UNIVERSITI PUTRA MALAYSIA

REHABILITATION OF A DEGRADED TROPICAL LOWLAND FOREST USING THREE INDIGENOUS TIMBER SPECIES IN PENINSULAR MALAYSIA

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By

EVELYN VARQUEZ BIGCAS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

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In memory of my loving parents Isidro Lumasag Bigcas and
Fe Varquez-Bigcas, without whose care and nurturing
I would not have reached this far....

Forest restoration means restoring forest ecosystems to their original condition for all plants and animals, as well as humans. Planting indigenous tree species is just the first step.

-Stephen Elliott-

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy.

REHABILITATION OF A DEGRADED TROPICAL LOWLAND DIPTEROCARP FOREST USING THREE INDIGENOUS TIMBER SPECIES IN PENINSULAR MALAYSIA

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Chairman: Prof. Dato' Dr. Nik Muhamad Nik Ab. Majid
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Seedlings of *Azadirachta excelsa*, *Hopea odorata* and *Vitex pinnata* were line- and gap- planted on a logged-over site in Pasoh Forest Reserve, Negeri Sembilan, Malaysia.

After two and a half years of planting, *H. odorata* exhibited the highest average survival percentage of 97% in the large discontinuous gaps of 20m x 20m (G3 method), followed by *V. pinnata* 91%, and *A. excelsa* 82%.

In G4 (10m x 10m X 9/ha gaps), the survival percentage of *H. odorata* was 95%, followed by *V. pinnata* (89%) and *A. excelsa* (84%). In G2 (10m x 10m x 5/ha gaps), *H. odorata* showed 90% survival, followed by *V. pinnata* (71%) and *A. excelsa* (64%). In the Line planting, *H. odorata* attained 93% survival, *V. pinnata* 84% and *A. excelsa* 75%.

Relatively high survival percentages of the seedlings were due to the capacity of the seedlings to survive under situation typical of degraded lands. Moreover, relatively high light environment and high organic matter content may have also contributed to the low mortality. Mortality can be attributed to the activities of the wild boars that collected small twigs and seedlings as nest during breeding periods. The broken stems (reduced heights) that sometimes led to seedling death were mainly due to

strong winds which are typical of Malaysia, the monkeys who play with and eat the top shoots, and the weeds who strangled and pulled the seedlings downwards. The relatively high survival rates are indicative of the species capacity to colonise and regenerate degraded lands.

In terms of stem growth, *A. excelsa* exhibited the highest growth among the species. It showed higher increments than *H. odorata* and *V. pinnata* in basal diameter, basal area, volume, and relative crown depth. *H. odorata* had comparable increments with *V. pinnata* except in total height where *V. pinnata* had comparable increments with *A. excelsa* and except in relative height where *H. odorata* had a lower relative height than *V. pinnata*.

In terms of crown growth, *A. excelsa* developed larger increments than *H. odorata* in crown diameter and crown surface area. *V. pinnata* had the highest foliage depth increment and had comparable crown surface area with *A. excelsa*. Both *A. excelsa* and *H. odorata* had the desirable lower crown-basal diameter ratio than *V. pinnata*.

Based on stem growth dynamics all three species can be mix-planted for enrichment planting and plantation establishment. *H. odorata* was the best survivor whereas *A. excelsa* exhibited the best growth performance among the species. *V. pinnata* showed moderate survival and growth performance.

Correlation and regression results showed that the growth indicators, namely; basal diameter, total height, crown height and crown diameter could be used to predict seedling growth efficiency at this stage of their development and thus, eliminate guess work.

Abstrak tesis yang dipersembahkan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan penganugerahan Ijazah Doktor Falsafah

PEMULIHAN KAWASAN HUTAN TANAH PAMAH (DIPTEROCARP) TROPIKA TERBIAR DI SEMENANJUNG MALAYSIA MENGGUNAKAN TIGA SPESIS POKOK BALAK TEMPATAN

Oleh

EVELYN VARQUEZ BIGCAS
Mac 2003

Pengerusi: Prof. Dato' Dr. Nik Muhamad Nik Ab. Majid
Fakulti: Perhutanan

Anak-anak benih *Azadirachta excelsa*, *Hopea odorata* dan *Vitex pinnata* telah ditanam secara berbaris dan di dalam ruang di atas kawasan bekas pembalakan di Hutan Simpan Pasoh, Negeri Sembilan, Malaysia.

Selepas dua setengah tahun tempoh penanaman, *H. odorata* menunjukkan purata peratusan kehidupan sebanyak 97% dalam ruangan berukuran 20m x 20m x 5/ha (kaedah G3), diikuti oleh *V. pinnata* 91%, dan *A. excelsa* 82%.

