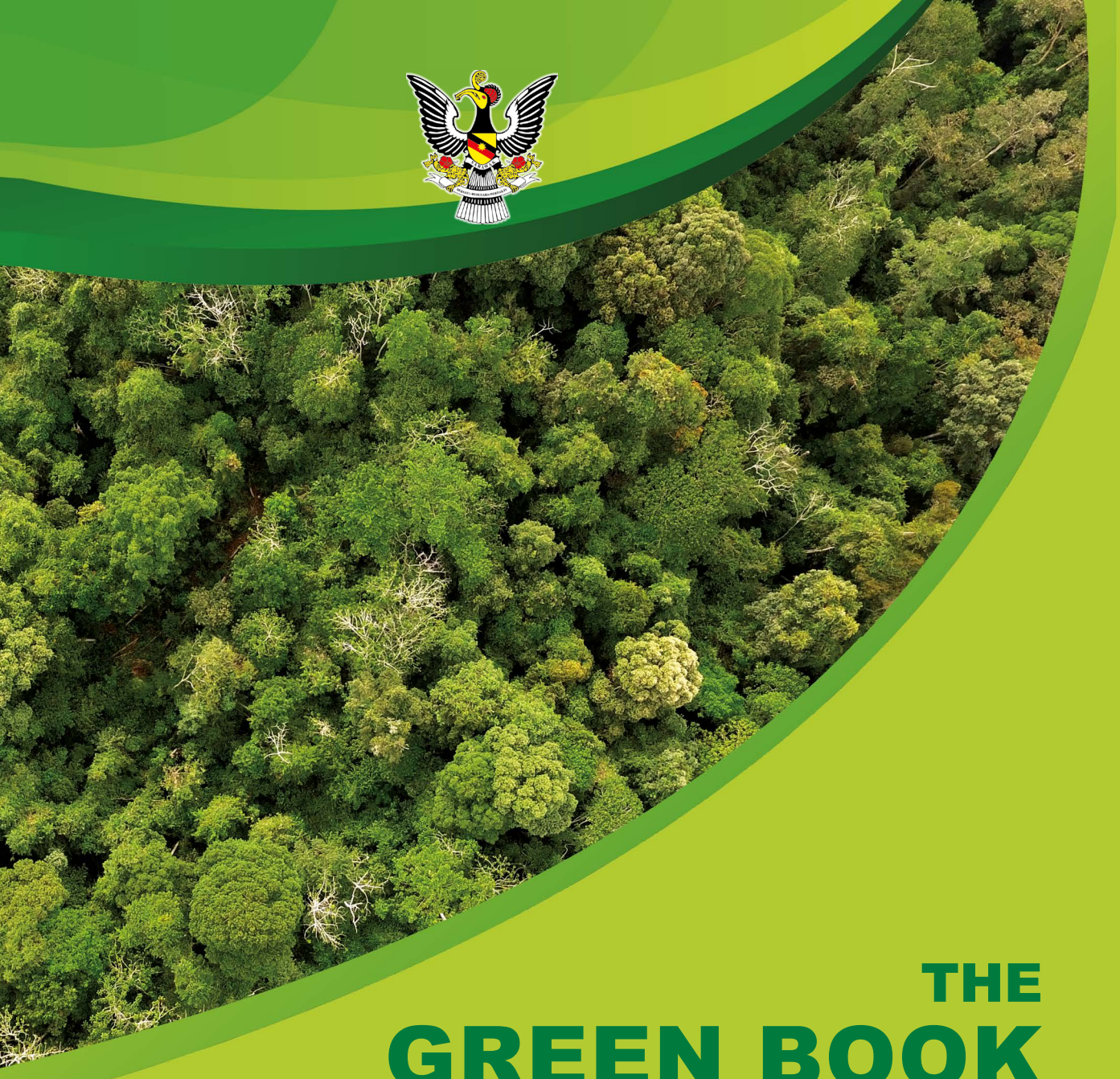

THE GREEN BOOK

MANUALS, PROCEDURES AND GUIDELINES FOR FOREST MANAGEMENT CERTIFICATION IN SARAWAK (NATURAL FOREST) 2019

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This Greenbook: Manual, Procedures and Guidelines for Forest Management Certification will be reviewed and updated based on feedback, research findings and current policies of Forest Management Certification in Sarawak.

Any amendments and revisions to this Greenbook shall be endorsed by the Forest Management Certification Technical Committee.

FOREWORD

The commitment of the State Government to have all long-term forest timber license areas to be certified by 2022 is a catalyst for all involved in the forestry sector to step up their effort in sustainable forest management.

Forest Management Certification ensures the sustainability of forest resources not only through documentation review but evaluation of forest management processes and their environmental, social and economic impact against international standards. I am pleased to see the progress of Forest Management Certification in Sarawak. As of December 2018, six (6) Forest Management Units (FMUs) have been certified covering more than 500,000 hectares of natural forests. This represents about 12.2% of 4.46 million hectares of certified forest under the Malaysian Timber Certification Scheme in Malaysia.

This Greenbook comprising compilations of manuals, procedures and guidelines for the implementation of Forest Management Certification (Natural Forests) is a revision based on previous guidelines, feedbacks from stakeholders and current State Government Policies. This Greenbook was prepared by the Forest Department Sarawak and Sarawak Forestry Corporation Sdn. Bhd. to provide guides or prescriptions required in the implementation of Forest Management Certification (Natural Forests) in Sarawak. This revised Greenbook comprised of 12 manuals, procedures and guidelines addresses some verifiers in the Malaysian Criteria and Indicators for Forest Management Certification (Natural Forests). It will be progressively reviewed and amended as required, subjected to current policies and issues. This book shall provide basic guidance to the Forest Management Units of the Forest Timber License holders in preparing their Standard Operating Procedures (SOPs) for the implementation of Forest Management Certification in their respective licenses.

The journey towards achieving the State Government target would not be possible without the commitment, cooperation and dedication of all parties involved especially of the officers and staff of the Forest Department Sarawak, Sarawak Forestry Corporation, Forest Timber Licence holders and relevant stakeholders. With the publication of this Greenbook, we look forward for more FMUs to be certified in the future.

HAMDEN HAJI MOHAMMAD
Director of Forests
SARAWAK

ACRONYMS AND ABBREVIATIONS

AAC	Annual Allowable Cut
CBH	Commercial Bole Height
CFI	Continuous Forest Inventory
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CRC	Community Representative Committees
CSN	Consecutive Stem Number
DBH	Diameter at Breast Height
DP	Detailed Harvesting Plan
EIA	Environmental Impact Assessment
EMR	Environmental Monitoring Report
ERT	Endangered, Rare and Threatened species
FDS	Forest Department Sarawak
FMC	Forest Management Certification
FMP	Forest Management Plan
FMU	Forest Management Unit
FRA	Forest Resource Assessment
FRB	Field Record Book
FSC	Forest Stewardship Council
FTL	Forest Timber License
GP	General Harvesting Plan
GPS	Global Positioning System
HCV	High Conservation Value
HCVF	High Conservation Value Forests
HWLR	Honorary Wild Life Ranger
IUCN	International Union fort Conservation of Nature
LG	Log Grade
LTS	Line Transect Sampling
MC & I	Malaysian Criteria and Indicators
MPWS	Master Plan for Wild Life in Sarawak
MT	Mother Tree
MTCC	Malaysian Timber Certification Council
MTCS	Malaysian Timber Certification Scheme
NREB	Natural Resource Environmental Board
NTFP	Non-Timber Forest Produce
PCT	Potential Crop Trees
PEC	Permit to Enter Coupe
PFE	Permanent Forest Estate
POM	Point of Measurement
PSP	Permanent Sample Plots
RIL	Reduced Impact Logging
RP	Road Planning
RS	Remote Sensing
SA	Shifting Agriculture
SFC	Sarawak Forestry Corporation
SIA	Social Impact Assessment
SIC	Stem Identity Class
SOP	Standard Operating Procedures
SU	Sampling Units
STD	Sexually Transmitted Disease
TB	Tuberculosis
TH	Total Height
TP	Totally Protected
WC	Woody Climber
WLPO	Wild Life Protection Ordinance

ACKNOWLEDGEMENTS

Special thanks to those involved in the preparation of this guidelines especially the authors of the original manuals, procedures and guidelines and the team of editors for their dedication in giving inputs and making sure the issues of concern in the implementation of Forest Management Certification are addressed as much as possible.

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INTRODUCTION TO THE GREENBOOK

MANUALS, PROCEDURES AND GUIDELINES FOR SUSTAINABLE FOREST CERTIFICATION IN SARAWAK (NATURAL FOREST)

1.0 BACKGROUND

The Greenbook is a compilation of several manuals, procedures and guidelines to facilitate forest practitioners in the implementation of activities required by the Criteria and Indicators for Forest Management Certification. This is the second and updated version from the previous Greenbook prepared in 2014. The first volume comprise of 15 manuals, procedures and guidelines.

Sustainable management of forest resources is a major component of the Forest Management Certification (FMC). The State of Sarawak has shown its commitment in managing the forest resources by imposing FMC on all long term timber licences by year 2020.

A series of workshops were carried out to review the guidelines in October 2017, following feedbacks received from various stakeholders including incompatible guidelines from FDS and SFC, as well as outdated and incomplete guidelines which were not sufficient to address the requirements of the FMC standard. The workshop was attended by officers from Forest Department Sarawak and Sarawak Forestry Corporation.

The outcome of the workshops is the development of the second version of the "Manuals, Procedures and Guidelines for Forest Management Certification in Sarawak" was produced. The updated version comprise of 12 manuals, procedures and guidelines which address relevant verifiers of the Malaysian Criteria and Indicators for Forest Management Certification (Natural Forests) [MC&I (Natural Forest)].

2.0 OBJECTIVE

The objective of this book is to provide guidance on the implementation of FMC. As such, FMU licence holders may also develop their own Standard Operating Procedures (SOP) based on the requirements of the certification standard.

3.0 THE PROCESSES FOR FOREST MANAGEMENT CERTIFICATION

The Forest Management Certification is obtained by passing an evaluation conducted by an accredited certification body by assessing forest management compliance against requirements of a prescribed standard or specifically the certification criteria and indicators. The evaluation process not only consists of documentation review but also an in-depth review of forest management processes and their environmental, social and economic impact. Example of stages in achieving forest management certification set by the Malaysian Timber Certification Council is illustrated in **Figure 1**. The certification validity in most schemes is 5 years and subjected to annual audit or surveillance audit, to ensure requirements of the certification scheme are continuously met.

Forest Management Certification Process

Figure 1. Certification process as outlined by Malaysian Timber Certification Council

Note: Subjected to the certification body, a Forest Management Unit shall repeat Stage 1 if they could not proceed or conduct the Stage 2 audit within 6 months of the first audit.

GUIDELINE 1

GUIDELINES FOR FOREST MANAGEMENT PLAN

GUIDELINES FOR FOREST MANAGEMENT PLAN

1.0 INTRODUCTION

The Forest Management Plan defines planned forestry activities such as inventory, yield calculation, harvesting, silviculture, protection and monitoring, specifying objectives, actions and control arrangements in a Forest Management Unit (FMU). It also includes mechanism or guides for the FMU holders in the engagement or participation of relevant communities and stakeholders in the management of FMU area. The FMP should cover strategic or long-term management plan, and reviewed mid-term or where necessary, revised periodically in the light of accumulated experience, new information and changing circumstances.

The FMP is a legal document for long-term FMU and it is required under Principle 7: Management Plan of the Criteria and Indicator of the Malaysian Timber Certification Scheme (MTCS). The document shall be produced by the FMU holders and submitted for approval by the Forest Department before going through the certification process.

2.0 FOREST MANAGEMENT PLAN

Preparation of Forest Management Plan should follow the Chapters as described below:

Executive Summary
The Executive Summary should include the following basic information:

- Land status and tenureship
- Period and review of FMP
- Biodiversity resources
- Operational plan (i.e. AAC, MAI, cutting cycle, RIL, silviculture)
- Description of EIA approval
- Conservation measures (i.e. HCVF)
- Brief description of social component
- Overall budget to implement FMC
- Public summary

Chapter 1: Background of Management Plan Area
This chapter should describe the FMU as follows:

- Legal status and tenure
- History (past operation in the FMU)
- Accessibility
- Ecological and biological environment (i.e. topography, geology and soils, forest type, precipitation)
- Socio and cultural environment
- Areas within the Heart of Borneo (HoB)

Chapter 1 should also include maps on locality, land status, terrain, geology and soil, forest type and location of settlements. The renewal of Forest Timber License shall be placed as **Appendix**.

Chapter 2: Forest Resource Base

- Description and findings from Forest Resource Assessment (FRA)
- Description and findings from Permanent Sample Plots (PSPs)
- Timber stocks
- List of Endangered, Rare and Threatened (ERT) Plants
- List of ERT wildlife
- Forest zoning

This chapter should be supported by location map of PSPs and forest zoning.

Chapter 3: Management Plan Prescriptions

- Forest Policy of Sarawak and FMU
- Management objectives
- Management system (cutting rules, minimum cutting limit, RIL)
- Yield regulation (growth and yield, AAC & monthly production limit)
- Harvesting period
- Annual coupe
- Amendment/ revision of Management Plan
- Map: Annual coupe layout

Chapter 4: Planning of Forest Roads and Harvesting Systems

- Forest road system
- Planning Procedures: General Planning, Operational Planning and Planning for Reduced Impact Logging.
- GP (soft and hard copies) shall be attached with the FMP

Chapter 5: Pre-Harvesting Activities

- Infrastructure development (existing road, construction of roads, drainage structures and bridges, new camp facilities)
- Demarcation of coupe and block boundaries
- Operational inventory
- Tree marking (tree marking, potential crop tree, tree for protection)
- Location of landing
- Alignment, marking and mapping of main skid trails and logging terraces
- Monitoring and control by FDS
- Monitoring and control by FMU holder

Chapter 6: Harvesting Operation

- Training of forest workers
- Tree felling
- Harvesting system selection
- Monitoring of harvesting operation by FMU holder
- Post-harvest activities
- Measurement of royalty marking and tagging logs
- Commencement and closing of coupe

Chapter 7: Environmental Impact Assessment

- Environmental impact consideration
- List of mitigation measures
- Monitoring

Chapter 8: Forest Research

- Establishment of PSP (methodology, number of sample plots, monitoring)
- Summary of PSP results (stem number, basal area, tree diversity, stand quality, timber stocking)
- Re-assessment of PSP
- Classification of PSP
- Scientific collaboration with other agencies

Chapter 9: Silviculture, Forest Rehabilitation and Reforestation

- Enrichment planting
- Rehabilitation of open/ highly degraded area
- Scheduling of silvicultural treatment
- Other silvicultural management

Chapter 10: Conservation of Biodiversity and Protection of Ecosystem

- Wildlife management
- Identification and management of Protection/ Conservation Areas (identification of protection area in FMU)
- High Conservation Value Forests
- Map of HCV

Chapter 11: Community Development

- Location and demography of local communities
- Community services and projects (government, FMU holder)
- Mechanism for conflict resolution (establishment CRC and FMC Liaison Committee)

Chapter 12: Occupational Health and Safety

- Occupational safety and health policy
- Safety practice procedure for forest activity
- Training of forest workers

Chapter 13: Budget and Cost Projection for FMC

- Objective & budget allocation (operation, training, silviculture, research, etc)
- Financial viability (assumptions)

3.0 BASIC GUIDANCE FOR WRITE-UP OF IMPORTANT ELEMENTS IN FMP

3.1 Forest Resource Assessment

The Forest resource assessment (FRA) is the basis for forestry planning and preparation of the FMP. The FRA should include wood volumes and growth, forest types and environmental and social-economic values, among others.

3.1.1 Annual Allowable Cut

The AAC is defined as volume of timber that may be harvested annually in accordance to management objectives and restrictions. The unit of measurement for AAC is cubic meter per annum (m3/a) for the entire coupes. It depends on the actual stocking condition of the whole FMU. The AAC is calculated based on continuous monitoring of Permanent Sample Plots within the FMU. Level of AAC will be variable in each FMU, depending on the actual resource condition. Under this system, harvesting time depends not on average but on actual stocking situation on the ground. In areas with low harvesting intensity, the AAC could be higher in comparison to heavily disturbed areas that need long time periods to accumulate the target growing stock levels. The Guidelines for Establishment of Permanent Sample Plots in Mixed-Dipterocarp Forest detailing the methodology for the establishment of permanent sample plots shall be used.

3.1.2 Establishment of Sample Plots

Forest Resource Assessment involves Continuous Forest Inventory (CFI), which is an enhanced enumeration procedure that provides growth information and stock data (annual growth and yield, mortality and recruitment of commercial timber trees). The CFI data is collected from Permanent Sample Plots (PSP). In a virgin forest, a cluster sample comprising nine 20 m x 100 m strips arranged 3 by 3, each 100 m from the next, the actual plots covering 1.8 ha and the cluster covering a total of 13 ha.

In logged-over forest, which is more difficult to traverse, a strip sample with a cluster of four 10 m x 100 m strips, located 100 m apart from each other shall be established. Each strip shall consist of five 10 m x 20 m subplots. Two sub-sub plots of 2 m x 2 m shall be set up on the third subplot (subplot 3). The actual plots cover 1.6 ha and the total cluster covers 13.6 ha. The CFI can be used for general planning of second-cycle harvesting and for this purpose it is recommended that:

- The sample area shall be at least one ha (to reduce sampling error) in order to capture the variation of commercial tree stock in a few main species groups;
- At least three samples per coupe area (e.g. 75 samples per management unit of 25 coupes), be selected from 1 km grid intersections;
- Commercial trees be enumerated down to a dbh below the lowest cutting limit, (e.g. 40 cm), preferably with a sub-sample down to 20 cm (Pearce, 2007).

3.1.3 High Conservation Value Forest

High Conservation Value Forest (HCVF) assessment provides information pertaining to identification and maintenance of environmental and social values in the FMU. There are six HCVs, namely:

HCV 1	Biodiversity values: Forest area contains globally, regionally or nationally significant biodiversity values (e.g. endemism, endangered species, sites of critical temporal use).
HCV 2	Landscape-level forest: Forest area contains or is part of a globally, regionally or nationally significant large landscape-level forest where significant populations of most if not all naturally occurring wildlife species exist in natural patterns of distribution and abundance.
HCV 3	Ecosystems: Forest area contains or is part of a threatened or endangered ecosystem.
HCV 4	Services of Nature: Forest area that provides basic services of nature in critical situations.
HCV 5	Basic needs of local community: Forest area is fundamental to meeting basic needs of local communities.
HCV 6	Cultural identity of local communities: Forest area is critical to local communities' traditional cultural identity.

Overall, these six values enable the FMU holder to identify, manage and maintain important forest areas deemed important for the conservation of biodiversity, protection of ecosystems and social values.

3.2 Planning of Forest Infrastructure

Forest infrastructure planning for each FMU comprised of buildings, service stations, log landings, basic permanent road network (existing and new roads, road repair, road maintenance) for the whole FMU, maps (1:50,000) or larger and tables of annual work programme for the certain period (normally 10 years). Under the present management system, road construction is planned and carried out by the FMU holder.

Example: Maintenance Plan
Annual Schedule for Road Construction and Maintenance in FMU No.....…

Year	New Construction	Repair	Bridges	Culverts	Renewal of surface Layer	Compaction	Reshaping
	(km)	(km)	(number)	(number)	(km)	(km)	(km)
2014							
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022							
2023							
2014-2023							

3.3 Planning of Harvesting Operation

The AAC which has been calculated and determined should be harvested from coupe/ blocks that have reached or passed target growing stock levels. Blocks ready for harvesting must be identified and verified by pre-harvest inventory. Harvesting plans includes:

- Coupe Number
- Block number
- Area (ha)
- Estimated Extraction Volume (m^3/a)
- Harvesting Year
- Extraction Method

Example: Harvesting Plan

Year	**Coupe**	**Block No.**	**Area (ha)**	**Commercial Volume**	**Gross**	**Estimated harvestable volume (m^3/ a)**
				Dipterocarp (≥60 cm dbh)	**Non-Dipterocarp (≥45 cm dbh)**	
2014						
2015						
2016						
2017						
2018						
2019						
2020						
2021						
2022						
2023						
Total						
Average/ Year						

3.4 Planning of Silvicultural Operations

The objective of silvicultural operations or forest rehabilitation is to improve/ increase survival and growth of commercial species and to ensure adequate stocking with commercial trees. The guiding principles are to maintain/ enhance structural and species diversity close to natural conditions with minimum intervention through removal of direct plant competition and also to avoid whenever possible the use of harmful chemicals in tree or weed removal. Proper silviculture treatment methods shall be applied to reduce the invasion of secondary plant species especially on lower slope and flat terrain, which have been heavily harvested in the past. It is well known from research that the creation of larger sized gaps will promotes the growth of light demanding species. In the early succession phase after logging most of these species are soft wooded species without proven commercial value. These species quickly colonize large gaps and suppress commercial regeneration underneath. Most of the Dipterocarp seedlings can tolerate some shade in the first few years but will perish eventually if they no access to light. As far as required, silvicultural methods shall focus on:

- Release of Natural Regeneration
- Liberation of Potential Crops Trees (PCT)
- Enrichment Planting

Areas to be treated shall be identified by a rapid ground diagnostic survey analysis.

Example: Silvicultural Operation Plan

Year	Coupe	Block	Release of Natural Regeneration (ha)	Liberation (ha)	Enrichment Planting (ha)	No Treatment (ha)	Total (ha)
2014							
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022							
2023							
Total							
Average/ Year							

3.5 Planning of Biodiversity Conservation and Ecosystem Protection

The chapter for biodiversity conservation and ecosystem protection in the FMP shall include the findings of the High Conservation Value Forest (HCVF) assessments and provisions of the Wildlife Protection Ordinance (1998). It shall be developed in consultation with relevant experts and conservation organizations in Sarawak. Maps showing the location of HCVFs, shall be included at the level of the FMU.

3.6 Planning of Community Development Project

Planning of community development is a process that identifies and assesses the needs and problems of local communities in the context of the FMU. The goal is to build community capacity in addressing their needs and problems as well as enhancing community capital to generate a better quality of life.

Any community development programme should be based on the assessment of the resources and needs of the community concerned, as well as the opportunities for action to improve the current situation in the community. As such, planning can take place in a variety ways, and there are no fixed forms for community development programme.

The implementation of the community development programmes should cover various areas that include community visioning, local institutions/ governance, leadership development, community tourism assessment and development, economic and business development, business retention and expansion projects. It covers community profiling, conflict management and resolution, economic impact assessment, planning facilitation and community survey.

Planning for community development should use both bottom-up and top-down approaches (FDS, 2008). Bottom-up approaches would help generate a better understanding of the community needs and aspirations. Bottom-up approach is very important as development cannot be imposed on the people. The community must have a feeling of ownership of the projects and programmes. For minor maintenance works, the community will have to manage it on their own. Top-down approaches would be useful where the community is neither aware of the types of development projects that can be offered by the FMU holder or government, nor recognise what types of development projects are suitable for them. There are also the issues of funding and facilities that the community is not able to provide or afford. For any development programmes to be successful, the FMU holder/ government has to play an integral role in the projects.

As forest management can also be perceived to be encroaching into areas deemed as important for the community, appropriate mechanism for conflict resolution and community participation should be developed.

4.0 DATA BANK STRUCTURE FOR EACH FOREST MANAGEMENT UNIT

List of data required by the FMU holder at the FMU and Coupe/ Block Level.

FOREST MANAGEMENT UNIT- LEVEL			
Data/ Information required		**Data Type/ Unit**	**Data Source**
1.	General information		
	Name of Forest Reserve	A – Name	FTL
	Timber Licence No.	A- Number	FTL
	Name of Licensee	A – Name	FTL
	Name of Contractor (if any)	A – Name	Licensee
	Start / end of licence contract	A – Date	FTL
	FMU external boundary/ area	S – Loc., ha	FTL
	Gross operational area	S – Loc., ha	FTL
	Coupes boundaries/ area	S – Loc., ha	Licensee
	Blocks boundaries/ area	S – Loc., ha	Licensee
2.	Silvicultural management system		
	Target commercial growing stock	A – m3/ha	
	Diameter cutting limits	A – cm	FMP
	Ratio Commercial/ Non-Commercial species (NF)	A - % /%	FMP
	Average cutting cycle length (or rotation period)	A - years	FMP
	Annual Allowable Cut (AAC)	A – m3/ha	FMP/ growth analysis

3.	Forest infrastructure (existing and planned)		
	Logging camps	S – Loc., ha	Licensee
	Primary roads, including formation width	S – Loc., ha	RS/ DP/ Road Plan
	Primary roads, including clearing width	S – Loc., ha	RS/ DP/ Road Plan
	Primary road sections, to be upgraded/ maintained		
	Secondary roads, including formation width	S – Loc., ha	RS/ DP/ Road Plan
	Secondary roads, including clearing width	S – Loc., ha	RS/ DP/ Road Plan
	Secondary road sections to be upgraded/ maintained		
	Feeder roads, including formation width	S – Loc., ha	RS/ DP/ Road Plan
	Feeder roads, including clearing width	S – Loc., ha	RS/ DP/ Road Plan
	Rail, including formation width	S – Loc., ha	Block layout/ DP
	Bridges	S – Loc	Road plan
	Culverts	S – Loc	Road plan
	Log landing sites (planned, active, abandoned)	S- Loc., CODE, ha	RS/ DP/ Road Plan
	Water bodies:		
	• rivers > 10 m width	S- Loc., ha	RS/ Topo map
	• lakes and ponds	S – Loc., ha	RS/ Topo map
4.	Socio-economic data		
	Longhouse:		
	Longhouse profiles	S- Loc., ha A- various	R/ S Socio- economic study
	Areas managed by longhouse community	S – ha	R/ S
	Areas of cultural, historical or spiritual importance	S – ha	Socio- economic study
	Logging camp staff (if applicable):		
	• total employees	A- Number	Licensee
	• management staff	A- Number	Licensee
	• administration staff	A- Number	Licensee
	• workshop technicians	A- Number	Licensee
	• truck drivers	A- Number	Licensee
	• tractor drivers	A- Number	Licensee
	• tree fellers	A- Number	Licensee
	• debarkers	A- Number	Licensee
	• surveyors for resource inventory	A- Number	Licensee
	• surveyors for road survey	A- Number	Licensee
	• logpond staff	A- Number	Licensee
	• other supporting staff (camp)	A- Number	Licensee
5.	Forestry/ transport equipment (if applicable)		
	Dump trucks	A- Number	Licensee
	Barges (log transport river)	A- Number	Licensee
	Tug boats	A- Number	Licensee
	Long Boats	A- Number	Licensee
	Pick-up/ landcruiser vehicles	A- Number	Licensee
	Motorgraders	A- Number	Licensee
	Rollers	A- Number	Licensee
	Boats	A- Number	Licensee

	Tractors	A- Number	Licensee
	Excavators	A- Number	Licensee
	Chain saws	A- Number	Licensee
	Generators	A- Number	Licensee
6.	Forest Resource Assessment		
6.1	Site & Soils		
	Rainfall data / distribution	S- mm/a	Met. service
	Topography (contour lines)	S- 100 ft	Topo map
	Geology	A	Geological map
	Soil groups	A- Number	Soil map
	Soil families	A- Number	Soil map
	Soil series	A- Number	Soil map
6.2	Wildlife		
	Occurrence of key animal groups (Mammals, birds, reptiles, ...)	N/ha (?) Presence/ absence	Wildlife survey
6.3	Vegetation		
	Forest area by Forest Types	S - ha	Forest type map
	Forest Resource Assessment plots	S, Coordinates	FRA inventory map/ GPS
	Plantation areas (existing/ planned)	S - ha	FRA-Inv. Map/ FMP
	Species diversity	A – No. of species/ FRA plot	FRA Analysis
	Analysis of Growing stock		FRA Analysis
	Size classes by species group:		
	• Small poles 5-9 cm	A– N, BA, m3/ha	FRA Analysis
	• Big poles 10 – 19 cm	A– N, BA, m3/ha	FRA Analysis
	• Trees 20 – 39 cm	A– N, BA, m3/ha	FRA Analysis
	• Trees 40 – 59 cm	A– N, BA, m3/ha	FRA Analysis
	• Trees ≥ 60 cm	A– N, BA, m3/ha	FRA Analysis
	Timber quality by Saw Log Grade:		
	• Trees 20 – 39 cm	A – CODE, N/ha, %	FRA Analysis
	• Trees 40 – 59 cm	A – CODE, N/ha, %	FRA Analysis
	• Trees ≥ 60 cm	A – CODE, N/ha, %	FRA Analysis
	Tree vitality:		
	• Crown form by species group/ size class	A – CODE, N/ha, %	FRA Analysis
	• Crown competition by species group/ size class	A – CODE, N/ha, %	FRA Analysis
	• Bole form/ defects by species group/ size class	A – CODE, N/ha, %	FRA Analysis
	Climber interference by species group/ size class	A – CODE, N/ha, %	FRA Analysis
	Impeding factors by species group/ size class	A – CODE, N/ha, %	FRA Analysis
	Non- wood forest products:		
	Rattan	A- Clumps/ha	FRA Analysis
	Palms	A- N/ha	FRA Analysis
	Bamboo	A- Clumps/ha	FRA Analysis
	Medicinal plants	A- N/ha	FRA Analysis
	Others (?)	A- N/ha (?)	FRA Analysis

COUPE/ BLOCK LEVEL			
Data/ Information required		**Data Type/ Unit**	**Data Source**
1.	General information		
	Coupe	A – Number	Block Layout Map/ DP
	Block number	A - Number	
	Block size	S - ha	GIS – Analysis
	Topography (contour lines)	S – 5 m	Pre- Felling Inventory
	Water bodies:		
	• Big rivers ≥ 10 m width	S – Loc., ha	RS / GP / Topo Map
	• Small rivers, 3 m - < 10 m width	S – Loc., ha	Pre- Felling Inventory
	Lakes and ponds	S – Loc., ha	Topo Map
	Areas ≥35°	S – Loc., ha	Map/ Pre- Felling Inventory
	Skid- trails (existing and planned)	S – Loc., ha	Pre- Felling Inventory
	Prominent terrain features/ obstacles (large rocks, waterfalls etc.)	S – Loc.	Harvesting Map
	Status / harvest year and system applied		
	Primary forest	A	Records
	Harvested forest 1st cut	A	Records
	Date of harvest 1st cut	A – mth/year	Records
	Harvesting system applied	A	Records
	Harvested forest 2nd cut (= re-entry)	A	Records
	Date of 2nd harvest (if applicable)	A – mth/year	Records
	Harvesting system applied	A	Records
	Log production prior to FMU establishment		
	Trees harvested	A – N/ha, m3/ha	Records
2.	Site Classification		
	Topography class	A	Topo Map
	Management restrictions:		
	• Prescribed harvesting system next cut		
	• Ground based system (tractor)	A	FMP
	• Off-ground system:		
	• Skyline system	A	FMP
	• Helicopter system	A	FMP
3.	Pre- Felling Inventory		
	Recording date	A – Date	Pre-F record Sheet
	All trees ≥ 60 cm DBH for Dipterocarp and ≥ 45 cm DBH Non- Dipterocarp	A – N/ha, m3/ha	Pre-F Analysis
	Potentially harvestable trees	A – N/ha, m3/ha	Pre-F Analysis
	Trees marked for felling	A – N/ha, m3/ha	Pre-F Analysis
	Seed trees marked for retention (Mother Tree)	A	Pre-F Analysis
	Potential Crop Trees (PCT):		
	• Trees 30 – 44 cm (Non-Dipterocarp)	A – N/ha	Pre-F Analysis
	• Trees 30 – 59 cm (Dipterocarp)	A – N/ha	Pre-F Analysis

4.	Post- Felling Assessment (after harvesting)		
	Stocking density of trees		
	0-5 trees/ha	A - N/ha	Post-F Inspection
	6-10 trees/ha	A - N/ha	Post-F Inspection
	11-15 trees/ha	A - N/ha	Post-F Inspection
	16-20 trees/ha	A - N/ha	Post-F Inspection
	> 20 trees/ha	A - N/ha	Post-F Inspection
	Potential Crop Trees (PCT):		
	• 30 – 44.9 cm (Non Dipterocarp)	A – N/ha	Post-F Inspection
	• 30 – 59.9 cm (Dipterocarp)	A – N/ha	Post-F Inspection
5.	Planning		
	Management objective		
	Target commercial growing stock natural forest management	A – m3/ha	FMP
	Target growing stock timber plantation (if any)		
	Tree marking, including skid-trail/ corridor		
	Planning		
	Year	A - year	FRB
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB
	Harvesting		
	Year	A - year	FRB
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB
	Silvicultural treatment		
	Year	A - year	
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB
	Treatment type (liberation, reg. release, enrichment)	A - CODE	FRB
	Area to be treated within Coupe/ Block	A - ha	RB, Silvicultural Assessment
6.	Implementation		
	Tree marking		
	Year	A - year	FRB
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB
	Harvesting		
	Date of permit to enter coupe (Block)	A – mth/year	FRB
	Actual harvesting date	A – mth/year	FRB
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB
	Log production:		
	• Log per species / species group	A – N/ha	FRB
	• Volume per species / species group	A – m3/ha	FRB
	Date of closing Block	A – mth/year	FRB
	Silvicultural treatment		
	Date	A – mth/year	FRB
	Area treated within Coupe/ block	A - ha	FRB
	Treatment type (liberation, reg. release, enrichment)	A - CODE	FRB
	Manpower	A – m/days/ha	FRB
	Costs	A – RM/ha	FRB

Note:

A	=	Attribute data
S	=	Spatial data
N	=	Number of trees per ha
BA	=	Basal area per ha
m3	=	Amount of timber in cubic meter per ha
CODE	=	A figure representing a (quality) class
FTL	=	Forest Timber License
FMP	=	Forest Management Plan (working plan), part of FTL
RS	=	Remote sensing data (e.g. Thematic Mapper, SPOT)
FRA	=	Forest Resource Assessment
FRB	=	Field Record Book

EXAMPLES FOR ANALYSIS OUTPUT			
Data/ Information required		**Data Type/ Unit**	**Data Source**
1.	General information		
	Analysis of infrastructure:		
	Primary roads:		
	• Length in FMU	Km/ FMU	GIS Analysis
	• Length within Coupes	Km/ Coupe	GIS Analysis
	• Opening Efficiency	m/ ha	GIS Analysis
	• Road standards regarding:		
	• clearing width	m	GIS Analysis
	• road width	m	GIS Analysis
	• gradients	% slope	GIS Analysis
	Secondary roads: - see above-		GIS Analysis
	Feeder roads: -see above-		GIS Analysis
	Skid-trails: (block basis)		
	• planned skid-trail alignment (before harvesting)	S – Loc	GIS Analysis
	• trail efficiency (after harvesting)	A – m	FRB & GIS Analysis
	Area covered by roads and other permanent infrastructure	S – ha	GIS Analysis
	Area covered by permanent water bodies	S – ha	GIS Analysis
	Nett production area	S – ha	GIS Analysis
2.	Input for Forest Planning		
	Terrain slope classification (0-5°, 6-15°, 16-25°, 26-35°, >35°)	A	Topo Map
	Areas for ecosystem / habitat protection	S –ha	Forest Type Map/ FRA & GIS Analysis
	Areas for protection of High Conservation Value Forest (HCVF)	S – ha	FRA & GIS Analysis
	Areas for protection of water resources (buffer zone)	S – ha	GIS - Analysis
3.	Timber harvesting analysis		
	Area logged per year	S – ha/ a	GIS Analysis
	Timber harvested per year	A – N/ ha, m3/ a	GIS Analysis
	Comparison approved area / actual area	S – Loc., ha/ ha/ a	GIS Analysis

4.	Impact analysis		
	Identification and verification of cleared / degraded areas:		
	• areas affected by shifting cultivation	S – Loc., ha	RS Interpretation
	• areas affected by forest fires	S – Loc., ha	RS Interpretation
	• areas affected by high harvesting intensity	S – Loc., ha	RS Interpretation
	• waterlogged areas	S – Loc., ha	RS Interpretation

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GUIDELINE 2

TECHNICAL MANUAL FOR FOREST RESOURCE ASSESSMENT (FRA) IN SARAWAK

TECHNICAL MANUAL FOR FOREST RESOURCE ASSESSMENT (FRA) IN SARAWAK

1.0 INTRODUCTION

Management of a defined forest area requires gathering of data or information on current situation of a managed forests or known in this Guideline as Forest Management Unit (FMU). The information or data obtained will be used to develop a Forest Management Plan, which is a requirement of the Criteria and Indicators for Forest Management Certification. The process of forest management planning comprise of the following aspects:

- assessment and analysis of current forest resources;
- forest zoning by specific functions, such as production conservation/ protection, community use, and any other functions as may be identified;
- determination of net timber production area;
- calculation of the Annual Allowable Cut (AAC);
- planning of infrastructure, harvesting and silviculture reforestation activities;
- identification and mitigation of environmental impacts,
- wildlife surveys and monitoring
- social surveys and impact assessment, socio-economic development planning
- organizational and financial planning

To identify types of forest functions occur in the FMU, collection of data and information for the following seven major aspects are required:

i. forest site conditions;
ii. timber resources;
iii. non-timber resources;
iv. wildlife occurrence and habitats;
v. diversity of species and ecosystems;
vi. socio-economic conditions, and potential for forest amenities and recreation.

Note that not all of these aspects may be relevant in a particular FMU.

This Technical Manual for Natural Forest Resource Assessment regulates the establishment and recording of Sampling Units at the Forest Management Unit (FMU) level. The objective of this Manual is to guide forest survey crews in the assessment of timber resources, important non-timber resources, and in a general assessment of wildlife occurrence.

Note that more detailed assessment of non-timber resources and wildlife will also need to be carried out at the forest compartment level, prior to the commencement of harvesting activities.

The leader of each inventory team shall make use of this manual throughout the fieldwork to ensure that the establishment of all sampling units and subsequent recording of field data and information are made according to these instructions.

Any questions, comments and suggestions concerning the implementation of this standard shall be settled before the start of the field work.

A review and amendment of this manual shall be undertaken following a field-testing phase at operational level.

2.0 SAMPLING DESIGN

2.1 Number of Sampling Units to be recorded

The key objective of this resource assessment is to quantify the growing stock at FMU-level at an estimated coefficient of variation (CV%) of the commercial/ total basal area, and an accepted percentage of standard error (SE%), at a given confidence or probability level.

The general formula used to calculate the number of required sampling units reads:

$$N = \frac{t^2 * CV\%^2}{SE\%^2}$$

The formula indicates the dependence of the number of sampling units on these three parameters:

SE% = Standard Error. The SE, expressed on a percentage basis, is used to describe the desired accuracy of the inventory results with regard to the main parameter to be assessed, e.g. commercial tree basal area or commercial timber volume. It is proposed that the standard error for commercial basal area is set to 10%.

CV% = Coefficient of variation. The CV% is used to describe the variability of stocking conditions. It is estimated from previous forest inventories carried out in the FMU, such as data from pre-harvest enumeration sampling and/ or data from Permanent Sample Plots (PSP), if available. In case no data exist to estimate the CV% the value will be set to 50%.

t = the t-value of the Student"s Normal distribution represents the probability or confidence level of the inventory result. It is recommended that the confidence level should be set to 95%, meaning that with a statistical probability of 95%, the true inventory results will fall within the range of the standard error. For a probability level of 95% the t-value approximates ≈ 2.

Depending on the variability of the stocking conditions the required number of Sampling Units (SU) typically ranges from 50 to 150 SU in any given FMU.

2.2 Distribution and spatial layout of Sampling Units

In principle, the distribution of sampling units over a forested area is either made systematically or randomly. Both methods have the advantages and disadvantages. From the practical point of view, it is preferable to follow a systematic distribution. In comparison with random sampling, it offers the advantage of a higher statistical efficiency, i.e. a higher precision is achieved with the same number of sample points. The other advantage is that sampling units laid out systematically can be easier to re-locate in the field; and that a portion of these can be selected and use as PSP following post-stratification of analyzed growing stock data.

Nevertheless, by employing a systematic layout the estimation of the average stocking figures could be biased if the sample distribution pattern follows a clear trend in the area to be sampled. For example, this could happen if the grid points of the sampling units would always fall on ridges or into valleys. This situation, however, is rarely encountered in the field, and can be avoided through a shifting of the entire sampling grid.

Example for layout of Sampling Units (SU):
Area coverage: whole production forest area within the FMU

Assumed number of sampling units calculated from sampling formula as per Chapter 2.1 = 100 SU
Area represented by 1 SU:
Estimated net production area: 100,000 ha
1 SU represents 100,000/ 100 = 1,000 ha of production forest

Sampling design/ grid:
Systematic layout with 3.16 km grid point distance
(grid point coordinates identical with SU tie point).

Figure 1 indicates the systematic layout of SU across the estimated net production area.

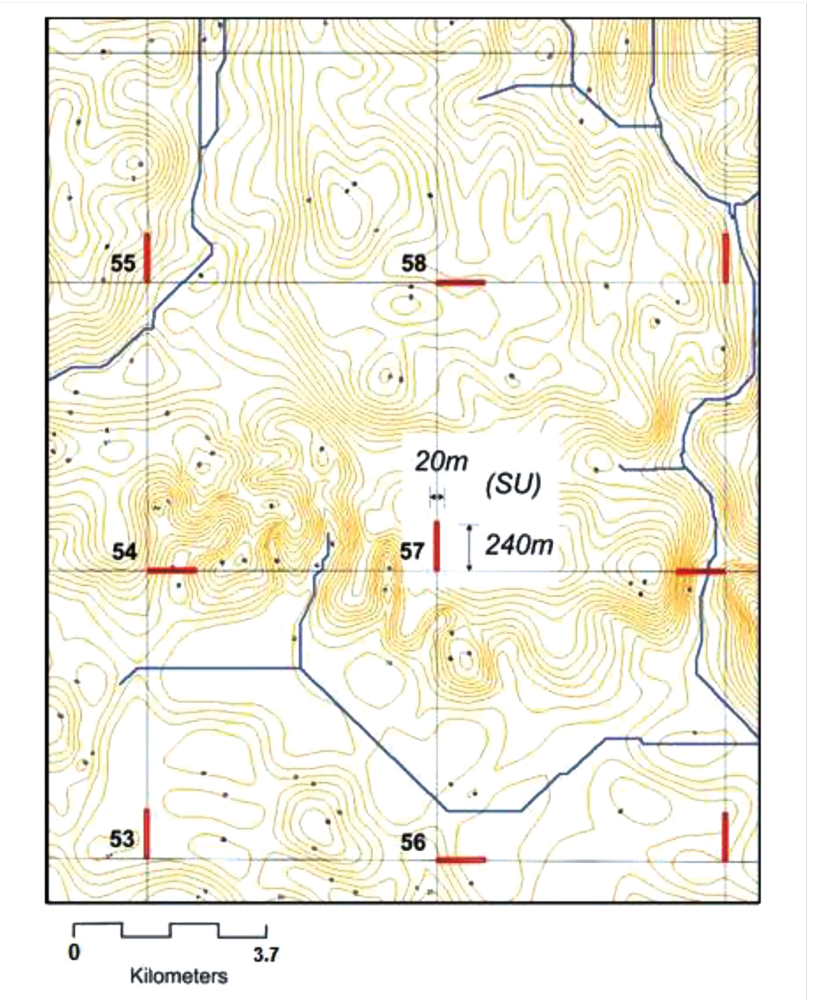


Figure 1. Layout example for Sampling Units within the production forest area.

2.3 Design of Sampling Unit

Figure 2 shows the design of the Sampling Unit. The main SU consists of a strip of 240 m length and 20 m width.

The Sub-sampling units (SSU) have a nested design with three areas for tree measurement, depending on the tree diameter:

1. Whole area of SU (240 m x 20 m): record trees ≥ 30 cm dbh or diameter above buttress.
   The SU area is divided into 12 Sub-sampling units (SSU) of 20 m x 20 m (400 m^2) Total area to be recorded: 12 x 400 m^2 = 4,800 m^2

2. Sub-area 1 (10 m x 10 m = 100 m^2): record trees ≥ 10 cm to 29.9 cm dbh in each of the 12 SSU
   Total area to be recorded: 12 x 100 m^2 = 1,000 m^2

3. Sub-area 2 (5 m x 5 m = 25 m^2): record trees ≥ 5 cm to 9.9 cm in each of the 12 SSU
   Total area to be recorded: 12 x 25 m^2 = 300 m^2

	DBH	No. of SSU	SSU Size (m)	SSU Area (m^2)	Total Size/ SU (m^2)
	≥30 cm	12	20 x 20	400	4,800
	10.0-29.9 cm	12	10 x 10	100	1,200
	5.0-9.9 cm	12	5 x 5	25	300

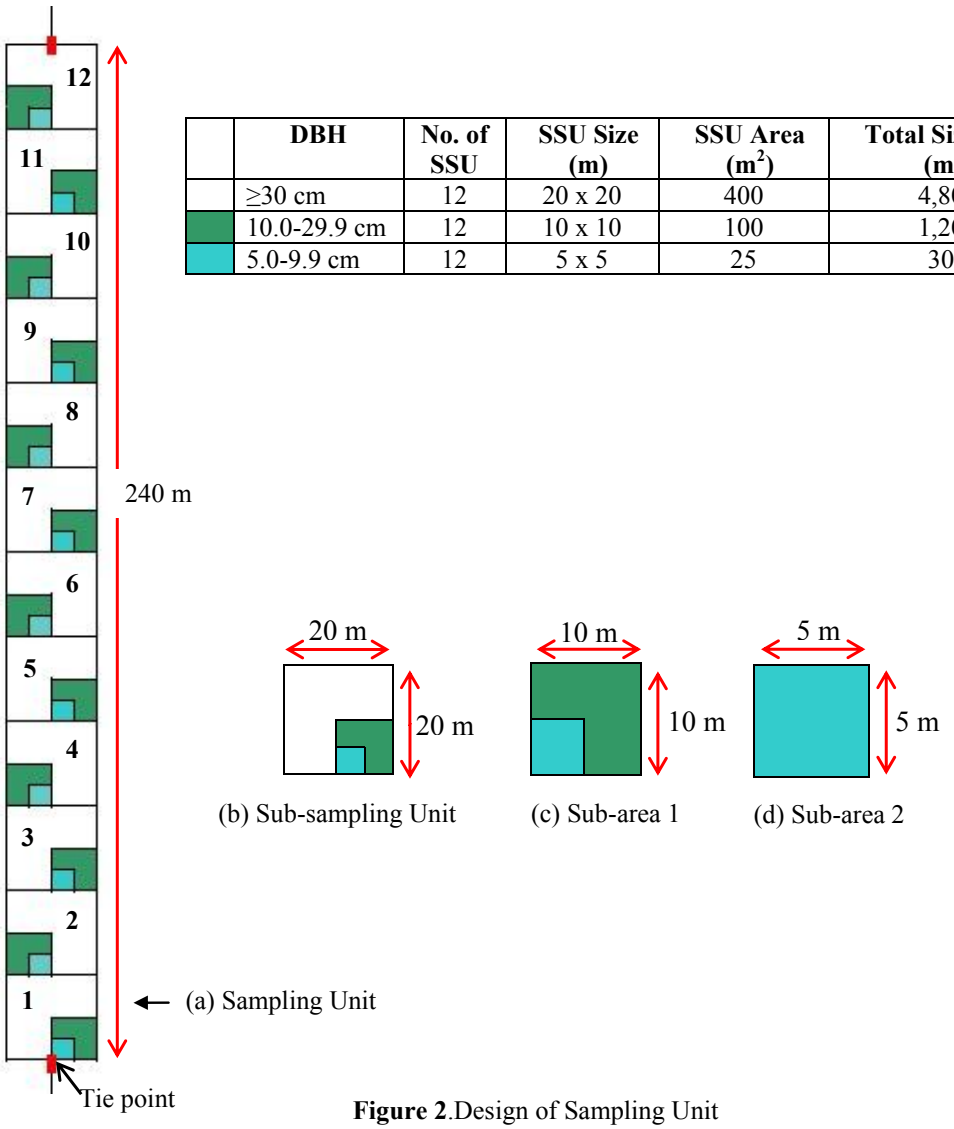


Figure 2.Design of Sampling Unit

2.4 Statistical data analysis

The software for field data analysis has been developed using MS Excel based VBA macro programming software. The software builds on compatible systems with proven record of being user-friendly, through a completely menu-driven system, such as entry masks, data validation routines, look-up tables, data processing, and standard output tables. Input and output tables will be created in standard MS Excel workbook formats (.xlsx) to facilitate data linkage to other systems, if required.

Two software components have been developed: one for data entry and one for data processing and analysis.

Standard outputs include stem numbers, basal area, and volume by species or timber groups, as presently classified in Sarawak. In addition, output tables are created by individual sampling unit, by groups of sampling units, by Coupes, by diameter classes, age after harvesting, terrain conditions, etc. Details of the inventory software package are described in the User Reference Manual.

3.0 FIELD TEAM COMPOSITION AND LOGISTICS

3.1 Team composition

The proposed team composition is listed in **Table 1**. The company shall provide qualified staff for organization of team logistics, SU establishment and recording. The standard team composition consists of 5 staff: Crew leader (1), Assistant Crew Leader (1), and support labour (3).

Table 1. Team Composition

Activity	No.	Function
Crew Leader	1	Crew management, team logistics, SU location, tree data recording
Assistant Crew Leader	1	GPS operation, SU establishment, species identification, tree data recording
Support Labour	3	Clearing SU baseline, transport of equipment, general support, marking of SU and SSU, tree marking, assist in tree data recording
TOTAL	5	

Additional staff such as cook and/ or support labour may have to be recruited in cases of difficult access where temporary field camps need to be set up.

3.2 Performance and time schedule

Previous experience with similar FRA systems has shown that the recording time for a single SU will be as follows:

average access/ shifting time between 2 SU"s	:	5.0 hrs (undulating to hilly terrain)
SU establishment and subdivision	:	2.0 hrs (measurement and marking)
Recording of trees	:	4 hrs (depending on tree density)
Total estimated time for 1 SU	:	11.0 hrs

In conclusion, it can be assumed that on average conditions it will be possible to record about 0.70 SUs per 8-hr field working day. In addition, a time buffer of 25% should be considered for adverse weather conditions and other factors causing delays.

In case of remote areas without communication links between field teams and coordinators radio sets should be used to stay in touch with the Base Camp of the FMU.

Based on a total number of 100 SU to be recorded from the net production area the total estimated implementation period for the Forest Resource Assessment in a FMU is calculated as follows:

Assumptions:
Number of field crews: 2 crews, consisting of 5 staff each
Recording time per SU including access/ shifting times: 1.38 days
Time buffer for adverse weather conditions and other delays: 25%
Working days per month: 24

Calculation of field survey time:
100 SU x 1.38 days + 25% = 172.5 days / 24 = 7.19 months/ 2 crews = 3.59 months
Note that the achievement of this estimate requires trained field crews, good logistic planning.

4.0 INVENTORY EQUIPMENT

The following basic equipment shall be provided for each recording team:

1. Field Manual for Natural Forest Resource Assessment, printed on durable, water-resistant paper
2. Set of 1:25,000 FRA Base Map, indicating conservation and protection/ exclusion areas
3. SU grid points with consecutive SU numbers
4. List geographical coordinates for all SU tie points (also uploaded into GPS)
5. Waterproof plastic tube for map transport
6. Protractor, square and ruler
7. Suunto compasses (1 units)
8. TruPulse laser, or Suunto clinometer/ height meter (2 units)
9. Reinforced measuring tapes (3 pcs., 30 m each, stretch-resistant)
10. Steel diameter tapes (3), cm.mm scale
11. Binoculars (1)
12. Digital camera (1) for recording condition/ shifting/ cancellation of SU, species ID, etc.
13. Coloured string (raffia or red-white banded) for demarcations along baseline and SSU boundaries
14. Red durable paint for marking sampling unit start and end tie points (sufficient to cover the number of sample units to be recorded during one field trip)
15. Writing board/ clipboard (2)
16. Field Record Sheets No. 1 – 3 (sufficient to cover the duration of one field trip)
17. Pencils (10)
18. Erasers (5)
19. Permanent marker pens (20)
20. Marking crayon (3 colours, 20 pcs each)
21. Tags for plant specimen (min 200)
22. Plastic bags for collection of plant specimen
23. Global positioning system with electronic compass (GPS, 1 set), including sufficient spare batteries. Basic topographic and operational layers/ boundaries should be uploaded to GPS.
24. Radio call set (1) – recommended -
25. First Aid Kit
26. Parang (one each crew member)

Notes:
Camp sheets and supplies, personal accessories are not included in list.

5.0 ACCESS AND ESTABLISHMENT OF SAMPLING UNITS

5.1 Establishment of SU Baseline

The location of each SU and its tie point are shown on a topographic map sheet of scale 1:25,000 (FRA Base Map).

The Global Positioning System (GPS) is used to verify the tie point locations of each SU in the field. All SU tie point coordinates shall be uploaded to the GPS.

Procedure:

1. Call up tie point for SU in GPS and proceed to tie point by following GPS guidance. Confirm tie point location with GPS. Mark a solid tree of at least 30 cm dbh using red paint. The mark shall consist of a ring of at least 3 cm at about 2 m distance from the ground. Paint the SU number and the bearing of the SU baseline below the red ring.

2. In case tie point falls onto non-productive area, follow instructions as per **Chapter 5.2 (Shifting of Tie Point)**.

3. Pre-check through quick ground survey whether the establishment of the SU along the planned direction is possible without encountering major obstacles (refer **Chapter 5.2**).

4. Establish a base line from the SU tie point line to the North (East) direction. As a principle, baseline of SU"s with odd numbers will be orientated in Northern cardinal direction whereas baseline of SU"s with even numbers will be orientated to the East. Other cardinal directions if base line is permitted only in case of obstacles incurred along the planned direction.

    - Confirm the bearing using GPS or Suunto compass. Make sure a correct reading is made to avoid accumulated errors along the baseline.

    - In case the range of vision is very low (below 5 m) the compass cannot be used. Use the "3-pole method" instead: establish a line along cardinal direction marked by two poles, then extend the line in same direction with a third pole. Use straight poles of 1.5 to 1.8 m height from non-commercial species only. Continue this practice along baseline until vision along baseline is normal.

    - Measure the horizontal distance of 20 m from SU tie point to the North (East) using either laser device with auto slope correction or measuring tape, clinometer and slope table. If the slope gradient in direction of the base line exceeds 10% the on-ground distance must be corrected in order to determine the horizontal distance. Refer to table in **Annex 1** for slope correction readings.

    - The base line brushers proceed in the measured direction for a distance of 20 m. Here, a pole is set. While brushing the baseline, care should be taken not to damage or cut non-timber vegetation or commercial tree species. Mark the pole with the respective number of the Sub-sampling Unit (SSU Nos. 1 to 12), and the accumulated distance from the tie point. Example: "8/ 160" = SSU 8 starting at 160 m distance from the SU tie point.

    - Continue to mark the access line at 20 m intervals using wooden labeled peg with the accumulated distance counted from tie point. Make sure each distance measurement is made horizontally and in direction to North (East), or South, West (if baseline cardinal direction has been changed due to obstacles)

5.2 Area exclusions, orientation, shifting and mirroring of SU's

Non-productive areas to be excluded from sampling:

1. Shifting cultivation areas, other agricultural production areas.

2. Continuous steep areas of more than 35° degrees slope (area extends over more than 2 ha).

3. Other unproductive areas (e.g., road bodies including a buffer width of about 20 m on either side, water bodies including riparian reserves, any areas with buffer zones where timber harvesting is not permitted (e.g. areas with identified High Conservation Value, such as salt licks, caves, swamps, nesting sites, areas with high density of important non-timber species, etc. as applicable).

4. Planted forests (to be assessed by different inventory system)

All such areas should be included in the FRA Base Map.

Orientation of Sampling Units:
Direction of SU"s shall be changed for each alternate SU number, i.e. baseline of SU Nos. 1, 3, 5, 7, etc. shall point to the Northern direction, whereas SU Nos. 2, 4, 6, 8, etc. shall be orientated to the Eastern direction. This method reduces the variability of FRA results in case of uneven terrain and stocking conditions.

Shifting of Tie Point:
In the rare event of a tie point falling into a non-productive area: shift the tie point by a fixed distance of 50 m to a convenient direction (i.e. to the North, South, East, or West). Enter a remark on tie point shifting on the SU Cover Sheet, indicating the reason.

Mirroring of Sampling Units:
Mirroring of the original planned orientation of a SU shall be carried out if the following situations occur along the 240 m baseline.

