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Multi Storied Forest Management System as an Enrichment Planting Arrangement on Poorly Stocked Inland Forest: An Experience in Peninsular Malaysia

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Abstract: The paper present the results of evaluation of the data set that contains the variety of trees species and approaches under Multi Storied Forest Management System on three (3) selected sites, namely, Secondary forest, *Acacia mangium* forest and Selective logged over forest in Peninsular Malaysia. The results showed that in Secondary forest, *Shorea roxburghii* showed the highest survival rate at 98% and the highest average of diameter growth with 2.13cm at one (1) year planting. While in *Acacia mangium* forest, *Hopea odorata* had exceeding the highest survival rate with 77% and has the highest average of diameter growth with 2.06cm at one (1) year planting. For Selective logged over natural forest, *Dipterocarpus baudii* shows the highest survival rate with 76% meanwhile *Shorea leprosula* has the highest average of diameter growth with 1.5cm at one (1) year after planting. These results indicate that with the right species selection used under several planting methods of Multi Storied Forest Management System will become the potential application for future large enrichment planting programme in poorly stocked inland forest in Peninsular Malaysia.

Keywords*:* growth performance, survival rate, diameter growth, enrichment planting, secondary forest, Acacia mangium forest, selective logged over forest

Introduction

The future of log or timber supply in Peninsular Malaysia is largely depending on the availability of the productive Permanent Reserve Forests. Most of the Permanent Reserve Forests are confined to the hilly and difficult terrain, which are poorly stocked with regeneration particularly on the slopes and valleys. Experiences with logging in the hills had often shown that the resulted forests were inadequately stocked with advanced growth and seedling regeneration. It was then realized that the renewal of the bulk in PFE after logging could not be solely depended upon natural regeneration. Therefore, artificial regeneration is needs to be addressed in order to ensure adequate regeneration in the forest. In this regards, enrichment planting is the most popular treatment option to enrich the poorly stocked forest.

The significant roles of enrichment planting are the introduction of selected and desired good quality timber species into the forest stand; the manipulation of stocking through specified planting distance; the enhancement of the rate of recovery of poorly stocked logged over forest; and the improving residual stocking of a poorly stocked logged over forest for next cut. Enrichment planting, on the other hand, has been defined as the introduction of valuable selected timber species into degraded forest areas without eliminating the existing timber trees in any single forest stand. In other words, it is essentially a process of supplementing the natural regeneration where it is insufficient, with seedlings of commercial species (preferably indigenous) (Appanah *et. al.*, 1993).

In Peninsular Malaysia forestry, the practice of enrichment planting in the early 1900's was very minimal in comparison to the period in the mid 1960's and onwards or during Malayan Uniform System shifted to Selective Management System era. Malayan Uniform System has been successfully applied to the lowland dipterocarp forest but unsuccessful in the hill dipterocarp forest. This is due to the silvicultural and environmental difficulties of the hill forest mainly lack of natural regeneration on the forest floor before logging and uncertain seedlings regeneration after logging. For this reason, artificial regeneration became important and was materialized in the mid 1960's. In the subsequent years, a timber harvesting activity has shifted from lowland dipterocarp forest to hill dipterocarp forest.

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Hence, Malayan Uniform System has been replaced by the Selective Management System. The success of Selective Management System in the hill forest amongst others lies on an adequacy of residual stocking for a particular diameter class that will form the next crop so as to ensure sustained yield management. In this regards, the implementation of enrichment planting became more prominent and important in the effort to ensure that relatively poor stocking of logged over forests is enriched with selective indigenous commercial species (Thang, 1987). Under the practice of Selective Management System, the two most important and commonly applied silvicultural treatment options, particularly significant in the silvicultural practice of the natural inland forest are enrichment planting and girdling of defective relic trees and climber cutting. These silvicultural treatments are only prescribed after the analysis of the Post-F inventory results.

However, the implementation of enrichment planting is more critical in natural gap (or open area) left after timber harvesting operation in the Permanent Reserve Forests, such as in the skid trail and log yard. In the natural gap areas, the major focus of enrichment planting is to rehabilitate or reforestation with the planting of suitable indigenous species of highly marketable. Enrichment planting is also implemented in the degraded forest areas or degraded land areas outside of Permanent Reserve Forests with the purpose to regain the richness of the planting site through several rehabilitation or restoration projects, which involving planting of forest species suitable to the site.

Enrichment planting will remain as an important component of the forestry development activity mainly for the poorly stocked-over forests. Earlier planting efforts may be hampered by limited knowledge and experience but to date there are sufficient bodies of technical knowledge such as research institution and government department to provide the technical backing for carrying out the rehabilitation activities in the poorly stocked-over forests successfully. New finding gained through years of research by researchers and works on forest planting experiences accumulated by field foresters since in the early century have enable to provide with greater confidence of knowledge for future successful implementation of enrichment planting towards maintaining sustainable forest management practices. Raja Barizan *et. al.* (1997) have outlined several key issues for future direction in enrichment planting, such as the right timing of planting, stump as a planting stocked, use of wildings to overcome irregular fruiting and unreliable quality of seeds, aspect of species-site matching crucially in hill forests, gap opening, cost effective, fertilizer application and biodiversity conservation. The future success story of enrichment planting are found to be continuously affected with new planting techniques, relatively small establishment and maintenance costs, good transportation facilities, better planting stock handling and sound approaches/techniques in the preparation of planting stock (Wan Yusoff *et. al.*, 1997).

The project called “Multi-Storied Forest Management Project in Malaysia” implemented as pilot study in Perak was carried out from 1991 to 1999 with the objective to generated immense technical and managerial information pertaining to multi-storied planting approaches in an endeavour to enhance the implementation of large scale forest tree planting activities with selective indigenous commercial species. Arifin *et. al.* (2008) and Karam *et. al.* (2012) stated that multi-storied forest management is a forest rehabilitation technique using high quality trees species to form two or more layers of the canopy. Forestry Department of Peninsular Malaysia (2003) claimed that the multi storied management system has gained notable attention as potential and suitable forest management techniques to protect the environment conserve biodiversity and produce timber.

