UNIVERSITI PUTRA MALAYSIA

FOREST RECOVERY AND REHABILITATION ASSESSMENTS IN NEGERI SEMBILAN, MALAYSIA, BASED ON VEGETATION SCIENCE

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Doctoral Thesis

Forest Recovery and Rehabilitation Assessments in Negeri Sembilan, Malaysia, based on Vegetation Science

マレーシア国 ネゲリセンビランに おける植生学を基礎とした
森林回復とその評価

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要約

植生学的研究を基礎として、荒廃した過伐採森林地域の自然回復と遷移の解明をおこない、森林回復とリハビ
った。本研究は、過伐採域をはじめ地域全体の森に対して植物調査を行うと同時に、2 カ所で実験植栽を行った。木材収穫時期に材木運搬道として使われたり、材木が積まれていたエリアは自然の回復が非常に遅く、*Melastoma*、*Eupatorium* と *Paspalum* のような先駆性の種だけがこのサイトに生育することができる。このような厳しい環境の条件下のサイトは、徹底的なリハビリテーション努力が必要となる。1963～1973 年に従来の収穫方法（Malayan Uniform System）が利用された森は、低～中の回復率を示していた。ここでは、超高木層の植被率が低く，数種のフタバガキ科の種だけがみられた。これらのサイトは、数年の間に収穫に先立ち、自然状態にもどることが望ましい。

一方、 1984 年に Selective Management System が導入されたサイトでは、平均植被率 12%の超高木層と、それぞれほぼ均等な植被率を持つ高木層、亜高木層、低木層、草本層が記録された。フタバガキ科の種を欠く林分は、構成種を増加させ為にフタバガキ科の種群を再植栽することが必要である。本研究より、過伐採地が元の状態に回復するには厳しい環境のため少くとも約 40 年かかることがわかった。また、リハビリテーションの査定試験では、陽性樹である *Azadirachta excelsa*、*Cinnamomum iners*、*Hopea odorata*、*Shorea leprosula* と *S. parvifolia* が、高い成長率を示した。例えば *A. excelsa* は植栽後 32 ヵ月で、平均値で胸高直径は 57.8 mm の増加を示し、樹高は 412 cm の成長を記録した。 *A. excelsa*、*C. iners, Intsia palembanica* の 3 種から成っているグループは、72.6～86.7%の高い生存率を記録した。*C. iners*、*Hopea odorata*、*S. leprosula*、*S. parvifolia* は、将来のリハビリテーションまたは再植栽プロジェクトのために、現在の研究サイト近郊では推奨される。

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Out of 4.1 billion ha of the total world's forest, an approximately 40% or 1.7 billion ha are the tropical rainforests, of which 20.1 million ha are located in Malaysia (Nik Muhamad & Mohd Zaki, 1995). These forests are among the richest if not the richest ecosystem in the world in term of biological diversity. For example, the forests contain many wild fruit trees, of which many are of medicinal importance and potential, and many of the world's main crop originated from tropical rainforests (Whitmore, 1990).

Tropical rainforest is one of the most important renewable natural resources in Malaysia. This forest is also of vital economic and ecological importance to the country. Apart from continuous supply of timber and forest produces, the forest also plays a pivotal role in environmental protection and provides a host of other intangible benefits.

The depletion of tropical rainforest including that of Malaysia has been a global concern in recent years especially after the Earth Summit in Rio de Janeiro, Brazil. It is estimated that by the end of this century, approximately one third of this forest will be depleted if its over-exploitation continues unabated (Marn & Jonkers, 1982). Large tracts of forest areas in Malaysia have been degraded as a consequence of deforestation, forest harvesting and shifting cultivation. One of the serious negative environmental impacts of these activities is land degradation, including increased soil compaction, erosion and decrease in soil fertility. Biological degradation of the soil reflects this.

As of mid-1980s a total of 4,604,000 ha of forest in the country (about 22.8% of the total forest area) is in various stages of degradation (Ahmad Zainal, 1992). Assuming that a third of every hectare would be degraded (Kamaruzaman, 1992; Sanchez *et al.*, 1994), then Malaysia would have at least 1.5 million ha of degraded forest land. This figure does not include ex-tin mining, which is about 113,700 ha in Peninsular Malaysia (Chan, 1990) and degraded agricultural soils. If the economic, environmental, social and cultural benefits of the forest are to be continuously enjoyed, the damage which in this context is land degradation has to be repaired by various technical approaches, such as rehabilitation.