Baseline hits a slope area exceeding 35˚ over a continuous distance along the SU of more than 50 m.

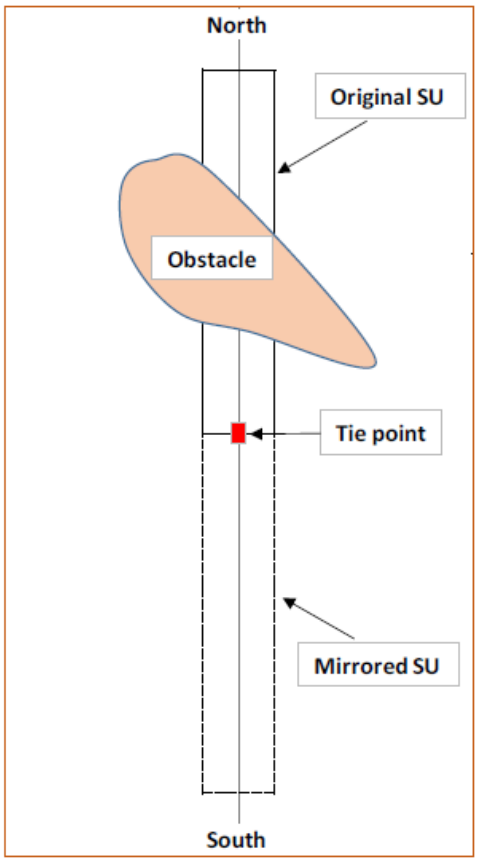
Baseline hits any area that is excluded from the net production area (all such areas hereinafter termed as "obstacle").

The complete Sampling Unit shall then be mirrored either southward or westward, whereas the position of the original tie point (inventory grid SU point) shall remain unchanged as fixed reference point.

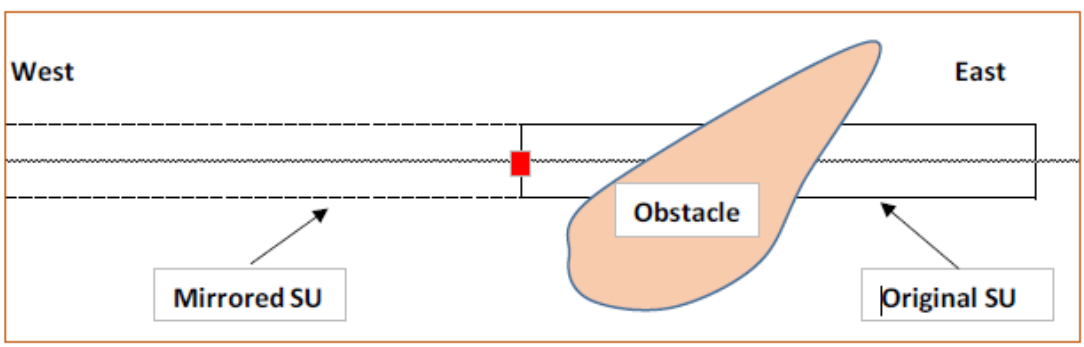
Sub-sampling units shall not be shifted, i.e. if these fall on an obstacle no records will be taken from the SSU.

Any mirroring must be recorded in the Field Record Sheet (Notes section).

Figure 3 shows the Mirroring of Sampling Units to the opposite direction when encountering an obstacle.



Mirroring SU from North to South using same tie point



Mirroring SU from East to West using same tie point

Figure 3. Mirroring of a Sampling Unit

6.0 SET-UP OF SAMPLING UNIT

Upon reaching the SU tie point of SU Unit No. XX, mark the tie point with a solid pole of 1.5 m length, push it into the soil to about 30 cm depth, remove the bark and mark the top 20 cm with red paint. Write the SU Number on the same pole at about 50 cm distance from the pole top, using red paint.

The tie point also forms the starting point for establishment of the SU baseline.

6.1 Sampling Unit set-up

After reaching the tie point of the Sampling Unit (SU) complete the Sampling Unit Cover Sheet.

The main Sampling Unit consists of 12 Sub-sampling Units (SSU) of 20 m x 20 m each, equivalent to 4,800 m², as indicated in **Figure 1**. Within each SSU, two Sub-areas of 10 m x 10 m and 5 m x 5 m are located in the lower right corner (odd SSU Nos.) and lower left corner of the SSU (even SU Nos.) respectively.

Procedures:

1. Each SSU can be set up progressively along the baseline, followed by tree recording, before progressing to the next SSU.

2. Following the establishment of the baseline with poles at 20 m intervals (refer **Chapter 5.1**) complete the measurement of the 10 m distances to the corner points of both sides of the SSU. This step will result in the formation of the 20 m x 20 m square for recording of trees ≥ 30 cm diameter.

3. In the next step, set up the 10 m x 10 and 5 x 5 m squares as shown in **Figure 1**.

4. Mark the established SSU squares using a coloured string. Preferably, use different colours for the different sub-areas.

6.2 Recording of Sub-Sampling Units

Make use of the following forms as further described in **Chapter 7.0**.

1. Sampling Unit Cover Sheet
2. Data record Sheet Trees ≥ 30 cm dbh
3. Data record Sheet Trees ≥ 10 – 29.9 cm dbh
4. Data record Sheet Trees ≥ 5 – 9.9 cm dbh

6.3 Additional Instructions

When establishing and measuring the sample unit the following points shall be observed:

1. All distances are measured horizontally.

2. When establish the boundaries of the Sub-sampling units and sub-areas, ensure that no trees or other vegetation is cut that needs to be recorded. Take extra care when moving around smaller sized trees within the sub-areas (regeneration and saplings).

3. Never cut any marking poles from the Sub-sampling unit or sub-areas.

4. Take special care of borderline trees, i.e, trees with their stem base located near the border of the SU/ SSU:

- If the centre of the SU/ SSU borderline tree falls into the sample sub-unit/ sub-area: tree is included, and must be recorded
- If the centre falls exactly on the border: enumerate only every second tree encountered in such situation

- If the centre falls outside the border: tree is out and shall not be recorded

Refer **Figure 4** for illustration.

5. Both dead and living trees shall be recorded. For dead trees, only the species (if possible) and diameter shall be recorded.

6. Note that trees with heavy crown damage and without crown may still be alive (carefully check for bark sap to confirm tree status).

7. Make sure all tools, devices and equipment function properly (GPS, compass, clinometer, distance and diameter tapes, optical and electronic devices).

8. Set up sub-areas and complete record sheets one by one, do not work several sub-areas simultaneously. Continue to next SSU only after the current SSU has been fully completed and all data have been entered into the corresponding Record Sheets

9. Before leaving the SU, cross-check all Record Sheets for completeness of data entry, and sign each Sheet (Team Leader).

10. Ensure nothing is left behind when shifting to the next SU: collect all non-biodegradable waste, bury bio-degradable waste.

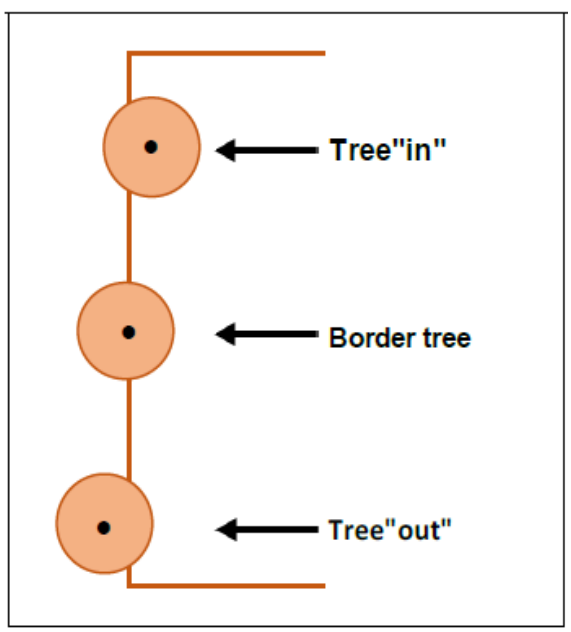


Figure 4. Trees falling inside, outside and on SU border line

7.0 FORMAT AND DESCRIPTION OF SU COVER SHEET

7.1 Recording of General SU Information

The following information shall be recorded on the SU Cover Sheet (refer **Figure 5**):

- Coupe ID: enter the Coupe ID (if applicable).
- Sampling Unit ID: enter the Sampling Unit ID according to the inventory base map.
- Compartment ID: enter the Compartment ID in which the SU is located.
- Terrain Position: enter the Terrain Position Code (1 to 8), according to the average conditions in the SU. Refer to Figure 6 for illustration.
- Terrain Class: measure and enter the average Terrain Class as follows:
  Class 0: = 0-5˚ avg. slope
  Class 1: = 6-15˚ avg. slope
  Class 2: = 16-25˚ avg. slope
  Class 3: = 26-35˚ avg. slope
  Class 4: =≥35˚ avg. slope

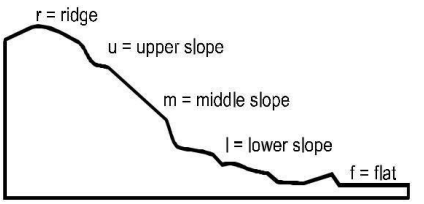
  Measure the slope degree at three (3) locations: SSU 1, SSU 5 and SSU 9, in direction of the terrain slope. Take one uphill and one downhill reading and calculate the average value. Following completion of the three readings, calculate the average value and enter the Class Code into the Cover Sheet.

- Altitude: record the Altitude (meter above sea level) using GPS device
- Age: enter the age of last year of logging (if known) .
- Tie Point Coordinates: record the geographical coordinates (Northern Latitude, Eastern Longitude) of the SU baseline start and end point using the Global Positioning System (GPS) device.
- Shifted Tie Point (TP): enter shifting distance (m) and direction (N, E S, W).
- Date: enter the recording date using the format “DDMMYY”.
- Start: enter the time of arrival at the SU using the format “HH/ MM”.
- End: enter the time of completing the SU using the format “HH/ MM”.
- Recorder: crew leader to sign the completed Cover Sheet.

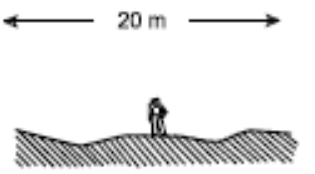
Notes: enter other relevant data, e.g., shifted or mirrored SU

FOREST RESOURCE ASSESSMENT			
Sampling Unit Cover Sheet – General Information			
Coupe ID		Sampling Unit ID	
Block ID		Terrain Position	
Terrain Class		Altitude	
Age			
	Tie Point Coordinates		
	Deg.	Min.	Sec.
Start North			
Start East			
End North			
End East			
	Dist. (m)	Direction	
Shifted TP			
Date		Recorder	
Start (hh/ mm)		End (hh/ mm)	
Recorder Signature		……..	

Figure 5. Sampling Unit Cover Sheet

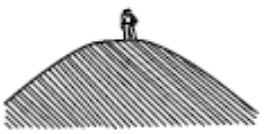


Flat =1:
the slope does not exceed 5°(9%), or
the difference in altitude between the highest and the lowest point does not exceed 2 m



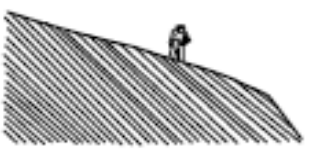
Rolling = 2:
the slope ranges from 5-15° (27%), or
the difference in altitude between the highest and the lowest point ranges from 2 to 5 m

Ridge = 3:
two slopes of opposite aspects reach their highest point, and the slope exceeds 15° (27%)

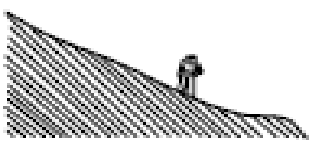


Upper slope = 4:
the sample unit is within the upper third portion of the slope, and the slope exceeds 15° (27%)

Middle slope = 5:
the sample unit is within the middle third portion of the slope, and the slope exceeds 15° (27%)



Lower slope = 6:
the sample unit is within the lower third portion of the slope, and the slope exceeds 15° (27%)



Valley = 7:
the sample unit is in an alluvial area at least 20 m wide

Ravine = 8:
two slopes of opposite aspects reach their lowest point, and the slope exceeds 15° (27%)

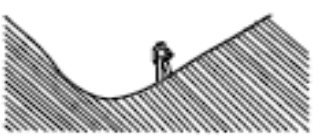


Figure 6. Recording of terrain position

8.0 PARAMETERS TO BE RECORDED IN THE SAMPLING UNIT

Table 2. Parameters and recording instructions

No.	Parameter	Description, units, accuracy	Trees to be recorded	Parameter use	DBH (cm) ≥ 30 cm	DBH (cm) 10.0 – 29.9	DBH (cm) 5.0 – 9.9
1.	Tree Number (No)	Consecutive number by Sub-sampling Unit	All trees falling into SU	Tree identifier			
2.	Species (SP)	Local species name	Each tree within	To enable differentiation between protected, commercial and non-commercial species			
3.	Species Code (SPCODE)	Transferred from Species Code List	---	To enable allocation of growth and/ or volume functions by species group			
4.	Status (ST)	1 = alive 0 = dead	Each tree falling into SSU	Assessment of mortality			
5.	Tree diameter at breast height (DBH), or above buttress	Measured with diameter tape to the nearest mm, at 1.3 m height above higher ground. For buttressed/ irregular shaped trees: measured 60cm above buttress, or where irregularity ends.	Each tree (including dead trees) within recording range falling into SU	Calculation of diameter distribution, tree basal area			
6.	Commercial bole height of trees (DBH)	Measured in decimal meters to crown point (lowest branch forming part of tree crown), using laser device or measuring tape, and clinometer. Trees up to 6 m may be measured with a pole.	Each 5th live tree falling into SU. Abnormal trees: select previous or next tree	Calculation of bole length and timber volume			

7.	Total Height (TH)	Measured in decimal meters to tree top, using laser device and/ or clinometers. Smaller trees up to 6 m may be measured with a pole.	Each 5th live tree falling into SU	Development of diameter height functions by species group			
8.	Crown Form (CF) refer **Figure 7**	CF 1: healthy, vital crown, forming an even or slightly irregular circle around the stem centre, ≥5 major branches forming crown CF 2: healthy, but less regular crown, 3-4 major branches forming crown CR 3: irregular crown with only 1-2 major branches, often damaged	Each live tree within recording range falling into SU	Assessment of tree crown quality and eligibility as Potential Crop Tree (PCT)			
9.	Competition (CO) refer **Figure 8**	CO 1: Crown free of competitors CO 2: Crown impeded by competing neighbour(s) from above CO 3: Crown impeded by competitor(s) both from above and laterally CO 4: Crown impeded by competing neighbour(s) laterally only	Each live commercial tree within recording range falling into SU	To determine the need for silvicultural treatment			
10	Climber infestation (CI) refer **Figure 9**	CI 1: Crown and stem free of climbers CI 2: Climbers occurring on stem only CI 3: Climbers occurring in crown	Each live tree within recording range falling into SU	To determine the need for silvicultural treatment			

11	Log straightness (LS) refer **Figure 10**	Whole stem assessment: LS 1: Good quality: sound log, straight with no or minor defects and/ or damage LS 2: Average quality: log bend or crooked over less than half log length LS 3: Low quality: log strongly bend or crooked over more than 50% of log length, or twisted	Each live tree within recording range falling into SU	General assessment of log quality, eligibility as Potential Crop Tree (PCT)			
12	Log Damage (LD) refer **Figure 11**	Record major damages affecting log value: LD 0: No damage LD 1: Hollow log LD 2: Broken stem LD 3: Severe bark damage LD 4: Fire damage LD 5: Lean: angle >20˚ from vertical line LD 6: Other damage LD 7: Multiple damage (combination of any of the above LD classes)	Each live tree within recording range falling into SU	General assessment of log quality, eligibility as Potential Crop Tree (PCT)			

9.0 ILLUSTRATIONS OF TREE QUALITY PARAMETERS

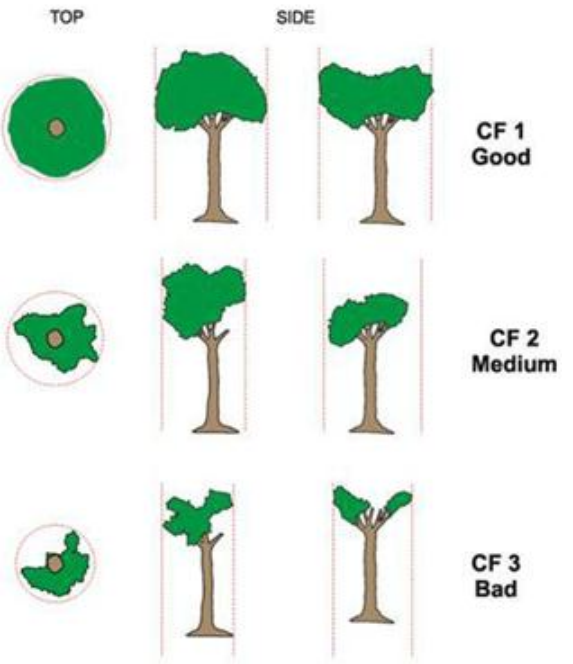


Figure 7. Crown Form Class (CF)

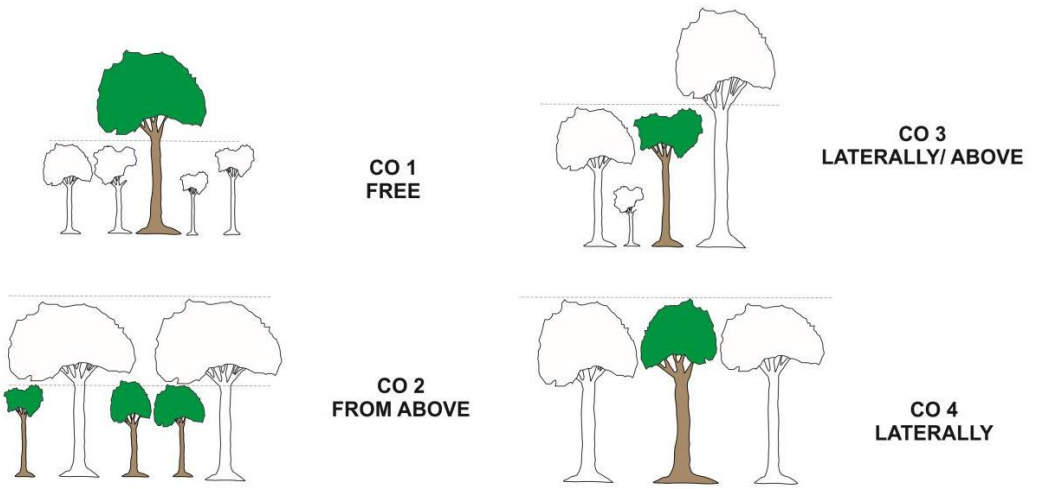


Figure 8. Competition Class (CO)

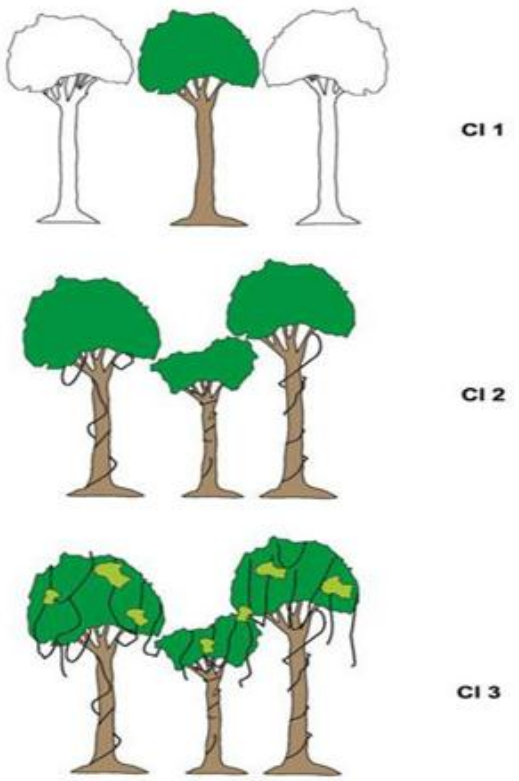


Figure 9. Climber Infestation Class (CI)

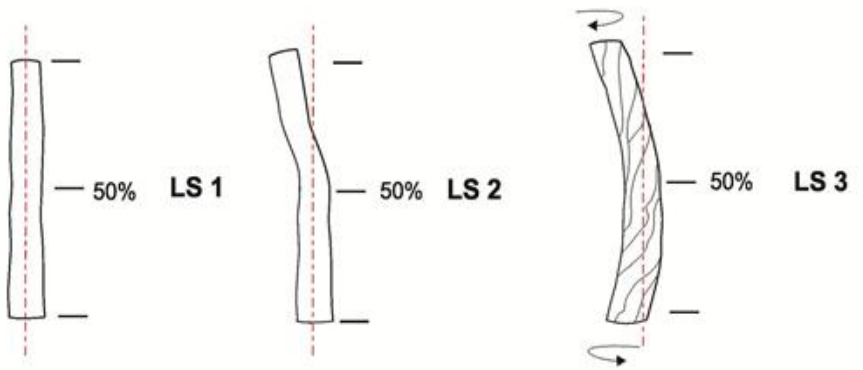


Figure 10. Log Straightness Class (LS)

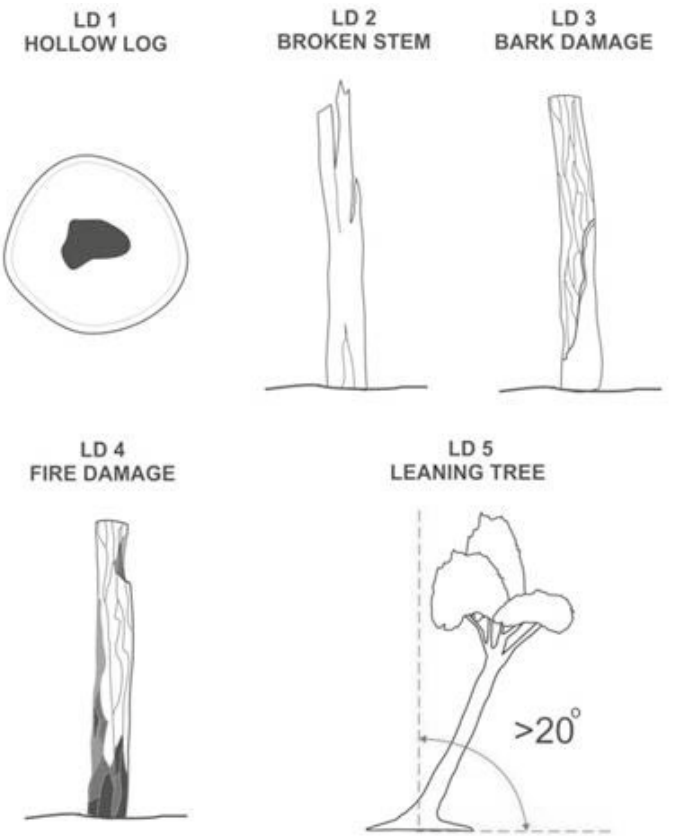


Figure 11. Log Damage Class (LD)

10.0 DESCRIPTION OF RECORD SHEET- TREES ≥ 30 CM DBH

All trees ≥ 30 cm diameter at breast height (dbh) shall be recorded in the 20 m x 20 m sub-quadrate as indicated in **Figure 2** (SU-Design). Use the same Record Sheet continuously across all Sub-Sampling Units (SSU) of the SU. Add more sheets with additional tree numbers as required, to complete all 12 SSU.

The following data shall be entered into the header of the Data Record Sheet (refer format as per **Figure 12**):

- Sampling Unit Number
- Recording Date

Subsequently, parameters for each tree within the Sampling Unit are recorded as follows:

- Serial tree number: pre-entered into Record Sheet

- Sub-sampling Unit (SSU) number: 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, 11A, 12A, as applicable

- Species name:
  - enter the local species name. Use the latest version of the approved Tree Species List. If unknown, collect a sample of a compound leaf and seed (if present) and mark the sample with a plant tag showing the specimen number, SU No. and the tree number. Enter the specimen number into the Species Name field. Take notes on other obvious leaf, or bark features (colour and odour of exudate, if any). If species is not listed enter the local or scientific name if known.

- Species code: enter the species code as per approved Tree Species List

- Status: enter the tree status: 1 = alive / 2 = dead

- Measure the tree diameter at breast height (dbh) using a steel diameter tape. For details of tree diameter measurement, refer to **Chapter 13.0**. Enter the value in decimal cm, e.g. 35.8 into the Data Record Sheet.

- Measure and record the Commercial Bole Height (CBH), i.e. the height up to the lowest major branch forming the tree crown (every 5th live tree of the SU), using either Suunto Clinometer and distance tape, or tree height recorders with built-in distance measurement (laser technology) and angle measurement functions (e.g. Tru Pulse Laser). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in meters or decimal meters, depending on device accuracy.

- Measure and record the Total Tree Height (TH), i.e. the height up to the top of the tree crown. Ensure major branch forming the tree crown (every 5th live tree of the SU). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in meters or decimal meters, depending on device accuracy.

- Assess and record the tree quality parameters as per **Table 2**. Apply the classification as described.

  - Crown Form: Classes 1 to 3
  - Competition: Classes 1 to 4
  - Climber infestation: Classes 1 to 3
  - Log straightness: Classes 1 to 3
  - Log damage: Classes 0 to 7

Data Record Sheet **Trees ≥ 30 cm dbh** **SSU Size: 20 m x 20 m**		**SU-No.**		**Date:**							
Tree No.	**SSU-No.**	**SP (Text)**	**SPCODE (Text)**	**ST (Code)**	**DBH (x.y cm)**	**CBH (x.y m)**	**TH (x.y m)**	**CR (Code)**	**CO (Code)**	**CI (Code)**	**LS (Code)**	**LD (Code)**
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Figure 12. Sample of Data Record Sheet for Trees ≥ 30 cm dbh

11.0 DESCRIPTION OF RECORD SHEET- TREES 10.0 CM TO 29.9 CM DBH AND NON-TIMBER FOREST PRODUCTS

All trees falling into the diameter class 10.0 cm to 29.9 cm diameter at breast height (dbh) and Non-Timber Forest Products shall be recorded in the 10 m x 10 m sub-quadrate as indicated in **Figure 2** (SU-Design). Use the same Record Sheet continuously across all Sub-Sampling Units (SSU) of the SU. Add more sheets with additional tree numbers as required to complete all 12 SSU.

The following data shall be entered into the header of the Data Record Sheet (refer format as per **Figure 13**):

- Sampling Unit Number
- Recording Date

Subsequently, parameters for each tree within the Sampling Unit are recorded as follows:

- Consecutive tree number: pre-entered into Record Sheet

- Sub-sampling Unit (SSU) number: 1B, 2B, 3B, 4B, 5B, 6B, 7B, 8B, 9B, 10B, 11B, 12B, as applicable

- Species name:
  - Enter the local species name. If unknown, collect a sample of the compound leaf and mark the sample with a plant tag showing the specimen number, SU No. and the tree number. Enter the specimen number into the Species name field. If species is not listed enter the local or scientific name if known.

- Species code: enter the species code as per approved Tree Species List.

- Status: enter the tree status: 1 = alive / 2 = dead

- Measure the tree diameter at breast height (dbh) using a steel diameter tape. For details of tree diameter measurement, refer to **Chapter 13.0**. Enter the value in decimal cm, e.g.14.6 onto the Data Record Sheet.

- Measure and record the Commercial Bole Height (CBH), i.e. the height up to the lowest major branch forming the tree crown (every 5th live tree of the SU), using either Suunto Clinometer and distance tape, or tree height recorders with built-in distance measurement (laser technology) and angle measurement functions (e.g. Trupulse Laser). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in meters or decimal meters, depending on device accuracy.

- Measure and record the Total Tree Height (TH), i.e. the height up to the top of the tree crown. Ensure major branch forming the tree crown (every 5th live tree of the SU). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in meters or decimal meters, depending on device accuracy.

- Assess and record the tree quality parameters as per **Table 2**. Apply the classification as described.

  - Crown Form: Classes 1 to 3
  - Competition: Classes 1 to 4
  - Climber infestation: Classes 1 to 3
  - Log straightness: Classes 1 to 3
  - Log damage: Classes 0 to 7

- Non-Timber Forest Products
  Commonly found non timber forest products (NTFP) have been listed in **Table 3** below. As the number of NTFP can be significantly larger in certain locations more detailed studies employing botanical expert knowledge may need to be carried out in such areas of high importance.

Below are the species and recording instructions for NTFP commonly found in Hill Dipterocarp Forests:

1. Palms with single stem: diameter at breast height (dbh), Status and Total Height (TH), as applicable, following the standard requirement of recording every 5th height in the SU.

2. Rattan, bamboo and stemless palms: record number of clusters and average total height only. A single „Tree No." shall be assigned to each cluster.

3. NTFP trees/ treelets: record dbh only.

4. Any NTFP species not included in the list below should be recorded using its local name. A photo of the plant and leaves should be taken, together with a compound leaf specimen and some basic description for subsequent identification at the plant herbarium.

Table 3. List and Species Codes for common NTFP occurring in Hill Dipterocarp Forests

Scientific Name	Local Name	Species Code
A. Rattan species		
Calamus filipendulus	Rotan anak	NTROAN
Calamus javensis	Rotan batu	NTROBA
Calamus caesius	Rotan sega	NTROSE
Calamus pogonacanthus	Rotan tut	NTROTT
Calamus pallidulus	Rotan tunggal	NTROTU
Calamus scipionum	Rotan semambu	NTROSE
Calamus manau	Rotan manau	NTROMA
Calamus sp.	Rotan lia	NTROLI
Calamus sp.	Rotan jalayan	NTROJA
Calamus sp.	Rotan janggut	NTROJG
Calamus spp.	Rotan lain-lain	NTROLL
Daemonocarpus formicaria	Rotan lepo	NTROLE
Korthalsia echinometra	Rotan semut	NTROSE
Korthalsia flagellaris	Rotan danan	NTRODA
Korthalsia sp.	Rotan chit	NTROCH
B. Bamboo species		
Racemobambos glabra	Buluh racemo	NTBURA
Gigantochloa levis	Buluh betung	NTBUBE
Schizostachyum latifolium	Buluh engkalad	NTBUEN
Schizostachyum brachycladon	Buluh lemang	NTBULE
Other Bamboo dbh> 5 cm	Buluh lain-lain	NTBUO1
Other Bamboo dbh ≤ 5 cm	Buluh lain-lain	NTBUO2
C. Palm species		
Arenga brevipes	Aping	NTAPIN
Caryota no	Entibab	NTENTB
Eugeissona utilis	Pantu	NTPANT
Licuala bintulensis	Biruk	NTBIRU
Pholidocarpus majadum	Jaung	NTJAUN
Salacca affinis	Ridan	NTRIDA
Other palm	Palma lain-lain	NTPALL
D. Other NTFP		
Antiaris toxicaria	Ipoh	NTIPOH
Areca jugahpunya	Pinang	NTPINA
Cinnamomum iners	Kayu manis hutan	NTKMHU
Eurycoma longifolia	Tongkat ali	NTTALI
Goniothalamus velutinus	Kayu hujan panas	NTKHPA
Labisia pumila	Kacip fatimah	NTKAFA
Nepenthes spp.	Periok kera	NTPEKE
Other NTFP	Produk bukan kayu lain-lain	NTFPLL

Data Record Sheet Trees 10.0 - 29.9 cm dbh + NTFP SSU Size: 10 x 10 m				SU-No.					Date:			
Tree No.	SSU-No.	SP (Text)	SPCODE (Text)	ST (Code)	DBH (x.y cm)	CBH (x.y m)	TH (x.y m)	CR (Code)	CO (Code)	CI (Code)	LS (Code)	LD (Code)
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Figure 13. Sample of Data Record Sheet for Trees 10.0 to 29.9 cm dbh and Non-Timber Forest Products

12.0 DESCRIPTION OF RECORD SHEET - TREES 5.0 CM TO 9.9 CM DBH

All trees falling into the diameter class 5.0 cm to 9.9 cm diameter at breast height (dbh) shall be recorded in the 5 x 5 m sub-quadrate as indicated in **Figure 2** (SU-Design). Use the same Record Sheet continuously across all Sub-Sampling Units (SSU) of the SU. Add more sheets with additional tree numbers as required, to complete all 12 SSU.

The following data shall be entered into the header of the Data Record Sheet (refer format as per **Figure 14**):

- Sampling Unit number
- Recording Date

Subsequently, parameters for each tree within the Sampling Unit are recorded as follows:

- Consecutive tree number: pre-entered into Record Sheet

- Sub-sampling Unit (SSU) number: 1C, 2C, 3C, 4C, 5C, 6C, 7C, 8C, 9C, 10C, 11C, 12C, as applicable

- Species name:
  - enter the local species name. If unknown, collect a sample of the compound leaf and mark the sample with a plant tag showing the specimen number, SU No. and the tree number. Enter the specimen number into the Species name field. If species is not listed enter the local or scientific name if known.

- Species code: enter the species code as per approved Tree Species List.

- Status: enter the tree status: 1 = alive / 2 = dead

- Measure the tree diameter at breast height (dbh) using a steel diameter tape. For details of tree diameter measurement, refer to **Chapter 13.0**. Enter the value in decimal cm, e.g. 6.9 onto the Data Record Sheet.

- Measure and record the Commercial Bole Height (CBH), i.e. the height up to the lowest major branch forming the tree crown (every 5th live tree of the SU), using either Suunto Clinometer and distance tape, or tree height recorders with built-in distance measurement (laser technology) and angle measurement functions (e.g. Trupulse Laser). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in meters or decimal metres, depending on device accuracy.

- Measure and record the Total Tree Height (TH), i.e. the height up to the top of the tree crown. Ensure major branch forming the tree crown (every 5th live tree of the SU). Refer to **Chapter 14.0** for detailed height measurement instructions. Enter the value in metres or decimal metres, depending on device accuracy.

- Tree quality parameters are NOT recorded for this diameter class.

Data Record Sheet Trees 5.0 - 9.9 cm dbh SSU Size: 5 m x 5 m				SU-No.			
					Date:		
Tree No.	**SSU-No.**	**SP (Text)**	**SPCODE (Text)**	**ST (Code)**	**DBH (x.y cm)**	**CBH (x.y m)**	**TH (x.y m)**
1							
2							
3							
4							
5							
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Figure 14. Sample of Data Record Sheet for Trees 5.0 to 9.9 cm dbh

13.0 TREE DIAMETER MEASUREMENT

The diameter at breast height (dbh) is the stem diameter over bark, measured at a height of 1.3 m above ground. Refer to **Figure 15** for details on diameter measurement techniques.

- to enable an exact measurement at 1.3 m, either use a wooden pole of 1.3 m length or mark a height of 1.3 m on the shirt of the measuring staff.

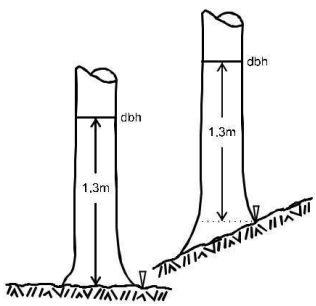
- before measurement, remove all vines, climbers, bark exudate, or other irregularities that may cause bias to the correct reading measuring at the point of measurement (POM)

- the dbh shall be measured with a steel diameter tape (fibre tapes are not recommended since they stretch over time and may give false readings) and recorded as, e.g. "38.4" cm, i.e. measured to the nearest mm.

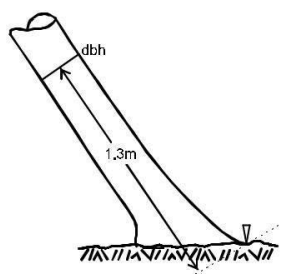
- place and level the diameter tape at breast height and tighten it. In the case of very big trees the assistance of an additional person is necessary.

To avoid reading errors, the diameter tape should always be correctly held (i.e. do not hold it upside down). Refer to graphical illustrations below for measurement methods.

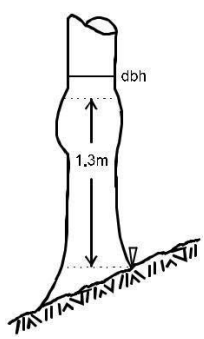
On slopes measure at the uphill side of the stem



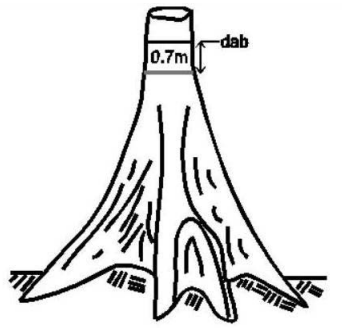
The breast height of leaning trees is determined along the stem axis



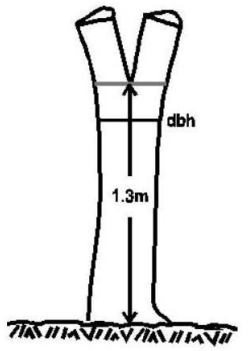
In case of swellings, depressions, branches or other irregularities at breast height, the dbh is measured just above the irregular feature at a point with normal stem form



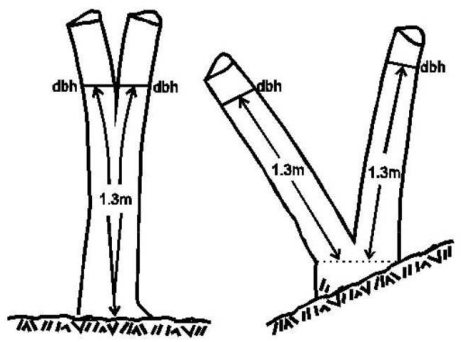
On trees with buttresses at breast height and higher the dbh is measured 70 cm above the end of the buttress



Trees forking immediately above breast height are measured just below the swell resulting from the fork



Trees forking <u>below</u> breast height are measured as individual trees



If the point of measurement is inaccessible, it is approximated with a metric tape held horizontally at the base of the tree. Alternatively, a pentaprism can be used, if available.

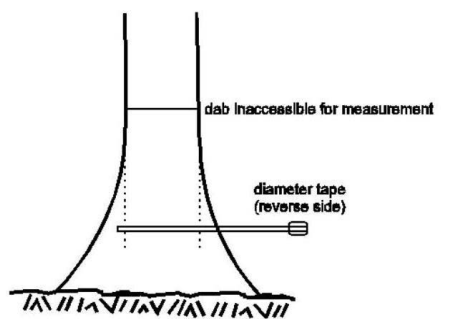


Figure 15. Diameter measurement techniques

14.0 TREE HEIGHT MEASUREMENT

The height of trees recorded in forest resource inventories usually refers to the height of the *crown point*. In case of insufficient data availability it is also necessary to measure the *total tree height* for the establishment of diameter/ total height curves which are useful for indication of overall site productivity.

The bole length of a tree is the linear distance along the axis of the stem from the ground level to the first major green branch of the crown.

The length is extended beyond the first branch, if a clear bole of at least 3 m follows. The total tree height is the linear distance along the stem axis up to the top of the tree crown.

Figure 16 illustrates the tree height measurement. Only every 5th live tree shall be measured.

- the height to the crown point is typically measured with the SUUNTO clinometer/ height meter as follows:

  - the assessor positions himself at a horizontal distance of 15 m (use centre scale), 20 m (use left scale), 30 m (use centre scale and multiply reading by factor 2) or 40 m (use left scale and multiply reading by factor 2) from the tree. From here the assessor should be able to target both the crown point and the base of the stem. To reduce errors the selected SUUNTO height scale should roughly correspond to the estimated tree height. Smaller trees can be measured with a telescopic pole or with a scaled bamboo stick.

  - carry out two clinometer readings: the first reading targets the stem base, the second reading targets the crown point

  - calculate the height in full metres:
    i. if the stem base reading is negative (-), add its absolute value to the crown point or tree top reading
    ii. if the stem base reading is positive (+), subtract it from the crown point or tree top reading

- the total tree height is measured, following the same method as described under bullet one above. However, the assessor needs to target the (often invisible) tree top through the crown foliage in this case. Targeting the crown periphery must be avoided, since it will result in an over-estimation of total tree height. This measurement requires good theoretical knowledge and practical experience.

- In case accurate height measurements of the 5th tree in the sub-sample unit/ sub-area are impossible due to poor visibility, the assessor may measure the previous or subsequent tree number.

- In order to facilitate bole and tree height measurements advanced technologies are available. These height recording devices combine laser technology (for distance measurement) with angle measurements, such as, e.g. the *TruPulse* brand. The distance to the tree is carried out by a laser measurement that will give an instant reading of the horizontal distance between the assessor and the tree from any position in the terrain. The distance measurement is followed by two angle measurements to the CBH/ TH point and stem base respectively, using a built-in binocular for clear view of the target point. Following the angle measurement the CBH/ TH value will be shown in the height recorder.

This technology significantly reduces time for distance, CBH and TH measurement

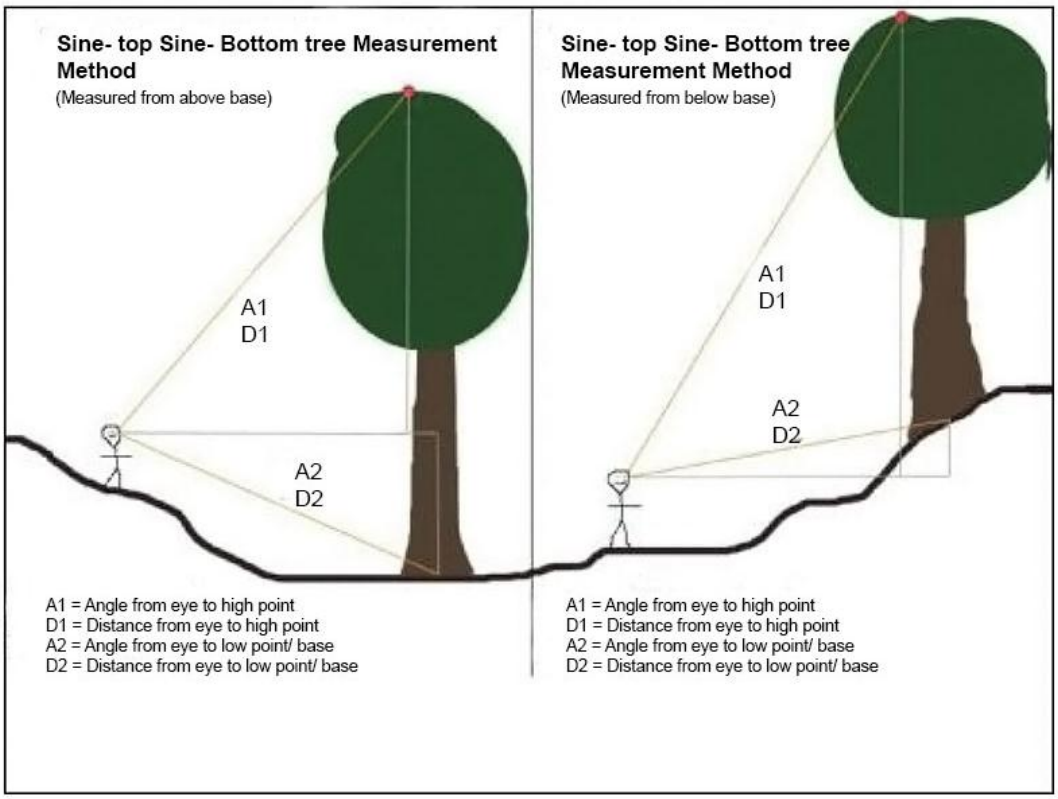


Figure 16. Angle measurements for calculation of tree height

15.0 RECORDING OF WILDLIFE

Wildlife surveys are typically carried out by an expert team that covers the area of interest with transects or reconnaissance walks at different times of the day (morning, dawn, evening/ night) and during different seasons of the year (dry season, monsoon season, inter-monsoon season). This type of expert work also requires special equipment such as camera traps, high-zoom cameras, high quality binoculars, etc. Team members must possess high skills and long-term experience in wildlife spotting and identification. The requirement for such specialist work cannot be met by a regular forest survey team which focuses on field survey work and tree species identification, measurements and quality assessments.

During the scope of the Forest Resource Assessment, however, it is possible to conduct a more general survey in conjunction with the ongoing forest inventory work. Due to the limitations in species knowledge and considering the lack of special equipment this type of wildlife survey is a more basic exercise to obtain general information about the presence or absence of the more common wildlife species known to most of the survey team members.

The objective of this wildlife survey is to obtain a general overview over wildlife occurrence in and around the Sampling Units being assessed within the scope of the FRA field work.

Results from wildlife recording can be used as supplemental information adding value to special wildlife assessments, and to gain a better understanding of the spatial distribution of common species occurring in the FMU.

Focus of wildlife observations: mammals, birds, amphibians, reptiles
Area of wildlife observations: typically limited to the area of the Sampling Unit and its immediate environment. However, in case wildlife is identified during approach to a Sampling Unit the Wildlife Record Sheet can still be used for this purpose, i.e. by entering the Fields “Coupe ID”, “Block ID”, “Altitude (m)”, whereas the Field “SU ID” is left blank.

Figure 17 on the following page provides a sample of the Wildlife Record Sheet to be completed by the forest survey crew.

Most of the fields of the Wildlife Record Sheet are self-explanatory. Concerning the Fields “Position” and “Signs” the record sheet includes Codes to be entered for the location of the animal and/ or for the type of sign identified, such as faeces, nest, scratch marks, feathers/ fur, casting, etc.

For example, a group of monkeys directly seen in the canopy would be classified as “3” (canopy layer) in the “Position” column and “1” (visual) in the “Signs” column. If the number of individuals can be clearly identified then it is to be entered in the “No. sighted” column. Otherwise the number will be estimated and entered in the “No. estim.” column.

If the species to which a “Sign” belongs is not known, enter a question mark (?) into the “Local species name” column.

Wildlife Record Sheet							
Coupe ID		**SU ID**					
Block ID		**Altitude (m)**					
Obs. No.	**Geo-Coordinates**	**SSU No.**	**Local species name**	**No. sighted**	**No. estim.**	**Position Code**	**Signs Code**
1	N E						
2	N E						
3	N E						
4	N E						
5	N E						
6	N E						
7	N E						
8	N E						
9	N E						
10	N E						

Date		**Name of recorder**		**Recorder signature**	……..…

Code	**Position**	**Code**	**Signs**	**Code**	**Signs**
1	Ground	1	Visual	10	Carcass
2	Understorey	2	Vocal		
3	Canopy layer	3	Faeces		
4	Emergent layer	4	Nest		
		5	Egg shell		
		6	Feathers/ Fur		
		7	Casting		
		8	Den		
		9	Marks		

Figure 7. Sample of Wildlife Record Sheet

Annex 1

Slope Correction Table

Slope gradient (%)	Degree (°)	Correction factor (1/ cosα°)	Horizontal distance (m)				
			2.5	5	10	20	25
			Distance along slope (m)				
10	5.71	1.00	2.51	5.02	10.05	20.10	25.12
15	8.53	1.01	2.53	5.06	10.11	20.22	25.28
20	11.31	1.02	2.55	5.10	10.20	20.40	25.50
25	14.04	1.03	2.58	5.15	10.31	20.62	25.77
30	16.70	1.04	2.61	5.22	10.44	20.88	26.10
35	19.29	1.06	2.65	5.30	10.59	21.19	26.49
40	21.80	1.08	2.69	5.39	10.77	21.54	26.93
45	24.23	1.10	2.74	5.48	10.97	21.93	27.41
50	26.57	1.12	2.80	5.59	11.18	22.36	27.95
55	28.81	1.14	2.85	5.71	11.41	22.83	28.53
60	30.96	1.17	2.92	5.83	11.66	23.32	29.15
65	33.02	1.19	2.98	5.96	11.93	23.85	29.82
70	34.99	1.22	3.05	6.10	12.21	24.41	30.52
75	36.87	1.25	3.13	6.25	12.50	25.00	31.25
80	38.66	1.28	3.20	6.40	12.81	25.61	32.02
85	40.36	1.31	3.28	6.56	13.12	26.25	32.81
90	41.99	1.35	3.36	6.73	13.45	26.91	33.63
95	43.53	1.38	3.45	6.90	13.79	27.59	34.48
100	45.00	1.41	3.54	7.07	14.14	28.28	35.36
105	46.40	1.45	3.63	7.25	14.50	29.00	36.25
110	47.73	1.49	3.72	7.43	14.87	29.73	37.17
115	48.99	1.52	3.81	7.62	15.24	30.48	38.10
120	50.19	1.56	3.91	7.81	15.62	31.24	39.05
125	51.34	1.60	4.00	8.00	16.01	32.02	40.02
130	52.43	1.64	4.10	8.20	16.40	32.80	41.00
135	53.47	1.68	4.20	8.40	16.80	33.60	42.00
140	54.46	1.72	4.30	8.60	17.20	34.41	43.01
145	55.41	1.76	4.40	8.81	17.61	35.23	44.03
150	65.31	1.80	4.51	9.01	18.03	36.06	45.07
155	57.17	1.84	4.61	9.22	18.45	36.89	46.11
160	57.99	1.89	4.72	9.43	18.87	37.74	47.17
165	58.78	1.93	4.82	9.65	19.29	38.59	48.23
170	59.53	1.97	4.93	9.86	19.72	39.45	49.31

Reading example:
Slope reading with Suunto clinometer is 35%. If the horizontal distance required is 10.0 m the distance along slope must be extended to 10.59 m.

Annex 2
Sarawak Tree Species List:
Refer to separate volume available from Forest Department Sarawak

GUIDELINE 3

GUIDELINES FOR ESTABLISHMENTAND ASSESSMENT OF PERMANENT SAMPLE PLOTS

GUIDELINES FOR ESTABLISHMEN AND ASSESSMENT OF PERMANENT SAMPLE PLOTS

1.0 INTRODUCTION

Permanent sample plots (PSPs) are permanently demarcated areas of forest, typically of 1 ha each, which are periodically re-measured. They are maintained over at least five years, and often for very much longer. Permanent Sample Plots are mean of measuring tree growth, mortality, and regeneration in relation to stand density and they have the unique role of providing data on changes in forest stocking and volume over time (Alder and Synnott, 1992). This information is essential for the rational management of the forest. Shorter re-measurement intervals are likely to have a higher level of error in the increment estimates to give useful data. However, shorter interval of two or three years for the first and second re-measurements may be desirable to develop and refine field procedures for the re-measurement data, and to provide some preliminary results.

2.0 ESTABLISHMENT OF PSPs

Linear plots are widely used in forest inventory, and have some advantages in that situation in minimizing demarcation costs. However, linear plots are very susceptible to error in area estimation, if the width is not exactly regulated, or if edge trees are not treated according to a carefully prescribed procedure. Square plots are most suitable for PSP work in mixed dipterocarp forests (MDF) and in a dense forest, the square shape also minimizes edge effects. A square 100 m x 100 m plot (1 ha) is a practical compromise and is convenient for subdivision into quadrats of 10 m x 10 m.

There is no satisfactory method of calculating numbers of PSPs required, but a sampling intensity of 0.25% i.e. one plot per 400 ha forest has been practiced in Sarawak. The manual in **Attachment I** was prepared as a reference for those responsible for the field operations related to the establishment and enumeration of PSPs in mixed dipterocarp forest. It covers the field instruction for the establishment of the plot, enumeration of trees, saplings and seedlings, and the data recording in data sheets. It does not cover the analysis of PSP data to produce growth and yield models, and AAC.

3.0 ENUMERATION

PSPs should sample and identify all plant species, while temporary sample plots for forest inventory sample only economic species and identify them to only trade groups. During the enumeration of PSPs, a preliminary determination of tree species should be made; voucher specimens of unidentified species should be collected for further identification at Sarawak herbarium (SAR).

Trees with 10 cm and above diameter at breast height (DBH) are measured for diameter in all quadrats, identified to species level and selected parameters recorded as in **Table 1** below. For measurement of saplings, 5 m x 5 m subplots are selected at random; saplings are defined as having diameter 1.0 cm - 9.9 cm and are measured, identified to species level and parameters recorded. For seedlings, 2 m x 2 m subplots are selected at random; seedlings are defined as those of height 20 cm, - < 1 cm diameter and are measured for height, identified to genus level and parameters recorded. Palms are measured for diameter and identified to species level while other non-timber forest products (NTFP) such as rattans, bamboos etc are identified and recorded.

A 30% samplings and seedlings intensity in all the PSPs in the MDF. This means that a total of 30 saplings and seedlings subplots shall be established in each plot and recorded as being present on the date the subplots were first enumerated.

The saplings and seedlings are located at random in any quadrat in each PSP.

Table 1. Summary of Parameters to be Recorded for Trees, Saplings, Seedlings and Palms.

Parameters	**Trees**	**Saplings**	**Seedlings**	**Palms**
Consecutive Stem Number	x	x	x	x
Stem Identity Class	x	x	x	x
Vernacular Name	x	x	x	x
Species Name	x	x	x	x
Diameter at Breast Height	x	x		
Upper Stem Diameter	x			
Trunk Height	x			
Stem Height			x	
Crown Illumination	x			
Crown Form	x			
Root Injury	x			
Lower Butt Injury	x			
Upper Trunk Injury	x			
Crown Injury	x			
Root Decay	x			
Lower Butt Decay	x			
Upper Trunk Decay	x			
Crown Decay	x			
Log Grade	x			
Woody Climbers	x			
Coordinates	x	x	x	x
Point Of Measurement	x	x		x

REFERENCE

Alder D. and T.J. Synnott (1992). *Permanent Sample Plot Techniques for Mixed Tropical Forest*. Tropical Forestry Paper No. 25, Oxford Forestry Institute. 140pp.

ATTACHMENT 1

FIELD INSTRUCTION FOR THE ESTABLISHMENT AND ENUMERATION OF PERMANENT SAMPLE PLOTS IN MIXED DIPTEROCARP FOREST OF SARAWAK

PART I – TREES

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1.0 INTRODUCTION

Permanent sample plots are samples of forest areas which are measured periodically to gather data on growth rates, mortality, recruitment, competitive status of selected trees, stand table distribution and species composition in order to predict the volume of timber and the time for subsequent harvest, and to study the condition of regeneration forest especially species dynamics, distribution, and development over a period of time after logging.

1.1 Objectives

- To provide information on the residual stand that includes basal area by diameter classes by species group (dipterocarp and non-diptercarp), mortality, recruitment, competitive status of individuals, injury, decay, log grade and woody climbers.

- To provide information on the status of individuals and distribution of dipterocarp and non-dipterocarp species in order to sustainably manage the forest resources notably tree species.

1.2 Sampling Intensity

Permanent sample plots are usually established at 0.25% sampling intensity with a dimension of 100 m x 100 m or one hectare in area. This means that one permanent sample plot is to be established for every 400 hectares of regenerating forest (forest that had been logged and silviculturally treated).

2.0 ESTABLISHMENT

2.1 Selection of areas to be sampled and sample plot location

- Locations of permanent sample plots in each coupe have to be decided first.

- Global Positioning System (GPS) coordinates will be taken for every four corners of the plot, whenever possible.

- The plot shall be moved from the randomly chosen point if only it falls within 20 m from a stratum boundary or poor quality, unexploited, riverine, as seen on the ground.

2.2 Access Line (Rentis Masuk)

The access line shall be worked out after the location of the permanent sample plots has been fixed. Normally an access line will be a straight line cut on a compass bearing from the nearest point which could be located with certainty on the ground and map. The start point is usually the river mouth and confluence of rivers or streams or logging roads or any natural prominent and permanent features.

The start point of the access line must be marked with great care. Tie-in line must be connected across to distinctive and permanent features, to assist in map plotting and locating the correct position.

Access lines cut to the plot shall be painted with rings of red and white paint; white ring at the top and red ring below. This is to differentiate from other markings on the ground.

2.3 Plot Layout

Usually each assessment plot is a square – measuring 100 m x 100 m, one hectare in area, and containing 100 square quadrats, each measuring 10 m x 10 m. These quadrats are numbered in groups of four, from 011 – 254 **(Figure 1)**.

All distances measured during the layout will be corrected to horizontal distances either by using slope correction table or by step measurement.

A (Northwest) 100 metres (Northeast) B

011	**012**	021	022	031	032	041	042	051	052
014	**013**	024	023D	034	033	044	043	054	053
101	102	**091**	**092**	081	082	071	072	061	062
104	103	**094**	**093**	084	083	074	073	064	063
111	112	121	122	131	132	141	142	151	152
114	113	124	123	134	133	142	143	154	153D
201	202	191	192	181	182	171	172	161	162
204	203	194	193	184	183	172	173	164	163
211	212	221	222	231	232	241	242	251	252
214	213	224	223	234	233	244	243	254	253

D (Southwest) (Southeast) C

Figure 1. The layout of a 100 m x 100 m plot and the distribution 10 m x 10 m quadrats.