MATERIAL AND METHODS

Study Site

The project was implemented in two study sites; Chikus Forest Reserve and Bukit Kinta Forest Reserve. The study site in Chikus Forest Reserve comprises 200ha of *Acacia mangium* plantation and 300ha of clear felled open land (Secondary forest) while the Bukit Kinta site comprises 500ha of selectively logged over natural forest. Basically, under planting method were employed for establishing multi storied forest, which the indigenous species were planted in between rows of established *Acacia mangium* or within gaps of logged over natural forests.

A multi storied forest by under planting in Secondary Forest was established in Block A94 in Chikus Block A. Block A94 was set up to three types of planting designs (Types A, B and C) (Figure 1) by using secondary forest as nurse trees with 2.5m x 5m spacing. Each plot lies from east to west with one planting design and one species employed. Weeding of 2m wide planting line was carried out. A total of 14 indigenous species (Table 1) were planted throughout BlockA94. Fertilizer was not applied. Weeding and climber cutting were carried out in the same time. The first weeding and climber cutting were done 2 to 3 months after planting. This was followed every 2 to 4 months depending on the undergrowth. The 2m wide line weeding by bush cutter was applied. Pruning has not been carried out. Any fatal damage of the seedlings by insects and diseases has not been observed.

Table 1: Species were planted in Block A, Chikus site (Secondary Forest)

No.	Species	Local name
1	*Dialium platysepalum*	Keranji kuning besar
2	*Gonystylus affinis*	Ramin dara elok
3	*Neobalanacarpus heimii*	Chengal
4	*Shorea acuminata*	Meranti rambai daun
5	*Shorea bracteolate*	Meranti pa'ang
6	*Shorea glauca*	Balau laut
7	*Shorea leprosula*	Meranti tembaga
8	*Shorea multiflora*	Damar hitam pipit
9	*Shorea ovalis*	Meranti kepong
10	*Shorea ovata*	Meranti sarang punai bukit
11	*Shorea parvifolia*	Meranti sarang punai
12	*Shorea pauciflora*	Meranti nemesu
13	*Shorea roxburghii*	Meranti temak nipis
14	*Sindora sp.*	Sepetir

While the multi storied forest by under planting in *Acacia mangium* Forest was established in Block B92, B93 and B94 in Chikus Block B. These experimental plots were set up to five types of planting designs with 3m x 3.7m spacing (Figure 2). Planting holes were 20 cm in diameter and 20 cm deep. A total of 18 indigenous species (Table 2) were planted in Block B consisting of three species in B92, eight species in B93 and nine species in B94. Fertilizer was not applied. A survival survey was carried out one month after planting. Supplementary planting was carried out within the next two months in plots with mortality of 20% or more. Weeding and climber cutting were carried out in the same time. The first weeding and climber cutting were carried out 3 to 4 months after planting. This was followed every 3 to 5 months depending on the undergrowth. Forest floor vegetation grew in accordance with the planting strip width. The major vegetation and weeding frequency in each planting design are shown in Table 3. While, the tending records are as shown in Table 4.

Table 2: Species were planted in Block B, Chikus site (*Acacia mangium* Forest)

No.	Species	Local name
1	*Dipterocarpus cornutus*	Keruing gombang
2	*Dryobalanops aromatica*	Kapur
3	*Hopea odorata*	Merawan siput jantan
4	*Hopea pubescens*	Merawan bunga
5	*Intsia palembanica*	Merbau
6	*Noebalanacarpus heimii*	Chengal
7	*Palaquium gutta*	Nyatoh taban merah
8	*Parashorea densiflora*	Gerutu pasir
9	*Pentaspadon motleyi*	Pelong lichin
10	*Shorea acuminata*	Meranti rambai daun
11	*Shorea assamica*	Meranti pipit
12	*Shorea glauca*	Balau laut
13	*Shorea leprosula*	Meranti tembaga
14	*Shorea macroptera*	Meranti melantai
15	*Shorea ovalis*	Meranti kepong
16	*Shorea ovata*	Meranti sarang punai bukit
17	*Shorea parvifolia*	Meranti sarang punai
18	*Shorea pauciflora*	Meranti nemesu

Table 3: Major vegetation and weeding frequency in Block B, Chikus site (*Acacia mangium* Forest)

Type	Strip width	Vegetation	Mean height of vegetation	Weeding frequency
D	1 row	Herb and fern	1 m	2-3 times per year
E	2 row	Herb and fern	1 m	2-3 times per year
F	4 row	Herb and fern	1 m	3 times per year
G	8 row	Grass	2 m	3-4 times per year
H	16 row	Grass	2 m	4-5 times per year

Table 4: Tending records in Block B, Chikus site (*Acacia mangium* Forest)

Year	Block	Jan	Feb	Mac	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	B92	C	C							C	C		
	B93	C	C							C	C		
	B94	W	W							W	W		
1998	B92						CN, W	CN, W	CA	CA	CA		
	B93			CN, W					CA	CA	CA	W	W
	B94				CN, W				CA	CA	CA	W	W
1999	B92						W	W	W				
	B93	W			W				W				
	B94	W			W				W				

Note: W : weeding/climber cutting for indigenous high quality timber species
C : climber cutting only for indigenous high quality timber species
CN : clearing for indigenous high quality timber species
CA : clearing for *Acacia mangium*

