

MANUAL OF FOREST ESTABLISHMENT AND SILVICULTURAL TREATMENTS FOR DEGRADED NATURAL FOREST

Malaysia-International Tropical Timber Organisation Joint Project: PD115/90 Rev.1(F)



Forestry Department
Peninsular Malaysia



Malaysia



International Tropical
Timber Organisation

MANUAL OF FOREST ESTABLISHMENT AND SILVICULTURAL TREATMENTS FOR DEGRADED NATURAL FOREST IN PENINSULAR MALAYSIA

Malaysia-International Tropical Timber Organisation
Joint Project: PD115/90 Rev.1(F)

by

Mohd Basri Hamzah
Dato' Mohamed Darus Mahmud
(Forestry Consultants)

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Manual of Forest Establishment and Silvicultural Treatments for Degraded Natural Forest

Malaysian-ITTO Project on Rehabilitation of Natural Forest: PD 115/90 Rev.1. (F)

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LIST OF SPECIES

Common name*	Botanical name
Acacia	<i>Acacia mangium</i>
Bertam	<i>Eugeissona triste</i>
Buluh beting	<i>Dendrocalamus asper</i>
Buluh tumpat	<i>Gigantochloa ligulata</i>
Durian	<i>Durio zibethinus</i>
Kembang semangkuk jantung	<i>Scaphium macropodum</i>
Kerdas	<i>Pithecelobium bubalinum</i>
Lallang	<i>Imperata cylindrica</i>
Mahogany	<i>Swietenia macrophylla</i>
Meranti sarang punai	<i>Shorea parvifolia</i>
Meranti tembaga	<i>Shorea leprosula</i>
Petai	<i>Parkia speciosa</i>
Rotan manau	<i>Calamus manan</i>
Rubber	<i>Heavea brasiliensis</i>
Sentang	<i>Azadirachta excelsa</i>
Sesenduk	<i>Endospermum diadenum</i>

* Malay vernacular names shown in italics

LIST OF FORMULA AND ABBREVIATIONS

Al	Aluminium (Chemical element)
Ca	Calcium (Chemical element)
CIRP	Christmas Island Rock Phosphate
cm	Centimetre
Cu	Copper (Chemical element)
Fe	Iron (Chemical element)
g	Gram
GARLON 250	3,5,6-Trichloro-2 Pyridyloxyacetic acid (herbicide)
GML	Ground magnesium
ITTO	International Tropical Timber Organisation
K	Potassium (Chemical element)
m	Meter
Mg	Magnesium (Chemical element)
mm	Millimetre
Mn	Manganese (Chemical element)
N	Nitrogen (Chemical element)
O	Oxygen (Chemical element)
P	Phosphorous (Chemical element)
PR	Phosphate Rock
RM	Ringgit Malaysia
SCA	Shifting Cultivation Area
TE	Trace elements
USD	United States Dollar
Zn	Zinc (Chemical element)

MANUAL OF FOREST ESTABLISHMENT AND SILVICULTURAL TREATMENTS FOR DEGRADED NATURAL FOREST

INTRODUCTION

The analysis of the second National Forestry Inventory conducted in 1981-1982 showed that an area of about 174,000 hectares of forest in Peninsular Malaysia has been degraded through shifting cultivation by aboriginal communities (Orang Asli). The repeated slash and burn agriculture has damaged and impoverished the forest and has resulted in degraded soils with low soil fertility status which often support a dense and smothering bamboo vegetation cover. There are also some long abandoned shifting cultivation areas that are in a more advanced stage of forest succession.

A feasibility study by the Asian Development Bank in February - July 1990 confirmed that about 54,300 hectares of forest areas in Peninsular Malaysia have been degraded by shifting cultivation. The findings of the study indicated that while technically such degraded forest areas can be rehabilitated, a great deal of work needs to be carried out to develop silvicultural measures to rehabilitate these areas and to determine the cost-effectiveness of such operations.

Substantial areas of tropical rain forest have been degraded through shifting cultivation. There is a dire and urgent need to increase the productivity of such areas with both indigenous and exotic commercial species.

As a result of the study, ITTO Project PD 115/90 REV.1(F): "Rehabilitation of Natural Forest" was implemented in compartments 181 and 6 at the Korbu Forest Reserve and compartments 103, 105 and 106 at the Piah Forest Reserve, Perak, Peninsular Malaysia in 1993-1999.

The main objectives of the ITTO project were as follows:

- (a) to formulate and implement suitable treatments for degraded natural forest,
- (b) to determine the most appropriate silvicultural treatments for degraded natural forest and the cost-effectiveness of the treatments, and

- (c) **to supplement the country's efforts to rehabilitate the degraded forests due to shifting cultivation or uncontrolled logging practices and as such contribute towards the global efforts to improve the world's forest resource and environment.**

The manual is based on the knowledge obtained from the above study and has been structured into two parts as follows:-

PART A: A Manual of forest establishment and silvicultural treatments for shifting cultivation areas, and

PART B: A Manual of forest establishment and silvicultural treatments for *matau* (log yard), logging road, skid trail and poorly stocked stand in logged-over forest.

The aim of the manual is to provide a guide to forest rehabilitation practices for degraded natural forest.

PART A

SHIFTING CULTIVATION AREA (SCA)

1.0 DEGRADED NATURAL FOREST

Degraded natural forest is defined as forest whose successive progress to restore to its original and sustainable climax has been delayed by excessive weed competition or by soil disturbance. Degraded forest is normally artificially created and characterized by poor wood production capability, weed infestation, an imbalanced uneven-aged structure and unstable environment. It has also been defined as forest which has undergone disturbance and not able to yield a future timber crop within two cycles or rotations without silvicultural treatments.

2.0 SHIFTING CULTIVATION AREA

Shifting cultivation area is a forest area cleared and subjected to transient farming mainly by local communities and subsequently abandoned once crop productivity declines. The area is usually of limited size and almost permanently maintained at varying seral stages by rotational farming with intervening fallow periods. Most of the soils of shifting cultivation areas have an overall low fertility status. **Plates 1-4.**



Plate 1: Slash and burn agriculture by aboriginal community showing area after burning



Plate 2: SCA planted with *Oryza spp.* (hill paddy), maize and banana



Plate 3: Abandoned SCA with *Imperata cylindrica* (lallang), bamboo and secondary forest (*belukar*)



Plate 4: Orang Asli huts

3.0 FOREST ESTABLISHMENT

3.1 Site preparation

3.1.1 Site preparation by partial vegetation removal

Clearing of strips or planting corridor of forest vegetation is the standard procedure adopted in the former shifting cultivation areas. Site preparation by complete clear felling is unnecessary and burning of secondary brush is not permitted. Site preparation of shifting cultivation areas must be carried out with minimum soil disturbance. Manual site preparation reduces loss of volatile nutrients and minimize erosion and nutrient run-off.

