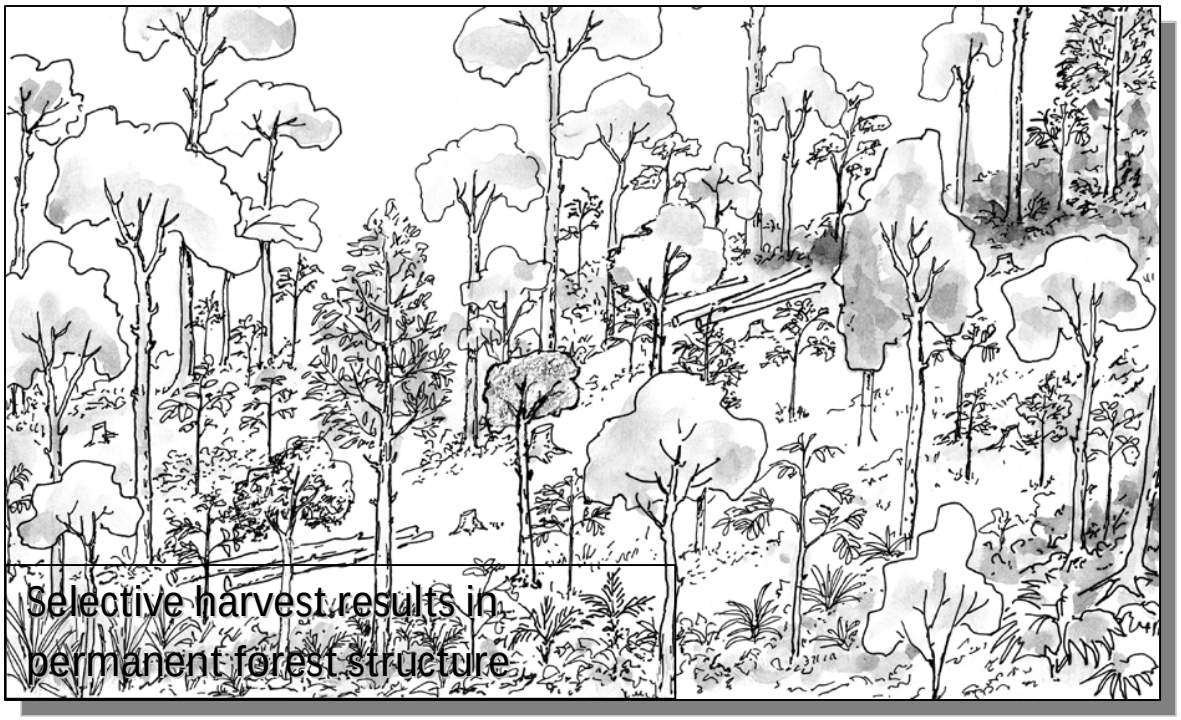
FAUNA & FLORA INTERNATIONAL

Myanmar Programme

# SILVICULTURAL, INVENTORY AND HARVEST GUIDELINES FOR COMMUNITY MANAGED FORESTS: SOME RECOMMENDATIONS FOR DISCUSSION




Bjoern Wode
*Independent Consultant*

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Author details Bjoern Wode is the FFI Myanmar International Community Forestry Officer.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CF | Community Forestry |
| CFMP | Community Forest Management Plan |
| dbh | Diameter at breast height (1.3m) |
| DFMP | District Forest Management Plan |
| EU | European Union |
| FAO | Food and Agriculture Organisation |
| FFI | Fauna & Flora international |
| FUG | Forest User Group |
| MAI | Mean Annual Increment |
| MOECAF | Ministry of Environmental Conservation and Forestry |
| NTFP | Non-timber Forest Product |
| PCT | Potential Crop Tree |
| RIL | Reduced Impact Logging |
| SFM | Sustainable Forest Management |

## 1. INTRODUCTION

This Working Paper examines options for improved sustainability and economic viability for community forest in Myanmar (See also Wode et al 2014). It was prepared under an EU-FAO Regional FLEGT Programme project implemented by Fauna & Flora International that is exploring opportunities and constraints for commercial timber production from community forests.

The paper is written in the form of a draft 'Guide for Forest Management' that could be applied by Forest User Groups who have been handed over natural forest resources for sustainable long-term management and protection under a Community Forest (CF) certificate and with a CF management plan available. It is not a substitute for government regulations or departmental guidance, and is intended to promote discussion on sustainable forest management in the context of legal CF in Myanmar. Comments are welcome and should be addressed to FFI Myanmar.

Table 1. Conventional silviculture compared against CFM

| Criteria | Conventional (eg, state) forest management | Community forest management |
|---|---|---|
| Assortment of harvested forest products | Selective exploitation of commercial timber species based on minimum harvest diameter concept. Stand improvement may be conducted through thinning of competitors in smaller diameters | Selected harvesting in all diameter classes based on SFM concept. Continuous stand improvement through removal of undesired trees, climbers and shrubs for firewood consumption |
| Planning units | Cubic feet of solid timber | Number of trees per diameter class |
| Harvesting cycle | Felling based on minimum harvest diameter, felling cycle and rotation | Continuous extraction of small quantities based on local demand (permanent forest structure) |
| Harvest volume per cutting cycle | Large harvest volume (entire timber increment extracted in one harvest) Guided, eg, by an Annual Allowable Cut, but ultimately driven by economic criteria e.g. transport costs, sales volume, wages and other fix costs | Small to medium (mainly for self-consumption and surplus for commercial sale) |
| Harvesting operation | High mechanised harvesting operations; dependency on sophisticated road network; high investment | Low impact logging with motor-manual harvesting, on site-processing, use of existing road network only, low investment |
| Post-harvest impact on remaining stand | High damage through intensive and mechanised logging and skidding operations. High risk of soil erosion, weed and climber infestation of logging sites due to canopy opening | All timber extraction oriented towards an improved forest structure following a permanent forest structure. Low risk of soil erosion and weed invasion due to low intensity timber extraction |

## 1.1 Silviculture in the context of community forest management

Since expertise in forest management and planning cannot be expected from a new Forest User Group (FUG), this document is intended to provide guidance on the main concepts and selected silvicultural techniques adjusted to the available capacities at grassroots level. Consequently, conventional silvicultural and planning procedures as applied under state forest management was simplified to ensure that sustainable forest utilization that can be conducted by FUGs with limited or no supervision from the Forest Department. A summary of the main differences in management approach and objectives is provided in Table 1.

## 1.2 Principles for Community Forest Management

Several principles are central to community forest planning and management which distinguish it from other forms of forest management. These are outlined in Table 2, and form the theoretical basis for the following sections on practical CF management approaches.

Table 2. Conventional silviculture compared against CFM

| Principles | Description |
|---|---|
| Participation of local people in all activities | Local forest users are involved in all planning, implementation and monitoring steps and main results are "owned" by them which leads to a commitment to implement it. All activities are within the capacity of FUGs for independent long-term continuation. |
| Multi-functional forest resources | CFM has to meet the diversified needs of local people in terms of timber, firewood and NTFPs. At the same time CFM has to ensure ecological functions of the forests following the thoughts of: "Forest protection through sustainable utilisation" |
| Relevant planning procedures | Only information really needed for forest management purposes is collected and compiled (minimised planning and reporting) |
| Cost- and time effectiveness | Procedures are cost and time effective to ensure that communities can comply with proposed planning, implementation and reporting. |
| Incorporate indigenous knowledge | Local knowledge and experiences on the use of forest products (medicinal plants, materials, food… ) are integrated into planning procedures to maximise the tangible benefits for forest users and to satisfy their diversified demand for forest products. |
| Technically sound forest management | Forest management planning and utilisation are following technical sound procedures and are in line with international standards for sustainable forest management. |
| Sustainable utilisation | Forest utilisation rates are only allowed below the actual growth potential of the forest resources ensuring a continuous flow of products and a permanent forest cover on the entire area at any time. |

## 1.3 Objectives of harvesting regulations

As above, certain principles for the regulation of harvesting practices are specific to community forest management as opposed to commercial or centralised forest management. CF-relevant harvest regulations thus:

- Form a basis for planning, implementation and monitoring of the approved CF management plan and the Annual Work Plan
- Ensure the safety of people working in the vicinity of felling operations
- Minimize damage to residual trees and seedlings, especially those that are expected to make up the population of future crop trees
- Minimise damage to soil and streams
- Ensure the protection of the ecological functions of the forest ecosystem
- Maximise the volume of timber that can be profitably utilized from each felled tree
- Maximise the value of the logs prepared for extraction

## 1.4 Legal policy frame for selective cutting

In conventional forest management, selective cutting is applied in un-even aged rich forests comprising trees of mature diameter classes for large-sized timber (see Forest Department *departmental instructions*). Furthermore, selective cutting is carried out in poor/degraded forests and forests in order to improve the structure of the dominant and lower tree layers.

In CFM, all silvicultural interventions are aiming at an improved forest structure and therefore can be applied in all natural forests such as young forests, poor/degraded forests, average or rich forests, as long as the two following conditions are met:

- Participatory forest inventory has revealed a surplus for harvesting
- FUGs are interested in utilising the timber surplus for self-consumption or commercial sale

## 1.5 Selective cutting

Selective cutting refers to the selection and utilisation of individual trees within a forest stand. In this system trees are removed on a felling cycle that occurs more frequently than a standardised rotation, and in which an uneven-aged forest structure is maintained (Fig 1). The harvesting is implemented based on participatory forest inventory outcomes as documented in the CF management plan.

Under this system, the forest can provide timber on a continuous basis, with natural regeneration constantly replacing harvested trees. Timber extraction is carried out in all diameter classes to fulfil the diversified demand of the local forest users for housing, fencing, poles, firewood and commercial timber sale.

Under this system the actual forest structure is continuously adjusted towards the structure of a permanent forest estate in line with the long-term forest management goal for the respective forest stand. Selection of trees to be harvested and those to be retained is based on criteria (e.g. species, quality, density, competition) detailed in a silvicultural guideline.

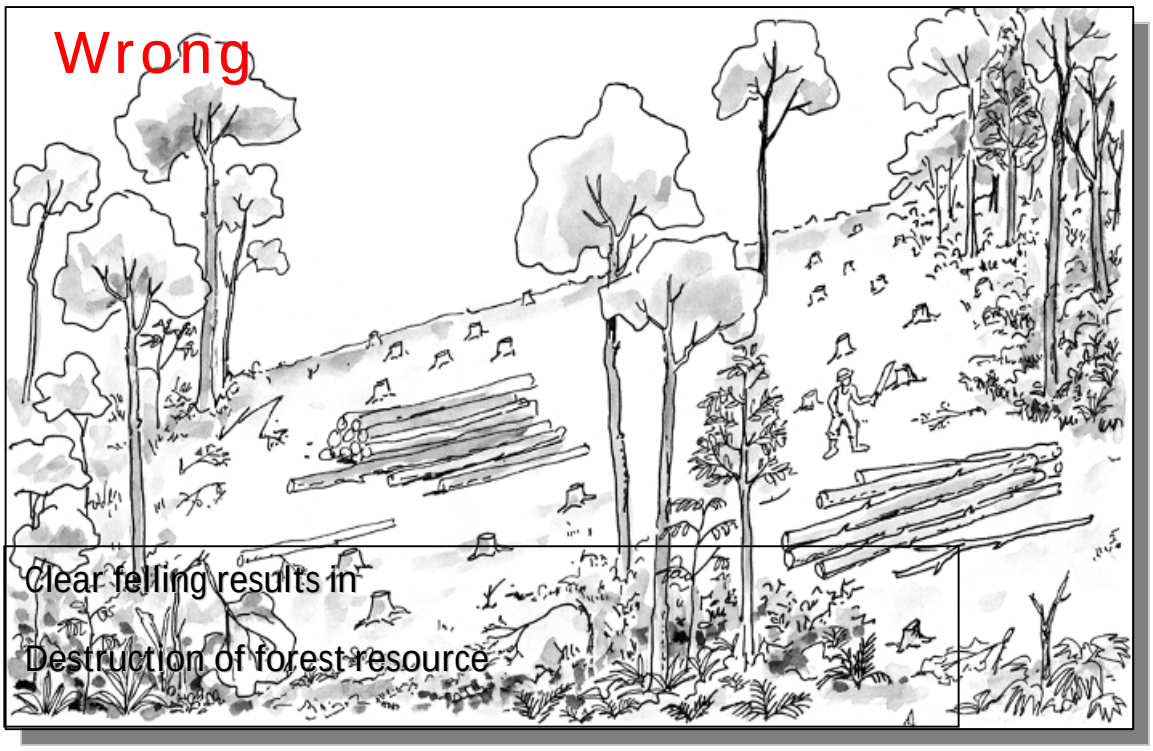




Fig 1. Diagrammatic representation of the outcomes of appropriate and inappropriate selective cutting in a community managed forest

# 2. PRE-HARVEST PLANNING

## 2.1 Preparation of a timber stock and slope map

Knowledge on field condition, harvestable trees and tree distribution, mother trees, protected trees and protection areas within a working area are the keys to selective harvest control. Participatory forest inventories are to be conducted in natural forest areas where a timber harvest is foreseen in the upcoming planning period.