For the multi storied forest by under planting in Selectively logged over natural forest, there were two (2) types of planting methods; Gap planting (GP) and Line planting (LP). GP were divided into two approaches; Natural Gap Planting (NGP) and Artificial Gap Planting (AGP). NGP is a plantation pre-existing canopy opening larger than 30m x 30m created naturally or by logging activities. AGP plots of 5m x 5m, 10m x 10m, 20m x 20m and 30m x 30m (Figure 3) were created by felling over-story trees. Three types of spacing were applied for GP, 5m x 2.5m in NGP, 2m x 2m in the smallest type of AGP and 3m x 3m in the larger three types of AGP (Figure 4) Seedlings were planted basically along contour lines in gap planting. LP plots of 2m, 10m and 20m width (Figure 5) were established in the same manner as AGP. Each line is 120-160m long and lies northeast to southwest. Two types of spacing were applied for line planting, 3m interval in LP2 and 5m x 2.5m in LP10 and LP20. Planting spots were cleared in circle of 1m diameter. Planting holes are 12cm in diameter and 20cm deep. Fertilizer was not applied in all the plots. A total of 7 indigenous species (Table 5) were planted. Weeding and climber cutting were carried out in the same time. All the undesirable plants were cut before exceeding 30 cm high and all the undergrowths within 45 cm from the seedlings were hoed up. All the climbers found on the seedlings were cut and removed. Weeding was done when climbers and undergrowth reached up to the tree height. The frequency weeding was generally 3 to 4 times in the first year. However, some plots did not need weeding during the first year. Tending records for 1994 to 1999 are shown in Table 6.

Table 5: Species were planted in Block A, Bukit Kinta site (Selectively Logged over Forest)

No.	Species	Local name
1	*Dipterocarpus baudii*	Keruing bulu
2	*Shorea curtisii*	Meranti seraya
3	*Shorea leprosula*	Meranti tembaga
4	*Shorea macroptera*	Meranti melantai
5	*Shorea parvifolia*	Meranti sarang punai
6	*Shorea pauciflora*	Meranti nemesu
7	*Shorea ovata*	Meranti sarang punai bukit

Table 6: Tending records in Block A, Bukit Kinta site
(Selectively Logged over Forest)

		Planting in 1994							Planting in 1995				Planting in 1996					
Block		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
94	May																	
	Jul																	
	Oct																	
	Dec																	
95	Mac																	
	Jun											NGP						
	Jul											AGP,LP						
	Aug											NGP						
	Sep											AGP,LP						
	Oct																	
	Nov																	
96	Mac																	
	Jul																	
	Oct																	
	Dec																	
97	Mac																	
	Jun																	
	Aug																	
98	Jan																	
	Jul																	
	Dec																	
99	Apr																	

: No weeding for half of the block

RESULTS

Growth performances of tried species

Secondary Forest

In 5 years planting, *Shorea roxburghii* show the highest survival rate with 98% followed by *Shorea ovalis* (64%) and *Dialium platysepalum* (63%). While, the highest average of diameter growth is *Shorea roxburghii* with 2.13cm at one year after planting followed by *Shorea leprosula* (2.08cm) and *Shorea ovalis* (1.65cm). For the highest average of height growth, *Shorea glauca* reaching 1.47 m at one year after planting followed by *Shorea leprosula* (1.43m) and *Shorea roxburghii* (1.34m). Table 7 shows the results of growth performance of selected species planted in Block A of Chikus Site.

Acacia mangium Forest

Result has shown that *Hopeo odorata* had exceeding the highest survival rate with 77% followed by *Shorea leprosula* (56%) and *Neobalanacarpus heimii* (55%) for 5 years planting. *Hopeo odorata* also has the highest average of diameter growth with 2.06cm at one year after planting followed by *Shorea leprosula* (1.92cm) and *Shorea parvifolia* (1.89cm). Meanwhile, for the highest average of height growth rate, *Shorea leprosula* lead all species with the height growth reaching 1.36m at one year after planting followed by *Shorea ovalis* (1.27m) and *Dryobalanops aromatica* (1.25m). The details of growth performance for selected species planted in Block B at Chikus site as shown in Table 8.

Selective Logged over Natural Forest

From Table 9, the growth performance of selected species planted in Bukit Kinta site or the multi storied forest by under planting in Selectively logged over natural forest shows that in 5 years planting, *Dipterocarpus baudii* shows the highest survival rate with 76% followed by *Shorea macroptera* (62%) and *Shorea parvifolia* (47%). Meanwhile, *Shorea leprosula* has the highest average of diameter growth with 1.5cm at one year after planting followed by *Shorea pauciflora* (1.03cm) and *Dipterocarpus baudii* (1.01cm). For the highest average of height growth, *Shorea leprosula* reaching 1.47 m at one year after planting followed by *Shorea glauca* (1.35m) and *Shorea parvifolia* (1.22m).

Table 7: Growth performance of selected species in Block A of Chikus Site (Secondary Forest)

