DFID Department For International Development

FRP Forestry Research Programme

Turning Trees to Timber

A Chainsaw Milling Manual

HDRA

Turning Trees to Timber: A Chainsaw Milling Manual

specifically developed for small diameter farm or dryland trees in the tropics

Pasiecznik NM, Brewer MCM, Fehr C, Samuel JH

Nick Pasiecznik
Agroforestry Enterprises
Villebeuf
71550 Cussy-en-Morvan
France
+33 (0) 3 85546826
npasiecznik@wanadoo.fr

Mark Brewer
Mgc Consultants
25 Chelston Avenue,
Hove, Sussex BN3 5SR
UK
+44 (0) 1273 410339
mark.brewer3@btopenworld.com

Clemens Fehr
Gourmet Gardens
PO Box 70066
Kampala
Uganda
+256 (0) 77 481158
clemens.fehr@unique-forst.de

John Samuel
2 Gelding Street
Dulwich Hill
Sydney, NSW 2203
Australia
+61 (0) 2 95607813
johnhsamuel@yahoo.com

HDRA – the organic organisation
International Research Department
Ryton Organic Gardens
Coventry CV8 3LG
UK
+44 (0) 24 7630 3517
ove-enquiries@hdra.org.uk
www.hdra.org.uk/international_programme

HDRA, Coventry, UK

2006

Disclaimer

Chainsaws are dangerous and potentially fatal and this must be acknowledged by all users. This manual contains information and best practice recommendations based on sources believed to be reliable. This is supplied without obligation and on the understanding that any person who acts on it, or otherwise changes their position in reliance thereon, does so entirely at their own risk.

Additional copies and information

Copies of this manual are available in English, French and Spanish, and are free to people and organisations in countries eligible for UK aid.

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This and associated project publications are also available to download via either : *http://chainsaw.gwork.org/*
or
www.hdra.org.uk/international_programme/ip_publications - follow the link to *Research Outputs*.

Any feedback on the contents or use of this manual would be greatly appreciated by the author and publishers.

For further information about training on chainsaw milling, contact a government forestry official who may be able to assist in training needs. Alternatively, contact mgc (www.mg-c.com) for information on chainsaw and sawmill training or HDRA (www.hdra.org.uk) for courses on agroforestry and related land management.

This manual was field tested during training courses run in Kenya in February 2006, and similar bespoke training can be arranged.

Photographs

Front cover:
Top left – Granberg Alaskan Mark III
Top right – Quadra Beam Machine
Bottom left – Stihl (Logosol) LSG 450*
Bottom right – Jober J100 Jobber

Back cover:
Top left – Freehand chainsaw milling*
Top right – Homemade slabbing rails
Centre left – Cutting a crooked log
Centre right - Cutting a board from a side slab
Bottom left – Granberg Small Log Mill
Bottom right – Granberg Mini Mill

Photo credits: Nick Pasiecznik, Clemens Fehr*

Neither DFID or the authors condone chainsaw use without the correct safety equipment.

Concept and layout: Nick Pasiecznik
Typography & graphics: Steve Hammett
Illustrator: Sally Hammett

Printed and bound by Emerson Press, Kenilworth, UK

Acknowledgements

For reviewing and adding their experience and insight to this manual at various stages, thanks go to Neil Bird (DFID-FRP), Sammy Carsan (ICRAF), Simon Choge (KEFRI), Jean Gerard (CIRAD), George Muthike (KEFRI), John Palmer (DFID-FRP), Simmoné Rose (FAO), and to the many chainsaw operators, sawyers, farmers and extensionists in Kenya who participated in the inaugural training courses and who all helped shape the final output. Thanks also to Katel Cadoret and Warner Orozco for translation into French and Spanish, and to Melissa Harvey for realisation.

Whereas the text and illustrations in this manual are original, they draw in part on some existing publications included in the bibliography. The manufacturers of chainsaw milling equipment are acknowledged for permission to use illustrations and information. Thanks also to Granberg International and Quadra Tools for discounted chainsaw mills and to Windsor and Oregon for free chainsaw spare parts and safety equipment used in the inaugural training courses.

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. R8510 Forestry Research Programme.

Foreword

Chainsaw lumbering is gaining widespread acceptance especially in many tropical countries as a means of producing timber in small volumes. It is also an important source of livelihood for small logging operators, farmers and forest fringe communities. However, chainsaw lumbering and milling has often been dogged by controversy. Its association with illegal forest harvesting activities and the relatively low recovery rates are two of the biggest problems facing the industry. Chainsaw milling may be done freehand or with the aid of a mill.

Chainsaw mills are relatively inexpensive and are portable which means that timber can be produced on site without having to transport uncut logs to sawmills. They are also very useful in areas where access is limited for skidding and transport. Portable chainsaw mills usually run off a framework constructed around the log or fixed to the saw. Most chainsaw mills require heavy-duty power heads on saws to effectively operate the mill. Special-purpose ripping chains and bars may be required and various accessories that are purchased as an extra item can help cut speciality wood products.

There are many elements which need to be taken into consideration when choosing a chainsaw mill. These range from the type of logs to be cut and the size of the operation, to the market where the timber will be sold.

This manual has been prepared not only as a guide for potential mill owners but also as a training manual for current owners. It details issues that should be taken into account when choosing a chainsaw mill and the advantages and disadvantages of choosing one type of mill over the other. It also includes a detailed step-by-step guide on milling techniques using the different types of chainsaw mills currently available. The publication concludes by addressing issues related to the post milling phase of the operation.

There is no other information of this kind and in such detail available today, which presents concise comparisons and contrasts between mechanisms and techniques employed on the different mills types. It is hoped that this manual will provide some enlightenment on issues and techniques related to chainsaw milling.

Simmone Rose
Forest Products and Economics Division
Forestry Department
Food and Agricultural Organization
Viale delle Terme di Caracalla
00100 Rome
Italy
+39 (0) 657053242
simmone.rose@fao.org

March 2006

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1 Introduction

1.1 The manual

Why is it needed?

Common opinions concerning the sawing of logs into boards with a chainsaw include: it is not possible, hardly anyone does it, it is very wasteful, it produces curved boards, and the finish is very rough. This manual will hopefully overturn these misconceptions, and allow the reader to see milling with chainsaws in a new light, as an increasingly common method of milling timber, being cheap and efficient, available to most people, producing quality timber, with appropriate technology already available and just waiting to be applied. Most chainsaw milling today is 'freehand', without the use of any guides, frames or rails that would otherwise help sawyers produce even better quality boards with less chance of accidents. The few studies on chainsaw milling that do exist highlight the need for further training.

However, supporting training materials are rarely available. For general chainsaw use and maintenance, there are many manuals produced by manufacturers (e.g. Stihl, Husqvarna) or training bodies (e.g. LANTRA). For chainsaw use in the tropics, see the excellent multi-lingual FAO training manuals. As for manuals on chainsaw milling there are a few such as Malloff's Chainsaw Lumbermaking and Bjorkland and Griffin's Sawmilling for Woodworkers, but both detail the use of single types of chainsaw mill. No generic training materials were found that could support the desired and emphasised demand for information on all types of chainsaw milling in general.

In a broader context, there is a rapidly increasing demand for timber products especially within tropical countries. This cannot realistically be met from remaining natural forests without over-exploitation and illegal practices, which appear to be increasing with negative environmental effects. On-farm trees or other sources from outside forests have been suggested as possible sources to meet at least some of this demand, but the low timber volumes, different sized and shaped trees and the presence of defects means they are of less interest for conventional sawmilling in fixed mills. Portable sawmilling has increased in popularity as an alternative for decades, chainsaw milling only much more recently, but is now being seen as one of many possible ways to increase timber production outside forests.

Many involved in timber production and processing may benefit from reading or using this manual. It was originally designed for use by trainers and extensionists in specific chainsaw milling training courses for farmers, tree owners and small processors. However, it became increasingly clear that the equipment was largely unknown, and even professionals in the field of timber processing seemed not to be aware of its current widespread use within tropical forests, or the potential it has outside of them. More text was added, turning a technical manual into a more comprehensive guide with practices and issues.

This manual is thought to be the first of its kind, looking at all aspects of chainsaw milling, surrounding issues, mill types and equipment available. It should prove useful to many groups of people involved in growing and processing trees, and it is hoped that it might stimulate more on-farm milling, contract chainsaw milling, use of 'waste' trees and timbers, small trees and very large trees, increasing timber processing close to the source of the wood, and maximise returns to tree owners, local people and to the rural economy.

It is often said that a tool is only as good as the person who uses it, and similarly, this manual cannot on its own resolve any of the problems that it intends too, without it being picked up and used by wise and committed individuals. This is only a tool, but hopefully it may also prove useful on farms, drylands, forest and urban margins, as intended.

When chainsaw milling makes sense

Parallel studies looking at chainsaw milling, particularly outside forests in the tropics, have helped to identify the conditions in which milling logs with chainsaws appear to be most appropriate, over all the other alternatives. These are presented in a range of associated publications (see Additional copies and information, page ii) and are only summarised here.

There are many methods for producing timber from trees using chainsaws. Some are common to all sawmilling techniques, whether with pitsaws, bandsaws or circular saws, portable or static. Some, however, are specific to chainsaws, and these may also be additionally dependent on whether the chainsaw is used on its own, or with a rail, frame or carriage-type chainsaw mill. All these techniques are considered here, if only in passing, from the standing tree to the end product, noting especially the differences related to chainsaw milling and those applicable to the context of on-farm and dryland trees in the tropics.

If capital is very limiting, then pitsawing is the only option available for sawmilling, but for a few dozen dollars a day, people can rent large chainsaws and cut their own timber. Whereas a small chainsaw with spares that can be used for milling can be purchased for less than US$500 dollars, buying a suitably large chainsaw will require over US$1,000 with enough spare parts for a full year's use. Then for only a few 10's or 100's of dollars more one can buy a chainsaw rail or frame mill that can be easily attached to any chainsaw.

There is then a quantum leap to chainsaw carriage mills

costing US$1,000-2,500, and the cheapest of a large number of available portable circular or bandsaw mills, from approximately US$4,000 to 40,000. With each increasing investment there is also an increase in potential production, potential recovery, and potential profit. However, there is also a broad range of non-economic factors that affect the choice of mill type to be bought and/or used, which are not always easy to identify.

Chainsaw mills are relatively low cost, highly portable, efficient, durable, easy to maintain and can produce a high quality product, and their use is likely to reduce the chances of personal accidents over freehand milling. Chainsaw milling where the tree falls is less damaging to the environment per cubic metre of wood processed than extraction to a static sawmill, but the additional deforestation caused by illegal logging and milling by chainsaw is another issue. Chainsaws are thus part of the problem, but also appear to be a part of the solution, to many of today's problems both within tropical forests and outside them.

When the resource is limited, i.e. trees are few, prices or species quality are high, total tree volumes are low, or logs are of small length and diameter, these all favour chainsaw milling over other methods. Where trees are inaccessible, either on very steep slopes or far from roads or tracks, favour chainsaw milling. Where trees are damaged or diseased, or may contain nails, favours chainsaw milling. There are, however, only rules of thumb, as no golden rules exist, every situation being very specific. What is already used in a region is likely to work, and whenever freehand milling is observed, milling with attachments could probably increase output and quality while reducing accidents. But sometimes, there are regions, such as in farmlands or drylands, that have no history of timber processing and the standing volumes will not attract conventional millers either, or if so, then very low prices are paid to the tree owner.

A quick calculation, including; volume of standing trees, recovery, market prices, time and equipment required, etc. will give an indication of whether it would be worth processing the tree yourself, or whether there is enough wood to set up as a contractor, or hire one. The capital outlay can be less than a thousand dollars, which is the cheapest of all mechanised milling machinery. Can it be profitable? - well, it depends. Read this manual for a better idea.

Using the manual

Chainsaw users require at least some basic training by qualified instructors to ensure that they can work efficiently, and to reduce the risks of accidents that could be fatal. In addition, training will help operators increase the working life of chainsaws, improve the quantity and quality of the outputs, whether logs or sawn timber, and to reduce harming their own health in the long term.

This manual and the associated set of posters are principally intended for use in short training courses for forest workers, farmers, or others who own trees or at least occasionally need to cut them. In addition to the technical information, it is also interspersed with adequate text and has explanations of issues surrounding chainsaw milling, so it can also be read as a book by professionals and laypersons alike.

However, it is not the purpose of this manual to improve existing freehand chainsaw milling techniques in tropical high forests, but rather to increase timber production, efficiency and safety in chainsaw milling outside forests, generally with smaller trees. For maximum impact, it should be used alongside one of many existing manuals on the correct and safe use of chainsaws for felling and cross-cutting, and chainsaw maintenance. It should then prove useful in increasing production, efficiency and safety within tropical forests, and even outside of the tropics.

The manual has been divided into five chapters; an introduction, different mill types, chainsaw milling techniques, adding further value, and further information on books and mill manufacturers. It deals with each in a general way, intended as an introduction to the subject only, and as such is not comprehensive in any of the areas covered. This manual has drawn from existing literature and training materials, and material from chainsaw, accessory and mill manufacturers, in addition to the experience of the authors and numerous reviewers. While concentrating on types and use of milling equipment, it cannot be understated that the chainsaw is the power source and its correct maintenance is very important, and health and safety aspects are essential but so often lacking. The manual has also been field tested in two on-farm training courses in Kenya in February 2006 prior to final publication.

It must also be noted that the authors have deemed it wise to suggest some 'best practice' that would not be included in standard chainsaw training courses. Correct safety procedures in Europe for example could not possibly be further from reality in much of the tropics, and this fact must be acknowledged if an aim is to reduce accidents. These are not 'recommended' by the authors and publishers, and no effort is made to disguise the serious injuries that may occur when using chainsaw in any situation.

Trainers may use any part of the manual depending on the existing expertise of the trainers or the experience of the trainees, however, it is suggested that all parts are covered in any course. In addition, basic chainsaw safety, felling, cross-crossing and maintenance should be covered as an introduction in any case, and will be a useful refresher even for experienced operators. The minimum possible time to cover the points in the manual briefly is one day, with a further day for general chainsaw training, better if extended to a week or two to include extensive demonstrations and practical experience in felling, de-branching, cross-cutting, milling, chain sharpening and daily, weekly and monthly maintenance. An accompanying set of 8 posters is available from the publishers.

1.2 The bigger picture

Implications for local economies

Chainsaw milling in natural forests in the tropics is clearly providing considerable income for chainsaw operators and labourers, as well as chainsaw owners, dealers and others in the timber trade. Outside of the traditional forest sector, however, the situation is quite different. Low tree densities and volumes mean many common forestry practices are not viable. Farmers with trees on their land are likely to sell them standing, rather than becoming involved in harvesting and processing, and thus receive only a fraction of the value of the tree as sawn timber, with the trader (middleman) and sawmill owner making most of the profit.