There must be minimal site disturbance and vegetation clearing must be restricted to the planting lines only. Strips of 1 meter wide are cleared at intervals of 8m as illustrated in **Figure 1**. Planting lines are aligned in an East-West direction so as to maximize exposure to sunlight. All planting lines are to be clearly established and marked with temporary 1 meter high markers. These markers are to be placed at 10m intervals to ensure the lines are straight.

When the planting lines have been laid out, vegetation within 0.5m to the left and 0.5m to the right of the planting line should be cleared. This is the standard for most species but for *Sesenduk* (*Endospermum diadenum*) the planting corridor is 3 m wide i.e. the vegetation should be cleared 1.5m to the left and 1.5m to the right of the planting line.

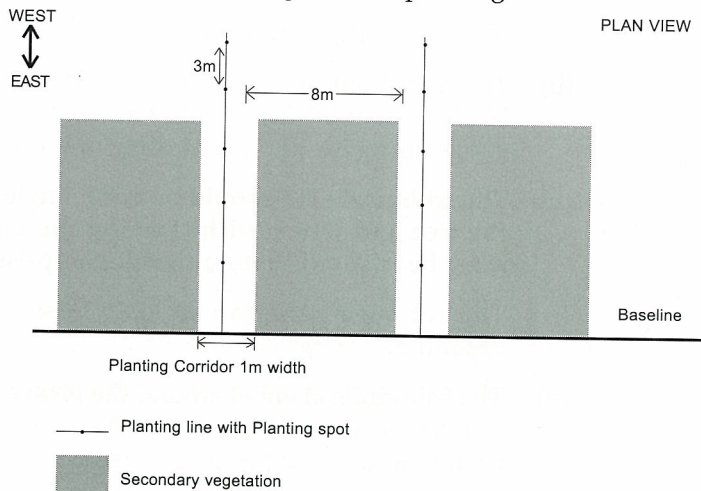


Figure 1: Planting layout in the SCA

Clearing of strips should be done manually. All vegetation ranging from herbaceous undergrowth to trees above 10cm diameter, except for merchantable species, must be removed.

All vegetation must be cleared using hand equipment for larger trees where a chain saw can be used. All trees outside the planting corridor but over hanging or over-wood must be poison-girdled. Vegetation cleared from planting strips must be stacked in the adjacent uncleared areas and allowed to degrade naturally.

When clearing the planting lines, all commercial species found within a meter of the lines should be left untouched. Bamboo and *Bertam* (*Eugeissona triste* a stemless palm which is a common forest weed) are to be poisoned if they are found growing in the planting corridor.

3.1.2 Frill-girdling and poisoning of trees

If trees outside the planting corridor are to be poisoned by frill-girdling the following should be carried out:

- (i) The frill-girdle is to be carried out
 - (a) at waist height,
 - (b) above the buttresses for buttressed trees (if the buttress is high, the frill-girdle must be cut at the buttress),
 - (c) below the irregularities of the tree, and
 - (d) below the coppice stems for coppiced tree.
- (ii) The tree should be frill-girdled with either a *parang* (a Malay machete) for small stems, a light axe or large gauge chisel for the frill-girdling of buttress.
- (iii) The frill-girdle cut should be at 45° angle to the bole of the tree and when withdrawing the cutting tool, it must be ensured that no twisting or prising occurs.
- (iv) The cut must penetrate at least 1.5cm into the tree's cambium.
- (v) The frill-girdle channel around the girth of the tree must be uniform with minimal slant. This is to ensure there are no low points for the poison from where it can over-flow.
- (vi) Sufficient poison is to be applied very carefully into the cut channel and it must be ensured that no spilling occurs.

- (vii) Poisoning should be carried out during the drought season.

For species with copious latex, the cut should be made wider and deeper than for other species. Two cuts must be made about 30cm apart, with the lower frill-girdle made first. The poison solution should then be directed at the both girdles. **Plate 5.**

3.1.3 Eradication of woody climbers

All woody climbers (lianas) between corridors are eradicated. Smaller lianas are simply slashed with a *parang*. Larger ones (bigger than thumb-size) are cut close to the ground and the remainder slashed within easy reach. The cut surfaces are then brushed with poison using paint brush. **Plate 6.**

3.1.4 Eradication of *Bertam* (*Eugeissona triste*)

All fronds of the *Bertam* are to be cut and stacked away from the planting corridor. The then sprayed with poison using a knapsack sprayer which is most convenient and to ensure better application of the poison. The poison must be evenly sprayed to cover all remaining vegetative parts of the palm especially the rhizomes. Indiscriminate spraying of poison around the planting strip should be avoided. **Plate 7.**

3.1.5 Eradication of unwanted bamboo

The poison is to be sprayed on the base of the erect culms. A knapsack sprayer is most convenient to use and to ensure better application of the poison. The poison must be evenly sprayed to cover all remaining vegetative parts of the bamboo. **Plate 8.**

3.1.6 Herbicide used

The recommended systemic herbicide is GARLON 250 (3,5,6-Trichloro-2 Pyridyloxyacetic acid). The mixture of herbicide to water is in the ratio of 1:3 The application of any herbicide must be carried out at least 10m away from any stream and or river and their tributaries. This is also applicable to secondary roads where surface water run-off occurs.