Species	Age (months)	Planting type	Height (cm)	Basal Diameter (mm)	Survival Rate (%)
Shorea leprosula	66	A~C	789/(735~849) @ 143cm/year	111/(102~122) @ 20mm/year	47/(40~57)
Shorea glauca	66	A~C	737/(642~825) @ 134cm/year	83/(79~86) @ 15mm/year	51/(43~66)
Shorea ovalis	66	A~C	720/(575~835) @ 131cm/year	91(76~107) @ 17mm/year	64/(55~76)
Shorea parvifolia	87	A~C	734/(585~906) @ 115cm/year	100/(69~120) @ 16mm/year	5/(1~10)
Shorea roxburghii	66	A, B	807/(749~879) @ 147cm/year	117/(107~132) @ 21mm/year	98/(96~100)
Shorea acuminata	66	A, B	639/(623~649) @ 116cm/year	91/(87~107) @ 17mm/year	19/(11~33)
Dialium platysepalum	66	A, B	502/(477~534) @ 91cm/year	62/(57~67) @ 11mm/year	63/(53~72)
Shorea pauciflora	66	A~C	590/(518~643) @ 107cm/year	89/(84~92) @ 16mm/year	35/(29~48)
Shorea multiflora	66	A, B	551/(461~636) @ 100cm/year	81/(69~94) @ 15mm/year	51/(38~66)
Gonystylus affinis	66	A, B	396/(380~412) @ 72cm/year	54/(46~61) @ 10mm/year	54/(36~74)
Neobalanacarpus heimii	66	A~C	334/(275~371) @ 61cm/year	47/(35~51) @ 86mm/year	44/(24~68)
Shorea bracteolate	66	A, B	125/(105~154) @ 23cm/year	27/(25~28) @ 5mm/year	53/(46~68)
Shorea ovata	66	A, B	561/(507~611) @ 102cm/year	77/(72~86) @ 14mm/year	8/(4~15)
Sindora sp.	66	A, B	309/(298~327) @ 56cm/year	38/(33~42) @ 7mm/year	35/(21~45)

Note: In an expression of X/(Y~Z); X – Average of plots' mean values
Y – Minimum plots' mean
Z – Maximum plots' mean

Table 8: Growth performance of selected species in Block B of Chikus site (*Acacia mangium* Forest)

Species	Age (months)	Planting type	Height (cm)	Basal Diameter (mm)	Survival Rate (%)
Shorea leprosula	95 67	D~H F	1210/(1114~1348) @ 158cm/year 708 @ 127cm/year	152/(141~174) @ 19mm/year 130@ 23mm/year	56/(18~74) 52
Shorea glauca	82	D	434 @ 63cm/year	54 @ 8mm/year	21
Shorea ovalis	67	D~H	853/(678~991) @ 152cm/year	107/(92~117) @ 19mm/year	43/(31~60)
Shorea parvifolia	95	D~H	1076/(836~1231) @135cm/year	149/(109~189) @ 18mm/year	39/(9~66)
Hopea odorata	82	D~H	883/(604~1236) @ 129cm/year	140/(102~174) @ 20mm/year	77/(61~89)
Parashorea densiflora	82	D~F	801/(698~971) @ 117cm/year	102/(93~114) @ 14mm/year	42/(38~49)
Dryobalanops aromatica	82	D~F	811/(583~1014) @118cm/year	91/(50~110) @ 13mm/year	29/(23~39)

Shorea acuminata	82	D~F	937/(880~980) @ 137cm/year	122/(117~127) @ 17mm/year	53/(44~63)
Shorea pauciflora	67	D~H	654/(564~863) @ 117cm/year	104/(83~125) @ 18mm/year	21/(7~36)
Shorea macroptera	82 67	E F	598/(531~664) @ 87cm/year 666 @ 97cm/year	66/(60~72) @ 9mm/year 83 @ 10mm/year	44/(38~50) 65
Dipterocarpus cornutus	67	D~H	484/(449~551) @ 87cm/year	70/(62~80) @ 13mm/year	37/(30~44)
Intsia palembanica	67	D~H	369/(321~401) @66cm/year	52/(43~60) @9mm/year	45/(30~66)
Neobalanacarpus heimii	95	D~H	489/(394~550) @ 61cm/year	70/(45~94) @ 9mm/year	55/(32~80)
Palaquium gutta	82	D~F	525/(467~556) @ 77cm/year	55/(38~66) @ 8mm/year	32/(12~58)
Pentaspadon montleyi	82	D~G	1067/(925~1243) @ 156cm/year	126/(95~168) @ 18mm/year	38/(26~58)
Shorea ovata	67	D~H	531/(355~649) @ 95cm/year	72/(50~98) @ 19mm/year	11/(1~23)
Shorea assamica	67	D~H	365/(247~511) @ 65cm/year	53/(34~81) @ 10mm/year	44/(29~68)
Hopea pubescens	67	D~H	431/(300~490) @ 77cm/year	55/(43~59) @ 10mm/year	20/(2~23)

Note: In an expression of X/(Y~Z); X – Average of plots' mean values
Y – Minimum plots' mean
Z – Maximum plots' mean

Table 9: Growth performance of selected species in Bukit Kinta site (Selectively logged over Forest)

Species	Age (months)	Planting type	Height (cm)	Basal Diameter (mm)	Survival Rate (%)
Shorea curtisii	72 60	NGP AGP (5~30)	569 @ 95cm/year 287/(263~338) @ 57cm/year	59 @ 10mm/year 23/(21~28) @ 5mm/year	18 37/(27~44)
Dipterocarpus baudii	72 60	NGP AGP (5~30)	449/(142~963) @ 75cm/year 232/(181~296) @ 46cm/year	61/(21~61) @ 10mm/year 23/(16~29) @ 5mm/year	83 70/(61~78)
Shorea pauciflora	72 72 72 72	NGP AGP (5~30) AGP(20) LP (2~20)	477 @ 80cm/year 486/(372~553) @ 81cm/year 74 @ 12cm/year 458/(349~549) @ 76cm/year	44 @ 7mm/year 62/(36~78) @ 10mm/year 10 @ 2mm/year 52/(35~67) @ 9mm/year	37 33/(27~40) 17 44/(36~50)
Shorea macroptera	72 72 72 72	NGP AGP (5~30) AGP(20) LP (2~20)	473 @ 79cm/year 486/(450~545) @ 81cm/year 168 @ 28cm/year 453/(367~509) @ 76cm/year	55 @ 9mm/year 52/(40~62) @ 9mm/year 14 @ 2mm/year 47/(37~55) @ 8mm/year	60 65/(52~81) 48 61/(58~63)
Shorea ovata	60	AGP (5~30)	247/(192~326) @ 49cm/year	26/(21~32) @ 5mm/year	7/(4~9)