Sawmilling machinery suitable for situations with low production must be very portable, able to efficiently cut small diameter, short and sometimes crooked logs, and of low enough capital cost to be economical if milling only a few cubic metres a week. Chainsaw mills are routinely used in some tropical moist forest and occasionally in temperate forest situations, and an increasing number of different types are becoming available. They have certain characteristics and requirements that make them suitable for only a limited number of operations in forestry, but show enormous potential for low volume farm forestry, agroforestry and dryland applications. There, the chainsaw has yet to prove itself, as a low-cost means of increasing the value of standing timber to the tree owner through on-farm milling.

If chainsaw milling were more widely used outside of tropical forests, it could increase supplies of sawn timber locally stimulating other rural wood processing industries, improving livelihoods. Another potentially valuable application is for the management of invasive trees and weedy stands, and making available suitable technologies for adding value to tree products is identified as a means to improve livelihoods in invaded areas. As in the harvesting of any natural resource, research and regulations are required to assess levels of sustainable production and ensure that management practices are practiced allowing the creation of a durable industry.

Environmental effects

Timber harvesting and extraction methods are detrimental to forests and the soils and ecosystems that support them, and clear cutting and the use of heavy machinery can cause irreversible effects. Assuming good felling practices are employed, portable sawmilling techniques can be beneficial in largely avoiding the need for extraction roads or skidding trails by processing the tree where it falls. Also, as only sawn timber is removed, the waste wood is left to nourish the soil and the next generation of trees. The portability of chainsaw milling potentially reduces the environment impact of logging and so could be promoted as part of 'reduced impact logging' practices.

Environmental effects are not all positive, however. Selective harvesting by chainsaw millers can lead to genetic depletion, with the better trees removed and leaving only the poorest to seed the next generation. Additional fuel and oil pollution from chainsaw milling can have adverse effects, and, much chainsaw milling is illegal and so is uncontrolled, unregulated, and no-one really knows its precise impacts.

Outside forests the environmental effects are similarly both positive and negative. Negative in the fact that when a portable processing technique arrives and farmers can receive a fair price for their trees, they are likely to sell them, especially if other crops are fetching a lower price or harvests have fallen. Farmers might then replant, knowing that the returns on the trees will be good, but more often do not, because of any of a large number of factors. Finding out these reasons and overcoming them is a big challenge. Farmers who plant trees and adapt better management will improve environmental benefits such as shade and shelter, as well as making a good return on their investment, and also reducing pressure on nearby forests.

Policy aspects

Chainsaw milling is economically viable in some situations, increasing revenues for the very poor. However, it is likely to have negative impacts, especially on the environment, if allowed to be used ad hoc and without any control. Existing enforcement of regulations is clearly inadequate, so alternative systems are required, involving governments, local people and/ businesses commercially involved in timber, chainsaws and milling attachments. Nonetheless, it is clear that the chainsaw is not the sole cause of illegal chainsaw logging and milling. It is a part of the problem, but it is certainly also a part of the solution. It is not in the scope of this manual to try and answer this apparent paradox, and there is no single right answer, each situation being quite different. But there is some consensus on issues to consider.

- The role of regulation - implementation of existing and improved regulation, licensing of chainsaw milling equipment, policies and policing them, whose responsibility it is, and what can be done about trade in illegal timber, corruption and organised crime.

- The case for certification - improved transparency in the chain of custody, establishment of tree growers', sawmillers' and timber traders' associations, consumers and commercial confidence in sustainability, changing markets.

- The time for training - manufacturers and dealers role, and that of government departments, extension services, associations and other civil society organisation.

1.3 Using a chainsaw

The use of any chainsaw may be very dangerous if not fatal, if used incorrectly. The information below gives only basic principles and is not a substitute for proper training and using detailed guidelines to safe chainsaw practice (see Further reading). Emergency procedures are strongly recommended (e.g. an agreed meeting point, telephone number, nearest hospital, etc.), and these should be communicated with others working nearby.

Personal protective equipment

Proper clothing should always be worn, though even wearing all the right clothing does not guarantee 100% protection against injuries from chainsaws. Strongly recommended are a helmet with visor and ear defenders, steel toed boots, and gloves, trousers and jacket with chain clogging material. However, be realistic. Full protective clothing is hot, and also expensive and difficult or impossible to obtain, so the relative level of protection from different types of clothing should be considered. For example, steel toed or leather boots or shoes will offer better foot protection that training shoes and more than sandals or bare feet. Any gloves are better than bare hands. Cotton wool in the ears and welding glasses or sunglasses will offer more ear and eye protection than nothing at all. Tie up long hair, do not wear loose clothing and remove anything that restricts movement or could become entangled in the chain. Also, a first aid kit should be carried, but if not, have at least a large, clean piece of material as a wound dressing if the worst does happen.

This manual does not recommend the measures above, but asks chainsaw users to consider the best protection available. Do not drink alcohol, take stimulants or other drugs that might affect your work, or smoke when handling petrol. Take extra care or find something else to do if you are ill or very tired, as fatigue causes many accidents. Common sense maybe, but possibly life-saving, so think about what you are wearing, carrying and consuming before starting work.

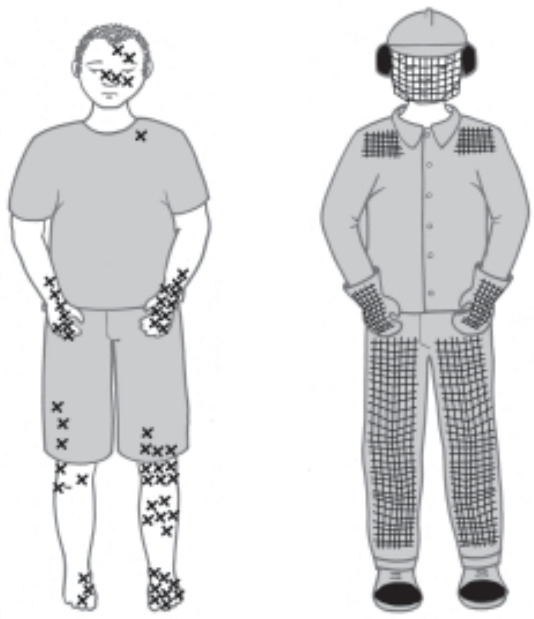


Fig. 1. Main areas of chainsaw injuries involving agricultural (or 'part-time') chainsaw users, and recommended safety clothing (hatched areas indicate presence of chain clogging material).

Basic safety

- Always use only a well maintained and sharp chainsaw.
- Always look around you when working.
- Make sure that there are no animals or people close by that might affect your work.
- Keep a distance of at least 5 metres between you and others when using a chainsaw.
- Keep others at least twice the tree height away when felling.
- If working alone, make sure someone knows where you

Chainsaw milling and illegal logging

Due to their role in illegal tree harvesting, there are increasing calls to control the use of chainsaws, particularly in tropical moist forests where large volumes of high value standing timber remain. Often in remote locations with inadequate laws or law enforcement benefits illegal logging. In contrast to negative effects on natural resources and biodiversity, such crime may bring in more money to poorer people than legal harvesting by big companies. Whereas it is true that a chainsaw has touched most illegally harvested timber, it is difficult to see it implicitly implicated as a cause, but merely a facilitating tool in the operation. As such, separating the use of this tool from others used in such activities and finding its specific role in the illegal timber trade and rural livelihoods has proved difficult and will continue to be so. Some estimates for tropical timber producing countries suggest that for every cubic metre of timber 'declared' and traded legally, there is at least another half a cubic metre that is felled and traded illegally. What percentage of this is milled (rather than exported as round wood), and how of much of that is milled by chainsaw can only be guessed, but the latter is likely to be significant. Some countries such as Ghana have banned the use of unlicensed chainsaws, others such as Guyana promote their use, and both have about 80% of local markets supplied by chainsaw millers. There is some progress by timber importing countries to establish a transparent system for tracing the origin of logs and tree products but no legal framework exists. However, even if it stopped, this would have little impact on illegal logging and milling as much illegal timber is sold either nationally or regionally. A much bigger impact may be made by reducing the demand for illegal timber from natural forests by promoting production and processing of timber from outside forests and in timber-deficit areas.

are when you should be back.
- ❖ Stand firmly on the ground with your legs well apart, one foot forward.
- ❖ Always carry a first aid kit or at least a large wound dressing.
- ❖ The left thumb must always be placed around the front handle to keep a tight grip.
- ❖ Keep the chainsaw close to the body, supporting its weight on the body or tree.
- ❖ Do not operate the saw with one hand as it cannot properly be controlled.
- ❖ Always apply the chain brake before walking with the engine running, taking one hand off the saw or putting it on the ground.
- ❖ Be extra careful when using the saw in poor conditions such as rain or wind or on slopes.

BE VERY CAREFUL OF KICKBACK

Kickback kicks the guide bar and saw chain upwards and backwards very suddenly, violently and uncontrollably, and can cause severe cuts to the head, face and upper body. It is one the most common singe type of chainsaw accident, and if not fatal, will leave the user permanently disfigured. It is to be avoided as much as possible at all costs. It is most common when removing branches or attempting a boring cut, i.e. when the moving saw chain in the upper quarter of the bar nose (the 'kickback zone') contacts a solid object or is pinched, causing a rotational force in the chainsaw in a direction opposite to the chain's movement.

Chainsaw users should practice locking the chain brake, by pushing the back of the left wrist on to the chain break lever when lifting the nose of the bar up, as this is one action that can prevent serious injury from kickback. Also, with the chainsaw engine stopped, try lifting the chainsaw bar nose sharply upwards and backwards yourself, and feel how a rigid left arm can help. Kickback can be minimised and the severity of accidents reduced if as many of the following as possible are followed when using a chainsaw.

- ❖ Make sure the chain brake and lever are working properly. This can save your life.
- ❖ Always use only a properly sharpened and tensioned saw chain.
- ❖ Do not use a ripping chain for cross-cutting.
- ❖ Do not use a chain with the depth gauges removed or reshaped.
- ❖ Hold the chainsaw firmly with both hands, with the left thumb around the handle.
- ❖ Stand to the side of the cutting path of the chainsaw.
- ❖ Keep your left arm straight and tense if making any risky cuts.
- ❖ Take extra care when cutting small branches, brush, scrub or hedges.
- ❖ Do not over-reach.
- ❖ Do not cut above shoulder height.
- ❖ Start the cut at high revs and maintain high engine speed during the cut.
- ❖ Avoid cutting with the upper quarter of the bar nose (the kickback zone).
- ❖ Do not cut branches with the nose of the guide bar.
- ❖ Cut only one log at a time.
- ❖ Be careful if re-entering a half-finished cut.
- ❖ Watch out for any movement of the log that might cause the cut to close.
- ❖ Do not attempt a boring cut if not experienced or trained to do so.

Routine maintenance

Sharpening the chain

This is probably the single biggest reason for inefficient cutting during chainsaw milling. Refer to one of the many detailed chainsaw manuals (see Further reading) for descriptions of methods and tools available. A chain which does not cut unless you press it hard against the wood is dull, damaged or incorrectly filed. Always cut with a sharp chain and never allow it to get to such a stage. Working with a dull chain is dangerous as they are more likely to break or cause kickback. It is also a waste of money, as more time and petrol are required for the same cut, and it will also increase wear and tear on the chainsaw. Some basic rules for keeping a good sharp chain include:

When to file
- ❖ Filing of the cutters is recommended after about every hour of normal chainsaw use, more often when milling and immediately if stones or metal are hit.
- ❖ Depth gauges should be checked around every fifth sharpening or about twice a day.
- ❖ Carefully check and accurately file the chain weekly under normal use, or immediately if stones or metal are hit.

Where to file
- ❖ It is better to sharpen chains in the workshop or at home by taking them off the bar and securing them in a bench vice, and this should be done regularly as part of routine maintenance, especially if a number of chains have to be sharpened.
- ❖ Less accurate but more rapid, the bar can be fixed in a bench vice, or find an alternative place to fix the bar as tightly as possible.
- ❖ Filing in the field will be required, so find a suitable log or stump to fix a small bar vice too, or alternatively cut a shallow slot with the chainsaw and insert the bar.

How much to file
- ❖ If a sharp chain is being filed every hour, only a few passes with a round file will be required on each cutter at each sharpening.
- ❖ If a cutter has been damaged by hitting metal or stone, file the most damaged one first and then all the others to the same size.

How best to file

- File frequently, removing as little of the cutter edge as possible.
- Only sharpen on the push stroke, away from yourself.
- File each cutter evenly and steadily.
- If the same number of file strokes and the same pressure is applied to each cutter, the cutters should always be of identical length and callipers will never be required.
- Maintain the correct top plate cutting angle on each cutter.
- Keep the file at the same angle for each cutter, horizontal or at 10 degrees depending on the chain.
- Sharpen all the cutters on the far side of the bar in turn, then turn the chainsaw around or move to the other side, and sharpen the other half of the cutters.
- After filing each cutter, tap it with the file handle or other piece of wood or plastic to remove the burrs that would otherwise come off and rapidly dull the chain again.
- 12 volt battery-powered sharpeners are available that can be used in the field.
- If large numbers of chains need to be maintained then it is easier to do this in a central workshop, and at least once a week or after hitting a hard object, check the chain carefully, and using callipers or improvising with a piece of wood or cardboard, find the shortest cutter and sharpen all to the length of the shortest.
- Check depth gauges with a depth gauge tool after several sharpenings, filing if needed with a flat file, rounding off the front.
- Carry spare chains, to replace any that brake and also any damaged chains, which can then be resharpened later.

Maintenance schedules

It is good practice to develop a maintenance routine, i.e. spending up to half an hour each day carrying out the daily checks and having a regular hour each weekend for the weekly checks. A bench and vice will be useful. The few hours a week spent on maintenance will easily be repaid many times over with fewer costly and time-consuming breakdowns in the field, increased fuel efficiency, fewer spare parts needed and longer chainsaw working life.

Daily maintenance

1. Start the chainsaw and check the throttle trigger for smooth operation.*
2. Check the chain brake by applying when at full revs, and the chain shop stop dead.*
3. Check the stop switch works properly.*
4. Check the oiler, e.g. with the saw at full revs near a light-coloured object.
5. Make sure the chain catcher is undamaged, or replace immediately.
6. Clean the outside of the chainsaw.
7. Clean the air filter, check for damage or holes and replace if required.
8. Clean fan and starter cover air intakes.
9. Clean cooling fins on the cylinder head.
10. Clean and service the chain brake and clean the side cover.
11. Check the starter cord and mechanism.
12. Look over the chainsaw for loose nuts, bolts, caps, covers, etc.
13. Remove the guide bar, turn, clean, check, lubricate and service as required.
14. Clean and inspect the sprocket, changing it if worn (and replacing the chain also).
15. Carefully check the whole length of the chain for damage.
16. Sharpen chain and file depth gauges as needed.
17. Re-assemble bar and chain and tension chain correctly.

*If the throttle trigger is not smooth, the chain break is not perfect, or the stop switch malfunctions – DO NOT USE the chainsaw, and take it to a professional mechanic or chainsaw dealer.