Rehabilitation effort includes silvicultural treatments to stimulate development for valuable timber producing capacity of forest land, i.e., the treatments can be carried out at the management (and harvesting) level or after harvesting itself. For example, the Selective Management System (SMS) adopted for the hill dipterocarp forest since 1978 in Peninsular Malaysia can be considered as a rehabilitative measure to reduce the problem of land degradation. The system advocates a choice between different management options based on pre-harvesting inventory of stocking levels to determine the diameter limits and species selection for harvesting. Only a selected portion of the stand is harvested leaving the residue for future harvest.

1.2 Problem Statement

Over the years, the tropical forests in Peninsular Malaysia have declined from 73% of the land area in 1966 to about 61% in 1970-72 and to 49% in 1981-82 (Nik Muhamad, 1995). According to Ahmad Zainal (1992), deforestation in Peninsular Malaysia increased from about 0.25 million ha per annum in 1981-85 to 0.48 million ha in 1989. The major cause of deforestation has been mainly the expansion of crop-tree plantations such as rubber and oil palm.

Besides outright deforestation, the remaining forest area in Peninsular Malaysia is under constant pressure from commercial and illegal harvesting. According to the estimates produced by the Ministry of Primary Industries Malaysia (1989), an average of 233,800 ha of forest land in Peninsular Malaysia was harvested annually from 1981 to 1987.

With all the deforestation, either outright or in the form of commercial harvesting, the deforested areas require some kind of assessment as to their natural recovery and succession. The information from this assessment can be used to formulate the rehabilitation requirement for any given logged-over area. The Forestry Department in particular has put a lot of effort into this. One of the strategies implemented by the department is to carry out post-felling inventory one or two years after harvesting in all harvested forest areas. The inventory is prescribed in the SMS.

Another approach towards this objective that can complement the post-felling inventory is the deforestation assessment by use of phytosociological vegetation studies. The phytosociological vegetation studies were made in primary and secondary forests surrounding the rehabilitation area in Pasoh Forest Reserve, Negeri Sembilan. Simultaneously, similar studies were carried out in regenerating or logged-over forests near the planting site or areas with similar vegetation features as the planting site. The studies would provide vital information on the succession processes taken place after harvesting. These data together with data from pre-felling and post-felling inventories were analyzed thoroughly to elucidate the degree of natural recovery of these logged-over forests towards achieving their natural states prior to harvest. Based on the present recovery rate of each forest, rehabilitation requirement would be recommended on that particular logged-over forest area.

1.3 Background of the Study

According to Lim (1992), rehabilitation is 'a process of restoring some form of vegetative cover (usually tree cover) to an area of land so as to improve its natural productivity and its environment and aesthetic values'. In other words, the rehabilitation process would involve the re-establishment or re-creation of a more intact and closed canopy as in the natural state prior to disturbance. The improvement of the structural aspect should correspond to the improvement of the functional aspects of the rehabilitated forests.

Rehabilitation of degraded or logged-over forest is essential in ensuring the continuous presence of the tropical forest in Malaysia. Forest rehabilitation either extensive or intensive will be beneficial at least in the following points (Brown & Lugo, 1994):

a) It converts unproductive lands to self-sustaining ecosystems,
b) It prevents further damage to downstream ecosystems,
c) It reverses a worldwide negative trend of land degradation, and
d) It removes impact on undisturbed lands and thus contributes to a reduction in further deforestation.

In cases of severe forest degradation such as a total loss of forest cover as a result of shifting cultivation, intensive rehabilitation approaches, namely exotic species plantation, replanting of indigenous tree species and replanting of indigenous tree species based on vegetation science can be taken.

1.3.1 Exotic species plantation

The establishment of forest plantations can be considered as a rehabilitation approach even though the main objective of establishing forest plantations is to meet future demands of timber. An estimated 500,000 ha of forest plantation will be established in the country by the year 2000 (Ministry of Primary Industries, 1989).

