University Pertanian Malaysia, Serdang, Selangor.

Azani, A. M, Zaki, H.M. & Fujiwara, K. (1998). Rehabilitation of tropical rainforests based on potential natural vegetation species for degraded areas in Sarawak, Malaysia. *Tropics*, 7(3/4), 223-239.

Bischoff W, N. D. (2005). *Secondary succession and dipterocarp recruitment in Bornean rain forest after logging*, The Straits Times Press, 49-55.

Bosman, M. T., Kort, I. D., van Genderen, M. K. & Baas, P. (1994). Radial variation in wood properties of naturally and plantation grown light red meranti (*Shorea*, *Dipterocarpaceae*). *IAWA Journal*, 15(2), 111-120.

Box, E. O. (1995). Factors determining distributions of tree species and plant functional types in Global change and terrestrial ecosystems in monsoon Asia (pp. 101-116). Netherlands Springer.

Burgess, P. F. (1972). Studies on the regeneration of the hill forests of the Malay Peninsula. *Malayan Forester*, 35(2), 102-123.

Burkill, I. H. (1935). A Dictionary of the economic products of the Malay Peninsula. Crown Agents for the Colonies, London.

Connell, J.H. & Lowman, M.D. (1989). Low-diversity tropical rain forests: some possible mechanisms for their existence. *American Naturalist*, 134 (88-119).

Corner, E.J.H. (1988) .*Wayside Trees of Malaya* (3rd Ed.). The Malayan Nature Society, Kuala Lumpur.

Chan LH. 2002. The impact of present forest policies on sustainable forest management in Malaysia. In Enters T & Leslie RN (eds) *Proceedings of the Forest Policy Workshop*. 22–24 January 2002, Kuala Lumpur..

Da Fangliang, H., Legendre, P. & LaFrankie, J. V. (1997). Distribution patterns of tree species in a Malaysian tropical rain forest. *Journal of Vegetation Science*, 8(1), 105-114.

Davis, S. M. (2003). Pasoh Ecology of a Lowland Rain Forest in Southeast Asia. *The trees of Pasoh Forest: Stand Structure and Floristic Composition of the 50-ha Forest Research Plot*, 35-50.

FAO. (2010). Rome: Food and Agriculture Organization of the United Nations, *Global Forest Resources*, 12-15.

Foxworthy, F.W. (1930). Forest planting in Malay Peninsula. Staff Conference, Forest Research Institute, Federated Malay States, Kuala Lumpur.

Ministry of Forestry. (2009). *The Guidance of Silviculture System in The Forest Production Area to Manage Forest*. Jakarta: Ministry of Forestry, 99-199

Harrison. P. (2012). Anatomical Features of Wood from Some Fast Growing Red Meranti. *The 4th International Symposium of Indonesian Wood Research Society*, pp 21-41

Harms KE, C. R. (2001). *Habitat associations of trees and shrubs in a 50-ha neotropical forest plot*. *J Ecol*.

Husch, B. T. (2003). *Forest Mensuration* (4th Ed). New York: John Wiley and Sons.

I. Ninomiya, K. S. (1999, November). Island and corridor planting system in ecosystem rehabilitation. *Proceedings of the Workshop on Forest Ecosystem Rehabilitation Kuching, Sarawak, Malaysia*, 18–21.

Ichie, T., Kenzo, T., Kitahashi, Y., Koike, T. & Nakashizuka, T. (2005). How does *Dryobalanops aromatica* supply carbohydrate resources for reproduction in a masting year? *19(6)*, 704-711.

Ishida, A., Toma, T., Matsumoto, Y., Yap, S. K. & Maruyama, Y. (1996). Diurnal changes in leaf gas exchange characteristics in the uppermost canopy of a rain forest tree, *Dryobalanops aromatica Gaertn. f.* *Tree Physiology*, *16(9)*, 779-785.