3.2 Choice of species

There are several tree species which are suitable for enrichment planting in abandoned shifting cultivation areas. These are shown in **Table 1.**



Plate 5: Frill-girdling and poisoning of unwanted trees

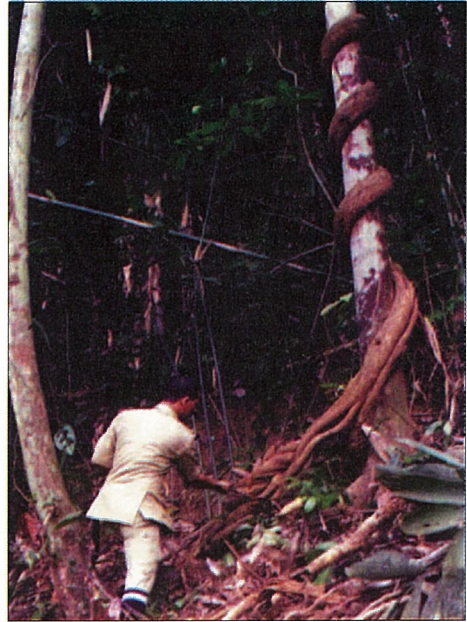


Plate 6: Climber cutting



Plate 7: *Bertam* clumps



Plate 8: Eradication of unwanted bamboo

Table 1: Some timber tree species suitable for enrichment planting in the SCA

Scientific name	Local name
<i>Azadirachta excelsa</i>	Sentang
<i>Durio zibethinus</i>	Durian
<i>Hevea brasiliensis</i>	Rubber
<i>Parkia speciosa</i>	Petai
<i>Scaphium macropodum</i>	Kembang semangkok jantung
<i>Shorea leprosula</i>	Meranti tembaga
<i>Swietenia macrophylla</i>	Mahogany

Other indigenous species with potential commercial value are listed in Appendix 1 of *Manual kerja luar. Sistem pengurusan memilih* (Selective Management System), 1992.

In addition, two other species of bamboo namely (a) *Buluh beting* (*Dendrocalamus asper*) and (b) *Buluh tumpat* (*Gigantochloa ligulata*), are suitable for planting in SCA.

The timber tree species can be planted by the 'line planting technique' as a monoculture or multiculture crop. The other two suitable species of bamboo, and rattan can be planted as a monoculture.

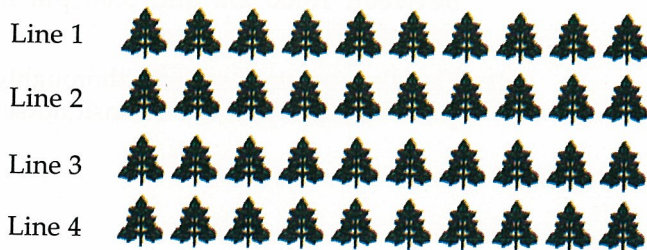
3.3 Size of planting block

The recommended size of planting block is 10 hectares.

3.4 Planting design and planting distance

3.4.1 Planting layout for monoculture

The layout for monoculture planting should be as shown in Figure 2.

**Figure 2:** Monoculture planting

Planting distance is 3m x 9m and planting lines 1-4 are aligned in an East-West direction

3.4.2 Planting layout for multiculture

The planting layout for multiculture comprising the three species (1) *Meranti tembaga* (2) *Sentang* and (3) Mahogany should also be planted at a distance of 3m x 9m. The arrangement is however completely random. The Forestry Department should be consulted for the combination of species since the multiculture design is suitable for species of similar growth rate.

3.5 Planting

3.5.1 Seedlings

Nursery-raised potted seedlings are used as planting stock for reforestation activities. When potted seedlings are transported to a transit nursery located within or near the planting site, the following should be adhered to:-

- (a) Potted seedlings in polybags must be in a firm upright position and placed in closely packed units to prevent them from swaying, sliding or falling while in transit in the vehicle. Wooden crates or compartments of appropriate size should be used for this purpose.
- (b) The planting stock in the transporting vehicle should be sufficiently covered to reduce desiccation by the sun and wind. However, it should have adequate ventilation to prevent "overheating" within the storage chamber.
- (c) It is recommended that transportation of the planting stock should be carried out before 10.00 am and after 5.00 pm. No planting stock should be transported between 10.00 am and 5.00 pm to reduce risk of dessication.
- (d) The planting stock must be thoroughly watered one day prior to the dispatch to a transit nursery.

3.5.2 Seedling conditioning

Only hardened planting stock should be dispatched for planting.

- (a) When the planting stock is temporarily in a transit nursery the stock must be watered at least once a day except on rainy days and placed under moderate shade conditions. One day prior to dispatch to the planting site, the planting stock must be thoroughly watered.
- (b) The planting stock irrespective of whether raised from seeds, wildings or by vegetative propagation should be graded and culled before being dispatched to the planting site. The root collar diameter of any selected tree species must be greater than 0.6cm.
- (c) To ensure survival at the planting site, the planting stock must be kept under moderate shade for at least two weeks. The planting stock should not be kept under heavy shade for periods exceeding two weeks.

3.5.3 Planting hole

Each planting spot along the planting line is marked with a 0.5 m high stick. Bamboo sticks are adequate.

The size of the planting holes for all planting stock must be twice the diameter of the polybag. The depth of the planting hole must be 3-5cm deeper than the height of the polybag as shown in **Figure 3**.

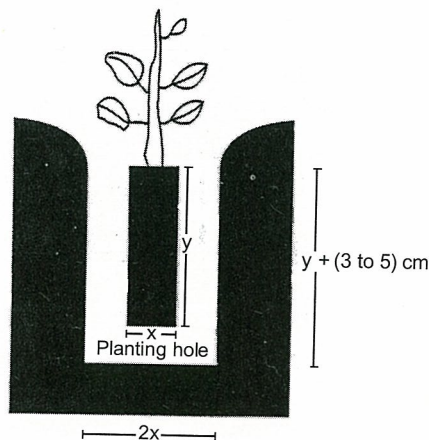


Figure 3: Planting hole

x — diameter of the pot/polybag
 y — height of the pot/polybag

The planting spot need not be fixed rigidly. The spots can be moved in any direction to avoid rocks, large stumps, gullies, etc.

Displacement of the planting spot should be either 1m to the left or 1m to the right of the original spot. If natural vegetation of the desired species occurs anywhere within a 1m radius of the planting spot, the spot is considered planted.

3.5.4 Fertiliser application at time of planting

Before planting, 75g of Christmas Island Rock Phosphate (CIRP) must be sprinkled into the planting hole and thinly covered with loose soil. The polybag is then cut and the planting stock is placed in the middle of the hole.