For timber/fuelwood plantations a description of age and general growth status (average height and diameter) is sufficient.

Inventory results will be analysed by the FUG under support from township technicians and a proposed harvest area delineated on the FUG forest map. Boundaries should, to the greatest extend possible follow natural landmarks that can be easily identified in the field.

Attached to the map a description of the expected harvest volume in terms of stem number per diameter class should be added.

## 2.2 Areas to be excluded from timber harvesting

Areas that are not accessible, with loose soil and rock outcrops on steep slope, or close to important water bodies are to be excluded from the harvest area.

- radius of 650 feet from the edge of a water springs;
- at minimum, 330 feet from the edge of a lake or coast measure from the highest tide toward the coast;
- at minimum, 330 feet from the sides of a river and 160 feet from the sides of a creek;
- near the edges of steep lands (> 40%);
- High biodiversity conservation areas.

The total harvest amount is to be calculated based on a stem number/acre to be extracted within the upcoming logging season.

## 2.3 Road and skid trail plan and location of log yards

Efficient access to logging sites can only be achieved by considering factors such as skidding on steep slope, stream crossings, protection areas, and by minimising the length of skid trails by aligning an efficient skid trail network.

Existing roads and paths should be used as much as possible and marked on the map. Road construction exceeds financial and technical capacities and should be avoided. Skid trails should be around 150-300 feet apart.

The felling direction is towards the skid trail provided the target tree's crown does not disturb the skidding activity and its branchless stem does not lie across the skid trail.


Skid trail and harvest design map

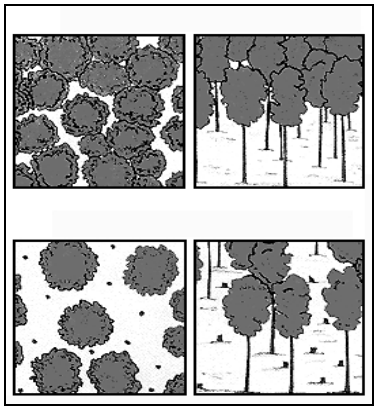
## 2.4 Species selection criteria

Before tree marking for harvesting, it is necessary to identify species that are not allowed to be harvested such as:

- Valuable and rare species as detailed in the IUCN Red List of Threatened Species.
- Valuable and rare species that have a cultural significance for traditional communities (e.g. graveyard trees, worshipping trees,...)
- Trees and species that need to be protected as source for propagation (seed trees) or as important source for NTFPs (bark, leafs, fruits, resin etc.)

Local forest users have to be consulted and a common agreement reached before any decision can be made. The species list as developed during the forest inventory analysis should be used as reference and species of cultural significance indicated separately.

## 2.5 Tree selection criteria

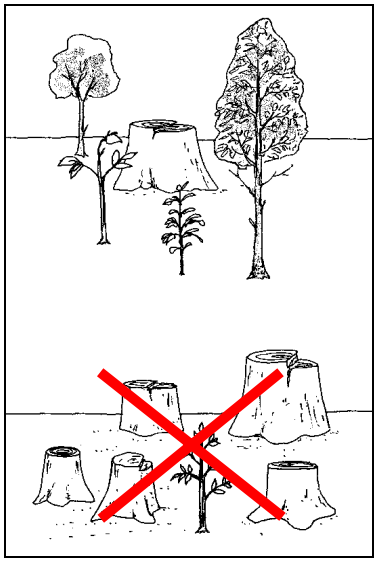


The selection of trees for harvesting has to be based on comprehensive criteria since harvesting is the most important silvicultural intervention which is defining the future production potential and environmental functions of the forest.

Timber extraction should never leave big tree-canopy openings, which can increase the risk of weed invasion and soil erosion.

After harvest at least 50% of the ground should be covered by a dense canopy (canopy closure at least 50%).

Single canopy gaps should not extend beyond the space taken by a mature tree crown.



Evenly distribute trees to be harvested within the entire forest block.

For every tree cut, enough smaller trees of various species have to be available as replacement, otherwise labour and cost intensive enrichment planting might be necessary in the future.

In areas with insufficient natural regeneration, mother trees have to be retained as future seed source.

A minimum distance of ~ 20 m between two mature trees to be extracted should be ensured.

## 2.6 Riparian buffer zones

No trees should be harvested within the buffer zone of streams or rivers, as tree shade protects sources of drinking water and fish. Recommended distances are:

| River width | Buffer zone width |
|---|---|
| 3-60 feet | 100 feet |
| 61-130 feet | 260 feet |
| > 130 feet | 650 feet |

Do not cut timber-sized trees on extreme slope or in areas with loose rock outcrops to avoid risk of soil erosion and damage to the remaining stand.

## 2.7 Tree marking - preparation of tree list

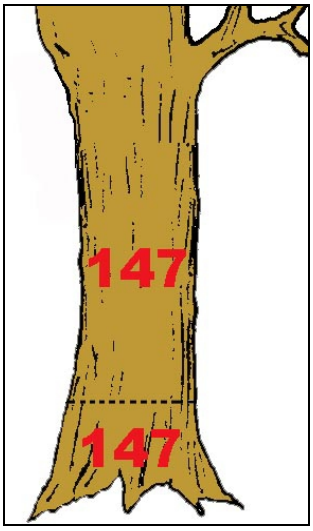
Trees that are selected for harvesting will be marked with oil paint in two positions:

1) at breast height and,

2) near the stump below the felling scarf.

The mark below the felling scarf will serve as identification mark for the post-harvest monitoring.

Marked trees are defined in terms of species, diameter class and recorded in a timber list. This will serve as baseline data to compare the number of trees marked with the annual harvesting plan of the forest block.




## 2.8 Harvesting season

Timber harvesting, preparing a skidding track for transportation, tree logging, timber felling, transportation and post-harvest site cleaning need to be done in the dry season. Avoid to harvest in growing season of timber trees.

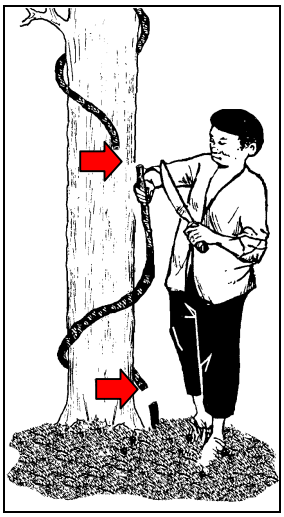
Harvesting season depends on the weather as well as the availability of labour. Therefore, a harvesting plan should be made together with communities to ensure a suitable timing for all harvesting related activities.

A harvesting plan should detail activity, time, location and responsibilities

## 3. TIMBER HARVESTING

The felling pattern always starts from trees on the down-side and then proceeds to the trees on the up-side. The felling should be started and carried out according to the indicated felling direction on the map of trees to be harvested. For example, it should start from the closest to the landing and then proceed to the next section. The following sections detail steps for a safe and appropriate harvesting of trees from a community managed forest.

### 3.1 Climber cutting during logging preparation

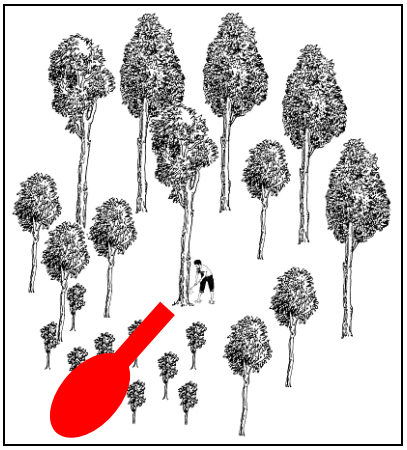


Cut climbers with diameters larger than 1 inch some time before harvesting. As climbers can bind tree crowns together damage can increase to other trees and create potential risks for the logging crew.

Climbers can furthermore strangulate the host tree and can cause deformation of the stem and loss of timber value.

This operation could be undertaken at the same time as the inventory of the forest stand is initiated.

### 3.2 Directional felling

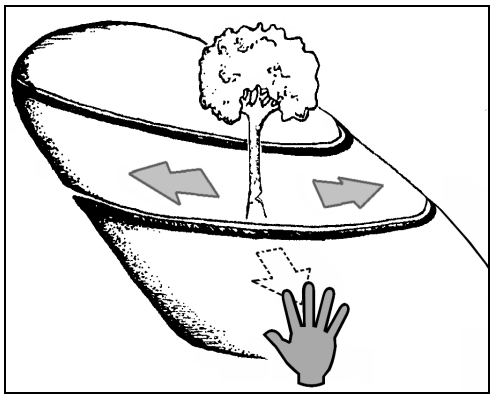


Select felling direction to reduce damage to remaining stand.

Try to fell trees into open areas or areas with only young trees or regeneration which can easily recover after the crown material has been removed from the felling site.

Do not fell trees during stormy weather as the wind might change the direction of the falling tree and create potential safety risks for the logging crew.

Before starting to cut, remove shrubs and other vegetation around the tree base that could impede your work.

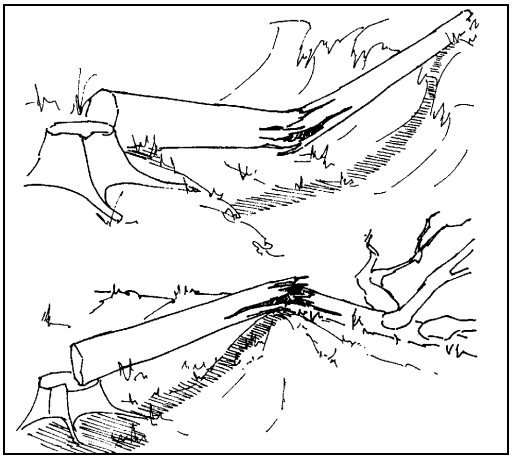


Do not fell trees down the slope unless their downhill direction is too dominant for directed falling. Try to fell trees along the contour lines. This will minimise breakage of felled trees and damage to the remaining stand.

Also void having trees fall across rivers and creeks, or disturbing the protection areas.

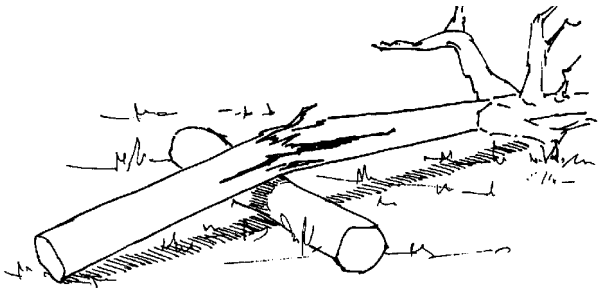
By looking at the lean of the tree, the location of the heaviest branches and the general crown weight, you'll be able to select the felling direction.