The first large scale planting of exotic species can be traced back to the planting of *Pinus caribaea*, *P. merkusii* and other conifers in 1966 under the First Malaysia Five-Year Plan for development. Pilot plantations of these species were established in Selangor, Johore, Pahang and Negeri Sembilan under the Quick Growing Industrial Tree Species with the assistance of United Nations Development Program (UNDP). The main objective of this venture was to reduce the import of paper into Malaysia by producing paper locally. The pulping properties (such as, long fiber and low lignin content) of these species were found to be suitable for paper manufacture, and the species generally was growing relatively well. But before the viability of such plantation could be ascertained, the planned paper mill for Peninsular Malaysia was abandoned due to economic problem, and the plantation project followed suit.

Following the timber boom in the late 1970s, fear of timber shortage finally showed its shroud. In the early 1980s, it was forecasted that there will be an impending timber shortage of general utility timber by 1990 (Chong, 1979). Freezailah (1982 cited by Paudyal & Nik Muhamad, 1992) predicted that with the trend of forest exploitation and the rising demand for forest products in the late 1970s and early 1980s, Peninsular Malaysia was going to face timber deficit well before the year 2000. The fear pushed the Forest Department to start the Compensatory Plantation Project, with the aim of producing general utility timber of small saw log dimensions for the domestic market in 15-year rotations. With the support from an Asian Development Bank loan, fast-growing tropical hardwoods such as *Acacia mangium*, *Paraserianthes falcataria* and *Gmelina arborea* were planted extensively. It was envisaged that the project would cover 188,000 ha, and as of December 1994 a total of 54,189 ha had been planted with mainly *A. mangium* (Forest Department

Pen. Malaysia, 1995). According to Shim (1992), the species performed well in plantations across Malaysia, but there was a problem with buyers who tend to offer low prices for these species. Moreover, many of the *A. mangium* harvested after 12 years tend to develop heart-rot, and in some cases the problem starts at the young age of 4, 5 or 6 years old (Lee *et al.*, 1988).

Since these projects only involve fast growing exotic species, they do not provide much help in restoring natural tropical rainforest ecosystem.

1.3.2 Replanting of indigenous tree species

There are a few countries worldwide that use indigenous species for their own plantation. The use of native species is often overlooked, possibly due to the lack of information on the species or perhaps the biased attitude that exotics are better. Lim & Faridah (1992) pointed out that among a few problems associated with the use of indigenous species are the lack of understanding on the silvicultural requirement for growth, the relatively slow rate of growth and inadequate supply of planting stocks due to inconsistent flowering and fruiting of the trees throughout the life cycle.

However these problems can be solved through appropriate research and several answers to these problems have been uncovered by various researches. On the other hand, there are many advantages associated with the use of indigenous species: indigenous species are already adapted to the local conditions; they possess good natural bole form; they are multipurpose in use; the genetic base is easily accessible; the species are more resistant or free from insect and fungal attack and they possess high natural durable timber (Evan, 1992; Lim & Faridah, 1992). Even the constant supply of seeds may not be as difficult as anticipated. In addition, indigenous species plantation will contribute towards the conservation of species diversity, as understorey species may come into the planted sites from adjacent forest land.

According to Appanah & Weinland (1993), the planting of indigenous tree species began in the early 1900s especially after the recommendation of Hill (1900 cited in Appanah & Weinland, 1993) of the Indian Forest Service. He recommended the planting of *Palaquium* spp., *Intsia palembanica* and *Neobalanocarpus heimii.* By the end of 1912, 373 ha of open plantation were established and 1,951 ha were line planted. Following the discovery of the potential of planting *Dryobalanops aromatica* in 1921, a block of 36.4 ha in Kanching Forest Reserve was planted with one-year old seedlings of *D. aromatica*, *Shorea leprosula* and *N. heimii* in 1928. Due to the cleaning of the compartment before planting (sudden exposure of sunlight onto seedlings) which might have contributed to the great extent of beetle attack, 10% of *D. aromatica* succumbed (Walton, 1933). In 1954-58, another batch of *D. aromatica* was planted successfully in the secondary forest of Kanching Forest Reserve.