2.4 Closing Error

A maximum of 30 cm is allowed for closing error i.e. compass and measurement. Any closing error greater than 30 cm, the plot will need to be resurveyed.

2.5 Rentises

Minimum rentises shall be cut while establishing and enumerating the assessment plot. Clear and wide rentises will be cut for the access line. All flagging stakes used to mark the corners of the quadrats, to determine the quadrat boundaries, should be cut outside the assessment plots, and not closer than 20 m to the outer boundary of any assessment plot.

3.0 ASSESSMENT

3.1 Quadrat

A quadrat is a unit area within each assessment plot where trees ≥ 10.0 cm dbh are measured. Each quadrat measures 10 m x 10 m. Each plot has 100 quadrats numbered from 011 – 254 **(Figure 1)**.

3.2 Consecutive Stem Number (CSN)

There are two digits to the consecutive stem number. Only the tree number (punched on aluminium) will be nailed to a tree. In all cases, this rectangular aluminium number shall be nailed about 30 cm

below the point of measurement for unbuttressed trees and at eye for buttressed trees. This rectangular aluminium plate number shall be nailed on the same side of the point of measurement.

In a quadrat, this number serves to identify each living stem that had been enumerated. This means that all living trees are to be recorded irrespective whether they are complete stems, broken stems, and broken stumps or cut stumps.

DO NOT use a consecutive stem number more than once in any quadrat. When a number has been assigned to a tree or sapling in a quadrat, that number is NOT to be used again, even if the tree or sapling disappeared without trace.

All trees, saplings and seedlings shall be number consecutively quadrat by quadrat, which means that the consecutive series will change from quadrat to quadrat. There will be three different sets of numbers in series in every assessment plot. Numbers for trees are punched on rectangular aluminium sheet, sapling are punched on triangular aluminium sheet and whereas number for seedlings are written with permanent marker on plastic tags.

Use aluminium nail to nail the consecutive number to the trees, copper wire to tie the tag number for saplings and plastic tag for seedlings.

3.3 Stem Identity Class (SIC)

There are three digits to this variable, each representing a different portion of the plant. First digit represents the size, second digit represents the status and the third digit represents the condition of the stem of the plants. Stem identity class shall be scored for all living and dead (standing or fallen) stems of trees and palm species. Dead stems of trees and palm species are to be recorded once (refer to **Figure 2**).

The following stem identity classes are to be used in this monitoring system. This stem identity class classification will provide:

3.3.1 First Position – Plant size

1 = Tree (≥ 10.0 cm dbh)
2 = Sapling (≥ 1.0 cm dbh – < 10.0 cm dbh)
3 = Seedling (≥ 20.0 cm high _ < 1.0 cm dbh)
4 = Individual/ single palm (≥ 0.5m high)
5 = Clumped palms (≥ 0.5m high)

3.3.2 Second Position – Plant Status

1 = Living, standing
2 = Living, fallen, or leaning ≥ 60° from the vertical, or leaning against a tree or trees or supported by woody climbers
3 = Dead, standing
4 = Dead, fallen, or leaning ≥ 60° from the vertical, or leaning against a tree or trees, or supported by woody climbers
5 = ≥ stems from one base, more than one stem measured
6 = Point of measurement (POM) in between branches, some branches are below the POM
7 = Coppice below POM with sign of old breakage
8 = Change in POM, dead at the POM but with coppice at the base, coppice may be too small for measurement or POM moved to coppice, or POM simply moved due to bad placement
9 = Dead or missing or not enumerated

3.3.3 Third Position – Stem Condition

1 = Complete, main meristem intact
2 = Broken stem, no replacement for meristem visible
3 = Broken stump
4 = Cut stump or stem
5 = Coppice above POM may be old or new damage evident
6 = Broken or damaged during measurement
7 = Coppice with old breakage, usually with elbow base
8 = Missing, tag or plate lost, or evidence of plant remains
9 = Dead or no trace of the plant, but tag or plate recovered

Table 1. Stem Identity Class for stems ≥ 10 cm dbh

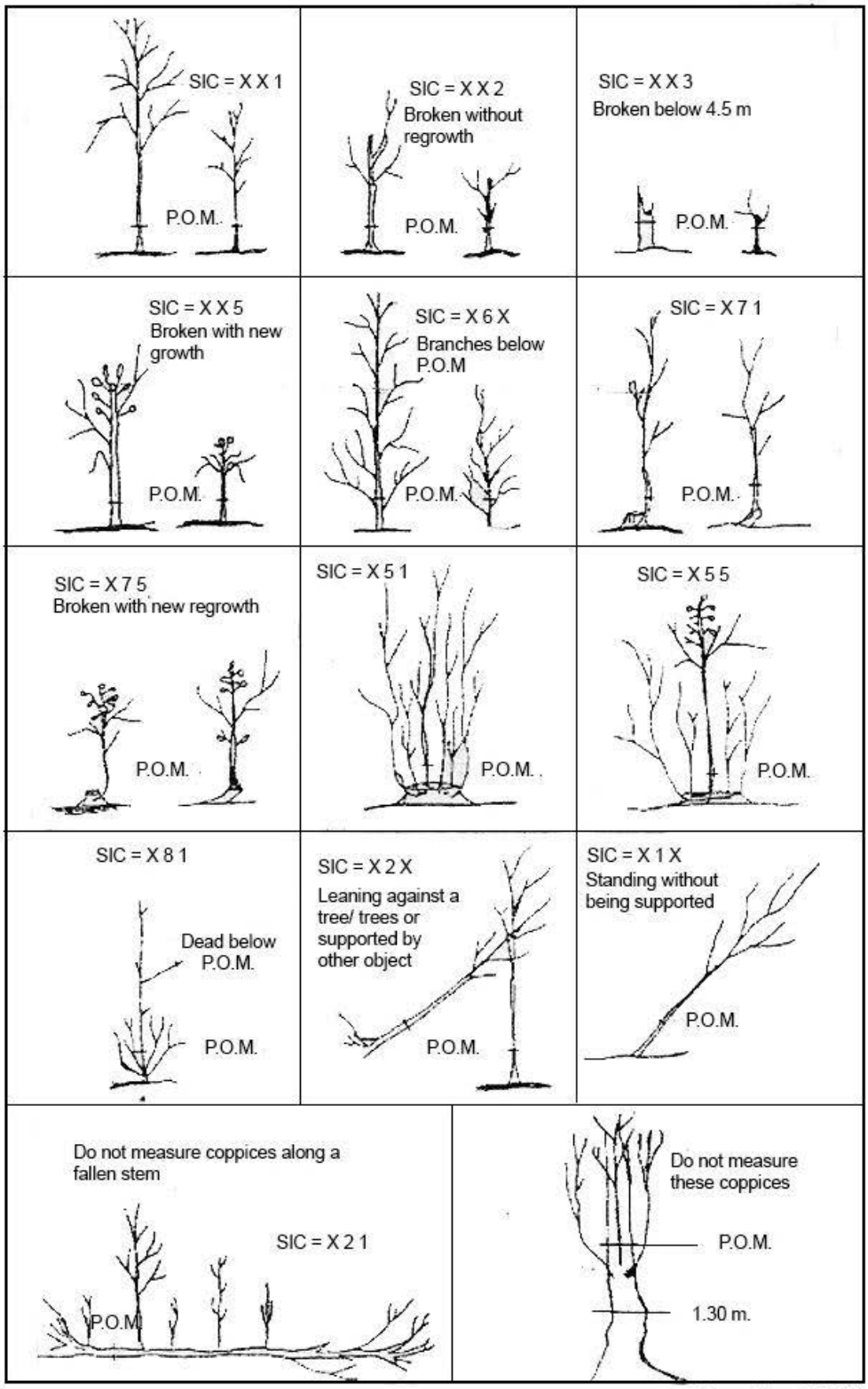
	STEM		**STUMP**		**Broken with coppices**	**Broken while measuring**	**Not found**
1.0 Trees	**Complete**	**Broken**	**Broken**	**Cut**			
1.1 Tree alive, standing	111	112	113	114	115		119
1.2 Tree alive, seen	121	122	123	124	125		129
1.3 Tree dead, standing	131	132	133	134			
1.4 Tree dead, fallen	141	142	143				
1.5 Tree ≥ 2 stems, standing, alive	151	152	153	154	155		159
1.6 Branch below POM	161	162	163	164	165		169
1.7 Coppice below POM	171	172	173	174	175		179
1.8 Dead at POM, coppice present	181	182	183	184	185		189
1.9 Seedling, missing	198		Seedling, missing, dead				199
4.0 Individual Single Palms							
4.1 Palm alive, standing	411	412	413	414	415		419
4.2 Palm alive, fallen	421	422	423	424	425		429
4.3 Palm dead, standing	431	432	433				
4.4 Palm dead, fallen	441	442	443	444			
5.0 Clumped Palms							
5.1 Palm alive, standing	511	512	513	514			
5.2 Palm alive, fallen	521	522	523	524			

Table 2. Stem Identity Class for Stems ≥ 1.0 cm high – < 10.0 cm dbh

Sapling	STEM		STUMP		Broken with coppices	Broken assessment
	Complete	Broken	Broken	Cut		
2.0 Tree species						
2.1 Alive, standing	211	212	213	214	215	216
2.2 Alive, fallen	221	222	223	224	225	226
2.3 Dead, standing	231	232	233	234		
2.4 Dead, fallen	241	242	243	244		
2.5 ≥ stem, standing, alive	251	252	253	254	255	256
2.6 Branch below POM	271	272	273	274	275	
2.7 Coppice below POM	261	262	263	264	265	266
2.8 Dead at POM, coppice present	281	282	283	284	285	
2.9 Seedling, missing	298		Seedling, missing, dead			299

Table 3. Stem Identity Class for Stems ≥ 20 cm high – < 1.0 cm dbh

Seedling	STEM		STUMP		Broken with coppices	Broken during assessment	Not found
	Complete	Broken	Broken	Cut			
3.0 Tree species							
3.1 Alive, standing	311	312	313	314	315	316	319
3.2 Alive, fallen	321	322	323	324	325	326	329
3.3 Dead, standing	331	332	333	334			
3.4 Dead, fallen	341	342	343	344			
3.5 ≥ 2 stems, standing, alive	351	352	353	354	355	356	359
3.6 Branch below POM	361	362	363	364	365	366	369
3.7 Coppice below POM	371	372	373	374	375		
3.8 Dead at POM, coppice present	381	382	383	384	385		
3.9 Seedling, missing	398		Seedling, missing, dead				399



Souce: Tan, S (1997)

Figure 2. Stem Identity Classes

3.4 Vernacular Name

Most trees species in the mixed dipterocarp forest are identified to genus level and very few, notably non-dipterocarp species (Rantai J. & Chai P.P.K. 2007, A new checklist of the trees of Sarawak; Anderson J.A.R, 1978 Checklist of Trees in Sarawak). When writing the vernacular name on the field data sheet, be sure to refer to the species list. These vernacular names will be identified to botanical name in the field, wherever and whenever possible; if not, leaf samples will be collected for identification and verification in the herbarium.

The measurer/ species identifier is to call out the CSN and the vernacular name of each tree being measured. When an "unknown" species or species with uncertain identity is encountered, be sure to collect good leaf samples to be further identified in the base camp or herbarium.

3.5 Species Identification

All plants recorded from the plots are to be identified to species level and given the botanical species code and code to six-letter code. The six-letter code will be entered into the computer and not the full botanical name.

3.6 Species Code

For data-entry and data-processing, a code number will represent each vernacular name. These code numbers represent the genera and the species which will be in six-letter code. The first four letters denote the genera and the last two letters denote the species. Consult the "List of vernacular names of trees for use in Mixed Dipterocarp Forests".

Whenever trees, sapling, seedling are encountered for which no botanical name is known, enter the code "ZZZZZZ" or it is only known to genus level, enter the first four letters of the genus followed by two "XX", e.g. SHORXX.

3.7 Trees

Within each assessment plot, enumerate all trees (≥ 10.0 cm dbh) of all species to study the basal area by diameter classes by species group for growth, recruitment and mortality rates, changes in forest type, stocking, species composition and distribution.

3.7.1 Living Trees

Within each quadrat all living trees shall be tagged, identified, diameter, stem identity class, crown illumination, crown form, tree injury, tree decay, log grade and woody climbers scored and their coordinates measured and plotted in the sketch-map (refer to **Appendix I** for further details).

3.8 Diameter – (in millimetres)

Diameter is measured at breast height, defined as 1.3 m from the highest side of the tree, for non-buttressed trees. In the case of buttressed trees, diameter is measured at a point 30 cm above the highest buttress **(Figure 3)**. The point of measurement (POM) should be cleaned of vines, thorns, mosses, loose bark, and surface vegetation, any of which would give false diameter reading. Be careful not to wound or injure the tree or sapling as swelling may occur. Do not cut any surface vegetation as to have a clean point of measurement.

Use height-stick of 1.3 metres to check and mark the POM. Do not use a measuring tape. In cases of leaning trees or sapling, measure breast height (BH) following the axis of the tree. In all cases, the diameter tape is to be placed at right angle to the axis of the stem at breast height. The diameter is to be measured by placing the edge of the diameter tape parallel to the upper edge of the 1.3 m point.

Record the diameter and height measurements as reduced to the nearest millimetre. For example, a reading on the diameter tape which falls between 10.1 cm and 10.2 cm or close to 1.2 cm should be recorded as 10.1 cm.

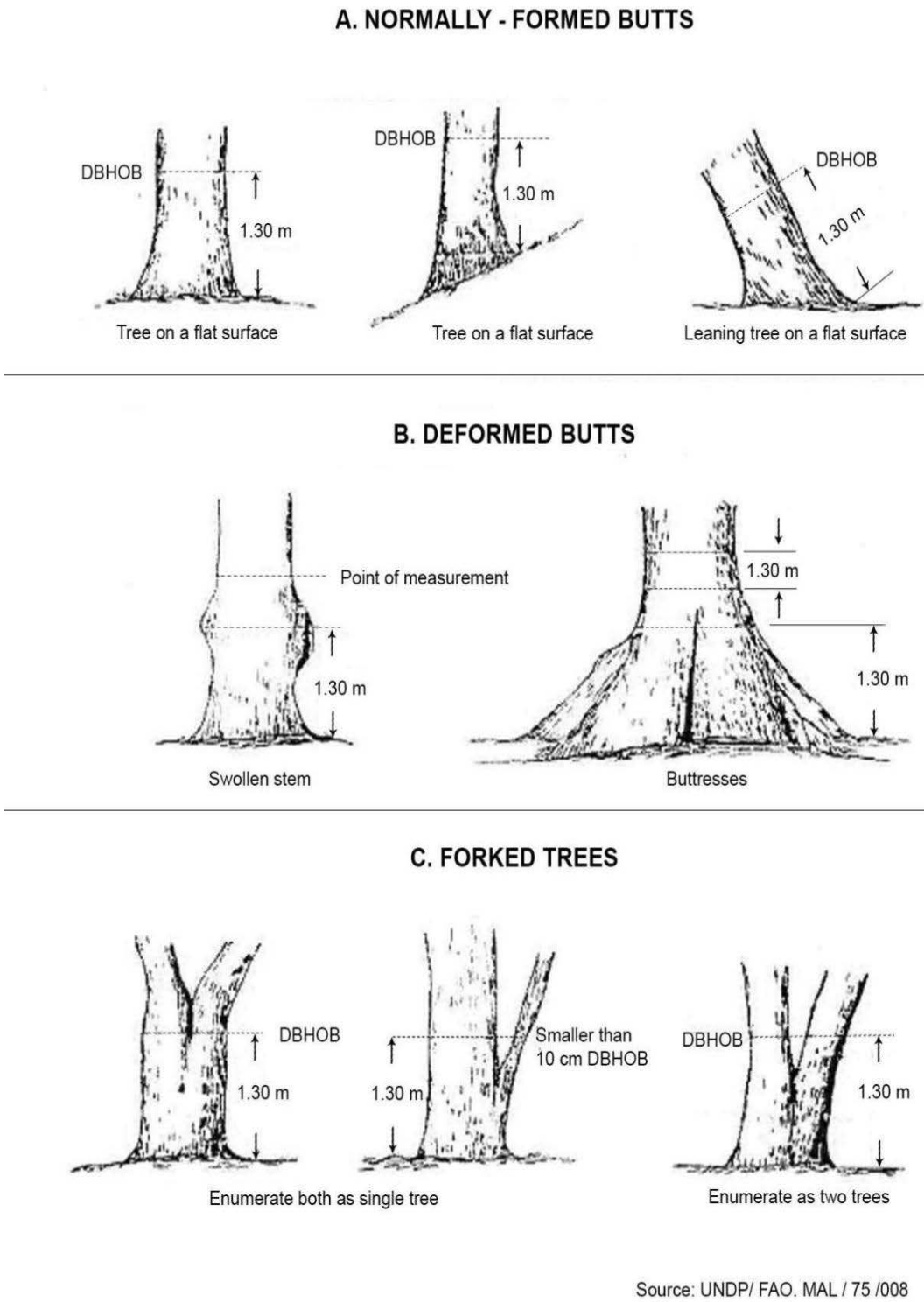


Figure 3. Measurement of diameter at breast-height in different circumstances

3.9 Point of Measurement (POM)

All diameters for trees and saplings shall be measured at breast-height for unbuttressed trees and 30 cm above the highest buttress for all buttressed trees. These points of measurement shall be painted with a yellow band for trees, and yellow ring for sapling. No painting shall be done on seedlings.

Note:
For cases (a) to (d) below, refer to **Figure 3** for diagrammatic illustrations.

(a) When the diameter measurement at breast-height does not represent the diameter of the stem, due to swelling, bump, or fork, etc., place the tape above the swelling, etc. in order to measure the nearest approximation of what diameter at breast-height would be. Paint this POM.

(b) For trees with high buttresses, measure the diameter of the stem at a point 30 cm above the highest buttress. Record this POM in cm.

(c) Measure the diameter of the severely fluted stems in normal manner.

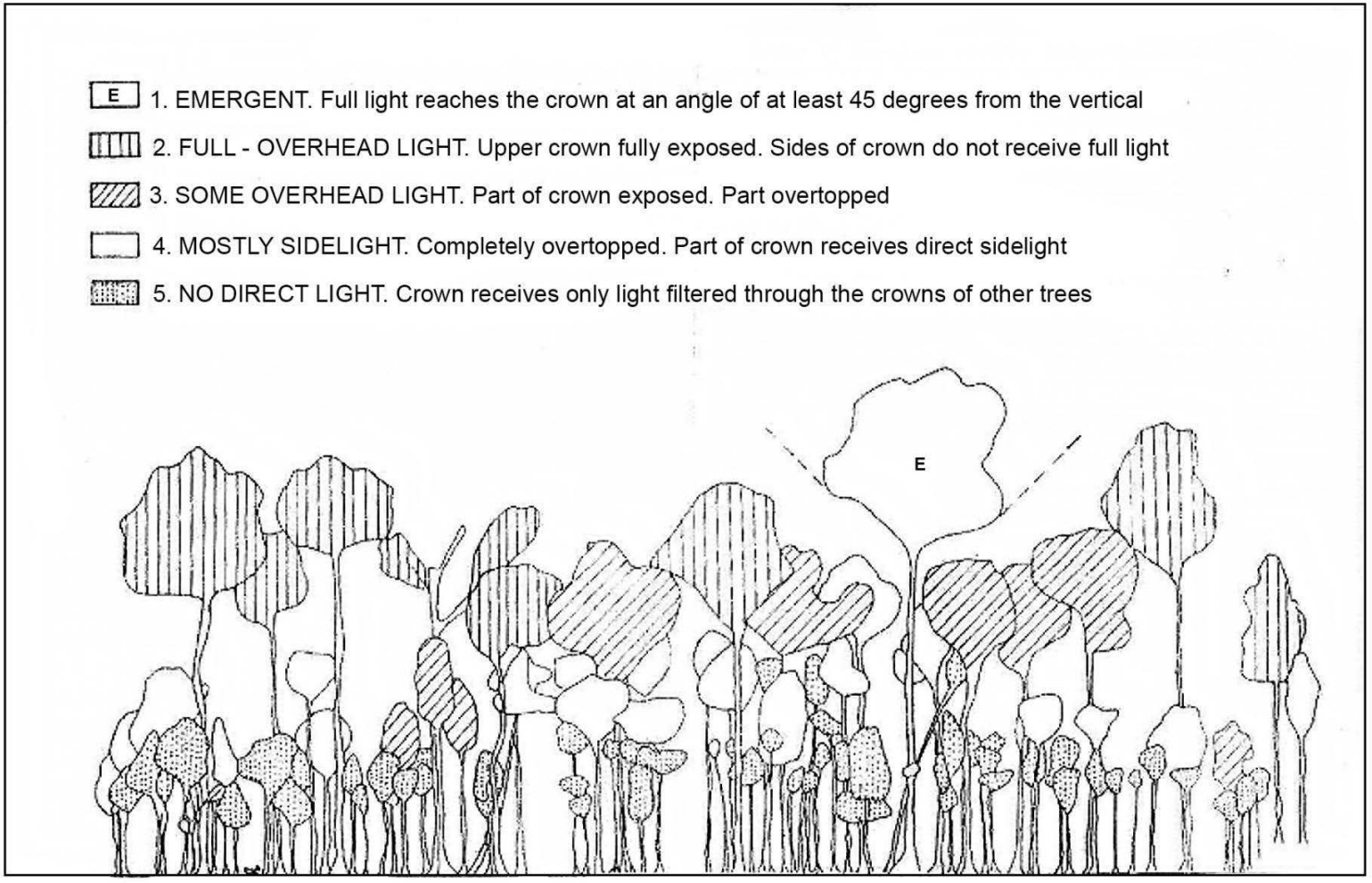
(d) For forked, or multi-stemmed trees, natural branches and coppices or sprout. When the coppice occurs above the POM (1.3 m) DO NOT measure that coppice. Measure only coppice(s) that occurs/occur below POM.

3.10 Crown Illumination (refer to Figure 4)

Estimate the crown illumination only for tree ≥ 10 cm dbh (complete or broken). In estimating the crown illumination, treat dead standing stems as not overtopping other stems. Trees standing below dead stems, may be classified as standing in full overhead light.

There are five code numbers for this parameter. Description for each of these five code numbers is given below (refer **Figure 4** for diagrammatic illustrations).

Light Description	**Illumination Code**
EMERGENT: Full light reaches the side of the crown at an angle of at least 45° from the vertical	1
FULL OVERHEAD LIGHT: Upper part of the crown fully exposed to overhead light, but sides of the crown do not receive full light.	2
SOME OVERHEAD LIGHT: Part of the crown is exposed to vertical light, but part is shaded from the above.	3
MOSTLY SIDELIGHT: The crown receives no vertical, part of the crown receives direct side light	4
NO DIRECT LIGHT: The crown receives only filtered through the crowns of other trees	5



Source: Baur (1964)

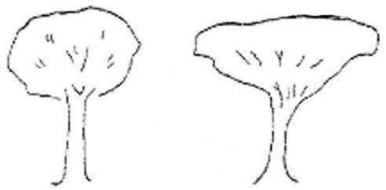
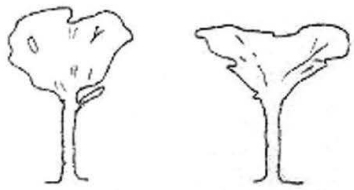
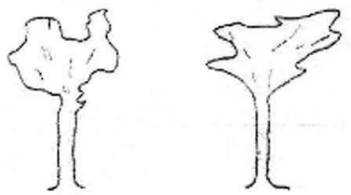
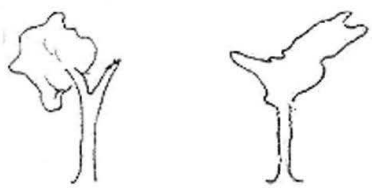
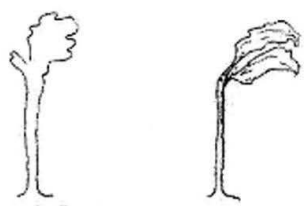
Figure 4. Crown illumination classes

3.10.1 Crown Form (refer to Figure 5)

This information will help to understand why and how species with smaller or poor crown form have little diameter increment compared to those trees with well formed crowns. Estimate the crown form for all living trees ≥ 10 cm dbh (complete or broken) as seen at the time of enumeration. No crown form is to be recorded for saplings, until further instruction is given. Do not be influenced by the presence of woody climber in or on the crown of a tree when making the estimated of the crown form. Call out the classification in words as well as by code number so that the staff present may assist in checking the classification. These are seven code numbers for crown form and the description for each code number is given below (refer to **Figure 5** for diagrammatic illustrations).

Classify crown form regardless of tree species. Do not downgrade a characteristically thin-crown. The crown form of some of the genera *e.g. Parkia, Copaifera* and *Sindora* is usually one-sided. These genera have no distinctive meristem.

Light Description	**Illumination Code**
COMPLETE CIRCLE: Ideal, circular and symmetrical.	1
IRREGULAR CIRCLE: Very nearly ideal and satisfactory silviculturally, but with some slight defect or symmetry or dead branch tips.	2
HALF-CIRCLE: Just in the satisfactory class, distinctly asymmetrical or thin, but apparently capable of improvement if given more room.	3
LESS THAN HALF-CIRCLE: Distinctly unsatisfactory, with extensive die back, few branches, strongly asymmetry, a few branches, but probably capable of surviving.	4
ONLY A FEW BRANCHES: Either definitely suppressed or degenerating, or badly damaged. Probably incapable of diameter increment.	5
MAINLY COPPICE: Mainly coppice	6
ALIVE BUT NO CROWN: Stem alive, but carrying n crown	7

DESCRIPTION	ELEVATION	PLAN
COMPLETE CIRCLE **1**	 Ideal, circular and symmetrical	
REGULAR CIRCLE **2**	 Almost ideal. Satisfactory silviculturally, but with some slight asymmetry, or dead branch tips	
HALF - CIRCLE **3**	 Only just satisfactory. Asymmetrical or thin, but apparently capable of improvement if given more space	
LESS THAN HALF - A - CIRCLE **4**	 Distinctly not satisfactory, extensive dieback, few branches: strong asymmetry. Probably will survive	
ONLY A FEW BRANCHES **5**	 Definitely suppressed, degenerating or badly damaged. Probably not capable of growth	

Source: Uganda Silvicultural Research Plan (1959-1963)

Figure 5. Crown form classes

3.11 Tree Injury (root, lower butt, upper trunk and crown)

Visible sign of injury should be recorded for all living trees (complete or broken) which are ≥ 10.0 cm dbh. Look for the signs of injury on the roots and lower butt at the time dbh measurement was taken. Remember what is seen. When assessing injury in the trees as a whole, stand back from the tree to obtain the best view possible. Be sure to look at the tree from all angles.

Position of Injury:

Column 30	:	signs of injury visible on the roots.
Column 31	:	signs of injury are visible in the butt and/ or lower trunk (between the top of the roots and the midpoint of the trunk).
Column 32	:	signs of the injury are visible in the upper portion of the trunk (between the midpoint of the trunk and the crown point).
Column 33	:	signs of injury are visible in the crown, (for broken stem and broken stumps without a coppice crown, record "0". When a coppice crown is present, apply the code numbers below).

When injury inside a standing tree has been revealed by a logger's chain saw cut, consider what you see to be sign of evident injury.

Code number indicating the causes of the injury:

For each position in the tree, as listed above, write in the columns 30 – 33 one of the code as tabulated below:

Description of Injury	Code
No injury evident	1
Due to storm	2
Due to flora and fauna	3
Logging- Heavy machinery	4
Logging- Felling only	5
Logging- Machinery and felling	6

3.12 Tree Decay (root, lower butt, upper trunk and crown)

Visible signs of decay should be recorded for all living trees (complete or broken) which are ≥ 10.0 cm dbh. Look for the signs of decay on the roots and lower butt at the time dbh measurement was taken. Remember what is seen there. When assessing decay in the tree as a whole, stand back from the tree to obtain the best view possible. Be sure to look at the tree from all angles.

Position of decay:

Column 34	:	signs of injury visible on the roots.
Column 35	:	sign of injury are visible in the butt and/ or lower trunk (between the top of the roots and the midpoint of the trunk).
Column 36:	:	signs of the injury are visible in the upper portion of the trunk (between the midpoint of the trunk and the crown point).
Column 37	:	sign of injury are visible in the crown, (for broken stem and broken stumps without a coppice crown, record "0". When a coppice crown is present, apply the code numbers below).

The code number indicates the seriousness of the injury. For each position in the tree, as listed above, write in the columns 34-37 one of the code number as tabulated below:

Description of Decay	Code
No sign of decay	1
Presence of decay	2
Decay is evident	3

3.13 Log Grade (LG) Column 38

The classification of log grade should be applied to all living trees and all living broken stems > 10.0 cm dbh. Log grade for all species should be recorded, regardless of the present commercial value of any species.

The term, “log grade”, is properly applied to the quality of a log for a tree with one straight section of 4.5 m. In some forest inventories, it is used as a means to indicate the quality of the stem of a standing tree, the stem being classified according to the quality of the best log in the stem, or according to the quality of the butt log and is NOT the case in this project.

The classification refers to the straightness of the trunk, no matter the diameter is. Each tree is classified according to whether it contains, or does not contain, one straight section of 4.5 m long regardless of its diameter.

By using these classifications of log grade we are able to distinguish those trees of potential commercial value from those which, for a variety of reasons, have no possibility of yielding at least one log. In case where log grade is affected by both injury and decay, record the log as decayed rather than injured. When portions of stem, previously injured are found to be now decayed, regard them as being decayed.

The code numbers for log grade are as follows:

Description of Log Grade	**Code**
Stem contains at least one straight section, not less than 4.5 metres long its dbh ≥ 50 cm above the highest buttress.	1
Stem smaller than the minimum cutting limit < 45 cm dbh or 30 cm above the highest buttress. It does contain at least one straight section, not less that four metres long which could be harvested in future.	2
Stem deformed. Because of its shape and form the trunk does not contain one straight section four metres long. Classify as ‘deformed’ any straight section which shows severe spiral grain or the harmful effects of damage (past or present) by woody climbers	3
Stem damaged. Even though the trunk contains one straight section four metres long, physical injury to the stem has removed or damaged wood volume so much that no possibilities remain for industrial conversion (either present or potential)	4
Stem decayed. As a result of decay the stem does not contain one sound portion four metres long, (when a stem is deformed or damaged in addition of being seriously decayed record it as decayed. That is when the effect of deformity and/ or decay upon log grade is approximately equal to the effect of decay give priority to recording decay	5

3.14 Woody Climber (WC) Column 39

The occurrence of woody climbers should be recorded on all standings stems, living or dead, which are 10.0+ cm dbh, using the code numbers shown below. Do not consider rattan to be a woody climber.

Description on Woody Climber	Code
Woody climbers not evident	1
Woody climbers recently cut. None living	2
Woody climbers recently cut. Harmless climbers remain alive	3
Harmless climbers on trunk	4
Harmless climbers on crown	5
Harmless climbers on trunk and crown	6
Harmful climbers on trunk	7
Harmful climbers on crown	8
Harmful climbers on trunk and crown	9

Woody climbers should be recorded on the stems of the following identity classes, 111, 112, 113, 115; 131, 132, 133.

3.15 Sapling Subplot

A sapling subplot is a unit area within each within each quadrat (measuring 5 m x 5 m) where trees species (≥ 1.0 – < 10 cm dbh) are measured (details in **Part II**).

3.15.1 Saplings

Saplings of all living trees species shall be measured in the 5 m x 5 m sapling subplot, tagged, identified, stem identify class scored, diameter measured and position recorded. No other parameters are to be collected (refer to **Part II** – for further details).

Sapling subplots and seedling subplots in each assessment plot shall be equal in number and shall be sampled based on 30% intensity.

3.16 Seedling Subplot

A seedling subplot is a unit area within each sapling subplot (measuring 2 m x 2 m) where tree species (≥ 20.0 cm height – < 1.0 cm dbh) are measured (details in **Part III**).

3.16.1 Seedlings

Seedlings of all living trees and palm species should be measured in the 2 m x 2 m seedling subplot, tagged, identified, stem identified, stem identity class scored, and height measured and position recorded (refer to **Part III** – for further details).

4.0 FIELD DATA SHEETS

These instructions refer to field data sheet specifically designed for the enumeration of permanent sample plots based on the experiments that had been carried out in the logged-over Mixed Dipterocarp Forest in Sarawak. Columns are numbered to assist the data entry onto computer. The field data sheet also shows the number of digits to be written under each column. For quick reference, all information to be recorded for each parameter to be collected is printed at the back of the field data sheet **(Appendices II –IV)**. Please also ensure the followings:

- Do not record data from more than one quadrat on a single field data sheet.
- Record the data from subplots (for sapling and seedlings) on separate field data sheet.

On the line below the last entry for each quadrat, write the word "END". Whenever records for a quadrat requiring the use of more than one field data sheet, write the word "CONTINUE" below the last entry on the field data sheet.

5.0 DETAILS OF FIELDS RECORDS

Details regarding the following information could be referred to **Appendix I** and other appendices and figures as indicated under each heading:

• Permanent sample plot number	
• Decimal date (refer to **Appendix VI** for further detail)	
• Line entries	
• Sample size	
• Stocking of the quardrat (1 = stocked, 2 = not stocked)	**Column 1**
• Forest type	**Columns 2-4**
• Assessment plot number	**Columns 5-7**
• Quadrat number (refer to **Figure 1**)	**Columns 8-10**
• Consecutive stem number	**Columns 11-13**
• Stem identity class (SIC) (refer to **Figure 2**)	**Columns 14-16**
• Vernacular name	**Column 17**
• Species code	**Columns 18-23**
• Diameter (refer to **Figure 3**)	**Columns 24-27**
• Point of measured	**Column 28**
• Crown illumination (refer to **Figure 4**)	**Column 29**
• Crown form (refer to **Figure 5**)	**Column 30**
• Tree injury	**Columns 31-34**
• Tree decay	**Columns 35-38**
• Log grade	**Column 39**
• Woody climber	**Column 40**
• X-coordinate	**Column 41**
• Y-coordinate	**Column 42**

6.0 PAINTING

Point of measurement (POM) should be painted with a stroke at right angles to the axis of the trunk, on the side of the trunk at which dbh is measured. The upper edge of the paint stroke represents the point of measurement.

The consecutive stem number shall be nailed on every stem which has been given the consecutive stem number. The consecutive stem number should be nailed at 20 cm below the point of measurement. This is to avoid the thickening of the point due to latex and damar as a result of injury from the nail, if placed above the point of measurement.

All cuts or slashes (except natural injury) made while making the species identification should be painted.

7.0 SKETCH MAP OF THE QUADRAT

Printed on the field data sheet is a square representing a quadrat at a scale of 1: 2000 (1 cm on the sketch-map represents 2 m on the ground). The square is subdivided into units to assist in estimating the area in metres. This forms a framework upon which a sketch of each quadrat shall be made.

Before sketching any quadrat, be sure to check the correct orientation of the assessment plot to correspond to the sketch – that is to magnetic north as shown by the compass. Not that corner A of the assessment plot should fall on or between due west and due north, corner B should fall on or between due south and due west. It is most important to ensure that, in an assessment plot, all quadrats are oriented in the same direction.

The sketch of every quadrat should resemble an aerial view in which the important features of the topography and vegetation of the quadrat are represented.

7.1 Sketching for Initial Assessment

- To show the position of each tree and their consecutive stem number, thus assisting to identify correctly each tree at successive measurement of the plot, development of previous injury and other changes will be recorded without errors. Also, the structure and composition of the stand would be clearly seen and studied.
- Excavator hauls, ramps, and similar areas of bare soils;
- Watercourse (indicate by arrow the direction of flow)
- Swamps and areas of impounded water
- Sterile site
- To show the development, aver a long period, of species regeneration recorded in the plot.

7.2 Sketching for Subsequent Enumeration

- To show the position of new recruits recorded at each enumeration. This will assist to identify correctly each treat successive enumerations of the plot. It also will provide important information about the new recruits themselves. Do not forget to measure all coordinates of new recruit horizontally.
- To correct all errors made in previous sketches, made during earlier enumeration.

8.0 MISCELLANEOUS

8.1 Stem identify class governs the nature of the entries to be recorded for a stem. In the case of trees where crown form is estimated, entries for complete, broken stems, and broken stumps are different. Indicated below is the relationship between SIC and CF:

	SIC	**Crown Form**
Tree complete	111	1, 2, 3, 4, 5
Broken stem	112	5, 6, 7
Broken stump	113	6, 7

8.2 Check to be sure that the consecutive stem number agrees with the botanical identification and the diameter. If not, an explanation must appear in the remarks column or on the lines below the last record. Leaf sample must be collected for identification at the base camp or in the herbarium.

8.3 Use equal sign (=) on species ONLY when the identity of the species is certain. If still doubtful, collect leaf sample to be identified at the base camp or in the herbarium specimen.

8.4 Collecting plants or part of plants. Make it a practice to disturb the plot as little as possible. Minimise cutting of any or part of trees, sapling, seedling, plant, vines or woody climbers. No collection of wild orchids, *Nepenthes,* or extraction of wood, living or otherwise, within or outside the plot. These actions are strictly prohibited.

REFERENCES

Anderson, J.A.R, 1978. *A Checklist of the Trees of Sarawak*. Forest Department Sarawak, Kuching. 364 p.

Rantai, J & Chai, P. P. K, 2007. *A new Checklist of the Trees of Sarawak*. Kuching, Sarawak. 340 p.

PART II - SAPLINGS

1.0 INTRODUCTION

Tree species of dbh ≥ 100 mm have been measured in the plot. In order to provide supplementary information (e.g. development, composition and spatial distribution of tree species below 100 mm dbh) on what had been collected during the general re-census (measuring all tree species ≥ 10 mm dbh), that sapling subplots are established where saplings shall be enumerated, tagged, measured, identified to species and their coordinates measured.

In this study, sapling is defined as any tree species having a minimum diameter of ≥ 10 mm – < 100 mm at breast height.

2.0 OBJECTIVES

- The immediate objective is to study the regeneration in unlogged and a regenerating forest after logging.
- To study the mortality and recruitment patterns of saplings in order to assess the effect of logging.
- To study species distribution, composition and development over a period of time.

3.0 METHODOLOGY

3.1 Sampling Intensity

A 30% sampling intensity had been agreed for the allocation/ distribution of the sapling and seedling subplot in all the permanent sample plots in Mixed Dipterocarp Forest. This means that a total of 30 sapling subplots shall be established in each plot and recorded as being present on the date the subplots were first enumerated.

The sapling subplots are located at random in any quadrat in each assessment plot.

Saplings and seedlings subplot in any quadrat in each assessment plot shall be equal in number and shall be sampled based on 30% sampling intensity.

3.2 Establishment of the sapling subplot

The sapling subplots (5 m x 5 m) are located at random in any of the quadrats in each assessment plot. Measure 5 m along any two boundaries of the randomised quadrat by taking any one corner of the quadrat. Lay out two perpendicular sets of lines measuring 5 m from two points and mark along the two boundaries of quadrat where the sapling subplot is to be located. This also means that these two points are the midpoint along the boundaries of the quadrat. This means that the midpoint of that quadrat had been marked. Mark this point and the other two points along the two boundaries with PVC pipes. The PVC pipes shall be painted blue so that these pipes will not be confused with other pegs planted within the plot.

Unfortunately, in a real forest, large trees and buttresses often pose difficulties in planting the corner post. In such cases, use six-inch zinc square nail to replace the PVC pipe. These nails shall also be painted blue. Do not plant any peg if any corner of the subplot happens to fall inside the tree trunk.

3.3 Subplot Numbering

The 5 m x 5 m subplots that are demarcated in the 10 m x 10 m quadrats become the units of field labour, and a simple and consistent numbering system for them is necessary. The most convenient system for the field work is to designate a sapling subplot by squares and rows as done to the trees. The numbering of the sapling subplots are as follows A, B, C, and D, following clockwise direction (refer to **Figure 6**).

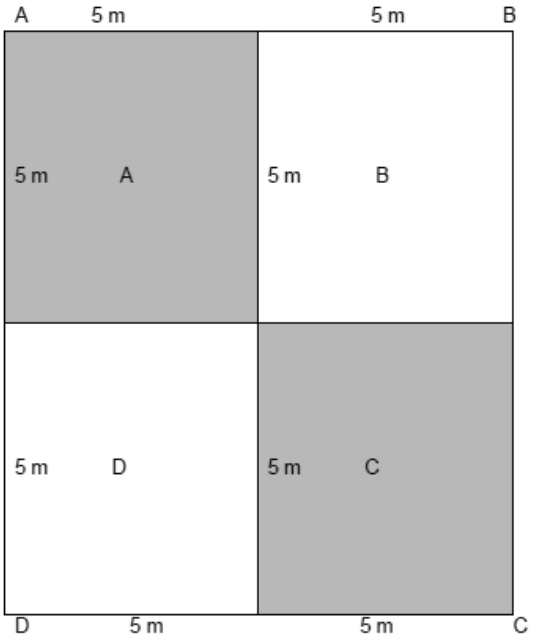


Figure 6. Distribution of Sapling Subplots within a quadrat

3.4 Rentis

No rentises are allowed while establishing the sapling subplots or enumerating the sapling. Disturbance within the subplots shall be minimal.

4.0 FILE INFORMATION

Same as for trees.

4.1 Sample size

Sample size for sampling is "2".

4.2 Quadrat **Column 1**

Stocked with at least one stand table = "1" and not stocked = "2".

4.3 Assessment Plot Number **Columns 2 – 4**

Same as for trees.

4.4 Quadrat Number + Subplot **Columns 5 – 8**

Same as for trees with additional of subplot.

4.5 Consecutive Stem Number (CSN) **Columns 9 – 11**

Separate series of CSN by quadrat.

4.6 Stem Identity Class (SIC) **Columns 12-14**
SIC for saplings.

4.7 Vernacular Name **Column 15**
Same as for trees.

4.8 Species Codes **Columns 16-21**
Same as for trees.

4.9 Diameter **Columns 22-23**
Same as for trees.

4.10 Point of Measurement **Column 24**
Same as for trees (1.3 m above highest ground level).

4.11 X – coordinates **Column 25**
Same as for trees.

4.12 Y – coordinates **Column 26**
Same as for trees.

5.0 ENUMERATION

5.1 Enumeration of tree species

Enumeration includes tagging, identifying, measuring and plotting of all that are enumerated. Saplings of all living tree species shall be measured in the 5 m x 5 m sapling subplot, tagged, identified to species, stem identity class scored, diameter measured and x – and y – coordinates recorded. No other parameters are to be collected.

In sapling subplots, the following shall be enumerated:-

- Stems of tree species, ≥ 1.0 cm – 9.9 cm dbh;
- Coppices of tree species, ≥ 1.0 cm – 9.9 cm dbh;

5.1.1 Coppices

Coppices are defined as stems arising from a stump or from fallen trees. In the case of coppices arising from a stump, measure the coppices individually and assign the tag to the biggest and tallest coppice in the clump. Consider coppices as individual stems if the coppices produce its own rooting system. In the case of coppices from a fallen stem and the stem itself is being enumerated, measure and tag only the coppice that produces its own rooting system. Ignore the coppices that arise from a fallen stem that do not produce its own rooting system or above the point of measurement.

5.2 Consecutive stem number (CSN) Columns 9 – 11

In a sapling subplot, the consecutive stem number serves to identify each living stem. An identification of this type simplifies any checking on errors done by the computer.

Every stem shall be numbered, tagged, diameter measured, stem identity class scored and coordinates measured. This means that all living tree and palm species shall be tagged, measured and numbered irrespective of whether they are complete stems, broken stumps, or cut stumps. The order of assessment shall be clockwise by measuring any sapling nearest to corner A or whichever sapling nearest to any corner, if it happens that there is no sapling in corner A or corner B, etc. A series of CSN will be used in each quadrat. This means that the CSN will not be continuous for the whole plot.

Number consecutively each stem in order of enumeration. When only one stem is present, number it "01".

The consecutive stem number shall be punched on an aluminium triangle e.g. 01. These tags are simply attached to copper wire which is tied loosely around the stem of each sapling which has been given such a number.

A consecutive stem number shall not be used for more than once in any sapling subplot. When a number has been assigned to a sapling subplot, that number shall not be used again, even if the sapling disappears without trace. However, should a number be found to be missing, because it was accidentally omitted during an earlier enumeration, that number may be assigned to a new recruit.

Tags of numerical sequence shall be prepared before going to the field. These tags are tied in order onto a piece of wire but allowing them to be pulled out one by one. Prepare an estimate of 20 tags per sapling subplot.

5.3 Stem Identity Class (SIC) Columns 12 – 14

There are three digits to this variable, each representing different portion of the plant. First digit represents the size, second digit represents the status and the third digit represents the condition of the stem of the plants. Stem identity class shall be scored for all living (standing or fallen) saplings. Do not measure any dead sapling in this enumeration.

The stem identity classes to be used when enumerating sapling subplots are set out below. In order to know which entries for the stem identity classes you encounter in the forest, please refer also to the specimen field card issued with these instructions.

The following stem identity classes are to be used in this enumeration. This stem identity class classification will provide:

5.3.1 First Position – Plant size

1 = Tree (≥ 10.0 cm dbh)
2 = Sapling (≥ 1.0 cm dbh – < 10.0 cm dbh)
3 = Seedling (≥ 20 cm high – < 1.0 cm dbh)
4 = Individual/single palm (≥ 0.5m high)
5 = Clumped palms (≥ 0.5m high)

5.3.2 Second Position – Plant Status

1 = Living, standing
2 = Living, fallen, or leaning ≥ 60° from vertical, or leaning against a tree or trees or supported by woody climbers
3 = Dead, standing
4 = Dead, fallen, or leaning ≥ 60° from the vertical, or leaning against a tree or trees, or supported by woody climbers
5 = ≥ 2 stems from one base, more than one stem measured.
6 = POM in between branches, some branches are below the POM
7 = Coppice below POM
8 = Change in POM, dead at the POM but with coppice at the base, coppice may be too small For measurement or POM moved to coppice, or POM simply moved due to bad placement
9 = Dead or missing or not enumerated

5.3.3 Third Position – Stem Condition

1 = Complete, main meristem intact
2 = Broken stem, no replacement for meristem visible
3 = Broken stump
4 = Cut stump or stem
5 = Coppice above POM may be old or new damage evident
6 = Broken or damage during measurement
7 = Not enumerated, was no part of the year's sample
8 = Missing, tag or plate lost, or evidence of plant remains
9 = Dead or no trace of the plant, but tag or plate recovered

Table 4. Stem Identity Class for Stems ≥ 10 mm – < 100 dbh

	STEM		STUMP		Broken with coppices	Broken assessment
Sapling	**Complete**	**Broken**	**Broken**	**Cut**		
2.0 Tree species						
2.1 Alive, standing	211	212	213	214	215	216
2.2 Alive, fallen	221	222	223	224	225	226
2.3 Dead, standing	231	232	233	234		
2.4 Dead, fallen	241	242	243	244		
2.5 ≥ stem, standing, alive	251	252	253	254	255	256
2.6 Branch below POM	271	272	273	274	275	
2.7 Coppice below POM	261	262	263	264	265	266
2.8 Dead at POM, coppice present	281	282	283	284	285	
2.9 Seedling, missing	298		Seedling, missing, dead			299

NB: SIC 2.3, 2.4, 2.8, 2.9 and broken with new growth will not be used during initial enumeration.

5.4 Vernacular name — Column 15

No tree species are to be excluded from the enumeration. The vernacular name of every sapling enumerated shall be entered on the field card. The manner of entry should follow as shown in the "List of Vernacular Names".

5.5 Species Codes — Columns 16-21

The 6-letter botanical code shall be used to represent any species. In case where botanical identification is doubtful, or when an "unknown" is encountered, a leaf sample should be collected for identification in the herbarium.

Whenever trees, saplings, seedlings are encountered for which no botanical name is known, enter the code "ZZZZZZ" or only known to genus level, enter the first four letters of the genus followed by two "XX", e.g. SHORXX.

5.6 Diameter at breast-height (DBH) — Columns 22-23

Diameter measurements should be recorded as reduced to the nearest millimetre. That is, a reading on a diameter-tape which falls between 2.1 and 2.2 or closed to 2.2, should be recorded as 2.1 cm. The diameter at breast height of stems of all species, and of the following identity classes-sapling, broken stem, broken stump and cut stump shall be measured.

The stem at the point of measurement should be cylindrical, and not irregularly-shaped due to the influence of flutings, swelling, wounds, bends, etc.

All saplings to be measured shall, at the point of measurement, be cleaned of vines, thorns, moss, loose flakes of bark, and surface vegetation, any of which would give false reading of diameter tape is to be placed at right-angles to the axis of the stem at breast-height. Please note the following:

5.6.1 When the diameter measured at breast height does not represent the diameter of the stem, due to a swelling, bump, or fork, etc., place the tape above or below the swelling in order to measure the nearest approximation of what diameter at breast height would be.

5.6.2 Forked, or multi-stemmed, saplings

- When the fork occurs below breast-height, consider the sapling has two stems.
- When the fork occurs below breast-height, consider the sapling as one stems.
- Do not record any stem smaller than 1.0 cm dbh

5.6.3 Consider each coppice growth from fallen trunks to be an individual sapling whenever its diameter is 1.0 cm diameter or larger, has developed its own root system and occurring below point of measurement.

5.6.4 When a broken stump is shorter than 1.30 m in height, measure a representative diameter at a convenient point. Do not measure any broken stump shorter than 30 cm in height.

5.7 Point of measurement **Column 24**

All diameters for sapling shall be measured at breast-height. All points of measurement shall be painted with a ring for sapling. Point of measurement shall be painted with a stroke at right angles to the axis of the stem. The upper edge of the paint stroke represents the point of point of measurement.

The consecutive stem number shall be loosely looped with copper wire around the stem upon every stem, which has been given the consecutive stem number.

All cuts or slashes (except natural injury) made while making the species identification shall be painted.

5.8 Paint

Only red colour is to be used to paint the point of measurement for sapling, the same as for trees.

6.0 COORDINATES (X – AND Y -) Columns 25-26

These x– and y- coordinates should show the position of all living saplings ≥ 1.0 cm – < 10.0 cm dbh and showing their consecutive stem number.

To show the position of all saplings, thus assisting to identify correctly all saplings at successive measurement of the plot; this information will provide the rate of mortality and recruitment, composition and distribution of the stand.

To show the development, over a long period, of any gap recorded in the plot.

7.0 FIELD DATA SHEET

Data from each subplot are recorded on the field data sheet specifically designed for this study. When data from one subplot do not fill a field data sheet, data from a second subplot should never be added; one field data sheet shall only have data from a single subplot. On the line below the last entry for each subplot, write the word “END”. On the other hand, whenever records from a subplot require

using more than one field data sheet, writing the word “CONTINUE” below the last entry on the field data sheet and the numbering sequence shall continue consecutively on the following field data sheet.

8.0 WORK SEQUENCE

Within each subplot, follow the same sequence in enumerating trees. Following a consistent sequence (clockwise movement) is useful because the tag sequence is then predictable, and this make later attempt to find a particular tag easier. It also helps to assure that every stem is located.

9.0 REMARKS

Remarks on the physical condition and location of sapling subplot are important. Physical condition includes open space as a result of tree fall, windblown, landslides, under shade, etc.

In addition, please indicate the presence of non-timber product but do not tag them.

PART III - SEEDLINGS

1.0 INTRODUCTION

Tree species, saplings ≥ 10 – <100 mm dbh had been measured in the plot. In order to provide supplementary information (e.g. development, composition and spatial distribution of tree species below 10 mm dbh) on what had been collected during the general re-census (measuring all tree species ≥ 100 mm dbh and saplings ≥ 10 – 100 mm dbh), seedlings plots are to be established and seedlings to be tagged, measured for height and identified to species, SIC scored and their x – and y – coordinates measured.

Seedling (in this study) is defined as any tree species having a minimum height of 20 cm but less than 10 mm in diameter at breast-height.

2.0 OBJECTIVES

- The immediate objective is to study the generation in unlogged and a regenerating forest after logging.
- To study the mortality and recruitment patterns of the seedling after logging especially commercial valued species particularly dipterocarps.
- To study species dynamic (distribution, composition and development) over a period of time.

3.0 METHODOLOGY

3.1 Sampling Intensity

Seedling subplot measuring 2 m x 2 m shall be established in randomised quadrats where sapling subplots had been established in each plot at a sampling intensity of 30%. These seedling subplots will be chosen by means of randomisation. The seedling subplot shall be located in any of the sapling subplot at any of the four corners in any of the randomised quadrat for saplings. This also means that in each quadrat there will be 16 seedling subplots, measuring 2 m x 2 m. Seedlings will only be enumerated in any one of these subplots.

3.2 Establishment of the seedling subplot

Lay out two perpendicular sets of lines measuring 2 m from any corner of the 10 m x 10 m sapling subplots where saplings have been enumerated. Measure 2 m along the two boundaries and mark those two points. This means that three points had been marked. The fourth point shall be determined by laying out a 2 m stick perpendicularly from the two marked points along the two boundaries. Mark this point with PVC pipe. The PVC pipes shall be painted blue so that these pipes will not be confused with other pegs planted within the plot.

A 2 m stick should be easy to measure horizontally even in very bushy area compared to measuring tape. Unfortunately, in a real forest, large trees and buttresses often pose difficulties in planting the corner post. If so, use six-inch zinc square nail to replace the PVC pipe. These nails shall also be painted blue. Do not plant any peg if any corner of the subplot happens to fall inside the trunk.

Establishment of seedlings subplot shall be done at the same time when doing the enumeration of the sapling. Enumeration includes tagging, identifying, measuring and plotting of all seedlings enumerated.

3.3 Subplot Numbering

The 2 m x 2 m subplots that are demarcated in the 5 m x 5 m squares become the units of field labour, and a simple and consistent numbering system for them is necessary. This means that there will be 25 seedling subplots in each quadrat. The most convenient system for the field work is to designate a seedling subplot by squares and rows as done to the trees. The numbering system for the seedling subplots are as follows: A1, A2, A3, A4, A5; B1, B2, B3, B4, B5; C1, C2, C3, C4, C5; D1, D2, D3, D4, D5; E1, E2, E3, E4, E5 (refer **Figure 7** below). Only one of these 25 subplots (2 m x 2 m will be selected through randomisation and will be measured for seedlings.

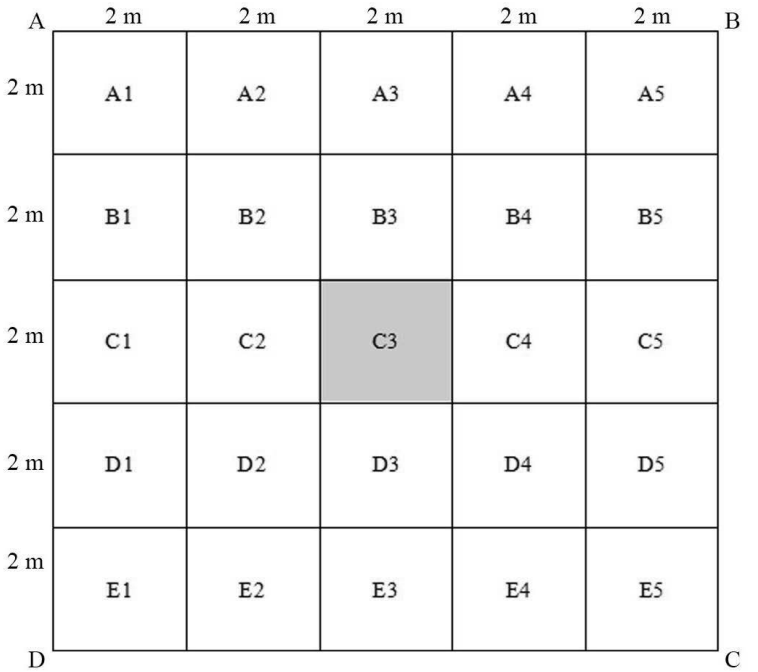


Figure 7. Distribution of seedling subplots within a quadrat

3.4 Rentises

No rentises are allowed while establishing the seedling subplots or enumerating the seedlings. Disturbance within the subplots should be minimal.

4.0 FILE INFORMATION

Same as for trees.