## 3.3 Avoid timber losses

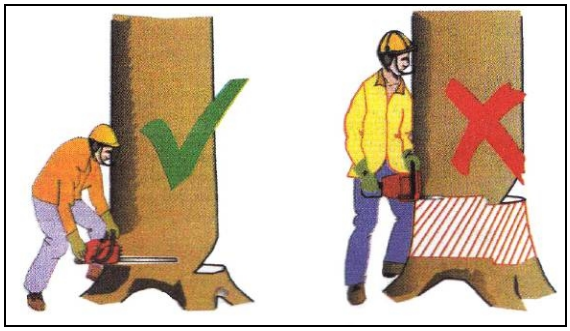


A considerable amount of valuable wood is lost when large trees are felled across obstacles on the ground such as hollows, ridges, logs or rocks. Most species break if they hit such obstacles. Although the broken part may be small, the loss caused by cutting out the break can be considerable.

Try to direct your felling to place tree crowns of several harvested trees into the same area to reduce disturbance in the remaining stand.



## 3.4 Maximise timber utilisation



Cut trees close to the ground to avoid waist of timber. High stumps are an indication of poor workmanship and insufficient supervision.

Except in special cases (e.g. hollow or heavily buttressed trees), the stump should be as low as possible.

The following table gives information on volume loss in cubic feet:

| | Diameter (inch) | | |
|---|---|---|---|
| Stump height (inch) | 16 | 24 | 32 |
| 8 | 0.88 | 2.01 | 3.53 |
| 16 | 1.76 | 3.99 | 7.06 |
| 24 | 2.65 | 6.03 | 10.59 |

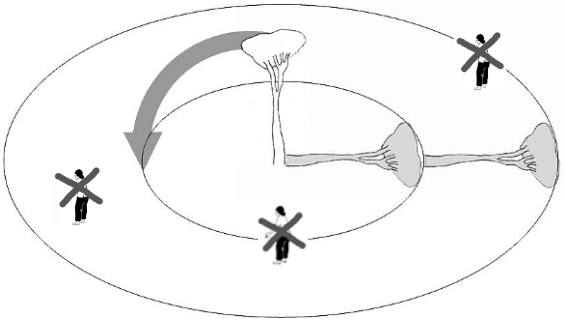
Considerable wood losses in felling can also occur if the tree is felled without an undercut or with an insufficient undercut. There is a risk that wood fibre will be pulled out of the butt end, reducing the value of the log.

## 3.5 Safety guidelines for using a chainsaw

Personal requirements when handling a chain saw:

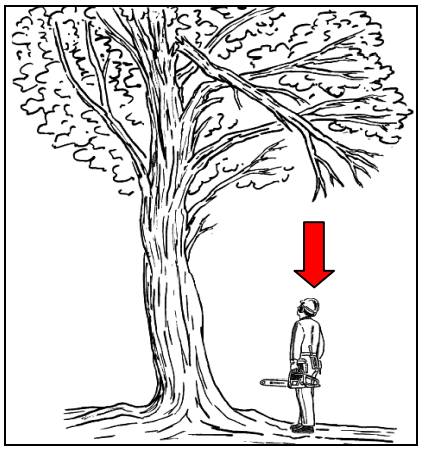
- physically fit and reasonably active;
- trained or experienced in the use and maintenance of chainsaws, felling and crosscutting;
- not under the influence of drugs or alcohol or are tired or fatigued;
- fully equipped to carry out the job;
- having a person with them who is able to assist or obtain help in an emergency; Remember: Never work alone while felling trees or using a chainsaw!

Before felling a tree, Check that there are no other persons, children or animals in the danger zone.



The danger zone is the distance twice the length of a tree to be harvested (twice the length of the falling tree, as it might hit another tree which can also fall). This distance should be increased if felling is directed downhill.

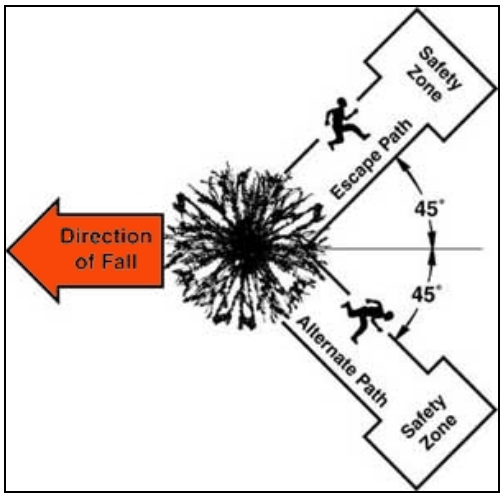
Check for any dead or broken branches that may stuck in the crown and fall into the work area as the tree falls. This is particularly common in old trees and causes serious accidents. View the tree from different angles so you don't miss anything.



Check for branches interlocking with branches of other trees. These can break off as the tree falls and drop into the work area, pull the tree away from the desired direction of fall, or cause other trees to uproot and fall.

## 3.6 Escape path

Having assessed the work area and tree to be felled, prepare the site for felling.

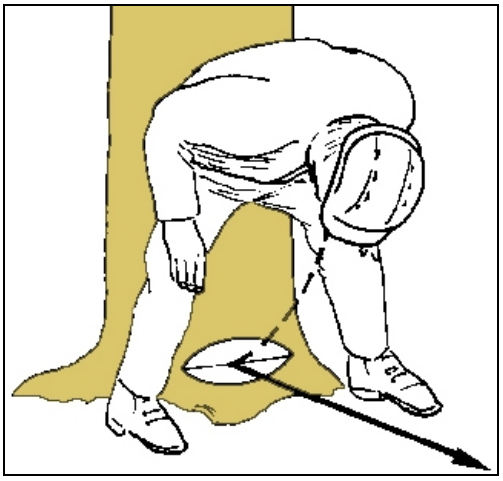



If there are any low branches that may get in the way during the felling, cut them off.

Clear an adequate work area around the base of the tree and provide an escape route diagonal to the rear.

Two paths are cleared to a length of 20-30 m beyond the reach of the crown opposite the felling direction. The angle between them should be about 45.

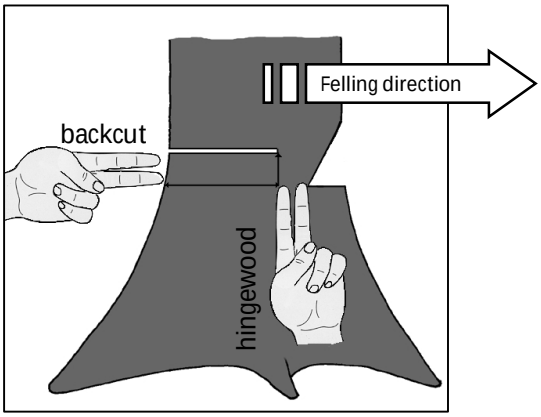
## 3.7 Harvesting techniques



Accurate felling makes the job safer, facilitates subsequent operations and reduces timber wastage. Felling should therefore be done with the greatest care and precision.

When making the first cut (undercut), care must be taken that it points precisely into the felling direction. This can be checked by standing in front of the undercut. If necessary, the undercut should be corrected.

If trees have buttresses, it is necessary to remove them before making the undercut and back cut, which can then be made with more precision and ease.




Cut the scarf in felling direction. The top cut is made first at a 45° angle between one-quarter and one-third of the tree's diameter. The cut must accurately face the desired direction of fall and finish level. The bottom cut must be made level to meet the top cut and form a clean, uniform "V" right across the diameter of the tree when the cut section is removed.

If your tree has a diameter of around 12 inch place the backcut from the other side "two fingers" above the base of the scarf. For a bigger tree increase to 3-4 fingers.

The backcut is the last cut and will finally fell the tree. The backcut is made level and always above the 'V' of the scarf (around one-tenth of the tree diameter). The backcut does not cut all the way through but stops until there is an even amount of hingewood about "two fingers" (or one-tenth of the diameter) parallel before the scarf to remain the hingewood.

Sufficient hingewood which acts as a hinge must always remain in order to maintain control of the tree so that it does not fall in any direction other than that intended

The hingewood controls the felling direction and prevents the tree from twisting or breaking sideways when falling.

Once the backcut has been done and the tree begins to fall:

- Remove saw from cut and switch off
- Move into the planned escape route
- Watch for falling material
- Watch for the tree kicking back or bouncing as it hits the ground

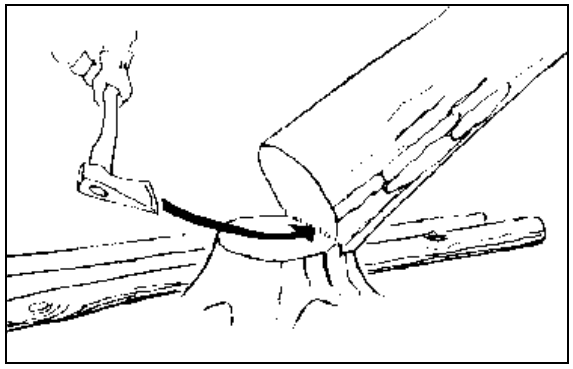
### Kick back

Look forward in the tree fell direction and identify any hazards such as stumps, logs, or ground undulations that may cause the fallen tree to kick backwards or sideways on contact.

Back off from the falling tree as soon as the tree shows any sign to give in, make sure to get away from it.

Do not stand behind the falling tree, as its butt might kick back and injure the logging operator.

### Releasing lodged trees

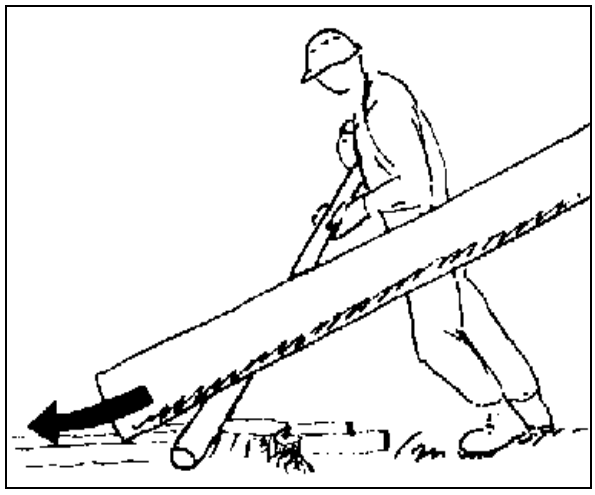


When falling smaller trees in dense forests they are frequently stopped by other trees. The tree is then lodged and is called a hang-up.

Directional felling is trying to avoid this by felling the tree into open spaces. A proper undercut, an adequate hinge and wedging will help to reduce lodging, but this cannot always be avoided.

In case of a hang-up, DO NOT:

- walk or work below a hang-up.
- try to fell the tree which is holding the lodged tree.
- fell another tree on to hang-ups.
- climb the lodged tree to loosen its crown.



Instead it is recommended to place suitable material (e.g. poles, split wood) on the ground on to which the tree can slide backwards. Cut the remaining wood which may still connect the tree with the stump, preferably with an axe. If a saw is used, it might easily get pinched – use a pole to push the butt end backwards.

## 3.8 Common Felling hazards

Felling uphill: Be aware that the tree may slide back or kick up into the work area once it hits the ground. Move quickly along the escape route away from the stump. Always watch the path and progress of the tree you have felled.

Felling trees along the contour lines: Make sure you are not in the path of a rolling tree. Move back along your escape route away from the falling tree.

Trees without crown (eg, after a storm or heavy rain): Make the scarf slightly deeper (max. to half of the diameter). Place a wedge in the backcut as soon as possible to ensure correct felling direction as there is no crown to force the tree in the felling direction.

“Hung-up” Trees: Where a tree is hung up in another tree it must be brought to the ground before continue any other work. Do not leave such trees unless you have marked the area while you seek assistance, or someone else is present to warn other people of the hazard.