Shorea parvifolia	84	NGP	535/(379~690) @ 76cm/year	57/(46~68) @ 8mm/year	47/(47~49)
Shorea leprosula	72 72	NGP AGP(30)	927 @ 178cm/year 841 @ 140cm/year	92 @ 16mm/year 90 @ 15mm/year	56 28

Note: In an expression of X/(Y~Z); X – Average of plots' mean values
Y – Minimum plots' mean
Z – Maximum plots' mean

Discussion

As a result of experiment on the 58 species, 23 species as listed in the Table 10 were selected as suitable species for establishment of multi storied forest. These species were categorized into four groups based on their height growing speed. Selection of species was made with their environmental adaptabilities (drought tolerance and suitable light condition) and growing tendencies (growing speed and climber tolerance) taken into account. While a preliminary yield table for the 23 selected species was prepared as in Table 11 based on the growth data collected by the project's experiment and from literatures.

Table 10: Suitable tree species

Group	Prospected height growth in 5 years	Species
A	920 cm	*Shorea leprosula* *Shorea glauca*
B	740 cm	*Dipterocarpus kerii* *Shorea ovalis* *Shorea parvifolia* *Shorea roxburghii* *Dipterocarpus oblongifolius* *Hopea odorata* *Parashorea densiflora* *Dryobalanops aromatica*
C	520 cm	*Shorea acuminata* *Shorea curtisii* *Dialium platysepalum* *Dipterocarpus baudii* *Shorea pauciflora* *Shorea multiflora* *Shorea macroptera* *Anisoptera leavis* *Dipterocarpus cornutus*
D	360 cm	*Intsia palembanica* *Gonystylus affinis* *Neobalanacarpus heimii* *Shorea bracteolata*

Table 11: Preliminary yield table of selected species

Age (year)	Group A			Group B			Group C			Group D		
	H (m)	DBH (cm)	Vol. (m^3/ha)	H (m)	DBH (cm)	Vol. (m^3/ha)	H (m)	DBH (cm)	Vol. (m^3/ha)	H (m)	DBH (cm)	Vol. (m^3/ha)
5	9.45	10.0	17	7.70	8.4	10	5.20	6.2	4	3.60	4.5	2
10	21.15	20.2	140	18.60	17.3	93	14.79	13.3	46	12.23	10.2	23
15	29.48	29.2	226	26.70	25.4	198	22.33	19.9	144	19.25	15.5	79
20	35.40	37.2	286	32.70	32.6	257	28.25	26.0	211	24.97	20.5	170
25	39.61	44.3	332	37.16	39.2	304	32.91	31.6	256	29.63	25.2	220
30	44.74	50.6	367	40.47	45.1	341	36.57	36.8	294	33.41	29.6	255
35	45.61	56.2	395	42.93	50.5	369	39.44	41.6	325	36.50	33.8	287
40	46.26	61.1	415	44.75	55.3	392	41.70	46.0	351	39.01	37.7	314
45	47.34	65.5	434	46.10	59.7	411	43.48	50.1	375	41.05	41.4	339
50	48.11	69.4	449	47.11	63.6	426	44.88	53.9	391	42.72	44.8	359
55	48.65	72.9	459	47.85	67.1	440	45.97	57.4	408	44.07	48.1	375

60	49.04	76.0	467	48.41	70.3	449	46.83	60.7	419	45.17	51.2	391
65	49.32	78.7	475	48.82	73.2	457	47.51	63.7	431	46.07	54.1	404
70	49.52	81.1	476	49.12	75.8	466	48.04	66.4	439	46.80	56.8	412
75	49.66	83.2	481	49.35	78.2	469	48.46	69.0	447	47.40	59.3	421
80	49.75	85.1	481	49.52	80.3	476	48.79	71.3	457	47.88	61.8	432

Selected Species

The successful species combination, indigenous and exotic; indigenous and indigenous has implemented in this project can applied in wider application with new combination and various. The selected species also has attracted great attention as a material to conserve biodiversity and environment while producing high quality timber.

Site selection

In the present situation, the detailed matching of species and site suitability has yet to be attained. There was an effort by researchers and foresters doing the species site matching. However, it is not the comprehensive species site matching. Hence, the immense technical and managerial information from the multi storied forest management system can be used to preparing the detailed species site matching.

Planting technique/planting approach

The flexible approach of mixed planting on different sites can be applied in other sites with more planting options and opportunity. The multi storied forest management system approach can be expanded to the large scale programmes and improving the implementation of enrichment planting.

Costing

The undeniable fact regarding enrichment planting today is that it is an expensive activity to implement and the benefits that could derive from the today's planting can only tapped perhaps a decade or more in the future. In multi storied forest management system, the costing is less due to no fertilizer used; effective mode of transporting planting stock; proper treatments and less manpower.

Observations

From the 23 selected species, 20 species are from the Family Dipterocarpaceae. Most of the species are high value commercial timber and the wood is useful in many utilities, such as *Hopea odorata*. *Hopea odorata* wood is suitable for weather boarding, tiling battens, boat and ship building and water barrels. It is also satisfactory for the manufacture of plywood, veneer and particleboard (PROSEA 1993). The selected species is also a relatively fast growing species such as *Shorea leprosula*. *Shorea leprosula* plantation can possibly be managed on a 30 to 40 years rotation with the recent development in wood processing technology that enables the utilisation of smaller diameter logs (Ang, 2002). The selection species can be expanding in the types of diverse species. Besides that, from this study, the information of site requirements of the species can be used to preparing the detailed species site matching.