Dalam ruangan G4 (10m x 10m X 9/ha), peratus kehidupan *H. odorata* ialah 95%, diikuti oleh *V. pinnata* (89%) dan *A. excelsa* (84%). Dalam ruangan G2 (10m x 10m x 5/ha), *H. odorata* menunjukkan 90% kehidupan, diikuti oleh *V. pinnata* (71%) dan *A. excelsa* (64%). Melalui kaedah penanaman berbaris, *H. odorata* mencapai 93% kehidupan, *V. pinnata* 84% dan *A. excelsa* 75%.

Peratusan kehidupan yang agak tinggi pada pokok-pokok ini adalah disebabkan oleh keupayaannya untuk terus hidup dalam keadaan yang biasa ditemui di tanah terbiar. Tambahan pula, keadaan persekitaran dengan pencahayaan agak tinggi dan kandungan bahan organik yang tinggi berkemungkinan telah membantu mengurangkan kadar kematian pokok. Kadar kematian mungkin berpunca daripada gangguan oleh babi hutan yang mengumpul dan merosakkan benih ketika peringkat

awal pertumbuhan. Dahan-dahan yang patah (menjejaskan ketinggian pokok) hingga menyebabkan kematian anak pokok adalah disebabkan terutamanya oleh angin kuat yang biasa berlaku di negara ini, angkara kera hutan yang bermain di dahan berkenaan serta memakan pucuk dahan serta tumbuhan menjalar yang membelit dan melentur dahan ke bawah. Kadar hayat yang panjang pula merupakan tanda-tanda spesies berkenaan berjaya mengkoloni dan membaikpulih tanah terbiar.

Merujuk kepada pertumbuhan batang, *A. excelsa* menunjukkan pertumbuhan tertinggi di kalangan spesies yang dikaji. Pokok in menunjukkan peningkatan lebih tinggi berbanding *H. odorata* dan *V. pinnata* pada garispusat banir, kawasan banir, isipadu dan ketebalan kanopi. *H. odorata* mempunyai peningkatan yang hampir serupa dengan *V. pinnata* kecuali ketinggian keseluruhan di mana *V. pinnata* mempunyai peningkatan yang hampir serupa dengan *A. excelsa*, dan ketinggian relatif di mana *H. odorata* mempunyai ketinggian relatif lebih rendah berbanding *V. pinnata*.

Merujuk kepada pertumbuhan kanopi, *A. excelsa* menunjukkan pertambahan terbesar berbanding *H. odorata* pada garispusat dan permukaan kanopi. *V. pinnata* mempunyai pertambahan ketebalan dedaun tertinggi serta pertambahan serupa dengan *A. excelsa* daripada segi permukaan kanopi. Kedua-dua *A. excelsa* dan *H. odorata* mempunyai nisbah garispusat bawah banir yang baik berbanding *V. pinnata*.

Berdasarkan kepada pertumbuhan dinamik batang, ketiga-tiga spesies ini boleh ditanam secara bercampur untuk memperbanyakkan penanaman. *H. odorata* mempunyai daya ketahanan terbaik manakala *A. excolsa* menunjukkan pertumbuhan terbaik di kalangan spesies yang dikaji. *V. pinnata* menunjukkan daya ketahanan serta pertumbuhan yang sederhana.

Keputusan melalui korelasi dan regresi menunjukkan bahawa penunjuk pertumbuhan garispusat banir, ketinggian keseluruhan, ketinggian kanopi dan garispusat kanopi boleh digunakan untuk meramalkan pertumbuhan anak benih.

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LIST OF ABBREVIATIONS

A	Basal Area increment
Ae	*Azadirachta excelsa*
Bd	Basal diameter
C	Crown diameter increment
CB ratio	Crown-basal diameter ratio increment
Cd	Crown diameter
CIFOR	Centre for International Forestry Research
CS	Crown surface area increment
D	Basal diameter increment
DMRT	Duncan's Multiple Range Test
F	Foliage or crown depth increment
FAO	Food and Agriculture Organisation
Fd	Foliage or crown height
G2	Gap planting at 10m x 10m x 5 subplots
G3	Gap planting at 20m x 20m x 5 subplots
G4	Gap planting at 10m x 10m x 9 subplots
H	Total height increment
Ho	*Hopea odorata*
Ht	Total height
L10	Line planting at 10m x 100m x 2 subplots
L3	Line planting at 3m x 100m x 2 subplots
L5	Line planting at 5m x 100m x 2 subplots
NGO	Non-governmental Organisations
PRF	Permanent Reserve Forest
RF	Relative crown or foliage height increment
RH	Relative height increment
UPM	Universiti Putra Malaysia
V	Volume increment
Vp	*Vitex pinnata*