# 4. POST-HARVEST ACTIVITIES

## 4.1 Limbing a felled tree

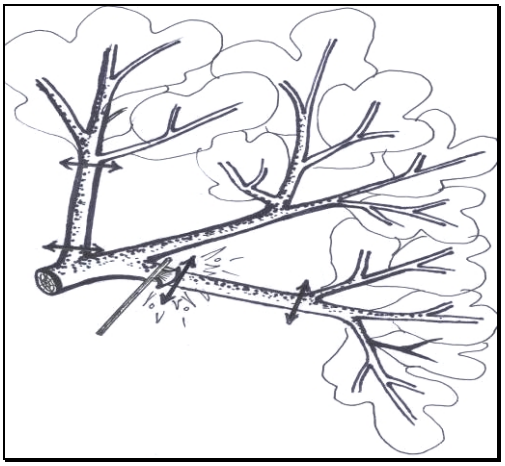
Limbing is the process of removing tree branches from the stem. Before starting examine the felled tree for any hazards (tensions, breakages etc.)

Check trees adjacent to the felled tree for any damage or hazard. Make sure the tree is stable and will not roll or move when you start to work on it. Place chocks if you think movement is possible — especially on slopes.

Only trim trees that are firmly lying on the ground; do not work with a chainsaw above shoulder level (1,5 m).

Beware of a tree suspended by its branches as one large branch may hold the tree up.

When a tree is held up off the ground, trim the large branches from out- to inside by making a couple of cuts to test the stability. Always work on the uphill side of a tree on a slope. pull the tree away from the desired direction of fall, or cause other trees to uproot and fall.

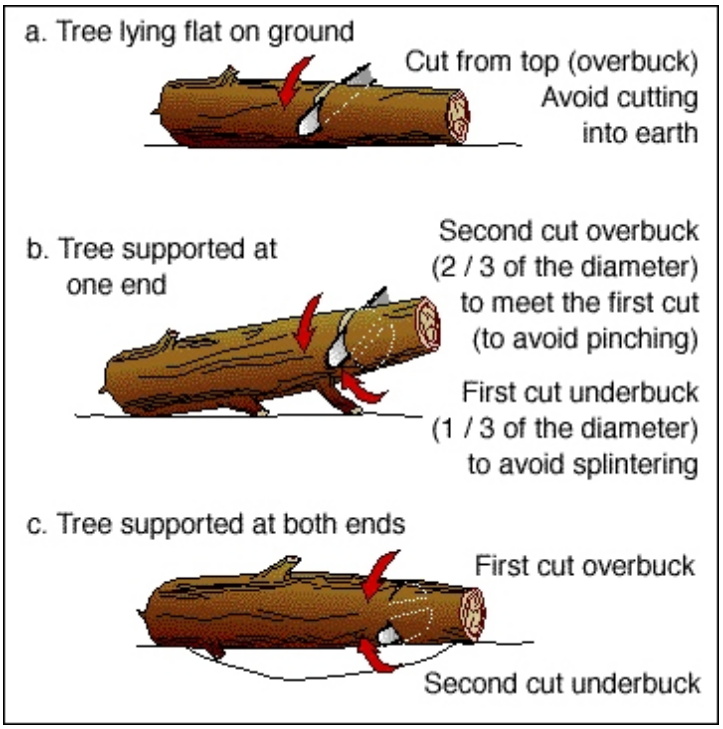


*Watch out for limbs that are under tension. These can spring back and inflict severe injury. Stand on the side away from the tension and release the tension with two cuts — first on your side and then on the other side.*

## 4.2 Bucking a felled tree

The process of cutting a tree into usable lengths is called bucking. Bucking often occurs as a tree is being limbed, such as when the limbs of the crown are to be used as firewood. When cutting firewood, make sure you know the needed length of wood before you leave home.

When cutting full-size products, such as sawlogs and veneer logs, you must cut logs longer than the final product to leave a trim allowance. For an 8-foot log, a trim allowance of 4 to 6 inches is common. Many bucking cuts are angled, and the trim allowance allows the ends of the boards to be cut square at the mill to the desired board lengths.



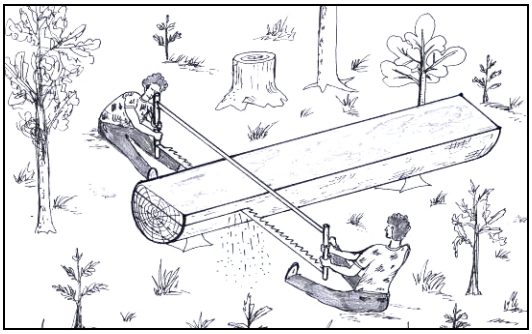
When a tree is suspended at one end, the bucking operation becomes more difficult. The figures show various bucking techniques. In all cases, stand on the uphill side of the log and keep a firm grip on the saw with both hands.

Also, keep a strong, even stance on the ground so you can move quickly if the log starts to roll.

When a tree is totally on level ground, the biggest problem during bucking is avoiding running the saw chain into the earth.

A 'sawbuck' can make bucking easier. It holds a log still at a good working height so that you can safely cut the wood to length. You can find plans for building a sawbuck in your local library or your chain saw owner's manual, or you can purchase a sawbuck from a variety of sources.

## 4.3 On-site processing



Heavy logs should be sawn into smaller planks directly at the logging site to reduce cost and to reduce the damage to the soil and the remaining stand by transport with heavy machines.

Sawn planks can easily be transported manually or by animal skidding without need for a road network.

Use of chainsaw frames can be applied to achieve high accuracy of sawn planks. A description of the use of chainsaw frames is provided below.

## 4.4 Cleaning of harvesting site

After the logs have been removed from the harvesting site, bigger crown material and branches should be used for firewood.

Remove and leave limbs and bark directly at the felling site. Small branches should be cut into smaller ones and spread evenly in the forest.

A large proportion of tree nutrients reside in the bark and foliage. Leaving limbs and bark at the felling site will thus contribute to improved growth of future trees.

Cleaning of stream or waterways where skidding took place or where felled trees cross water flows.

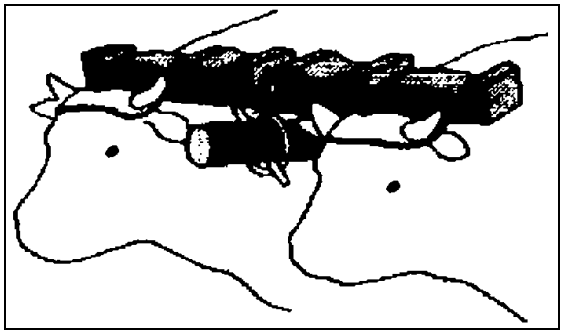
## 4.5 Skidding

The principles to reduce damage to the remaining trees when transporting timber is as follows:

- Check and select suitable trails for transport (use a map with contour lines)
- Use as much indigenous knowledge and local resources as possible (use animals, transport timber on streams or rivers)
- Devices such as skidding pans or sledges can greatly improve productivity in animal skidding because they reduce skidding resistance and thus allow larger loads to be pulled.

Improper extraction of big logs can lead to:

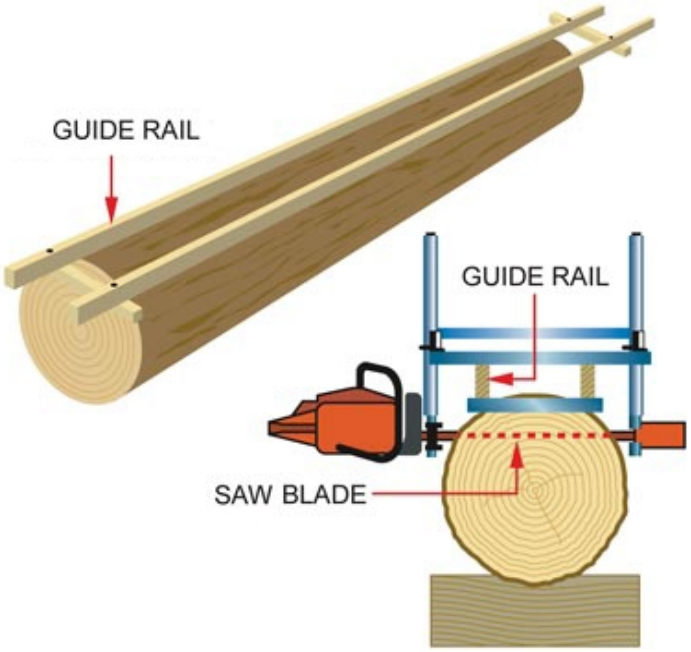
- Loss of log volume or value during skidding
- Excessive damage to soil and streams
- Excessive damage to residual trees/ seedlings



*Animal skidding must allow for short extraction distances (typically 200 m or less) and relatively gentle slopes only.*

*Proper harnesses are essential in order to prevent injury to the animals and to avoid cumulative discomfort over long working periods.*

## 4.6 Chainsaw mill operation



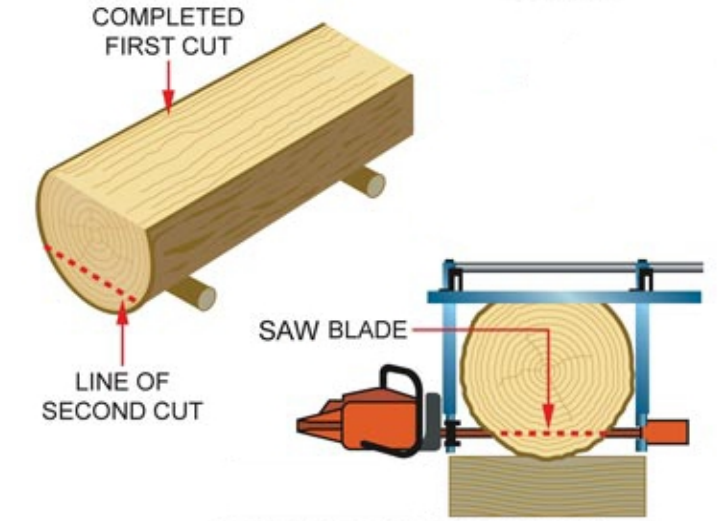

Step 1

To prepare for the first cut a guide rail is placed and secured on top of the log. The guide rail is defining the orientation and quality of all later cuts.

The guide rail must project at least six inches beyond the end of the log so that the saw will leave the cut level and even.

The mill frame is gliding on the guide rail to produce an accurate levelled cut.

Maximum width of a cut is determined by the workable length of the saw bar and the width of the mill on which it is mounted.

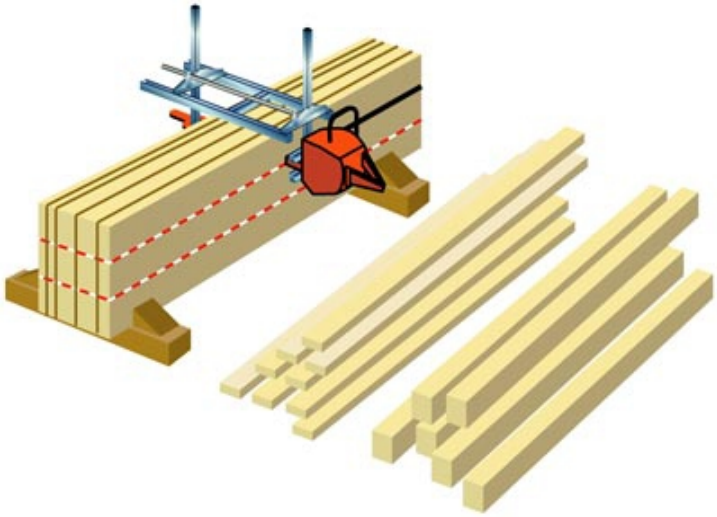



Step 2

After the first cut the guide rail is removed and the mill frame glides on the surface of the first cut.