Ishizuka, S., Tanaka, S. Sakurai, K., Hirai, H., Ogino, K., Lee, H.S. & Kendawang, J.J. (1998). Characterisation and distribution of soils at Lambir National Park in Sarawak, Malaysia, with special reference to soil hardness and texture. *Tropics* *8*: 31–44.

Itoh, A. (1995). Effects of forest floor environment on germination and seedling establishment of two Bornean rainforest emergent species. *Journal of Tropical Ecology*, *11(04)*, 517-527.

Itoh, A., Yamakura, T., Ogino, K., Lee, H. S. & Ashton, P. S. (1995). Population structure and canopy dominance of two emergent dipterocarp species in a tropical rain forest of Sarawak, East Malaysia. *Tropics*, *4(2/3)*, 133-141.

Itoh, A., Yamakura, T., Ohkubo, T., Kanzaki, M., Palmiotto, P., Tan, S. & Lee, H. S. (2003). Spatially aggregated fruiting in an emergent Bornean tree. *Journal of Tropical Ecology*, *19(05)*, 531-538.

Jalonen, R., Hong, L. T., Lee, S. L., Loo, J. & Snook, L. (2014). Integrating genetic factors into management of tropical Asian production forests: A review of current knowledge. *Forest Ecology and Management*, 315, 191-201.

Kahane, L. (2008). *Regression Basics. Second Edition*. London: Sage Publication.

Krishnapillay, D. B. & Varmola, M. (2002). Case Study of the Tropical Forest Plantations in Malaysia. Forest Plantations Thematic Papers. Working Paper (FAO). Forest Resources Division.

Krishnapillay, B. & Tompsett, P. B. (1998). Seed handling. A review of dipterocarps: taxonomy, ecology and silviculture, 3-88. Center for International Forestry Research.

Lepun, P. (2007). Tree Species Distribution in Ayer Hitam Forest Reserve, *Proceedings. Of the 3rd IASME/WSEAS Int. Conf. on Energy, Environment, Ecosystems and Sustainable Development*, 50-62.

Lee, K. S., Wickneswari, R. & Choong, C. Y. (2007). Stand structure and the genetic diversity of *Koompassia malaccensis* and *Dryobalanops aromatica* in unlogged and logged-over stands. *Sains Malaysiana*, 36(2), 233-242.

Lee, S. L., Ang, K. C. & Norwati, M. (2000). Genetic diversity of *Dryobalanops aromatica Gaertn. f.* (Dipterocarpaceae) in Peninsular Malaysia and its pertinence to genetic conservation and tree improvement. *Forest Genetics*, 7(3), 209-217.

Lee, S. L., Wickneswari, R., Mahani, M. C. & Zakri, A. H. (2000). Genetic Diversity of a Tropical Tree Species, *Shorea leprosula* Miq. (Dipterocarpaceae), in Malaysia: Implications for Conservation of Genetic Resources and Tree Improvement¹. *Biotropica*, 32(2), 213-224.

Leigh Jr, E. G., Davidar, P., Dick, C. W., Puyravaud, J. P., Terborgh, J., ter Steege, H. & Wright, S. J. (2004). Why do some tropical forests have so many species of trees? *Biotropica*, 36(4), 447-473.

Lim, M.T. & Faridah Hanum. (1992). Indigenous species for forest plantations: proceedings of a national seminar. Faculty of Forestry, Universiti Pertanian Malaysia, Serdang, Selangor, 23-24 Apr 1992, 1-7.

Manokaran N. (1992). Tree Growth in Primary lowland and hill dipterocarp species. *Journal of Tropical Forest Science*, 332-345.

Manokaran N. (2010). Recruitment, growth and mortality of tree species in a lowland dipterocarp forest in Peninsular Malaysia. *Journal of Tropical Ecology*, No. 3, 1987, 315-330.

Newman MF, B. P. (1996). *Manual of Dipterocarps for Forester: Borneo Island Light Hardwoods, Anisptera, Parashorea, Shorea (Red, White and Yellow Meranti)*. Jakarta: Royal Botanic Garden Edinburgh.