4.1 Sample Size

Sample size for samplings is "3".

4.2 Quadrat Stock **Column 1**

Stocked with at least one stand table = "1" and not stocked = "2".

4.3 Assessment Plot Number **Columns 2 – 4**

Same as for trees.

4.4 Quadrat Number and Subquadrant **Columns 5 – 9**

Same as for trees plus the subquadrat for the assessment of seedlings.

4.5 Consecutive Stem Number (CSN) **Columns 10 – 12**
CSN series will be by subquadrat. New CSN series will begin on new subquadrat

4.6 Stem Identity Class (SIC) **Columns 13 - 15**
Seedlings Stem Identity Class. See **5.3** and **Table 1** for detail.

4.7 Vernacular Name **Column 16**
Same as for trees. See paragraph **5.5** for detail.

4.8 Species Codes **Columns 17-22**
Same as for trees. See paragraph **5.7** for detail.

4.9 Coordinates (x- and y-) **Column 25-26**
Same as for trees. See paragraph **5.8** for detail.

5.0 ENUMERATION

5.1 Consecutive Stem Number (Seedling Numbering) **Columns 10 -12**
Seedlings are to be numbered consecutively by plot, that is exactly the same system as the trees and saplings except that the material used will be plastic tags and not aluminium plates. The order of assessment should be clockwise by measuring nearest to corner A or whichever seedling is nearest to any corner if it happens that there is no seedling in Corner A or Corner B, etc.

Consecutive stem number shall be written on the plastic tag e.g. 01254B3-01 which means that this seedling is the first seedling found in plot 01, quadrat 254, subplot B3 and 01 is the first seedling in that subplot. These tags are simply attached in loop round the trunks of the seedlings.

Tags of numerical sequence shall be prepared before going to the field. These tags are tied in order with piece of wire but allowing them to be easily pulled out from the wire one by one. Prepare an estimate of 30 tags per subplot (see **Figure 8** below).

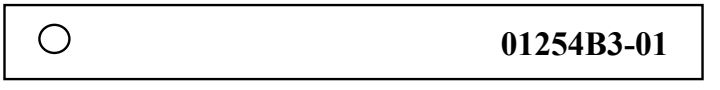


Figure 8.Sample of tag

5.2 Coppices
Coppices are defined as stems arising from one e.g. from a stump or from fallen trees. In the case of coppice arising from a stump, measure the coppices individually and assign the tag to the biggest and tallest coppice in the clump. Consider coppices as individual stem if the coppices produces its own rooting system. In the case of coppices from a fallen stem and the stem itself is being enumerated, measure and tag only the coppice that the produces its own rooting system. Ignore the coppices that arise from a fallen stem that do not produce its own rooting system or above the point of measurement.

5.3 Stem Identity Class (SIC) **Columns 13 -15**
There are three digits to this variable, each representing a different portion of the plant. First digit represents the size, second digit represents the status and the third digit represents the condition of the stem of the plants. Stem identity class shall be scored to all living (standing or fallen) seedlings. Do not measure any dead seedling in this enumeration.

The following stem identity classes are to be used in this enumeration. This stem identity class classification will provide:

5.3.1. First Position – Plant Size

1 = Tree (≥ 10.0 cm dbh)
2 = Sapling (≥ 1.0 cm dbh – < 10.0 cm dbh)
3 = Seedling (≥ 20 cm high – < 1.0 cm dbh)
4 = Individual/single palm (≥ 0.5m high)
5 = Clumped palms (≥ 0.5m high)

5.3.2. Second Position – Plant Status

1 = Living, standing
2 = Living, fallen, or leaning ≥ 60° from the vertical, or leaning against a tree or trees or supported by woody climbers.
3 = Dead, standing
4 = Dead, fallen, or leaning ≥ 60° from the vertical, or leaning against a tree or trees, or supported by woody climbers.
5 = ≥ 2 stems from one base, more than one stem measured.
6 = POM in between branches, some branches are below the POM
7 = Coppice below POM
8 = Change in POM, dead at the POM but with coppice at the base, coppice may be too small for measurement or POM moved to coppice, or POM simply moved due to bad placement.
9 = Dead or missing or not enumerated

5.3.3. Third Position – Stem Condition

1 = Complete, main meristem intact
2 = Broken stem, no replacement for meristem visible
3 = Broken stump
4 = Cut stump or stem
5 = Coppice above POM may be old or new damage evident
6 = Broken or damaged during measurement
7 = Not enumerated, was no part of the year"s sample
8 = Missing, tag or plate lost, or lost, or evidence of plants remains
9 = Dead or no trace of the plant, but tag or plate recovered

Table 5: Stem Identity Class for stems ≥ 20 cm high – < 1.0 cm dbh

	STEM		STUMP			
Seedling	**Complete**	**Broken**	**Broken**	**Cut**	**Broken with coppices**	**Broken while measuring**
3.0 Tree species						
3.1 Alive, standing	311	312	313	314	315	316
3.2 Alive, fallen	321	322	323	324	325	326
3.3 Dead, standing	331	332	333	334		
3.4 Dead, fallen	341	342	343	344		
3.5 ≥ 2 stems, standing, alive	351	352	353	354	355	356
3.6 Branch below POM	361	362	363	364	365	366
3.7 Coppice below POM	371	372	373	374	375	
3.8 Dead at POM, coppice present	381	382	383	384	385	
3.9 Seedling, missing	398		Seedling, missing, dead			399

NB. The SIC 3.3, 3.8, 3.9 and broken with new growth are NOT to be used in the initial enumeration.

5.4 Seedling enumeration

Record all seedlings tree species (≥ 20 cm high – <1.0 cm dbh), tag, score stem identity class (**Table 1**), measure the height from the highest ground level to the growing point of the main living shoot or the meristem, identify, and measure and record x- and y-coordinates in the field data sheet.

5.5 Vernacular name **Column 16**

No tree species are to be excluded from the enumeration. Enter on the field data sheet, the vernacular name of every seedling enumerated. The manner of entry should follow the codes as shown in the "List of Vernacular Names" provided separately.

5.6 Species Codes **Columns 17 -22**

The vernacular name will be translated into botanical name and given the 6-letter code. The 6-letter codes shall be used to present any species. In cases where botanical identification are doubtful, or when an 'unknown' is encountered, a leaf sample should be collected and identified in the herbarium. Whenever seedlings are encountered for which no botanical name is known, enter the code "ZZZZZZ" or only known to family level, enter the first four letters of the family followed by two"YY" e.g.

"CLUSSY", or only known to genus level, enter the first four letters of the genus followed by two "XX",e.g. SHORX.

5.7 Height Measurement **Columns 23 -25**

Height is defined as the distance from the highest ground level to the growing tip of the seedling. Growing tip is defined as the tip of the meristem and not the tip of the branches. Sometimes the tip of the meristem is lower than the branches.

Measurement of height should be in complete millimetres. Record the height in appropriate columns. Good measurement of the seedling height is critical, since the result from repeat censuses is growth. Unfortunately, growing tip of the meristems is seldom perfect and therefore a variety of difficulties in measuring height arise. To ensure accurate, long-term records of growth, there is one fundamental adage to keep in mind: think about the next census and the person to measure these seedlings all over. Give remarks whenever such information is useful. Remarks help a lot in making right decision.

5.8 Coordinates (x- and y-) **Columns 26 -27**

Measure the x- and y- coordinates for each seedlings being enumerated in each subplot and record the measurement in the appropriate columns.

6.0 FIELD DATA SHEET

Data from each subplot are entered onto the field data sheet specifically design for this study. When data from one subject do not fill one field data sheet, data from a second subplot should never be added: one field data sheet should only have data from a single subplot. On the line below the last entry for each quadrat, write the word "END". On the other hand, whenever records from a subplot requires to use more than one field data sheet, write the word "CONTINUE" below the last entry on the field data sheet and the numbering sequence should continue consecutively on the following field data sheet.

7.0 WORK SEQUENCE

Within each subplot, follow the same sequence in enumerating trees and saplings. Following a consistent sequence (clockwise movement) is useful because the tag sequence is then predictable, and this makes later attempt to find a particular tag easier. It also helps to assure that every stem is located.

8.0 REMARKS

Remarks on the physical condition and the location of the seedling subplot are important. Physical condition includes open space as a result of tree fall, windblown, landslides, under shade, etc.

REFERENCES

Hutchinson, I.D. (1982). *Field Enumeration of Permanent Sample Plots in Mixed Dipterocarp Forest of Sarawak*. Field Document No. 16. Forest Department Sarawak

Lee, H.S & K.K. Lai. (1977). *A Manual of Silviculture for the Permanent Forest Estate of Sarawak*. Forest Department Sarawak

PART IV – GENERAL DEFINITIONS

1.0 GENERAL DEFINITIONS

1.1 Trees
Stems of diameter ≥ 10.0 cm dbh.

1.2 Saplings
Stem ranging in diameter from 1.0 – 9.9 cm dbh.

1.3 Seedlings
Stems not shorter than 20 cm total height, and not larger than 1.0 cm dbh.

1.4 Quadrat stock **Columns 01**
Quadrat stock refers to either the quadrat contains any living stand table. In sapling and seedling subplots either the subplot contains any living tree species of specified size for such subplot.

1.5 Assessment plot number **Columns 02 -04**
Assessment plot number will be available in the design of the experiment. These particulars will be different from one area/ site to the other. The assessment plot number will determine the number of plot within each forest type within one location/site.

1.6 Quadrat number **Columns 05 - 07**
Quadrat numbers may be obtained from attached diagrams of assessment plots. They are also marked on the PVC pegs set out in the forest.

1.7 Forest type code **Columns 08- 10**
The numbers are designed specifically for each forest type. The information will give the number in which the plot is established within each forest type within the Mixed Dipterocarp Forest.

1.8 Consecutive stem number **Columns 11- 13**
In a quadrat, this number serves to identify any living stem. An identification of this type simplifies any checking for errors done by the computer.

Every stem should be numbered. This means that all living trees and palms are to be numbered irrespective of whether they are complete stems, broken stems, broken stumps, or cut stumps. Number consecutively each stem in order of enumeration. When only one stem is present, number it “01”.

The consecutive stem number that had been assigned upon each stem has been given such a number. The aluminium plate number should be nailed about 30 cm below the point of measurement.

A consecutive stem number should not be used for more than once in any quadrat. When a number has been assigned to a tree in a quadrat, that number is not be used again, even if the tree disappears without trace. However, should a number be found to be missing, because it was accidently omitted during an earlier enumeration, that number may be assigned to a new recruit.

1.9 Stem identity class (SIC) **Columns 14-16**
The stem identity classes to be used in enumeration for trees are as follows. When in the forest, refer to the table on the back of your field card.

Table 6: Identity classes for stems 10.0+ cm dbh

	STEM		STUMP		Broken with coppices	Broken while measuring	Not found
	Complete	Broken	Broken	Cut			
	4.0 + m		0.30- ≤ 0.45 m				
A) Tree species, living stems							
Standing	111	112	113	114	115		119
Fallen	121	122	123		125		129
B) Tree species, dead stems							
Standing	131	132	133	134			139
Fallen	141	1421	143				149
C) Palms living							
Standing	411	412	413	414	415		419
Fallen	421	422	423		425		429

For "not found" tree during the later enumeration, an observation should be written on the field card, making clear whether the previous entry was a recording error (in which case it should be deleted), or whether the stem really existed but, over the period between the enumerations, has for example, been cut and taken away, or fallen and disappeared because of injury.

NB: Stem identity Classes described in (b) and XX9 are not be used during the initial enumeration.

1.10 Vernacular name **Columns 17- 20**

No tree species are to be excluded from the enumeration. The vernacular name of every tree and the name of the palm enumerated should be entered on the field data sheet. The manner of entry should follow as shown in the "List of Vernacular Name". Letter-codes should not be used to represent any tree or palm species and unknown tree species. In such cases where botanical identification are not known, use the vernacular name and collect leaf samples to be matched and identified in the herbarium. When writing vernacular names upon the field cards, be sure to distinguish palms and tree species.

1.11 Species Code

For data-entry and data processing, a code number will represent each vernacular name. These code numbers represent the genera and the species which will be in six-letter code. The first four letters denote the genera and the last two letters denote the species. Consult the "List of vernacular names of trees for use in Mixed Dipterocarp Forest".

Whenever saplings, seedlings are encountered for which no botanical name is known, enter the code "XXXXXX".

1.12 Diameter at breast-height **Columns 21-24**

Diameter at breast-height should be measured by a member of the staff, not by one of the labourers. Diameter measurements should be recorded as reduced to the nearest millimetre. That is, a reading on a diameter-tape which falls between 12.1 and 12.2 or close to 12.2 cm, should be recorded as 12.1 cm. The diameter at breast height of stems of all species, and of the following identity classes – tree, broken stem, broken stump, and cut stump should be measured. The stem at the point of measurement should be cylindrical, and not irregularly-shaped due to the influence of buttresses, swelling, wounds, bends, etc. All trees to be measured should, at the point of measurement, be cleaned of vines, thorns, moss, loose flakes of bark, and surface vegetation, any of which would give false reading of diameter. All diameters are to be measured at breast-height (1.30 m above highest ground-level). For trees

growing on slopes, measure breast-height on the higher side of the trunk. In the case of leaning trees, measure breast-height along the axis of the trunk. In all cases, the diameter tape is to be placed at right-angles to the axis of the stem at breast-height. Please note the following:

1.12.1 When the diameter measured at breast height does not represent the diameter of the stem, due to a swelling, bump, or fork, etc. place the tape above the swelling in order to measure the nearest approximation of what diameter height would be.

1.12.2 In the case of trees with high buttresses, measure the diameter of the stem at a point 30 cm above the top of the highest buttresses. When it is not possible to reach this point, either use a ladder to reach the point of measurement, or measure the stem diameter with a wheeler pentagrams optical callipers note that this instruction will apply to all trees in which the top of the buttresses is higher than 10.0m above ground-level. If the diameter measured is higher than 1.3 m, indicate that P.O.M.

1.12.3 Record the diameter of severely fluted stems in the normal manner. In many cases the fluting will be revealed when the log grade of the stem is judged to be "deformed".

1.12.4 Forked or multi stemmed trees - when the fork occurs below breast-height, consider the tree as two stems, when the fork occurs above breast-height, consider the tree as one stem.

1.12.5 Consider each coppice growth from fallen trunks to be an individual tree whenever is 10 cm diameter or larger has developed its own root system.

1.12.6 When one tree is contained inside another (as is sometimes the case with 'ara' , the strangler fig) in such a way that is impossible to measure or estimate the girth of the host tree and when the crown of the host tree dominated by the fig, measure the diameter of the 'ara' and record it as the species. In the case of an early stage of attack by strangler fig, measure and record the original tree.

1.12.7 When a broken stump is shorter than 1.30 m in height, measure a representative diameter at a convenient point. Do not measure any broken stump shorter than 30 cm height.

1.12.8 When it is not possible to measure the diameter for a palm at breast height, estimate its diameter at ground level.

1.12.9 In the case of cut stumps, record the diameter of the surface without buttresses (ideally, cut stump should not be enumerated later than two years after logging. Among other things, this limitation helps to avoid uncertainty as to whether stump or coppices should be enumerated).

1.12.10 In future enumeration, remember that whenever you feel obliged to alter the point of measurement on a tree, record the diameter reading for both points of measurement for the original point of measurement, and also for the new point of measurement you have chosen.

1.13 Crown illumination **Column 25**

Estimate the crown illumination for all living trees (complete or broken), and for parasite crown upon all dead trees or palms (complete or broken). Do not describe the crowns of living stems which have fallen to the ground. To assist in deciding the degree of lighting reaching the crown of a tree, a page of diagrams is attached **(Figure 4)**. Note that the code numbers that are being used are opposite to those shown in "A Manual of Silviculture" (Lee & Lai, 1977). The illumination of each crown should be recorded as seen at the time of enumeration. The classification should be called out "in words" as well as by code number so that staff present may assist in checking classification. The code numbers for crown illumination are shown below:

DESCRIPTION ON CROWN ILLUMINATION	CODE
EMERGENT CROWN: Full light reaches the side of the crown at an angle of at least 45° from the vertical	1
FULL OVERHEAD LIGHT: Upper part of the crown fully exposed to overhead light, but sides of the crown do not receive full light.	2
SOME OVERHEAD LIGHT: Part of the crown is exposed to vertical light, but part is shaded from the above.	3
MOSTLY SIDELIGHT: The crown receives no vertical. Part of the crown receives direct side light	4
NO DIRECT LIGHT: The crown receives only filtered through the crowns of other trees	5

In the case of broken stem which is alive but carrying no crown at the time of enumeration, estimate the illumination class for the top of the broken stem.

1.14 Crown form **Column 26**

A page of diagrams is attached **(Figure 4)** to assist in guiding this classification. Note that the code numbers are different from those shown in "A Manual of Silviculture" (Lee & Lai, 1977). The code numbers for classifying crown form are shown below. The form of each crown should be recorded as seen at the time of enumeration.

DESCRIPTION ON CROWN FORM	CODE
COMPLETE CIRCLE. Circular and symmetrical.	1
IRREGULAR CIRCLE. Very nearly ideal and satisfactory, silviculturally but with some slight defect of symmetry or some dead branch tips.	2
HALF CIRCLE. Just in the satisfactory class, distinctly asymmetrical or thin, but apparently capable of improvement if given more room.	3
LESS THAN HALF CIRCLE. Distinctly unsatisfactory, with extensive debark, asymmetry a few branches, but probably capable of surviving.	4
ONLY A FEW BRANCHES. Either definitely suppressed or degenerating or badly damaged. Probably incapable of diameter increment.	5
MAINLY COPPICE	6
STEM ALIVE BUT CARRYING NO CROWN	7

1.15 Injury (root, lower butt, upper trunk, crown)

Visible signs of injury should be recorded for all living stems (complete or broken) which are ≥ 10.0 cm dbh. Look for the signs of injury on the roots and lower butt at the time dbh measurement was taken. Remember what is seen there. When assessing injury in the tree as a whole, stand back from the tree to obtain the best view possible. Be sure to look at the tree from all angles.

Position of injury:

Column X : signs of injury visible on the roots

Column X : sign of injury are visible in the butt and/ or lower trunk (between the top of the roots and the midpoint of the trunk)

Column X : signs of the injury are visible in the upper portion of the trunk (between the midpoint of the trunk and the crown point)

Column X : signs of injury are visible in the crown, (for broken stem and broken stumps without a coppice crown, record "0". When a coppice crown is present, apply the codes numbers below).

The code numbers indicating the cause of the injury is as following. For each position in the tree, as listed above, write in the column X-? One of the code numbers as tabulated below:

DESCRIPTION ON INJURY	**CODE**
No injury evident	1
Due to storm	3
Due to flora and fauna	4
Logging- Heavy machinery	5
Logging- Felling only	6
Logging- Machinery and felling	7

1.16 Decay (root, lower butt, upper trunk, crown)

Visible signs of decay should be recorded for all living stems (complete or broken) which are ≥ 10.0 cm dbh. Look for the signs of decay on the roots and lower butt at the time dbh measurement was taken. Remember what is seen there. When assessing decay in the tree as a whole, stand back from the tree to obtain the best view possible. Be sure to look at the tree from all angles.

Position of decay:

Column X : signs of decay visible on the roots

Column X : sign of decay are visible in the butt and/ or lower trunk (between the top of the roots and the midpoint of the trunk)

Column X : signs of the decay are visible in the upper portion of the trunk (between the midpoint of the trunk and the crown point)

Column X : signs of decay are visible in the crown, (for broken stem and broken stumps without a coppice crown, record "0". When a coppice crown is present, apply the codes numbers below).

The following code numbers indicate the seriousness of the decay. For each position in the tree, as listed above, write in the columns X-?

Description on Decay	Code
No signs of decay to be seen. No reason to suspect decay	1
Decay suspected. A sign or signs cause you to suspect the present of decay. Do not use this code without a good reason	2
Decay is evident. Clear sign or signs of decay is/are seen	3

When injury inside a standing tree has been revealed by a loggers' chain saw cut, consider what you see to be a sign of evident decay.

1.17 Log Grade **Column 42**

The classification of log grade should be applied to all living broken stems 10.0+ cm dbh. Log grade for all species should be recorded, regardless of the present commercial value of any species.

The term, "log grade", only refers to the straightness of the trunk that contains at least one straight section of 4.5 m long. In some forest inventories, it is used as a means to indicate the quality of the stem of a standing tree, the stem being classified according to the quality of the best log in the stem, or according to the quality of the butt log and is not the case in this project. The classification does not consider the quality of individual logs. Each tree is classified according to whether it contains, or does not contain, one straight section of 4.5 m long regardless of its diameter.

By using these classifications of log grade we are able to distinguish those trees of potential commercial value from these which, for a variety of reasons, have no possibility of yielding at least one log. In case where log grade is affected by both injury and decay, record the log as decayed rather than injured. When portions of a stem, previously injured are found to be now decayed, regard them as being decayed. The code numbers for log grade are as follows:

DESCRIPTION OF LOG GRADE	CODE
COMMERCIAL NOW. Stem contains at least one straight section, not less than 4.5 m long and with a diameter of ≥ 45 cm at BH or 30 cm above the highest buttress.	1
COMMERCIAL IN FUTURE. Stem contains at least one straight section, not less than 4.5 m long and with a diameter ≥ 45 cm at BH or 30 cm above the highest buttress.	2
NO LOG. Stem is deformed. When a stem is deformed because of its shape and form the trunk does not contain one straight section 4.5 m long. Classify as 'deformed' any straight section which shows severe spiral grain or shows the harmful effects of damage or deformity (past or present) by woody climbers.	3
NO LOG. Stem damaged. As a result of injury the stem does not contain one sound portion 4.5 m long.	4
NO LOG. Stem decayed. As a result of decay the stem does not contain one sound portion 4.5 m long.	5

1.18 Woody climber **Column 43**

The occurrence of woody climbers should be recorded on all standing and living stems, which are 10.0+ cm dbh, using the code numbers shown below. Do not consider rattan to be a woody climber.

Description of Woody Climber	**Code**
Woody climbers not evident	1
Woody climber recently cut. None living	2
Woody climbers recently cut. Harmless climbers remain alive	3
Harmless climbers on trunk	4
Harmless climbers on crown	5
Harmless climbers on both trunk & crown	6
Harmful climbers on trunk	7
Harmful climbers on crown	8
Harmful climbers on both trunk and crown	9

Woody climbers should be recorded on stems of the following identity classes: 111, 112, 113, 115, 131, 132, 133, 411, 412, 413, 415. In the case of "climber towers" – dead trees or dead palms supporting woody climbers – code number 5, 6, 8, 9 may be applied that climbers are high upon the dead stem and cover any dead branches which may exist.

APPENDICES

APPENDIX 1- FIELD DATA SHEET FOR RECORDING TREES

FIELD DATA SHEET FOR RECORDING TREES

GPS READING FOR QUADRAT

FIELD DATA SHEET FOR TREES

TOTAL NUMBER OF RECORDS (LINE ENTRIES IN THIS QUADRAT): ....

MAXIMUM VALUE RECORDED FOR CONSECUTIVE STEM NUMBER: ....

SKETCH - MAP OF A QUADRAT

FILE INFORMATION

SAMPLE PLOT NUMBER	FRT TYPE CODE	YEAR OF ENUMN	DECI	DATE

DATE: ..../ ..../ ....

NAME OF STAFF MEMBERS

LINE ENTRIES TREE SPECIES - ≥ TREES 100 mm DBH

QUADRAT STOCKED? YES =1: NO = 2 ☐ FOREST TYPE CODE ☐ ☐ ☐

PLOT NUMBER ☐ ☐ ☐ QUADRAT NUMBER ☐ ☐ ☐

LOCALITY:

REMARKS FOR THE QUADRAT

PAGE 1,2

SCALE 1: 2000

STEM IDENTITY				STEM DESCRIPTION																	Co-ordinates (cm)	
CSN	SIC	VERNACULAR NAME	SPECIES CODE	DIAMETER (MM)				POM	CI	CF	INJURY				DECAY				LG	WC	X	Y
xxx	000			0	0	0	0	x	0	x	0	0	0	0	x	x	x	x	0	x	0000	xxxx

KEY

GPS	=	GEOGRAPHICAL POSITIONING SYSTEM	FRT	=	FOREST	ENUMN	=	ENUMERATION	DECI	= DECIMAL
CSN	=	CONSECUTIVE STEM NUMBER	SIC	=	STEM IDENTIFY CLASS	BH	=	BREAST HEIGHT	POM	= POINT OF MEASUREMENT
CI	=	CROWN ILLUMINATION	CF	=	CROWN FORM	LG	=	LOG GRADE	WC	= WOODY CLIMBER

TABLE OF IDENTITY CLASSES AND OTHER CODES FOR STEMS 10 + CM

STEM IDENTITY CLASSES	X X 1	X X 2	X X 3	X X 4	X X 5	X X 9
	COMPLETE TRUNK	BROKEN		CUT	BR ST WH	NOT
		STEM	STUMP	STUMP	CO	FOUND
1.0 TREE SPECIES, STEM 10+ CM DBH						
1.1 TREE ALIVE, STANDING	111	112	113	114	115	119
1.2 TREE ALIVE, FALLEN	121	122	123	124	125	129
1.3 TREE DEAD, STANDING	131	132	133	134		139
1.4 TREE DEAD, FALLEN	141	142	143	144		149
1.5 2+ STEM STANDING	151	152	153	154	155	159
1.6 BRANCH BELOW POM	161	162	163	164	165	169
1.7 COPPICE BELOW POM	171	172	173	174	175	179
1.8 DEAD AT POM. COPPICE PRESENT	181	182	183	184	185	189
1.9 TREE MISSING		198	TREE MISSING, DEAD			199

SKETCH - MAP OF THE QUADRAT
COMPASS ORIENTATION OF QUADRAT
CORNER A: DUE WEST- DIE NORTH
CORNER B: DUE NORTH - DUE EAST
CORNER C: DUE EAST - DUE SOUTH
CORNER D: DUE SOUTH - DUE WEST

THE CORNERS, ABCD, OF ALL QUADRAT IN AN ASSESSMENT PLOT ARE ORIENTED IN THE SAME DIRECTION FOR THE FIRST ENUMERATION, SHOW ALL TREES 10 + CM DBH, LIVING OR DEAD. (STANDING OR FALLEN) EXCAVATOR TRACKS, WATERCOURSES, OPEN SPACES AND OTHER PHYSICAL FEATURES FOR THE LATER ENUMERATOR. SHOW NEW RECRUITS AND CORRECTIONS ONLY.

CROWN ILLUMINATION	CODE
EMERGENT	1
FULL OVERHEAD LIGHT	2
SOME OVERHEAD LIGHT	3
MOST SIDELIGHT	4
NO DIRECT LIGHT	5

CROWN ILLUMINATION FORM	CODE
COMPLETE CIRCLE	1
IRREGULAR CIRCLE	2
HALF CIRCLE	3
LESS THAN HALF CIRCLE	4
FEW BRANCHES	5
MOSTLY COPPICES	6
STEM ALIE BUT NO CROWN	7

TREE INJURY	CODE
NO INJURY EVIDENT	1
DUE TO STORM	2
DUE TO FLORA AND FAUNA	3
LOGGING - HEAVY MACHINERY	4
LOGGING - FELLING ONLY	5
LOGGING - MACHINERY + FELLING	6

TREE DECAY	CODE
NO SIGNS OF DECAY	1
PRESENCE OF DECAY SUSPECTS	2
DECAY EVIDENCE	3

WOODY CLIMBERS	CODE
NO EVIDENT OF WOODY CLIMBERS	1
WOODY CLIMBERS RECENTLY CUT. NONE LIVING	2
WOODY CLIMBERS RECENTLY CUT. CLIMBERS REMAIN ALIVE	3
HARMLESS CLIMBERS ON THE TRUNK	4
HARMLESS CLIMBERS ON THE CROWN	5
HARMLESS CLIMBERS BOTH ON TRUNK AND CROWN	6
HARMFUL CLIMBERS ON TRUNK	7
HARMFUL CLIMBERS ON CROWN	8
HARMFUL CLIMBERS BOTH ON TRUNK AND CROWN	9

LOG GRADE	CODE
STEM CONTAINS STRAIGHT PORTION OF AT LEAST (4.5 + M)	1
DEFORMED (NO STRAIGHT PORTION OF 4.5 M)	2
DECAY, DEFORMED AND DAMAGED	3

NB

BR ST WH CO Broken stem/ stump with coppices

Stem Identity Class 1.3, 1.4, 1.8, 1.9 and X X 9 are not to be used during initial enumeration

APPENDIX II - FIELD DATA SHEET FOR RECORDING SAPLINGS

FIELD DATA SHEET FOR RECORDING SAPLINGS

FIELD DATA SHEET FOR TREES	TOTAL NUMBER OF RECORDS (LINE ENTRIES) IN THIS QUADRAT: .... MAXIMUM VALUE RECORDED FOR CONSECUTIVE STEM NUMBER : ....
FILE INFORMATION SAMPLE PLOT NUMBER | FRT TYPE CODE | YEAR OF ENUMN | DECI DATE	DATE: ..../ ....../ .... **NAMES OF STAFF MEMBERS** BOOKER : .... MEASURER/ SPECIES IDENTIFIER : ....

LINE ENTRIES FOR TREE SPECIES - SAPLINGS ≥ 1.0 CM - < 10 CM DBH

QUADRAT STOCKED ? (YES = 1: NO =2) ASSESSMENT PLOT NUMBER ☐☐☐ QUADRANT NUMBER ☐☐☐

SAMPLE SIZE = 2 SUBPLOT: QUADRANT A: B : C : D (CIRCLE ONE)

LOCALITY:	REMARKS ON THE SAPLING SUBQUADRAT	PAGE 1,2

STEM IDENTITY													**DBH**			**CO-ORDINATES**	
CSN			**SIC**			**VERNACULAR NAME**	**SPECIES CODE**						**(mm)**		**POM**	**X**	**Y**
x	x	x	o	o	o		o	o	o	o	o	o	x	x	oo	xxxx	ooo

KEY:

FRT = FOREST ENUMN = ENUMNERATION DECI = DECIMAL

CSN = CONSECUTIVE STEM NUMBER SIC = STEM IDENTITY CLASS BH = BREAST HEIGHT

DBH = DIAMETER AT BREAST HEIGHT

TABLE OF IDENTITY CLASSES AND OTHER CODES FOR STEMS ≥ 1.0 - <10.0 CM DBHOB

STEM IDENTITY CLASSES	X X 1	X X 2	X X 3	X X 4	X X 5	X X 6	X X 9
	COMPLETE TRUNK	BROKEN		CUT STUMP	BR ST WH CO	BD EN	NOT FOUND
		STEM	STUMP				
2.0 TREE SPECIES,STEM ≥ 1.0 - < 10.0 CM DBH							
2.1 SAPLING ALIVE, STANDING	211	212	213	241	215	216	219
2.2 SAPLING ALIVE, FALLEN	221	222	223	224	225	226	229
2.3 SAPLING DEAD, STANDING	231	232	233	234			
2.4 SAPLING DEAD, FALLEN	241	242	243	244			
2.5 2+ STEM STANDING	251	252	253	254	255	256	259
2.6 BRANCH BELOW POM	261	262	263	264	265	266	269
2.7 COPPICE BELOW POM	271	272	273	274		276	279
2.8 DEAD AT POM. COPPICE PRESENT	281	282	283	284		286	
2.9 TREE MISSING		298	TREE MISSING, DEAD				299

KEY: BR ST WT CO — Broken stem/ stump with coppices
BD EN — Broken during enumeration
Stem identity class — 2.3, 2.4, 2.8, 2.9 and X X 9 are not to be used during initial enumeration

SKETCH - MAP OF THE SUBPLOTS
COMPASS ORIENTATION OF SUBPLOT
CORNER A: DUE WEST- DIE NORTH
CORNER B: DUE NORTH - DUE EAST
CORNER C: DUE EAST - DUE SOUTH
CORNER D: DUE SOUTH - DUE WEST

THE CORNERS, ABCD, OF ALL SUBPLOTS IN AN ASSESSMENT PLOT ARE ORIENTED IN THE SAME DIRECTION FOR THE FIRST ENUMERATION, SHOW ALL STEMS 1.0 -< 10 CM DBH, LIVING OR DEAD. (STANDING OR FALLEN) EXCAVATOR TRACKS, WATERCOURSES, OPEN SPACES AND OTHER PHYSICAL FEATURES FOR THE LATER ENUMERATOR. SHOW NEW RECRUITS AND CORRECTIONS ONLY.

APPENDIX III- FIELD DATA SHEET FOR RECORDING SEEDLINGS

FIELD DATA SHEET FOR RECORDING SEEDLINGS

FIELD DATA SHEET FOR TREES

TOTAL NUMBER OF RECORDS (LINE ENTRIES) IN THIS QUADRAT: ....

MAXIMUM VALUE RECORDED FOR CONSECUTIVE STEM NUMBER : ....

FILE INFORMATION

SAMPLE PLOT NUMBER			FRT TYPE CODE		YEAR OF ENUMN				DECI DATE	

DATE: ..../ ..../ ....

NAMES OF STAFF MEMBERS

BOOKER : ....

MEASURER/ SPECIES IDENTIFIER : ....

LINE ENTRIES FOR TREE SPECIES - SEEDLINGS ≥ 20 CM - HT < 1.0 CM DBH

QUADRAT STOCKED ? (YES = 1: NO =2) ASSESSMENT PLOT NUMBER [| |] QUADRANT NUMBER [| |]

SAMPLE SIZE = 2 SUBPLOT: QUADRANT A1, A2, A3, A4, A5; B1, B2, B3, B4, B5; C1, C2, C3, C4, C5; D1, D2, D3, D4, D5; E1, E2, E3, E4, E5 (CIRCLE ONE)

LOCALITY:

REMARKS ON THE SAPLING SUBQUADRAT
....
....

PAGE 1,2

STEM IDENTITY																CO-ORDINATES	
CSN			SIC			VERNACULAR NAME	SPECIES CODE						HEIGHT			X	Y
x	x	x	o	o	o		o	o	o	o	o	o	x	x	x	xxxx	ooo

KEY:

FRT = FOREST   ENUMN = ENUMNERATION   DECI = DECIMAL DATE

CSN = CONSECUTIVE STEM NUMBER   SIC = STEM IDENTITY CLASS   HT = HEIGHT

TABLE OF IDENTITY CLASSES FOR STEMS ≥ 20 CM HEIGHT - <1.0 CM DBH OF TREE SPECIES

STEM IDENTITY CLASSES	X X 1	X X 2	X X 3	X X 4	X X 5	X X 6	X X 9
	COMPLETE TRUNK	BROKEN		CUT STUMP	BR ST WH CO	BD EN	NOT FOUND
		STEM	STUMP				
3.0 TREE SPECIES,STEM ≥ 20 CM HEIGHT - < 1.0 CM DBH							
3.1 SEEDLING ALIVE, STANDING	311	312	313	314	315	316	319
3.2 SEEDLING ALIVE, FALLEN	321	322	323	324	325	326	329
3.3 SEEDLING DEAD, STANDING	331	332	333	334			
3.4 SEEDLING DEAD, FALLEN	341	342	343	344			
3.5 2+ STEM STANDING	351	352	353	354	355	356	359
3.6 BRANCH BELOW POM	361	362	363	364	365	366	369
3.7 COPPICE BELOW POM	371	372	373	374	375		
3.8 DEAD AT POM. COPPICE PRESENT	381	382	383	384	385		
3.9 TREE MISSING		398	TREE MISSING, DEAD				399

NB : SIC 3.3,3.8, 3.9 & X X 9 are not to be used during the initial enumeration. These SIC are only applicable during the re-enumeration

SKETCH - MAP OF THE SUBPLOT
COMPASS ORIENTATION OF SUBPLOT
CORNER A: DUE WEST- DIE NORTH
CORNER B: DUE NORTH - DUE EAST
CORNER C: DUE EAST - DUE SOUTH
CORNER D: DUE SOUTH - DUE WEST

THE CORNERS, ABCD, OF ALL SUBPLOTS IN AN ASSESSMENT PLOT ARE ORIENTED IN THE SAME DIRECTION.

APPENDIX IV- DECIMAL DATE

Table for Converting Celendar Dates into Decimals of a Year

Mnth. Day	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	0.00	0.09	0.16	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92
2	0.01	0.09	0.17	0.25	0.33	0.42	0.50	0.59	0.67	0.75	0.84	0.92
3	0.01	0.09	0.17	0.25	0.34	0.42	0.50	0.59	0.67	0.76	0.84	0.92
4	0.01	0.10	0.17	0.26	0.34	0.42	0.51	0.59	0.68	0.76	0.84	0.93
5	0.01	0.10	0.18	0.26	0.34	0.43	0.51	0.59	0.68	0.76	0.85	0.93
6	0.02	0.10	0.18	0.26	0.35	0.43	0.51	0.60	0.68	0.76	0.85	0.93
7	0.02	0.10	0.18	0.27	0.35	0.43	0.52	0.60	0.68	0.77	0.85	0.93
8	0.02	0.11	0.18	0.27	0.35	0.44	0.52	0.60	0.69	0.77	0.85	0.94
9	0.02	0.11	0.19	0.27	0.35	0.44	0.52	0.61	0.69	0.77	0.86	0.94
10	0.03	0.11	0.19	0.27	0.36	0.44	0.52	0.61	0.69	0.78	0.86	0.94
11	0.03	0.12	0.19	0.28	0.36	0.44	0.53	0.61	0.70	0.78	0.86	0.95
12	0.03	0.12	0.19	0.28	0.36	0.45	0.53	0.61	0.70	0.78	0.87	0.95
13	0.04	0.12	0.20	0.28	0.36	0.45	0.53	0.62	0.70	0.78	0.87	0.95
14	0.04	0.12	0.20	0.28	0.37	0.45	0.53	0.62	0.70	0.79	0.87	0.95
15	0.04	0.13	0.20	0.29	0.37	0.45	0.54	0.62	0.71	0.79	0.87	0.96
16	0.04	0.13	0.21	0.29	0.37	0.46	0.54	0.62	0.71	0.79	0.88	0.96
17	0.05	0.13	0.21	0.29	0.38	0.46	0.54	0.63	0.71	0.79	0.88	0.96
18	0.05	0.13	0.21	0.30	0.38	0.46	0.55	0.63	0.72	0.80	0.88	0.96
19	0.05	0.14	0.21	0.30	0.38	0.47	0.55	0.63	0.72	0.80	0.88	0.97
20	0.05	0.14	0.22	0.30	0.38	0.47	0.55	0.64	0.72	0.80	0.89	0.97
21	0.06	0.14	0.22	0.30	0.39	0.47	0.55	0.64	0.72	0.81	0.89	0.97
22	0.06	0.15	0.22	0.31	0.39	0.47	0.56	0.64	0.73	0.81	0.89	0.98
23	0.06	0.15	0.22	0.31	0.39	0.48	0.56	0.64	0.73	0.81	0.90	0.98
24	0.07	0.15	0.23	0.31	0.39	0.48	0.56	0.65	0.73	0.81	0.90	0.98
25	0.07	0.15	0.23	0.32	0.40	0.48	0.56	0.65	0.73	0.82	0.90	0.98
26	0.07	0.16	0.23	0.32	0.40	0.48	0.57	0.65	0.74	0.82	0.90	0.99
27	0.07	0.16	0.24	0.32	0.40	0.49	0.57	0.65	0.74	0.82	0.91	0.99
28	0.08	0.16	0.24	0.32	0.41	0.49	0.57	0.66	0.74	0.82	0.91	0.99
29	0.08		0.24	0.33	0.41	0.49	0.58	0.66	0.75	0.83	0.91	0.99
30	0.08		0.24	0.33	0.41	0.50	0.58	0.66	0.75	0.82	0.92	1.00
31	0.08		0.25		0.41		0.58	0.67		0.82		1.00

APPENDIX V- FIELD DATA SHEET FOR COLLECTING SOIL SAMPLES

FIELD DATA SHEET FOR RECORDING SOIL SAMPLES

Permanent Plot No. : .... **Date: ..../ ..../ ....**

Recorder : .... **Suunto Clinometer Reader : ....**

SQ												

KEY:

QN =	QUADRAT NUMBER	CSN =	CONSECUTIVE STEM NUMBER	SPC = 4-LETTER SPECIES CODE
GL =	GROUND LEVEL	LC =	LOWEST CROWN	TC= TIP OF CROWN
S=	SOUTH	E = EAST		CH = CROWN HEIGHT
HD =	HORIZONTAL DISTANCE	W= WEST		

GUIDELINE 4

FOREST ZONING: PROCEDURES TO IDENTIFY PRODUCTION, PROTECTION AND COMMUNITY-USE AREAS

FOREST ZONING: PROCEDURES TO IDENTIFY PRODUCTION, PROTECTION AND COMMUNITY-USE AREAS

1.0 SCOPE

These procedures are meant to identify and demarcate sensitive areas for the protection as well as production and community use, and shall apply to all the Forest Timber licences except those Occupational Ticket (OT) licences covering alienated or titled land in Sarawak. The whole process is called Forest Zoning.

2.0 OBJECTIVES

Forest zoning by specific pre-determined functions integrates the needs of different stakeholders in forest management. It integrates soil and site-related aspects to minimize detrimental environmental effects during timber harvesting, timber stocking density, wildlife protection zones, community use zones and areas or locations suitable for recreational activities. As a result, a forest function map is produced with three key forest functions.

3.0 POLICIES

Forest zoning should be the first activity during the pre-harvesting planning stage to derive the net area available for the production function of the forest.

Forest zoning is based on one or more of the following sources of information:

a) Aerial Digital Images
b) Aerial Photographs
c) Satellite Imageries
d) Contoured Maps from the Lands and Surveys Department

The Forest Function Map with a scale of 1:50,000 produced will be used for the planning of forest roads, landings and skid-trails.

Forest zoning is to be done by the licensee and then incorporated into the General Harvesting Plan (GP) and Detailed Harvesting Plan (DP)/ Road Plan for the coupe scheduled for harvesting. This forest zoning exercise is an update to the earlier one, which was done when the timber license was first issued, and incorporated in the GP. Areas zoned for the protection of wildlife, for example, may need to be changed in the light of more surveys conducted or discoveries made since the forest zoning exercise was first done 10 years earlier when the license was issued.

4.0 PROCEDURES

4.1 Definition

Forest zoning is defined as the zoning of a Forest Timber licence area into the various forest functions based on the topography and the prevailing land use patterns. It is broadly zoned into 3 key forest functional zones namely, production, protection and community use zones.

i. Production Zone

The production forest zone of a coupe is the total net area that can be harvested for timber by employing either ground-based skidding system or air-borne yarding system.

ii. Protection Zone

The protection forest zone is to be left untouched during harvesting operations for conservation purposes.

This zone includes:

a) Soil and water protection zone (Terrain class IV)
b) Wildlife protection zone
c) Low timber volume stocking zone

iii. Community Use Zone

The community use zone is also not to be harvested. This area is reserved for the use of the local communities living in the vicinity of the forest area.

The zone includes:

a) Water Catchments
b) Farming and shifting cultivation areas
c) Areas of cultural interest such as burial ground, ritual and archaeological sites, and recreational potential sites.

4.2 Timing for Implementation

Ground work for forest zoning will commence once operations 1 to 4 of Permit to Enter Coupe (PEC) is endorsed. The completed report together with the Forest Zoning Map is to be submitted to the relevant agency for ground verification and approval before the application of Pre-Felling Checking.

4.3 Information Database

The Forest Zoning database consists of four GIS layers of information.

The Forest Zoning Map, which is the resulting output of the forest zoning exercise, is produced using the GIS and involves the integration of the followings:

a) Site Classification Layer
b) Timber Stocking Density Layer
c) Wildlife Zones Layer
d) Community Use Layer

These layers of information are derived from the following sources depending on their availability.

a) Aerial Digital Images
b) Aerial Photographs
c) Satellite Imageries
d) Contour Maps (Scale 1:50,000) of the T735 series printed by Directorate of National Mapping or T738 series by JUPEM.

4.4 Steps Involved

4.4.1 Compartmentalization

A forest harvesting block (compartment) is a permanent, geographically recognizable unit of forest land that forms the basis for planning and management prescription, implementation, monitoring and recording of forest operations (the smallest accounting unit).

Boundaries of a harvesting block should preferably be based on permanent geographical features such as rivers, streams, ridges and gullies. Roads and wide skid trails from previous timber harvesting may also serve as permanent boundaries.
The average size of a forest harvesting block ranges from 50 to 100 hectares. However, those blocks belonging to non-commercial timber stocking areas, such as Kerangas Forest, Montane Forest, Limestone Forest and shifting cultivation affected areas may have larger sizes. These blocks are sequentially numbered.

In forest zoning, each and every single harvesting block shall be allocated with a specific end function based on the outcome of analysis of the four main layers of database as described in Paragraph 4.4.2 below.

4.4.2 Layers of Database Used For Forest Zoning

a) Site Classification

This layer of database on site classification shall form the basis for forest zoning.

Site classification is based on topography. The whole area is classified into four terrain classes as tabulated below:

Terrain Class	Description
I	Flat to gentle rolling country.
II	Undulating with dissected broken hill country.
III	Mountainous with moderate to long slopes. Country usually rough and dissected.
IV	Steep mountainous country and more than half of the area has long, continuous slopes with gradients in excess of 35^{o}.

The terrain classification can be done using either one of the following means.

i. Interpretation of suitable aerial photographs using a mirror stereoscope. Pairs of aerial photographs must be available with 50% overlapping as to obtain a stereoscopic effect for terrain classification.

or;

ii. Using Contour Map. A ruler is used to measure the distance between two contour lines for identifying areas with slope of 35^{o} and above. For a slope gradient of 35^{o}, the spacing between the contour lines for different contour intervals are as shown below.

Provided, that any latest information received or any updating of Forest Type Map B.

Contour interval (in meter)	Spacing (in mm)
100	2
200	4
300	6
400	8
500	10

Field verification through either aerial reconnaissance or ground truthing is conducted to confirm the terrain classes identified.

For site classification, the area is broadly classified into two main classes, namely:

i. Protection area: Terrain Class IV. The area shall be reserved for soil, water and environmental protection and no logging activity is allowed.

ii. Production area: Terrain Class I, II and III. It is further divided into two end use sub-functions namely,

- Area under ground-based harvesting system in Terrain Class I, II and III. These areas are less than 35^{o} in slope gradient.
- Area under airborne harvesting system in Terrain Class IV. This area generally has slope gradient in excess of 35^{o}.

b) Timber Stocking Density

This layer of database is based on timber stocking volume of the natural forest vegetation.

Generally, in the inland hill forest, six forest types can be recognized via:

i. Kerangas forest
ii. Limestone forest
iii. Montane forest
iv. Mixed-Dipterocarp Forest Class I
v. Mixed-Dipterocarp Forest Class II
vi. Mixed-Dipterocarp Forest Class III

Based on the potential commercial timber volume stocking density in each forest type a function is allocated.

To summarize, the allocation of forest functions is as tabulated below.

Forest Type	**Potential Timber Stocking**	**Function**
Kerangas	Predominantly non-commercial timber stocking	Protection
Limestone	Non-commercial timber stocking	Protection
Montane forest	Non-commercial timber stocking	Protection
Mixed-Dipterocarp I	Low timber stocking	Production
Mixed-Dipterocarp II	Medium timber stocking	Production
Mixed-Dipterocarp III	High timber stocking	Production

The determination of the forest function for each harvesting block depends on the dominant forest type that covers the block:

i. Protection Function: in case ≥ 50% of a logging block is covered by non-commercial forest types.

ii. Production Function: in case ≥ 50% of the logging block is covered by any commercial forest type (i.e. MDF I, II or III) or by a combination of different commercial classes.

c) Wildlife Protection Zone

The layer of database on wildlife protection zone is identified with the assistance of the officers from the authority.

Basically, the creation of wildlife protection zones requires two subsequent steps of data collection:

i. Habitat diversity and extent
ii. Wildlife composition of each habitat type

Habitat types, such as limestone outcrops and montane forest, have special significance for wildlife, because they support species that are not found elsewhere. These areas have a higher priority for conservation.

For wildlife conservation three forest functions have been determined:

i. Core protection zone
ii. Low-use production zone
iii. Production zone (without restrictions)

The core protection zone is fully reserved as conservation area so that no timber harvesting is permitted.

Low-use production zone means, timber harvesting is allowed though with lower volume output and minimum disturbance to maintain habitat structure and composition at higher levels. This is achieved through airborne harvesting methods.

The production zone without restrictions, where resilience to habitat disturbances is greater, would be suitable for ground based skidding systems.

d) Community Use Zone

This layer of database on community use area is based on the actual land use of the area in which all-existing shifting cultivation areas, gravity feed water catchment and area of cultural interest are identified. The area proposed as Community Use areas is based on the following facts:

i. Most of the areas identified as Community Use areas may be subjected to future claims under Native Customary Rights, and therefore cannot serve as production area until the land claims have been legally settled.

ii. Most areas presently do not bear commercial timber stocks but softwood pioneer flora that has developed by natural succession.

iii. Water catchment to the communities, area of cultural interest such as burial ground, ritual and archaeological sites are reserved and not to be disturbed.

A block is to be allocated as a community use area if the shifting cultivation portion covers at least 50% of the block.

e) Eco-tourism Potential Spot

The locations of places where there are eco-tourism potential shall be included in the Forest Functions Map whenever they are being identified and confirmed on the ground. It is not considered as a layer of database by itself.

Among the key attractions are waterfalls, fast flowing rivers and mountain ridges with viewpoints for scenic landscapes and local community settlements.

Their potential activities include :

i. Mountain climbing
ii. Jungle trekking
iii. Picnicking
iv. Swimming
v. Caving
vi. Rafting
vii. Longhouse visit and traditional events.

4.4.3 Forest Function Determination

After overlaying all the layers of database as described in paragraph 4.4.2 above, the final forest function for each and single forest harvesting block is then determined.

The procedure for determining the final forest function of a harvesting block is as follows:

i. For each data layer in the overlay map allocate the harvesting blocks with the two differing functions either protection or production function

ii. Protection harvesting blocks remain as protection function.

iii. The protection function is superior to the production function. Thus those production harvesting blocks where the protection function is given through any layer are reclassified as protection.

iv. The next is to determine the harvesting system in the production harvesting blocks .

v. From the set of production harvesting blocks, those harvesting blocks are selected where the site classification function is determining that this area is only suitable for airborne yarding and the appropriate function is allocated.

vi. The remaining production areas where the site classification function is ground based skidding system are grouped into the function ground based skidding system.

In short, if any of the aspect recommends protection then that harvesting blocks is allocated a protection function except for the harvesting blocks where shifting cultivation is the dominant land use. In this case, the harvesting blocks are allocated as a community use area. To determine the harvesting system in the production areas the forest function based on site classification served as the basis.

5.0 FORMAT FOR REPORT

a) Statement of Area by Forest Functions

No.	Forest Function Zones	Land Size (ha)	Coverage (%)
1.	Production Zone		
2.	Protection Zone		
	i. Soil and Water Protection Zone (Terrain IV)		
	ii. Wildlife Protection Zone		
	iii. Low Timber Volume Stocking Zone		

3.	Community Use Zone		
	i. Water Catchment		
	ii. Farming/S.A.		
	iii. Cultural Area		
	Total		**100 %**

b) List of reference materials used for Forest Zoning Process

No.	Material Source	Reference / Specification No.	Forest Functions
1.	Aerial Digital Images		
2.	Aerial Photographs		
3.	Satellite Imagery		
4.	Contour Map		

GUIDELINE 5

GUIDELINES FOR MONITORING OF HIGH CONSERVATION VALUES

GUIDELINES FOR MONITORING OF HIGH CONSERVATION VALUES

1.0 INTRODUCTION

The high conservation values associated with natural forests is addressed as one of the principle i.e **Principle 9: Maintenance of the High Conservation Value Forests** in the forest management certification. In Malaysia, the High Conservation Value Forest (HCVF) Toolkit for Malaysia by WWF-Malaysia is used for the Assessment of the High Conservation Values (HCVs) in a Forest Management Unit (FMU) going for certification.

The Forest Management Plan (FMP) and prescribed activities use a precautionary approach to the process of management for the monitoring and minimizing the negative impacts on biodiversity, soil and water. Certification requirements have brought improvements to aquatic and riparian areas, identification and protection of HCV and threatened and endangered species. Reduce Impact Logging (RIL) practices tends to have a relatively positive effect on wildlife through lower species loss in RIL forests.

Certified forests can be useful supplement to the protected areas such as National Parks and Nature Reserves which offer ideal habitats for wildlife. It's because certified forest provide corridor connectivity between individual and isolated habitats in logging concessions. Hunting and logging are also strictly controlled. The maintenance or enhancement of HCV is ensured to serve as critical habitat for rare and threatened species.

2.0 PURPOSE OF HCV MONITORING

The overall purpose of HCV monitoring is to determine whether HCV management strategies are being implemented and management objectives are being met (i.e are HCVs being maintained?). Monitoring does not always require comprehensive biodiversity survey but should use appropriate indicators to assess whether HCVs are being maintained and whether management activities are effective.

Indicators need to be efficient, consistent, standardised and repeatable. Consistent, standardised monitoring is important to understand the changes in HCV area. Monitoring data should be recorded and stored in a centralised database, as it will be useful for analysing long term trends in HCVs. However, it should be noted that monitoring specific HCVs does not always reveal the cause of observe changes in an HCV as it is not an assessment of cause and effect.

2.1. Effective Monitoring

An HCV may be declining, or a management strategy may be ineffective because of number of reasons, including:

- Practical barriers to management implementation, e.g. no-fishing zones have the potential to reverse declines of threatened fish species, but may be hard to enforce in areas with high rural population densities.

- Poor implementation of management strategies, e.g. a conservation area is unlikely to effectively maintain an HCV unless it is combined with patrols to prevent illegal or restricted activities.

- New or changing threats/conditions i.e. FMU cannot be held responsible for all changes due to threats that are beyond its control, e.g. climate change.

Therefore it is also important to monitor the effectiveness of the management activities and threats to HCVs.

3.0 TYPES OF HCV MONITORING

3.1. Operational Monitoring

Operational monitoring is to evaluate whether management plans are being implemented. This covers all management prescriptions (e.g SOPs) across the FMU andnot limited to HCV management. This allows managers to monitor operational compliances. Examples include monitoring of SOPs relating to road construction, harvesting operations and maintenance of HCV boundaries. Operational monitoring should be carried out frequently enough to uncover areas of concern to be followed up by more targeted monitoring, e.g. evidence of polluted waterway that could be followed up by more detail water quality analysis.

3.2. Strategic/ effectiveness Monitoring

Strategic/ effectiveness monitoring aims to assess whether HCVs are being maintained by current management plans. Strategic monitoring focuses on assessing longer-term trends in the status of HCVs and, therefore, tends to be conducted less frequently than operational monitoring. It typically requires more time-consuming techniques and analysis, e.g. flora and fauna surveys. Data collected during strategic monitoring can be supplemented by less standardised data from operational monitoring or opportunistic observances.

The schedule of strategic monitoring will depend in part on the vulnerability of the value being monitored and the cost of monitoring. For example, the presence of a concentration of endangered animal species that is at great risk from poaching may need considerable, regular monitoring patrols. However, this may be costly and require support from external conservation organisations or government.

3.3. Threat Monitoring

Understanding threats to HCVs is a critical step in making management recommendations to maintain and/ or enhance the values. The threats are typically group according to the following categories:

i. Indirect vs. Direct threats: All direct threats that are likely to be encountered but indirect threats can be more complicated. For example, wildlife hunting by local villagers may be direct threat to and HCV 1 species, but indirect causes of this may include no available, affordable, or palatable alternative protein sources.

ii. Internal vs. External threats: Threats to HCVs can have internal sources, from the FMU's own operations (e.g. road building, habitat fragmentation, pollution, conversion), or external sources (e.g. encroachment, illegal logging and hunting, poor governance).

3.4. HCV Monitoring Scope

The HCV assessment has identified the HCV attributes for management and monitoring by the FMU. The management measures and monitoring recommendations are summarised in Appendix I. The scope of monitoring the HCV attributes are shown in **Table 1** below.