The mill frame depth is adjusted to define the thickness of the board produced with the second cut.

In order to produce a cant, the log has to be turned by 90° before the third cut.



Step 3

Sawn planks can be further sawn into dimension lumber of any size.

For this, planks need to the gathered and firmly clamped and the depth of the mill frame adjusted accordingly.

# 5. THINNING AS A SILVICULTURAL OPTION FOR FOREST IMPROVEMENT

## 5.1 Introduction

At the time of being allocated to local people, many community forests are rather young or degraded. A key management objective will therefore be to improve the forest condition with the aim of making it more productive in the future.

There are various options for doing this depending on forest type, condition and on the forest product demand of the forest users. Some of these options will also have utilisation benefits, but their main purpose is medium to long term forest improvement.

Thinning is normally carried out in young forests (often called pole-stage) when the tree size is too small for use as sawn timber. Thinning is particularly important where there is a dense stocking of trees of similar age and size, to allow the remaining trees more space, light and nutrients to grow.

Conventional commercial forest management often does not include thinning since the cost can be greater than the value of the poles produced. In community forestry this is not the case, because poles are required for fencing, animal stalls etc. and cost of thinning done by the forest managers is low.

Definition: Thinning means removing some of the trees in densely stocked forest or patches of forest before they have reached timber size.

## 5.2 Objectives of thinning

- To improve the growth rate and diameter of the remaining trees in the forest (by reducing competition)
- To improve the final timber crop by removing deformed tree stems which will not be needed for timber
- To open the canopy to allow more light to penetrate to the natural regeneration
- To produce poles and fuelwood to meet the needs of local forest users
- To ensure forest remains in a healthy and stable conditions (resistant to storm)

## 5.3 Regulations for thinning

The first thinning should take place when trees start to compete with each other for light and space. Tree competition can only be assessed by crown competition, ie, where the crowns are starting to touch.

The management objective is to support selected crop trees by removing competitors. These are trees of lower quality than the crop tree, but which are growing next to a crop tree and shading out the crown from above or the side.

Thinning has to be limited to the dominant tree layer in form of a selective crown thinning from above. Only by removing trees in the dominant canopy layer, the development of the crop trees can be improved. Thinning in the lower layer and under storey has to be limited to dead material or diseased trees.

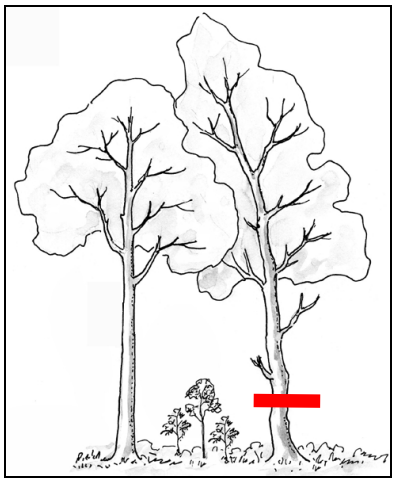
In the understory, climbers are extracted and natural regeneration is strictly protected from any negative impacts like grazing or fire. Shrubs and undesired trees in the understory are spared from thinning for improvement of the forest structure and for ecological reasons but can be selectively harvested if desired for firewood consumption. Only collect dry firewood and leave small branches and leaf material on the site to protect the soil.

The frequency of the thinning depends on the time until crown competition will start again. In forests with fast-growing pioneer species a more frequent thinning is required. In general a five-year thinning period should be sufficient to ensure good stand development.

Rare tree species, especially seed trees that are important for future stand development should be excluded from thinning.

## 5.4 Improvement thinning

Improvement thinning is aiming to continuously protect and develop Potential Crop Trees (PCTs) to reach large diameters for a final selective harvest.



PCTs are trees that can produce large sized, high valuable timber to be sold at local and international markets. PCTs are defined by a straight, at least 4 m branchless and damage-free stem. PCT selection is only based on quality regardless of density and spacing.

PCTs have to be provided sufficient space for optimal growth. This can only be achieved by removing of competing trees through thinning operations (see above).

Only trees with crowns higher or at the same height as the PCT can cause competition. Smaller trees have no effect on the growth of the PCT and should only be extracted if desired for their direct products.

Tree selection for harvest is therefore based on canopy competition as main criteria. PCTs to be protected until they reach final harvesting diameter have to have the following characteristics:

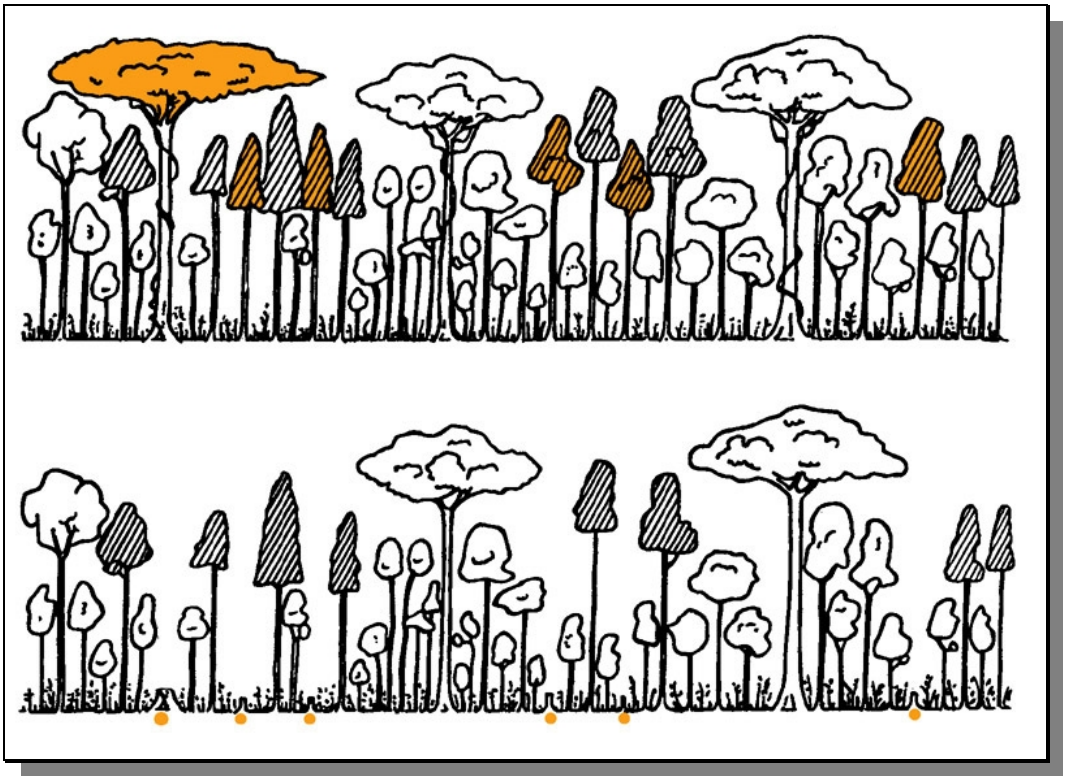
- Vital, not diseased and no major bark injuries
- Straight with round solid stem
- Wide and dense crown
- Species with production potential (timber or NTFP)
- Dominant or co-dominant position in the upper canopy layer

Undesired trees to be extracted from smaller diameter classes should be limited to trees that are:

- Diseased or dead with a potential risk of spreading diseases to remaining trees in the forest
- Trees of undesired species or stem form (bended or forked) competing with a good timber species
- Undesired trees shading out natural regeneration

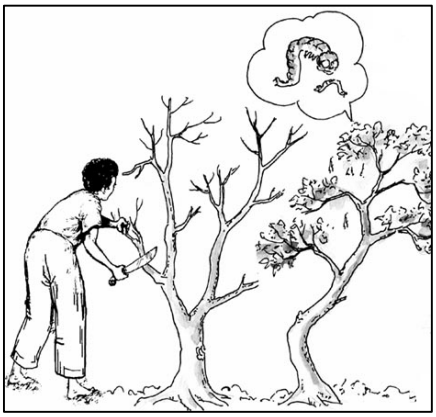
## 5.5 Thinning impact on remaining stand structure

The effect of improvement thinning is illustrated in the following graphic. Trees marked orange in the upper picture are to be removed during stand improvement thinning. The result of the thinning with no crown competition and favourable growth conditions for crop trees is shown in the lower graphic.



## 6. FUELWOOD HARVESTING

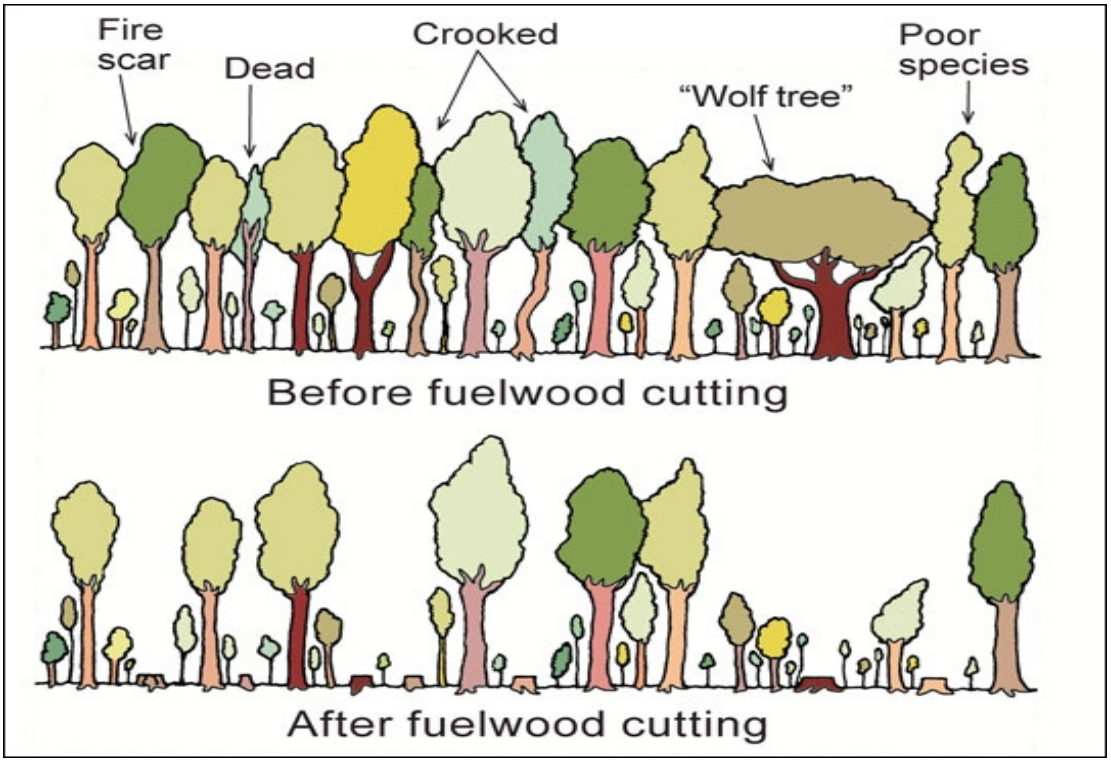
Fuelwood is an important forest product. Even degraded forests can produce some fuelwood, and most silvicultural options for utilisation or improvement of the forest will yield some fuelwood.



Recommended firewood selection criteria:

- Harvested trees unsuitable for timber (e.g. crooked or damaged stems)
- Dead and diseased trees unsuitable for timber
- Trees that are competing with valuable trees
- Branches and other tree parts remaining after harvested trees have been converted into timber
- Unwanted poles and other stems from thinning operations
- Woody shrubs produced during cleaning and weeding operations
- Branches and stems from pruning and singling operations
- Dead branches and trees which have already fallen and can be collected without any new cutting

Note: Potential timber species should be strictly protected to grow into higher diameter classes



# 7. COPPICING

Coppicing is a woodlot management technique in which stools (living tree stumps) are cut on a regular cycle to provide a valuable supply of small-wood and a variety of habitats for wildlife. Not all species will coppice, but local forest managers should know which.