Weekly maintenance

1. Lubricate the clutch drum bearing (not all chainsaw models).
2. Check for burrs on the bar and file off if necessary.
3. Check the spark plug for cracks and colour, clean and check the gap.
4. Clean and check the starter and recoil spring.
5. Clean cooling system including fins on the cylinder and flywheel.
6. Clean or change the screen on the exhaust.
7. Clean the carburettor body and air box.
8. Check the anti-vibration rubber mountings.

Monthly maintenance

1. Check the break band on the chain.
2. Check the clutch centre, clutch drum and clutch spring for wear.
3. Clean the outside of the carburettor and exhaust outlets.
4. Check the filters in the fuel and oil tanks and replace if required, at least annually.
5. Wash out the inside of the fuel tank and oil tank with petrol.
6. Check all cables and connections.

Time will be saved if common spare parts are available immediately if required, such as air, fuel and oil filters, bars and chains, spark plugs, case nuts and screws, sprockets, starter rope and spring. A full set of tools will also be needed, of which the most important are a box spanner, large and small screwdrivers, a spanner set, files and gauges appropriate for the chain, a grease gun, and bar groove cleaner.

2 Choosing a chainsaw mill

2.1 Mill choice considerations

Chainsaw mills over other mill types

The options
The first decision to be made is whether chainsaw milling is the most appropriate technique to use, i.e. the most practical, economical, environmental, cultural, etc. (see When chainsaw milling makes sense). This manual does not suggest that chainsaw milling is a technology suitable for all and every situation, in fact quite the reverse, that it is appropriate for only certain circumstances, and it is not only economic reasons that affect the choice, but a range of other social and environmental factors, will also come into play.

When timber is in plentiful supply, static sawmills are likely to be most viable, with a highly mechanised and efficient operation able to process at least tens of cubic metres of timber per day, with larger ones producing hundreds of cubic metres of sawn timber. These may also have additional machinery to produce other value added products such as veneers, plywood and particle boards. The size of such mills varies greatly, with some being very small indeed. Other are 'semi-mobile', i.e. can be dismantled and moved with some effort, but the time required means that a certain amount of timber has to be milled to ensure profit before changing location again. Then there are the truly portable mills.

Gang saws, circular saw and band saws are the three alternative sawing systems, each with its own inherent advantages and disadvantages, each which must be considered in mill choice. Only the latter two are employed in commercial portable mills, the principal alternatives to chainsaw milling. Band saws have the lowest kerf (mostly around 3 mm), and high output, quality and efficiency, but require much expert resharpening, especially with hardwoods. Circular saw blades have a slightly wider kerf (around 6 mm), but as they come in so many designs, swing blades, double blades, etc., it is difficult to generalise on their output and efficiency. Less expert resharpening is needed as compared to bandsaws, but hitting nails or stones is costly as blades are expensive.

Chainsaws and chainsaw mills are the cheapest, but have the widest kerf (mostly around 9 mm), lowest output and efficiency, with variable quality. It might also be not a straightforward question of 'either or', but of how to best mix several mill types into a single operation. Chainsaw mills are, for example, sometimes used to cut slabs in the forest or other less accessible locations, for carrying to a site where the timber is resawn by a bandsaw or circular saw. There are so many possible combinations and possibilities, and this manual can only suggest what should be considered in making the choice, and offer much more information on type of chainsaw mills and techniques than is readily available elsewhere.

Access
Pitsawing, the original and still commonly used method involving cutting by handsaw, takes place where the tree falls, with the saw and scaffolding being carried in and the sawn timber being carried out, by hand. Chainsaw milling is equivalent in terms of portability, and as such, can be used in any situation, however inaccessible by other forms of transport.

Even portable bandsaw and circular saw mills generally require putting onto the back of a pick-up truck, are carried and powered by tractor, or are 'trailer types' requiring the aid of tractor or pick-up. Some portable circular and bandsaw mills can, however, be entirely dismantled and carried by hand to otherwise inaccessible sites, and where the 'portability' is measured by the weight of the heaviest component, often the motor.

Nonetheless, a chainsaw is much more portable than any circular or bandsaw type mill, and even with attachment, is still by far the lightest equipment able to consistently cut regular boards. For example, a Stihl MS066 with a Granberg Mark III frame weighs less than 12 kg, and so is easily carried by a single person, even with the fuel, spares and safety equipment required for a day's milling.

Productivity
Different sawmills and milling techniques have different levels of productivity, i.e. the number of cubic metres of sawn timber that can be produced in an average day. The more wood that is available for processing, the more likely it will be that a more productive sawmill will be appropriate. There are, however, many other factors that affect this choice, such as end products required and capital and labour availability (see below), but also the availability of the technology, the means to operate it, spare parts, and other social and environmental considerations.

As for the productivity of chainsaw sawyers and chainsaw mill operators, one cubic metre a day of sawn timber appears possible and reasonable, including maintenance and set up times, which would then relate to 200-300 cubic metres per year depending on how often the saw and operator can realistically work and how much timber is available. Compare this to pitsawing which can not cut more than this, requires more labour and produces a lower quality product, or portable circular sawmills or bandsaw mills which can cut at least several times this amount with some cutting well over 10 cubic metres per day.

These figures must be considered when deciding what milling equipment to rent, but if wanting to buy, then the timber

resources available must also be taken into consideration, i.e. how much timber is available for milling, within a reasonable area, during the estimated lifetime of the machine to be purchased, or the 'payback period' if credit is to be obtained. Generally, the lower the volume of timber to be cut and the more intermittent the available opportunity, the more likely it becomes that chainsaw milling will be more appropriate than other portable mills.

The amount of timber that can be cut from a log is another consideration, known as 'recovery' and usually measured as a percentage of the volume of the whole log. Factors that affect this are the thickness of the blade, the quality and size of the log, the skill of the operator, and the end products required. Chainsaws do have thicker blades, though 'low-kerf' chains available are comparable to the kerf taken by some circular saw blades.

Also, chainsaw mills have the ability to be more flexible, and thus could potentially extract more marketable timber from a log than other methods, however this may not always be the case if the market dictates the timber sizes without any scope for the sale of smaller pieces.

Maintenance is another important factor affecting productivity and choice of mill. 'Down time' wastes time and money, and is itself affected by the ability of the machine's ability to undertake the milling operation given to it, the operator's ability to fix any faults, and the availability (and cost) or spare parts. Chainsaws are fairly ubiquitous tools and easy and cheap to repair in comparison with circular and band saws, which also require more time for general maintenance such as sharpening. Chainsaw mills and milling attachments have few if any moving parts and as such require very minimal maintenance.

In general then, if there are only a certain number of trees to be cut now and in the foreseeable future, or there might be only a few farms or villages to work for, then it may make sense to invest in no more than a chainsaw and a basic frame attachment at the outset. The same chainsaw can be used to fell, de-branch and cut the trunk the trunk to length, as well as mill into boards and cants. A rail or frame attachment will allow even an inexperienced user to produce high quality and consistently sized pieces, and they will continue to have uses even if upgrading to carriage, bandsaw or circular sawmills in the future.

Available capital
For the lowest capital requirement, pitsawing is the technique of choice, still widely practiced in parts of the tropics, though it is the slowest method and labour demanding, often working in teams of four or more. The next step is freehand chainsaw milling, which requires a relatively low investment for the chainsaw (US$500-1,500), and is rapid and needs less labour. The addition of a rail mill (US$40-240), frame mill (US$140-640) or carriage mill (US$1,000-3,500) increasingly improves output and accuracy (see Additional information at the end of the manual for approximate prices of individual chainsaw mills and attachments).

For increased productivity, portable bandsaws and circular saws are needed, of which the range is enormous, with the most basic models costing around US$2,500, some around US$4,000 with necessary accessories, though most others cost at least US$10,000, and even up to US$40,000 or more. However, when undertaking such calculations, a fact often overlooked is that most portable mills require the use of a tractor, pick-up truck or other 4-wheel drive vehicle, the purchase and running costs of which needs to be considered.

Credit may be available, but be certain that there are adequate sources of logs for the entire period of repayment, as an idle mill will not pay back the bank. Chainsaw milling uses a very low capital sawmill, and so has a low opportunity cost of unused capacity, meaning it can be left idle with less of a risk of losing money.

Availability of mills
None of the mills featured on the cover of this manual, in the chapter on mill type or in the list of mill manufacturers in the back are readily available in tropical regions. Some have dealerships in a few countries, often selling only one type of mill, though this is likely to increase. Availability will also be limited of course if the use or operation of chainsaws is illegal in a certain country, though if not the case, then all of them could be bought and imported, though freight and import duties may add a significant amount to the total cost.

Labour considerations
All portable milling can be done by a single operator, but two is better and larger teams may be preferred. The larger (and more expensive) the mill, the greater the production, but then the more people are required to either bring the wood to the mill, move the mill to the wood, and to transport the sawn timber to roadside or other location. Lower labour availability favours smaller operations of which chainsaw milling is one. Or in agricultural areas, labour may not be available year-round, thus limiting when certain operations can be carried out.

End products
This is also important, as not all sawmills can produce all different types of products, though with some variation in the ease or efficiency. The most common products are planks and cants (2.5 cm and 5 cm thick, respectively) of varying widths and lengths, and posts and beams (e.g. 10 x 10 cm) often but not always edged. End products may also be related to the types of tree to be milled, diameter and length, density, etc. Comparisons with other mill types are made difficult because there are many different types available, e.g. single, multiple and swing blade, bandsaws and circular saws, each making certain cuts easier than others.

With chainsaw mills, frame mills are most efficient for through and through (live or slab) sawing, rail mills either

on their own or in conjunction with a frame mill allow for easy cutting of edged timber, with quarter sawing being more difficult. Quality is also a consideration, particularly the finish, i.e. how much planning will be required for use in furniture and flooring, with careful conversion of timber from the log and its drying being important in producing a high quality product, independent of the mill type employed. Much of this will relate to operator skill, though mills and chain type have affects, chainsaws often seen as producing boards of lower finish quality than bandsaws or circular saws.

Comparing mill types

Choice of mill type depends on the type of log being milled and the type of timber being produced, cost, portability (see table below), and a range of other criteria already discussed. The appropriate milling techniques for log types are covered in detail in the following section. Referring to individual makes and models, it is not really the role of this manual to judge them though some generalisations may be made and some reviews exist (see Further reading).

Rail mills often provide just a simple means to guarantee a straight board, or for edging timbers or producing beams, but can be purchased very cheaply. These include the Beam Machine and the Boardmaster. The former is simply clamped, the latter requires bar drilling. Some are also able to make angled and specialty cuts. If a rail mill is being used alone, there are likely to be benefits from also owning a frame mill.

Frame mills are general purpose, being able to process both very small and very large diameter and crooked logs, they are also cheap and very efficient with mid-range logs. Although the Gruminette and Westford Slabbing Mills have certain advantages, Granberg's range of frame mills generally offer the best choice with reasonable prices. A rail mill can also make a useful complement to a frame mill.

Carriage mills are much less portable. Models such as the Jober J100, Logosol M7 and the two Woodbug mills are very efficient in processing large numbers of small round logs such as forest thinnings, whereas the Lennartsfors and Hud-son mills can also saw larger diameter logs, and may be more suitable for farm woodlands that for single or extreme sized trees.

Table 1. The relative suitability of chainsaw milling techniques for different products and types of log.

Type of log	Freehand milling	Rail milling	Frame milling	Carriage milling
Small diameter logs	-	-	*Yes*	*Yes*
Short logs	-	*Yes*	*Yes*	*Yes*
Crooked logs	-	-	*Yes*	-
Tapered logs	*Yes*	*Yes*	*Yes*	*Yes*
Oversized logs	*Yes*	*Yes*	-	-
Side slabs	-	-	*Yes*	-
Defective logs	*Yes*	*Yes*	*Yes*	*Yes*
Speciality cutting	-	*Yes*	-	-
Type of timber				
Slabs	*Yes*	*Yes*	*Yes*	*Yes*
Edged timber	*Yes*	*Yes*	*Yes*	*Yes*
Quartersawn boards	-	-	-	*Yes*
Extra long lengths	-	*Yes*	*Yes*	-
Various				
Portable by one man	*Yes*	*Yes*	*Yes*	-
Approximate cost (US$)	-	*40 - 240*	*140 - 640*	*1000 - 3500*

2.2 Powering the mill

Choice of chainsaw

An important consideration for choosing a chainsaw mill is the chainsaw to be used with it. The chainsaw is, after all, the component that makes the cut, the mill itself being nothing more than a 'guide', to ensure a straight cut. If you already own a chainsaw, then it may make most sense to choose a mill to fit, but consider whether this saw can cut the trees you want.

Amongst the very many manufacturers from around the world, Stihl and Husqvarna tend to dominate sales of chainsaws and the supply of spare parts and accessories, although other companies specialise in certain items such as Oregon for chains and bars. There are, however, a large number of different makes that are common and widely used in other countries such as China and Russia, though rarely seen elsewhere. Whereas Stihl, Husqvarna and Jonsered may be the makes of chainsaw most often recommended by chainsaw mill manufacturers and users, this in no way means that other makes are not appropriate, though it must be noted that milling, or ripsawing is likely to put additional stresses on a chainsaw, and this must be considered when investing in a chainsaw for sawmilling.

It is generally recommended that chainsaws of at least 50 cc capacity are required for chainsaw milling with rails, frames or carriages. However, smaller chainsaws can be used, especially if that is all that is available. It will just take more time to make the same cut, and inflict more wear and tear on the chainsaw for the number of cubic metres of sawn timber produced. Chainsaws as small as 36 cc have been used successfully to cut hardwood logs up to 40 cm diameter and softwood logs up to 50 cm diameter, easily but slowly. So, if you already have access to a chainsaw, however small, it can produce timber with a suitable milling attachment.

A rule of thumb for milling logs above 50 cm diameter, the size of chainsaw in cubic centimetres (cc) should be at least the same as the diameter in centimetres (cm), but 90 cc chainsaw are often recommended and are preferred, in order to mill logs with any efficiency. The most commonly recommended models by chainsaw mill manufacturers are the Stihl 660MS (92 cc), the Husqvarna 395XP (94 cc), and the Jonsered CS2186 (85 cc). For freehand milling common in tropical high forests, larger chainsaws are likely to be even more appropriate, such as the Stihl MS076 (111 cc), MS880 (122 cc) and the 090, due to large tree sizes and the benefits from using an even heavier tool.

In milling, more sawdust is produced, meaning that air filters have an increased liability to blockage and require more frequent cleaning, and high density (HD) filters are recommended. Spur sprockets are usually found on new chainsaws, though rim sprockets are preferred for milling, and it is worth having a spare, as after bars, chains, filters and spark plugs, this is likely to be the next most important spare part that may require replacement.