The hole is covered with soil and the soil is firmed by foot to ensure the planting stock is firmly embedded in the ground. The root collar should not be totally covered.

3.5.5 Time of planting

All planting must be carried out during the rainy season and planting should stop when three consecutive dry spell days occur. A dry spell day is defined as a 24-hour period during which rainfall is less than 0.25mm. No planting should be carried out during the dry season.

4.0 MAINTENANCE

4.1 Maintenance operations

Maintenance operations are activities required to promote suitable conditions which are favorable for seedling survival after planting and to enhance vigorous and healthy growth. These silvicultural operations will lead to successful forest establishment.

4.2 Treatments

4.2.1 Weeding

Weeding is vital to ensure maximum growth of seedlings and to increase the chances of survival. Weeds are removed by circle weeding as shown in **Figure 4**.

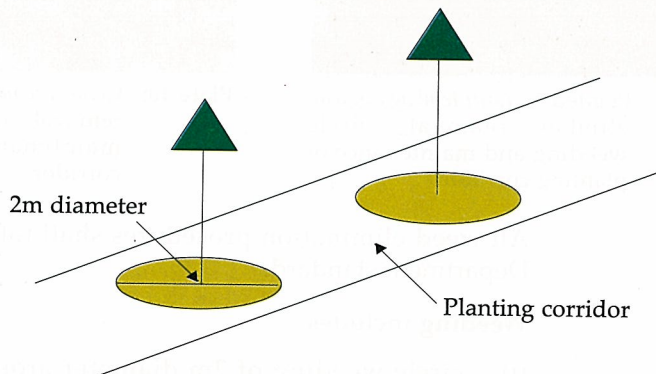


Figure 4: Circle weeding

Circle weeding is carried out by using a hoe (*cangkul*). Weeding must be carried out early before seedlings are suppressed. Initial weeding must be carried out 3 months after planting. All impeding weeds and overshadowing vegetation surrounding the seedlings are eliminated from ground level and vertically upwards. This would allow for a cylinder-shaped cleared crown space with unimpeded direct sunlight from above during the middle of the day (around noon). See **Plates 9 and 10**.



Plate 9 : Planted *Meranti tembaga* before climber removal, circle weeding and maintenance of planting corridor



Plate 10: *Meranti tembaga* after climber removal, circle weeding and maintenance of planting corridor

All weed elimination procedures shall follow the Forestry Department standards.

Weeding includes:

- (i) circle weeding of 2m diameter around the seedling using a hoe (*cangkul*),
- (ii) manually using a weeding tool like a slashing knife and sickle on small woody undergrowth and wild bananas (*Pisang hutan*),
- (iii) climber removal of mainly *Mikania* spp. with the herbaceous climber pulled off the seedling or slashed as necessary.

4.2.2 Survival Inventory

A 100 percent enumeration or inventory to determine the mortality of planted seedlings is carried out 3 - 6 months after planting. Mortality of seedlings could be due to the following causes:

- poor quality of planting stock
- injuries during transport
- improper planting
- damage by insects or rodents
- suppression by weeds
- dry spell after planting

Additional 50 percent and 20 percent survival are carried out as shown in the schedule of post planting operations. The inventory shall follow Forest Department procedure.

4.2.3 Refilling

Acceptable survival rate is 80 percent. Refilling or beating-up should be implemented if the overall percentage of mortality is above 20 percent. If the rate of failure is below 20 percent, refilling should be carried out only where the failures are heavily concentrated.

There may be a need for more than one refilling operation in the same area during the first year of the forest establishment. If after two replanting operations the area remains inadequately stocked, another species should be chosen as replacement or planting procedures should be revised to improve the operation. See **Plate 11**.

4.2.4 Fertilizer application

Soil sampling and analysis

It is essential that two types of soil sampling be carried out. Namely:

- (i) for the determination of soil series,
- (ii) for evaluating the fertility status of the area before planting.

Soil profile

Sites for digging soil pits for profile description, should be carefully chosen to get representative samples. Soil analysis for the soil profiles should include pH, basic exchangeable cations, exchangeable Al, nitrogen, organic carbon,

phosphorus and cation-exchange capacity (NH_4OAc). Additional analysis should be carried out for the determination of micronutrients (Fe, Mn, Zn and Cu) if necessary.

Fertilizing is required if there is a lack of certain nutrients in the soil which will prevent optimum growth of the planted seedlings.

Types of fertilizer, schedule and method of application

The amount of nitrogen and phosphorous are generally inadequate in most tropical soils. The application of fertiliser containing nitrogen, phosphorous and some potassium helps to offset this deficiency. Some fertilisers have trace elements or micronutrients such as Fe, Mn, Zn, Cu and others. These can be applied if necessary based on the soil analysis. Fertilizer are best applied at the onset of the rainy season. See **Plates 12-14**.

The fertilizer guides used should be based on the soil properties. Recommended fertilisers are as follows:

(i) Fruit tree species for fruit and timber production

Incorporate 100g organic fertilizer: 6(%N):15(% P_2O_5): 3(% K_2O):1(%MgO) + TE (trace elements) and 100g of Ground Magnesium Limestone (GML) with topsoil to fill up the planting hole. Schedule of fertiliser application is shown in **Table 2**.

Table 2 : Schedule of fertilizer application for fruit trees fruits and timber

Time of Application		Type of Fertilizer and Rate (g/ tree)	Method of Application
1 st year	6 th month	200g of 8:4:4:2: * 3(% CaO) + TE	Ring apply evenly about 20cm from plant base.
	12 th month	Repeat	
2 nd year	6 th month	200g of phosphate rock (PR) + 200g 12:12:17:2 + TE	Ring apply about 40cm from plant base.
	12 th month	Repeat	
3 rd year	6 th month	300g of PR + 500g Of 12:12:17:2 + TE	Ring apply about 80cm from plant base.
	12 th month	Repeat	
4 th year and above repeat as for the 3 rd year with addition of 500g of PR during alternate years.			