Nix, S. (2014). *How a Forest Ecosystem is defined*. Retrieved 5 5, 2016, from Forestry about.com

Perumal, M. A. (2012). Reforestation Efforts and various studies on Rehabilitation of Degraded Areas in. *Growth Performance And Survival Rate Of Planted Shorea Macrophylla At Various Age Stands In Sampadi Forest Reserve*, (pp 21- 31).

Putz, F. E. (1978). *A survey of VJRs in Peninsular Malaysia*. Forest Research Institute Kepong 10-40.

Rutten, G. E. (2014). *Forest Ecology and Management*. Switzerland, 22-49

Soekotjo (2009). *Intensive silviculture to improve productive capacity of forests: Large scale enrichment planting of dipterocarps*. Buenos Aires, Argentina, 55-100.

Suratman, M. N. (2012). *Tree Species Diversity and Forest Stand Structure of Pahang National Park, Malaysia*. Shah Alam: University of Technology MARA 23-45.

Suzuki, R. O., Numata, S., Okuda, T., Supardi, M. N., & Kachi, N. (2008). *Growth strategies differentiate the spatial patterns of 11 dipterocarp species coexisting in a Malaysian tropical rain forest*. Japan: The Botanical Society of Japan 80-90.

Turner, E. C. (2016). Deforestation in Southeast Asia. *Biological and Environmental Hazards, Risks, and Disasters*, 317-334.

Weitskittel, A. H. (2011). *Forest Growth and Yield Modelling*. Singapore: Willey-blackwell, 67-80.

Widiyano, S.Purnomo, Soekotjo, & M.Na'iem. (2012). *The growth of selected Shorea spp in secondary tropical rain forest: the effect of silviculture treatment to improve growth quality of Shorea spp*. Yogyakarta: Faculty of Forestry, Universitas Gadjah Mada.

Widiyatno, M. N. (2014). Evaluation of Four Years Old Progeny Test of Shorea macrophylla in PT Sari Bumi Kusuma, Central Kalimantan. *Procedia Environmental Sciences*, 809–815.

Widiyatno, S. P. (2012). The Growth of Selected Shorea Spp in Secondary Tropical Rain Forest: The Effect of Silviculture Treatment to Improve Growth Quality of Shorea Spp. *Procedia Environmental Sciences*, 160–166.

Wyatt-Smith, J. (1966). Ecological Studies on malayan Forest. I. Composition of and dynamic studies in lowland evergreen rain forest in two hal-acre plots in Bukit langgong and Sungai Menyala Forest Reserves and in two half-acre plots in Sungai Menyala Forest Reserve. *Malayan Forestry Department research Pamphlet No.52*, 89-99.

Wyatt-Smith, J. (1949). A note on tropical lowland evergreen rain-forest in Malaya. *Malayan Forestry* 12: 58-64.

Wyatt - Smith, J. (1963). Manual of malayan silviculture for inland forests. Malayan Forest Record No. 23. Forest Research Institute, Kepong, Malaysia.

Yong, C (2014). *Deforestation Drivers and Human Rights in Malaysia*. Kuching: Sarawak Report 55-60.

Zaidi, N (2010). *Penilaian Kepelbagaian Biologi Hutan bagi Simpanan Hutan Dara (VJR) di Hutan Simpan Sungai Menyala, Negeri Sembilan*. Jabatan Perhutanan Negeri Sembilan Darul Khusus.

Zimmerman, B. L. & Kormos, C. F. (2012). Prospects for sustainable logging in tropical forests. *BioScience*, 62(5), 479-487.

Zuhaidi, Y. A. (2006). Modelling tree diameter growth of plantation grown *Dryobalanops sumatrensis*. *Journal of Tropical Forest Science*, 18(4), 203-211.

Zuhaidi, Y. A. (2009). Local growth model in modelling the crown diameter of plantation-grown *Dryobalanops aromatica*. *Journal of Tropical Forest Science*, 21(1), 66-71.