Plantings in Kepong (presently the site of Forest Research Institute of Malaysia) represent the single biggest reforestation work in Malaysia. Species such as *Calophyllum* spp., *Dipterocarpus* spp., *Dryobalanops* spp., *Hopea* spp., *N. heimii* and *Shorea* spp. were planted in three phases: in the open forest, in the young regenerating but scrubby forest (locally known as belukar) and in secondary forest. Watson (1935) reported that one-year old *D. aromatica* planted in Kepong reached an average height and diameter of 6m and 11.3cm in six years, respectively. He also reported that among the *Shorea* spp., the most outstanding was *S. laevis* which attained 85% survival and an average height of 3m five years after planting.

In recent years, one of the biggest reforestation projects is the Multi-Storied Forest Management (MSFM) Project, which is jointly conducted by the Forest Department of Peninsular Malaysia and Japan International Cooperation Agency (JICA). The project which was implemented on two study sites, Chikus Forest Reserve and Bukit Kinta Forest Reserve involved two planting techniques, namely the open planting and the under planting methods. Anon. (1996)[1] reported that the open planting technique has resulted in low survival rate of 9.5% (except *Hopea odorata* which recorded a 77.9% survival) and poor height growth. The indigenous tree seedlings which were line-planted between rows of *A. mangium* (a few lines or rows of *A. mangium* was cut) exhibited better average survival percentage which ranged from 37.3% to 64.5%. *S. leprosula* with an average survival rate of 85.1% and height growth of 1.36m one year after planting showed the best performance.

Generally, the selection of indigenous species used in MSFM project and other similar projects is mainly based on the growth performance of the selected species from the early reforestation studies in Kepong and other smaller studies. As a result,

[1] Anon. is an abbreviation used for an anonymous author (or authors).

only the fast growing indigenous species will be continuously planted, while the slow growing species will be discarded.

1.3.3 Replanting of indigenous species based on vegetation science

One of the pioneers of this rehabilitation approach is Prof. Dr. Akira Miyawaki who has done a lot of rehabilitation project in Japan (Miyawaki, 1992; Miyawaki, 1993; Miyawaki *et al.*, 1993). The technique employed by Miyawaki is the open-dense planting method which calls for the replanting of indigenous species, or as Miyawaki puts it 'native trees in the native land' (Miyawaki, 1993; Miyawaki *et al.*, 1987; Miyawaki *et al.*, 1993).

The same approach has been successfully tested in the Rehabilitation of Tropical Forest project in Bintulu, Sarawak, Malaysia. According to Meguro and Miyawaki (1998), as of mid-1998, a total of 330,000 seedlings representing 92 species and 20 families of indigenous trees was randomly planted on a 47.5-hectare site. The success of this project has been extensively reported by Abas (1993), Mohamad Azani (1998), Mohd Zaki *et al.* (1993), Mohd Zaki & Nik Muhamad (1995) and Mohd Zaki *et al.* (1995). Mohamad Azani *et al.* (1998) reported that the biggest growth increment in the study was recorded by *D. aromatica*, followed by *Pentaspodon motleyi, Shorea ovata* and *S. leprosula*.

Similar rehabilitation approach was implemented in Pasoh Forest Reserve and Setul Forest Reserve, Negeri Sembilan. This approach is unique in itself, since most probably, there has been no replanting effort ever done based on the result of phytosociological vegetation studies in Peninsular Malaysia. As prescribed by Miyawaki *et al.* (1993), phytosociological vegetation studies have been conducted in primary forest and secondary (regenerating) forest of different ages. The studies provided needed information on the succession processes taken place after different harvesting techniques and periods. These data combined with that of the pre-felling and post-felling inventories were analyzed thoroughly to elucidate the current state of natural recovery of these logged-over forests.

Concurrently, trial planting of indigenous tree species, namely *Azadirachta excelsa* (Jack) Jacobs, *Cinnamomum iners* Reinw. *ex* Bl., *Dryobalanops aromatica* Gaertn. f., *Hopea odorata* Ridl., *H. pubescens* Ridl., *Intsia palembanica* Miq., *Neobalanocarpus heimii* (King) Ashton, *Shorea acuminata* Dyer., *S. bracteolata* Dyer., *S. curtisii* Dyer. *ex* King, *S. leprosula* Miq., *S. ovalis* (Korth.) Bl. and *S. parvifolia* Dyer. was carried out to elucidate the suitable species and appropriate silviculture treatment for each species.