A coppice is a forest stand composed of stools that produce coppice shoots which form the major part of the crop. The stand my be simple coppice or 'coppice with standards'. In a simple coppice the crop is clear-felled to give even-aged stands which may be of a single Species.

'Coppice with standards' a is a system in which selected stems are retained at each felling to form an uneven-aged over storey of mature 'standards', which are removed selectively on a rotation, creating a multiple coppice cycle.

Although mixed coppice woodlands are likely to be the most diverse, differences between growth rates of different species, and thus the length of the coppice cycle, will make management more difficult.

## 7.1 Main benefits of coppice

- It provides a rich variety of habitats, as the woodland always has a range of different-aged coppice growing in it, and is thus beneficial for biodiversity.
- It can provide a regular, maximum output of fuelwood whilst also growing poles and timber (on different cycles).
- The coppiced stools regenerate fast and economically if suitably protected.
- It allows for natural regeneration of selected coppice species, where some are maintained as seed trees.
- It is very easy to ensure a sustainable harvesting.

## 7.2 Common characteristics

- Well-managed coppices are cut on a regular cycle of 5-10 years depending on species and product required.
- Coppice stands are best established at a wider 8-9 feet spacing. The longer the rotation the wider the spacing should be, eg, for a 15 year rotation spacing should be up to 13 feet.
- The initial cut to stimulate coppicing is made after 5-6 years of establishment and should be as close to the ground as possible. The ability of a tree to coppice depends on the tree having an established root system to feed new growth.

- Cuts on established stools should not be more than half a foot from the ground, and have a slight southwards angle to allow quicker drying. This is because shoots developing from close to the ground are less susceptible to storm damage.
- Felling should be close to the height of the initial cut for the same reason.

- Cutting should be done before new leaves are developing, to reduce water stress of the tree.
- The quality of the cut is more important than the tool used; cuts should be clean with no bark damage inflicted to the stump. For unskilled workers a sharp bow saw is probably the safest and simplest tool to use.
- Growth of coppice shoots is depressed when the shade cast by standards is too great. The amount of shade cast is more important than the number of standards per hectare; the canopy coverage of standards should be kept below 30% at the start of each coppice cycle.
- Protection of stools from excessive browsing damage is the most important practise necessary in managing coppice.

## 7.3 For successful management of coppice

- Prevent excessive browsing damage
- Cut coppice during winter dormancy
- Cut stools close to the ground leaving short stumps
- Use sharp, well maintained tools
- Limit shade cast by standards

# 8. PROMOTION OF NATURAL REGENERATION

## 8.1 General Principles

Promotion of natural regeneration follows the idea of utilizing the potential of forests to naturally regenerate. This saves labour and avoids cost intensive measures for replanting or enrichment planting.

For forest management to be sustainable, regeneration is needed to replace harvested trees, or to improve forest which is already degraded. Getting regeneration of the desired species and making sure that it survives and grows is an essential part of forest improvement through:

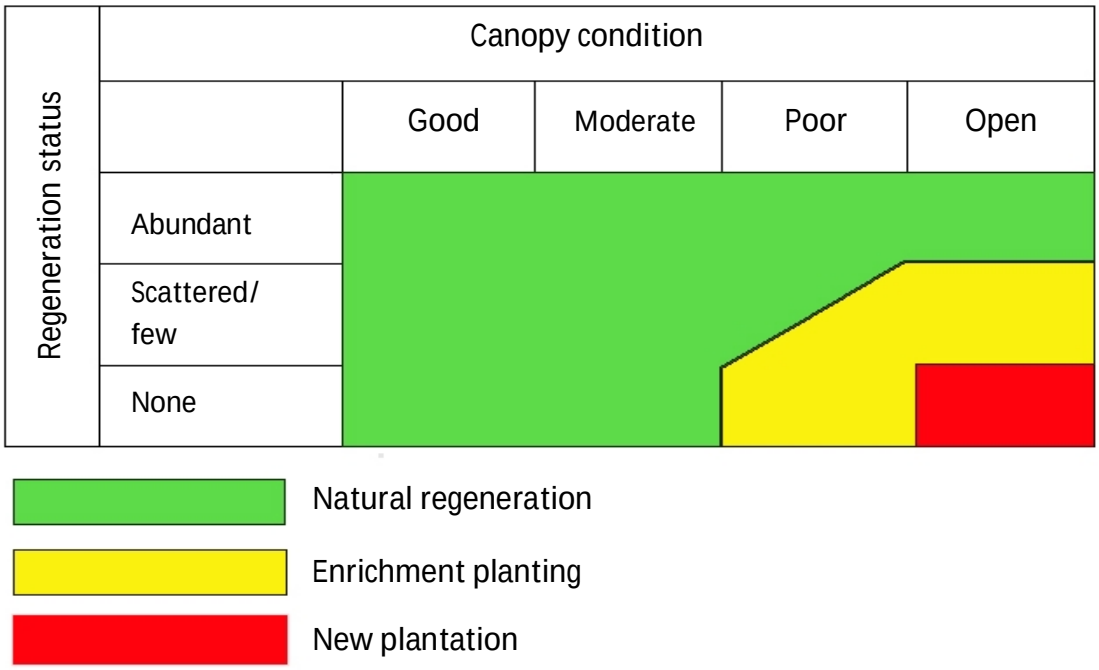
- Promoting existing natural regeneration through strict protection from grazing, firewood collection, forest fire and during all silvicultural operations.
- Strict protection of any vegetation growing in open gaps especially along rivers and streams, in areas with steep slope and areas with thin soil layers or with rock outcrops. Regardless of the utilisation potential of the species a vegetation cover has to be maintained for crucial soil protection.
- Shrubs and non-target trees in the under storey are spared from thinning for improvement of the forest structure and for ecological reasons but can be selectively harvested if desired for firewood consumption.

Existing natural regeneration should be protected and promoted during all silvicultural operations (including plantation sites) in view of achieving mixed natural forest stands of indigenous tree species.

Forests which have been subject to frequent fires and grazing in the past usually do not have enough regeneration capacity, and might therefore require enrichment planting to ensure a sufficient number of crop trees in the future.

Since plantation establishment is a costly and labour intensive silvicultural option, it should be avoided unless there is no alternative method for regenerating the forest. The diagram below gives an indication of the regeneration status and forest canopy conditions for selecting plantation establishment as an option.

This shows that only where the site is completely open (no forest canopy) and where there is no existing natural regeneration should plantations be established. Otherwise natural regeneration is a more suitable option. Enrichment planting is an intermediate option where planting is only done (at lower density) to supplement any natural regeneration already taking place.




## 8.2 Main interventions under promotion of natural regeneration

- Strict protection of young trees with potential for timber and NTFP production.
- No grazing or fodder collection.
- No burning (including controlled burning) allowed at any time.
- Harvesting of firewood has to be limited to undesired non-valuable trees.
- Climbers are to be removed from desired trees to ensure a good stem development.
- Strict protection of mother or seed trees in areas with insufficient natural regeneration.
- Selection of desired tree species and mother or seed trees has to be based on the demand of the local forest users.
- In areas dominated by bamboo, the silvicultural option of natural regeneration with or without enrichment planting can only be applied if bamboo is considered a desired species of the long-term management goal. The active elimination of competition from bamboo to support tree regeneration is a very difficult and labour intensive process due to the strong vegetative regeneration capacity of bamboo.
- Existing coppices should be singled, ie, cut back leaving only one or two main branches to develop into larger diameters.

# 9. FUG INVENTORY TECHNIQUE FOR NATURAL FOREST

## 9.1 Background

This chapter describes a participatory concept for forest inventory that was field tested during two on-site trainings with forest user groups currently being supported by FFI in Mohnyin township, Kachin state, and the Tanintharyi Nature reserve Project in Dawei district, Tanintharyi region.

The inventory concept detailed is designed to obtain data on forest standing timber volume, to be used for:

(i) Pre- and post-harvest forest inventories as stipulated in District Forest Management Plans (DFMP)

(ii) Project impact monitoring

(iii) Above Ground Biomass (AGB) estimates for carbon measurements.

Furthermore, if conducted on a regular basis, community forest inventory data could become an integrated part of district and state forest management planning.

The protocol to be followed for litter and deadwood measurement for AGB estimates can be taken from the Winrock Standard Operating Procedures1 (SOP Measurement of Litter layer and SOPs Measurement of Lying Dead Wood and Standing Dead Wood, respectively). The Winrock manual does not include any information on how to set up an inventory or how to conduct the surveying, including design and establishment of sampling plots, but the information on the measurement techniques is comprehensive. As such, the Winrock manual is a valuable companion to the concept presented here. For litter assessment, a plastic bag and a hanging scale would be required; deadwood assessment does not require additional tools.

## 9.2 Field testing

No problems were encountered during forest inventory data collection using the below method, and two Mohnyin FUG teams completed six sample plots within one extended morning. This would translate into an average of at least five sample plots per day for a single team, and confirms the time efficiency of the proposed technical concept.

The applied sample plot layout applied a rectangular sample plot size of 0.1 acre (66 x 66 feet). By applying a sample intensity of 1%, a total area of 100 acre would require the measurement of 1 acre, which would translate into 10 sample plots or a time requirement of around two days only.

According to Forest department data (Feb 2014), the average size of existing CF areas is 160 ac, so this method would appear to be suitable for most user groups. However the range is large and some CF areas have over 1000 ac of natural forest, so a revised method or sampling intensity may be needed in some cases.

[1] The manual can be downloaded from the LEAFAsia website at http://www.leafasia.org/resources_tools

## 9.3 Survey method

The participatory inventory concept is designed to be jointly conducted by Forest Department staff or technical project staff along with some of the FUG members, at least until the FUG's competency is established.

One measuring team consists of only one recorder and two measurers.

The entire set of measurement tools comprises of improvised measurement equipment which can be purchased at local markets for under 10 USD per set.

Sample plot distribution follows a random sample design with a regular distribution of sample plots along a predefined transect line.

The bottom line is defined by a 66 feet nylon rope laid out in a right angle towards the transect line.

Slope measurement is conducted for each sample plot, and required additional distance added to the standard plot length following the dominant slope of the site (up- or downhill). A design for an improvised slope tool is provided in Annex 1.

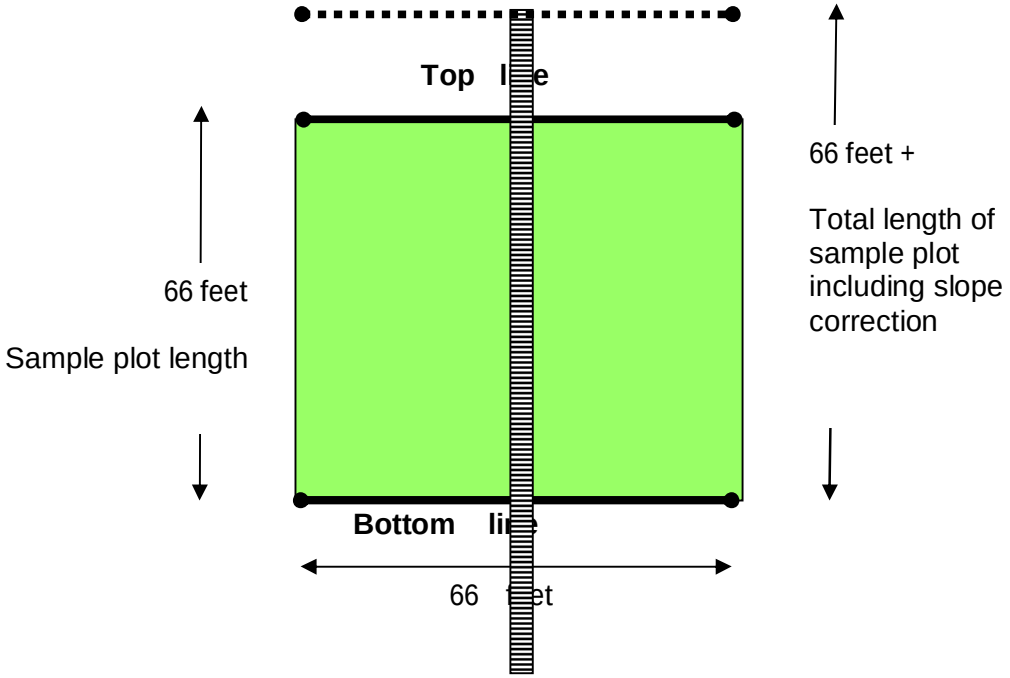



Figure. Plot layout cum slope correction

The total length of the sample plot (following the natural gradient) is defined by a distance of 66 feet plus slope correction, and is measured using a conventional 100 feet measure tape running along the transect line (see figure).