In multi storied forest management system, the new and creative approaches of planting techniques in variable sites with the regime of management have been proposed and its show great potential for wider application in other forests. Most of these planting techniques have achieved better survival rates of species. In the Under-planting method in the *Acacia mangium* Forest, all selected species have achieved better survival rates exceeding 50% except *Shorea ovata* and *Shorea acuminata* while in the logged over forest, all selected species have attained high survival rates between 50% to 88% except for *Shorea curtisii*. It has been concluded that in general the gap and line planting (except for 2 m strip) are effective methods for the better regeneration of logged over natural forest (Wan Yussoff *et. al*., 1997). Besides that, the planting design of mixed crop; indigenous species and indigenous species, indigenous species and exotic species; will encouraging the growth of trees caused by the tight competing against species. Also thus, indirectly, the multi storied of tree planting will be acts like the light manuvouring. The slow release of light wills effecting the growth of trees especially seedlings. It was reported that dipterocarp seedlings normally requires 30% to 40% of sunlight while non dipterocarp seedlings requires 50% to 60% of sunlight (Aminah *et.* al., 1997).

The effective mode of transporting planting stock to the planting site will be cost effective and minimal evapo-transpiration to the seedlings. In multi storied forest management system, the approach does not reside to only permanent nursery but expanded to temporary nursery using relatively better equipments and material but producing hardy planting stock. These nurseries are located close to the planting areas. With no fertilizer used; effective mode of transporting planting stock; proper treatments and less manpower, this system doesn't need big costing.

The study was considered successful in identifying species and planting technique, effective and viable, and contributing towards the country's effort to enriching poorly stocked inland forest. Hence, the application can be expanded to the large-scale programmes. However with regards to the status of pilot study, the implementation of project only focused on three selected sites namely Selective

Logged over Natural Forest; Secondary Forest; and *Acacia Mangium* Forest. The implementation should be expanding to other site for wide application. Other than that, the selection of species is too narrowed. It should be expanded, probably based on timber classification, timber marketability or timber usage. Also thus, the planting scale needs to expand to the bigger scale for getting the precise result.

Conclusion

Enriching poorly stocked forest is very constraint. Its role in attaining sustainability of forest has been long recognized. In order to attain this, its approach must be an efficient and effective technique of planting, cost effective, selection of suitable species for effective rehabilitation programmes and the application on wider sites. Multi storied forest management system provides opportunity to practice intensive forest silvicultural activities for enriching poorly stocked forest, degraded lands and production areas. However, more works are required to be done and the study needs to be expanded to others sites because the tropical forest comprise of different forest types that require different methods and techniques of management. Also thus, on the harsh condition sites namely coastal area, peat swamp forest and log yard. Other than that, the selection and combination of used species should be expanded to diverse indigenous and exotic species. Nevertheless, multi storied forest management system shows a promising planting success, has a great potential and very useful in enriching our knowledge to explore, refine and use the information and experiences through years of research and work to improve the selection of the suitable species, planting techniques and species-site matching in order to increase the implementation and success of enrichment planting for future large enrichment planting programme for poorly-stocked inland forest in Peninsular Malaysia.

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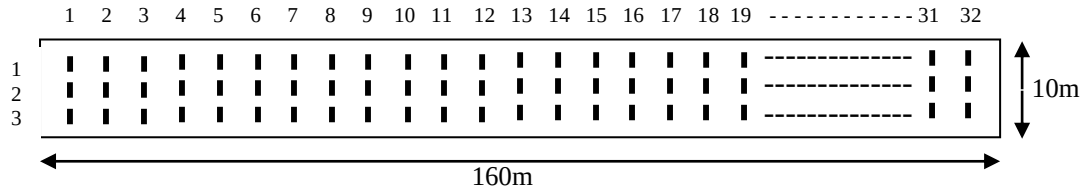
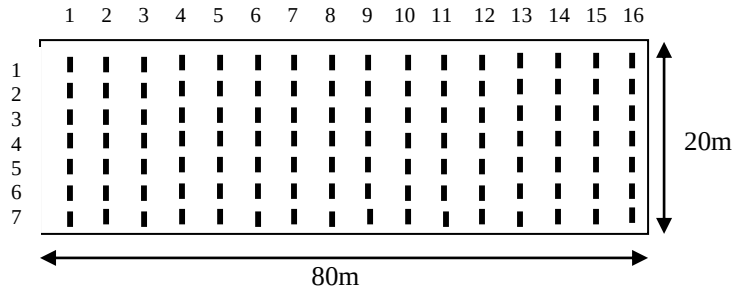
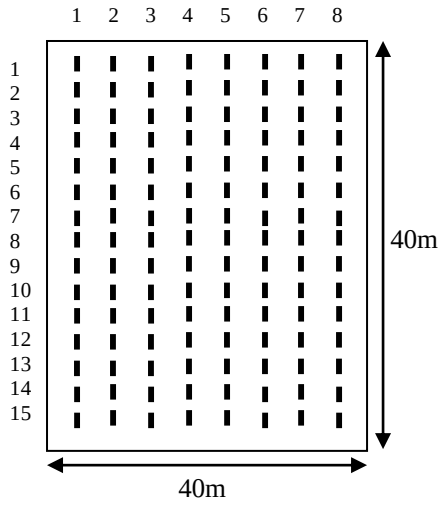
Figure 1: Planting design of multi storied forest by under planting in Secondary Forest