Forest recovery assessment was then carried out to determine the level of closeness of the recovered forests to the natural state. The assessment also detailed out the degree of rehabilitation requirement and suitable rehabilitation technique(s) of these forests. The results of current and previous trial plantings were used to predict the time needed to artificially recover a degraded area through rehabilitation approach.

1.4 Objectives of the Study

The general objective of the study is to obtain information on the current status of natural recovery of the logged-over forests and their closeness to their natural states prior to harvesting. The specific objectives of this study are:

a) To identify and explain main vegetation found in the vegetation studies,
b) To assess the rate of natural recovery (succession) of the logged-over forests,
c) To recommend rehabilitation requirements for each logged-over forest, and
d) To elucidate suitable species for future rehabilitation projects.

CHAPTER 2: MATERIALS AND METHODS

2.1 Description of the Study Sites

2.1.1 Location

This Ph.D. project was conducted in the state of Negeri Sembilan which has 184,844 ha of forest area (about 27 % of the total land area), of which 169,202 ha is located in the forest reserves (Anon., 1994a). The majorities of these forests are classified as the lowland and hill forests. The major part of the study was carried out in Pasoh Forest Reserve which is accessible by Bahau-Kemayan road and Batu Kikir-Simpang Pertang road. The other parts of the study were conducted in Angsi Forest Reserve, Berembun Forest Reserve, Serting Forest Reserve and Setul Forest Reserve (Figures 1 and 2).

2.1.2 Climate

According to the meteorological data obtained from the Meteorological Service Department Malaysia, the state of Negeri Sembilan in general receives relatively moderate annual rainfall. The annual rainfall for the period between 1981 to 1992 ranges from 1800 to 2800mm (Roslie, 1986)(Fig. 3). The highest precipitation normally occurs during the months of March-May and September-December. The mean monthly temperature in the Negeri Sembilan ranges from 24.5°C to 27°C.

According to Anon. (1992a), the Pasoh Forest Reserve site is classified as area which receives heavy rainfall (wet month) in only two months, November and December. The Setul Forest Reserve site, on the other hand, is considered as site which has only two wet months, in October and November. The amount of rainfall into these two areas can be considered as lower than the national average.

2.1.3 Vegetation

According to Anon. (1991), the rehabilitation assessment (trial planting) site in Compartment 121, Pasoh Forest Reserve was classified as lowland dipterocarp forest (of Red Meranti type) which was predominated by high-quality timber species such as *Dipterocarpus* spp., *Intsia palembanica* and *Shorea* spp. The site was clear-cut in 1984 for the purpose of oil palm plantation. Before the trial planting, the vegetation of the area was dominated by pioneer species such as *Macaranga gigantea, M. denticulata, Mallotus macrostachys, Melastoma* spp., *Trema* sp. and *Vitex pubescens.* The most commonly found herbaceous layers are *Mikania scandens, Imperata cylindrica* and climbers along with *Musa* spp.

The other trial-planting site in Setul Forest Reserve is the leftover area from the *Acacia mangium* plantation. The whole site was clear-cut in 1950s, and was leveled in the late 1970s for the plantation. Before trial planting, the site was basically barren, with only a small part covered with *I. cylindrica* and *Paspalum* spp.

2.1.4 Soil description

2.1.4.1 Soil type

Geologically, the soil type in Pasoh Forest Reserve is classified as of Rengam series which is brownish yellow, with sandy clay loam texture, and of moderate to highly fertile (Roslie, 1996). According to Wyatt-Smith (1963; 1995), the soil is of the Palaeozoic sedimentary rock which is principally characterized by limestone, quartzite and shale.

The soil in Setul Forest Reserve is classified as of Batu Anam series which is pale yellow to light grey, with silty clay texture, and of moderate to low fertility (Wyatt-Smith, 1963; Wyatt-Smith, 1995). The soil is of shale parent material.

2.1.4.2 Soil sampling

Prior to planting, 30 soil samples were randomly taken from the Pasoh planting site. The samples were taken from the 0-15 cm and 15-30 cm depths for analyses of macronutrients, namely Nitrogen, Phosphorus, Kalium (Potassium), Calcium and Magnesium. Cation exchange capacity (CEC), moisture contents and soil pH were also analyzed. The results of the physical and chemical properties are given in Table 1.