*Ratio of N:P:K:Mg



Plate 11: Dead *Durian* where refilling is necessary



Plate 12: 24-month old *Meranti tembaga* after application of fertilizer



Plate 13: SCA which has been successfully regenerated with line planting of *Meranti tembaga*

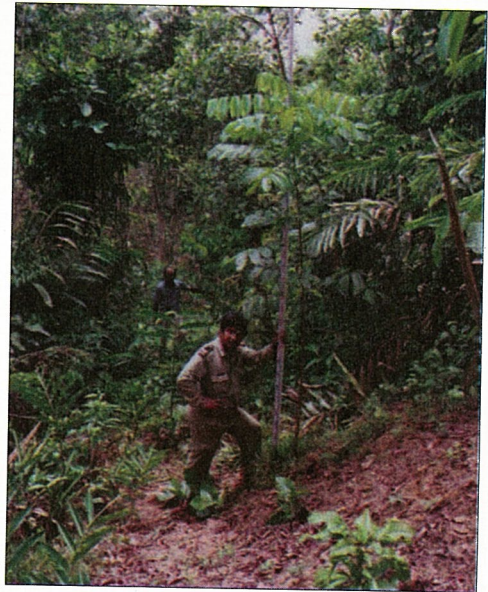


Plate 14: 48-month old Mahogany in SCA

(ii) Non-legume species for timber production

Incorporate 50g of GML + 100g of PR at the time of planting. Schedule of fertilizer application is shown in **Table 3**.

Table 3 : Schedule of fertilizer application for non-legumes for timber

Time of Application		Type of Fertilizer and Rate (g/tree)	Method of Application
1 st year	Incorporate at Planting or 1 st month	100g of 15:15:6:4*	Ring apply evenly about 20cm from plant base.
	6 th month	Repeat	
	12 th month	Repeat	
2 nd year	6 th month	200g of 15:15:6:4	Ring apply about 40cm from plant base.
	12 th month	Repeat	
3 rd year	6 th month	500g of 15:7:18:2	Ring apply about 80cm from plant base.
	12 th month	Repeat	

*Ratio of N:P:K:Mg

(iii) Legume species for timber production

Incorporate 200g of GML and 100g of PR at the time of planting. The schedule of fertilizer application is shown in **Table 4**.

Table 4: Schedule of fertilizer application for legumes for timber

Time of Application		Type of Fertilizer and Rate (g/tree)	Method of Application
1 st year	Incorporate at Planting or 1 st month	100g of 15:15:6:4*	Ring apply evenly about 20cm from plant base.
	6 th month	Repeat	
	12 th month	Repeat	
2 nd year	6 th month	200g of 15:15:6:4	Ring apply about 40cm from plant base.
	12 th month	Repeat	
3 rd year	6 th month	400g of 0:14:17:2	Ring apply about 80cm from plant base.
	12 th month	Repeat	

*Ratio of N:P:K:Mg

Once an efficient nutrient cycling system is established (5-10 years), only minimal fertilization is required for the legume and non-legume species.

Fertilizers containing 12N:12P:17K:2MgO + TE (Nitrophoska yellow) and 15N:15P:6K:4MgO (Nitrophoska blue) are readily available and can be easily purchased. However, the other fertilizers prescribed in Section 4.2.4 are not in the market and have to be prepared according to the buyer's specification by the fertilizer company.

5.0 SCHEDULE OF POST-PLANTING OPERATIONS

5.1 Timber tree species

The schedule of operations for timber tree species after the completion of planting is shown in **Table 5**.

Table 5: Schedule for post-planting operation for timber tree species

After completion of planting (months)	Post-planting operation
3-6	(1) 100% survival inventory. (2) Refilling of dead seedlings. (3) Circle weeding. (4) Climber removal. (5) Maintenance of planting corridor and eradication of bamboo and lallang. (6) Fertilizer application.
12	(1) 50% survival inventory. (2) Refilling of dead seedlings. (3) Circle weeding. (4) Climber removal. (5) Maintenance of planting corridor. (6) Fertilizer application.
18	(1) 50% survival inventory. (2) Climber removal. (3) Maintenance of planting corridor and eradication of bamboo and lallang. (4) Fertilizer application.
24	(1) 50% survival inventory. (2) Climber removal. (3) Maintenance of planting corridor. (4) Fertilizer application. (5) Opening of over-wood canopy if necessary.
36	(1) 20% survival inventory. (2) Climber cutting. (3) Maintenance of planting corridor. (4) Opening of over-wood canopy if necessary. (5) Fertilizer application.
42	(1) Fertilizer application.
48	(1) 20% survival inventory. (2) Climber cutting. (3) Maintenance of planting corridor. (4) Opening of over-wood canopy if necessary. (5) Fertiliser application.
54	(1) Fertilizer application.
60	(1) Climber cutting. (2) Maintenance of planting corridor. (3) Opening of over-wood canopy if necessary. (4) Fertilizer application.

5.2 Bamboo - *Buluh beting* (*Dendrocalamus asper*) and *Buluh tumpat* (*Gigantochloa ligulata*)

The schedule of post-planting operations for *Buluh beting* and *Buluh tumpat* are as in Table 6.

Table 6: Schedule of post-planting operation for bamboo and rattan

After completion of planting (months)	Post-planting operation
3-6	(1) 100% survival inventory. (2) Refilling of dead planted bamboo. (3) Circle weeding. (4) Climber removal. (5) Maintenance of planting corridor and eradication of lallang. (6) Fertilizer application.
12	(1) 50% survival inventory. (2) Refilling of dead planted bamboo. (3) Circle weeding. (4) Climber removal. (5) Maintenance of planting corridor and opening of over-wood canopy if necessary. (6) Fertilizer application.
18	(1) 50% survival inventory. (2) Climber removal. (3) Maintenance of planting corridor and opening over-wood canopy if necessary. (4) Fertilizer application.
24	(1) Climber removal. (2) Maintenance of planting corridor and opening of over-wood canopy if necessary. (3) Fertilizer application.
36	(1) Climber cutting. (2) Opening of over-wood canopy if necessary. (3) Fertilizer application.

5.3 Rattan - *Rotan manau* (*Calamus manan*)

The schedule of post planting operations for *Rotan manau* is shown in Table 6.

6.0 COST OF ESTABLISHMENT

6.1 Cost of establishment of abandoned SCAs with timber tree species and *Rotan manau* (*Calamus manan*)

Cost of Establishment of abandoned SCAs with timber tree species and *Rotan manau* (based on planting distance of 3m x 9m i.e. 370 seedlings per hectare) is as indicated in Table 7.