Table 1. Scopes of HCV Monitoring by Action Plan

HCV	Monitoring Recommendation	Action Plan
1.1 Protected Areas	Buffer zones should periodically or regularly monitored. Records of patrols are to be kept and made available.	To be carried out minimum half yearly.
1.2 Threatened and Endangered Species	1. Records of entry by outsiders and incidents of hunting should be kept and made available. 2. Database on wildlife found in the areas should be kept for reference and made available. 3. A long term monitoring of all Totally Protected (TP) plants and Endangered, Rare & Treatened (ERT) species shall be carried out to understand their survival and population/ regeneration. The data shall be made available. 4. Internal auditing shall be conducted on the Reduced Impact Logging (RIL) implementation to ensure compliance with measures in RIL Guidelines: a) Do not damage or push nest trees used by birds and bees; and b) Only tagged trees for felling are allowed to be cut.	1. Procedures of Hunting Control and Wildlife Monitoring (SFM/PR004) 2. RIL Guidelines
1.3 Endemism	1. Long term monitoring of the species including the identification, recording of the sighting and mapping is undertaken with assistance from the relevant agency or organisation. 2. The data shall be made available. 3. For protected plants under Wildlife Protection Ordinance (WLPO) 1998, proper documentation of tagged plants and shall be carried out during RIL monitoring operation. 4. Guidelines on mother trees are in accordance to RIL Guidelines.	Guidelines for Selection of Seed Trees, Potential Crop Trees, Fruit Trees and Protected Trees Species (SFM/GL004)
1.4 Critical Temporal Use	1. Critical sites for feeding nesting and roosting shall be monitored and updated on frequent basis. 2. Saltlicks shall be monitored and protected. Data and record are kept and made available.	1. Procedures on Hunting Control and Wildlife Monitoring (SFM/PR003) 2. Guidelines for Fauna Conservation and Ecosystem Management.

2 Landscape Level Forest	RIL compliance area.	1. Quarterly Environment Monitoring Report (EMR) 2. RIL Guidelines
3 Ecosystem	Changes of the forest in the FMU shall be monitored through latest satellite imagery.	Latest spot Satellite Imagery Interpretation
4.1 Watershed Protection	Class IV terrain areas and buffer zones area mapped on Detailed Harvesting Plan/ Road Plan (DP/RP)	Compliance with guidelines on DP/RP preparation
4.2 Erosion Control	Periodical and random auditing of the buffer zones shall be done to monitor the health of the rivers before and after harvesting operation to ensure buffer zone is functioning and properly demarcated.	Quarterly EMR
4.3 Barriers to Destructive Fire	1. Periodic auditing shall be conducted to ensure the integrity of the buffer zones. 2. During long period of draught, the Emergency Response Team is to be alerted and on standby all the time.	1. Forest Fire Management Plan 2. EIA Report
5 Basic Needs of Local Communities	1. Annual monitoring of areas surrounding the water catchment to ensure no illegal felling or encroachment. 2. Monitoring shall be jointly carried out with the CRC representative of local communities.	1. Consultation with the community Representative Committees (CRC) 2. SFM Liaison Committee Meeting.
6 Cultural Identity of Local Communities	Identification and locality of salt spring and burial/ cultural/ historical/ spiritual sites	1. CRC of local communities. 2. Procedures for forest zoning (Production, Protection and Community Use Areas)

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GUIDELINE 6

GUIDELINES AND PROCEDURES FOR SOCIAL IMPACT ASSESSMENT AND MONITORING OF FOREST MANAGEMENT OPERATIONS FOR FOREST MANAGEMENT CERTIFICATION IN SARAWAK

GUIDELINES AND PROCEDURES FOR SOCIAL IMPACT ASSESSMENT AND MONITORING OF FOREST MANAGEMENT OPERATIONS FOR FOREST MANAGEMENT CERTIFICATION IN SARAWAK

1.0 INTRODUCTION

This guideline is adopted from UPM Guidelines and Procedures for Social Impact Assessment and Monitoring of Forest Management and updated to suit local condition of forest management activities in Sarawak. Social impact assessment (SIA) is a process to identify, predict, evaluate and communicate information on the adverse and beneficial impacts of proposed policy, plan, programme, project or operation that affects the community.

SIA basically serves as a planning tool to avoid or minimise adverse social impacts and enhance beneficial impacts. The SIA findings shall be used as part of the key elements in Forest Management Plan (FMP) which shall be updated periodically appropriate to the scale and intensity of forest management operation.

Evaluation of social impact is stipulated as one of the requirements in the Malaysian Criteria and Indicators for Forest Management Certification (MC&I) for the certification of a Forest Management Unit (FMU). The SIA findings need to be shared with the relevant stakeholders particularly the directly affected communities.

The key steps in implementing SIA are as follow:

a. Assessment and prediction of potential social impacts that may affect local communities as a result of the implementation of forest management operations in the FMU;
b. Recommendation of mitigation measures to avoid or minimize adverse social impacts which may occur during and after implementation of such operations;
c. Recommendation of measures to enhance the potential beneficial social impacts of forest operations; and
d. Development of a monitoring programme to evaluate the mitigation/ enhancement measures after their implementation.

2.0 SOCIAL IMPACTS

2.1 What are the key social impacts?

Steps	Activities	Issues
Step 1	Assessment of Impacts	Key social impacts include: • Impact on Environment • Impact on Socio Economy • Impact on Cultural and Spiritual
Step 2	Mitigation/enhancement measures	Key mitigation/ enhancement measures include: • Conduct pre-harvesting consultations with affected community. • Ensure that RIL/EIA measures are effectively implemented. • FMU manager to closely cooperate with relevant agencies and stakeholder groups conducting training programmes for community.

Step 3	Monitoring	Social monitoring includes: • Compliance monitoring • Impact monitoring
Step 4	Updating	Reporting and disseminating of information

2.2 Identification of Key Social Impacts

The key social impacts shall be identified based on the findings of the survey. The key impacts are likely to be related to water supply and quality, local economy and socio-cultural life. The river is the most important source of potable water for domestic use in bathing and washing.

Forests play an important role in the local economy through the provision of employment from forest operations as well as income generation from forest produce, harvesting and services.

In addition, aspects of local socio-cultural life which are affected by forest operations include increased accessibility of the forest, safety and health, traditional knowledge and skills, sanctity of cultural, historical and archaeological sites, aesthetics of the surrounding environment and general social health.

2.2.1 Key Social Impact 1: Environment

Community water supply: Harvesting of forest stands that serve as catchment to gravity-fed system will increase sediment loads and degrade the quality of drinking water due to siltation. Besides the lowered water pressure, the other usual complaints about water supply from villagers living close to forest harvesting or conversion areas is the turbidity of the water they use for drinking and cooking as well as other domestic uses such as bathing and washing. The water also has an unpleasant odour and taste. This in turn leads to health problems such as skin diseases and other water pollution related diseases.

River water quality: Adverse impact of forest harvesting or conversion activities may also be in the form of pollution and decreased volume of river water which contributes to declining aquatic life particularly fish, as well as threatening aquaculture. Water for farming (rice, vegetables) is affected by clogging of the irrigation system. There is also the hazard of flooding caused by increased water run-off during storm events.

2.2.2 Key Social Impact 2: Local Economy

Adverse impacts

- **Forest resources**: Depletion of nearby forest resources forces local communities to go deeper and further into the forest to obtain the forest resources (petai, honey, rattan, building materials and medicinal plants) to maintain their livelihood, making their life more difficult. Forest roads facilitate the entry of outsiders looking for forest produce, thereby increasing the number of people collecting the resources and thus contributing further to its depletion.

- **Occupation and income**: The depletion of forest produce could lead to a decrease in forest-related occupations (main and secondary) such as hunting and gathering for forest and river produce (flora and fauna). This decrease could also be the result of competition with outsiders whose accessibility to the forest has improved as a result of the forest roads. This reduces the family income of the local communities.

- **Landscape aesthetics**: Adverse impacts resulting from harvesting or conversion activities include landscape degradation due to excessive damage to natural vegetation cover and

proliferation of secondary vegetation (resulting in reduction of aesthetic values) and clogging of rivers with harvesting debris as well as river siltation (resulting in degradation or loss of water recreation sites). There adverse impacts on the landscape aesthetics may affect the potential of the natural forest as an ecotourism product.

Beneficial impacts

- **New job opportunities**: New jobs comprise those which are related to forest management operations, off-forest jobs and ecotourism.
    - **Forest management operations**: Jobs such as tree tagging, boundary marking, felling, bucking and tractor driving are possible new jobs for the communities. Other opportunities include nursery jobs, supply and planting of seedlings, supply of provisions to logging camps and etc.
    - **Off-forest jobs**: There are also opportunities for non-forest jobs resulting from the improved accessibility, which facilitates job seeking beyond the forest, such as in neighbouring oil palm and timber plantations.
    - **Ecotourism**: Ecotourism activities may also be created as a result of the improvement in the accessibility due to the presence of forest roads. Nature tourism activities such as trekking, kayaking, motivation camps, homestay, camping and outdoor recreation may be possible, thus providing business or employment opportunities to the local communities.
- **General local development**: Forest operations can catalyse development on a local scale. Accessibility is usually a precursor to local development, enabling systematic development by government and the private sector (such as infrastructure, schools, clinics and sundry shops).
    - **Forest roads**: Roads (mainly primary ones) that have been decommissioned can be upgraded to serve as the main access.
    - **Vehicle access**: Vehicular access results in greater movement of people and goods leading to an increase in economic activity.
    - **Access to external services**: Hitherto isolated communities now have better access to government and services (such as clinics, mobile medical services, schools and agricultural services) thus improving their living standards.

2.2.3 Key Social Impact 3: Socio-cultural Life

Adverse impacts

- **Health and safety**
    - **Infectious diseases**: Forest operations may result in possible afflictionsdue to water pollution (such as skin diseases/ itchiness, diarrhoea, vomiting), dirt and dust during dry seasons (like bronchial afflictions and coughs). Disease such as pulmonary tuberculosis (TB) and sexually transmitted diseases (STD) are attributed to contacts with forest workers.
    - **Wildlife disturbances**: The opening of the forest canopy due to forest operations often results in lush regrowth which attracts the herbivores and in their wake, the carnivores. The presence of these wildlife may lead to increased disturbances to community life.

- **Traditional knowledge and skills of local community**

    - **Forest-based knowledge**: There is a decrease in traditional and forest-based knowledge and skills (such as herb identification and use, hunting/ trekking and fishing skills) among the younger generation in the local community due to reduction in their practice as a result of resources being less accessible, decreasing interest as well as the availability of alternative sources of income.

    - **Knowledge on handicrafts**: Reduction in materials has led to a diminishing practice in the art of making traditional handicrafts such as fish/ animal traps and musical instruments.

- **Use of traditional knowledge and compensation**: The traditional knowledge of the community on herbs, languages and the arts, as well as skills in hunting and fishing, which has been studied by researchers or acquired by outsiders, is generally not compensated.

- **Historical and cultural sites (including scared areas)**: Such sites are at times destroyed or degraded unintentionally through forest operations. These may also include sites of potential archaeological significance. Such sites may be in the form of graves/ *pendam*, ancestral areas and rock/ monolithic formations.

- **Road-related safety and health**: Road safety is affected by traffic of logging lorries, road construction and repair. In addition, damage to village roads resulting from timber haulage also endangers the safety of road users. Further, increase in dust during the dry season, and muddy, slippery roads during the wet season affect road safety. Noise from logging vehicles using the road is another impact that the community has to cope with. These impacts are especially felt by the communities in cases where the logging roads are passing through and near to their villages.

Beneficial impacts

- **New knowledge and skills**: The community acquires new knowledge and skills related to forest management operations such as felling, planting, tractor driving, nursery works, inventory and surveying. As a result of the existence of forest roads, local people find it easier to go out and acquire new knowledge and skills by attending training programmes organized by various government agencies and the private sector.

- **New values and ethics**: Interactions with outsiders may bring positive values and ethics such as on work and outlook.

3.0 MITIGATION AND ENHANCEMENT MEASURES

What are the key mitigation and enhancement measures?

Steps	Activities	Issues
Step 1	Assessment of impacts	Key social impacts include: • Impact on Environment • Impact on local economy • Impact on socio-cultural life
Step 2	Mitigation and enhancement measures	Key mitigation/ enhancement measures include: • Conduct pre-harvesting consultations with affected community. • Ensure that RIL/EIA measures are effectively implemented. • FMU manager to closely cooperate with relevant agencies and stakeholder groups conducting training programmes for community.
Step 3	Monitoring	Social monitoring includes: • Compliance monitoring • Impact monitoring

3.1 Introduction

This section is designed to assist in determining the possible preventive, remedial, compensatory and enhancement measures for each of the key adverse/ beneficial impacts. Mitigation and enhancement measures will consist of related actions, which are aimed at ensuring effective management and control of site or operational activities. Mitigation and enhancement measures should be site-specific and based on the results of the assessment. To be effective and implementable, the mitigation/ enhancement measures recommended should be practical and easy to monitor.

Elements needing mitigation/ enhancement measures identified in the three key social impacts are listed below:

- Water supply and quality
- Forest resources
- Occupation and income
- Landscape aesthetics
- New job opportunities
- Health and safety
- Traditional knowledge and skills of local communities
- Historical and cultural sites
- Road-related safety and health
- New knowledge and skills

3.2 Mitigation and Enhancement Measures

Recommended mitigation and enhancement measures relating to the elements identified in the three key social impacts due to forest operations are summarised in **Table 1**.

Table 1. Key social impacts and mitigation / enhancement measures

No	Key Social Impacts	Mitigation/ Enhancement Measures
1.	Environment	• Conduct pre-harvesting consultations with affected community to identify hill water intake points to ensure that local water supply and quality are not adversely affected. • Ensure RIL/EIA measures are effectively implemented specifically in relation to water sources and intake points.
2.	Local economy • Forest resources • Occupation and income • Landscape aesthetics • New job opportunities and general local development	• Ensure all measures to conserve and protect forest resource are complied with as per the requirements set out in the RIL, EIA and MC&I. • Stricter enforcement on access to FMU Area/ PFE by non-authorised persons. • Ensure all measures to conserve and protect forest resources are complied with as per the requirements set out in the RIL, EIA and MC&I. • Stricter enforcement on access to FMU Area/ PFE by non-authorised persons. • FMU manager should encourage employers to provide employment opportunities to local community. • Forest areas identified as having High Conservation Value (HCV) attributes, aesthetic and tourism values are not to be logged and appropriate buffer zones should be established. • The relevant agencies, in collaboration with the FMU management, should ensure adequate and permanent access for external services (such as medical and agricultural) to benefit the local community.
3.	Socio-cultural life • Health and safety • Traditional knowledge and skills, their use and compensation • Historical and cultural sites • Road-related safety and health • New knowledge and skills, new values and ethics	• FMU manager to closely cooperate with the licence holder, relevant authorities and JKKK to take measures to minimise impacts of forest operations on the health of the community; e.g. safeguarding water quality to prevent water-related ailments and reducing dust pollution associated with coughing and eye diseases. In order to protect the community from spread of communicable diseases from forest workers, FMU manager and licence holder should ensure that such threats are minimized. • FMU manager to work closely with relevant authorities in monitoring wildlife in the FMU Area/ PFE and take preventive measures to reduce wildlife disturbances. • Ensure all measures to conserve and protect forest resources are complied with as per the requirements set out in the RIL, EIA and MC&I. • FMU manager to make available relevant sections of SIA reports to relevant government agencies as well as NGOs to enable them to conduct programmes to preserve traditional knowledge and skills of local community and to document the use of their traditional knowledge for purposes of fair compensation. • FMU manager to consult closely with the community in the identification and protection of sites of cultural, historical and archaeological significance as per the MC&I.

		• FMU manager to monitor the conditions of forest roads through regular maintenance, in cooperation with the licence holders. • Local community to be given the opportunity and priority to gain new skills related to forest operations. They may also be encouraged to adopt new values and ethics related to work.

3.3 Multiple Impacts

In an assessment, an area that is expected to suffer multiple impacts should be given more attention than an area with a single impact. If forest operations in a certain licence area are expected to impact the surrounding communities in more than one aspect then this should be highlighted in the assessment and taken into account in designing the mitigation/ enhancement measures.

3.4 Scheduling and Responsibilities

Forest harvesting or conversion activities in the PFE are carried out in numerous areas at the FMU level. Therefore the mitigation/enhancement measures have to be identified and managed at this level. The overall responsibility to plan and implement the mitigation/enhancement measures shall rest with the FMU manager.

3.5 Incorporation of SIA Findings and Recommendations into the Forest Management Plan

The relevant findings and recommendations of the SIA report comprising the identified key social impacts, mitigation/ enhancement measures and monitoring procedures shall be incorporated into the FMP and implemented by the FMU manager. In implementing these mitigation measures, appropriate mechanisms should be put in place to resolve conflicts including provision for fair and equitable compensation, on a case by case basis.

4.0 MONITORING

What type of monitoring is required?

Steps	Activities	Issues
Step 1	Assessment of impacts	Key social impacts include: • Impact on Environment • Impact on local economy • Impact on socio-cultural life
Step 2	Mitigation and enhancement measures	Key mitigation/enhancement measures include: • Conduct pre-harvesting consultations with affected community. • Ensure that RIL/EIA measures are effectively implemented. • FMU manager to closely cooperate with relevant agencies and stakeholder groups conducting training programmes for community.
Step 3	Monitoring	Social monitoring includes: • Compliance monitoring • Impact monitoring

4.1 Introduction

This section elaborates the following:

- Compliance monitoring to ensure compliance with the recommended mitigation/enhancement measures.
- Impact monitoring of relevant key social impacts after forest harvesting or conversion activities to evaluate the effectiveness of the mitigation/ enhancement measures.

4.2 Compliance Monitoring

As the social impacts of forest harvesting or conversion activities generally became a requirement over a period of time, the monitoring of compliance with the mitigation/ enhancement measures is essential and must be accorded high priority by the FMU manager.

In the monitoring compliance with mitigation/ enhancement measures, relatively easy and economically viable methods of checking for compliance should be employed.

The following are examples of compliance monitoring requirements that could be considered in relation to the mitigation/ enhancement measures.

A. Environment

Self-monitoring by FMU managers through evaluation of compliance of forest harvesting to RIL/EIA measures. Visits to randomly selected communities to obtain feedback regarding compliance with RIL/EIA requirements by licence holders.

B. Local economy

Forest resources

- Self-monitoring by FMU manager through evaluation of compliance of licence holders to RIL, EIA and MC&I requirements in relation to measures for the conservation of forest resources.
- Assess response to measures preventing access to PFEs by non-authorised persons.
- Visits to randomly selected communities to obtain feedback regarding compliance with these requirements.

Occupation and income

Self-monitoring by FMU manager through evaluation of compliance of licence holders to RIL, EIA and MC&I requirements in relation to measures for the conservation of forest resources. Assess response to measures preventing access to PFEs by non-authorised persons.

Landscape aesthetics

Self-monitoring by FMU manager to ensure that forest areas with HCV attributes, aesthetic and tourism values are not logged and buffer zones are established.

New job opportunities and general local development

Obtain feedback from development agencies, regarding response of the local community to efforts in encouraging them to take up new job opportunities; and to record benefits obtained from external services resulting from local development.

C. Socio-cultural life

Health and safety

Self-monitoring by FMU manager, in cooperation with relevant government agencies and the JKKK to assess effectiveness of measures taken to minimize negative impact of forest operations on the health of the community.

Traditional knowledge and skills, their use and compensation in the local community
Obtain feedback from local community regarding their response on programmes to preserve traditional knowledge and skills of the community; and on payment of compensation for knowledge and skills used by outsiders.

Historical and cultural sites
Self-monitoring by FMU managers to ensure that sites with historical, cultural and archaeological significance are identified and protected during forest harvesting operations.

Road-related safety and health
Self-monitoring by FMU manager on the conditions of forest roads through regular maintenance, in cooperation with the licence holders.

New knowledge, skills, values and ethics
Obtain feedback from local community regarding extent to which they have received information on new knowledge and skills, especially those related to forest operations, and encouragement on adoption of new values and ethics related to work.

4.3 Impact Monitoring
As follow up to the mitigation/ enhancement measures taken by the FMU management the impact on the community need to be monitored in order to gauge their effectiveness.

The following are examples of such impact monitoring measures that can be undertaken.

A. Environment
The main water quality parameter associated with forest harvesting or conversion activities in the PFE is the increase in total suspended solids, largely in the form of suspended sediments, which affects the community's potable water supply as well as river water for domestic use. Under normal circumstances the water quality is restored within 2-5 years after the harvesting activities have stopped. Thus the water supply needs to be monitored in the following manner:

- FMU manager to monitor the quality of water supply to the community during the preparation of the closing report for each harvesting operation.
- FMU manager to monitor actions taken to improve water quality.

B. Local economy

Forest resources
Post-harvesting visit by the FMU manager to the community to assess and obtain feedback regarding the status of forest resources important to the community.

Occupation and income
Post-harvesting visits by FMU manager to the community to assess and obtain feedback regarding the effect of forest operations on the occupation and income of the community.

New job opportunities and general local development
Post-harvesting visit by the FMU manager, in cooperation with the relevant agencies, to the community to assess the uptake of new job opportunities by the community; and to record beneficial impacts on the local community resulting from assess to external services.

C. Socio-cultural life

Health and Safety
Post-harvesting visit by the FMU manager, in cooperation with the relevant agencies, to the community to assess the health of the community. Post-harvesting visit by FMU manager, in cooperation with other relevant agencies to the community to assess the situation with regard to wildlife disturbances.

Traditional knowledge and skills, their use and compensation in the local community
The FMU manager to obtain feedback from local community on their response to the training programmes, and on the use of their traditional knowledge and skills and compensation for such use.

Historical and cultural sites
The FMU manager to obtain feedback from local community on the impact of forest harvesting operations on sites with historical, cultural and archaeological significance as identified.

Road-related safety and health
Field inspection by the FMU manager to assess impact of forest operations on road conditions in relation to road-related safety and health of the local community.

New knowledge, skills, values and ethics
Obtain feedback from local community regarding their response to opportunities for learning new skills, especially those related to forest operations; and record changes in attitude towards work resulting from interaction with outsiders.

4.4 Monitoring Techniques
The techniques listed below may be primary means used in compliance and impact monitoring:

- **Photographs**. Photographs can be used as evidence of the implementation of the recommended mitigation/enhancement measures. When photographs are submitted as evidence for compliance and impact monitoring, the date and time the photographs were taken should also be recorded.

- **Field checks**. Post-harvesting field checks should be undertaken to ensure compliance with the mitigation/enhancement measures.

- **Reports from local community**. Written or oral reports with substantiated evidence from local community can assist in checking compliance with the mitigation/ enhancement measures.

- **Satellite images**. Even though land-bound photography can be used to monitor mitigation/ enhancement measures related to protecting local community water supply and nearby rivers used by the community, satellite imagery provides a quick way to conduct compliance monitoring of these measures.

4.5 Managing Unexpected Impacts
Monitoring shall also cover the monitoring of unexpected impacts that is impacts not identified by the SIA report, which may occur during and after forest operations. If such unexpected impacts arise, additional mitigation and enhancement measures shall be developed, implemented and monitored.

5.0 SOCIAL IMPACT ASSESSMENT REPORT FORMAT

5.1 Introduction

The findings of an SIA of forest operations have to be presented in a clear and concise manner that can be easily understood by the relevant stakeholders as well as the affected parties. The usefulness of a SIA report is measured by how accurately the potential adverse and beneficial impacts are identified and how clearly their mitigation and enhancements measures are formulated to ensure effective implementation, prior to forest operations.

To facilitate the FMU manager's review of the findings, the following must be included in the SIA report:

- An Executive Summary of the SIA findings.
- A summary table of key social impacts, mitigation and enhancement measures as well as monitoring procedures.

5.2 Executive Summary

An Executive Summary is a brief and concise summary of the SIA findings and recommendations. The Executive Summary should be written in straight forward non-technical language to enable easy understanding by the FMU manager and staff as well as the affected parties.

The contents of the Executive Summary should generally include the following information:

- Name of the party undertaking the assessment.
- Key areas/ aspects of the existing social environment where significant impacts are expected to occur.
- Key social impacts and proposed mitigation and enhancement measures.
- Compliance and impact monitoring procedures.
- Conclusions and recommendations of the SIA.

5.3 Main Report

5.3.1 Initiator of SIA and Consultant

- Initiator (FMU manager) - Name, address, contact number(s) of person(s) to whom may be referred to for information. List of all FMU staff involved in the assessment.

- SIA Consultant/ Assessor (if any) - Name, address, contact number of person (normally the chief consultant/assessor) to whom may be referred to for information. List all consultants/ assessors involved in the assessment.

5.3.2 Baseline Socio-economic and Cultural Profile

A description of the following elements will provide a clear picture of the baseline socio-economic and cultural profile of the communities which may be affected by the forest operations within the FMU. This will allow an accurate assessment of the likely social impacts that may arise due to these operations.

- Location of the community
- Background information on the community
- Community infrastructure
- Socio-economic and cultural profile of community members
- Land use surrounding the FMU

5.3.3 Identification of Key Social Impacts

- Impact on Environment
- Impact on local economy
- Impact on socio-cultural life

5.3.4 Mitigation and Enhancement measures

- Measures to mitigate adverse social impact on water supply and quality
- Measures to mitigate adverse social impact on local economy
- Measures to mitigate adverse social impact on socio-cultural life
- Measures to enhance beneficial impact on local economy
- Measures to enhance beneficial impact on socio-cultural life

5.3.5 Monitoring

- Compliance monitoring
- Impact monitoring

5.3.6 Conclusion

Conclusions and recommendations of the SIA

5.3.7 References

List of references

5.3.8 Annexes

All information supportive of the main text of the SIA

REFERENCES

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Annex A: Questionnaire for Interviewing Local Community

QUESTIONNAIRE FORM - A
TO BE ANSWERED BY PENGHULU/VILLAGE HEAD

Social Impact Assessment of Forest Management Operations

Village:		Enumerator/ Date:		Reviewer/ Date:	

VILLAGE INFRASTRUCTURE
Note: You may tick more than one [1] answer.

1. Water supply

Please tick [/] the relevant information							
No.	Items	Yes	No	No.	Items	Yes	No
1	Piped water (govt. water supply)			4	Well water (including tube well)		
2	Community water supply (hill spring/gravity water)			5	Rain water		
3	River water			6	Others (please state)		

2. Electricity supply / Telephone

Please tick [/] the relevant information							
No.	Items	Yes	No	No.	Items	Yes	No
1	Generator			5	Battery		
2	Solar panel			6	Telephone - fixed line		
3	Rural electricity supply (TNB)			7	Telephone - mobile		
4	Mini Hydro						

3. Community facilities

Please tick [/] the relevant information							
No.	Items	Yes	No	No.	Items	Yes	No
1	Community hall			6	Clinic		
2	*Rumah Sakai*/Guest House			7	Playing court		
3	Hall stage			8	Playing field		
4	School			9	Others (please state)		
5	Kindergarten						

4. Place of worship

Please tick [/] the relevant information							
No.	Items	Yes	No.	No.	Items	Yes	No
1	Surau (small muslim prayer house)			4	Sacred areas		
2	Mosque			5	Temple		
3	Church			6	Others (please state)		

5. Road facilities

Please tick [/] the relevant information							
No.	Items	Yes	No.	No.	Items	Yes	No
1	Tar road			4	Track		
2	Crusher run road (Gravel road)			5	Others (please state)		
3	Laterite road						

6. Nearest town: Name of town .....Distance.....km

Prepared by:

Name : .....

Position : .....

Date : .....

Signature : .....

Person interviewed:

Name : .....

Position : .....

Date : .....

Signature : .....

QUESTIONNAIRE FORM - B

TO BE ANSWERED BY THE RESPONDENT

Social Impact Assessment of Forest Management Operations

Village: Enumerator/Date: Reviewer/Date:

Name of Respondent: I.C.No.:

1.0 Socioeconomic Profile of Respondent

1.1 Status of respondent
Head of household/ Wife/ Offspring/ Others (please state)

1.2 Gender of Respondent:
1. Male
2. Female

Gender of Household Members:
1. No. of male:
2. No. of female:

1.3 Age of Respondent:

1.4 Ethnic group of respondent
1. Malay
2. Chinese
3. Iban
4. Bidayuh
5. Kayan
6. Kenyah
7. Kelabit/ LunBawang
8. Penan
9. Punan
10. Others (please state)

1.5 Religion of respondent
1. Islam
2. Christianity
3. Buddhism
4. Hinduism
5. Pagan
6. Others (please state)

1.6 Marital status of respondent
1. Single
2. Married
3. Widow
4. Widower
5. Divorced

1.7 Occupation and work place of respondent
1. Unemployed:
   Please tick [/]
2. Employed: Please state job.....
3. Place of work .....
4. Distance to place of work (km)
   ……

Employment status of household members
1. Number of working household members
2. Number of unemployed household members

1.8 Income per month
Respondent: Total income RM.....

Household: Total income RM.....

1.9 Highest education level achieved:

1. No formal education
2. Primary school
3. Secondary School
4. College
5. University
6. Others (please state)

Household

1. Number of working household members with no formal education
2. Number of household members who attended primary school
3. Number of household members who attended secondary school
4. Number of household members who attended college
5. Number of household members who attended university

11.0 Mode of transport

Please tick [/] in the appropriate spaces provided							
No.	Items	Yes	No	No.	Items	Yes	No
1	Car			4	Boat		
2	Motorcycle			5	Bicycle		
3	Van			6	Others (please state)		

1.11 Main construction material used for dwelling

Please tick [/] the relevant information			
No.	Items	Yes	No
1	Concrete		
2	Wooden		
3	Bamboo		
4	Others (please state)		

1.12 Dependence on nearest permanent forest estate (PFE)/FMU area for subsistence

Please tick [/] in the appropriate spaces provided							
No.	Items	Yes	No.	No.	Items	Yes	No
1	Food source (game, fish, plants)			10	Grave sites		
2	Bamboo			11	Sacred sites		
3	Rattan			12	Recreational areas		
4	Honey			13	Wood oil		
5	Medicinal plants and herbs			14	Tree resins		
6	Village/housing areas			15	Gaharu/Agarwood		
7	Water supply source (drinking/bathing)			16	Others (please state)		
8	Construction materials			17	Not dependent		
9	Firewood						

1.13 Forest related economic activities of respondent and household members (in the last 12 months)

Please tick [/] in the appropriate spaces provided									
No.	Items	Yes	No	ANB*	No.	Items	Yes	No	ANB*
1	Rattan collection				8	Hunting			
2	Farming				9	Gaharu/ Agarwood collection			
3	Forest-based homestay				10	Bamboo collection			
4	Medicinal herbs collection				11	Petai collection			
5	Honey collection				12	Shifting cultivation			
6	Tour guide				13	Collection of handicraft materials			
7	Fishing								

**ANB=Estimated Value RM/Month*

2.0 Social Impact of Forest Management Operations

Have logging activities occurred near your village?

- Please state yes/no
- If yes please state year of logging

2.1 Social Impact (water supply and quality)

2.1.1 Impact of logging on water supply

Please tick [/] in the spaces provided whether logging in forest reserves negatively affect water supply:

NN = Logging has no negative impact
N = Logging has negative impact

No.	**Items**	**NN**	**N**
1	Community drinking water supply		
	• Quality		
	• Quantity		
	• Source		
2	Community water supply for bathing and washing		
	• Quality		
	• Quantity		
3	Water supply for agriculture		
4	Water supply for fish rearing		

2.1.2 Impact of logging on river water and transportation

Please tick [/] in the spaces provided whether logging in PFE/FMU area negatively affect, or otherwise, on the following:

No.	Items	Yes	No.
1	River depth		
2	Siltation/ murkiness of river water		
3	Private river transport		
4	Frequency of river flooding		
5	Possibility of mud flood		
6	River water pollution (by engine oil/ diesel)		

2.2 Social Impact (Local Economy)

2.2.1 Impact of logging on forest resources

Please tick [/] in the spaces provided whether logging negatively, or otherwise, affect supply of forest/river produce and ecotourism opportunities

NNA = Does not negatively affect
NA = Negatively affect

No.	Items	NNA	N
1	Supply of forest produce		
2	Supply of river produce		
3	Ecotourism activities		

2.2.2 Impact of logging on job opportunities (salaried work/wage) for the local community

Please tick [/] in the spaces provided whether logging in forest reserves provide job opportunities (as listed below) for the local community

A = Agree
D = Disagree

No.	Items	A	D
1	Tree marking, tree felling, debarker, lorry driver's, assistant lorry driver, machinery operator, road construction		
2	Forest inventory, surveyor, nursery, enrichment planting, General Worker, Cook		

2.2.3 Impact of logging on traditional/new economic activities of the local community

Please tick [/] in the spaces provided whether logging in forest reserves negatively affect the traditional/new economic activities of the local community

NNA = Logging has no negative impact
NA = Logging has negative impact
LA = Logging is beneficial

No.	Items	NNA	NA	LA	No.	Items	NNA	NA	LA
1	Collecting forest herbs including medicinal herbs				10	Fishing and trapping/ collecting, other river resources (shrimps, frogs, *labi-labi*, terrapin's eggs, etc.)			
2	Collecting gaharu/ agarwood				11	Rearing caged river fish			
3	Collecting rattan and bamboo				12	Collecting firewood and construction materials (wood, roofing materials, bamboo, etc.)			
4	Collecting wild fruits (durian, petai, jering, tampoi, etc.)				13	Collecting forest materials for making handicrafts			
5	Collecting ornamental plants (orchids, creepers, ferns, etc.)				14	Farming			
6	Collecting other food produce (wild vegetables, sago, grubs, insects, etc.)				15	Operating forest-based homestay			
7	Hunting wild animals (deer, barking deer, wild boar, porcupine, monitor lizard, etc.)				16	Tour guide activities (ecotourism)			
8	Trapping birds								
9	Collecting honey								

2.2.4 Forest job vacancies

Please tick [/] in the spaces provided how information on forest job vacancies are made known/available to the local community

No.	Items	(/)	No.	Items	(/)
1	Information on job vacancies directly conveyed by the local community		4	Offers made by the logging contractors directly to the community.	
2	Offers made by the Forest Department directly to the community.		5	Offers made to the community through third parties (friends, relatives, visiting traders, etc.)	
3	Offers directly informed by other government agencies (name the agencies)		6	Offers made through other means (name the agencies)	

2.3 Social Impact (socio-cultural life)

2.3.1 Logging roads have facilitated the Orang Asli/local community and outsiders as well as wildlife, to move in and out of the forest areas. This has resulted in changes as listed below

Please tick [/] in the spaces provided whether these changes are beneficial, or otherwise, for the community

B = The changes are beneficial; NB = The changes are not beneficial

No.	Items	B	NB	No.	Items	B	NB
1	Use of forest produce as well as activities like fishing, hunting and gaharu/ agarwood collection by outsiders have increased			7	The opening of spaces due to logging road has resulted in lush regrowth which attracts animal (like civets, wild boars and deers)		
2	Use of forest produce by the community has increased			8	The increase in logging activities has resulted in predators (clouded leopards, sun bear) more frequently encountered near villages		
3	Improved accessibility has allowed government departments and agencies (health, education, safety and security, development, etc.) to increase efforts to develop the community			9	Level of education has improved as a result of increased accessibility for the community		
4	Improved accessibility makes it easier for outsiders to enter the community resulting in an increase in social problems and crimes (such as alcohol and drug abuse, gambling and theft) among the community			10	Logging roads facilitate the local community's movement from village to village		

5	Increase in marriage between community members and outsiders are good for the community			11	Forest road construction facilitates the community to commute to their work place		
6	Increase in accessibility by middlemen with higher purchasing power brings more benefits to local producers/ suppliers						

2.3.2 Effect of logging on the comfort/safety/health of the local community

Please tick [/] in the spaces provided whether logging negatively affect, or otherwise, the comfort/safety/health of the community

NNI = Logging has no negative impact; NI = Logging has negative impact

No.	Items	NNI	NI	No.	Items	NNI	NI
1	Condition of village roads			3	Air quality due to movement of logging vehicles and its relation to villager's health particularly that of children and the aged		
2	Safety of traffic on village roads and surrounding areas especially for school children						

Please tick [/] in the spaces provided regarding ailments/ diseases which are linked to logging

A = Agree: D = Disagree

No.	Items	A	D	No.	Items	A	D
1	Skin diseases			4	Coughs		
2	Diarrhoea			5	Eye irritations		
3	Vomiting			6	Allergies		

2.3.3 Effect of forest activities on indigenous knowledge and skills

Please tick [/] in the spaces provided whether acquisition of knowledge/skills by outsiders benefits, or otherwise, the local community.

B = Benefits local community: NB = Does not benefit local community

No.	Items	B	NB
1	Acquisition of forest related knowledge and skills (traditional medicine, hunting, fishing, forest exploration, jungle trekking) by outsiders		
2	Acquisition of knowledge and skills of the arts (handicraft, songs/singing, music, dancing) by outsiders		

2.3.4 Decline in traditional knowledge and skills of local community due to impact of harvesting

Please tick [/] in the spaces provided your opinion on the effect of logging in forest reserves on the following traditional knowledge/skills

NNA = Logging has no negative impact; NA = Logging has negative impact

No.	Items	NNA	N
1	Skills in hunting and fishing		
2	Knowledge on making products from forest produce (e.g. Blowpipe, poison from sap of the *ipoh* tree)		
3	Knowledge on building traditional houses		
4	Knowledge on making traditional handicrafts		
5	Knowledge on medicinal plants		

2.3.5 Effect of forest activities on land used/owned by local community

Please tick [/] in the spaces provided to indicate your opinion on impact logging on villagers' land

A = Agree: D = Disagree

No.	Statements	NNA	N
1	Ownership of traditional agricultural land (*adat* land) not affected		
2	Graveyard/grave sites not affected		
3	Taboo/sacred areas not affected		
4	Historical/Pre-historical areas not affected		
5	Land affected should be compensated		

2.3.6 Skills related to forest harvesting in PFE.

What skills were acquired by the local community through involvement in logging activities in the FMU area?

Please tick [/] in the spaces provided.

No.	Items	
1	Felling skill	
2	Skills in driving vehicles and operating machineries	
3	Skill in planting forest trees	
4	Skill in applying fertilizers in nurseries	
5	Skill in surveying and forest inventory	
6	Skill in tree marking	
7	Others (please specify)	

2.3.7 Effect of forest activities on forest aesthetics

Please tick [/] in the spaces provided to show your opinion regarding the effect of forest activities on forest aesthetics

MA = Mildly Affected : BA = Badly Affected

No.	Items	MA	BA
1	Effect of logging on forest landscape aesthetics in the village vicinity		

Prepared by:		Person interviewed:	
Name	:	Name	: .....
Position	:	Position	: .....
Date	:	Date	: .....
Signature	:	Signature	: .....

GUIDELINE 7

GUIDELINES TO IDENTIFY ENDANGERED, RARE, THREATENED OR PROTECTED FOREST TREE SPECIES IN SARAWAK

GUIDELINES TO IDENTIFY ENDANGERED, RARE, THREATENED OR PROTECTED FOREST TREE SPECIES IN SARAWAK

1.0 INTRODUCTION

Threatened plant species are the species that are categorized as Critically Endangered, Endangered or Vulnerable in the IUCN Red List or other regional Red List. Where there may be differences between the IUCN Red List and the regional red list, the regional red list should take precedence. Rare plants refer to the plants species that are very uncommon, scarce or infrequently encountered including species with narrow endemic range in Sarawak as identified in published literature. Protected species are the species in Sarawak listed under the Wild Life Protection Ordinance, 1998.

2.0 IDENTIFICATION OF ENDANGERED, THREATENED AND RARE SPECIES

Carry out a baseline study to determine the plant species diversity in the areas based on:

- Literature (including Forest Management Plan, log production records) and Herbarium records
- Ground survey using standard transect line method:

Transect line 100 m x 5 m
Transect line location – randomly selected

Enumerate:

- All trees with dbh > 10 cm
- Non-trees – selected plant groups particularly the groups representing the threatened and protected species in Sarawak

Voucher specimens of the enumerated species should be collected for identification and record purposes

Parameters such as habitat, habit and plant description to be recorded

Determine if forest areas contain any endangered, threatened and rare species.

Identify the species - For basic guideline on how to identify plant species, please refer Attachment 1 and Appendices I & II.

Identify the endangered, threatened and rare species - data source include:

- IUCN Red List (www.iucnredlist.org)
- Sarawak Red List and Malaysian Red List
- Tree Flora of Sabah & Sarawak (particularly for rare species) (http://www.chm.frim.gov.my)
- Appendix I and II of CITES (www.cites.org)
- Published peer-reviewed journals or publications
- Totally Protected and Protected Plant in Sarawak (WLPO, 1998)
- Experts

Establish conservation zones appropriate for the endangered, threatened and rare species [e.g., as High Conservation Value Areas (HCVAs)].

Refer to High Conservation Value Forest (HCVF) Toolkit for Malaysia: A national guide for identifying,managing and monitoring High Conservation Value Forests, (WWF, 2009), for further reference (WWF-Malaysia, 2009). Obtain input from experts/ specialists in determining appropriate conservation action for the species.

3.0 ATTACHMENT 1: BASIC PLANT IDENTIFICATION

3.1 Introduction

Systematic botany is the science that deals with the classification and naming of the plants. The science of classifying the plants is plant taxonomy and lays emphasis upon phylogenetic relationship. The naming of the plants is known as nomenclature and provides each plant with a name. This way, the systematic botany consists of classifying and naming of the plants. The important task included in the field of systematic botany is the collection of the plant specimens from all over the world and building the great herbaria. The plants are being classified chiefly on the basis of the study of their comparative morphology.

Taxonomy is the method by which scientists, conservationists, and naturalists classify and organize the vast diversity of living things on this planet in an effort to understand the evolutionary relationships between them.

Nomenclature makes the important part of systematic botany. It deals with names which may or may not indicate relationships. Without naming the plants, they cannot be classified and therefore, nomenclature makes a very important part of systematic botany. Sorting and grouping of plants of similar characters into groups or level following certain system of classification is called plant classification. Plants are placed in family, genus and species according to certain distinguished characters.

Species is a group of similar individuals which can reproduce successfully with each other while at the same time being reproductively isolated from other similar species (known as the "Biological Species Concept"). Two individual are called the same species when they can reproduce and their offspring can survive and reproduce. Although there are many levels of classification, you only need to know family, genus or species.

Plant identification is a process in which plant names are obtained. It can be achieved by comparing a twig to known specimens in a herbarium or referring to flora publication, monograph, manual, guide to identification or keys to family, genus or species. Plant names can be vernacular names or local names, trade names or scientific names. Local names are useful only in certain area, district or country and may vary in different localities or local communities. A local name can refer to a species, genus or even a family of plants.

Scientific name are unique plant names used globally by scientists and other professionals regardless of the language they speak or write, because scientific names are always Latin or Latinized words. They are standardized, using the same name for the same organism and are always used in published research. Scientific names cannot be changed except by international scientific agreement.

The aim is purely to provide some general basic information and enable any one to identify tree species in the forest. By using the keys, species name of endangered, threatened, protected tree or plant can be identified. The guideline can only be applied when one is familiar with the botanical glossaries or terms used. Intended users shall at least attend basic botany course so that the can be effectively applied.

3.2 Guidelines for Plant Identification

There are two different processes of plant identification. Species can be obtained by either through standing tree identification or by means of a twig or leaf. In most cases, both keys are given. However, standing tree identification will only give local name or name of a group of tree species unless it is the only species in the genus or family. For example, it will give you names like meranti, kapur or durian but no scientific name.

The first step in tree identification is to know that there are always distinguishing characteristics that separate one tree species from another. By examining different tree parts you will be able to

confidently identify the different trees around your school. This will require some careful detective work on your part, but it should be fun and easy.

Here are some clues that you will need to examine:

TREE TYPE--Deciduous or Conifer? Tree or a shrub? Determining these things starts you off on your way to tree identification.

LEAF--Leaves are often the easiest way to identify most trees. Are the leaves arranged in an opposite or alternate pattern? Compound or simple?

BARK--Bark can be helpful for identifying some types of trees. Are the bark flaky, papery or fissure?

EXUDATE OR LATEX –White, yellow, red or black latex?

FRUIT--The wide variety of fruit shapes makes them useful when identifying trees. Wing fruits?

TWIG--You can actually tell a lot just by looking at the twig.

After collecting all of your clues, you should use our leaf key to verify the tree species you are identifying. It also contains links to detailed descriptions about different tree species. It will lead you to family, genus and finally the tree species a you are looking for.

3.3 Common Characters Used In Identification

Bole Characters

Divided into 3 categories:-
- Form and shape of boles
- Bark features
- Slash characters

Form and Shape of Bole
- Rounded (Circular)
- Fluted (Berbelimbing)
- Angular (Bersudut)
- Cylindrical (Dian)
- Tapered
- Buttressed

Bark Features
- Fissured (Merekah)
- Flaky (Mengelupas)
- Hooped (Bergelang)
- with lenticles (Berlentisel)
- Papery (Kekertas)
- Pock-marked (Bopeng)
- Scaly (Bersisik)
- Scrolled (Bergulung)
- Smooth (Licin)
- Cankered (Berbuku-buku)
- Cracked (Retak)

Slash Characters
- Outer bark
- Brittle (Rapuh)

Corky (Bergabus)
Crumbly (Bersepih)
Soft (Lembut)
Hissing Sound (Berbunyi Zzzzzz)

Bark Characters
Middle Bark
Coloured (Berwarna)
Mottled (Berbelak)
Striated (Berbelang)

Inner Bark
Thin (Nipis)
Thick (Tebal)
Soft (Lembut)
Hard (Keras)
Fibrous (Berserabut)
Mottled (Berbelak)
Striated (Berbelang)

Exudate
Clear (Jernih)
Opaque (Legap)
Watery (Berair)
Resinous (Berdamar)
Latex (Getah)
Creamy (Berkrim)
Sticky (Melekat)
Coloured (Berwarna)

Smell
Resinous (Berdamar)
Sweet (Manis)
Green beans (Kacang hijau)
Mango (Mangga)
Onion (Bawang)

Leaves Morphology
Simple or compound
Arrangement
Venation
Shapes
Apices
Bases
Surface features

Simple Leaf
A leaf with a singe blade is a simple leaf
Lateral bud at base of petiole

Compound Leaf
Refers to leaf that is divided into 2 or more blades attached to a common stalk
Rachis, leaflets, petioluls

Type of Compound Leaf

- Palmate
  - Leaflets attached to a common point at rachis like a fan
- Pinnate
  - Leaflets attached laterally along the rachis
- Bipinnate
  - Leaflets attached to second order rachis
- Tripinnate
- Trifoliate

Leaf Shape

- ☐ Linear
- ☐ Oblong
- ☐ Oval
- ☐ Elliptic
- ☐ Lanceolate
- ☐ Oblanceolatee
- ☐ Ovate
- ☐ Obovate
- ☐ Orbicular
- ☐ Cordate
- ☐ Obcordate
- ☐ Reniform
- ☐ Spatulate

Leaf Apices

- ☐ Acute
- ☐ Acuminate
- ☐ Rounded
- ☐ Cuspidate
- ☐ Mucronate
- ☐ Retuse
- ☐ Obtuse
- ☐ Truncate
- ☐ Emarginate

Leaf Bases

- Attenuate
- Cuneate
- Auriculate
- Cordate
- Obtuse
- Oblique
- Rounded

Leaf Margin

- Entire
- Revolute
- Crenate
- Dentate
- Serrated
- Serrulate
- Lobed

Leaf Venation

- Primary vein (Mid-rib)
- Secondary veins (Lateral veins)
- Tertiary veins (Intercostal veins)
- Parallel, ladder-liked, etc

Leaf Surface
- Glabrous
- Glaucous
- Pubescent
- Hairy
- Stellate
- Tomentoese

Stipule
- A leaf-like appendage at the side of leaf insertion
- Stipules are always caduceus leaving behind scars at twigs
- Stipulate/ Exstipulate
- Free, adnate, interpetiolar

Leaf Arrangement
- Alternate
- Opposite
- Decussate
- Spiral
- Whorled

Standing Tree Identification
- Bole characters
- Present of buttress, stilt roots
- Branching & crown shape
- Slash charactgers

Slash Characters Check for:
- Exudate
- Old slash mark, new slash
- Colour, rate of flow
- Resin (smell)
- White, yellow, red, black, iodine, clear

Resin Present
- Dipterocarps, bindang
- Dipterocarps

Kapur (*Dryobalanops* spp.)
- Long, flaky, outer bark
- Cambium turn purple when slash
- Inner bark aromatic smell

Keruing (*Dipterocarpus* spp.)
- Resin from wood and bark
- Rounded buttress
- Present of lenticles

Resak (*Vatica*&*Cotylelobium*)
- Resin from both wood and bark
- Present of hoped mark or ring at bole (Vatica)
- Bark scaly, scrolled marked, inner bark tangentially laminated (*Cotylelobium*)
- No rounded buttress
- No lenticel

Luis (*Hopea* spp.)
- Presence of stilt roots
- Cambium light purple
- Crystal-like resin

Lun (*Shorea* spp.)
- Presence of black resin at old slash mark
- Both ark and sapwood yellow

Selangan Batu (*Shorea* spp.)
- Yellow bark and sapwood
- Timber very hard
- Slash edge shape like cutting edge of knife
- Resin not black

Meranti (*Shorea* spp.)
- Bark usually fissued
- Inner bark very fibrous
- Opening of slash produce 'crack' sound
- Buttress if present high, plank

White Exudates
- Apocynaceae (Jelutong & pelai)
- Moraceae (Pudau, Ficus)
- Sapotaceae (Nyatoh)
- Euphorbiaceae (Rubber tree, Kelampai)

Apocynaceae
- White latex
- Fast flowing
- Jelutong (rounded bole, no buttress)
- Pelai (Fluted bole, high buttress)

Moraceae
- White latex
- Moderately fast flowing
- Latex clotted, sticky

Sapotaceae
- White latex
- Latex emitted in droplets
- Inner bark reddish

Euphorbiaceae
- White latex
- Moderate flow of latex
- Latex flow along slash mark

Red Exudate
- Kumpang (exudates waterly)
- Keranji (concentrated, in droplets, sticky)

Yellow Exudates

Bintangor, kandis mergasing
Bintangor-exudate yellow, crystal, shinning, bark boat fissued, laminated, soft
Kandis (exudates pale yellow, dull)
Mergasing (exudates in droplets, light yellow, bark hard)

Iodine Exudates

Iodine / orange exudates
Hypericaceae
Geronggang
Flaky bark, leather-liked middle bark

Exudate Turned Black

Anacardiaceae (Rengas, Terentang)
Sapwood white
Exudate clear turned black after exposed
Inner bark striated with reddish and greenish colour

Leaf Identification

Compound leaf: Burseraceae, Meliaceae, Sapindaceae, Leguminosae, some Euphorbiaceae, Anacardiaceae
Important parts to look for : petiolul, distal end of rachis, young shoots

Burseraceae

Petiolul swollen at both ends: Dabei, seladah

Sapindaceae

Rachis ending with terminal bud: Rambutan, Serait, kasai

Leguminosae

Petiolul ringed, Strong smell of raw bean: Sepetir, Tampar hantu, Biansu, Keranji, Saga, Petai, Kayu machis, Tapang

Meliaceae

Young shoots curved like fern shoots, Creamy exudates: Segera, Ranggu/ Sentang (*Azadirachta excelsa*), Kelampu (*Sandoricum*)

Simple Leaf

Simple opposite (bintangor, kandis, ubah, sawih etc)
Simple alternate (dipterocarps, durian, etc)
Simple spiral (Nyatoh, Annonaceae, etc)

Simple whorled (jelutong)

Dipterocarps

Key to family : Kneed petiole, simple alternate leave
Kapur – lateral veins closely parallel
Keruing – wavy margin, grooved blade, large hairy stipule
Meranti – ladder-like tertiary veins, usually with rough blade
Lun – reticulate tertiary vein
SB – ladder-like tertiary veins, thin, shinny, smooth blade
Luis – with short subsidiary tertiary veins
Resak – *Vatica* (presence of glands at back of blade)
Resak - *Cotylelobium* (lateral veins arching and formed leaf margin)

APPENDIX I

FIELD KEY TO THE COMMON FAMILIES AND SOME GENERA OF TREES IN SARAWAK

(Based mainly on Characters of Leaves and Twigs, adopted from Paul P.K. Chai, 1976)

1.	Trees with SIMPLE Leaves	2
	Trees with COMPOUND leaves	62
2.	Leaves opposite, sub-opposite or whorled	3
	Leaves alternate or spiral	22
3.	Coloured exudate present	4
	Exudate absent or colourless	5
4.	Exudate white, freely flowing	APOCYNACEAE (Pelai-*Alstonia* spp., Jelutong-*Dyera* spp., etc.)
	Exudate often yellow, cream sometimes white, coming out in droplets	CLUSIACEAE (Bintangor, Kandis , mergasing) HYPERICACEAE
	Exudate iodine/ orange, sticky	*Cratoxylum* spp. (Geronggang)
5.	Stipules present	6
	Stipules absent	9
6.	Stipules fused with based of leaf stalks and come off with the stalks when the latter are detachable	LOGANIACEAE (Tembusu)
	Stipules usually separate from leaf stalks	7
7.	Stipules not dropping of early, usually a few pairs are seen	RUBIACEAE (Kopi hutan etc.)
	Stipules drop off early usually only the terminal pair or only the scars remain	8
8.	Leaves stiff, twigs solid, inflorescences terminal	LINACEAE (Litoh)
	Leaves soft (if stiff then twigs hollow), inflorescences axillary	Some RHIZOPHORACEAE (Rabong etc.)
	(i) Twigs not hollow, leaf margin rarely toothed, inflorescence axis up to 1.5 in. long Twigs usually hollow leaf margin usually	

	finely toothed, inflorescence stalks less than 1 in. Long	*Carallia* spp.
	(ii) Leaves generally more stiff, these and young twigs not hairy; inflorescence in fascicles of many flowers, flower stalks articulate	*Gynotroches* spp.
	(iii) Leaves soft, together with young twigs usually hairy or rusty pubescent; flowers single or in groups of two stalks not articulate	*Pellacalyx* spp.
9.	Young twigs ridged or 4 angled in cross-section	10
	Young twigs not ridged or 4 angled in cross-section	13
10.	Leaves without marginal veins	VERBENACEAE (Many spp. also trifoliate)
	Leaves with marginal veins	11
11.	A line or scar present across the twigs just above the leaves, leaf base distinctly heart-shaped	12
	Line or scar absent; leaf base rarely heart-shaped	Some *Syzigium* spp. Ubah (MYTACEAE)
12.	Leaves thin and soft, marginal veins distinct, secondary veins parallel and all distinctly reaching margins	*Duabanga moluccana* (Sawih) Sonneratiaceae
	Leaves thick and stiff, marginal veins faints, secondary veins not parallel, becoming faint towards margins	*Crypteronia* spp. Ubah Samak (Crypteroniaceae)
13.	Leaves with marginal veins	11 and 12 above
	Leaves without marginal veins	14
14.	Leaves usually with 3 to 5 main veins	(a) MELASTOMATACEAE (b) *Rhodamnia* spp. (MYRTACEAE)
	Leaves without 3-5 veins	15
15.	Leaves usually glaucous or whitish below	Some Lauraceae (Medang)
	Leaves not glaucous or whitish below	16

16.	Leaves exactly opposite	17
	Leaves sub-opposite, tending to be alternate	20
17.	Leaf margins entire	18
	Leaf margins not entire	19
18.	Twigs swollen at nodes; leaves thick, small, usually less than 3 ins. long	*Dactylcoladus stenostachys* (Jongkong)
	Twigs not swollen at the nodes; leaves thin, more than 3 ins. Long; a linear or broad stipules present at tip of twig	*Microtropis* spp. (Celastroceae)
19.	Leaf margins undulate (distantly toothed)	*Euonymus* spp. (Celastraceae) *Glyptopetalum quadrangulare*
	Leaf margins finely toothed	(Celastraceae)
20.	Leaves glaucous or whitish below	Lauraceae (some spp.) (Medang)
	Leaves not glaucous or whitish below	21
21.	Twigs usually whitish, often powdery flaky	*Linociera* spp. (Mok) OLEACEAE
	Twigs usually light yellow or chocolate brown, flaky or smooth	*Kokoona* (Bajan) and *Lophopetalum* (Perupok), CELASTRACEAE
22.	Coloured exudates present	23
	Exudate absent or colourless	28
23.	Exudate pinkish or red often watery	MYRISTICACEAE (Kumpang)
	Exudate blackish (often white or cream at first) in droplets, secondary veins nearly at right angles with midrib	ANACARDIACEAE (Rengas etc.)
	Exudate white and freely flowing	24
	Exudate white, not freely flowing but coming out in droplets	26
24.	Stipules usually large, scars completely clasping twigs leaf stalks not swollen near leaf base	MORACEAE (Terap etc.)
	Stipules small, scars not completely clasping twigs	25