Bar length must exceed log diameter, as several centimetres of bar length will be lost when attaching to either a rail, frame or carriage mill. Much longer bar lengths are used when freehand chainsaw milling as the angle of cut is much shallower to ensure a straighter board. For use with attachments, a rule of thumb would be to chose a bar length about one fifth more than the maximum diameter to be cut, as long as this is within the maximum recommended bar length for that chainsaw. Sprocket nosed bars are recommended for freehand milling, though others find the sprocket very quickly needs re-greasing. As in cross-cutting, frequent turning of the bar is recommended. Double-ended bars (e.g. Granberg, USA) are also available where a second chainsaw motor is added for processing very large logs. Extra long bars are also commercially available (e.g. Griffiths and Beerens, Australia).

Ripping chain

Types of chain

Length – normally measured as the number of drive links in a loop, and must match bar length, pitch and gauge.

Gauge – the thickness of the bottom of the drive links, which must match bar groove width, common gauges including:

- 0.043" (1.1 mm)
- 0.050" (1.3 mm)
- 0.058" (1.5 mm)
- 0.063" (1.6 mm)

Pitch – the average distance between two rivets, measured as the distance between any three consecutive rivets divided by two, which must match the chainsaw and bar sprockets, common pitches including:

- 1/4" (6.4 mm)
- .325" (8.3 mm)
- 3/8" (9.5 mm)
- .404" (10.3 mm)

Chain profile – as seen when looking at a cutter face, common profiles including:

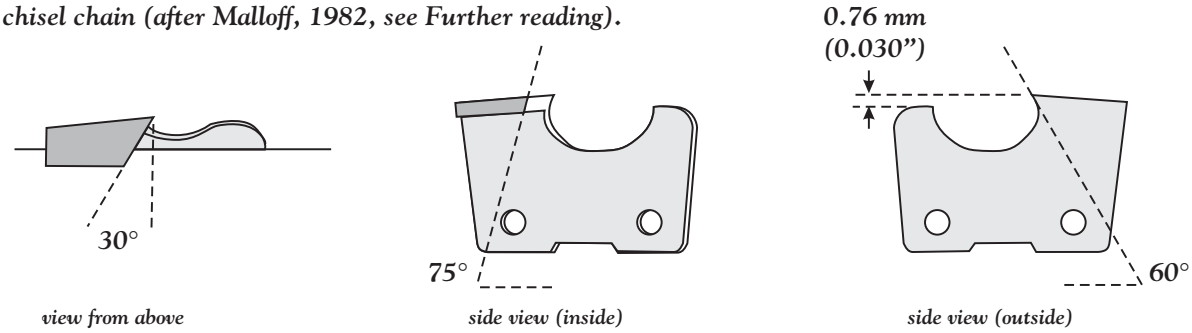
- chisel chain – square cornered, bigger 'bite', generally preferred for milling,
- chipper chain – more rounded profile, safer to use, lower risk of kickback, holds it edge longer, less sharpening required,
- semi-chisel chain – intermediate, sometimes just with corners removed,
- micro chisel and chamfer chisel – only for use with smaller chainsaws.

Chain cutter sequence – the number of cutters per length of chain, common sequences including:

- standard sequence chain, with cutters after every second tie strap, generally best for milling,
- full skip chain with many fewer cutters, only after every

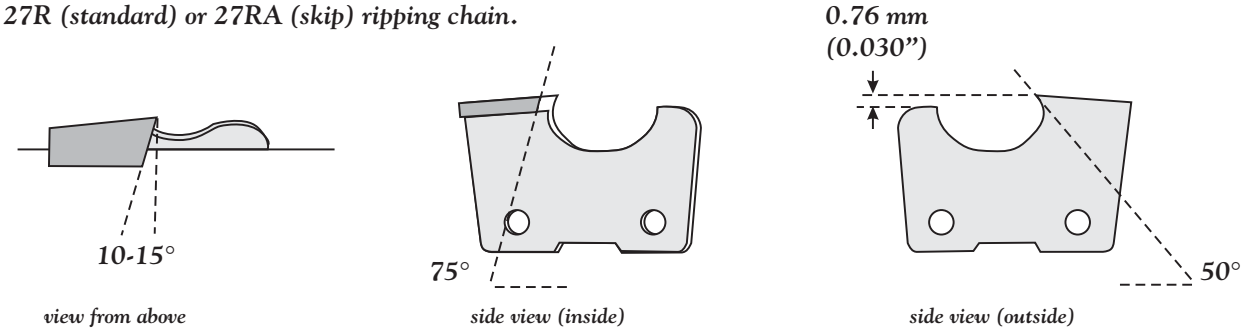
Fig. 2. Examples of different types of ripping chain.

Typical chisel chain (after Malloff, 1982, see Further reading).



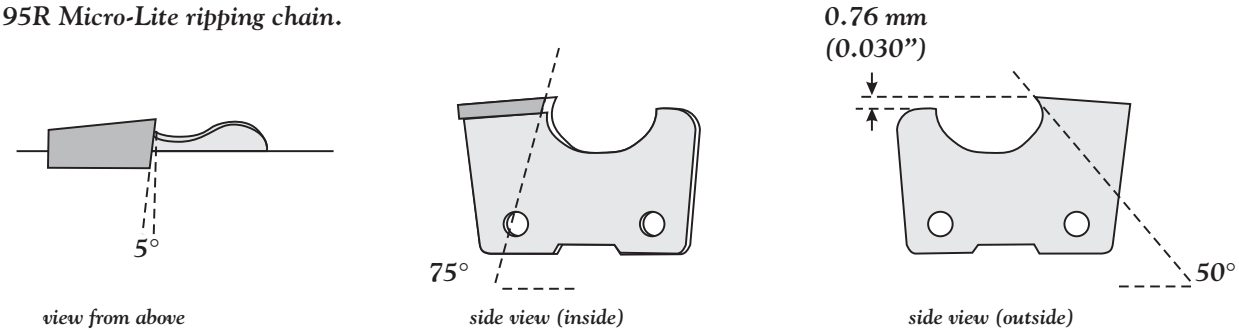
view from above | *side view (inside)* | *side view (outside)*

Oregon 27R (standard) or 27RA (skip) ripping chain.



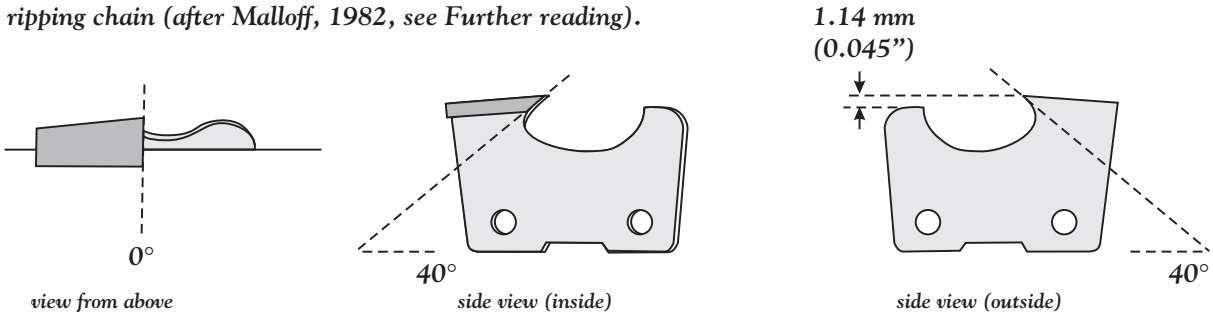
view from above | *side view (inside)* | *side view (outside)*

Oregon 95R Micro-Lite ripping chain.



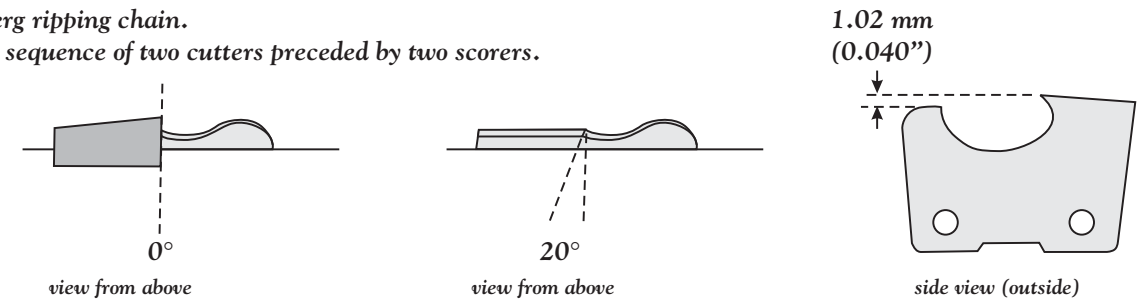
view from above | *side view (inside)* | *side view (outside)*

Modified ripping chain (after Malloff, 1982, see Further reading).



view from above | *side view (inside)* | *side view (outside)*

Granberg ripping chain.
Special sequence of two cutters preceded by two scorers.



view from above | *view from above* | *side view (outside)*

third tie strap, for use only with larger chainsaws,
- ❖ semi-skip chain with fewer cutters, intermediate between standard and skip.

Specialist chains – for certain operations or safety features, including:
- ❖ ripping chains, with reduced top plate angles (0-15 degrees instead of 25-35 degrees in felling and cross-cutting chains), lower depth gauges, and increased hook,
- ❖ reduced kerf chains, narrower that standard chains to reduce the amount of wood removed with each cut and so also the power required for cutting,
- ❖ reduced kickback chains, with special features, e.g. the Oregon Vanguard.

Making the choice

As for choice of chain in chainsaw milling, this is an ongoing and never ending debate
- ❖ Ripping chain or felling chain?
- ❖ If ripping chain, then 0, 5 or 15 degree top plate angle?
- ❖ Chain with a full complement of cutters, semi-skip chain, or Granberg chain?
- ❖ Buy them or grind down your own?
- ❖ File down depth gauges how much?

There are no right answers to these questions, different people all having their own opinions. What is most suitable will depend on the situation in each case, what chainsaw and bar are being used, what wood is being cut, what the end products are, the finish required, what chain and tools are available, operator skill and experience, etc. The final decision is likely to be a compromise between such factors. Most chainsaw mill manufacturers recommend ripping chains, though many users still prefer to use normal felling chains, especially if felling and milling with the same chainsaw and bar, so as to save time in changing chains (and possibly bars), and the need to buy and carry different types of chain. Felling chains will cut as quick or quicker than many types of ripping chains, and are readily available.

Ripping chains can be purchased ready made to fit most guide bars. If not available locally, they can be bought by mail order from most chainsaw mill manufacturers (see Additional information). However, most sell chains made or designed by one of the main three manufacturers, Granberg, Oregon and Stihl.
- ❖ Granberg - ripping chain at 0 degrees top plate, and half the cutters converted to 'scorers', having a top plate reduced to the thickness of the side plate.
- ❖ Oregon - ripping chains at 5, 10 and 15 degree top plate angles, and also a reduced kerf Micro-Lite chain at 5 degrees.
- ❖ Stihl - ripping chains at 0, 5 and 14 degree angles, and the reduced kerf PMX chain.

Ripping chains can also be made by modifying regular felling chains, normally chisel chains. If modifying your own, whatever is tried and preferred, all cutters should be the same angle and the same length, and all depth gauges must be the same height. Ripping chains should NOT be used in cross-cutting as they greatly increase the risk of kickback.

As the top plate angle is reduced, the finish or quality of the resulting boards is improved. However, the lower the angle, the slower the cutting speed, assuming that there are the same number of cutters per unit length of chain. A right angle, 0 degree chain, gives the smoothest finish which can be comparable to that from a bandsaw, but also generally gives the slowest cut. Thus, some users prefer top plate angles of 5, 10 or 14 degrees, sacrificing some board quality for a greater cutting speed. The side plate angle of cutters in ripping chains is also often reduced to 40-50 degrees.

Depth gauges can be modified, often increased to a cutting depth of 0.76-1.00 mm (0.030-0.045") depending on the size of the chainsaw, rather than 0.63-0.76 mm (0.025-0.030") for felling chains. Depth gauges are commonly cut off or filed right down on chains used for freehand chainsaw milling to increase cutting speed, but this increases vibration, the chance of kickback, operator injury and bar and chainsaw damage.

Chains with a full complement of cutters give the smoothest cut and are generally preferred especially for small and medium sized chainsaws. Semi-skip and full-skip chains give an increasingly quicker but rougher cut, require more power, and so are only suitable for larger chainsaws. Chisel chains are generally preferred in all cases.

The Granberg ripping chain is unique in being a hybrid between a standard and full-skip chain, with half of the cutters being 0 degree chisels, and half modified to 'scorers' with a deeper cut, each of the four cutters in a sequence taking one quarter of the cut. This has the benefits of increasing both board finish and cutting speed.

The normal kerf (width of cut) is 9 mm (around 3/8"), though 7 mm (1/4") narrow kerf chains are also available, e.g. the Micro-Lite (Oregon) and the PMX (Stihl). These also require the use of special, thinner bars ('picco' bars) to maximise the benefits of reduced kerf. However, such chains have a much higher risk of breaking and causing severe personal injury, and so are only recommended for small chainsaws and not for bars over 63 cm (24") long. Reduced kerf chains should NOT be used with powerful chainsaws and/or long bars.

Chain oil

Due to the increased workload of a chainsaw in milling, the role of chain lubricants is even more important than in felling and cross-cutting. Standard commercially produced chain oil is recommended by mill manufacturers, of which very many brands are available. Special biodegradable chain oils of plant origin are now also available, such as from rape seed oil. Running a chainsaw without saw chain oil will seriously damage the bar and chain, so when refuelling, it is good

practice to fill the saw chain oil before fuel/oil mixture. See guidance from manufacturers for which chain oil to use, normally non fling oil with adhesive properties.

In many tropical regions, recommended chain oil may not be used due to both cost and availability. In such situations, used engine oil is the common substitute, being freely and readily available, though its use is very strongly NOT recommended by chainsaw manufacturers and chainsaw millers. It also contains minute pieces of metal which damage the oil pump. New engine oil is better for cross-cutting though inadequate for milling unless it is also repeatedly added to the end of the bar. Palm oil has also been used, though the exact effects of prolonged use on the chain, bar and engine has not been assessed. In addition, there are anecdotal reports of the effects of chain oil residues on board quality especially when using old engine oil. There appears to be scope for developing chain oils and lubricants of plant origin for milling that are both cheap and readily available in tropical situations and that could effectively replace petroleum-based oils, with consequent economic and environmental benefits.

2.3 Mill types

The following is a description of currently available equipment, classified into rail mills, frame mills and carriage mills, with selected accessories also covered. A number of the most widely available and well known makes and models are illustrated and included as examples. All the chainsaw milling equipment mentioned in this section are listed in the additional information at the end of this manual, followed by full postal, phone and internet details for each, if more information is required.