Table 7: Establishment cost of abandoned SCAs with timber species and rattan

Item	Cost per ha. (RM)*
1. Seedlings	370.00
2. Transportation	175.00
3. Site preparation	70.00
4. Lining	50.00
5. Digging planting holes	80.00
6. Planting	50.00
7. Fertilizer at time of planting	50.00
8. Survival inventory	410.00
9. Refilling of dead seedlings	40.00
10. Fertilizer	
(a) 1 st year	50.00
(b) 2 nd year	50.00
(c) 3 rd year	50.00
(d) 4 th year	50.00
(e) 5 th year	50.00
11. Weeding	
(a) circle weeding	415.00
(b) climber removal	250.00
(c) maintenance of planting corridor	150.00
(d) eradication of bamboo and lallang	250.00
(e) opening of over-wood canopy	200.00
TOTAL	2810.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

6.2 Cost of establishment of abandoned SCAs with *Buluh beting* (*Dendrocalamus asper*) and *Buluh tumpat* (*Giganthocloa ligulata*)

Cost of Establishment of abandoned SCAs with *Buluh beting* and *Buluh tumpat* (based on planting distance of 3m x 9m i.e. 370 seedlings per hectare) is as indicated in **Table 8**.

Table 8: Establishment cost of abandoned SCAs with bamboo species

Item		Cost per ha. (RM)*
1.	Seedlings	925.00
2.	Transportation	175.00
3.	Site preparation	70.00
4.	Lining	50.00
5.	Digging planting holes	80.00
6.	Planting	50.00
7.	Fertilizer at time of planting	50.00
8.	Survival inventory	410.00
9.	Refilling of dead seedlings	40.00
10.	Fertilizer	
	(a) 1 st year	50.00
	(b) 2 nd year	50.00
	(c) 3 rd year	50.00
	(d) 4 th year	50.00
	(e) 5 th year	50.00
11.	Weeding	
	(a) circle weeding	415.00
	(b) climber removal	250.00
	(c) maintenance of planting corridor	150.00
	(d) eradication of bamboo and lallang	250.00
	(e) opening of over-wood canopy	200.00
TOTAL		3365.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

Growth performance of some species in the SCA, between 18 - 48 months, are shown in **Plates 15 to 27**.



Plate 15: 48-month old *Durian* in SCA



Plate 16: 48-month old Rubber in SCA



Plate 17: 48-month old *Kerdas* in SCA



Plate 18: 48-month old *Petai* in SCA



Plate 19: 48-month old *Meranti tembaga* in SCA



Plate 20: 36-month old multiculture planting of Mahogany, *Meranti tembaga* and *Sentang*



Plate 21: 48-month old multiculture planting of Mahogany, *Meranti tembaga* and *Sentang*



Plate 22: Under-planting of *Meranti tembaga* and Mahogany under nurse trees of 18-month old *Acacia mangium*



Plate 23: 24-month old *Buluh tumpat*



Plate 24: Shoot of *Buluh tumpat* which is a delicacy



Plate 25: 18-month old *Rotan manau*



Plate 26: 48-month old of *Rotan manau*

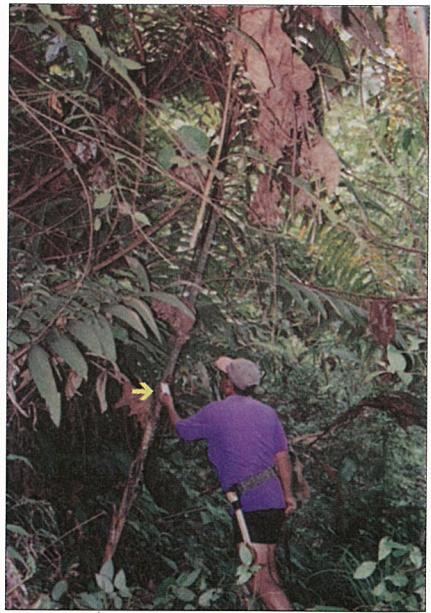


Plate 27: 48-month old *Rotan manau* showing stem tagging

PART B

LOGGING ROAD, SKID TRAIL, MATAU AND POORLY STOCKED STAND IN LOGGED-OVER FOREST

1.0 INTRODUCTION

The construction of road, skid trail and *matau* (log landing) in logging operations results in a high degree of mineral soil disturbance and exposure. This deleterious impact increases with more pronounced topography. Exposed and degraded soils in logged-over forest should be rehabilitated after completion of logging. Improvement of forest productivity is recommended for inadequately stocked forest stand through enrichment planting.

2.0 DEGRADED AREAS OR OPENED AREAS AND POORLY STOCKED FOREST STAND

There are three main areas with relatively high degree of degraded soils, namely:

- (a) logging roads
- (b) skid trails and
- (c) *mataus*

For poorly stocked stand in logged-over forest, enrichment planting is necessary since the forest cannot regenerate naturally.

3.0 FOREST ESTABLISHMENT

3.1 Site preparation

In most cases, complete vegetation removal for logging road, skid trail and *matau* is not necessary. However, partial vegetation removal can be carried out for the purpose of establishing planting lines in planting corridors. The procedure is similar to the one adopted for regenerating former SCA as described in Section 3.1.1 of Part A.

Eradication methods for lianas, *Bertam* and bamboo, and the recommended herbicide, are also similar to those described above for site preparation of abandoned SCA. Please refer Sections 3.1.3 to 3.1.6 in Part A.

3.2 Planting design and planting distance

Line planting is to be carried out along logging roads and skid trails. Along the roads seedlings should be planted in Y-shaped groupings with two seedlings per species at 1m apart and at a distance of 10m between groups as shown in Figure 5.

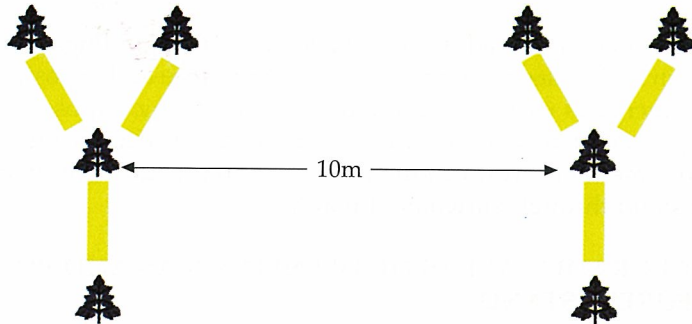


Figure 5: Y-shaped group planting

Buluh beting should be planted between the 'Y' groups and located 1.5m from the road edge into the forest and on both sides of the road except on steep slopes.