25.	Leaf stalks swollen at leaf base	*Elateriospermum tapos* (Kelampai) EUPHORBIACEAE
	Leafs stalks not swollen at leaf base	SAPOTACEAE (Nyatoh)
26.	Latex turning blackish or muddy coloured	ANACARDIACEAE (Rengas)
	Latex not turning blackish or muddy coloured	27
27.	Secondary veins less than 8 pairs ascending	*Ochanostachys amentacea* (Sentikal) OLACACEAE
28.	Stipules present (note the scars)	29
	Stipules absent	39
29.	Stipules or their scars completely clasping twigs	30
	Stipules or their scars not completely clasping twigs	31
30.	Stipules, leaves, twigs and fruits with soft or stiff hairs which are rough to the touch; usually low altitude	ULMACEAE (*Gironniera* spp.) Medang Kasap
	Stipules, leaves etc. not hairy or if hairy, hairs soft to the touch; usually high altitude	MAGNOLIACEAE (Medang limo)
31.	Undersurfaces of leaves, twigs and inflorescences covered in light golden yellow, golden brown or silvery scales	BOMBACEAE (Durian)
	Twigs and leaves etc. without such scales	32
32.	Leaves with 2 wavy marginal veins on each side	OCHNACEAE (Chenaga lampong)
	(i) Secondary veins few and ascending	*Brakenridgea* spp.
	(ii) Secondary veins many fine and not ascending	*Gomphia* spp.
	Leaves without marginal veins	33
33.	Bark strong and stringy and can be stripped off in long pieces	34
	Bark not stringy and cannot be stripped off in long pieces	35

34.	Bark and wood with radiating rays; leafs venation slightly raised above	STERCULIACEAE (Kembang semangkok etc.)
	Bark and wood usually without radiating rays; leaf venation sunken or flat above	TILIACEAE (Baru bukit etc.)
35.	Inner bark striated, darkens on exposure; cambium ridged and penetrated by wood rays; leaves generally silvery and shiny below	FAGACEAE (Berangan, Empili)
	Inner bark and cambium not as above; leaves not shiny below	36
36.	Leaves mostly stiff and leathery; wood very hard; fruits warty (leaves and twigs of some Prunus spp. smell or almond)	ROSACEAE (Enteli, Merbatu)
37.	Stipules long, triangular, bent-shaped and ribbed with a bigger rib down the center	*Rinorea* spp. (Siku enseluai) VIOLACEAE
	Stipules tiny or linear, or if big, broad and rounded not boat-shaped, not ribbed	38
38.	Twigs round; leaves distinctly spiral, margins toothed; leaf stalks long, often half the length of leaf blade; secondary veins always strong and distinct and more or less parallel	*Elaeocarpus* spp. (Empedu, Sengkurat) ELAEOCARPACEAE
	Twigs usually not round; leaves spiral or alternate, margins mostly entire, if toothed, then leaf stalks usually short; secondary veins distinct or not so secondary veins parallel or not so. Many species of these two families are often very difficult to distinguish when sterile. With flowers and fruits they can be recognized as follows:	(i) EUPHORBIACEAE (Tampoi etc) (ii) FLACOURTIACEAE (Senumpul)
	EUPHORBIACEAE	FLACOURTIACEAE
	(i) Flowers generally without petals (ii) Fruits usually 3-lobed and splitting open into 3 to 6 parts when dry	(i) Petals present (ii) Fruits not lobed, not splitting open when dry (with rare exceptions)
39.	Leaves with 3 (or 5) main veins arising from near leaf base	39a
	Leaves without such main veins	39c
39a.	Mountain species	Some *Lindera* spp. (LAURACEAE)
	Lowland species	39b
39b.	Leaf base usually equal; veins on upper leaf	

	surfaces mostly distinctly raised	*Cinnamommun* spp. (Medang tija) LAURACEAE
	Leaf base unequal or very unequal; veins on upper leaf surfaces flat or sunk	*Anisophyllea* spp. (Mertama) RHIZOPHORACEAE
39c.	Leaf stalks winged or deeply grooved; leaves big, margins mostly toothed	DILLENIACEAE (Simpoh)
	Leaf stalks not winged or deeply grooved, leaves small or big, margins entire	40
40.	Fresh leaves usually with numerous translucent resin pores when seen against the light	41
	Leaves without such pores	42
41.	Bark stringy, curshed leaves and fruits without smell of oranges	*Gonystylus* spp. (Ramin) THYMELAEACEAE
	Bark not stringy crushed leaves and fruits usually with smell or oranges	Many RUTACEAE spp. (Limo hutan)
42.	Cross-sections of bark and wood with radiating rays	43
	Cross-sections of bark and wood without radiating rays	44
43.	Bark stringy and can be stripped off in long pieces; leaves mostly elliptic or oblong	ANNONACEAE (Semukau)
	Bark not stringy and cannot be stripped off in long pieces; leaves usually obovate or lobed	PROTEACEAE (Palis)
	(i) Leaves not lobed	*Helicia* spp.
	(ii) Leaves large lobed	*Heliciopsis* spp.
44.	Bark surface reddish brown or purplish-brown, coming off in long flakes or scrolls; leaves with marginal veins	*Tristanopsis* and *Whiteodendron* (MYRTACEAE)
	(i) Leaves symmetric (sides equal)	Tristanopsis spp. (Selunsor)
	(ii) Leaves symmetric (sides very unequal)	*Whiteodendron moultonianum* (Kawi)
	Bark surface dark brown or black; leaves usually with dark brown or black dry patches on lower surfaces	EBENACEAE (Kayu malam)
	Bark and leaves not as above	45
45.	Leaves distinctly spiral, obovate with tapering	

	base	46
	Leaves alternate, elliptic, ovate or oblong, base rounded or wedge-shaped	51
46.	Leaf stalks short and flat, leaf base continuing down the stalks	47
	Leaf stalks long and usually slender, leaf base not continuing down the stalks	49
47.	Leaf margins shallowly toothed near apex	Some THEACEAE (Legai)
	(i) *Gordonia* spp. in M.D.F.	
	(ii) *Ploiarium alternifolium* (Somah) in Kerangas forest	
	Leaf margins not toothed	48
48.	Sandy beach species widely planted as ornamental	*Terminalia catappa* (Ketapang) COMBRETACEAE
	Semi-mangrove or riverine species; secondary veins distinct	Some *Barringtonia* spp. (Putat) LECYTHIDACEAE
	Peat swamp, Kerangas or Riverine or hill species; secondary veins indistinct below	*Tetramerista* spp. (Entuyut) TETRAMERISTACEAE
49.	Secondary veins and intercostals invisible or very faints	*Ternstroemia* spp. (Legai) THEACEAE
	Secondary veins and intercostals distinct	50
50.	Branching in distinct layers like a pagoda; lower leaf surfaces usually whitish or glaucous, base of leaf stalks not swollen, fruits winged	Most *Terninalia* spp. (Kedandi, Telinsi) COMBRETACEAE
	Branching not in distinct layers; lower leaf surfaces not glaucous, base of leaf stalks swollen; fruits not winged but ridged or angled	Most *Barringtonia* spp. (Putat) LECYTHIDACEAE
51.	Leaf margins finely toothed or undulate	52
	Leaf margins not toothed or undulate	54
52.	Hill primary forests	*Schmia* sp. (Legai) THEACEAE
	Lowland primary or secondary forests	53

53.	Leaves small, narrow, base sharply tapering, margins always finely toothed, ovaries superior, fruits rounded, soft, styles persistent	*Eurya acuminata* (THEACEAE)
	Leaves small or big, base gently tapering or rounded, margins finely or often indistinctly toothed or undulate, ovaries inferior, fruits oblong, hard, styles not persistent	SYMPLOCACEAE (Jirak)
54.	Bark and fruits with strong small of garlic	*Scorodocarpus borneensis* (Bawang hutan) OLACACEAE
	Bark and fruits without smell of garlic	55
55.	Leaf stalks articulate (2-sectioned), leaves breaking off at the articulations; mainly Peat Swamp forest	*Sarcotheca* spp. (Piang) OXALIDACEAE
	Leaf stalks not articulate; mainly Hill forests	56
56.	Under surfaces of leaves usually glaucous or whitish	Many LAURACEAE spp. (Medang)
	Under surfaces of leaves not glaucous	57
57.	Fresh twigs usually dark green and smooth	58
	Fresh twigs generally not dark green, not smooth	59
58.	Leaf venation distinct, leaves drying yellow or greenish yellow	*Xanthophyllum* (Nyalin) POLYGALACEAE
	Leaf venation not visible or very faint; leaves drying light grey	*Stemonurus* spp. (Semburok) ICACINACEAE
59.	Leaf venation mostly not visible or faint, if visible terminal buds silvery hairy	*Adinandra* spp. (Legai) THEACEAE
	Leaf venation distinct; terminal buds not silvery hairy	60
60.	Leaves thick, leathery, stiff and often brittle	Some IXONANTHACEAE
	(i) Leaves oblong	*Allantospermum* (Tulang)
	(ii) Leaves obovate	*Ixonanthes* (Inggi burung)
	Leaves generally thick, not leathery, stiff or brittle	61

61.	Secondary veins generally steeply ascending, prominent, not branched	
	(i) Midribs and secondary veins of old leaves often with brownish glands, leaf stalks thick	Some OLACACEAE
	(ii) Midrib and secondary veins without glands, leaf stalks slender	*Strombosia* (Belian landak) *Ochanostachys amentacea* (Sentikal)
	Secondary veins not steeply ascending, rather faint and often branched towards forming marginal veins	AQUIFOLIACEAE (Merdang)
62.	Leaves trifoliate or palmate	63
	Leaves pinnate	67
63.	Leaves opposite	64
	Leaves alternate or spiral	65
64.	Upper leaf surfaces punctate (i.e. with black dots or holes; midribs not hairy above	Evodia spp. (Serang) RUTACEAE
	Leaves not punctate above, midrib usually hairy above (except Vitex negundo, a sandy beach species)	*Vitex* spp. (Leban) VERBENACEAE
65.	White latex present	*Sandoricum* spp. (Kelampu) MELIACEAE
	White latex absent	66
66.	Leaves punctate; crushed leaves and fruits often with resinous orange smell, small tree or hooked climbers	*Luvunga* spp. (Serang) RUTACEAE
	Leaves not punctate; crushed leaves and fruits without resinous orange smell; trees small to medium-sized	*Heritiera* spp. (Mengkulang) STERCULIACEAE
67.	Leaves opposite	Some BIGNONIACEAE
	(i) *Dolichandrone spathacea* (Tulih) in Mangrove forests;	
	(ii) *Oroxylom* spp. in Hill and Secondary forests;	
	(iii) *Radermachera* spp. in limestone forest	
	Leaves alternate or spiral	68

68.	Leaves punctate; Limestone forest *Micromelum minutum* (RUTACEAE)	
	Leaves not punctate; non-limestone forests	69
69.	Stipules, rounded, usually the terminal pair is seen	*Weinmannia* spp. (CUNONIACEAE)
	Stipules absent or not rounded	70
70.	Coloured exudates present	71
	Exudate absent or colourless	75
71.	Exudate white or cream, coming off in droplets	72
	Exudate red, sticky, sparse	74
72.	Exudate strongly resinous	Some BURSERACEAE (Kedondong)
	Exudate nor resinous	73
73.	Exudate turning black after sometime	Some ANACARDIACEAE
	(i) Leaves about 1 ft. long; stalks and ridbid of young leaflets reddish	*Pentespadon motleyi* (Pelajau)
	(ii) Leaves up to 2 ft. long or more, stalks and young leaflets not reddish	*Dracontomelon dao* (Senkuang)
	Exudate not turning blackish, after sometime	Some MELIACEAE
74.	Bark reddish-brown, bole without knobs or swelling fruits roundish	*Dialium* spp. (Keranji)LEGUMINOSAE
	Bark grey or brownish-grey, bole often with knobs or swellings; fruits in long flat pods	Some *Millettia* spp. (Kedang belum)
75.	Exudate with resinous smell, nodes and leaflet stalks mostly swollen below base of leaflets	Most BURSERACEAE (Kedondong)
	Exudate not resinous	76
76.	Leaves ending in terminal buds	77
	Leaves ending in leaflets	79
77.	Terminal buds long and usually coiled up; leaves usually long (up to 3 ft.) leaflets large	*Chisocheton* spp. (Segera) MELIACEAE
	Terminal buds smalls and not coiled, leaves generally short, leaflets small	78
	Young leaves not reddish; leaflets not	

78.	Glaucous or whitish below, punctate (with numerous tiny holes); fruits winged	*Engelhardtia* spp. (Sansanlang) JUGLANDACEAE
	Young leaves reddish, leaflets often glaucous or whitish below, not punctate; fruits hairy or smooth	SAPINDACEAE (Rambutan, Kasai)
79.	Wood soft; base of leaf stalks often expanded	Arthrophyllum spp. (ARALIACEAE)
	Wood hard; base of leaf stalks not expanded	80
80.	Leaves ones pinnate, sometimes reduced to a single leaflet, young buds, leaves and twigs often with brown, powdery tomentum or rarely with golden shiny scales, midribs usually sunken above; intercostals faint above; leaflets usually drying olive green above	MELIACEAE (Aglaia spp.) (Segera)
	Leaves one to three times pinnate; young buds, leaves and twigs usually not tomentose or scaly; midribs generally raised above, intercostals mostly net-like and distinct above, leaflets drying brown	LEGUMINOSAE (Merbau, Petai etc.)

APPENDIX II

FIELD KEY TO GENERA OF DIPTEROCARPACEAE BASED ON SLASH CHARACTERS

Family key: Trees must have resin / Damar

1.	Cambium turns purple	2
	Cambium not turning purple	3
2a.	Bark flaky, aromatic smell, cambium turns purple immediately	*Dryobalanops* (Kapur)
2b.	Bark smooth to flaky, stilt roots present, cambium turns light purple after a few minutes	*Hopea* (Luis)
3.	Resin from both wood and bark	4
	Resin from bark only	5
5a.	Buttress rounded, lenticles present	*Dipterocarpus* (Keruing)
5b.	Bole with ring or hoped mark, bark smooth, wood close texture, slash opens in long rectangular piece	*Vatica* (Resak)
5c	Bark scaly or scrolled mark	*Cotylelobium* (Resak)
6.	Resin at old slash mark black, wood yellow	*Shorea* (Lun)
	Resin not black	7
7.	Bark surface fissured	8
	Bark not fissured	9
8a.	Bark pale brown to dark purplish brown, shallowly fissured, later flaking into small oblong pieces	*Parashorea* (Urat nata)
8b.	Bark surface irregularly section fissured, flaking, sapwood yellowish	*Anisoptera* (Mersawa)
8c.	Bark fissured, inner bark strongly fibrous, slash opens with crack sound	*Shorea* (Meranti)
8d.	Bark closely fissured, flaking	*Upuna* (Penyau)
9.	Bark fissured or scaly, wood hard, slash edge shape	*Shorea* (Selangan batu)

GUIDELINE 8

GUIDELINES FOR FAUNA CONSERVATION AND ECOSYSTEM MANAGEMENT

GUIDELINES FOR FAUNA CONSERVATION AND ECOSYSTEM MANAGEMENT

1.0 HOW TO USE THIS DOCUMENT

This document aims to provide a practical and easy to use guidance to forest managers and other stakeholders to identify, manage and monitor issues related to wildlife outside Totally Protected Areas in Sarawak.

These guidelines are not meant to be exhaustive or prescriptive. The aim is to provide some general principles for reducing the impact on wildlife during operation. The guidelines are derived from existing state's laws, state's policies and relevant directives such as the Wild Life Protection Ordinance, 1998 (WLPO), A Master Plan for Wildlife in Sarawak (MPWS), Reduced Impact Logging (RIL) Guidelines, Director of Forests Circular etc. In the case where such laws, policies or directives are inadequate in providing the warranted guidelines, it is suggested that guidance from experts and literature such as the High Conservation Value Forest (HCVF) Toolkit for Malaysia: A national guide for identifying, managing and monitoring High Conservation Value Forests, (WWF, 2009), Common Guidance for the Identification of High Conservation Values (2013), Life After Logging, International Union for Conservation of Nature (IUCN) be referred to.

Scale and intensity which refer to the appropriateness of the degree of efforts to be carried out is further defined in Appendix 1.

If there is a need to assess species and change in the population of forest fauna, relevant methodologies are attached in the appendices prescribing how such studies are to be carried out for various groups of species i.e. primate, big mammals, bats, small mammals, amphibians, birds and aquatic life.

2.0 GUIDELINES FOR IDENTIFYING FOREST FAUNA

This guideline provides additional information and tools to the existing available references for identification of forest fauna in the region. The lists of the references are as follow:

Category	List of References
Mammal	A Field Guide to the mammals of Borneo. Junaidi Payne and Charles M. Francis
Birds	Phillipp's Field Guide to the Birds of Borneo Sabah, Sarawak, Brunei and Kalimantan. Quentins Phillipps and Karen Phillipps. A Field Guide to the Birds of Borneo. Susan Myers. A field Guide to the Birds of South-East. Craig Robson
Amphibian	A field Guide to the Frogs of Borneo. Robert F. Inger and Robert B. Stuebing
Reptile	A Photographic Guide to Snakes and other Reptile of Borneo. Indraneil Das. A Field Guide to the Snakes of Borneo. Robert Stuebing and Robert Inger. Turtles of Borneo and Peninsular Malaysia. Lim Boo Liat and Indraneil Das.

Fish	Freshwater fishes of Peninsular Malaysia. Universiti Pertanian Malaysia, Serdang. Mohsin, A.K.M. and M.A.Ambak. 1993. Fresh Water Fish of North Borneo. Robert Inger, Chin Phui Kong, 1962. Freshwater fishes of Western Indonesia and Sulawesi. Kottelat, M.A., Whitten, J., Kartikasari, S.N. and Wirjoatmodjo. 1993.
Others	High Conservation Value Forest (HCVF) Toolkit for Malaysia: A national guide for identifying,managing and monitoring High Conservation Value Forests, (WWF - Malaysia, 2009) Common Guidance for the Identification of High Conservation Values (Brown, *et. al*., 2013) Life After Logging (Meijaard, *et. al*., 2005) International Union for Conservation of Nature a (IUCN)

3.0 GUIDELINE FOR IDENTIFICATION OF ENDANGERED, RARE AND THREATENED SPECIES OF FOREST FAUNA

Identification of endangered, rare and threatened species (ERT) shall refer to either one of this instruments namely; the Wild Life Protection Ordinance, 1998 (WLPO), Convention on International Trades in Endangered Species of Wild Fauna and Flora (CITES) and IUCN Red List of Threatened Species. Definition of ERT species is further discussed in Appendix 2.

Totally Protected Animals and Protected Animals are listed under Part I and Part II of the First Schedule of the Wild Life Protection Ordinance 1998, as listed in Appendix 3.

All species listed under Appendix 1 and Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) are automatically accorded protected Species under the Wild Life Protection Ordinance, 1998 unless the species has already been listed as Totally Protected Species. CITES Appendices are readily available on CITES website.

IUCN Red List of Threatened Species categories species as Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Near Threatened and Least Concerned. For the purpose of ERT species, ONLY the first three categories are taken into consideration.

ACTION: To keep a list of ERT species of Forest Fauna which is to be updated regularly or whenever necessary. The sample format below is recommended.

No.	**Species**	**Local Name**	**Conservation Status**		
			WLPO	**CITES**	**IUCN**
Mammals					
1	*Manis javanica*	Pangolin	Protected	App.II	Endangered
Birds					
1	*Anorrhinus galeritus*	Bushy-crested Hornbill	Totally Protected	App.II	Least Concern

4.0 GUIDELINES FOR PROTECTION OF ENDANGERED, RARE AND THREATENED SPECIES OF FOREST FAUNA

The following are some guidelines to protect the endangered, rare and threatened species of forest fauna. Most of these are related to hunting and the ban of commercial sale of animal taken from the wild.

No.	Action required (item)	References/ Remarks
1	Employees of the Timber Companies shall not hunt in the licensed areas while being employed by the Company.	DF Circular 6/99, WLMP Signboard to be erected WLMP: Wildlife populations must be conserved throughout Sarawak's Permanent Forest Estate (PFE). Hunting by logging company employees, and hunting by outsiders for sport and trade along logging roads, should be stopped throughout the PFE
2	Company vehicles are not to be used for hunting or carrying meat of wild animals.	
3	Selling of wild animals or meat of wild animals is not allowed in the licensed areas.	
4	Feeder roads are to be closed after the final block inspection to prevent further entry of vehicles. This can be done by taking out bridges or digging trenches across the roads.	
5	WLPO, 1998 & it Rules strictly adhered	WLPO, 1998 & Rules A copy must be available
6	Wire snares are to be banned throughout PFE	WLMP
7	Community leaders and camp managers to be appointed as Honorary Wild Life Ranger (HWLR) to assist with the implementation of the WLPO, 1998 & its rules.	
8	Any observation of the highly endangered (flagship or iconic) species such as Sumatran rhinoceros, orang-utans or proboscis monkey are to be recorded, continuously monitored and to inform Sarawak Forestry Corporation (SFC)/ Forest Department Sarawak (FDS). This occurrence will be treated as a High Conservation Value.	As per listed in Schedule 1 Part 1 of the WLPO, 1998.

5.0 GUIDELINES TO ESTABLISH AND PROTECT REPRESENTATIVE CONSERVATION AND PROTECTION AREAS IN FOREST ECOSYSTEM

Habitat types	Recommendations/ Action required	References
Keystone mineral resources such as salt springs, salt licks and mud volcano. Note: As there are three different recommendations, the size of the buffer should be appropriate to the scale and intensity from a minimum of 100 m width to a radius of 2 km.	Keystone mineral resources should be identified and mapped. No logging activities within 100 m radius (buffer zone) from the edge of each salt licks area. No roads shall be constructed and no hunting is allowed within this area. Should be identified throughout FMU, mapped and marked on the ground.	A Master Plan for Wildlife in Sarawak, 1996 RIL Guidelines
Caves & limestone block	A buffer zone of width 100 m around the perimeter of such critical resources and sites is to be established.	RIL Guidelines
	The published Guidelines for Cave and Karst Protection. A summary of the guidelines is listed in Appendix 4.	IUCN
Nesting sites (i.e. nesting trees)	All hollow trees with hornbill nesting should be marked and protected (if present). At least 200 m radius from the edges of the nesting trees for all Hornbills. Should be identified throughout FMU, and mapped with GPS location and marked accordingly. No roads should be constructed in this protected zone. This is to ensure full physical protection of the nesting areas and protect from illegal hunters. Should be identified throughout FMU, mapped and marked on the ground.	HCV Guidelines
Roosting areas (i.e. Flying Foxes)	At least 300 m radius from the edges of the roosting areas for all Flying Foxes (if present). Should be identified throughout FMU, mapped and marked on the ground. No roads should be constructed in this protected zone. This is to ensure full physical	HCV Guidelines Management and Restoration of Flying-Fox Camps. Guidelines and Recommendations, 2012

	protection of the roosting sites and protect from illegal hunters.	
Banteng wallows and Rhinoceros wallows.	A buffer zone of width 100 m around the perimeter of such critical resources and sites is to be established. Should be identified throughout FMU, mapped and marked on the ground.	RIL HCV Guidelines

6.0 GUIDELINES FOR THE CONSERVATION OF GENETIC, SPECIES AND ECOSYSTEM DIVERSITY AND GUIDELINES FOR BIOLOGICAL CORRIDORS AND BUFFER ZONE FOR WILDLIFE

Protection of inoperable areas in PFE	A system of inoperable areas throughout the PFE should be established. This can be done either: 1. by making retention of the specified inoperable areas within the; or 2. by declaring some blocks as conservation areas under the Natural Resources and Environment (Amendment) Ordinance. Each inoperable area should be clearly marked in DP and on the ground. All hunting in inoperable blocks should be banned.	A Master Plan for Wildlife in Sarawak, 1996 Detailed Harvesting Plan (DP)
FMU adjacent to TPAs	The width of the buffer zone should be stated in the forest management plan (FMP).	FMP of timber licence
	Buffer zone of 1 km shall be established along the boundary of TPAs and FMU.	RIL
	No logging activities within a buffer zone in the PFE along the TPA boundary. All logging and hunting activities are prohibited within buffer zone, and it protection shall be spelled out in the FMP.	A Master Plan for Wildlife in Sarawak, 1996 FMP
Wildlife management should be incorporated into plantation management.	Buffer zone of one (1) km wide shall be established within the plantations along TPAs boundaries.	A Master Plan for Wildlife in Sarawak, 1996 EIA Report HCV Guidelines
	Buffer zone shall be established along all riverbanks as spelled out in approved EIA report.	
	High Conservation Value Forests (HCVFs) shall be assessed and identified (if any) in plantations throughout Sarawak.	
	Pest control in plantations should be done according to proper planning, and in consultation with Forest Department Sarawak.	

7.0 GUIDELINES TO CONDUCT SURVEY TO MONITOR FOREST FAUNA

Example of survey techniques are given in the appendices. Researches or forest managers are not bound by these techniques as they can choose to use the survey techniques according to their training and professions.

Indicator Species	**Methodology**	**Remark**
Primate	Transect line	**APPENDIX 5**
Big Mammal	Line transect (King's Census Method) Camera trapping	**APPENDIX 6**
Bats	Harp trap Mist net	**APPENDIX 7**
Small Mammals	Trapping (Using live traps)	**APPENDIX 8**
Amphibians	Stream transect Quadrate sampling Pitfall Traps with Drift Fences Funnel Traps	
Avifauna (Birds)	Line transect Point count Sample plot Playback calls Spotlighting owls Mist nets	
Aquatic life	Monofilament gill nets Cast net Hook & Line Electro fishing	

LIST OF RECOMMENDED READINGS

1. Brown, E., N. Dudley, A. Lindhe, D.R. Muhtaman, C. Stewart and T. Synnott (Eds.). (2013). *Common guidance for the identification of High Conservation Values*. HCV Resource Network.

2. Meijaard, E., D. Sheil, R.Nasi, D. Augeri, B. Rosenbaum, D. Iskandar, T. Setyawati, M. Lammertik, I. Rachmatika, A. Wong, T. Soehartono, S. Stanley, and T. O'Brien (2005). *Life After Logging: Reconciling Wildlife Conservation and production forestry in Indonesia*. Borneo Centre for information Forestry Research, Jakarta.

3. Ministry of Natural Resources and Environment. (2010). *Managing Biodiversity in the Riparian Zones: Guidelines for Planners, Decision – makers and Practitioners*. Putra Jaya

4. Rabinowitz, Alan (1995). Diterjemahkan oleh Maryati Mohamed *Manual Latihan Pemuliharaan Dan Penyelidikan Hidupan Liar Di Lapangan*. Natural History Publication (Borneo) Sdn.Bhd. Kota Kinabalu

5. Sarawak Forest Department, n.d. *Guidelines/Procedures for Reduced and Low Impact Harvesting System*

6. Yoneda, M and H. Bernard (2004). *Ecological Methodology in Conservation Biology. Part 1: Methods of measuring and monitoring biodiversity.* Research and Education Component, Bornean Biodiversity & Ecosystem conservation programme (UMS-BBEC), Kota Kinabalu.

7. Watson, John, Hamilton-Smoith, Elery, Gillieson, David and Kiernan, Kevin, (Eds.) (1997) *Guidelines for Cave and Karst Protection*, IUCN, Gland, Switzerland and Cambridge, UK. 63pp

8. Wildlife Conservation Society and Sarawak Forest Department. 1996. *A Master Plan for Wildlife in Sarawak*. Kuching.

APPENDIX 1
SCALE, INTENSITY AND RISK

Excerpt from the Common guidance for the identification of High Conservation Values. HCV Resource Network (2013) on scale, intensity and risk:

Scale, Intensity and Risk

The larger the scale, intensity and risk of project activities, the more effort should be devoted to detecting, identifying and understanding the characteristics, distribution, sensitivity and vulnerability of HCVs. The assessor must adequately describe the potential impact and scale of proposed operations and ensure that assessment efforts are adequate.

Defining scale, intensity and risk

Scale*: A measure of the extent to which a management activity or event affects an environmental or social value or a management unit, in time or space. An activity with a small or low spatial scale affects only a small proportion of the area each year, an activity with a small or low temporal scale only at long intervals.*

Intensity*: A measure of the force, severity or strength of a management activity or other occurrence affecting the nature of the activity's impacts.*

Risk*: The probability of an unacceptable negative impact arising from any activity in the management unit combined with its seriousness in terms of consequences.*

APPENDIX II

DEFINITION OF ENDANGERED, RARE AND THREATENED SPECIES

Endangered Species and Threatened Species are defined in MC&I as the following:

> *Endangered species: Any species which is in danger of extinction throughout all or a significant portion of its range.*
>
> *Threatened species: Any species which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.*

Common Guidance for the Identification of High Conservation Values by HCV Resource Network (2013) elaborated on RTE as the following:

> *Rare, threatened or endangered (RTE) species refers to species that are at risk of, undergoing or have undergone severe population decline. Although the HCV definition mentions threatened and endangered species, these are often, together with vulnerable, subsumed under the overarching term threatened and endangered in an IUCN Red List context.*
>
> *Rare is scale dependent and includes species that are*
> - *Naturally rare, existing only at very low densities in undisturbed habitat, or*
> - *Rare because of human activities e.g. habitat destruction, overhunting, climate change*
> - *At the limit of their natural distribution (even if they are common elsewhere)*
>
> *Threatened and endangered species can include species classified by IUCN as Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) at a global or regional level, or whose trade is regulated under international agreements (e.g. CITES), as well nationally protected species. IUCN Red Listing remains incomplete and many RTE species have not yet been assessed by the IUCN Species Survival Commission. In some countries, especially those lacking national IUCN red lists or nationally protected species lists, expert consultation is needed to learn if any such species might be present.*

IUCN Red List of Threatened Species categories concerned species as Critical Endangered, Endangered, Vulnerable, Conservation Dependent, Near Threatened and Least Concerned.

Category	**Summary of Definition**
Critically Endangered (CR)	A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future
Endangered (EN)	A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction the wild in the near future
Vulnerable (VU)	A taxon is Vulnerable when it is not Critically Endangered but is facing a high risk of extinction in the wild in the medium-term future
Conservation Dependent (CD)	Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which result in the taxon qualifying for one of the threatened categories above within a period of 5 years
Near Threatened (NT)	Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable
Least Concerned (LC)	Taxa which do not qualify for Conservation Dependent or Near Threatened

APPENDIX III

FIRST SCHEDULE
(Section 2(1))

PART 1

TOTALLY PROTEDTED ANIMALS

English Name	Scientific Name	Local Name
A. MAMMALS		
Slow loris	*Nycticebus coucang*	Ukang; bengkang (I)
Silvered langur	*Presbytis cristata*	Kera hantu; ingkat (I)
Hose's langur	*Presbytis hosei*	Berangad
White-fronted langur	*Presbytis frontata*	Puan
Banded langur	*Presbytis melalophos*	Penetat
Maroon langur	*Presbytis rubicunda*	Lotong merah; jelu merah (I)
Proboscis monkey	*Nasalis larvatus*	Orang belanda; rasong (I)
Borneon gibbon	*Hylobates muelleri*	Wak-wak; empeliau (I)
Orang-utan	*Pongo pygmaeus*	Mawas; maias (I)
Giant squirrel	*Ratufa affinis*	Tupai kerawak
Tufted ground	*rheithrosciurus*	Tupai squirrel macrotis
Clouded leopard	*Neofelis nebolusa*	Rimau dahan; engkuli (I)
Bay cat	*Felis badia*	Kucing merah
Marbled cat	*Felis marmorata*	Kucing dahan
Flat-headed cat	*Felis planiceps*	Kucing hutan
All whales, dolphins and porpoises	*All species of Cetacea*	Paus; Lumba lumbi
Dugong	*Dugong dugon*	Dugong; dugong (I)
Rhinoceros	*Dicerorhinus sumatrensis*	Badak
Wild cattle	*Bos javanicus*	Tembadau
Naked bat	*Cheiromeles torquatus*	
B. BIRDS		
Oriental darter	*Anhinga melanogaster*	
Pacific reef egret	*Egretta sacra*	Ujoh laut
Cattle egret	*Bubulcus ibis*	Burung apuh; burung lima ringgit
Storm's stork	*Ciconia stormi*	Bangau
Lesser adjutant stork	*Leptoptilos javanicus*	Bangau
White-bellied fish eagle	*Haliaeetus leucogaster*	Lang laut
Grey-headed fish eagle	*Lchtyophaga ichthyaetus*	Lang laut
Borneon peacock pheasant	*Polyplectron schleiermacheri*	Ruai
Argus pheasant	*Argusianus argus*	Ruai
Bulwer's pheasant	*Lophura bulweri*	Bekia
Black-naped tern	*Sterna sumatrana*	Burung laut
Bridled/brownwinged tern	*Sterna anaethetus*	Burung laut; entala puteh (I)
All phalaropes	*Phalaropes spp.*	Kedidi
All imperial pigeons	*Ducula spp.*	Rawa
Silvery (grey) wood pigeon	*Columbia argentina*	Pergam
White-crowned hornbill	*Aceros comatus*	Sentuku (I)
Bushy-crested Hornbill	*Anorrhinus galeritus*	Kakalau (I)
Wrinkled hornbill	*Aceros corrugatus*	Alau buloh
Wreathed hornbill	*Aceros undulatus*	Alau sangoh

Asian black hornbill	*Anthracoceros malayanus*	Alau babi; gagak/ rengak (I)
Oriental pied hornbill	*Anthracoceros albirostris*	Alau pedada; bruie (I)
Rhinoceros hornbill	*Buceros rhinoceros*	Kenyalang (I)
Helmeted hornbill	*Buceros vigil*	Tajai (I)
All pittas	*Pitta spp.*	Burung pacat
Straw-headed bulbul	*Pycnonotus zeylanicus*	Barau-barau
Bornean bristlehead	*Pityriasis gymnocephala*	

C. REPTILES

All marine turtles	*All species of* Chelonidae *and* Dermochelyidae	Penyu-penyu laut
Painted terrapin	*Callugur borneensis*	Beluku
Terrapin	*Orlitia borneensis*	Beluku
Niah cave gecko	*Cyrtodactylus cavernicolus*	Cicak gua niah
Earless monitor lizard	*Lanthanotus borneensis*	Cicak purba

PART II
PROTECTED ANIMALS

English Name	**Scientific Name**	**Local Name**
A. MAMMALS		
All Treeshrews	All species of Tupaiidae	
All bats	All species of Chiroptera excluding those already listed in Part I	
All primates	All species of Primates excluding those already listed in Part I	
Flying lemur/ colugo	*Cynocephalus variegatus*	Kubung
Pangolin	*Manis javanica*	Tenggiling
All flying squirrels	All species of Petuaristinae	Tupai terbang
Porcupines	All species of Hystricidae	Landak
Sun bear	*Helarctos malayanus*	Beruang
Bear cat	*Arctitis binturung*	Binturung
All civets and mongooses	All species of Viverridae	Musang
All otters	All species of Lutra and Aonyx	Memerang
All cats	All species of Felidea excluding those already listed in Part I	Kucing hutan
B. BIRDS		
Christmas	*Frigatebird Fregata andrewsi*	
All herons, egrets and bitterns, excluding those already listed in Part I	All species of Ardeidae	
All storks, excluding those already listed in Part I	All species of Ciconiidea	
Osprey	*Pandion haliaetus*	Lang; menaul
All falcons	All species of Falconidae	Rajawali; menaul
All scrubfowl, partridges and pheasants excluding those already listed in Part I	All species of Phasianidae	
All waders, excluding those	All species of Charadiiformes	

already listed in Part I		
Metallic pigeon	*Columbia vitiensis*	Pergam
Nicobar pigeon	*Caloenas nicobarica*	Pergam
All owls	All species of Tytonidae and Strigidae	Burung hantu
All swiftlets	All species of Aerodramus, Hydrochous and Collocalia	Burung laying
All kingfishers	All species of Alcedinidae	Pekaka
All woodpeckers	All species of Picidae	Belatok
Asian paradise flycatcher	*Terpsiphone paradisi*	Burung sambar ekor panjang
Grackle or hill myna	*Gracula religiosa*	Burung tiong
All parrots and parakeets	All species of Psittacidae	Bayan
White-rumped shama	*Copyschus malabaricus*	

C. REPTILES

Burmese brown tortoise	*Geochelone emys*	Baning
All soft-shelled turtles	All species of Tryonychidea	Labi-labi
False gharial	*Tomistoma schlegii*	Buaya jujulong
Estuarine crocodile	*Crocodylus porosus*	Buaya katak
All monitor lizards	All species of Varanus	Biawak
King cobra	*Ophiophagus hannah*	Ular tedung
Common cobra	*Naja naja*	Ular tedung
All pythons	All species of Python	Ular sawa

D. FISH

Arowana (dragonfish)	All species of Osteoglossidea	Ikean seruk; ikan siluk

E. INVERTEBRATES

All hard and soft corals	All species of Hydrozoa and Anthozoa (Actinozoa)	Batu karang
Raja Brooke's birdwing	*Triodes brookiana*	

F. ADDITIONAL SPECIES

All species of animals listed in Appendices I and II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), excluding those already listed in Part I.

PART III
(Section 31)

ANIMALS WHICH MAY BE IMPORTED OR EXPORTED UNDER LICENCE

All animals, other than totally protected animals.

APPENDIX IV

GUIDELINES FOR CAVE AND KARST PROTECTION, IUCN WORLD COMMISSION ON PROTECTED AREAS

Prepared by the WCPA Working Group on Cave and Karst Protection

1. Effective planning for karst regions demands a full appreciation of all their economic, scientific and human values, within the local culture and political context.

2. The Integrity of any karst system depends upon an interactive relationship between land, water and air. Any interference with this relationship is likely to have undesirable impacts, and should be subjected to thorough environmental assessment.

3. Land managers should identify the total catchment area of any karst lands, and be sensitive to the potential impact of any activities within the catchment, even if not located on the karst itself.

4. Destructive actions in karst, such as quarrying or dam construction, should be located so as to minimise conflict with other resource or intrinsic values.

5. Pollution of groundwater poses special problems in karst and should always be minimised and monitored. This monitoring should be event-based rather than at merely regular intervals, as it is during storms and floods that most pollutants are transported through the karst system.

6. All other human uses of karst areas should be planned to minimise undesirable impacts, and monitored in order to provide information for future decision making.

7. While recognising the non-renewable nature of many karst features, particularly within caves, good management demands features be restored as far as is practicable.

8. The development of caves for tourism purpose demands careful planning, including consideration of sustainability. Where appropriate, restoration of damaged caves should be undertaken, rather than opening new caves for tourism.

9. Government should ensure that a representative selection of karst sites is declared as protected areas under legislation which provides secure tenure and active management.

10. Priority in protection should be given to areas or sites having high natural, social or culture value; possessing a wide range of values within the one site; which have suffered minimal environmental degradation; and/ or of a type not already represented in the protected areas system of their country.

11. Where possible, a protected area should include the total catchment area of the karst.

12. Where such coverage is not possible, environmental controls or total catchment management agreements under planning, water management or other legislation should be used to safeguard the quantity and quality of water inputs to the karst system.

13. Public authorities should identify karst areas not included within protected areas and give consideration to safeguarding the values of these area by such means as planning controls, programs of public education, heritage agreements or covenants.

14. Management agencies should seek to develop their expertise and capacity for karst management.

15. Managers of karst areas and specific cave sites should recognise that these landscapes are complex three-dimensional integrated natural systems comprised of rock, water, soil, vegetation and atmosphere elements.

16. Management in karst and caves should aim to maintain natural flows and cycles of air and water through the landscape in balance with prevailing climatic and biotic regimes.

17. Managers should recognise that in karst, surface actions may be sooner or later translated into impacts directly underground or further downstream.

18. Pre-eminent amongst karst processes is the cascade of carbon dioxide from low levels in the external atmosphere through greatly enhanced levels in the soil atmosphere to reduced levels in cave passages. Elevated soil carbon dioxide levels depend on plant root respiration, microbial activity and a healthy soil invertebrate fauna. This cascade must be maintained for the effective operation of karst solution processes.

19. The mechanism by which this is achieved is the interchange of air and water between surface and underground environments. Hence the management of quality and quantity of both air and water is the keystone of effective management at the regional, local and site specific scales. Development on the surface must take into account the infiltration pathways of water.

20. Catchment boundaries commonly extend beyond the limits of the rock units in which the karst has formed. The whole karst drainage network should be defined using planned water tracing experiments and cave mapping. It should be recognised that the boundary of these extended catchments can fluctuate dramatically according to weather conditions, and that relict cave passages can be reactivated following heavy rain.

21. More than in any other landscape, a total catchment management regime must be adopted in karst areas. Activities undertaken at specific sites may have wider ramifications in the catchment due to the ease of transfer of materials in karst.

22. Soil management must aim to minimise erosive loss and alteration of soil properties such as aeration, aggregate stability, organic matter content and a healthy soil biota.

23. A stable natural vegetation cover should be maintained as this is pivotal to the prevention of erosion and maintenance of critical soil properties.

24. Establishment and maintenance of karst protected areas can contribute to the protection of both the quality and quantity of groundwater resources for human use. Catchment protection is necessary both on the karst and on contributing non-karst areas. Activities within caves may have detrimental effects on regional groundwater quality.

25. Management should aim to maintain the natural transfer rates and quality of fluids, including gases, through the integrated network of cracks, fissures and caves in the karst. The nature of materials introduced must be carefully considered to avoid adverse impacts on air and water quality.

26. The extraction of rocks, soil, vegetation and water will clearly interrupt the processes that produce and maintain karst, and therefore such uses must be carefully planned and executed to minimise environmental impact. Even the apparently minor activity of removing limestone pavement or other karren for ornamental decoration of gardens or buildings has a drastic impact and should be subject to the same controls as any major extractive industry.

27. Imposed fire regimes on karst should, as far is practicable, mimic those occurring naturally.

28. While it is desirable that people should be able to visit and appreciate karst features such as caves, the significant and vulnerability of many such features means that great care must be taken to minimise damage, particularly when cumulative over time. Management planning should recognise this fact and management controls should seek to match the visitor population to the nature of the resource.

29. International, regional and national organisations concerned with aspects of karst protection and management should recognise the importance of international co-operation and do what they can to disseminate and share expertise.

30. The documentation of cave and karst protection/ management policies should be encouraged and such policies made widely available to other management authorities.

31. Data bases should be prepared listing cave and karst areas included within protected areas, but also identifying major unprotected areas which deserve recognition. Karst values of existing and potential World Heritage sites should be similarly recorded.

APPENDIX V

METHODOLOGY FOR PRIMATE STUDY

INDICATOR SPECIES : PRIMATE
METHODOLOGY : DISTANCE SAMPLING USING LINE TRANSECT METHOD

1.0 INTRODUCTION

There are many factors that determine which methods are suitable for estimating animal abundance in the wild, especially in tropical forest. These factors include size and habits of the animals, habitats where they live and the time frame of the research (Marsh and Wilson 1981). Poor visibility conditions may also limit the accuracy of counts. In order to reduce effects of poor visibility one needs to stay close to the animal for a certain period of time to record all information needed in the study. Lines transect sampling (LTS) has been used in many situations (e.g. Dahaban 1996; Johns 1983; Lambert 1992; Zakaria 1994), and the versatility of the method lies in the variety of ways in which a transect line can be traversed. The advantage of this method is that it allows a relatively large area to be discovered in a short period time 9Marsh and Wilson 1981) and more habitats or elevations can be covered during the survey (Jones 1998).

In the topics, the line transect sampling (LTS) method has been used in many wildlife studies (e.g. Blouch 2000, Dahaban 1996; Johns 1983; Meredith 1993; Gurmaya and Sundai 2004, Wilson and Wilson 1975,). Since animals are highly mobile and sometimes occur in a relatively low population density, LTS is found to be more useful in estimating their populations in the wild compared to other methods (e.g. point sampling) because LTS is more appropriate when study species that are relatively easy to identify but mobile and occur at low density (Llyod et al.1998). Generally, line transect sampling (LTS) has found its major application in the assessment of wildlife populations.

2.0 ESTABLISHMENT OF LINE TRANSECT

It is good to site the start of transect randomly or through a stratified random technique. However, most of the time, transects are not randomly situated due to logistic and safety reasons. Apart from that, the topographical conditions also greatly influence the position of transects. In places where the topography is rugged with steep slopes, it is almost impossible to have straight line transects (Gurmaya and Sundai 2004; Sundai 2001). Therefore, transects are usually laid out based on a contour or obvious feature in the landscape, such as a track or a river. In order to reduce bias in terms of double counting, transects should be set apart for at least 100 m from one another. Transects should be marked at 20 m, 30 m or 50 m interval (depending on convenience) to form a station. This is important when transferring locations of observed animals onto a map.

The length of a line transect depends upon how long it takes to get an adequate sample size for the target species and how many habitats are to be sampled. Generally, the longest transect walked in any one day is not likely to be more than 10 km because census is often restricted to periods of high animal activity with the quality of data collected declining as the observers begin to tire. It is advisable to do many short transects, perhaps around 2 – 3 km, in lieu of a few long transects. By having short lines ones can reduce bias due to time of day (Llyod *et* al. 1998). It is advisable to partition each transect into distance intervals along the transect length. This helps observers follow the correct track, and also allows habitat information to be collected for specific sections of transect.

3.0 COLLECTION OF DATA USING LINE TRANSECT

On the transect line, observers walk at the fairly constant speed between 500 m to 1000 m per hour, looking either side of the trail and recording all animals seen. It is not recommended to walk too fast (during survey) because the observer may miss a lot of the samples during observation.

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APPENDIX VI

METHODOLOGY FOR BIG MAMMALS STUDY

INDICATOR SPECIES : BIG MAMMALS
METHODOLOGY : STANDARD METHODS FOR BIG MAMMALS SURVEY

1.0 KING CENSUS METHOD (LINE TRANSECT SURVEY)

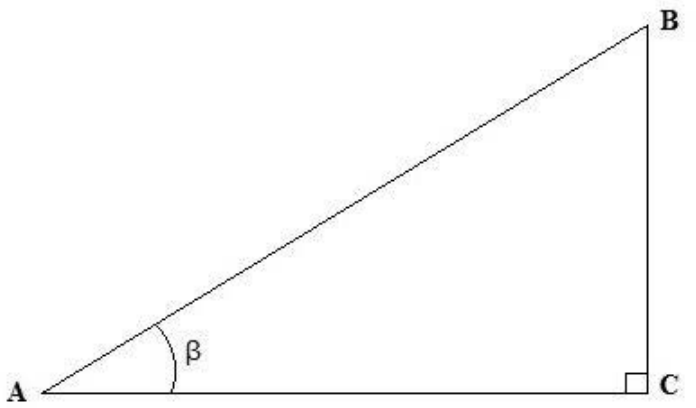
The method involves cutting of a transect line of 2- 3 km long, across as many vegetation and habitat types as possible, preferably representative of that for the area. Every 50 m of the line would be marked by using flagging tapes. These marks would be used as observation points on both sides of the transect lines. Animal species sighted would be recorded, so as their number, activities, groups, distance from the line, left or right side of the line, estimated distance and angle between the animal and the transect line would be determined. This is to calculate the perpendicular distance of the animal sighted so that the area coverage could then be determined for the area, so as the index of species abundance. The data would also enable the calculation of Species Diversity Index and the Index of Species Richness as well.

Management prescription would be done once the data have been collected.

In the event that manpower is not a constraint 2 or 3 transect lines could be put up at three to four km apart from each other. Each transect line should be walked by two or one person, equipped with 10x50 binoculars, a field notebook and a compass. Daylight surveys were done between 0600 hours – 1100 hours at a walking pace between observatory stations of approximately 1 km/hr, stopping for 3-4 minutes at each station to record all sightings and calls of mammals and birds at 360^0 around each station. Tracks, footprints, feces and scratches on trees, stumps and ground should be noted to assist in species identification where possible. Night surveys are to be done between 1900 hours – 2200 hours, once along each transect.

Mammal identifications should follow Medway (1996) and Payne, et. Al (1984), while species nomenclature of mammals is to follow the later. Birds identification should be based on Symthies (1981) and MacKinnon and Phillipps (1993) and Robson (2000) while species nomenclature following the former.

The divers program, modified by Mr. Charlie Laman (2001) from Krebs (1989) could be used to determine the Species Diversity of mammals and avifauna (birds) detected during the survey. This method enables the calculation of Shannon-Weiner Diversity Index, Simpson Diversity Index and also Brillouin Diversity Index as well. It also would work out figures for Species Richness and Species Evenness for the mammals and birds detected.



Shannon-Weiner Diversity Index (H')

$H' = \sum P_i \log_{10} P_i$, where $P_i = n_i/N$, n_i =no. of ind. Of species $_i$, N = total no.of ind. detected.

Note: A: Observer
B: Animal (s)
AB: Angular Distance
AC: Transect Line
BC: Perpendicular Distance

2.0 CAMERA TRAPPING METHOD (for survey of big mammal species)

Commercially made Cam Trakker brand camera trap units (manufactured by Camtrak South, 1050 Industrial drive, watkinville, GA 30677. USA) or any other brand of camera traps could be used in the survey. In the event that the Cam Trakker brand is used each unit consists of a plastic casing camera with built in flash, sensors with selectors and a viewing window. Cam Trakker consists of a fully automatic 35 mm camera with a passive infrared heat-in-motion detector. The heat-in-motion sensor operates on a horizontal plane, thus it is important that is aimed parallel to the ground. When something that moves and gives off heat, asilent electronic switch engages the camera, which takes a photograph. For obtaining clear photographs of animals in the dense tropical rainforest, 400 ASA color print would be used. These units are equipped with a delay selector mechanism that precludes the camera from taking a photograph for a set period time. The time delay between photographs is set to a minimum of three minutes, which eliminates wastage of film on a single situation. All cameras would be set to be operational for 24 hours a day with no break in monitoring except in instances of malfunction or excessive moisture on the film due to high humidity and condensation.

Five to ten sets of camera traps are recommended to be used and to be set about 500 m apart from each other. This is to reduce possible repetition of capture of similar animals by the different cameras.

The cameras would be checked every 30 days to reload new film rolls. 9If the Camera is of digital type that the pictures should be downloaded into a computer and the batteries are to be replaced with new ones). However in instances where the films have been fully consumed before checking, there could be gaps in the record. The same camera locations would be maintained throughout the duration of the study.

Cameras would only be removed or relocated to accommodate changes in local conditions such as as tree fall. Dense undergrowth or inundation by rainwater. Due to these factors the trapping effort in

each camera trap site would not be similar. However, only the active Camera-Days are included in order to calculate the total number of camera days, which would be accumulated to 1504 camera days.

Total Camera Days (TCD) = $\sum cd_i$ (1)

The Relative Abundance Index (RAI) for each species is also calculated as

$RAI_{CT} = \sum_{I=1} d_i X100 / \sum_{i=1} cd_I$ (2)

Where $_i$ is a trap location and d is a detection of the species at i^{th} location (Kawanishi et. Al. 1999). The Relative Abundance Index would only be calculated for mammal species, which would be recorded through the camera traps.

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APPENDIX 7

METHODOLOGY FOR BATS STUDY

INDICATOR SPECIES: BATS

Methodology:
A description of bat survey methods can be found in Helman and Churchill (1986). Surveys for bats should be carried out by an experienced bat investigator as (apart from the fruit bats) little is known of their biology or taxonomy and species can be difficult to identify.

Methods not involving animal capture
Ultrasound detectors (for example, the AnaBat ^{TM}) can be used to detect bats without any impact and should be used whenever possible.

Methods involving animal capture

General

The following general points need to be considered when trapping bats:

- Whenever possible avoid trapping during the breeding season.
- Bats should be released at the point of capture as soon as possible. However, they should not to be released in daylight. Those which cannot be released before dawn should be held until the following dusk.
- When necessary, bats should be held separately in suspended cloth bags in a dark, quite and warm place.
- Bats may go into torpor in the trap or while held bags and will need to be re-warmed before released.
- Care should be taken when handling both flying foxes and microbats, due to the zoonotic disease.

i. Harp Traps

Feature: Combination of pocket to catch bats and slender string to lead bat to the pocket. The strings are set up vertically.

Trapping: Set up the trap at the entrance of bat colony (cave, tree holes, etc).
Note: Size and trap design are flexible according to study site condition and target bat species.

- Set traps in a sheltered spot in potential flyways.
- Clear within two hours of dusk and again after dawn but before the sun begins to warm the hessian.
- Harp traps must not be used where large numbers of bats could be caught (for example at the entrances to roost sites) to avoid the overheating of bats in the collection bag.

ii. Mist nets

Feature: Nets made by slender yarn. Same type of net for bird banding study. There are following mesh size. Length of the size net is 6 m or 13 m and height is 2.5 m with 5 sections (pocket).

Trapping: Set up mist nets cross bat fly way or entrance of colony using poles both sides. Experiences are needed for treatment of net.

Mesh sizes	Target animals
24 mm	Special small birds
30 mm	Small birds and small bats
36 mm	Small birds (sparrow size) and bats
61 mm	Medium size birds (thrush etc)
121 mm	Large size birds (ducks)

Mist nets must only be used by trained and competent personnel.

- Only use mist nets after dark to avoid catching birds.
- The net must be attended at all times and captured bats removed immediately.
- Mist nets should not to be used in areas where large numbers of bats could be caught (e.g. at entrances to roost sites).
- Nets should be closed when not attended and during the day.

GUIDELINE 9

GUIDELINE FOR PREPARATION OF GENERAL HARVESTING PLAN (GP) OF FOREST TIMBER LICENCE AREA

GUIDELINE FOR PREPARATION OF GENERAL HARVESTING PLAN (GP) OF FOREST TIMBER LICENCE AREA

1.0 INTRODUCTION

The planning procedure for harvesting operation will be in accordance with the **Forest Engineering Plan (FEP)** which was drawn up based on the Engineering Studies carried out by FAO/ UNDP project 1977-1981, has two distinct stages:

i. General Planning Stage
ii. Operational Planning Stage

In the General Planning Stage, once a long-term hill licence has been issued, the logging operator is required to submit a General Harvesting Plan (GP) to the Authority. The GP would serve as a basis for the preparation of the Detailed Harvesting Plan/Road Plan (DP/Road Plan) for individual coupes under the operational planning stage.

2.0 CONTENT OF GENERAL HARVESTING PLAN

Map type and scale to be used for the preparation of the GP is either:

a) 1:50,000 T735 series Land and Survey map sheets

OR

b) 1:50,000 T738 series map from the Department of Survey and Mapping Malaysia (JUPEM).

(Note: The submission of General Harvesting Plan shall utilize either of the map series format as mentioned above, but not both in one General Harvesting Plan.)