Rail mills

With some variation, rail mills comprise of a small attachment that fixes onto the bar, that rides along a 'rail' fixed onto the length of the log. They may have been developed by innovative freehand chainsaw millers to aid them in making straight vertical cuts through a log. Some attachments require the pre-drilling of the bar for the attachment to be bolted on to, others simply clamp on. Rails may be specially supplied metal units (strips, bars, angle iron, etc.) or pieces of wood, typically in common sizes such as 10 x 5 cm or 15 x 5 cm (4 x 2" or 6 x 2"), for nailing or screwing on to the log. Several rail mills have additional features such as an ability to set the chainsaw at angles other than 90 degree (vertical), cut mitres, can control the depth of cut, or cut curved lines. As well as their advantage for producing custom timbers, many have been designed especially for the log cabin and timber frame housing market.

Two common rail mills using timber rails are the Beam Machine (Quadra Tools, Canada) and the more recently developed Micro-Mill (Accutech, Canada). Both of these have the advantage of being simply clamped to the bar, which does not require pre-drilling as in a number of the other rail mills such as the Boardmaster (Hud-son, USA) and the Lumbermaker (Haddon, USA). The Mini Mill II (Granberg, USA) runs on a specially supplied metal rail and also does not require bar pre-drilling. In all rail mills the depth can be set accordingly, and they are useful complements to frame mills.

In addition to these typical rail mills, Logosol have designed an upgradable system, more advanced but more complicated that other rail mills. The basic unit is the improved TimberJig (Logosol, Sweden), running on a homemade wooden rail attached to the side of the log, improved by the addition of a metal rail, or further into a frame mill, made from high quality aluminium and steel parts. Other rail mills include some that are also able to make angled, curved or other precision cuts, such as the Miter Mill (Accutech, Canada), Headcutter (Big Foot Tools, USA), and EDM Tracer II (Schroeder, USA). The Westford Rail Mill (Westford, Australia), and Ripper Mk IV are more similar to carriage mills and are not included here.

Frame mills

Frame mills are probably the best known, original and most commonly available of chainsaw milling attachments. Often called 'alaskan' mills or 'slabbing' mills, they are also sometimes referred to by a manufacturuers name, especially in countries where that make is used exclusively, such as 'Granberg', 'Logosol' or 'Stihl' mills or frames.

These are simple frames or guides that are fixed to the chainsaw bar, and can be adjusted to be set at differing distances from the bar thus allowing for various cutting depths. They are used almost entirely, and most efficiently, with the bar and frame horizontal for 'live', 'slab' or 'through and through' sawing, producing boards, slabs or beams of various dimensions. These frames are made of square tubular steel or aluminium, with or without rollers, and some makes have various sizes to accommodate different chainsaw bar lengths, and thus corresponding log diameters. When using a frame mill, slabbing rails, slabbing boards or similar attachments are essential when using frame mills in order to make the first cut, and these are described in detail later.

Probably the best known frame mills are manufactured by Granberg International (USA), established in 1955. These are robust, lightweight and ergonomically designed, attach to the bar by clamping (bar drilling is not required), are made of square tubular steel, and are very quick and simple to assemble using a standard chainsaw T-wrench spanner. The most commonly sold model is the Alaskan Mark III, available in various sizes to accommodate bar lengths from 63 to 210 cm (24 to 84 inches). There is also the versatile Alaskan Small Log Milling Attachment designed for smaller saws and logs, which can also be used similarly to

the Mark III. For larger logs, there is the Alaskan Mark III C2, which comes complete with a double ended bar, supplemental oiler, a helper handle (so a second person can push at the other end), and a 12 volt chain sharpener. Granberg also manufacture and sell numerous chainsaw milling accessories such as those used in the C2, separately.

Another old design of frame mill is La Gruminette, manufactured by Zimmer (France). These are sold in eleven sizes accommodating bar lengths from 40 to 90 cm (16 to 36 inches). These are also fully adjustable, relatively small and easily carried by one person along with chainsaw, though bar drilling is required. The main difference is that La Gruminette is a frame with two wooden rollers, which requires reduced human effort in pushing the chainsaw mill through the log as compared to sliding on tubular steel. However, the flat working surface of the log needs to scraped and the rollers cleaned regularly, as there is a tendency for sawdust to adhere to the rollers, thus increasing the effective roller diameter and reducing board thickness.

The Stihl LSG 450 and LSG 600 are common in some tropical regions, and may be the only chainsaw milling attachment available in some countries. Known as 'Stihl mills', they are in fact manufactured by Logosol, and so are also sometimes called 'Logosol mills'

The true Logosol frame mill is quite different from that made for Stihl, and forms part of the upgradable Big Mill System (Logosol, Sweden). This allows for two TimberJigs (see Rail mills) to be combined creating the LSG or LSG Pro frame mill from a rail mill. A further extension allows the cutting of over-sized logs. This incorporates some of the advanced technology employed in the M7 sawmill (see Carriage mills), but in a more portable and lower cost format.

Westford (Australia) manufacture a slabbing mill similar to the Granberg Mark III, also available in various sizes for bar lengths from 63 to 165 cm (24 to 66 inches). Some frame mills in use do not appear to be currently manufactured, such as the Sperber mill, marketed in the 1980s as the 'Stihl mill' and with two motor units on a double-ended bar.

Slabbing rails or boards are an essential part of a frame mill to make the first cut, Granberg, for example, supplying a set of slabbing rail brackets free with the Mark III. Others are specially designed, such as the Granberg EZ and Westford slabbing rails. However, they can also be made using timber or metal bars, and even an aluminium ladder fixed to the trunk has been used. The longer the rails, the thicker the wood or metal should be and systems exist for very long logs (see Chainsaw milling techniques). Hand winch and pulley systems that draw the saw and mill through the log without the great effort of pushing can be homemade or bought (Westford, Australia). A weatherboard attachment (Westford, Australia) cuts profiles, though Granberg suggest the addition of washers on one side of their frames for the same effect.

Carriage mills

These differ from frame and rail mills in that the chainsaw is fixed onto or into a type of carriage, which rides along a form of frame or set of rails that is assembled underneath, over or adjacent to the log, or the log is brought to it. One principle difference is the angle of cut, with most cutting horizontally, though a few models provide a vertical (or near-vertical) cut. These are all larger, heavier, more expensive, and require more setting up time than the simpler alternatives already mentioned. However, they do then generally allow the user to cut more timber in a given time, reduce muscular stress and strain and eliminate almost entirely the risk of accidents.

Carriage systems cannot be carried by a single person, requiring a team or vehicle, and share many similarities with existing portable bandsaw and circular saw mills. In fact, several carriage mills can be upgraded to a bandsaw mill, i.e. the same frame can be used with a range of carriages and saw types. Saw types can be differentiated in a number of ways, including the maximum log length and diameter log that can be cut, the height the log has to be raised, and whether the cut is horizontal or vertical.

Probably the two most well-known carriage mills are the M7 Sawmill (Logosol, Sweden) and the J100 Jobber (Jober, Canada). The M7 is an improved version of the original M5 Sawmill also sold as the Woodworkers' Mill. It makes a horizontal cut and the working height is excellent so avoiding excessive bending, but this means the log must be lifted quite high. There are, however, log lifting and many other attachments to improve working efficiency. The J100 Jobber has a near vertical cutting angle, and maintains an acceptable working height and safe working position while the log has only to be lifted slightly, a one-person operation with the hand winch available. It uses heavy steel parts, but is easily assembled.

Both were designed with the chainsaw in mind and both also have alternative bandsaw heads. A disadvantage is that the maximum log length is limited by the rail lengths, and maximum log diameters are not as great as with other mills. They both appear especially suitable for milling large numbers of small diameter softwood logs such as might result from thinning operations.

Other carriage mills, using a vertical cut so wedges are not needed, are Woodbug sawmills (Woodbug, Canada), with a system of frame and rails similar to the others in this section and two sizes corresponding to different maximum log diameters. The Baby Bug can mill logs up to 28 cm (11") and the Wood Bug up to 50 cm (20"). There are also the Rail Mill (Westford, Australia) and Ripper Mk IV (IV (Beerwah, Australia) which are effectively vertical cut carriage mills. Most of these can also be fitted with additional rails to cut longer logs. Other carriage mills have been developed, such as the vertical cut carriage mill designed and built by the Forestry Research Institute in New Zealand,

capable of processing logs up to 100 cm in diameter, though it is unknown whether these are still manufactured or in use.

Other typical carriage mills, with the chainsaw mounted to make horizontal cuts and similar design of frame and rails, are the Hud-son Chainsaw Mill (Hud-son, USA), the SM2186 Chain Saw Mill, formally known as the Jonsered 600+ (Lennartsfors, Sweden), and the EcoSaw Chainsaw mill (EcoSaw, Australia). Others such as the Macquarrie Chainmill do not appear to be still in production. Procut (Procut, Canada) also sell 'make your own' plans for a chainsaw mill, using readily available materials with apparently good results.

EcoSaw also manufacture the ChainMill, which merits a note as it uses a standard chain and a similar frame as above, but on a 1.5-2.0 m Cannon bar powered by a 18 hp engine. Other different mill types have been developed but are not commercialised, such as homemade mills with two chainsaws allowing the cutting of two-sided slabs in one pass.

Milling accessories

Many other accessories, such as rail extensions, slabbing rails, winches, supplemental oilers, double-ended bars, ripping chains, etc., have already been covered in previous sections. However, there is a range of additional chainsaw-powered equipment and milling accessories that merit at least a mention, some included in the Additional information section at the end of the manual. These include two attachments that fix to the end of the bar with bar drilling, being the Log Wizard debarker/planer, and the Log Master gouger for cutting troughs (Log Wizard, Canada). For grooves of different profiles, there is a chainsaw router, the Log House Moulder (Logosol, Sweden).

Unique amongst chainsaw mills is the Logosol Big Mill System, which includes a wide range of accessories and interchangeable parts that can be combined to create a rail mill, frame mill and a frame-rail combination, with rail extensions. When upgrading, the next combination uses some components already purchased, reducing capital outlay each time. It is ingenious in its design and excellent in the quality of its component parts and manufacture.

Upgrading a chainsaw mill to a bandsaw

With carriage mills, the chainsaw can be replaced with an alternative cutting head using the same frame. Some manufacturers sell electric chainsaws, or more often bandsaw mills of various types and sizes. It is such an upgrade from a chainsaw carriage mill to a bandsaw mill by just changing the cutting head that offers the lowest cost means of greatly increasing recovery, efficiency and productivity in one single step. No indication is given of the relative merits of one make over another, and Hud-son, Jober, Lennartsfors and Logosol all manufacture and sell special bandsaw heads, that can allow a carriage mill owner to upgrade to a portable bandsaw at less cost that buying a entirely new mill.

For those who own only a frame or rail mill, and not a carriage mill, there is also a single mill that uses a chainsaw engine to power a portable bandsaw, called the Ripsaw (Southeastern Industrial Resources, USA). This hybrid between a bandsaw and a chainsaw mill cuts horizontally like a frame mill and is designed to be powered by a range of common makes and models of chainsaw. It is unique in this regard, and its efficiency and productivity merits its inclusion in this review.

Also, the smallest freestanding bandsaw mills with their own power supply may cost less or only a little more that such bandsaw 'upgrades', or vertical cut 'workshop' bandsaws can also be modified for use. However, the manufacturers still often recommend that the bandsaw head is used in combination with the chainsaw head. The chainsaw still has advantages, such as being more robust and better at dealing with soil or sand in the bark. Thus it is suggested that a chainsaw mill is still preferred for the initial slabbing cuts, especially with rough logs, with the bandsaw used for resawing the boxed heart.

Similar hybrid systems combining chainsaw milling with other mill types are also used with circular saws and semi-mobile and static sawmills including larger bandsaw mills. Again, side slabs are removed by chainsaw, and the square log is further cut into slabs that can be extracted and/or loaded onto awaiting transport, often by hand. And so it appears that chainsaw milling has an important role to play in the conversion of trees to timber, even when more efficient and more productive bandsaw or circular saw mills are available and in use.

Speciality mills

A number of special rail mills are made that allow the guide bar to be set at any angle, including the Accutech Miter Mill, the Schreoder EDM Tracer II, and the Big Foot Headcutter. Add this to a depth setting, and many types of grooves and joints can be prepared such a V-notch and wavy-edged cuts, mortise and tenons and other timber joints. Another specialist attachment for cutting grooves of many shapes into logs or beams is a chainsaw-powered router, the Logosol Log House Moulder (see Accessories). These have largely been developed for making log cabin and timber framed housing. The chainsaw really comes into its own in such construction, and clearly many involved have seen the possibility for developing attachments for specific tasks in often very isolated locations. For cutting troughs, there is also the Log Master and Log Wizard (see Debarking).

Fig. 3. The Quadra Tools Beam Machine.

Fig. 4. The Hud-son Boardmaster.

Fig. 5. The Logosol TimberJig.

Fig. 6. The Granberg Alaskan Mark III.

Fig. 7. The Zimmer Gruminette.

Fig. 8. The Logosol LSG.

Fig. 9. The Logosol M7 Sawmill.

Fig. 10. The Jober J100 Jobber.

Fig. 11. The Lennartsfors SM2186 Chain Saw Mill.

3 Chainsaw Milling Techniques

3.1 Choosing the right trees

Selecting the logs

What to think about
One option is not to mill the tree at all. If alive and left standing it will grow and increase in value, and may be better to fell and mill in years to come.

It is unlikely than any one single factor will decide what tree to fell in every case, and that the final choice will be depend on a mixture of reasons. Consider the probable final timber dimensions, especially length, and divide tree into a number of logs, roughly in your head, before making the final choice.

Only fell the tree if you are comfortable with the choice and with the intended felling operation, taking into consideration the time it will take, all the risks and dangers that this might pose. Remember, felling trees is the single most dangerous operation in forestry and should not be undertaken lightly, and not without the right tools and training.

Fig 12. Choosing the tree for felling and milling depends on many things.

Assuming you have choice (see The logs selecting you), there are a number of criteria which will effect which trees are selected for felling and milling.

End users and end uses
What will finally happen to the timber produced may be in response to personal needs, such as timber for a new barn, beams for the house roof, a new kitchen table, etc. It is, however, more likely to be market driven, with timber sold to traders or middlemen, or more profitably, directly to end users, builders, carpenters, furniture makers or other artisans. The more targeted the marketing of the timber is to be, the better is the market information required, for example dimensions preferred, when the timber is required, quantity and quality premiums and general prices paid.

Time and resources available
This includes whether there is sufficient time, manpower and equipment to undertake the operation, but also, if the tree is your own or you will be paid for the job, whether you need the money. In on-farm situations, this might just mean waiting for a particular season, such as after harvest, as with trees in coffee or cacao plantations, or trees in or around fields of annual agricultural crops. Felling and milling 'out of season' not only makes sense to reduce crop damage, but also more labour will be available. A suitably sized and maintained chainsaw will of course be needed, enough fuel, oil and spares, and people experienced enough to carry out the operation.

Location
One great advantage of chainsaw milling is its extreme portability, and the ability to mill logs anywhere. They will thus be more suitable in inaccessible locations, or wherever the costs of log extraction exceed the value of the timber, including areas far from roads or on steep slopes, especially where the timber volume or value is low. Also, chainsaw milling may be appropriate in nature reserves and similar protected areas where reduced environmental impact is desired and the use of heavy machinery is to be avoided.