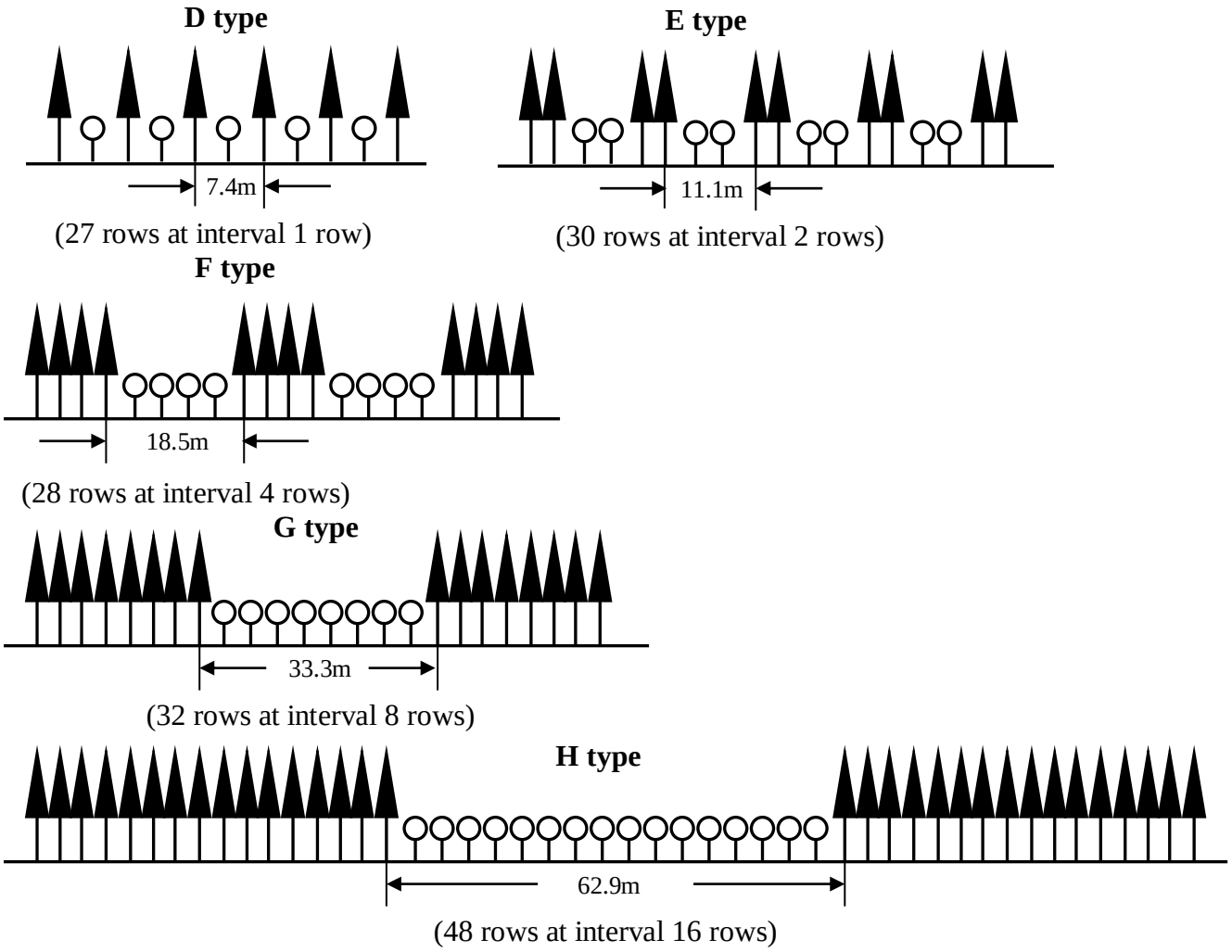






A type (10m width); 3 x 32 = 96 seedlings/plot
B type (20m width); 7 x 16 = 112 seedlings/plot
C type (40m width); 15 x 8 = 120 seedlings/plot

Figure 2: Planting design of multi storied forest by under planting in *Acacia mangium* Forest



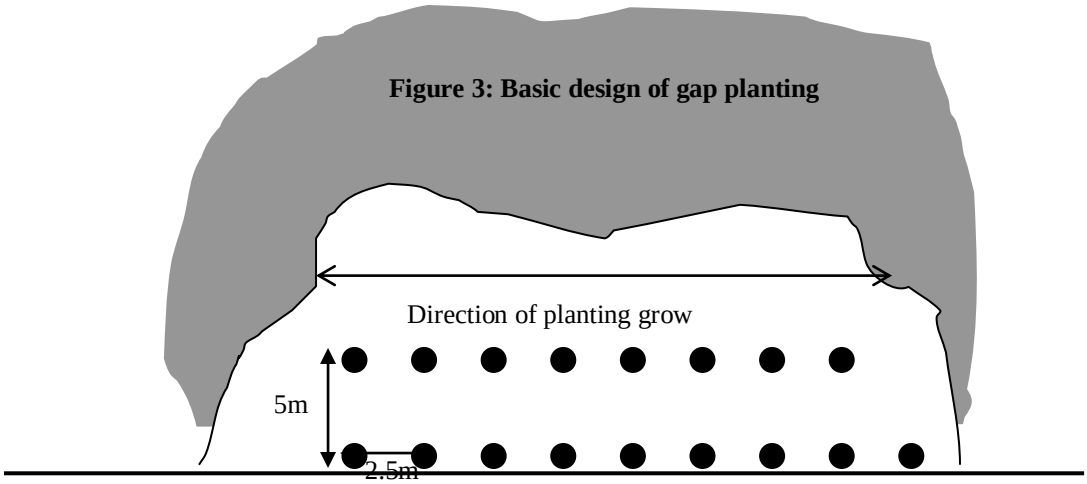
Notes :

Indicates Fast Growing Species (e.g. *Acacia mangium*)