At the top end of the plot the second line is laid out which defines the outer top boundary of the plot. Inside this defined area all trees from 10 inch girth at breast height (~8 cm dbh) and above are measured (in inches) with a normal tape measure. Tree name, girth, quality and height are recorded for each tree in a standard form (Annex 2).

Figure. Chinese clinometer purchased in 39 Hang Ga street Hanoi, Vietnam

Tree height measurements were based on estimates as no height measure tool was available during the training course. However, due to the rather small tree heights commonly encountered in CF sites, this error is considered to be acceptable for the training purpose.

Ideally, Chinese clinometers should be purchased for each interested FUG network (price approx. 40 USD). At present even Township Forest Departments may not own a clinometer. It is not recommended to buy expensive state-of-the-art (eg, SUUNTO) clinometers as they depend on optical lenses with a high risk of being destroyed by mould and fungus during the rainy season.

Three quality classes (A=timber potential, B=firewood potential, C=no usage) were defined for each measured tree to defined the economic potential of the forest site (see Annex 2).

In our pilot, elderly FUG members proved very confident in identifying tree names and timber usage, which would have been not been possible by employing external technicians only. Selection of appropriate team members is therefore important.

During training, after the first sample plot was measured the FUG members immediately completed the following sample plots without any additional advice required from project staff. This indicates that replication would potentially be relatively cheap and easy.

Sample plot location is conventionally identified using a grid, with a regular spacing of sample plots identified in the field by use of GPS. In the case of CF, a simplified procedure would be applicable; by identifying a starting point at the bottom of the forest block from which a specific walking distance (e.g. 60-80 yards) would be defined up a transect that cut at approximately right angles to the geological gradient. Distance measurement could be simply applied by counting steps. The next sample plot would be located after the same walking distance continuously following the transect until the end of the forest block. In case a natural obstacle is encountered (road, rock boulder, river) the sample plot is moved to the nearest location after the obstacle.

## 9.4 Data analysis

Data analysis is designed as a two-staged approach with a) computer-based and b) manual data analysis.

Computer-based data analysis is supported through pre-prepared Excel worksheets which automatically provide pre-defined output tables (see figure, below). These provide for a standardised and time efficient data storage and analysis (see Annex ). Data input is provided in inch and feet, while output data is provided in both m³/ha (international standard) and feet³/acre (Myanmar national standard).

Data entry only requires the input of the total forest area, plot ID, tree name, girth, quality and tree height. All forest characteristics (volume, basal area, stem number, average tree height, average diameter, volume per diameter class) are automatically calculated by the spreadsheet.

Furthermore, stem number and volume distribution per diameter class are shown in a column chart, which has proven a very effective way to illustrate abstract inventory results to FUG members. Data entry per sample plot requires less than 15 min.

Due to the absence of tree-specific diameter-height functions and form factors, a general volume function was applied from comparable forest types in Vietnam:

$$H = 2{,}718282^{A+B*LnD_{1.3}}$$

Where: H = Tree height

A, B = Variables A, B

$LnD_{1.3}$ = Logarithmic diameter at Dbh

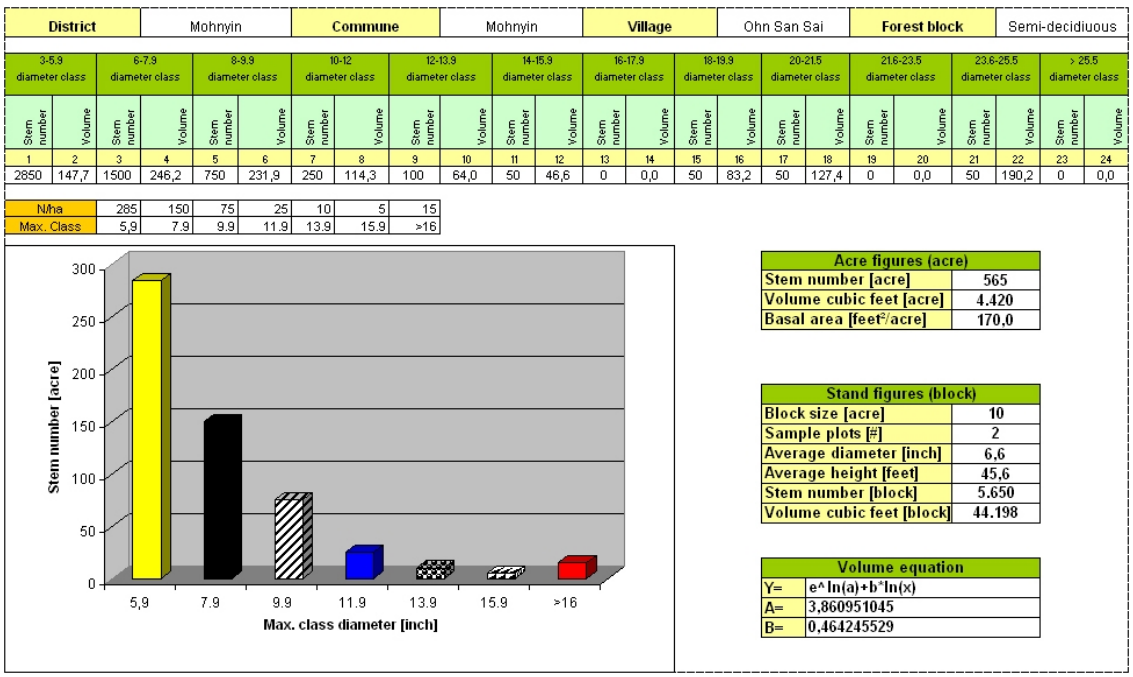



Figure. Example for a forest inventory result sheet

Once sufficient tree height measurements are available from specific townships or districts, a non-linear regression analysis can be conducted to derive a more specific volume estimate. New values for the equation factors A and B could then be entered into the Excel spreadsheet to provide more accurate volume figures.

Manual data analysis was tested after the inventories, on the request of the FUG members. This proved to be extremely easy to comprehend and would only require a conventional pocket calculator or mobile phone with calculator function.

A volume conversion table was developed which can be printed out as A3 and would ideally be sealed in plastic. The volume conversion table provides for each combination of girth at dbh (inch) and tree height (feet) a corresponding volume figure in cubic feet of solid timber.

The sample plot tally sheets (Annex 2) provide a column where the volume can then be entered for each measured tree while in the field.

All sample plot data is then aggregated into a summary sheet (see Annex 3), which guides the user towards the calculation of volume and stem number per acre and finally per entire forest block. Time requirements for 10 sample plots is estimated at roughly 45 minutes.

If tree marking was conducted prior to the inventory and marking results recorded in the tally sheet, the calculation of timber volume and stem number for the remaining stand and the proposed harvest amount of timber could be objectively obtained and reported to the Forest Department. The proposed concept would at the same time comply with monitoring standards under FSC SLIMF certification (see FFI Myanmar Working Paper No.2).

## 9.5 Pre-harvest inventory concept

*Example for a pre-harvest tree marking (pine forest improvement thinning). Red ring indicates PCTs to be protected, white ring indicates tree for extraction during subsequent thinning/harvest)*

In preparation for a timber harvest application, an FUG could permanently mark i) trees to be harvested and ii) Potential Crop Trees (PCTs) that need protection until reaching the required harvest diameter.

After completion of marking, a forest inventory would then be conducted.

Tree selection would follow agreed silviculture and reduced impact logging guidelines such as those presented in early chapters of this guide.

In the inventory summary form the volume for trees to be protected and to be removed would be calculated separately. This will depict the pre- and post-harvest scenario, which would then be approved by the Forest Department prior to the harvest.

### 9.6 Pilot inventory results

Inventory results from piloted sites in Mohnyin and Tanintharyi (Annex 4) reveal that only some sites would at present provide sufficient timber volume to justify immediate commencement of a selected timber harvest. Other sites would require a period of strict protection or very moderate thinning before a harvest could be considered.

## 10. REFERENCES

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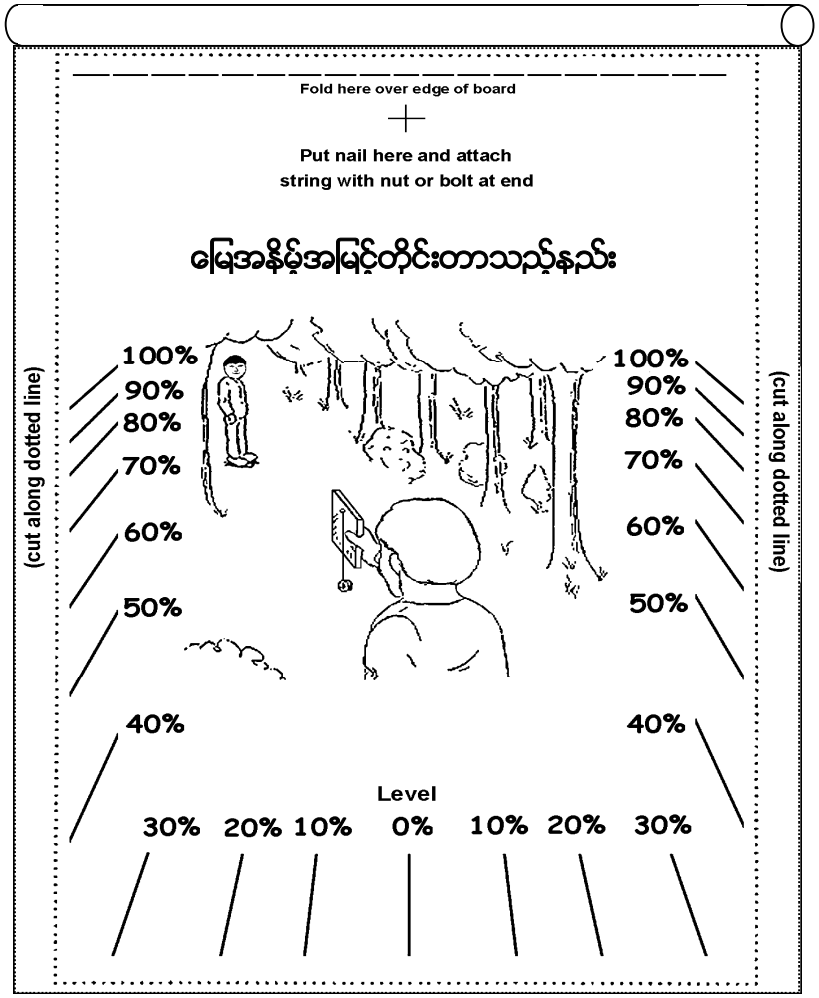
## ANNEX 1: SLOPE MEASURE TOOL KIT

| မြေအနိမ့်အမြင့် | အကွက်အလျား | | မြေအနိမ့်အမြင့် | အကွက်အလျား |
|---|---|---|---|---|
| % | 66 ပေ | | % | 66 ပေ |
| 15 | 66,7 | | 70 | 80,6 |
| 20 | 67,3 | | 80 | 84,5 |
| 25 | 68 | | 90 | 88,8 |
| 30 | 68,9 | | 100 | 93,3 |
| 35 | 69,9 | | 110 | 98,1 |
| 40 | 71,1 | | 120 | 103,1 |
| 45 | 72,4 | | 130 | 108,2 |
| 50 | 73,8 | | 140 | 113,6 |
| 60 | 77 | | 150 | 119 |

Note: The slope conversion table provides corrected distances for 66 feet horizontal distances, as function of the slope, e.g. the distance correction for a horizontal distance of 66 feet, with a slope of 25% is 68 feet.