Species
This will affect the quantity and quality of usable timber produced and the ease of cutting. Choice may depend on personal needs if intending to use the timber, or more often the market demand, whether this be local, regional or international. Well-known commercial species are always preferred, whereas lesser-known timber trees such as fruit trees and dryland species though yielding some very good wood, may be difficult to market. Markets and their preferences can change, however, but this takes time.

Size
Chainsaw milling is more appropriate for non-standard log sizes that are often left alone by commercial sawmills, especially the extremes, i.e. very short, small diameter or oversized logs. These will require more work and are likely to yield less timber than if milling regular sized logs, but may be available at a lower cost.

Quantity
The number of a certain species present is important, with trees common locally likely to have an accepted and ready market, whereas trees locally rare may not, or instead could have a price premium due to such a small supply. Many small trees or one big tree can yield the same amount of timber, however, and there will be an optimum size for cutting efficiency depending on the size of chainsaw, type of mill, experience of the operator and other factors. Further processing into end products can overcome consumer resistance to lesser known species and small sizes/lengths.

Log quality
Factors likely to affect the quantity and quality of the timber produced and also the recovery and efficiency when milling, include: tree form (stem straightness, branching), defects (splits, shakes, holes, hollows, rots, diseases), tension, and presence of foreign objects (nails, etc.). Recovery, efficiency and profitability will be higher from long straight logs, though chainsaw milling does offer the possibility of processing crooked or branched stems more than other milling techniques (see Making the best of the rest). Many branches gives lots of knots and poorer timber quality. Diseased or otherwise defective logs are of little interest to most sawmillers, but some marketable timber could be produced by chainsaw milling. Logs with significant inherent tension, as found in some eucalypts, are difficult to cut and also disliked by sawmillers, but contain useful timber. Street trees too, are often not considered suitable due to the possible presence of nails or other metal objects which cause much damage to bandsaw blades and circular saw teeth, and while they also damage chains, the cost in materials and down-time will be less in chainsaw milling.

Market value of milled timber
This is related to many of the factors already described, but also by cultural preference and experience, the quantity and quality of imported timber or other materials that could be used as a substitute, and other reasons that may not be immediately apparent and/or difficult to ascertain.

The logs selecting you

Chainsaw milling is peculiar amongst sawmilling techniques due to its high portability, low cost, and suitability for milling logs that might otherwise become firewood or left to rot. There are many log types that fit into this category, all of which are already milled by chainsaws at least somewhere in the world.

The following is a miscellaneous list of potential and actual sources of sawn timber than have been identified as having some potential as an increased source of sawn timber for local markets with appropriate conversion techniques such as chainsaw milling.

1. Farm trees
2. Street and city trees
3. Dryland trees
4. Weedy trees

5. River side and rail side trees
6. Small diameter logs
7. Short logs
8. Branches/prunings
9. Oversized trunks
10. Trees of poor form
11. Wind blown trees
12. Forest thinnings
13. Logged over sites
14. Firewood and fodder trees
15. Fallen trees
16. Diseased trees
17. Standing storm-damaged trees
18. Washed up trees
19. Sawmill waste
20. Reclaimed timbers

Some of these are of particular interest for increased exploitation as sawn timber in on-farm, urban or dryland situations in the tropics. Others may also be found in farm woodlands, near farms or drylands or on forest margins, with potential for making timber and money from what would otherwise be a low value or valueless resource, as they may be unsuitable for milling using other methods, or not yet been considered as possible sawn timber such as currently uncommercialised species.

Farm trees
This include trees in hedgerows, shelterbelts or windbreaks, single trees in or around fields, shade trees, border trees, orchard or plantation trees, or small woodland blocks. These make up an often underestimated percentage of a regions standing timber, and are being increasingly looked at to help meet the increasing demand for timber. But farmers are farmers, expert in growing crops and raising livestock, but generally less skilled in growing trees for quality sawn timber. Tree planting, weeding, pruning, etc. are all important but commonly overlooked. In some countries, on-farm trees are being harvested for timber, but the volumes produced can be greatly increased with the proper management, and the returns to the farmer can be greatly increased if the farmer mills them, or has them milled, where they are felled. Realising most of the value of the tree may then inspire farmers to plant more.

Dryland trees
Some tree species currently only thought of as a source of firewood or fodder also have very hard wood and could yield valuable timber, including many Acacia trees for example. 'Recovery' in all these cases is not an issue as all the wood would have become firewood anyway. However, even if only 10% of the wood could be converted to boards or beams, with a conservative 10-fold increase in value per volume from fuel wood to sawn timber, milling of the larger logs is likely to make good economic sense.

Street trees
This covers roadside trees, but also includes those in gardens, squares, cities and suburbs, on railway sidings and along riversides. They offer a great choice of size and species, and generally an immediate market where the tree falls. They will all need replacing sometimes, or may have outgrown their space, have branches in power lines, obscure visibility or present other dangers. They are commonly just cut into short lengths and removed for fuel, but may well contain much valuable timber that a chainsaw miller could convert. Some situations such as gardens may have no access for any other type of mill, and sawmillers often will not mill street

Other trees potentially suitable for chainsaw milling

Fallen trees have an advantage in that they do not require felling, saving time and resources. Within forests these are often called 'windthrows', especially in plantations. In any case, they may require immediate removal because they block roads or may offer a sanitary risk, so man and chainsaw will be called anyway, and not only may they be free, someone may even be willing to pay to have them removed. Standing storm-damaged or diseased trees can also fall into this category, as they will fall down anyway and it may be better to fell them in a controlled manner. Logs may also be found washed up on beaches or riversides.

Within forests, besides windthrows, forest thinnings and logged over sites can provide a valuable source of free or low-cost timber. In plantations, thinning is essential, but will cost the forest owner money unless the sale of the small round wood removed can cover the cost of the operation. If there is no ready market for pulp or poles, they are sometimes even just cut and left to rot, but should be considered as a possible source of sawn timber.

In natural forests, chainsaw millers are already buying cheap concessions on logged over land, finding adequate supplies of logs left by the original fellers, already on the ground so with no felling required. Logs not the right length, tops, below the minimum diameter, branches, split or hollow logs, or even perfect logs that could not be extracted or were one too much for the last lorry, all provide a ready source of usable timber. Such a practice, minimising the sometimes considerable 'waste' in logging operations should be promoted if it can be regulated.

Old timbers, beams, telegraph poles, sleepers, sawmill waste, etc. can also provide a cheap or free source of wood, for resawing into demanded dimensions. The chainsaw miller may just offer his services as a contractor, or try to sell the wood produced. See 'Making the best of the rest', for example, for how easy it is to cut a few extra boards from a log side slab, and such practices, minimising the sometimes considerable waste from sawmills should be promoted.

trees due to the likelihood of nails or other metal items in the trunk.

Weedy trees
Woody weeds or trees as 'invasive species', have become a problem in parts of the tropics, spreading, and threatening peoples' livelihoods and environmentally sensitive areas. Controlling them is very expensive, and heavy machinery, fire, herbicides or biological control also present their own risks. As with forest thinnings, the best option would be to increase the value of what is removed, and firewood, charcoal, wood chips, posts and poles all offer increasing value, but none as much as sawn timber.

3.2 Setting up

Situating the log

Choosing where to mill
It is assumed that the tree or trees to be milled have been felled safely with branches removed following the techniques and guidelines described in previous sections. One of the main advantages of all portable milling techniques is that they can process a tree wherever it falls, thus extraction is not required. In such cases, choosing where to mill is not an issue, but this may affect intended felling direction.

Logs are thus normally milled on the ground with most chainsaw mills, though will benefit from the logs being raised, either after felling, or by felling onto branches or 'bearers' laid across the intended felling area. Branches or logs with V-notches cut into them help to secure the log and stop it rolling. Carriage mills such as the Jober J100 and Logosol M7 require the log to be rolled or lifted onto the sawing platform. Also with carriage mills, due to the time taken to set them up, if intending to cut many logs, it may be more efficient to site them in a central location and bring the logs to the mill.

Moving logs
It is surprising how easy it is, with the correct tools, to roll and move quite large logs without injuring oneself. However, handling logs can be very dangerous. Always take your time, especially if you are working in a group, and make sure everybody knows what is being done and no-one is in the way. Never put yourself in a position where a log can break, drop or roll onto you or others. If control of the log is lost, there is a real danger of people becoming crushed, either their whole bodies or just their legs or feet. Steel toed boots will help prevent damage to the feet and strong shoes or boots might reduce harm in such cases. The bigger the log the more manpower you will need if mechanical assistance is not available.

There are many tools that make log handling easier. Hydraulic equipment is now common in forestry operations, but when dealing with just one or a few logs, it is normally down to manpower, though certain simple tools will help.

- Cant hooks are the most useful equipment and can be made out of very basic materials if you are unable to find or buy one, as a blacksmith can make a rough design with a wooden pole inserted for the lever handle. The hook must be sharp, and the longer the handle, the better the leverage. Larger logs are much easier to move with more that one person and more than one cant hook. Be careful of loose bark, as the hook can slip from the log, and a knot or a branch stub gives extra security.
- Always make sure that you have wooden wedges at hand to secure logs as required.
- Timber tongs and pulp or lifting hooks enable you to get a really good grip on the log.
- A winch, electric, hydraulic, or hand cranked, can save much time and effort.
- A small pry bar or crowbar and an axe will also prove useful.

Orientation
It is normally recommended to mill on flat, firm ground. This is important for carriage mills and other portable mills, and if the ground is not entirely flat, pieces of wood can be used to level the frame, and/or to have it positioned along a contour. However, for frame milling in particular, having the log on a slope can be advantageous, as milling a log down a gradient requires less effort to push through, using gravity to help. The rotation of a log is also important when deciding the cuts to be made, to optimise recovery and/or quality, and logs can be turned using cant hooks or similar tools. Consider any obvious defects in the log, or if the heart is not in the true centre of the log.

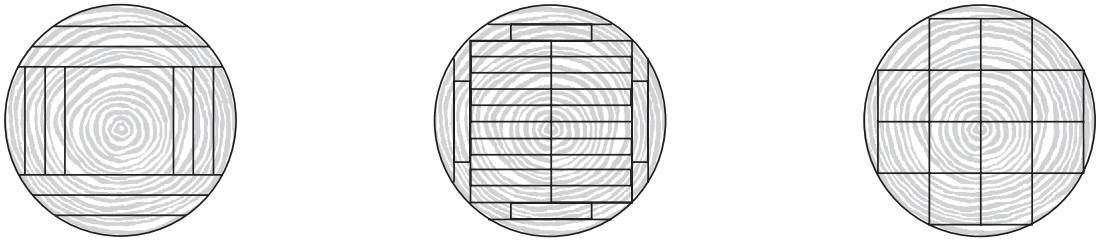
Deciding what to cut

Common dimensions
Marketable timber sizes vary around the world. The following are given in metric, though imperial measures are still commonly used (2.5 cm = 1 inch or 1") and are also given in brackets. The most commonly produced chainsaw sawn timbers are boards 2.5-5.0 cm thick, of various widths but normally 15-30 cm wide, and 2.5-4.5 m long (6x1" and 6x2" to 12x1" and 12x2").

Posts and beams are also produced, either various larger sizes for construction or for fence posts, e.g. 10 x 10 cm (4x4") and 1.8-2.0 m. Smaller sized timbers can also be easily produced, such as 10 x 5 cm, 5 x 5 cm and 5 x 2.5 cm (4x2", 2x2" and 2x1"), again, of varying lengths, though the smaller the sections, the greater the wastage due to the larger chainsaw kerf. It may be better to cut larger slabs for resawing with other saw types. Larger beams (slabs, cants) can also be produced, either for a specific use such as in construction, or for resawing with bandsaw or circular saws.

Market forces
If not using the timber produced yourself, then the market will decide the dimensions to be produced. This occurs preferably (for the sawmiller) as pre-ordered or commissioned

Fig. 13. Examples of different dimensions and maximising recovery from a log.



timbers, i.e. known to the sawmiller before milling begins. If not, then the sawmiller must make an educated guess as to what possible dimensions will fetch the best price and be easily sold. This must not be underestimated, as many small sawmillers have gone out of business by sawing and stocking large amounts of timber that they are then unable to sell at a reasonable price. It is wise to ask around and get a good idea of what people want in terms of quantity and quality, and what they will pay for it, before starting to mill.

Speciality cutting
It is useful to know what is possible with a chainsaw, and with the skill of the operator. An advantage of some chainsaw mills is their ability to produce very long pieces of timber not normally possible by other means. These might be desirable for specific uses such as in bridges or large buildings. Single curved pieces of wood are required for wooden boat parts, or for other special uses in house or furniture construction, and can be easily made, especially with frame mills. Some of the rail mills available also allow the cutting of notches, grooves and various timber joints that are needed in making timber frame housing and log cabins.

Preparing to cut

Cutting to length
Cross-cutting, sometimes also called 'bucking', will be needed for longer logs to obtain the desired lengths. A long tape measure and a machete or hand axe will be very useful. Always mark off a little more than the desired length, to allow for off-square or split ends. Then cut to length, taking care of tension and compression, and of log movement, especially on sloping ground.

Mounting a mill
With freehand milling, there is of course nothing to mount, and procedures for mounting other chainsaw milling attachments vary between types and makes. These are adequately detailed in the instructions that accompany each, and the following is only intended as an approximate guide to those who are unused to the use of such attachments. In all cases, the felling spikes (or 'dogs') on large chainsaws are not needed and can be removed. Change the bar if required, and replace the felling chain if a ripping chain is to be used. Replace and tension correctly.

Rail mills and frame mills are most often just simply clamped to the guide bar, taking only a matter of minutes. The type of clamp varies, but this commonly requires the tightening of two bolts to secure it to the bar. Take great care to keep in mind the depth of the bar rails, because if the attachment is clamped too close to the edge of the guide bar, this will pinch the rails and hinder chain movement. Larger frame mills have two sets of clamps for each end of the bar. Again, take care not to pinch the sprocket nose, leaving enough space from the end of the bar.

Several attachments require bar drilling, i.e. holes need to be drilled through the bar at special places, so a bolt can be passed through securing the attachment. This is the case with, for example, the Zimmer Gruminette or the Hud-son Boardmaster. While not difficult, due to the very hard steel from which bars are made, it is recommended to use a powerful drill and a very hard drill bit, preferably in a drill press to keep it perfectly vertical, and to drip water, oil or other coolant on the bit as the cut progresses to prevent overheating. Both with bar clamps or bar drilling, these will have to be removed each day to turn the bar and to remove and sharpen the chains, so the operator will very soon become well practiced in this.

In carriage mills, the chainsaw needs to be attached to the trolley that runs along the rails in the frame. Different systems exist, e.g. with the Jober J100 Jobber, the side cover nuts are removed, and a curved wedge-shaped plate is attached, fixing the side cover, while offering a means to easily slide the chainsaw into the trolley, and pointing downwards (being a vertically cutting carriage mill), is locked into place by gravity. In all cases the technology is relatively simple and does not require any permanent modifications to the chainsaw.