The GP should show the following:

i. Coupe layout.

ii. Number of coupes to be based on the management plan prescriptions of the Licence.

iii. Coupes are numbered in the order in which they will be harvested.

iv. Proposed coupe harvesting year.

v. Area summary for each individual coupe. See Appendix 1 (For illustrative purpose only)

vi. Proposed/ existing road network (Main Road & Secondary Road) for the licensed area. The road distance summary should be included. See Appendix 3.

vii. Locality of camp site and log-ponds.

viii. Boundary of protected forests (e.g Terrain IV) and conservation forests (e.g shifting cultivation area & Kerangas Forest).

ix. Public and private utilities facilities, (eg tarred road, substations, pipe Line, communication tower etc.)

x. Buffer zone of one (1) kilometre width adjacent to International Boundaries and Totally Protected Areas i.e. National Parks, Wildlife Sanctuaries, Nature Reserves or as otherwise indicated in the forest timber licence document.

xi. All GP submission shall includes the revision history block depict at the bottom right corner of the drawing. Revision number shall be upper case and following numerical sequence beginning with the number "0". GP for "REVISION 0" shall be reserve exclusively for the newly established FMU area. Any further amendment shall be following a running sequence as follows, "REVISION 1", "REVISION 2", "REVISION 3" etc.

xii. Contours. Contour lines shall be illustrated on the GP to show in detail the geographical terrain of the FMU area. Index contour lines will be in SI Unit (International System of Units) and labelled at 100 metres interval with thick lines. A normal contour of 20 metres interval in between shall be illustrated with thin lines and need not be labelled. **(Applicable only to T738 map series)** See **Appendix 2**.

xiii. Three (3) copies of GP shall be submitted to the relevant authority concurrently with the FMP. Soft copy of the GP shall be submitted in a form of Shape files stored in a standard issue compact disc (CD) after the approval of GP. Output format for vector layers (softcopy): shape file in Geographic projection Timbalai - 1948 datum.

xiv. Other information to be included are as follow:

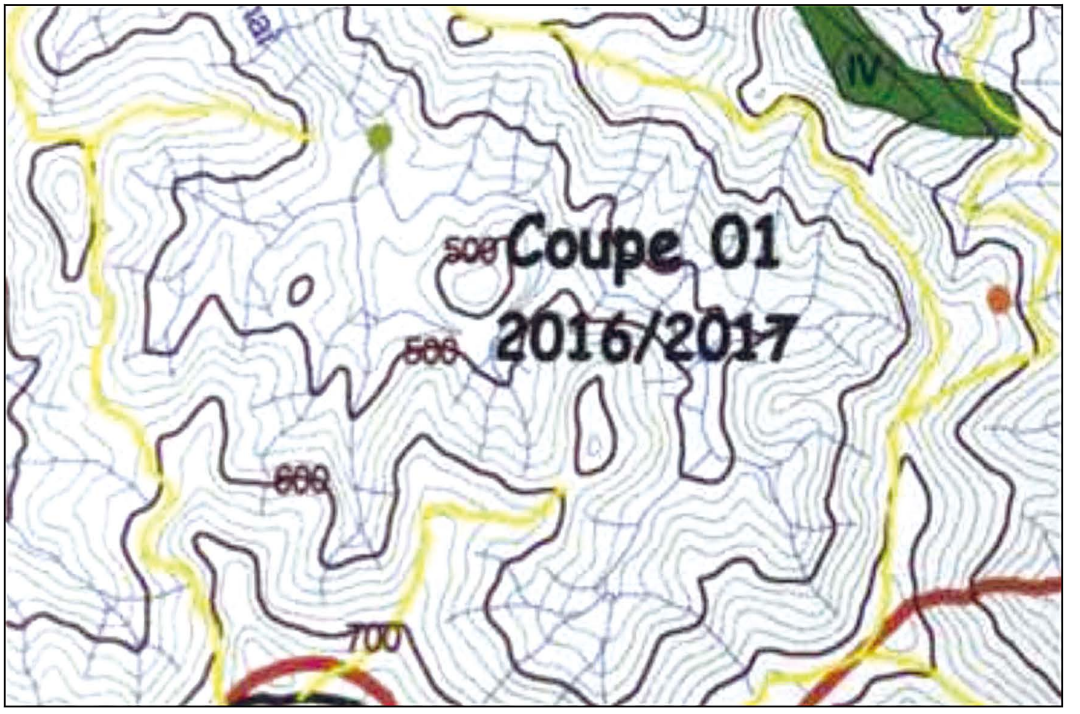
- Scale Bar
- Scale Ratio
- North Arrow
- Map Title
- Legend
- Gridline of 1km by 1km

APPENDIX 1

AREA SUMMARY FOR EACH INDIVIDUAL COUPE

Coupe Year/ No	OPERABLE AREA (HA)	INOPERABLE AREAS (HA)						TOTAL AREA (HA)
		KERANGAS FOREST	TERRAIN IV	SHIFTING AGRICULTURE	WATER CATCHMEMT	RIVER BUFFER	INTERNATIONAL & TPA BUFFER ZONE	
2021/01	1648			563		23		2234
2022/02	1435	106		695		10		2246
2023/03	1205			865		21		2091
2024/04	1824					11		1835
2025/05	1732	126		433		14		2305
2026/06	1658	202		454		23		2337
2027/07	2004				666	28		2698
2028/08	1694					25		1719
2029/09	2001				560	33		2594
2030/10	1154					31		1185
2031/11	1448			1022		15		2485
2032/12	1224			1228		16		2468
2033/13	1325					19		1344
2034/14	1698	325				20		2043
2035/15	2321	251	331			55		2958
2036/16	1873		20			64		1957
2037/17	1478		55	633		33		2199
2038/18	2321		412			11		2744
2039/19	2600		210			9		2819
2040/20	2898		597			5		3500
2041/21	905	44				45	877	1871
2042/22	996	554				16	761	2327
2043/23	1654	15				18		2289
2044/24	1332					22		1354
2045/25	1555					33		1588

APPENDIX 2



APPENDIX 3

EXAMPLE OF ROAD SUMMARY

Road Index	Distance		Total
	Proposed Road	Existing Road	
M-1	-	29.4	29.4
M-2	-	33.6	33.6
M-3	5.9	16.3	22.2
S-1-1	-	28.5	28.5
S-1-2		14.3	14.3
S-1-3		15.7	15.7
S-1-4	1.0	21.3	22.3
S-1-5	0.4	12.3	12.7
S-1-6		10.8	10.8
S-1-7		17.0	17.0
S-1-8		12.9	12.9
S-2-1	9.8	38.3	48.1
S-2-2		43.2	43.2
S-2-3		38.2	38.2
S-2-4		26.9	26.9
S-2-5		37.9	37.9
Total	17.1	396.6	413.7

GUIDELINE 10 A

RIL FOR GROUND-BASED HARVESTING SYSTEM

PART 1

COVERING

A) PRE-HARVEST PLANNING OF LOGGING ROADS, BLOCK LAYOUT, LANDINGS & SKID TRAILS;

B) PRE-FELLING INVENTORY OF TREES FOR HARVESTING;

C) IDENTIFICATION, MARKING AND RECORDING OF TREES FOR PROTECTION;

D) PREPARATION OF REDUCED IMPACT LOGGING PLAN

RIL FOR GROUND-BASED HARVESTING SYSTEM

PART 1

1.0 INTRODUCTION

The Sarawak State Government had instructed for all long-term Forest Timber Licenses to obtain Forest Management Certification (FMC) in order to ensure the sustainable management of natural forest in Sarawak and minimize adverse environmental impacts. The Reduced Impact Logging (RIL) is one of the important elements in Sustainable Forest Management (SFM) as it promotes responsible harvesting practices through provisions and regulations of forest harvesting.

The RIL covers, but is not limited to, the following main activities:

a) Preparation of Detailed Harvesting Plan/ Road Plan (DP/ Road Plan) to show logging road alignments and block layout.
b) Preparation of the RIL workmap for individual blocks to show landing locations and skid trail layout.
c) Pre-felling inventory involving the enumeration of all trees selected for felling.
d) Identification, marking and recording of trees for protection.
e) Preparation of the Reduced Impact Logging Plan (RILP).
f) Construction/ upgrading of logging roads, landings and skid trails.
g) Felling and skidding operation.
h) Post-harvesting operation.

This guideline comprises of two (2) parts. The first part (Part 1) provides guidelines for activities (a) to (e) above, whilst Part 2 consists of guidelines for activities (f) to (h). This document will be revised and improved following updated information, data and research.

2.0 OBJECTIVE

The logging operators are required to carry out pre-harvest planning and preparatory work for annual working coupe prior to the commencement of harvesting operation.

Part 1 of the RIL guideline have the following objectives:

- To facilitate and standardize preparation of Detailed Harvesting Plan/ Road Plan (DP/ Road Plan) for submission to the authority;
- To facilitate and standardize preparation of RIL workmap for submission to the authority;
- To standardize selection, enumeration, marking and tagging of harvested trees;
- To guide directional felling for marked trees;
- To ensure legal source of logs through felling of tagged trees, i.e: only tagged trees are felled in order to facilitate the tracking of the harvested logs right to the stump.
- To ensure protected trees are properly identified, marked and recorded.
- To standardize the preparation of the Reduced Impact Logging Plan (RILP) for submission to the authority.

3.0 PREPARATION OF DETAILED HARVESTING PLAN/ ROAD PLAN (DP/ ROAD PLAN) OF INDIVIDUAL COUPES

The annual working coupes are mainly located in logged-over forest where logging roads had previously been constructed. Therefore, a combined Detailed Harvesting Plan/ Road Plan (DP/ Road Plan) for individual coupes should be prepared based on the specifications below:

Map type and scale to use

- Scale of 1:10,000 topographic workmaps with contour interval not exceeding 10 m. Such maps can be prepared either by photogrammetric mapping using stereo plotters and suitable aerial photographs or by direct enlargement from the 1:25,000 Land and Survey map sheets with contour interval of 25 ft. If these two options are not available, the 1:50,000 T735 map series can be used for direct enlargement. In this situation, the contour interval of 10 metres is exempted.

The DP/ Road Plan should have the following:

- Harvesting block layout. The block boundary should follow natural features wherever possible and block size about 50 to approximately 100 hectares. Allocation of blocks to be worked by tractors should be clearly indicated. The use of tractors should confine to blocks with slopes not exceeding 35°.

- Logging road network should provide access to all harvesting blocks and consists of main, secondary and feeder road. The layout of the road network should include existing logging roads and new road alignments in order maximum skidding distance to within 1,000 metres. For a tractor harvesting operation, road density is to be kept at around 10 metres per hectare. However, certain unavoidable circumstances such as pre-existing roads and diversion, road density up to a maximum of 13 m per hectare are allowed, but subjected to approval from the authority.

- The position of new road alignments are as below:
  - Follow natural topography to avoid excessive cut and fill.
  - Align outside buffer zone (except for waterway crossings), water catchment, High Conservation Value (HCV) area and Terrain IV wherever possible.
  - Keep number of stream crossings to a minimum. Minimize stream crossings.
  - Avoid permanent waterways wherever possible to minimize risk of earth material entering the waterways.

- Permanent Forest Estate (PFE) boundaries.

- Boundaries of gazetted water catchments and/ or gravity feed water catchments established by Health Department (if any).

- Terrain IV and Shifting Agriculture (SA) areas as indicated in Forest Type Map B of the Licence Document or detected from latest remote sensing sources/ ground information.

- Conservation areas for protection of:

  (a) Totally Protected Plants as listed in Part I of the Second Schedule of the Wild Life Protection Ordinance, 1998.

  (b) (Critical resources and sites i.e. saltlicks, mudflats, mud volcanoes, caves and limestone blocks. A buffer zone of 100 m wide around perimeter of such critical resources and sites

should be established. Refer to 10.5 Guidelines to Establish and Protect Representative Conservation and Protection Areas in Forest Ecosystem for details.

- Buffer zone for International boundaries and Totally Protected Areas i.e. National Parks, Wildlife Sanctuaries, Nature Reserves or as otherwise indicated in the Forest Timber Licence documents should be one kilometer (1km) wide.

- Buffer zone of approximately 20 m wide on both banks of permanent waterways. If there is an approved EIA Report for the licensed area, the width of the buffer zone along the waterways will be according to the mitigation measures indicated in the report.

- Buffer zone of 500 m wide for Research and Ecological Plots established by the authority for research purposes.

- Buffer zone of 100 m wide for HEP reservoir or otherwise indicated in the prescribed mitigation measures of approved EIA Report or as directed by the authority, unless shall be deemed to prohibit with the permission in writing of the authority.

- Information on harvesting block sizes, road classification and road distances.

After the approval of DP/ Road Plan by the authority, the logging operator can commence with the following:

- Demarcation of the licence boundary (if it also serves as the coupe boundary), coupe boundary and block boundary.

  Method of demarcation:
  - For coupe boundary, standing trees or permanent natural features along the boundary line shall be marked with **red paint** at regular spacing intervals for easy identification in the forest.
  - For sections of the coupe boundary that form part of the licence boundary, demarcation shall be marked with **orange paint** on standing trees or permanent natural features at regular spacing intervals along common license/ coupe boundary.
  - For block boundaries, marking on standing trees or permanent natural features shall be carried out at regular spacing intervals using **yellow paint**.

- Demarcation of approved surveyed road alignments to facilitate identification by road construction team. The alignments shall be marked with **white-coloured vertical strip line** that is sprayed or painted on standing trees or permanent natural features at five (5) m interval along the surveyed alignments.

- Demarcation of water catchment boundary, buffer zone, conservation areas and SA areas (that are under secondary forest and claimed by local people, if any).

  Method of demarcation:
  - The catchment boundary shall be demarcated by marking on standing trees or permanent natural features with either **blue paint** at regular spacing interval or signboard (with the letters "WC" in blue on it) affixed to the trees with regular intervals along the boundary line.

  - The boundary of the buffer zone adjacent to the waterways shall be demarcated by marking on standing trees or permanent natural features with **blue paint** at regular spacing interval and **signboard** (with the letters "SBR" on it) affixed to the trees along the boundary line.

- For other buffer zones, protection areas, HCV area, Terrain IV areas and SA areas, their boundaries shall be demarcated by marking on trees with **blue paint or signboard(s) placed along the road with arrow pointing to the direction of the boundary.** The logging operator is permitted to work in these SA areas provided a written consent must be given by the land owners and approval is given by the authority.

4.0 PREPARATION OF RIL WORKMAP OF INDIVIDUAL BLOCKS

After approval of the DP/ Road Plan by the authority and field reconnaissance carried out, the logging operator shall prepare the RIL workmap for each individual logging block. This RIL workmap will initially show existing road/ surveyed road alignment, locations of the roadside log landing identified during the field reconnaissance and proposed skid trail layout within the block.

Map type and scale to use
1:5,000 topographic workmap enlarged from the Detailed Harvesting Plan/ Road Plan (DP/Road Plan).

4.1 Criteria for Planning and Selecting Roadside Landing Locations

- Landing sites shall be on both sides of the forest road to avoid pulling logs across or along the road.
- Landings shall be adjacent to spurs/ ridges which are intended to be used as main skid trails.
- Landings shall be located in well-drained areas.
- Sites that require major earth works shall be avoided.
- Landings shall not to be located within any buffer zone.
- Spacing of the landings shall be planned so that maximum skidding distance is kept within 1,000 m.

4.2 Criteria for Planning Skid Trails

- Skid trails shall commence from the landing and normally shall be along the ridgelines.
- Allowable skid trail gradient shall be up to 20° (36%) with distances up to one kilometer (1 km). In logged-over areas, the maximum gradient can go up to 35° (70%) but the distance shall not exceed 30 m.
- No skid trails are allowed within buffer zones, protection and HCV areas.
- Use old skid trails wherever possible.
- Allowable skid trail density under RIL is 80-90m/ha.
- The numbering system for the skid trail layout shall be based on the table below.

TRAIL TYPE	NUMBERING SYSTEM	REMARKS
Main skid trail	MT-1, MT-2	-
Secondary skid trail	ST-1-1, ST-2-1	Branching out from main trail
Feeder skid trail	FT-1-1-1, FT-1-2-1	Branching out from secondary trail
Breakout trail	-	Short trail up to 20 metres branching out from any of the above trails

Use of modified excavator/ mobile yarder along skid trail for log winching
The modified excavator/mobile yarder operates efficiently by winching the log uphill. Therefore the skid trails need to be aligned along ridgelines or located as high up the slope as possible.

4.3 Field Alignment, Marking and Mapping of Skid Trails

(a) Team Composition

The composition and functions of the trail alignment team are as follows:

Team leader	-	Supervision, field recording
Assistant team leader	-	Identifying and choosing alignments, instrument reading
Labourer(s)	-	Marking/ flagging of trail alignments, measuring distance

(b) Procedure for Field Alignment and Marking

- Based on the planning done on the 1:5,000 topographic workmap, the alignment of the skid trail shall commence from the roadside landing.

- Skid trail shall be located either on the top of the ridge or left / right side of the ridge, but whichever way the skid trail gradient shall not exceed 20° (36%) except for short distances not exceeding 30m where the maximum allowable gradient can reach up to 35° (70%).

- For re-entry blocks, old skid trails shall be used wherever possible.

- The alignment of the skid trails shall continue until the end of the block is reached or when it encounters steep slopes of more than 35° (70%).

- Where side cutting is needed, the terrain slope gradient shall not exceed 35° (70%).

- The alignments shall be located outside buffer zones, protection and HCV areas.

- Skid trail marking shall be carried out to ensure that the tractor drivers follow the marked trails only and do not break out. This is to ensure that the skid trail density is kept to the lowest minimum necessary to extract the commercial timber.

- The skid trail alignment shall be marked with **white-coloured vertical strip line painted** on the trees **or with red or red-white plastic flagging** to trees along the alignment.

(c) Mapping of Skid Trail Alignments

There are 2 options of mapping the skid trail alignments:

Option 1 - Ground measurement using compass, clinometer and tape

- The mapping of the skid trail commences at the Global Positioning System (GPS) tie point at the roadside to which the main skid trail is connected.

- Each trail section is measured and recorded for ground distance; slope and bearing into the mapping sheet (see **Appendix 1**).

- Each time the slope changes by more than 10% or the alignment bends to a different direction, a new section is recorded.

- The minimum length of each section shall not be less than 10 m.

- The end of each section shall be marked with **red or red-white plastic flagging** on a stick or pole.

- After reaching the end of a main trail, the skid trail team returns to the nearest junction and continues recording the secondary/ feeder trails.

- Measurement is done along the middle of the marked skid trail for existing trails that are to be used.

- The ground distance will need to be corrected using the slope correction table (see **Appendix 2**) to obtain the horizontal distance and this is then entered into the mapping sheet.

- The RIL workmap shall be updated to show the mapped skid trail layout as well as the existing road/ newly constructed road (if any) within the logging block and confirmed locations of the roadside landings. A typical RIL workmap is shown in **Appendix 3**.

- The RIL workmap shall comprise of a table on skid trail numbers and their respective distances within the logging block as shown in **Appendix 3a.**

Option 2 - GPS mapping

- Mapping of skid trail alignments can also be done using GPS receiver in a much shorter time compare to Option 1.

- Although faster, the accuracy may deteriorate due to forest canopy.

- However, knowledge of GPS technology including post-processing will help to improve the accuracy of the points along the skid trail alignments.

- The RIL workmap shall be updated to show the mapped skid trail layout as well as the existing road/ newly constructed road (if any) within the logging block and confirmed locations of the roadside landings. A typical RIL workmap is as shown in **Appendix 3**.

- The RIL workmap shall comprise of a table a table on skid trail numbers and their respective distances within the logging block as shown in **Appendix 3a.**

4.4 Criteria for Planning the Location of the Modified Excavator/Mobile Yarder Platforms or Shuttle Landings along Skid Trails

- The location of the modified excavator/ mobile yarder platforms or shuttle landings can only be accurately identified after the skid trails have been constructed and the marking/ tagging of trees for felling have been completed.

- The location and spacing of the modified excavator/ mobile yarder platform is dependent on the locality of the trees that have been marked and tagged for felling.

- The modified excavator/ mobile yarder will normally be positioned on the skid trail itself and a clearing of about 20 m x 20 m around the platform area is permitted to allow for the stacking of logs before the tractor comes in to skid out the winched logs to the roadside landing.

- The locations of the modified excavator/ mobile yarder platforms need not be reflected in the RIL workmap, which forms part of the RILP. The RILP has to be submitted by the logging operator to the authority at the time of application for pre-felling inspection. Prior to pre-felling inspection by the authority, construction of the skid trails is not allowed.

5.0 PRE-FELLING INVENTORY OF TREES FOR HARVESTING

- Pre-felling inventory shall be guided by the management plan prescriptions of the Forest Timber Licence.

- The logging operator shall undertake the Pre-felling inventory in all the harvesting blocks of each authorized coupe.

- It shall be carried out after the demarcation of harvesting block boundaries and skid trail alignments on the ground and will basically follow the skid trail alignments.

- The basic steps involved are therefore as follows:
  - Tree selection, enumeration and recording of tree data
  - Tree tagging

5.1 Tree Selection, Enumeration and Recording of Tree Data

(a) Team Composition

The composition and functions of the tree selection, enumeration, marking and tagging team are as follows:

Team leader	-	Overall supervision and recording
Assistant team leader	-	Monitoring tree selection, choosing felling direction
Tree marker(s)	-	Tree selection, species identification
Labourer(s)	-	Tree spotting, measuring Diameter at breast height (DBH) and height, tree tagging

(b) General Procedure

- Tree selection starts along the skid trail moving either towards or from the back of the block.

- The end of the trail shall be the point beyond which no trees are to be felled.

- The team leader and his assistant will position themselves along the marked trail alignment or in the middle of the existing skid trail.

- The tree marker(s) and the labourer(s) will cover the skid trail corridor on both the left and right side of the trail and spot the potential harvestable trees.
  - Alternatively, the operator can carry out enumeration based on **parallel-strip line system.**

(c) Tree Selection Criteria

For a tree to be selected for harvesting, it must fulfill the following criteria:

- Located inside the harvesting block.

- Tree is not located within the buffer zone [if there is any as imposed under the EIA mitigation measures required by Natural Resource Environment Board (NREB)].

- Tree is not located on steep slopes [gradient greater than 35° (70%)].

- Tree does not belong to any protected species under the list of Totally Protected and Protected Plants (see **Appendix 4**).

- Not a mother tree and PCT.
- Able to produce at least one merchantable log greater than 3.6 m in length.
- Harvestable tree is restricted to DBH measurement of 45 cm and above for Non-Dipterocarp species and 50 cm and above for Dipterocarp species.
- The distance of the tree position from the skid trail does not exceed 60 m measured along the ground. It can be extended to 100 m for favorable terrain conditions, which minimize damages to the environment.

(d) Enumeration and Recording of Selected Trees

The enumeration of the selected trees for harvesting will involve:

- Identifying the species.
- Measuring the tree diameter at breast height (1.3 m above the highest ground level) or at a point just above the highest buttress if it is higher than the breast height.
- Visual (ocular) estimate of the tree height in full metres up to merchantable height.
- Allocation of a tree number as identified in the tree tag.

The field data is then recorded in the Pre-felling Inventory Recording Sheet (see **Appendix 5**). For each trail, the trees on the left side and the trees on the right side are recorded in the sheet. recorded in the sheet. "Left" and "Right" can be viewed from the starting point of the skid trail either at the beginning or end of the block.

5.2 Tagging of Selected Tree for Harvesting

- All trees selected for harvesting are tagged with **white-coloured plastic tag**. The tag will have 6 sub-sections, each with an identical serial number consisting of an alphabet (Tag Code) followed by 4 digits to denote the tree number. A sample of the tag is shown in **Figure 1**.
- Before the tag is fixed to the tree, the coupe number, block number, tree species, DBH, estimated tree height and skid trail number are written on the 6 sub-sections of the tag using a permanent marker pen of **black or blue colour**.
- The tag shall be fixed to the tree stump area at about 0.5 m from the lower ground.
- Tree shall be felled opposite to the side where the white-coloured plastic tag has been affixed.
- Wherever possible, the direction of the tree fall shall be at an angle of between 30^{o} to 60^{o} towards the skid trail to facilitate the winching operation by the tractor.
- The direction of the fall shall also ensure that the selected tree does not damage the surrounding protected trees, important wildlife resource trees and potential crop trees.
- Selected trees shall also be felled away from the streams and steep valleys.
- In determining the felling direction, the natural lean of the tree has to be taken into consideration from safety point of view as it may not be always possible to go against the lean when the tree is being felled.
- After the tree has been felled, the tree feller shall keep the bottom detachable sub-section (denoted as "0") of the tag for record purposes.

- The other 5 detachable sub-sections of the tag are denoted as “0”, “1” and “2” for identification of the tree stump, first log and second log respectively.

- The top “0” sub-section of the tag remains on the stump. If it has come loose during the felling of the tree, the tree feller will have to fix it back to the stump after the completion of the felling operation.

- The 2 sub-sections (denoted as “1”) of the tag shall be fixed onto both ends of the first log.

- The other 2 sub-sections (denoted as “2”) of the tag shall be used for the second log in the situation where the length of the felled tree is long and has to be cross-cut into 2 logs.

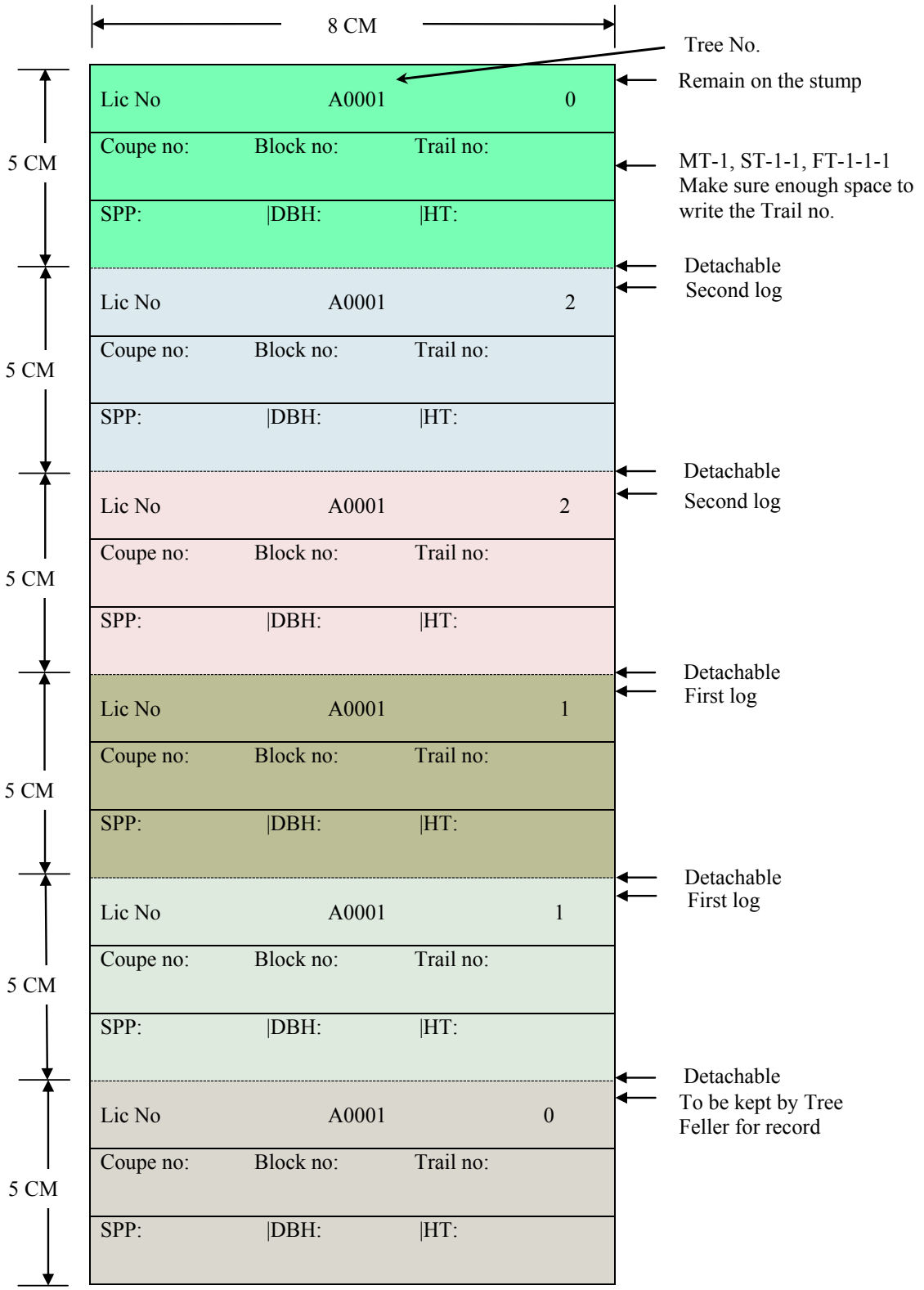


Figure 1: A sample of white-coloured plastic tag for harvestable tree
(Colour coding is just to denote the sub-sections of the tag)

5.3 Harvestable Trees that are Missed Out During the Tree Selection Operation

- Harvestable trees may be missed out by the tree marker during the tree selection operation in the field and therefore will not have any tree tag affixed to the tree.

- The tree feller will detect some of these untagged trees as he moves around the block to locate the tagged tree for felling.

- The tree feller shall be provided with supplementary tags (similar to that shown in **Figure 1**).

- If the tree feller decides that the tree without any tagging is a harvestable tree that can be felled and extracted, he shall proceed with the felling of the tree.

- The tree feller shall then write the coupe number, block number, tree species, DBH, estimated tree height and skid trail number on the 6 sub-sections of the tag using a permanent marker pen of **black or blue colour**.

- Subsequently the tree feller shall attach the tree tags on to the stump of the felled tree and the logs.

- The tree feller shall keep the bottom detachable sub-section of the tag for record purposes.

- Only 10% of the harvestable trees in the block would be allowed for supplementary tags

6.0 IDENTIFICATION, MARKING AND RECORDING OF TREES FOR PROTECTION

Trees for protection cover the following:

(a) Trees of any protected species under the list of Totally Protected and Protected Plants (see Appendix 4), fig tree, fruit tree or mother tree

- Only such trees that are in danger of being damaged by the fall of a harvestable tree during the felling operation or nearby skid trail alignment will be identified.

- In the case of Mother Trees (MT), at least two trees (either non-dipterocarp species with DBH of 45 cm and above or dipterocarp species with DBH of 50 cm and above) with good form are to be identified for every 500 m length of the skid trail alignment (one tree on each side).

- These trees shall be marked with **blue-coloured tags** affixed around the tree which contain information such as species and species codes (Totally Protected tree = TP, Protected tree = P, Mother tree = MT, and Fig tree or Fruit tree = FT). For mother trees, the tags must also include the measurement for DBH in additional to species and species codes.

- The tagged trees shall not be felled and the tree feller must take precautions to minimize damage to these trees during the felling of trees that have been selected for felling or harvesting.

Notes: Mother Tree means trees that possess good physical form are marked and to be maintained for seed production.

(b) Potential Crop Trees (PCTs)

- Definition of Potential Crop Tree:
  - Tree likely to become harvestable tree for next cutting cycle
  - Minimum DBH of 30 cm
  - Tree with well-developed crown
  - Tree with straight cylindrical bole
  - Tree with no major bark damage
  - Tree with no major bole defect
  - Tree with lean of not more than 20° from the vertical

- The PCTs along the skid trail corridor within a width of 60 m measured on ground distance (but can be extended to 100 m on favourable terrain conditions) shall be identified with **orange tags** affixed on the trees. The species, species code and DBH shall be written on the tags. Any substitution of the colour due to non-availability must obtain approval the authority.

- The tagged trees shall not be felled and the tree feller must take precautions to minimize damage to these trees during the felling of trees that have been selected for felling or harvesting.

- All the undersized trees located within (a) the skid trail corridor (normally of with 5 metres but can be increased to 7 metres if the skid trail is constructed on side slopes) and (b) cleared width of the logging road alignments (as specified in the Logging Road Design Standards) are allowed to be felled & extracted. All the undersized trees must be measured & tagged with single section of white plastic during the pre-felling inventory stage.

- For such undersized trees that may be affected by the harvesting operations, the species of the PCT has to be identified and its DBH and estimated height recorded in the Operational Inventory Recording Sheet as in **Appendix 11**.

Recording of trees for protection

- All the trees that have been tagged for protection shall be recorded in stock sheets [Samples of the stock sheet that can/may be used by the Licensee are indicated in **Appendix 6** (Tree for Protection) & **Appendix 6a** (Potential Crop Tree)].

- The recording of the trees on the stock sheet shall be based on individual skid trail section. Tree positions based on GPS readings are not required but it is recommended that their locations be recorded based on the left or right of the trail to facilitate the tracking of the tree position on the ground. "Left" and "Right" can be viewed from the starting point of the skid trail either at beginning or end of the block.

- Undersized trees that are allowed for felling within the skid trail corridors and the logging road cleared width shall also be recorded in a recording or stock sheet (based on the standard formation **Appendix 11** for submission to the authority.)

7.0 PREPARATION OF THE REDUCED IMPACT LOGGING PLAN (RILP) FOR SUBMISSION TO THE AUTHORITY

The RILP shall be prepared for submission to the authority after the completion of the pre-felling inventory works in the individual logging blocks.

The RILP will consist of the following documents:

- RIL workmap on scale of 1:5,000 to show all existing road/ newly constructed road alignments, existing/ surveyed skid trail alignments and locations of log landings at the roadside for each block. A table to provide information on the distances of the individual skid trail numbers is to be attached. The format of the RIL workmap is as shown in **Appendix 3** and **Appendix 3a.**

- Operational Inventory Summary Sheet covering each Skid Trail of the Individual Block (Format **RILP 1** as shown in **Appendix 7**).

- Summary of Skid Trail Network and Trees to be Harvested for Individual Block (Format **RILP 2** as shown in **Appendix 8**).

- Summary of Trees for Protection within Individual Block (Format **RILP 3** as shown in **Appendix 9**).

- Summary of Trees for Protection within the Coupe (Format **RILP 3a** as shown in **Appendix 9a**).

- Summary of the Coupe Operational Inventory Analysis (Format **RILP 4** as shown in **Appendix 10**). This summary will cover all the blocks for which the five (5) documents listed above are completed and these blocks are ready for inspection by the authority.

- Operational Inventory Summary Sheet covering the undersized tree allowed to be felled (Format **RILP 5** as shown in **Appendix 11**).

The RILP shall **be submitted** to the authority at the time of application for Pre-felling Inspection.

APPENDIX 1

A SAMPLE OF MAPPING SHEET

Sheet No:……

LICENCE NO:	**TEAM LEADER:**
COUPE NO:	**DATE:**
BLOCK NO:	**SKID TRAIL NO:**

STATION NO.		**BEARING (^{O})**	**SLOPE (%)**	**GROUND DISTANCE (m)**	**HORIZONTAL DISTANCE HD (m)**	**CUMULATIVE HD (m)**	**REMARKS**
FROM	**TO**						

- *For Licensee Record only*

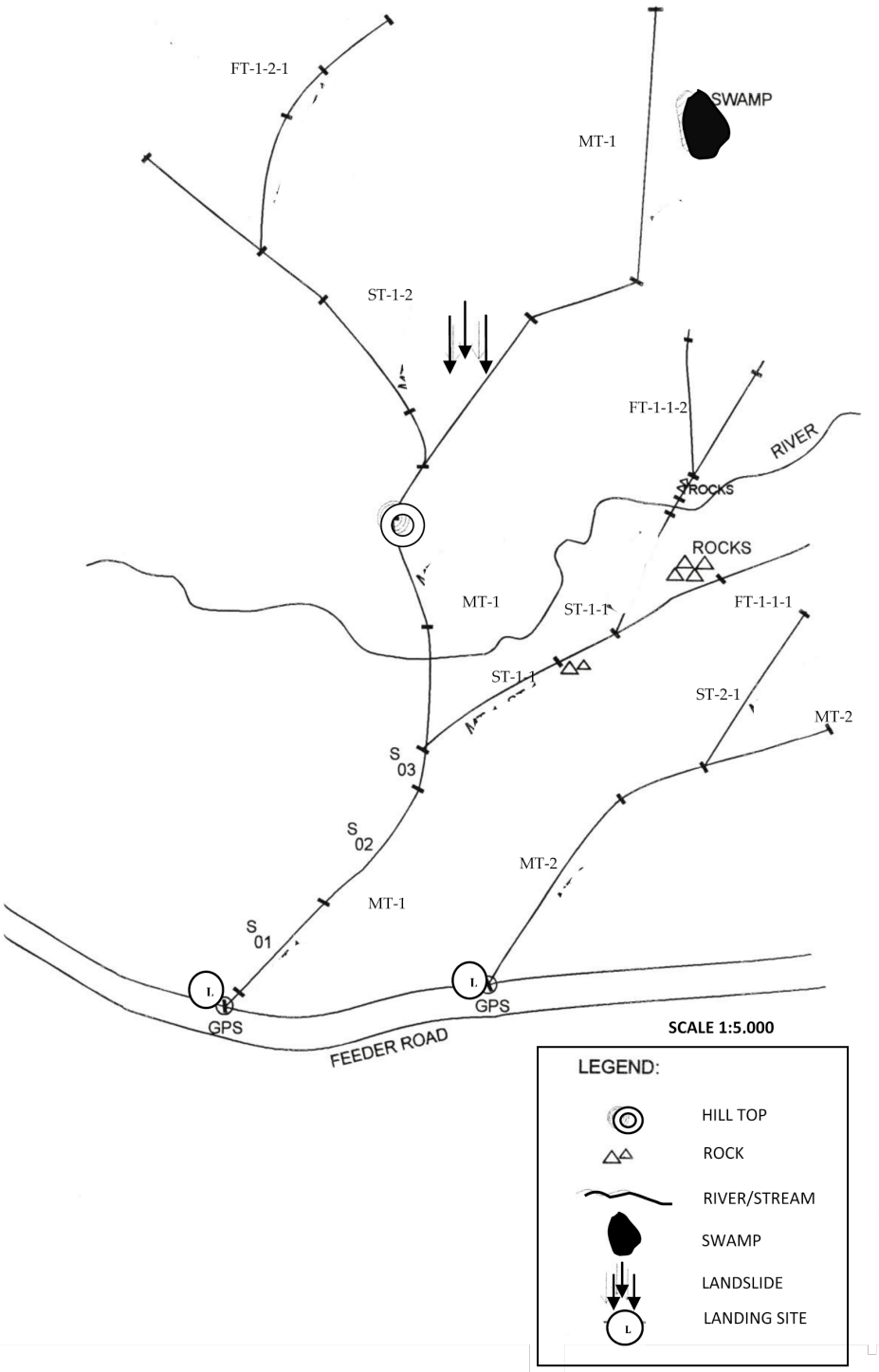
APPENDIX 2

SLOPE CORRECTION TABLE

SLOPE GRADIENT IN %	CORRECTION FACTOR (1/COS *)	HORIZONTAL DISTANCE (M)					
		2	3	5	10	20	52.5
		DISTANCE ALONG THE SLOPE (M)					
10	1.00	2.00	3.00	5.00	10.00	20.00	52.50
15	1.01	2.02	3.03	5.05	10.10	20.20	53.03
20	1.02	2.04	3.06	5.10	10.20	20.40	53.55
25	1.03	2.06	3.09	5.15	10.30	20.60	54.08
30	1.04	2.08	3.12	5.20	10.40	20.80	54.60
35	1.06	2.12	3.18	5.30	10.60	21.20	55.65
40	1.08	2.16	3.24	5.40	10.80	21.60	56.70
45	1.10	2.19	3.29	5.48	10.96	21.92	57.54
50	1.12	2.23	3.35	5.59	11.17	22.34	58.64
55	1.14	2.28	3.42	5.71	11.42	22.83	59.93
60	1.67	3.33	5.00	8.33	16.65	33.3	87.41
65	1.19	2.38	3.58	5.96	11.92	23.84	62.58
70	1.22	2.44	3.66	6.10	12.20	24.40	64.05
75	1.25	2.50	3.75	6.25	12.49	24.98	65.57
80	1.28	2.56	3.84	6.40	12.80	25.60	67.20
85	1.31	2.62	3.93	6.56	13.11	26.22	68.83
90	1.35	2.69	4.04	6.73	13.46	26.91	70.65
95	1.38	2.76	4.14	6.89	13.79	27.57	72.37
100	1.41	2.83	4.24	7.07	14.14	28.28	74.24
105	1.45	2.90	4.34	7.24	14.48	28.96	76.02
110	1.48	2.97	4.45	7.42	14.85	29.70	77.96
115	1.52	3.05	4.57	7.62	15.24	30.48	80.01
120	1.57	3.13	4.70	7.83	15.67	31.33	82.25
125	1.60	3.20	4.80	8.00	16.00	32.00	84.00
130	1.64	3.27	4.91	8.18	16.36	32.72	85.89
135	1.67	3.35	5.02	8.37	16.75	33.49	87.92
140	1.72	3.44	5.17	8.61	17.22	34.44	90.41
145	1.76	3.52	5.27	8.79	17.58	35.16	92.30
150	1.80	3.61	5.41	9.02	18.04	36.08	94.70
155	1.84	3.69	5.53	9.22	18.44	36.89	96.83
160	1.89	3.77	5.66	9.44	18.87	37.74	99.07
165	1.93	3.86	5.80	9.66	19.32	38.64	101.44
170	1.97	3.94	5.91	9.85	19.70	39.41	104.44

APPENDIX 3

RIL workmap



➢ *To be submitted to the authority*

APPENDIX 3A

SKID TRAIL NO.	DISTANCE IN METRES
MT-1	
ST-1-1	
ST-1-2	
FT-1-1-1	
MT-2	
ST-2-1	

Table showing distance of individual skid trail to be attached to the map

- *To be submitted to the authority*

APPENDIX 4

LIST OF TOTALLY PROTECTED AND PROTECTED TREES

SECOND SCHEDULE

(Section 2(1))

PART I

TOTALLY PROTECTED PLANTS

Scientific Name	*Common Name*
1. All *Rafflesia* species	Bunga Pakma
2. *Dipterocarpus obloglofolius*	Ensurai

PART II

PROTECTED PLANTS

1.	*Shorea macrophylla*	Engkabang jantong
2.	*Shorea splendida*	Engkabang bintang
3.	*Shorea helmsleyana*	Engkabang gading
4.	*Shorea siminis*	Engkabang terendak
5.	*Shorea palembanica*	Engkabang asu
6.	*Shorea stenoptera*	Engkabang rusa
7.	*Shorea pinanga*	Engkabang langai bukit
8.	*Shorea ochracea*	Raru
9.	All *Ficus* species	Pokok ara
10.	*Sonneratia alba*	Perepat
11.	*Sonneratia caseolaris*	Pedada
12.	*Avincennia alba*	Api-api hitam
13.	*Avincennia lanata*	Api-api
14.	*Avicennia marina*	Api-api merah
15.	*Avicennia officinalis*	Api-api sudu
16.	*Lumnizera littorea*	Teruntum merah
17.	*Koompassia excelsa*	Tapang
18.	*Koompassia malaccensis*	Menggris
19.	*Aetoxylon sympetalum*	Kayu gahru
20.	*Aquilaria beccariana*	Kayu gahru, engkaras (I)
21.	*Aquilaria malaccensis*	Kayu gahru
22.	*Aquilaria microcarpa*	Kayu gahru
23.	*Didesmandra aspera*	
24.	*Casuarina equisetifolia*	Rhu laut
25.	All *Rhodedendron* species	

26.	All *Nepenthes* species	Periok kera
27.	All *Orchidaceae* species	Orkid
28.	*Salacca magnifica*	
29.	*Johannesteysmannia altifrons*	Ekor buaya
30.	*Areca triadra*	Pinang
31.	*Areca jugahpunya*	Pinang
32.	*Pinanga mirabilis*	Pinang
33.	*Areca subcaulis*	Pinang
34.	*Licaula orbicularis*	Biris
35.	*Eurycomalongifolia*	Tongkat ali, sengkayap
36.	*Goniothalamus velutinus*	Kayu hujan panas
37.	All *Monophyllaea* species	
38.	*Antiaris toxicaria*	Ipoh
39.	All peat swamp species of *Madhuca*	Ketiau
40.	*Calophyllum lanigerum*	Bintangor
41.	*Calophyllum teysmanii*	Bintangor
42.	*Cycas rumphii*	Paku gajah, pakulaut
43.	All epiphytic *Lycopodium* species	Ekor tupai
44.	All *Begonia* species	Riang, telinga gajah
45.	All *Aeschynanthus* species	
46.	All *Cyrtandra, Didymorcarpus* and species	Melebab

47. All species of plants listed in Appendices I and II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), excluding those already listed in Part I.

APPENDIX 5

PRE-FELLING INVENTORY RECORDING SHEET
FOR HARVESTABLE TREES MARKED FOR FELLING

LICENCE NO:	**TEAM LEADER:**
COUPE NO:	**BLOCK NO:**
SHEET NO:	**SKID TRAIL NO:**
DATE:	**NAME OF RECORDER:**

LEFT SIDE FROM THE TRAIL(FRONT/BACK)						**RIGHT SIDE FROM THE TRAIL(FRONT/BACK)**				
NO.	**TREE TAG NO.**	**SPECIES CODE**	**DBH (cm)**	**HEIGHT (m)**		**NO.**	**TREE TAG NO.**	**SPECIES CODE**	**DBH (cm)**	**HEIGHT (m)**

- *For Licensee Record only*

APPENDIX 6

STOCK SHEET FOR LIST OF TREES FOR PROTECTION

LICENCE NO:	**TEAM LEADER:**
COUPE NO:	**BLOCK NO:**
SHEET NO:	**SKID TRAIL NO:**
DATE:	**NAME OF RECORDER:**

LEFT SIDE FROM BACK OF TRAIL							
NO.	CODE	SPECIES	DBH (FOR MT ONLY)	NO.	CODE	SPECIES	DBH (FOR MT ONLY)
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			

RIGHT SIDE FROM BACK OF TRAIL							
NO.	CODE	SPECIES	DBH (FOR MT ONLY)	NO.	CODE	SPECIES	DBH (FOR MT ONLY)
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			

SUMMARY

CODE	DESCRIPTION	COUNT OF NUMBER OF TREES		
		LEFT SIDE	RIGHT SIDE	TOTAL
TP	Totally Protected tree			
P	Protected tree			
MT	Mother tree			
FT	Fig or fruit tree			

- *For Licensee Record only*

APPENDIX 6A

STOCK SHEET FOR LIST OF POTENTIAL CROP TREE (PCT)

LICENCE NO:	**TEAM LEADER:**
COUPE NO:	**BLOCK NO:**
SHEET NO:	**SKID TRAIL NO:**
DATE:	**NAME OF RECORDER:**

LEFT SIDE FROM THE TRAIL (FRONT/BACK)				
NO	**DIPTEROCARP**		**NON-DIPTEROCARP**	
	SPECIES	**DBH (cm)**	**SPECIES**	**DBH (cm)**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

RIGHT SIDE FROM THE TRAIL (FRONT/BACK)				
NO	**DIPTEROCARP**		**NON-DIPTEROCARP**	
	SPECIES	**DBH (cm)**	**SPECIES**	**DBH (cm)**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

SUMMARY

DESCRIPTION	**COUNT OF NUMBER OF TREES**		
	LEFT SIDE	**RIGHT SIDE**	**TOTAL**
DIPTEROCARP SPECIES			
NON-DIPTEROCARP SPECIES			

- *For Licensee Record only*

APPENDIX 7 **RILP 1**

OPERATIONAL INVENTORY SUMMARY SHEET COVERING EACH SKID TRAIL OF INDIVIDUAL BLOCK
(100% TREE ENUMERATION FOR HARVESTABLE TREES)

LICENCE NO:	**ACCOUNT NO:**
LICENSEE:	**PEC REF. NO.:**
PA HOLDER/CONTRACTOR:	**DATE OF ISSUE:**
MANAGEMENT PLAN:	**BLOCK NO./AREA (Ha):**
FOREST TYPE:	**SKID TRAIL NO./DISTANCE (m):**

LEFT SIDE FROM THE TRAIL (FRONT/BACK)				
TREE NO.	**SPECIES CODE**	**DBH (cm)**	**HEIGHT (m)**	**VOL. (m^3)**
SUBTOTAL:				

RIGHT SIDE FROM THE TRAIL(FRONT/BACK				
TREE NO.	**SPECIES CODE**	**DBH (cm)**	**HEIGHT (m)**	**VOL. (m^3)**
SUBTOTAL:				

PREPARED BY:

DATE:DATE OF INVENTORY:

- *To be submitted to the authority*

APPENDIX 8 **RILP 2**

SUMMARY OF SKID TRAIL NETWORK & TREES TO BE HARVESTED FOR INDIVIDUAL BLOCK

FOREST TIMBER LICENCE NO:		**COUPE NO:**	
BLOCK NO.	**BLOCK SIZE (Ha)**	**PEC REF. NO.**	**DATE OF PEC ISSUED**

RILP SUMMARY				
SKID TRAIL NETWORK		**HARVESTABLE TREE**		
SKID TRAIL NO.	**DISTANCE (m)**	**TAG CODE**	**NO. OF TREE**	**REMARKS**
TOTAL				
SKID TRAIL DENSITY (m/ha):				
TREE DENSITY (Tree/Ha):				
PREPARED BY:				
DATE:				

- *To be submitted to the authority*

APPENDIX 9

RILP 3

SUMMARY OF TREES FOR PROTECTION WITHIN INDIVIDUAL BLOCK

LICENCE NO.:		**COUPE NO.:**					**BLOCK NO.:**
SKID TRAIL NO.	**LENGTH OF SKID TRAIL (m)**	**NUMBER OF TREES TO BE PROTECTED**					
		TP	**P**	**MT**	**FT**	**PCT**	**TOTAL**
GRAND TOTAL							

ABBREVIATIONS	
TP - Totally Protected tree	**MT - Mother tree**
P - Protected tree	**FT - Fig tree or fruit tree**
PCT - Potential crop tree	

- *To be submitted to the authority*

APPENDIX 9A

RILP 3a

SUMMARY OF TREES FOR PROTECTION WITHIN THE COUPE

LICENCE NO.:								**COUPE NO.:**
BLOCK NO.	**BLOCK SIZE (Ha)**	**TOTAL LENGTH OF SKID TRAIL (m)**	**NUMBER OF TREES TO BE PROTECTED**					
			TP	**P**	**MT**	**FT**	**PCT**	**TOTAL**
GRAND TOTAL								
ABBREVIATIONS								
TP - Totally Protected tree							**MT - Mother tree**	
P - Protected tree							**FT - Fig tree or fruit tree**	
PCT - Potential crop tree								

- *To be submitted to the authority*

APPENDIX 10

RILP 4

SUMMARY OF COUPE OPERATIONAL INVENTORY ANALYSIS

LICENCE NO.:				**COUPE NO.:**			
PEC REF. NO.:							
BLOCK NO.	**BLOCK AREA (Ha)**	**TOTAL LENGTH OF SKID TRAILS (m)**	**TOTAL NO. OF TAGGED TREE**	**ENUMERATED VOL. (m^3)**	**AVERAGE TREE PER HA.**	**AVERAGE VOL. / HA.**	**AVERAGE VOL./ TREE**
TOTAL							

- *To be submitted to the authority*

APPENDIX 11

RILP 5

OPERATIONAL INVENTORY RECORDING SHEET

(UNDERSIZED TREE ALLOWED TO BE FELLED WITHIN CLEARED WIDTH OF LOGGING ROAD ALIGNMENTS & ALONG SKID TRAIL CORRIDORS)

LICENCE NO:	**ACCOUNT NO:**
LICENSEE:	**PEC REF. NO.:**
PA HOLDER/CONTRACTOR:	**DATE OF ISSUE:**
MANAGEMENT PLAN:	**BLOCK NO./AREA (Ha):**
FOREST TYPE:	**ROAD NO/ SKID TRAIL NO.*:**

TREE NO.	SPECIES CODE	DBH (cm)	HEIGHT (m)	VOL. (m^3)
SUBTOTAL:				

TREE NO.	SPECIES CODE	DBH (cm)	HEIGHT (m)	VOL. (m^3)
SUBTOTAL:				

PREPARED BY: **DATE OF INVENTORY:**

DATE:

- *To be submitted to the authority*

GUIDELINE 10 B

RIL FOR GROUND-BASED HARVESTING SYSTEM

PART 2

COVERING

A) CONSTRUCTION OF LOGGING ROAD, SKID TRAIL, ROADSIDE LANDING;
B) LOG SKIDDING AND POST HARVESTING ACTIVITIES

RIL FOR GROUND-BASED HARVESTING SYSTEM

PART 2

1.0 INTRODUCTION

RIL Guidelines for ground-based harvesting covering:
i. Construction of logging roads, skid trails and roadside landings;
ii. Tree felling;
iii. Skidding operation; and
iv. Post harvesting activities.

2.0 OBJECTIVE

The objective Part 2 is to ensure:

- The construction, repair and maintenance of logging roads are properly carried out and managed to minimize adverse impacts on the environment particularly on soil and water.

- Skid trails and roadside landings are properly constructed to minimize the adverse impact to the environment.

- The logging operators undertake the tree-felling, log winching and log skidding operations in a manner to minimize damage to the surrounding forest area to ensure the success of sustainable forest management.

- Measures are taken to rehabilitate the forest after the completion of logging operation.

3.0 CONSTRUCTION OF LOGGING ROAD

- All forest roads shall be constructed following the planned alignments as laid out in the authority-approved Detailed Harvesting Plan/ Road Plan (DP/ Road Plan).

- The construction of the roads shall be carried out in accordance to the road design standards as outlined in **Appendix 1 and Figure 1.**

- The tractor/ bulldozer shall commence road construction following closely to the painted or flagged alignments on the ground. No deviation is allowed unless prior approval is obtained from the authority. If in later years, it is necessary to make any road deviations from the original route, prior permission must obtained from the authority indicating/ stating clear reasons for such deviations together with a map to show these deviations.

3.1 Measures to Take

- Debris and earth material from the road construction shall be deposited in stable areas and in such a manner that they will not enter the waterways.

- Earth material must not be pushed into the waterways during cut and fill operation.

- Construct roads during dry season. Avoid working in wet weather.

- Appropriate machinery shall be used i.e. bulldozers for bulk earthworks, excavators for work in wet areas, streams and where minimal soil disturbance is necessary and graders for shaping the road.

- The main and secondary forest roads shall be using suitable surfacing material such as stones, laterite or hard shale if available within economic hauling distance.

- Formation and surface layer of the road shall be stabilized through compaction using soil compaction machinery.

- Where there is a risk of instability and erosion on bare areas, measures shall be taken to stabilize them by seeding, re-vegetation, terracing or any other suitable methods.

- Adequate drainage shall be provided during construction by maintaining a good road shape and camber.

- Adequate side drains, culverts and sediment traps shall be installed to prevent scouring.

- Waste oil, lubricants, fuel, old wire rope, oil drums and other waste shall be disposed in an environmentally appropriate and legal manner.

3.2 11.8.2 Repair/Upgrading of Existing Logging Road

When old existing roads are to be repaired or upgrades for the logging operation the measures are highlighted in Section 11.8.1 are to be adhered to.

3.3 Road Numbering System

- All roads shall be numbered and clearly shown at the road junctions by sign posts. The numbering system is as outlined below.

Road Class	Numbering System
Main Road	M-1, M-2, etc.
Secondary Road	S-1-1, S-1-2, etc. for secondary roads branching out from Main Road M-1 and so forth.
Feeder Road	F-1-1-1, F-1-1-2, etc. for feeder roads branching out from Secondary Road S-1-1 and so forth.

3.4 Kilometre Pegs

- Kilometre pegs shall be placed along the side of main and secondary roads. For main roads, the origin (i.e. Km 0) shall start from the base camp or the dumping station, while for secondary roads the origin shall be from the junctions with the main road.

3.5 Road Surface Drainage

- Proper road camber shall be provided to facilitate road surface drainage to the side drains.

- Road side drains shall be constructed especially on hill sides with adequate turnouts to channel water away from the road structure and into the surrounding vegetation.

- Cross road drainage shall be by means of culverts which are laid across the roadway with a minimum fall of 5%. The culverts shall be skewed to allow easy entry of the water.

- Culverts shall be placed on the same level or slightly lower than the bottom of the waterway to avoid flooded areas at the inlet end.

- The apron at the outlet end of the culvert shall be on hard ground if possible. Otherwise, scour protection is required.

- Adequate cover must be provided between the top of the culvert and the road surface.

- Use of an excavator is preferred to place culverts.

  Log clusters with earth fill are not recommended for use as culverts.

3.6 Water Crossing Using Bridges

- Bridges shall be used for crossing permanent flowing waterways and shall be properly designed.

- Wooden bridges shall be constructed from the most durable timber species available in the vicinity.

- Bridge decks may be constructed from sawn timber.

- Abutments must be protected from scouring by the river through the construction of wing walls.

- Adequate headroom must be provided between the flood level and the underside of the deck to allow for the passage of floating debris.

- Options to wooden bridges are pre-fabricated steel truss or concrete bridges.

- Crossing of the waterways must be at right angles and approaches shall have a straight and level alignment for at least 20 m on either side to minimize high impact on the bridge.

- Debris collected around the abutments and piers shall be removed on a regular basis.

3.7 Installation of Sediment Trap

- Proper sediment traps shall be constructed and maintained at strategic points along the forest road to filter surface runoff before the water is discharged into the waterways.

- It is usually located near the waterways or other discharge points to reduce the sediment content of the surface runoff.

- The sediment traps shall be cleaned periodically in order to be effective.

3.8 Road Maintenance

- All roads shall be adequately maintained when still in use to maintain a stable surface and to have an effective drainage system.

- The road camber shall be maintained using the grader to ensure that the water from the road surface can flow smoothly to the side drains.

- Roadside vegetation shall be trimmed regularly to ensure visibility and safety for road users.

- Culvert inlets and outlets shall be cleaned periodically to prevent clogging of culverts and formation of stagnant ponds.