User manual: (1) Print out the slope measurement and glue the page on a piece of carton or veneer board and cut it along the dotted line. (2) The top has to be cut precisely along the bold dotted line. (3) Glue the slope conversion on the other side of the measurement tool. (4) Fix a plastic straw on the top of the tool. (5) Drill a hole through the '+' at the top of the tool and attach a string with a bolt at the end exceeding the size of the measurement tool.

## ANNEX 2: INVENTORY FIELD DATASHEET

| ကျေးရွာ | | ရက်စွဲ | | | | မှတ်တမ်းတင်သူ | |
|---|---|---|---|---|---|---|---|
| သစ်တောအမည် | | ရွက်အုပ်အလွှာ | 1 | 2 | 3 | မြေအနိမ့်အမြင့် | |

| အကွက်အမှတ် | သစ်ပင်အမည် | လုံးပတ် (လက္ခ) | အရည်အသွေး | | | အမြင့်ပေ | သစ်ကုပေ |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| | | | A | B | C | | |
| **သစ်ပင်အရေအတွက်** | | | **ကုဗပေ** | | | | |

Quality classes explanation

| | |
|---|---|
| A **အရည်အသွေး** : | အဓိမ်သုံးသစ်အဖြစ်ထုတ်ယူနိုင်သည့်သစ်ပင် |
| B **အရည်အသွေး** : | ထင်းအဖြစ်အသုံးခြနိုင်သည့်သစ်ပင် |
| C **အရည်အသွေ** : | အသုံးချ၍မရသောသစ်ပင် |
| **ရွက်အုပ်အလွှာ** : | တစ်လွှာ၊ နှစ်လွှာ၊ သုံးလွှာ |

## ANNEX 3: AGGREGATED INVENTORY SUMMARY SHEET

| **Sample plot** [number] | **Stem number [per plot]** | Volume [per plot] | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| **[ A ]** | **[ B ]** | **[ C ]** | **[ D ]** | **[ E ]** |
| **Total plot number** | **Total stem number** | **Total Volume** | | |

| | |
|---|---|
| Calculate factor Y as shown: | = ( 1 / total number of plots [A] ) * 10 |
| Enter result here [ Y ] | |

| | | | | |
|---|---|---|---|---|
| Figures per acre | | | | |
| | **[ F= B * Y ]** | **[ G= C * Y ]** | **[H= D * Y ]** | **[I= E * Y ]** |
| | **Total stem number (acre)** | **Total Volume (acre)** | | |

| | |
|---|---|
| Enter total area of forest block in acre [ Z ] | |

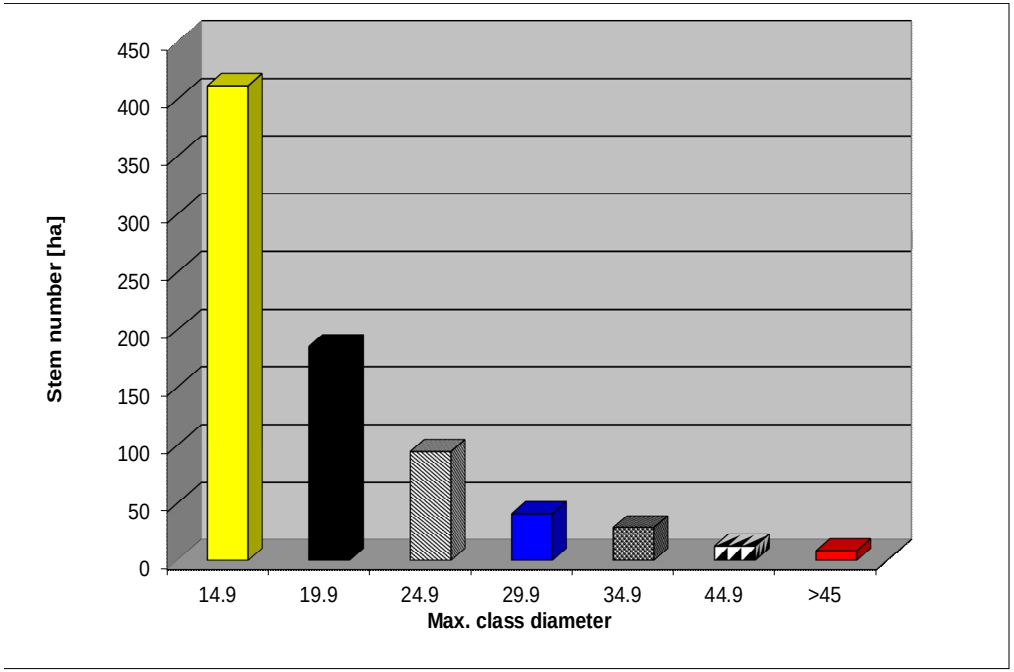
| | | | | |
|---|---|---|---|---|
| Figures per whole forest block | | | | |
| | **[ F * Z ]** | **[ G * Z ]** | **[ H * Z ]** | **[ I * Z ]** |
| | **Total stem number** | **Total Volume** | | |

## ANNEX 4: SELECTED INVENTORY RESULTS TABLES

| District | Mohnyin | Township | Mohnyin | Village | Belu | Forest block | Shwekyikone CF |
|---|---|---|---|---|---|---|---|

| 08-14,9 cm diameter class | | 15-19,9 cm diameter class | | 20-24,9 cm diameter class | | 25-29,9 cm diameter class | | 30-34,9 cm diameter class | | 35-39,9 cm diameter class | | 40-44,9 cm diameter class | | 45-49,9 cm diameter class | | 50-54,9 cm diameter class | | 55-59,9 cm diameter class | | 60-64,9 cm diameter class | | > 65 cm diameter class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 1667 | 109.4 | 750 | 113.1 | 383 | 104.9 | 167 | 69.6 | 117 | 81.0 | 33 | 32.4 | 17 | 23.9 | 17 | 32.4 | 17 | 36.6 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| N/ha | 412 | 185 | 95 | 41 | 29 | 12 | 8 |
| Max. Class | 14.9 | 19.9 | 24.9 | 29.9 | 34.9 | 44.9 | >45 |




| Area figures | | | (acre) | |
|---|---|---|---|---|
| Stem number | 783 | [ha] | 317 | [acre] |
| Volume | 149.1 | [m³/ha] | 2130.58 | [f³/acre] |
| Basal area | 20.2 | [m²/ha] | 4.64 | [f²/acre] |

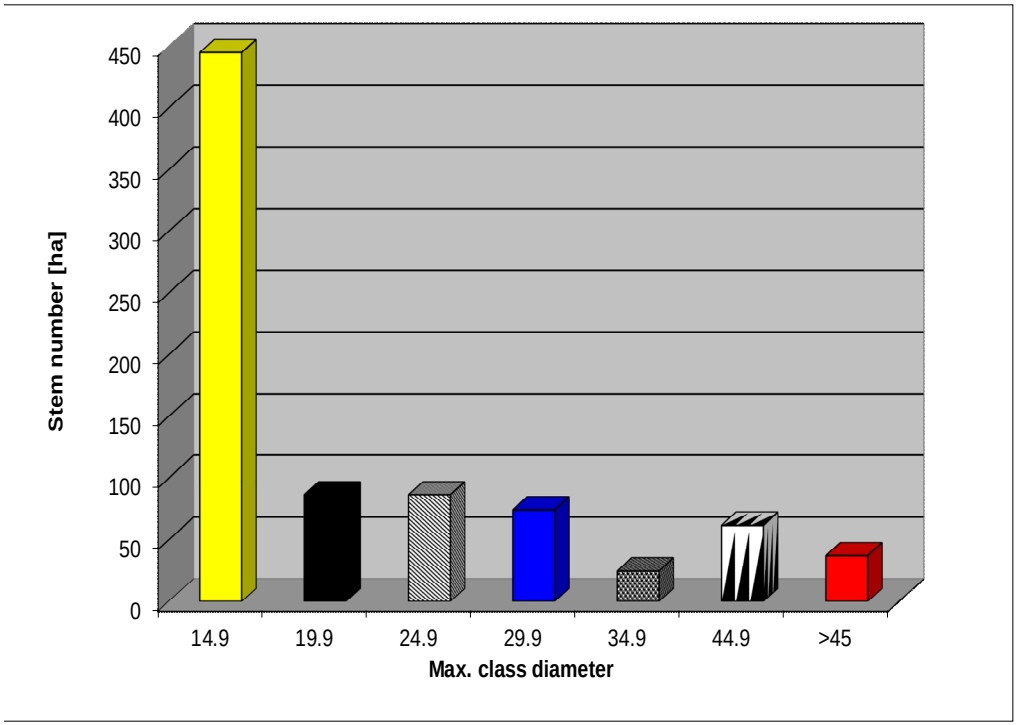
| Stand figures (block) | | | (acre) | |
|---|---|---|---|---|
| Block size | 4.0 | [ha] | 10 | [acre] |
| Sample plots | 6 | [#] | 6 | [#] |
| Average diameter | 52.6 | [cm] | 20.7 | [inch] |
| Average height | 14.0 | [m] | 46.0 | [feet] |
| Stem number | 3,167 | [block] | 3,167 | [block] |
| Volume | 603 | [block] | 8,622 | [block] |

| Volume equation | |
|---|---|
| Y= | e^ln(a)+b*ln(x) |
| A= | 3.860951045 |
| B= | 0.464245529 |

| | Mohnyin | **Township** | Mohnyin | **Village** | Bilu Myohaung | **Forest block** | Semi-decidiuous |
|---|---|---|---|---|---|---|---|

| 08-14,9 cm diameter class | | 15-19,9 cm diameter class | | 20-24,9 cm diameter class | | 25-29,9 cm diameter class | | 30-34,9 cm diameter class | | 35-39,9 cm diameter class | | 40-44,9 cm diameter class | | 45-49,9 cm diameter class | | 50-54,9 cm diameter class | | 55-59,9 cm diameter class | | 60-64,9 cm diameter class | | > 65 cm diameter class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume | Stem number | Volume |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 1800 | 90.6 | 350 | 55.3 | 350 | 92.1 | 300 | 143.6 | 100 | 76.5 | 150 | 154.6 | 100 | 130.4 | 100 | 175.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 50 | 813.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| N/ha | 445 | 86 | 86 | 74 | 25 | 62 | 37 |
| Max. Class | 14.9 | 19.9 | 24.9 | 29.9 | 34.9 | 44.9 | >45 |




| Area figures | | | (acre) | |
|---|---|---|---|---|
| Stem number | 815 | [ha] | 330 | [acre] |
| Volume | 428.0 | [m³/ha] | 6116.30 | [f³/acre] |
| Basal area | 40.3 | [m²/ha] | 9.25 | [f²/acre] |

| Stand figures (block) | | | (acre) | |
|---|---|---|---|---|
| Block size | 4.0 | [ha] | 10 | [acre] |
| Sample plots | 2 | [#] | 2 | [#] |
| Average diameter | 61.5 | [cm] | 24.2 | [inch] |
| Average height | 14.6 | [m] | 47.9 | [feet] |
| Stem number | 3,300 | [block] | 3,300 | [block] |
| Volume | 1,732 | [block] | 24,752 | [block] |

| Volume equation | |
|---|---|
| Y= | e^ln(a)+b*ln(x) |
| A= | 3.860951045 |
| B= | 0.464245529 |