Along skid trails Mahogany, *Petai* and *Rotan manau* seedlings are planted along one side of any ledge except on steep slopes. Planting is carried out in groups of three, linearly arranged at a distance of 1m between seedlings and 10m between group. Behind each mahogany group, about 1.5m into the forest, a *Rotan manau* seedling is planted singly as shown in Figure 6.

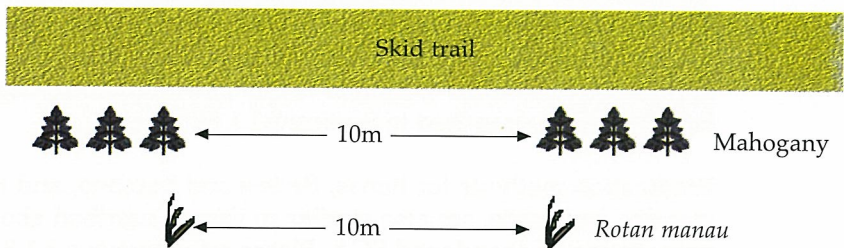


Figure 6: Planting design and planting distance in group plantings of mahogany and *Rotan manau* seedlings

Planting of nurse trees of *Acacia mangium* is carried out in the *mataus* at a planting distance of 3m x 3m. The planting lines are oriented at right angle to logging road. When the *Acacia mangium* is between 18 months to 24 months old, *Meranti tembaga* seedlings are inter-planted for every third row of *Acacia*. **Figure 7** shows the planting arrangement.

Line 1	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 2	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 3	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 4	TTTTTTTTTTTTTTTTTTTTTTTTTTTT	
Line 5	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	<i>Acacia mangium</i>
Line 6	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 7	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 8	TTTTTTTTTTTTTTTTTTTTTTTTTTTT	<i>Meranti tembaga</i>
Line 9	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 10	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 11	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 12	TTTTTTTTTTTTTTTTTTTTTTTTTTTT	
Line 13	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	
Line 14	AAAAAAAAAAAAAAAAAAAAAAAAAAAA	

Figure 7: Matau planting of *Acacia mangium* and *Meranti tembaga*

Planting of multiculture crops consisting of three or more species can be carried out for enrichment planting. The layout for planting the different species is shown in **Figure 8**. Planting distance is 3m x 9m and the planting pattern is repeated between lines with one species per planting line.

Line 1	AAAAAAAAAAAAAAAAAAAAAAAAAAAA
Line 2	BBBBBBBBBBBBBBBBBBBBBBBBBBBB
Line 3	CCCCCCCCCCCCCCCCCCCCCCCCCCCC
Line 4	DDDDDDDDDDDDDDDDDDDDDDDDDD
Line 5	AAAAAAAAAAAAAAAAAAAAAAAAAAAA
Line 6	BBBBBBBBBBBBBBBBBBBBBBBBBBBB
Line 7	CCCCCCCCCCCCCCCCCCCCCCCCCCCC
Line 8	DDDDDDDDDDDDDDDDDDDDDDDDDD

Figure 8: Multiculture crop layout in enrichment planting

3.3 Choice of species and planting stock

There are several potential commercial timber tree species which are

suitable for planting in logged-over forests. *Acacia mangium* with under planting of *Meranti tembaga* thrive well in the *mataus*. Mahogany, *Petai*, *Durian*, and two species of bamboo namely *Buluh beting* and *Buluh tumpat* are suitable for planting on sides of logging road and side berms of skid trails.

Other indigenous species having commercial potential are listed in *Appendix 1 of Manual kerja luar. Sistem pengurusan memilih* (Selective Management System) 1992.

The planting stock, irrespective of whether raised from seeds, wildings or by vegetative propagation, should be graded and culled before being dispatched to the planting site. The root collar diameter of tree species to be planted must be greater than 0.6cm. The size of polybag used is 15cm x 23cm.

3.4 Planting

3.4.1 Planting hole, fertilizer application and time of planting

An auger is used to dig planting holes to a depth of 1m in the *matau* because of the compactness of the soil. The size of planting holes for all planting stock must be twice the diameter of the polybag and its depth must be 3-5cm deeper than the height of the polybag, except for *matau*. Refer **Figure 3**.

Fertilizer application and time of planting are similar to those described for the SCA. Refer Sections 3.5.4 and 3.5.5 respectively in Part A.

3.4.2 Overhead shading

All overhead shading is removed through appropriate cutting or felling of shrubs and trees for all planting. Secluded aspects which do not have sufficient duration of sunlight should be avoided.

3.5 Size of planting block

For enrichment planting in poorly stocked forest stand, the recommended size of the planting block is 10 hectares.

4.0 MAINTENANCE

4.1 Maintenance operations

Maintenance operations are similar to those for the SCA. Please refer to the respective section in Part A for weeding (Section 4.2.1), survival inventory (Section 4.2.2), refilling (Section 4.2.3) and fertilizer application (Section 4.2.4).

4.2 Pruning, thinning, road and bridge maintenance, fire protection and disease control

Pruning, thinning, road and bridge maintenance, fire protection and disease control (not described in this manual) should follow departmental standards and guidelines.

5.0 SCHEDULE OF POST-PLANTING OPERATIONS

The schedule of operations for timber tree species, *Rotan manau* and bamboo after completion of planting is shown in **Table 9**.

Table 9: Schedule of post-planting operations for timber species, rattan and bamboo

After completion of planting (months)	Post planting operation
3-6	(1) 100% survival inventory. (2) Refilling of dead seedlings. (3) Circle weeding. (4) Climber removal. (5) Fertilizer application For <i>matau</i> only (1), (2) and (5) are carried out.
12	(1) 50% survival inventory. (2) Refilling of dead seedlings. (3) Circle weeding. (4) Climber removal (5) Fertilizer application.
18	(1) 50% survival inventory. (2) Climber removal (3) Weeding. (4) Fertilizer application.
24	(1) 20% survival inventory (2) Climber cutting. (3) Weeding (4) Opening of over-wood canopy if necessary (5) Fertilizer application.
36	(1) 20% survival inventory. (2) Climber cutting. (3) Opening of over-wood canopy if necessary. (4) Fertiliser application.
42	(1) Fertiliser application.
48	(1) 20% survival inventory. (2) Climber cutting. (3) Opening of over-wood canopy if necessary. (4) Fertiliser application.
54	(1) Fertilizer application.
60	(1) Climber cutting (2) Opening of over-wood canopy if necessary (3) Fertilizer application.