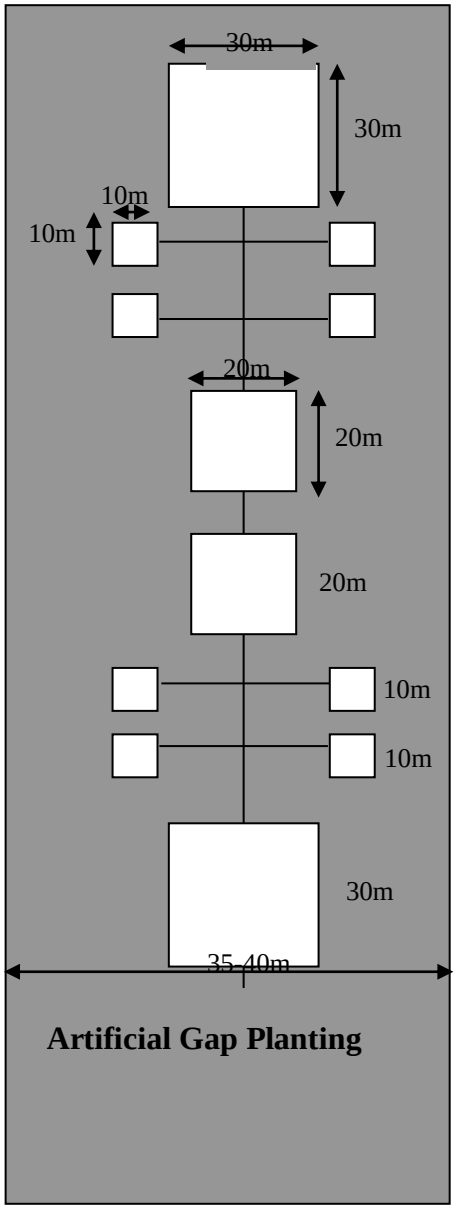
Indicates High Quality Timber Species (e.g. Dipterocarpaceae)

Planting distances : 3m x 3.7m

Figure 3: Basic design of gap planting



Natural Gap Planting



Artificial Gap Planting

Legend

Non cut area

Cut area

Track

Spacing (AGP) : 3m x 3m in 30m x 30m and 20m x 20m openings

: 2m x 2m in 10m x 10m and 5m x 5m openings

Figure 4: Examples of spacing for each planting type in Selectively Logged over Forest

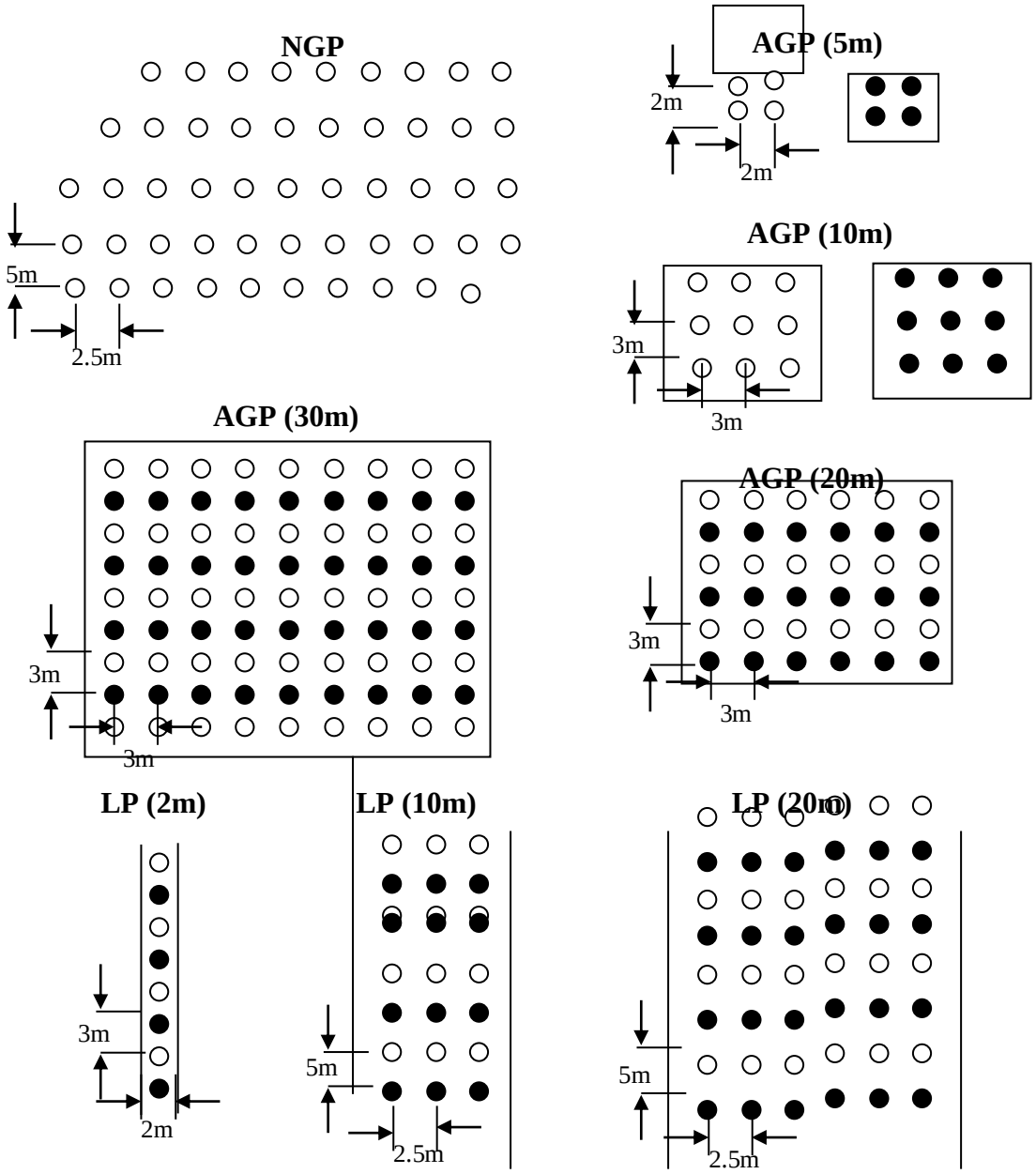


Figure 5: Basic design of line planting