Debarking
Sand, stones and soil in the bark can quickly dull or damage a chain, and so some people go to the length of debarking the log to be milled. This is very likely in situations where chainsaw milling is most appropriate, such as on farms, in drylands, in towns, or anywhere sand and soil may have been blown continuously onto the tree. Street trees may also have nails, which if not too deep could be found during debarking.

This may need to be carried out all around the log if slabbing or, if producing edged timber, at least along the lines of the

first cuts until all side slabs have been removed. For freehand milling, debarking a strip along the log it is also used as a means to help mark the line of the first cut. This is time consuming, but a helper could be debarking one log as another is being milled. It is also highly dependent not only on the tree species but also the time of year, as the bark from some species is very easily removed only during a certain season. Debarking is most simply done by hand, with a machete, axe, adze (similar to a square-ended mattock) or other one- and two-handed tools. Many mechanical types of debarkers are available, but most will not be economical for such small operations. One deserves a mention, the chainsaw-powered Log Wizard (see Milling accessories). This comprises of a rotating head attached to the nose of the bar (bar drilling required), with two blades as in an electric hand planer, and is used as both debarker and planer.

Marking up

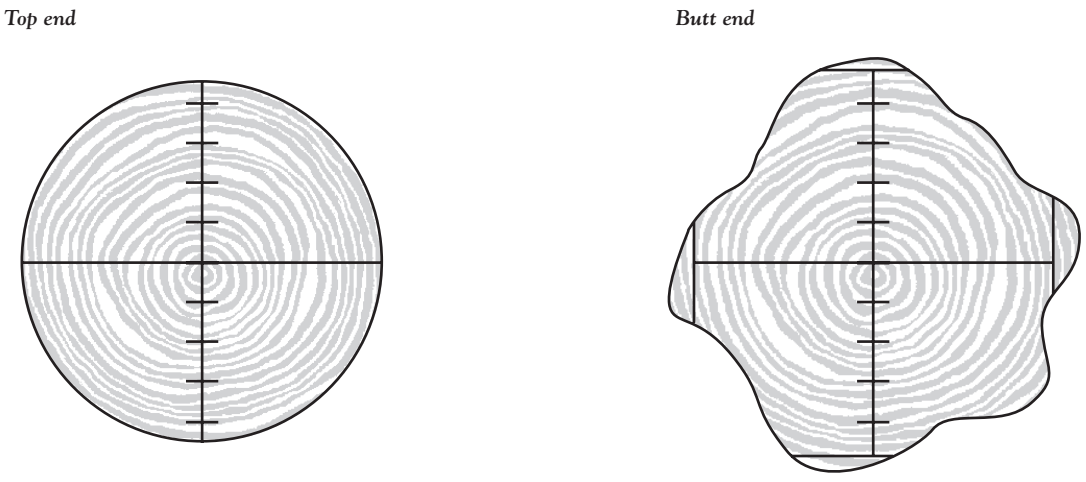
In freehand milling, a line is made along the length of the log to be followed by the operator. This is achieved by using a modified 'chalk line' used in building and carpentry. In most cases, the chalk is replaced with powdered carbon or graphite powder from old vehicle batteries. A length of string is mixed with the powder, fixed into position along the length of the log, and picked up in the middle and released like a bow string, which 'snaps' back and leaves a straight black line. Straight edged boards fixed with nails can also be used.

Smaller logs can easily be chainsaw milled without the need for any marking up, especially if simply being slab sawn, as can larger logs can be dealt with similarly by an experienced operator and when only large single-sized dimensions are to be sawn. However, it is still good practice to at least measure the diameter of the top and butt ends of the log, to get an idea of the number of pieces that could be milled. Some chainsaw millers always mark up logs to be cut, recommending that care taken at this stage increases the amount and quality of timber produced. For this, a spirit level, carpenters square, crayons and a tape measure are needed.

Index lines are drawn on the ends of the log. Start at the top, narrow end. First decide whether to use the actual centre of the log as measured from the outside, or the true growing centre of the tree where the growth rings begin. These two points may be some way apart, and if so, turn the long so that one lies directly above the other, whatever method of milling is being used. Using a spirit level, then draw a cross, vertically and horizontally through the chosen centre. These are useful in fixing the slabbing rails, especially on tapered logs (see below).

The operator can now better visualise what size timbers may be cut from the log, minimising waste by, for example, deciding that narrower boards could be cut from each side. Repeat the process on the butt end of the log. Here, it is very possible that the base of the trees has 'flared', or has buttresses or other such widening of the trunk, which will have to be removed before milling. Mark and cut off.

Fig. 14. Marking up the ends of a log.



3.3. Milling the log

Making the cuts

Cutting angles

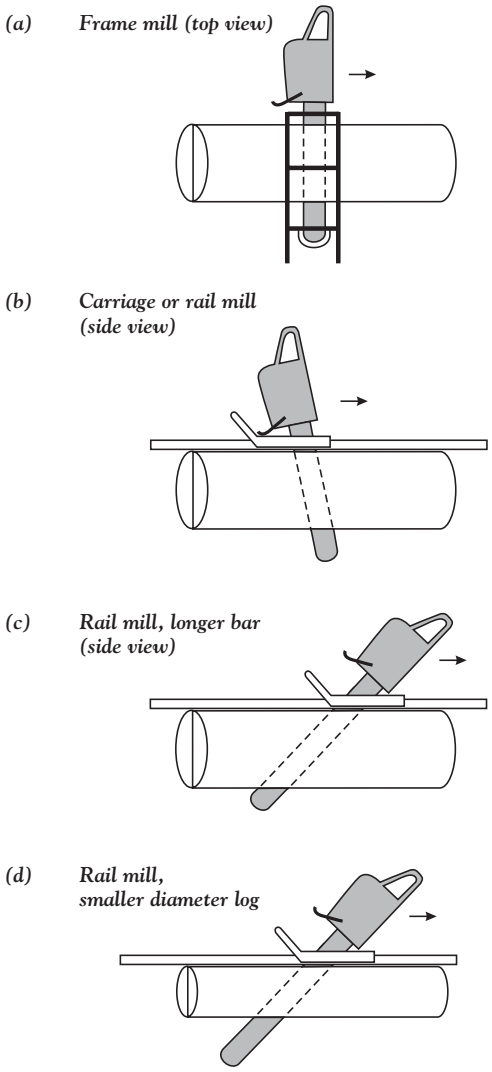
The underside of the bar (pulling chain) is used in all cases. With freehand milling and some rail milling, the operator starts at the far end of a log and moves backwards, pulling the chainsaw. But with frame milling, carriage milling and some rail milling, the operator starts at the near end pushing the chainsaw forwards, with the saw either horizontal with the engine on the left (in frame milling), or vertical with the engine upwards and facing backwards. The cutting angles, however, vary with mill type and/or log diameter.

Frame mills are mostly used to cut at right angles to the log (a), though can be moved to cut at a slight angle, especially at the start and end of cuts or with small diameter logs. Carriage mills are set either perpendicular to the log, or at an angle of 5-15 degrees, nose forward (b). Rail mills have one of two systems, either fixed or 'swinging'. If fixed, the bar is set at right angles or often at around 10 degrees (b), but the angle can be increased if the bar length greatly exceeds the log diameter (c and d), increasing the length of cut, speed of cut, and also eliminating the need to raise the log. Freehand chainsaw millers, in contrast, always hold the chainsaw at an angle of at least 45 degrees to increase speed if cut and ensure a straighter cut, and often cutting with the nose, which never occurs with milling attachments.

Rail mills such as the Beam Machine or Micro-Mill that allow the clamped guide bar to rotate around a bearing mean the operator can vary the angle during the cut, and use the 'swing' or 'lever' method, where the angle varies through the cut in a repeated cycle. Whereas for an experienced freehand chainsaw miller such a process may be less time efficient, for a casual or infrequent chainsaw miller it will help produce straight timbers that would not otherwise be possible.

Starting with the guide bar vertical (a), the engine and milling attachment are drawn backwards while trying to keep the nose of the guide bar in roughly the same place, until the guide bar is at an angle of anything up to 45 degrees,

Fig. 15. Cutting angles in chainsaw milling.



depending on bar length and log diameter (b). Then keeping the milling attachment unmoved on the rail, a rotating pressure is applied, pushing the engine and forcing the nose of guide bar back towards the operator until the guide bar returns to a vertical position (c). This process is then repeated all the way through the cut. Care needs to be taken that the attachment does not move forward (i.e. away from the operator) during the final part of this process. Teeth found on the underside of the Beam Machine for example are especially helpful here.

Fig. 16. The 'swing' or lever' method in rail milling.

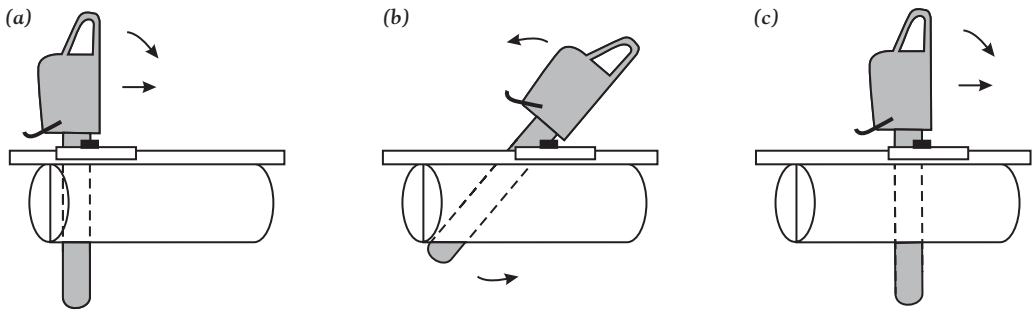
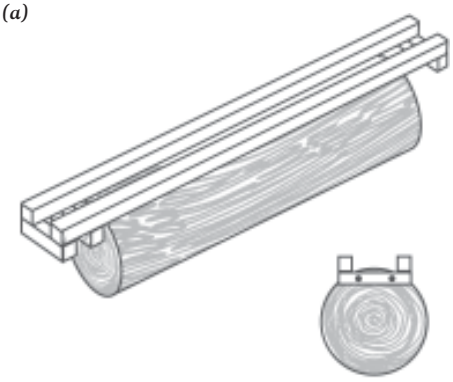
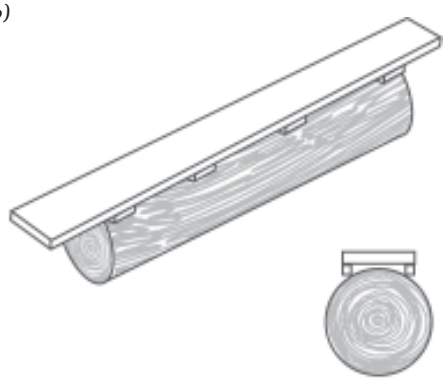


Fig. 17. Preparing for the first cut with a frame mill using slabbing rails or board.

(a)



(b)



The first cut

Large logs will have to be split or quartered (see below), otherwise, the first cut is always to remove a side slab.

- ❖ With freehand milling this can be done with the help of a piece of string or other straight edge, though with great care if the side is to be consistently straight.
- ❖ With rail mills, a straight board will be required, wedged and fixed to the log.
- ❖ Frame mills, however, require some form of 'slabbing rails' to make the first cut, and as such are an essential part of the mill, described below.
- ❖ Carriage mills offer the best method, whether over, under or around the log, the frame provides the guide and making the first cut is straightforward.

Removing excessively large side slabs is common and time efficient, but it is more wasteful unless usable timber can be subsequently made from them (see Making the best of the rest).With a frame mill, a straight and flat surface must be fixed to the top of the log before the first cut can be made. Slabbing rails, as previously described (see Frame mills), are available. These comprise of metal brackets to be bolted (and countersunk) to two straight lengths of wood, or a set of adjustable metal rails and brackets, a wide wooden board, a ladder, or any other means of securing a fixed and flat surface to the curved top of a saw log, but the method of fixing must not protrude above the top of the rails or penetrate deeper than the depth of the first cut.

Slabbing rails can also be simply made, requiring some nails, screws or bolts, two straight lengths of wood at least 5 x 2.5 cm in section (5 x 5 or 10 x 5 cm preferred), and two short pieces to fix to each end of the long lengths, leaving them parallel and 10-30 cm apart, with a general rule of thumb being that they should be separated by a distance at least one third of the log diameter. If longer than the log to be milled, which is ideal, this assembly is then placed on top of the log and fixed by means of a nail hammered horizontally through at least one of the short lengths and into the end of the log, leaving the nail head protruding for easy removal. This then provides a level surface for the first cut to be made (a). Alternatively, a wide board can be used, either supported by pieces of wood fixed to the log ends, or by pieces of wood fixed under both edges (b). Decide the depth of the first cut, set the frame mill accordingly, and proceed. A special system exists when logs are longer than the rails (see later).

Cutting slabs

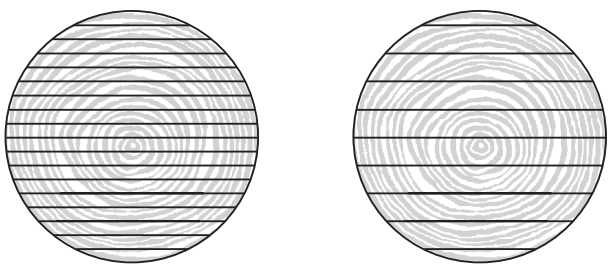
Whereas pitsawyers can cut vertical slabs through and through, freehand, rail milling and vertically cutting carriage mills almost always require the turning of the log after the first cut has been made. In such cases, continue with the cut face upwards, giving boards that are edged on one side, or to turn again for timber edged on both sides (see later). True 'through and through', live or slab milling, producing boards or slabs with bark on both edges can only be produced with frame mills and horizontally cutting carriage mills, and is the most simple of chainsaw milling techniques.

When cutting horizontally, once the first cut has been made (see above), there is a level surface on the log that will provide the guide, directly and indirectly, for the subsequent cuts. With simple slab sawing, waste can be reduced by removing only the smallest of flitches in the first instance. Re-set the frame mill cutting depth to the desired board thickness, or with carriage mills, simply set the carriage to the required distance, and then proceed.

It is very important to note that when cutting slabs horizontally, the weight of the cut board will tend to close up the cut and pinch the bar and chain. It also alters the 'level', and can cause boards of unequal thickness to be produced. To avoid this, it is good practice to have at hand

Fig. 18. Slab sawing (slabbing), live sawing or through-and-through sawing.