CHAPTER 1

INTRODUCTION

1.1 Tropical Rainforests

Tropical rainforests are considered the most productive of all terrestrial ecosystems, as plant growth and primary production are highest under the warm and wet conditions that are typical of such forests. This productivity has resulted in their immense diversity that has paved the way for all the other goods and services that these forests have afforded humankind (Geocities, 2002; Sudarmadji, 2001; Yusoff *et al.*, 2001; Bush, 2000; Julie and Anna, 1997; Wilson, 1988; Myers, 1986, 1984). Their functional roles, including bio-diversity conservation, world climate amelioration, soil and water conservation, and timber production, among others, cannot be over-emphasised. Tropical rainforests are universally valuable and indispensable. They provide a habitat for more than 50% of the world 's plant and animal species. Their role in carbon sequestration has a critical effect on world climate change, as they reduce the accumulation of greenhouse gases that is responsible for global warming. Through their root systems, the trees help prevent soil erosion and enhance water catchments, thereby regulating the hydrologic cycle. On dry or infertile surface soils, deep tree roots reach down to the underground reservoirs of nutrients and water and bring them to the surface. The tropical forests also play an important role in the local economy. They supply food, medicine, fuelwood energy for local consumption, and raw materials for the forest-based industries thereby providing employment to the local community.

1.2 Global Initiatives on the Conservation of Tropical Rainforests

The conservation of tropical rainforests used to be a national or regional matter. In the last few decades however, this has escalated to be a global concern, not only of those directly but also of those indirectly involved in forest resources management. Tropical rainforests are being degraded at an alarmingly increasing rate, creating a situation that is now widely accepted as one of the great threats not only to forest wildlife but also to every living creature on earth. The consequences of deforestation in the tropics have brought serious global implications (Bush, 2000; Elliott, 2000; Wilson, 1988; Myers, 1986, 1984). In 1995, a consensus document of international climate scientists, economists, and risk-analysis experts declared that evidence suggested a discernible human influence on global climate. The projected melting of polar ice caps that would raise sea levels by between 60 – 75 cm by the mid 21st century, suggested major storm and erosion impacts on coastal areas and islands (UNFCC, 1992). The current rate of tropical deforestation and its undisputed environmental threat to world climate change and other effects has repeatedly elicited an urgent call for improved management of the forest recovery process. Moreover, forest regeneration or reforestation has to keep up with the ever-increasing demand for forest goods and services.

Recent awareness on forests and forest resources conservation has linked reforestation with the equally important task of maintaining biodiversity. As a result, international summits, conferences and guidelines on forest utilisation procedures have been conducted and formulated to address the serious issue of tropical forest conservation. For example, Agenda 21 (1992 UN Conference on Environment and Development Action Plan), highlighting UN efforts at managing the world's forest, has stressed the importance and value of national strategies for sustainable development (UNDSV, 2000). Since 1993, the Plan has involved 75 developing countries in adopting innovative capacity-building approaches to address environmental degradation, social inequity, and economic decline (UNDP, 2000). In addition, such activities as conventions on biological diversity, climate change, and combating desertification have been held internationally (NSSD, 2002). The Kyoto Protocol that primarily aims to undertake climate change as part of the wider commitment to sustainable development embraced a two-fold task: to maintain global economic development and to do so on an environmentally sustainable basis (Priddle, 1997). It focused on the reduction of the emission of greenhouse gases that are primarily caused by burning fossil fuels (coal, oil and natural gas) and has set at least a 5% reduction from 1990 levels for industrialised countries over the 2008-2012 period, as agreed in December 1997 (UNFCC, 1992). The Timber Certification plan that also aims to protect the world's forests was a move to ensure sustainable management of forest resources and to curb over-logging in natural forests. This was introduced by international environmental NGO's as a certification project for environmentally friendly wood, for nations to cope with increasing worldwide logging (Baharuddin, 2002; Bourke, 1999).

1.3 Approaches to Tropical Rainforest Conservation

In the effort to alleviate tropical reforestation concerns, three approaches, namely; restoration, rehabilitation and reclamation with corresponding reference to the use of species, may be adopted (Lamb, 1994). Of these three, restoration and rehabilitation consider the use of native species while reclamation fully use exotics. Restoration involves only the native species while rehabilitation includes exotic species whenever necessary. Artificial regeneration or rehabilitation however, has been viewed as the least desirable method because of the intensive and expensive operations it entails. Unfortunately, there is little choice left. In 1981, two billion