The post-treatment operation for *Buluh beting* is for duration of 36 months only.

6.0 COST OF ESTABLISHMENT

6.1 Cost of establishment of *Acacia mangium* on *mataus* in logged-over forest

Cost of establishment of *Acacia mangium* on *mataus* in logged-over forest (based on a planting distance of 3m x 3m i.e. 1111 seedlings per hectare) is shown in **Table 10**.

Table 10: Establishment cost of *Acacia mangium* on *mataus* in logged-over forest

Item		Cost per ha. (RM)*
1.	Seedlings	555.00
2.	Transportation	15.00
3.	Site preparation	0.00
4.	Lining	10.00
5.	Digging planting holes	500.00
6.	Planting	50.00
7.	Fertilizer at time of planting	140.00
8.	Survival inventory	700.00
9.	Refilling of dead seedlings	0.00
10.	Fertilizer	
	(a) 1 st year	50.00
	(b) 2 nd year	50.00
	(c) 3 rd year	0.00
	(d) 4 th year	0.00
	(e) 5 th year	0.00
11.	Weeding	
	(a) circle weeding	0.00
	(b) climber removal	0.00
	(c) maintenance of planting corridor	0.00
	(d) eradication of bamboo and lallang	0.00
	(e) opening of over-wood canopy	
TOTAL		2070.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

The additional cost of under-planting of *Meranti tembaga* is RM1,050 per hectare.

6.2 Cost of establishment of timber species and *Rotan manau* (*Calamus manan*) on skid trails of logged-over forest

Cost of establishment of timber tree species and *Rotan manau* on skid trail of logged-over forest (based on 370 seedlings per hectare) is shown in **Table 11**.

Table 11: Establishment cost of timber tree species and rattan on skid trails of logged-over forest

Item		Cost per ha. (RM)*
1.	Seedlings	370.00
2.	Transportation	50.00
3.	Site preparation	280.00
4.	Lining	50.00
5.	Digging planting holes	100.00
6.	Planting	200.00
7.	Fertilizer at time of planting	200.00
8.	Survival inventory	400.00
9.	Refilling of dead seedlings	95.00
10.	Fertilizer	
	(a) 1 st year	235.00
	(b) 2 nd year	235.00
	(c) 3 rd year	235.00
	(d) 4 th year	235.00
	(e) 5th year	235.00
11.	Weeding	
	(a) circle weeding	180.00
	(b) climber removal	80.00
	(c) maintenance of planting corridor	390.00
	(d) eradication of bamboo and lallang	500.00
	(e) opening of over-wood canopy	200.00
TOTAL		4270.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

6.3 Cost of establishment of timber species and *Buluh beting* (*Dendrocalamus asper*) on sides of logging roads in logged-over forest

Cost of establishment of timber tree species and *Buluh beting* on the sides of logging roads in logged-over forest (based on 370 seedlings per hectare) is shown in Table 12.

Table 12: Establishment cost of timber tree species and bamboo on the sides of logging roads in logged-over forest

Item		Cost per ha. (RM)*
1.	Seedlings	650.00
2.	Transportation	50.00
3.	Site preparation	50.00
4.	Lining	10.00
5.	Digging planting holes	30.00
6.	Planting	50.00
7.	Fertilizer at time of planting	30.00
8.	Survival inventory	400.00
9.	Refilling of dead seedlings	50.00
10.	Fertilizer	
	(a) 1 st year	50.00
	(b) 2 nd year	50.00
	(c) 3 rd year	50.00
	(d) 4 th year	50.00
	(e) 5 th year	50.00
11.	Weeding	
	(a) circle weeding	310.00
	(b) climber removal	50.00
	(c) maintenance of planting corridor	30.00
	(d) eradication of bamboo and lallang	0.00
	(e) opening of over-wood canopy	50.00
TOTAL		2010.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

6.4 Cost of enrichment planting of poorly stocked stands in logged-over forest with timber tree species

Cost of enrichment planting of poorly stocked stands in logged-over forest with timber tree species (based on planting distance of 3m x 9m i.e. 370 seedlings per hectare) is shown in **Table 13**.

Table 13: Establishment cost of enrichment planting of poorly stocked stands in logged-over forest with timber species

Item	Cost per ha. (RM)*
1. Seedlings	370.00
2. Transportation	50.00
3. Site preparation	280.00
4. Lining	50.00
5. Digging planting holes	100.00
6. Planting	200.00
7. Fertilizer at time of planting	200.00
8. Survival inventory	400.00
9. Refilling of dead seedlings	95.00
10. Fertilizer	
(a) 1 st year	235.00
(b) 2 nd year	235.00
(c) 3 rd year	235.00
(d) 4 th year	235.00
(e) 5 th year	235.00
11. Weeding	
(a) circle weeding	180.00
(b) climber removal	80.00
(c) maintenance of planting corridor	390.00
(d) eradication of bamboo and lallang	50.00
(e) opening of over-wood canopy	200.00
TOTAL	4270.00

*Actual cost of establishment for the years 1993-1997
RM 3.80 = 1 USD

Performance of the various timber tree, bamboo and rattan species in the logged-over forest, between 24-48 months, are shown in **Plates 28 to 36**. The species were planted on disturbed sites on *mataus* and sides of logging roads and skid trails.



Plate 28: 36-month old *Acacia mangium* planted on a matau



Plate 29: 48-month old *Acacia mangium* planted on a matau



Plate 30: 36-month old Mahogany planted on side of logging road



Plate 31: 24-month old *Durian* planted on side of logging road



Plate 32: 48-month old *Petai* planted on side of logging road



Plate 33: *Meranti sarang punai* planted in enrichment planting area



Plate 34: 48-month old *Sesenduk* planted in enrichment planting area



Plate 35: Enrichment planting of 48-month old *Meranti tembaga*



Plate 36: *Rotan manau* planted on side of logging road

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