4.0 CONSTRUCTION OF SKID TRAIL

- **What should be done**
  - Skid trails must be constructed before tree felling and log extraction can start.
  - The tractor shall commence construction of the trail from the landing site and follow closely to the painted or flagged trees. Deviations are allowed if sub-surface rocks or deep moist soil pockets are encountered.
  - Generally skid trail shall follow ridges and spurs. For flat or gentle terrain areas, the construction of the trail shall be on the higher and drier sections.
  - Removal of the vegetation and soil must be done carefully using the blade of the tractor.
  - Soil removal must be restricted to the barest minimum necessary for safe machine operation
  - A buried log bund, with a 45˚ angle across the skid trail, shall be constructed at the end of the main skid trail, near permanent waterways, to channel the surface flow into the forest and to prevent from running directly into the waterways.
  - Side cutting is permitted up to 35° (70% slopes).
  - At the end of the skid trail alignment, a **blue-painted cross sign (X)** must be properly installed
  - Unused existing skid trails must be clearly marked with **blue-painted cross sign (X)** on the skid trail.
- **What should not be done**
  - The width of the skid trail corridor normally shall not exceed five (5) m to minimize bare area created during the construction. If constructed on side slopes, skid trail width could be increased to a maximum of seven (7) m.
  - Sunken trail sections with depth exceeding 2.5 metres along steep slopes greater than 20° are to be avoided because sunken trails usually result in very serious gully erosion for a long time. Instead, detours along side slopes shall be made.
  - On flat and gentle terrain areas, the removal of topsoil must be avoided to reduce potential soil losses.
  - Construction of the skid trail is not allowed inside the buffer zones and conservation areas for the protection of Totally Protected Plants and critical resources and sites.
  - The skid trail shall not be constructed across waterways unless absolutely unavoidable.

5.0 CONSTRUCTION OF NEW ROADSIDE LANDING

- The location for the construction of the roadside landing must be based on the 1:5,000 RIL workmap for the individual blocks and confirmed/verified by Global Positioning System (GPS) readings.
- When clearing the landing site, do not push trees and soil into the forest edge with the tractor.

- The landing shall include 2%-3% drainage slope back into the forest.

- Drainage of water shall be directed into vegetation or sediment traps, not directly into the waterway. Runoff from main skid trails shall be prevented from entering the landing site.

- Size of roadside landing shall not exceed 900 square metres or 30 metres x 30 metres.

6.0 TREE FELLING

- **What should be done**
  - Harvesting operation shall be made compulsory to starts from the back of the block where the skid trail ends and gradually proceeds to the landing at the front of the block besides the road.

  - Tree fellers must be competent on directional felling and occupational safety and health.

  - Harvestable trees with tree tags are to be felled.

  - If the tree feller detects harvestable trees missed out by the tree marker and therefore do not have any tags on such trees, he shall proceed with the felling of the trees.

  - The tree feller shall be provided with spare **white-coloured plastic tags** so that the tags can be affixed to the stump and logs after the completion of felling (refer to section 11.4.2 of RIL Guidelines Part I).

  - Felling in the block is permitted, only after felling operation is endorsed and the skid trails have been constructed. It shall commence from the end of the trail.

  - Wherever possible, the direction of the tree felling shall be at an angle of 30° to 60° to the skid trail to facilitate the winching operation.

  - Tagged trees, located at the back of the block where the skid trails are furthest away from the landing, shall be felled first and the logs winched to the skid trail and skidded to the landing.

  - Tagged trees shall be felled into areas which do not have potential crop trees, mother trees and protected trees.

  - Trees shall be felled away from waterways and buffer zones.

- **What should not be done**
  - The minimum cutting limit is specified in the Forest Management Plan (FMP) of the license document. Therefore, felling of undersized trees is prohibited except within five (5) m from the centre line of the skid trail on both sides.

  - In gentle terrain areas, trees shall not to be felled haphazardly but shall be concentrated as much as possible in the direction of the skid trail to avoid large open patches.

  - On steep slopes, trees shall not be felled directly down the slope. It shall be done laterally across the slope in an uphill direction to minimize breakage to the felled tree and damage to the surrounding stand.

- Felling of trees shall not be carried out during windy and rainy weather conditions.

- Totally protected plants and protected plants, fig trees shall not be felled unless permitted under Section 30 of the Wildlife Protection Ordinance, 1998.

- Felling of trees within buffer zone is not allowed.

7.0 SKIDDING OPERATION

- **What must be done**
  - Tractor driver must be competent in constructing skid trails and skidding logs and also in occupational safety and health.

  - The tractor shall remain on the skid trail wherever possible and use the cable winch to pull the log from the stump to the skid trail. In cases where the log extraction is too difficult with the use of the winch, short skid trail breakouts of up to 20 m are permitted.

  - Winching path must be properly identified to avoid damaging the potential crop trees and protected trees during the winching operation.

  ❖ **Use of modified excavator/ mobile yarder along skid trail for log winching**
    - The modified excavator/ mobile yarder shall be positioned at strategic locations (referred to as modified excavator/ mobile yarder platform or shuttle landing) along the skid trail to do the winching.

    - Clearing area not exceeding 20 m x 20 m around the platform is permitted to allow for stacking of logs.

    - Winched logs shall be skidded from the modified excavator/ mobile yarder platform to the roadside landing by the tractor only.

- **What must not be done**
  - Not more than one (1) tractor is allowed to work in a skid trail at any one time.

  - Skidding across or along the waterways shall be avoided. If unavoidable, crossing shall be done at site where there is a rock or gravel bed.

  - Skidding inside buffer zones and conservation areas is prohibited.

  - Blading of the soil off the main skid trail and side cutting shall be avoided.

  - Crown debris on the main skid trail shall not be removed unnecessarily by blading with the tractor, but track over the debris instead.

  - During wet weather conditions, skidding operation shall be halted.

  - Fuel tanks shall not be placed near the waterways.

  ❖ **Use of modified excavator/mobile yarder along skid trail for log winching**
    - The tractor must not be used to winch the logs out from the stump as this shall be carried out using modified excavator/ mobile yarder only to minimize logging damages.

8.0 POST HARVESTING ACTIVITIES

- After the completion of the harvesting operation, bunds of at least one (1) m high shall be constructed every 20 m along the skid trail sectors where gradient exceeds 20° (36%) to avoid gully erosion and divert skid trail runoff into the forest.

- Rehabilitation activities shall be carried out in areas within the block such as **log landing and shuttle landing**.

- The landing sites shall be rehabilitated to reduce runoff, to promote colonization and to reduce soil erosion.

- Unusable fuel drums, tanks, oil filters, wire ropes and other wastes shall be removed from the felling sites, landings and refueling pads shall be disposed in an environmentally appropriate and legal manner.

- All non-essential forest roads shall be closed.

REFERENCES

Chua, D. K. H. (1986). *Forest Engineering - Its Role in the Management of the Mixed Dipterocarp Forest of Sarawak*. Forest Department Sarawak, Kuching

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APPENDIX 1: LOGGING ROAD DESIGN STANDARDS*
(For New Road Construction)

Description	**Road Class**		
	Main Road	**Secondary Road**	**Feeder Road**
Lanes	Dual lane	Single lane	Single lane
Design speed	50 km/hr to 60 km/hr	25 km/hr to 40 km/hr	15 km/hr to 25 km/hr
Formation width (see **Figure 1**)	9 m to 12 m	8 m to 10 m	6 m to 8 m
Cleared width (see **Figure 1**)	40 m to 50 m	30 m to 40 m	20 m to 30 m
Maximum road gradients: • Favourable grade i.e. uphill towards forest • Adverse grade i.e. uphill towards mill • Preferred maximum length at maximum grade	 8% to 10% 6% to 8% 1000 m	 10% to 14% 8% to 12% 1000 m	 14% to 18% 10% to 14% 1000 m
Road camber	2% to 6%	2% to 6%	2% to 6%
Super elevation	1:10	1:12	1:15
Minimum curve radius	50 m	30 m	20 m
Embankments (height to width) • Hill side • Valley side • Rocky terrain	 1:1 1:2 1:0.2 to 0.5	 1:1 1:2 1:0.2 to 0.5	 1:1 1:2 1:0.2 to 0.5
Culverts • Type • Size	 Corrugated/Round metal pipes or Timber/Log types culverts Big enough to allow free flow of water and to prevent ponding	 Corrugated/Round metal pipes or Timber/Log types culverts Big enough to allow free flow of water and to prevent ponding	 Corrugated/Round metal pipes or Timber/Log types culverts Big enough to allow free flow of water and to prevent ponding
Bridges • Type	 • Wooden • Pre-fabricated steel truss or concrete bridge	 • Wooden • Pre-fabricated steel truss or concrete bridge	 • Wooden
• Minimum width	4 metres	4 metres	4 metres

**Based on forest engineering plan*

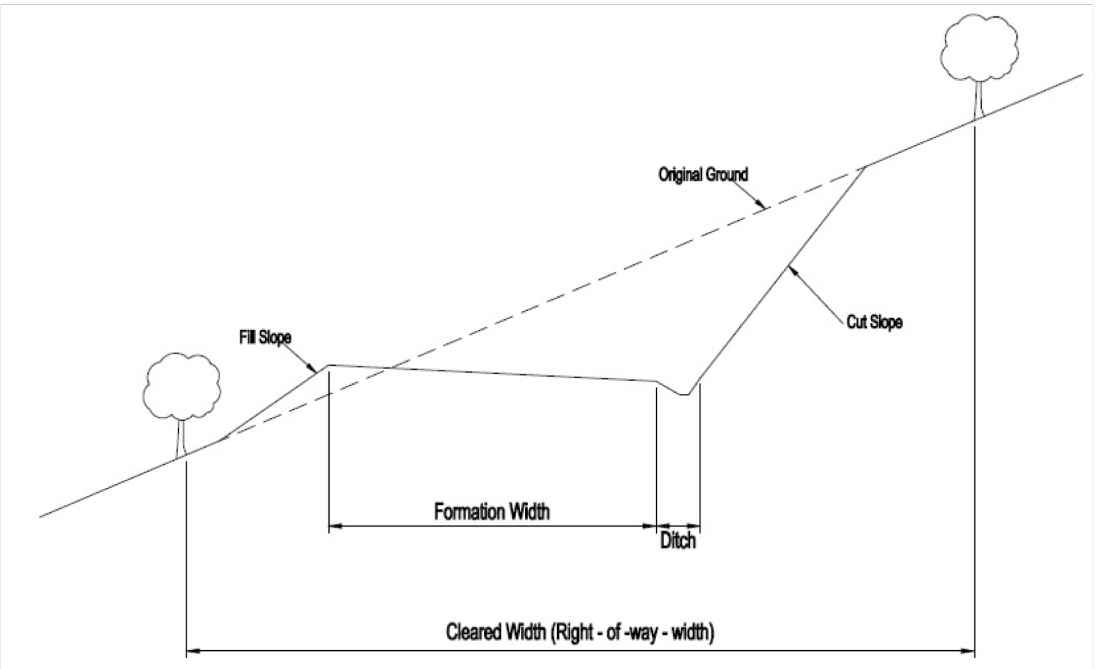


Figure 1. Typical road cross-section

GUIDELINE 11

GUIDELINES FOR SILVICULTURE PRACTICE (ENRICHMENT PLANTING)

GUIDELINES FOR SILVICULTURE PRACTICE (ENRICHMENT PLANTING)

1.0 INTRODUCTION

Timber harvesting with heavy machinery more often caused substantial disturbance to the residual stand of Potential Crop Trees. Patches of bare area created in harvesting blocks are further degraded especially by soil erosion, compaction and soil nutrient lost. Logging operations cause severe disturbance to these areas, in terms of excessive removal of canopy trees and soil disturbances, with negative effects on the growth of residual stock (Hahn-Schilling *et al*. 2000, Pinso & Moura-Costa, 1993).

Silvicultural management goal is to attain the highest possible output of the natural stands of primary forest with economically satisfactory stocks without altering the composition and structure of the forest (Lamprecht, 1993). The treatment operations include Liberation Thinning, Regeneration Release, enrichment planting, rehabilitation of severely degraded areas and complete reforestation (Hahn-Schilling *et al.* 2000, Moura-Costa *et al.,* 1994).

This guideline emphasizes the need to assess the necessity of silvicultural treatment in FMU (Forest Management Unit). It is envisaged that enrichment planting can improve the long-term sustainability of timber production and this guide in this respect generally serves as a tool to implement enrichment planting within the concession areas. If enrichment planting is required than the know-how should include site-species matching, seedling production, wildling collection, planting and maintenance and others.

2.0 FUNDAMENTALS OF ENRICHMENT PLANTING

The original enrichment planting system as described by Lamprecht (1993) provides planting lines with equidistant lines from 10 m to 25 m and is opened in an east-west direction. On both sides, along the line axis, a 1-m-wide strip is completely cleared, all climbers are cut; the brush layer and small trees at a height of up to 4 m with the exception of the valuable species are cut within a distance of 5 m or more (**Figure 1**). Also felled are wide-crowned trees of the under storey. The enrichment plants are planted on the axis of the line, at equal distances of 5-10 m. Stumps or young trees that are at least 1 m high are planted; about 100-200 trees per ha are needed.

The planted rows are regularly cleared. During the first year, up to three tending operations are needed. With increasing height of the young plants, tending can be reduced. Later, they are replaced by selective thinning, at which time the natural forests successively disappear. The upper story of the final stand should be composed solely of the high value introduced by enrichment.

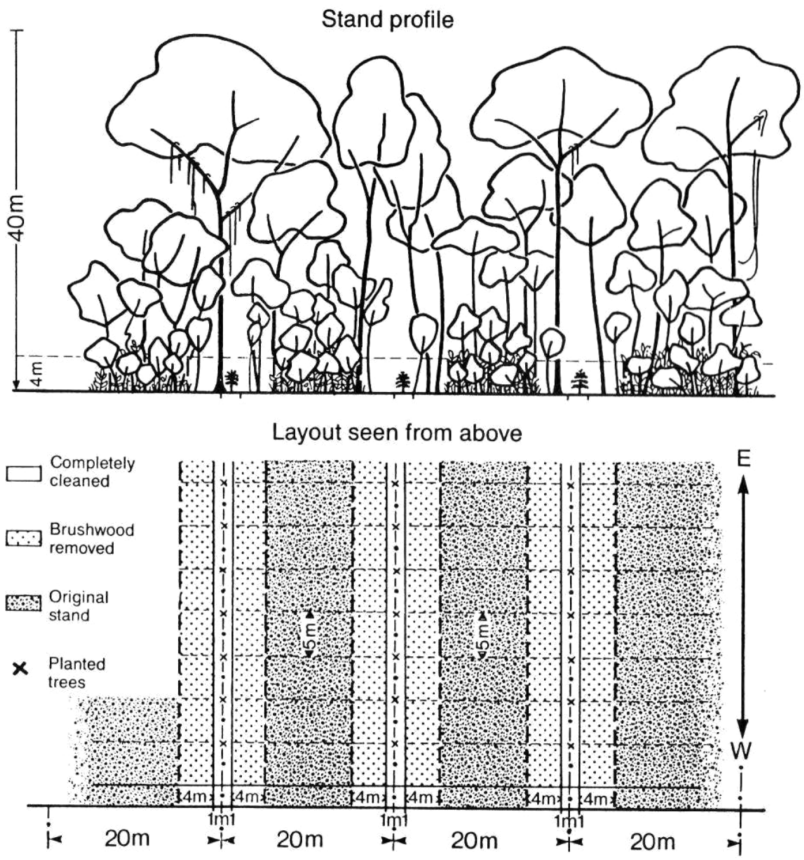


Figure 1. A schematic view of the Line Planting enrichment system (Lamprecht, 1993)

3.0 IMPLEMENTATION OF ENRICHMENT PLANTING

3.1 Decision for silvicultural treatment

The need for silvicultural treatment in an individual block is usually evaluated through diagnostic sampling of residual forests at certain intervals after harvesting. The Botanist is required until such time the Crew Leader and Assistant/ Laborers have gained sufficient experience in identifying commercial species, particularly in their seedlings and sapling stages (Forest Department Sarawak, 2001, Hahn-Schilling *et al*. 2000).

3.1.1 Diagnostic Sampling

The stocking conditions of logged-over forests dictate the silvicultural treatment options. The main criteria for selection of these areas are (Hahn-Schilling *et al.* 2000):

- High disturbance from previous harvesting operations
- Irregular, patchy regeneration conditions
- Commercial seedlings for planting (collected as wildlings) available from within the block
- Easy accessibility by roads

The typical approach of stand diagnostics for silvicultural treatment is as follows (Hahn-Schilling *et al.* 2000):

- Representative sampling of area, i.e. 2-5% of the area are sampled for commercial stocking in all diameter classes, including quality assessment
- Data are analyzed and compared with pre-defined minimum stocking standards
- Decision on necessity of treatment is made, based on stocking standards
- If treatment is found to be necessary, field work is planned and implemented. These general procedures need to be analyzed with regards to their practicality and efficiency relating to Hill MDF of Sarawak.

Ground-based sampling methods, however, are generally too costly to implement at a large scale and hence, a more practical approach, Silvicultural Decision Support System, based on a combination of both terrestrial information, aerial; photos and GIS has been developed (Forest Department Sarawak,2001).

3.1.2 Silvicultural Decision Support System

The Silvicultural Decision Support System (SDSS) for treatment of harvested natural forest is based on establishing the relationship between the actual commercial stocking situation and the number of big trees left behind. A limited number of ground control plots covering typical residual stocking conditions were used. It was determined that a threshold value of one big tree/ha is a suitable threshold value to distinguish the poorly stocked areas from those areas richer in commercial stocking.

The SDSS follows three decision steps:

- Selection of blocks for silvicultural treatment
- Selection of type of silvicultural treatment
- Priority ranking of selected treatment blocks, based on accessibility

After the selection of the treatment areas, the silvicultural operation is carried out by Enrichment Planting. A priority ranking is made according to accessibility for treatment operations.

A block is selected for enrichment planting if it shows on average less than one big tree per ha with a crown diameter of at least 17.5 m. The selection is based on aerial photo interpretation with scale of 1:25,000. Prior to commencement of enrichment planting operations in a pre-identified block, a rapid regeneration reconnaissance survey should be carried out. This will avoid extra cost through identifying areas within the block that do not require replanting. In such areas the Multi-layer Approach can be implemented.

3.2 Implementation

3.2.1 Site-Species Matching

An important factor determining the success of enrichment planting is the right choice of species. However, little is known about site-species matching of indigenous species to be planted and also mycorrhizae interactions with different tree species and soil types (Pinso & Moura-Costa, 1993).

Detailed soil surveys could be carried out so that soil factors can be correlated with stand development in future. Soil survey transect line plan based on plantation roads as baseline is suggested as shown in **Figure 2** (Sabang *et al*. 2012).

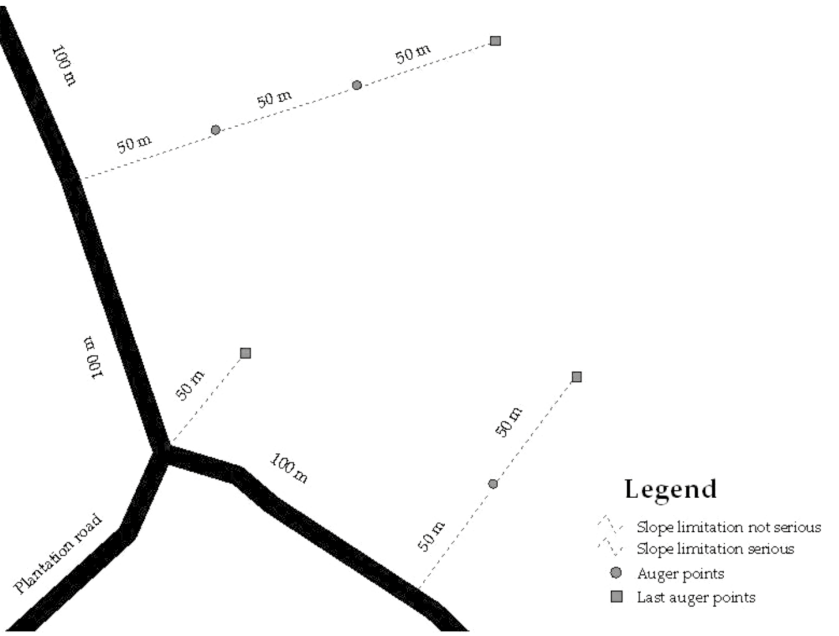


Figure 2. Plan of transect lines for soil survey

Soil survey transect lines are spaced 100 m along a logging road that crossed or border a planting block. The lines are set to the direction perpendicular to the road. Along each line, auger points are fixed at every 50 m interval. Auger points are fixed along transect line at 50 m interval as long as the terrain condition is deemed suitable for tree planting or categorized as 'slope limitation not serious'. The transect line will end with the last auger point when the stretch is observed as with 'slope limitation serious'.

Tree planting should probably be limited to areas within 150 m -200 m from the road side to ensure proper supervision during planting and subsequent maintenance work. The intensity of soil description would be about 2 auger points/ha which could be increase by reducing transect lines interval along plantation road such as to 50 m to increase the accuracy of soil survey.

The soils of the FMUs are largely comprised of the association of the Red Yellow Podzolic and the Skeletal Soils groups on ridges and hill slopes. Gley Soils and Alluvial Soils would be encountered in valleys and on river banks. The brief description of the common soil types in FMU is as shown in **Table 1** below.

Table 1. Common soil types limitation and proposed mitigation measures

Soil Group	**Soil Family**	**Limitation**	**Mitigation /Amelioration**
Skeletal Soils	KAPIT	Depth to impervious layer Fertility	Evade usage or maintain natural vegetation
	TUTOH	Moisture holding capacity Fertility	Evade usage or maintain natural vegetation
	MELUAN	Depth to impervious layer	Evade usage or maintain natural vegetation

Arenaceous Soils	(PENINJAU)	Moisture holding capacity Fertility	Evade usage or maintain natural vegetation
Gley Soils		Wetness Inundation hazard Depth to massive clay	Evade usage or maintain natural vegetation Drainage
Alluvial Soils		Inundation hazard Erosion	Plant well adapted trees
Red Yellow Podzolic Soils	NYALAU	Moisture holding capacity Fertility	Evade usage or maintain natural vegetation Discreet fertilizer application
	BEKENU	Fertility	Discreet fertilizer application
	MERIT	Fertility	Discreet fertilizer application
	SEMONGOK	Depth to massive clay Fertility	Discreet fertilizer application
(Deposited Soil)		Wetness Fertility Depth to massive clay Erosion	Plant well adapted trees Discreet fertilizer application

The establishment of canopy trees prior to the Line Planting could be initiated using selected planting material of pioneer tree species with potential commercial use, such as *Neolamarkia cadamba* (*kelampayan*), *Duabanga moluccana* (sawih), and *Octomeles sumatrana* (binuang).

Treated area could also be planted with indigenous fruit trees such as *Durio*, *Mangifera*, *Artocarpus*, *Dacryodes* (kedondong) and some trees of the Leguminosae family (*e.g.* petai). These trees grow to a large size, are long-lived and their fruits are edible to humans as well as palatable to primates, ungulates and birds. This effort could not only enhance biodiversity of the treated areas and sustenance for wildlife but could also create short term revenue (Pinso & Moura-Costa, 1993).

Whenever they are available, seeds and wildings will be used to supply planting stock for the enrichment planting.

3.2.2 Seedling Production

During the fruiting season, collection must be carried out daily in order to avoid predation by insects or mammals. In the case of dipterocarps, seeds must be taken immediately to the nursery for germination. When fresh seeds are used, high germination rates may be achieved within 2 weeks. Sharp decrease in germination rates were observed when seeds were kept for more than two weeks, with less than 50 % germination (Pinso & Moura-Costa, 1993). Seeds collected in the forest are brought to the nursery for processing and seedling production.

Criteria for seedling selection (Hahn-Schilling *et al.* 2000):

- Seedling of commercial species that includes fruit trees below should be given the highest priority (**Table 2 and 3**).

- Select preferably young seedlings, which generally have a higher survival percentage. Their root system is not fully developed yet and here will be less damage done during the transplanting process.

- Avoid seedlings with excessive branches, which indicates that they are already progressed in age

- Transplanting older, bigger seedlings requires extreme care, due to their expanded root system.

- Maximum seedling height is 1.0 m.

Table 2. Fast to moderate growth rate tree group (Hahn-Schilling *et al.* 2000)

Scientific name	**Vernacular name**
Shorea leprosula	Meranti tembaga
Shorea parvifolia ssp. *parvifolia*	Meranti sarang punai
Shorea parvifolia ssp. *velutina*	Meranti sarang punai
Shorea johorensis	Meranti majau
Shorea scaberrima	Meranti paya bersisek
Shorea pubistyla	Meranti bulu merah
Shorea beccariana	Meranti langgai
Shorea ferruginea	Meranti binatoh
Shorea hopefolia	Lun siput jantan
Shorea resinanigra	Lun meranti
Dryoblanops lanceolata	Kapur paji
Dryoblanops aromatica	Kapur peringgi

Table 3. Moderate to slow growth rate tree group (Hahn-Schilling *et al. 2000*)

Scientific name	**Vernacular name**
Shorea superba	Selangan batu tulang ikan
Shorea falciferoides ssp. *Glauccens*	Selangan batu kilat
Shorea sagittata	Meranti mata lembing
Shorea argentifolia	Meranti binatoh
Shorea pauciflora	Nemesus
Shorea collaris	Lun kelabu
Shorea ochracea	Raruk
Shorea virescens	Meranti sulang-sulang
Shorea bracteolate	Meranti pang
Shorea lamellate	Meranti lapis
Shorea acuminatissima	Lun runcing
Shorea multifolia	Lun jantan
Shorea faguetiana	Lun siput

Shorea atrinervosa	Selangan batu hitam
Shorea crassa	Selangan daun tebal
Shorea foxworthyi	Selangan batu bukit
Shorea isoptera	Selangan batu main bulu ayam
Azadirachta excelsa	Sentang (Ranggu)
Dipterocarpus confertus	Keruing kobis
Dipterocarpus conformis	Keruing beludu kuning
Dipterocarpus palembanicus ssp. *palembanicus*	Keruing ternek
Anisoptera grossivenia	Mersawa kunyit
Parashorea parvifolia	Urat mata daun kecil
Scaphium macropodum	Kembang semangkok
Scaphium borneensis	Kembang semangkok
Dyera costulata	Jelutong bukit
Lophopetalum beccarianum	Perupok
Lophopetalum subovatum	Perupok
Cratoxylon arborescens	Geronggang
Sindora leiocarpa	Tampar hantu
Sindora beccariana	Tampar hantu
Mangifera parvifolia	Raba daun kecil
Palaquium gutta	Nyatoh rian
Dacryodes rostrata forma *rostrata*	Seladah ungit
Dacryodes rostrata forma *cuspiadata*	Seladah
Santiria tomentosa	Seladah bulu
Myristica iners	Kumpang

3.2.3 Wildling Collection

Seeds not collected from the forest quickly germinate, and the resulting wildings may then be collected and cultivated. Wildings are simply pulled from the forest floor in the most efficient way but this often damages their root system. Special care must be given during an acclimatization period after transfer to the nursery. Wildings are watered and kept in plastic covered chambers with high humidity until a new root system is formed. Satisfactory rates of survival have been obtained with this system after a 4 week acclimatization period (Pinso & Moura-Costa*, 1993*).

Criteria for wildling collection (Hahn-Schilling *et al. 2000*):

- Wildling collection and planting shall only be carried out following rainfall in the previous night. This will ensure that the soil has sufficient moisture to secure the planting success.

- Wildlings should be collected from any place within the block, but outside the treatment area.

- To maintain wildling vitality these should be collected as near as possible to the area to be planted. Keep time between collection and planting to a minimum.

- Seedlings should be preferably collected with a half cylindrical planting scope, salvaging the whole root system with organic layer and soil. This will be easier to manage for smaller (mostly younger) seedlings. Push a wooden stick into the soil and shake it to loosen the soil around the selected seedling.

- Alternatively, bare rooted seedlings can be collected by carefully pulling them from the soil, after loosening it.

- For short-distance (up to 20 m) transport of seedlings with soil to planting site, use a basket which can accommodate at least 3 seedlings, including soil and humus.

- For transport over longer distances within the block, make use of bare-rooted seedlings by carrying them to the planting site in a plastic bucket filled with water, thus preventing the root system from drying up.

3.2.4 Planting

The planting system described is by Pinso and Moura-Costa (1993). The spacing used in the planting of dipterocarps and fruit trees was 10 m between lines and 3 m along the lines, giving a density of 333 plants per hectare. The high density of planting allows for reductions caused by damage from browsing and shoot borers without the need for replacement of seedlings, minimizing the costs involved in this operation. Pioneer species was planted at 1 m x 3 m, giving a density of 3270 plants/ha. The width of planting line was 2.0 m, oriented in an East-West direction. In some areas where mammal browsing causes excessive damage, seedlings are planted at the edge of the planting lines. All plants and trees with a DBH of up to 25 cm found along the planting lines are cut, with the exception of natural regeneration of dipterocarps and fruit trees. These are identified during site preparation, and tagged with colored ribbons to prevent damage during weeding operations.

Planting holes are approximately 10 cm in diameter and 20 cm deep. Planting was carried out throughout the year, only interrupted if there was more than 3 consecutive days without rain (Moura-Costa *et al., 1994*). A dose of 100 g of rock phosphate was applied in the planting hole. Subsequent application of fertilizers could be carried out to compare the effects of fertilizers on initial establishment of dipterocarps. Weeding was carried out every three months, for two years, removing lianas and climbing vines. In the case of recently logged areas, weeding is carried out every 2 months, in a total of 6 rounds a year (Pinso & Moura-Costa, 1993).

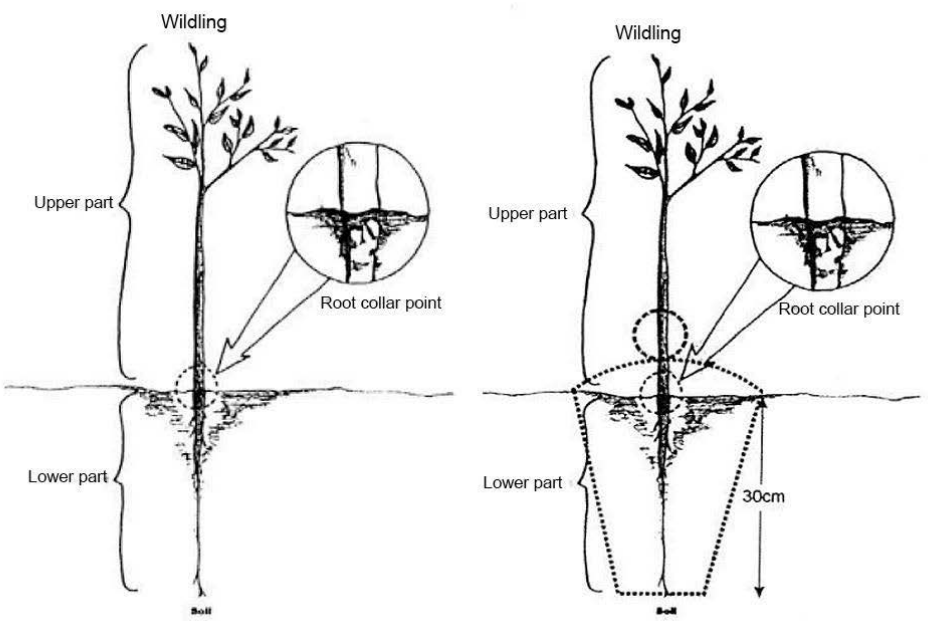
Criteria for planting (Hahn-Schilling *et al. 2000*):

- Seedling tap roots longer than 30 cm shall be cut off with a small-sized pruning shear. Take care not to damage any lateral roots.

- Open the planting hole with the planting scope, down to 30 cm soil depth.

- Accommodate the root system in a conical arrangement with all roots pointing downwards. Do not twits, bunch or shorten lateral roots. No roots must be exposed to the soil surface.

Place seedlings with soil and humus into planting hole. Re-use soil from planting hole to fill the hole and compact it slightly around the seedling. Ensure that no space is left between roots and soil. Watch the critical "root collar point" (**Figure 3**): do not cover it with soil. Cover the soil around the planting hole with thick layer of plant debris/ leaves for prevention of soil erosion and soil moisture, and to serve as mulch. If necessary, carefully pull up the seedling to ensure that the root collar is free of surrounding soil.



a) b)

Figure 3. Position of root collar; a) In natural forest before collection, and b) After planting (Hahn-Schilling *et al. 2000*)

- When using bare-rooted seedlings, hold the seedling straight and in the center of the hole, with its root just touching the bottom level. While holding the seedling, fill up the planting hole with loose soil and compact it very carefully.

- After planting, cut off some of the branches (particularly of older seedlings) and/or leaves from very broad-leaved seedlings, or cut off part of the leaves, to reduce transpiration. Do not damage the meristem and terminal bud.

- In open areas, shade the planted seedling by erecting e.g. fern leaves or small saplings around the seedling for protection from direct sunlight.

- Do not plant seedlings on compacted areas of skid-trails. Shift the planting site to the track shoulders or on loose soil between tracks.

- Do not plant seedlings within a 10 m (30m) buffer zone along rivers of more than 3 m (10 m) width, unless the area has been affected by previous timber harvesting.

- Do not plant seedlings with a durable orange colored plastic flag.

3.2.5 Maintenance

The highest mortality rates were observed in bushy vegetation, presence of grasses and lianas, open canopy and patches of dense vegetation, steep slopes and extremely disturbed site. However it appeared that the most important factor determining initial survival of seedlings was rainfall following planting. The high mortality in these sites was related to the low amount of rainfall and number of rain days during the 30 days following planting (Moura-Costa *et al., 1994*).

Lack of light is the principal cause for the unsatisfactory growth of some enrichment plantings. Improvement of the system is necessary if light, which is the limiting factor, can be enhanced (Lamprecht, 1993). However, Moura-Costa *et al.* (1994) reported that there were no significant differences in the average canopy density above seedlings planted in lines of different widths (1.5 m, 2.0 m and 3.0 m). Since line width was measured on the ground, opening wider lines did not necessarily affect the canopy. In many cases seedlings were shaded by branches of trees located outside the lines, which were not removed. Although there were no significant differences in the average canopy density of different planting lines, there was great variability in the canopy density above individual seedlings. There was a positive correlation between height of *Dryobalanops lanceolata* seedlings and the degree of canopy openness

Criteria for maintenance (Hahn-Schilling *et al,. 2000*)

- During the first year after initial treatment, check the performance of the selected trees, saplings and seedlings at gradually extended intervals of 3 months, 4 months and 5 months, i.e. 3 operations per year. Carry out general weeding of the treated areas as necessary. Replace any perished seedlings on the enrichment planting treated areas.

- During the second year after the initial treatment, recheck the treated areas at 6-monthly intervals and carry out treatment as necessary.

- During years 3 to 5 after initial treatment, recheck and treat the areas at annual intervals. If the stands are found to develop successfully random planting line checks will suffice.

- Following the fifth year after initial treatment, random checks should be carried out at 5 years intervals. These checks can also be utilized to undertake growth measurements and calculations on the expected harvesting date.

4.0 CONCLUSION

The costs involved in artificial regeneration are often prohibitive, and in some cases funds are not available from local sources. However, it could be considered that the timber from enrichment planting could be classified as "sustainably produced" by wood certification schemes, not subjected to trade embargoes and possibly attain higher market prices. Other benefits of enrichment planting include conservation of biodiversity, wildlife, and large areas of natural tropical forest, which otherwise would attain higher opportunity costs by conversion to plantations of fast growing trees or oil palm (Pinso & Moura-Costa, 1993*,* Moura-Costa *et al.* 1994).

A large scale operational nursery needs to be established specifically to supply planting stock for the project. The use of vegetative propagation by cuttings is an alternative method of supplying dipterocarp planting stock. Hedge orchards with stock plants could be established to guarantee a steady supply of plant material for cutting production using available techniques for the vegetative propagation of dipterocarps (Pinso & Moura-Costa*, 1993*).

To established large areas of enriched forests it is necessary for planted stands to be monitored and silviculturally treated so that growth and survival rates are maintained at high levels (Moura-Costa *et al.* 1994). Site preparation was found to be the most time consuming, followed by the planting and the maintenance. Further improvements in efficiency are expected after field staffs are given more practical training.

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GLOSSARY

Biodiversity:
The variability among living organism from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystem and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystem. (CBD: Convention on Biodiversity, 1993)

Diagnostic Sampling:
Sampling of 2-5 % of an area for commercial stocking in all diameter classes, including quality assessment and comparing with pre-defined minimum stocking standards.

Dipterocarp:
Member of the Dipterocarpaceae, prominent tree family of lowland rain forests of western Malesia.

Forest Management Unit (FMU):
A Forest Management Unit (FMU) is the clearly defined forest area, managed to a set of explicit objectives and according to a long-term management plan.

Multi-layer Approach:
Adoption of Silvicultural treatment referring to the Malayan Uniform System (MUS), Liberation Thinning and Regeneration Release.

Potential Crop Tree (In the context of Silviculture):
Tree of preferred species with minimum DBH of 10 cm and 15 cm for coppice regeneration, good crown form, minimum bole length of 5.0 m, straight and cylindrical, free from defects, and on stable and gentle terrain.

Silvicultural Decision Support System (SDSS):
The Silvicultural Decision Support System establishes the relationship between the actual commercial stocking situation and the number of big trees left behind based on aerial photo interpretation with scale of 1:25,000.

Enrichment Planting:
Enrichment system has many variants all over the tropic and is useful where the number of marketable individuals in an initial stand is insufficient. Artificial regeneration of forests in which seedlings of preferred timber trees are planted in the under-storey of existing logged-over forests and then given preferential treatment to encourage their growth. The best known technique is Line Planting which was introduced in 1935 and still in use today (Lamprecht, 1993, Moura-Costa *et al.* 1994).

Liberation Thinning:
Liberation Thinning aims at improving the growth of selected Potential Trees by providing adequate growing space and light to the tree crown to maximize their diameter increment (Hahn-Schilling *et al.* 2000).

Reforestation:
In severe case where stocking situation and regeneration dynamic are impaired such as by forest fire, complete reforestation is required. The standard practice adopted for reforestation by Forest Department Sarawak is under brushing and felling along planting line to a width of 3 m. All vegetation less than 10 cm in DBH except fruit trees and *Shorea* species along the line are slashed to ground level. Sapling and trees felled are cut into short length stacked by the sides of cleared lines. About 200 seedling per ha are planted with spacing of 10 m between lines and 5 meter along a line (Forest Department Sarawak, 2004, Forest Department Sarawak, 2001).

Regeneration Release:
Regeneration Release is to be applied when Potential Crop Trees cannot be found. All vegetation within a 1 m radius from selected seedling is cleared. Competitors outside the 1 m radius are also removed if requires to provide overhead or side light to selected seedlings (Hahn-Schilling *et al.* 2000).

Severely degraded areas:
Log landings and skid trails can account for up to 30 % of logged areas and little regeneration is observed in these areas even many years after logging. Plowing, application of fertilizers and use of cover crops are necessary for planting of pioneer species and indigenous fruit trees. This could increase biodiversity and attract wildlife (Moura-Costa *et al.,* 1994).

GUIDELINE 12

CONFLICT RESOLUTION GUIDELINES FOR SUSTAINABLE FOREST MANAGEMENT

CONFLICT RESOLUTION GUIDELINES FOR SUSTAINABLE FOREST MANAGEMENT

1.0 INTRODUCTION

In the 1980s there were calls for a better forest management. Events following the Earth Summit in 1992 resulted in various forest certification schemes to enhance forest management practices. Forest certification prescribes certain environmental, economic and social standards to manage forest in a sustainable manner; therefore providing assurance to consumers that they are buying products from forest managed in a socially responsible way (Mery *et al.,* 2005).

In this regard, an important aspect of forest certification involves the human dimension, particularly indigenous peoples and local communities whose livelihood largely depends on collection of non-timber forest products. Over the turn of 21st Century, as many as 1.6 billion people still depend on forest for their livelihoods and about 240 million people live in predominantly forested areas (World Bank, 2001, 2003). In view of this, industrial harvesting of timber should be done in a manner that enables communities to maintain their forest-based livelihood systems.

Even so competition over forest resources is inevitable as the same forest that is used by local communities is also used for timber harvesting. Conflict among stakeholders over land, forest resources and control or ownership is a major impediment to achieving sustainable outcomes in the forest sector. It leads to loss of income, employment, government revenues and environmental services. Conflict, in its different forms, is often inevitable and unavoidable. As such, a credible forest certification scheme should contain a frame work for conflict resolution mechanisms to resolve disputes arising from such convergence of different resource utilization systems, and to ensure the interest and concerns of the peoples are taken care of.

Forest Management Certification (FMC) is a major commitment to maintain and enhance the good image of forest management in Sarawak. Under Principle 3, Criteria 3.1 of the Malaysia Criteria and Indicator (MC&I) stated that "Indigenous peoples shall control forest management on their lands and territories unless delegate control with free and informed consent to other agencies." Indicator 3.3.1requires the availability of appropriate mechanism to resolve any conflicts and grievances between parties involved. The conflict resolution guidelines need to be formulated to provide platform and practical guidance to forest managers and other stakeholders in addressing and resolving conflicts arising from forest operation activities related to SFM.

2.0 THE GUIDELINES

The Conflict Resolution Guidelines for Sustainable Forest Management provide practical guidance to forest managers and other stakeholders to identify and resolve conflicts arising from forest operation activities.

This Guideline comprise of three components:

(a) Forest Management Certification Liaison Committee (FMCLC) Consultation framework
(b) Conflict Resolution mechanism, and
(c) Mediation

2.1 FMCLC Consultation Framework

FMCLC is a consultative framework involving multi-stakeholder representatives from local communities residing within or surrounding the FMU that are directly or indirectly affected by the forest operation, FMUs representatives and Forest Agencies as well other relevant Government Agencies as and when required. Prior to the formation of FMCLC, the following committees at various levels are to be established or identified. These committees are as follow:

- Community level - Community Representative Committee (CRC)
- FMU level - Forest Management Unit Representative Committee (FMURC)
- Forest Agencies level - Forestry Agencies Representative Committee (FARC)

2.1.1 Formation of FMCLC

A. Function of the Committee

It is recommended that besides taking steps to resolve conflicts, there is a need for proactive measures to be first taken to avert the occurrence of disputes. When a potential conflict arises, it is best solved at the local level between the parties involved, namely the local villagers, communities and the forest managers. This could be achieved via local consultation, discussion and negotiation. It may involve a third party such as knowledgeable local leaders or a government agency. It is only when the informal consultation fails to resolve the matter that further step is taken to resolve it in a formal manner, i.e., following the conflict resolution guidelines.

However, the formal conflict resolution process shall be activated by the FMCLC.

The FMCLC shall be entrusted with the following tasks and responsibilities, to ensure the effective implementation of the forest management certification in the State:

i. To identify, manage and resolve conflicts arising from the implementation of forest management certification in the State (e.g. land and resource tenure, lack of stakeholder communication, cooperation and coordination);

ii. To initiate dialogues/ discussion with communities, FMU licence holders and FMU representatives at regional level;

iii. To provide platform for information sharing between government agencies, communities and FMUs;

iv. To liaise with relevant government agencies, elaborate funding requests for community development project;

v. To arrange for provision of financial, technical and logistic support and advice to local communities on community development, if any;

vi. To monitor the implementation of community development projects and programmes, if required;

vii. To report to the FMC Technical Committee on issues that could not be resolved at regional level or require the higher level decision.

B. Organisation and Membership
The FMCLC will comprise of the followings:-

Chairman: Regional Forest Officer, Forest Department Sarawak (FDS)

Secretary: Assistant Director of Forest, Social Forestry Division (SFD, FDS)

Members: Representative, Sarawak Forestry Corporation (SFC)
Representative of Community Liaison Committee (CLC)
Representative, Forest Management Unit Licence Holder (FMU)
Representative, Preventive and Enforce Division of FDS (PED)
Representative, Management and Planning Division of FDS (MPD)

Other members: Representative, District Office (DO)
Representative, Department of Agriculture (DOA)
Representative, Land and Survey Department (L & S)
Other relevant agencies as deem necessary

C. Roles and Responsibilities of the Committee
The FMCCLC shall be entrusted with the following tasks and responsibilities, to ensure the smooth implementation of the forest management certification in the State:

No.	Agency	Roles
1.	RFO	• To chair the FMCCLC meeting • To coordinate the meeting and monitor the overall implementation of FMCCLC.
2.	SFD (Regional Level)	• Secretariat of the meeting • To record minutes of meetings and distribute them to members accordingly
3.	MPD	• To monitor the FMCCLC state-wide and advice on Forest Management Certification.
4.	PED	• To advice on matters pertaining to compliance with Forest Ordinance, Rules and Regulations
5.	CLC	• To represent communities living within/surrounding FMU • To discuss issues brought up by the communities and to communicate any matters discussed/decided by the FMCCLC to the communities.
6.	FMU Licence Holder	• To address matters pertaining to local communities and environment in FMU operations as reflected in Principle 3 (Indigenous Peoples' Right), 4 (Community Relation and Worker's Right), 6 (Environmental Impact) and 9 (Maintenance of High Conservation Value Forests) of the MC & I.

7.	SFC	• To carry out checking on the ground especially after PEC is endorsed by Forest Department • To facilitate on any dispute on operational issues on the ground
8.	Department of Agriculture (DOA)	• To assist and collaborate in the implementation of community development project, e.g. Tagang System
9.	Lands and Surveys Department	• To facilitate and advice on issues related to land matters
10.	District Office	• To facilitate matters pertaining to district administrative

This committee is to enable the involvement of relevant agencies and stakeholders to ensure the Sustainable Forest Management is implemented effectively.

D. Meeting and Reporting
The meeting will be conducted at least once a year and when necessary. Members of the Committee to be notified at least two weeks before the meeting.

2.1.2 Formation of Community Representative Committee (CRC)

The CRC members and number of representatives are to be determined by the communities themselves. However, it should be well represented of at least one (1) from each village. A female representative is also encouraged because they could play an important role in the conflict resolution process.

The organisation of the CRC comprises of the following:

- Chairman
- Secretary
- Treasurer
- Members:
  - Gender Representative

A. Terms of Reference
The CRC is provided with the following terms of reference.

- To promote mutual understanding, and facilitate conflict avoidance/ resolution pertaining to rights, disputes and community development affecting the FMU
- To enhance the effectiveness of the SFM Liaison Committee
- To enhance mutual benefits in forest management

B. List of Specific Tasks
The specific tasks of the CRC include the followings,

1. Contribute towards Social Baseline study and Environmental Impact Assessment (encompassing social impacts of forest operation)
2. Contribute towards community development program
3. Communicate to JKKK and community, the recommendations of the CRC

4. Monitor action plan and implementation of activities affecting/benefiting the communities

5. Contribute towards problem-solving that might arise, for example:
   a) Tenurial disputes (area and resources, formation of settlements in FMU areas, etc, as claimed/caused by people)
   b) Conservation and protection of community resources and cultural sites in the course of forest operation

6. Additional tasks to be included as and when necessary

C. Commitment in Handling Conflict
The CRC is committed to handling conflict. It accepts cooperation and conflict as part and parcel of living with others.

2.1.3 Agencies Representative Committee

The representative for permanent members of the FMCLS shall comprise of relevant agencies appointed by the Director of Forests. Other relevant agencies will be invited to the meeting as and when necessary. The representatives are preferably from the following agencies:

Permanent members

- Forest Department
  - Regional Forest Office
  - Management and Planning Division
  - Preventive and Enforcement Division
  - Social Forestry Division

- Sarawak Forestry Corporation Sdn Bhd
  - Regional Manager
  - Regional Community Liaison Officer
  - Representative from HQ (Social/AFSID/SF&C)

- District Office
  - District Officer or representative

Other Relevant Members by Invitation

- Ministry (MUNDR/MORE)
- NGO (WWF/WCS)
- STA
- DOA
- Land and Survey
- Harwood

2.1.4 FMU Representative Committee

At the FMU level, the licensee is required to establish a Community unit or group or people. The members are determined by the FMU. However, the representative to attend the FMCLC meeting or consultation should consist of the Forest Manager, Camp Manager and their Community Liaison Officer.

2.2 Conflict Resolution Guidelines for Sustainable Forest Management

These guidelines help aggrieved parties feel that they have given a fair hearing and therefore better able to accept the decisions.

The basic trust of conflict resolution is to build mutual trust between the parties involved. Mutual trust serves as a foundation in conflict resolution. In a trusting relationship, conflicts enable the parties

involved to have a deeper understanding and search for constructive solutions. Mutual trust creates good will, which sustains the relationship when a party does something that the other disagrees. It builds confidence in the relationship to achieve a "win-win" situation. Win-Win situation involves cooperative, not a competitive, relationship. It means that agreements or solutions reached are mutually beneficial, and commits the parties to the action plan.

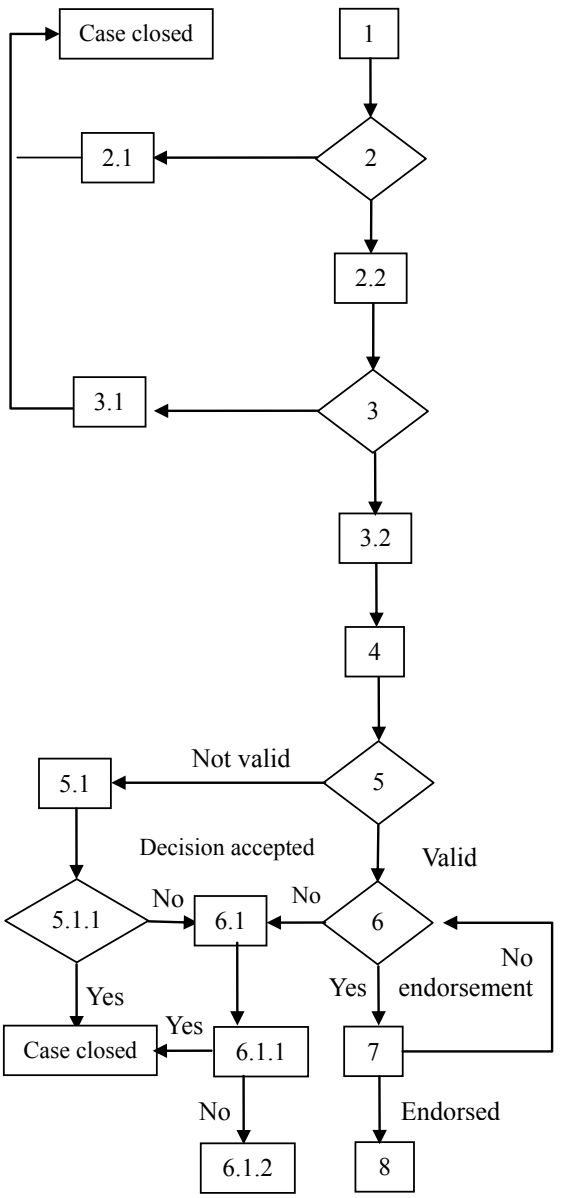
Conflict resolution also involves negotiation. It is a process of convincing others to assist us advance ours' and their interest. In negotiation, the parties find ways to help each other achieve the objectives so that both are better off than before. Adjustments are necessary in negotiation. Successful negotiation involves a high degree of trust and commitment from both parties.

Based on mutual trust and the spirit of negotiation, the CRC's role in resolving a conflict may involve the processes below.

The sequential steps of conflict resolution shall follow **Table 1**.

Process of Conflict Resolution

Table 1. Conflict Resolution Process Flow

Process Flow	Activities	Action By
	1. Receive complain	CRC/ EXCO
	2. Solution? 2.1 Advice to solve complain 2.2 No informal solution	CRC/ EXCO
	3. Identify Issue 3.1 If it is non-issue- Case closed 3.2 If there is issue but no jurisdiction	CRC/ EXCO
	4. Form Panel	CRC/ EXCO
	5. Find, verify and assess fact 5.1 Inform Complainant 5.1.1Decision?	Panel
	6. Consult complainant and parties concerned 6.1 Mediation 6.1.1 Option? 6.1.2 Legal Process	Panel
	7. Forward recommendation for endorsement by CRC - If no endorsement by CRC back to Step 6	CRC
	8. Record the case as closed	CRC

Notes:

- If an issue cannot be resolved at the local level or by the FMU managers, only then shall the issue be brought to the CRC.

- Third party can come from organizations such as government agencies, community leaders (e.g., Penghulu, Pemanca/Temenggong), ethnic association and community organization, professional and non-profit organizations if and when necessary.

2.2.1 Steps of Conflict Resolution

Following Table 1, the steps to be taken by the CRC and its panel are as follows:

Step 1: When a dispute is brought to the attention of a CRC member, the complainant should be advised to resolve the conflict informally. At this stage the CRC suggests the complainant to speak directly with the parties involve and resolve the conflict as soon as possible.

The steps below shall be taken if the conflict could not be resolved.

Step 2: Record an issue raise by a complainant.

Step 3: Identify issues–whether within jurisdiction of the partnership body or to be assigned to the right body.

1. If the matter raised is a non-issued, the CRC shall explain to the complainant and matter is closed.
2. If the matter is an issue relating to sustainable forest management but the CRC has no jurisdiction, the complainant shall be advised to refer the matter to the relevant bodies such as the Land and Survey Department on matters relating to land.
3. If the issue warrants further investigation by the CRC, the following steps shall be taken.

Step 4: Appoint a Panel to look into the matter. Panel membership depends on the parties involved.

1. For issues involving only the community affecting the FMU management, panel comes from the CRC excluding parties involved.
2. For issues involving both FMU and one communities, panel comes from CRC members who are not involved and a third party acceptable to both parties.

Step 5: The panel shall find, verify and assess fact involving two stages.

In the first stage, the panel members shall interview and record statements from:

1. All parties concerned
2. Witnesses and evidences produced by parties concerned

In the second stage, the panel shall assess the finding by

1. Obtaining clarification from individuals and/ or elders with background knowledge of the issue.
2. Consulting knowledgeable individuals (who may and may not be the same individuals as in (1), if necessary.
3. Developing a summary of findings.
4. Proposing resolution(s).

In the process of documentation, the panel is to be assisted by a secretariat. The assessment may end in two options.

1. If the assessment finds that the issue raised is not valid, the Panel shall inform the complainant. If the complainant accepts the assessment, the case shall be closed. Otherwise, the complainant may opt for mediation (Component 3 on mediation).
2. If assessment finds the issue raised is valid, the Panel shall take the following step.

Step 6: Consult the complainant and other Parties Concerned. This consultationinvolves three activities.

1. Present summary of findings.
2. Dialogue to obtain feedback.
3. Seek agreement on action to resolve the problem.

The consultation may result in two outcomes.

1. If the consultation reaches an agreement to resolve the conflict, it shall be brought for endorsement by the CRC as in Step 7.
2. If no agreement is reached, the matter may be brought for mediation as in Component 3.

Step 7: Decision recommended to CRC for endorsement. The CRC executive committee shall examine the recommended solutions reach by the complainant and the parties concerned.

1. If the CRC finds the recommended solution as acceptable, it shall endorse it. The case is then closed as in Step 8.
2. If the CRC finds the recommended solution unacceptable, the matter shall be reverted back for another round of consultation between the complainant and the parties concerned. The revised solution shall be re-submitted to the CRC for endorsement.

Step 8: The case is recorded as closed.

2.3 Mediation

To fulfil requirement of mediation in the conflict resolution process, it is recommended that a Technical Working Group led by Sarawak Forestry Corporation/ Social Forestry Division (Forest Department Sarawak) develop a panel of mediators in consultation with Majlis Adat Istiadat, Sarawak Timber Association (STA), ethnic associations and the Sarawak Bar.

It is recommended that the procedures to do mediation be developed by the panel of mediators themselves.[2]

The process of mediation may end up with two outcomes.

1. If the option proposed during the mediation process is acceptable to the complainant and other parties concerned, the case is closed.
2. If the mediation process cannot reach an agreeable solution, the complainant may bring the matter to the formal court law.

[2] In the course of formulating the mediation guidelines, it is recommended to take note of the following: Mediation is a non-binding, procedure, meaning that parties involved are not obliged to continue with the mediation process and a decision cannot be imposed on the parties (WIPO 2004). In a mediation procedure, the mediator, a neutral intermediary, helps the parties to reach a mutually satisfactory settlement of their dispute or conflict. Mediation is an efficient and cost-effective way of achieving an end-result that is agreeable to the parties involved. It is thus a conflict resolution method designed to help the parties involved to resolve their dispute without need to go through the lengthy and costly legal process of court arbitration.

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