(a) *(b)*



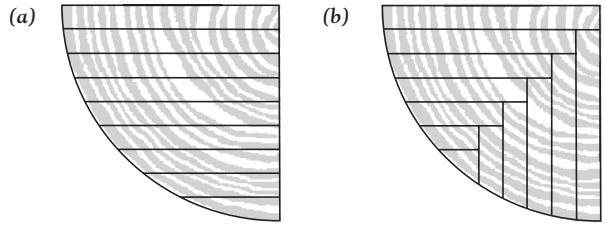
a number of thin wedges to be inserted on either side of the cut at least every couple of metres. It is much easier to have another person do this. With the wedges in place, backing the chainsaw and frame mill out then becomes complicated, so make extra sure than there is enough fuel to complete the cut.

There is no reason why different board thicknesses cannot be cut from the same log, as this only requires the simple and relatively quick operation of changing the depth setting. However, generally, and most efficiently, slabs of a single thickness are milled from a single saw log, either finished boards for direct use or sale (a), or thicker slabs or cants for resawing elsewhere (b).

Cutting quartered logs

Large diameter logs, wider than the guide bar is long, will require quartering before milling can begin, which can be done by freehand milling and/or with splitting wedges. The quarters can then be treated as 'normal' logs for cutting with any means of chainsaw milling after turning, supporting and wedging into position, such as slabbing with a frame mill (a). However, turning the quartered log after cutting each board allows for the production of generally higher value 'quartersawn' boards (b). These are more time consuming to cut using chainsaw mills. Some carriage mill users claim success in this, but use techniques which may only be justified with high value timbers and guaranteed specialist markets offering high prices.

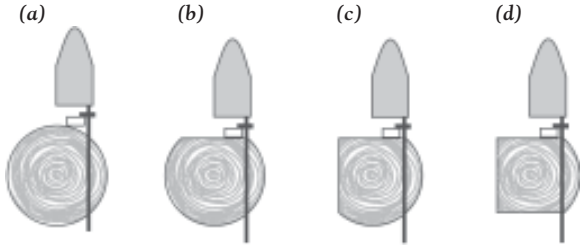
Fig. 19. Slab sawing and quartersawing from quartered logs



Beams and edged timber

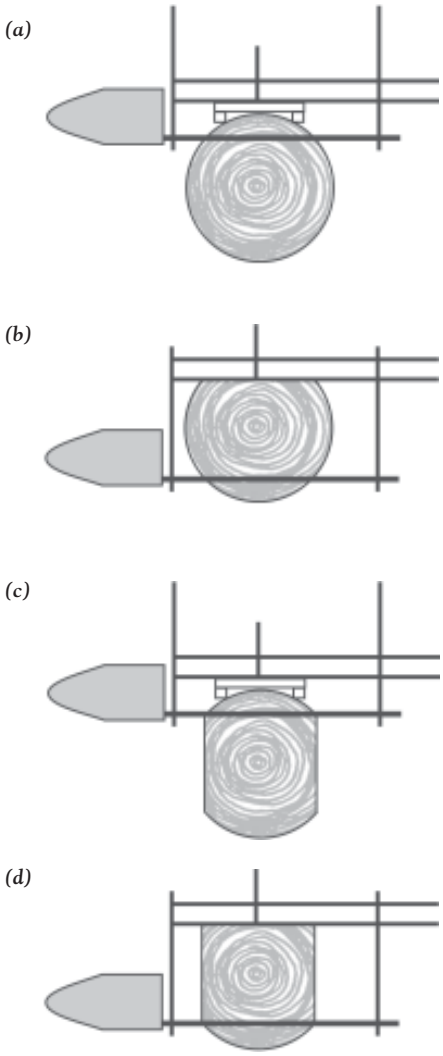
The normal means of producing square or rectangular beams are the same for freehand, rail and carriage milling. Make the first cut as normal (a), then turn the log 90 degrees. Turn the cut side down in carriage mills, immediately giving a right angle for the second cut. Turn the cut side up for freehand or rail mills, and wedge securely. Use a spirit level (or plumb line) and set square to mark the second vertical cut for freehand or rail milling. Proceed with the second cut (b), and turn again. The third (c) and fourth cuts follow in the same fashion leading to a squared beam (d).

Fig. 20. Cutting a square beam with a rail (or carriage) mill.



With frame mills the process is slightly different. A first cut is made as normal (a), but do not turn the log for the second cut. Open the depth setting right out to remove a flitch from the base of the trunk (b), when wedges are essential to prevent pinching of the bar and chain. Then turn the two-sided log around 90 degrees and secure well using wedges and/or by nailing a length of wood from the log end to another solid object. Use the slabbing rails again for the third cut (c), removing as little as possible to reduce waste. Then repeat the second step to produce a squared beam (d).

Fig. 21. Cutting edged timber using a frame mill.



To produce edged boards, beams can be cut into any thickness as required using rail or frame mills, or resawn with a bandsaw or circular saw. Using a frame mill, this can also be carried out immediately after the third side slab has been removed (c) by re-setting the cutting depth of the frame for the desired board thickness.

Slab sawn timber can also, of course, be edged later, which can be done with a rail mill. This can be carried out on individual boards or slabs, with the potential advantage of maximising the amount of edged timber from each slab and so increasing total recovery. However, this is likely to lead to boards of different widths, though can improve board grade or quality and so price. Several boards can also be clamped together to reduce the number of cuts required, and can also be used to cut many pieces of timber all the same size.

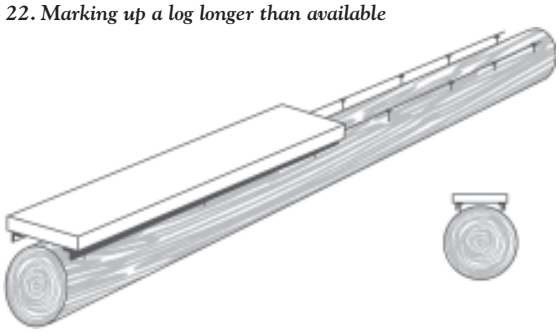
Extra long lengths

These can be cut using the same procedures as previously described, with some exceptions or considerations when using different mill types. With freehand milling, experienced operators are able to produce boards of relatively even thickness up to 5 m long, but the chance of cutting perfectly straight boards will decrease with longer lengths.

Carriage mills can cut logs of only a certain length, depending on the length of the frame, commonly 2-3 m for basic models, though some have options of adding further lengths of railing to extend the frame and so the size of log that can be cut, but rarely in excess of 5-6 m.

Rail milling is also limited by the length of the rail, but this can be repositioned several times along the length of a log following a straight line, or extra pieces of rail can be added, both of which can increase the possible cutting length indefinitely.

Fig. 22. Marking up a log longer than available



Frame mills appear not to have any of these limitations, but they have the same problem as rail mills with the first cut, due to the length of the available slabbing rails or boards. However, there exists a simple system using nails and string whereby a continuous level can be marked along the length of a log of any size, following which a slabbing board can be moved to create a first complete and flat cut. If regularly cutting long logs, it will save time to make a slabbing board with angle iron screwed onto the bottom that can then 'ride' on the levelling nails.

Tapered logs

Tapered logs are those when the diameter at the top is much smaller that the diameter at the bottom. This varies with site, species and tree, but is a common difference between

Fig. 23. Increasing recovery and quality from tapered logs.

species, with some producing quite cylinder-shaped trunks whereas others have more cone-shaped (tapered) trunks. Most logs are at least slightly tapered, and whether to use the corrective techniques proposed depends on the amount of taper and timber quality and recovery required.

Ignoring a large taper leads to poorer recovery and poorer quality timber. The aim is to take half of the taper off each side, maximising the amount of usable wood produced. With carriage mills, this requires the raising of the top end of the log so the true centre of the log is horizontal, or with frame mills, to raise one end of the slabbing rails. With freehand or rail milling, the same principles can be applied when making the first cuts.

Small diameter logs

Depending on 'how small is small', small diameter logs are generally difficult to cut using freehand or rail milling, yielding very little usable timber. Some carriage mills, such as the Jober J100 Jobber and the Logosol M7, are very suitable for milling timber, such as softwood, with a high productivity rate. Frame mills are also quite appropriate. Both can relatively quickly process small round woods into single beams, or narrow slabs or edged timbers, depending on the demand.

Small diameter timber though, is also more likely to contain in-built tensions due to high growth rates. In such cases, it is recommended that they are cut into beams or posts by 'boxing the heart', i.e. removing the four side slabs, and not by slabbing. This will retain most of the tension in the beam or post, and is much easier to produce using a carriage mill than with a frame mill. Frame milling is much more suitable for producing slabs.

Speciality cutting

Chainsaws can also be used to make precision or unique cuts in timber in addition to squared edges. With most rail mills, the guide bar can be fixed at any depth, and so narrow grooves can be cut which can aid in the cutting of larger channels or troughs. There are also specially designed attachments for this purpose (see Debarking) to cut channels such as in making single log canoes, troughs, log cabins and timber framed housing.

Oversized logs

These can be a challenge to chainsaw millers. The maximum size is limited by the size of the frame cage in carriage mills, and although there is some variation between different carriage mills, none can mill logs over 100 cm in diameter, and some are unable to cut logs above 50 cm diameter. With carriage mills therefore, the only possibility of cutting an oversized log is to reduce it by quartering it for further milling by freehand chainsaw or splitting wedges (see Cutting quartered logs).

In freehand milling, rail milling and frame milling, the limiting factor is the length of the guide bar. Bigger bars are possible, but there is a maximum recommended bar length for each chainsaw model, related to engine size and thus power, and the ability of the oiler to keep such long chains adequately lubricated. In freehand and rail milling, the maximum bar length that is routinely used is 120 cm.

Of all chainsaw mills, frame mills are able to cut the largest logs, made in different sizes to accommodate longer guide bars for larger logs, with some able to take bars in excess of 200 cm long, i.e. able to cut the largest of logs likely to be found. They are also able to take a number of modifications to cut oversized logs, including extra oilers for attaching to the far end of the frame, and helper handles to attach to the nose of the bar allowing a second person to push the mill (see Milling accessories). Also, for the biggest of logs, double-ended bars are manufactured for fixing a second chainsaw motor thus doubling the power and oiling ability of the unit, and these are very suitable for very large diameter logs.

Making the best of the rest

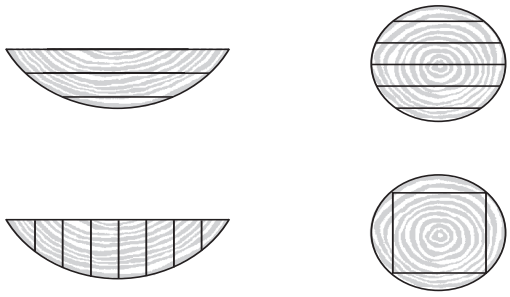
Side slabs

Side slabs are often treated as waste, whether in the forest or at the sawmill. However, with one flat face, frame milling can often easily produce at least one additional board from such otherwise unusable timber. With the slab flat face upwards, insert wedges underneath to make secure, set the cutting depth, and proceed to cut a further slab, or possibly more depending on the thickness. A rail mill could be used to edge the slab if required.

Very small diameter logs

Milling small diameter logs has been covered earlier, but there will always be logs deemed too small to mill, practically, or based on economic criteria such as on time taken, output, markets, etc. Logs as small as 10 cm diameter can be made into square 5 x 5 cm timber or narrow boards using carriage or frame mills, though whether this is viable is another matter.

Fig. 24. Possible cuts from otherwise unusable timber such as side slabs and very small logs.

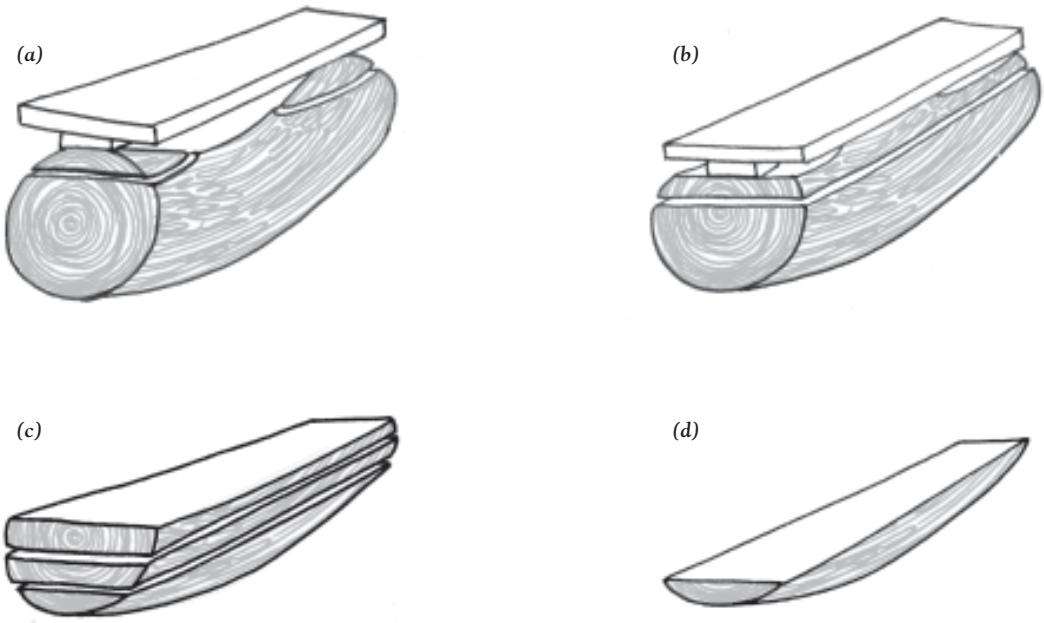


Short or crooked logs

Whereas there is in principle no minimum log length when milling by chainsaw, technically or practically, the minimum length will of course be set by what is marketable. However, with the possibility of making small and standard sized 'blanks' for flooring, furniture parts or craft items, then lengths as short as 25 cm can still be milled. When milling very short logs it is likely that frame milling will be most suitable, though rail or carriage milling may be appropriate if the log can be securely fixed. Even with frame milling, the log will need to be adequately wedged to avoid rolling during cutting, and if also of a small diameter, may need to be fixed by nails and wood or stakes.

Many species, especially in drylands, are rarely erect and others, such as street trees or those found around farms or farmsteads, often have poor form. These are commonly left

Fig. 25. Milling a crooked log.



well alone by conventional sawmillers, being considered only as firewood. Recovery will be much lower than from straight logs, but nonetheless, usable timber can be produced. Recovery will be greatly increased if there is a need or a market for shorter timber lengths (such as for craft wood, flooring or furniture parts) and such crooked logs can then be cut into shorter lengths, made straighter by reducing the curvature of each and allowing processing by other means (see above).

However, crooked logs can be easily sawn by frame or carriage mills. The first cut must be made on the concave, or cupped, side of the log. Position the log accordingly, either within the frame of a carriage mill, or on bearers or the ground for frame milling (a). Make the first cut, which might only remove short sections from either end of the crooked log (b). With frame mills, the slabbing rails may have to be also used for the second or subsequent cuts until a flat surface has been produced along the entire length of the log (c). Slabbing can then proceed as previously described (d).

Crooks, forks or sections of trunks where they branch can also produce valuable products if milled to retain natural bends in the wood ('knees'), such for as keels and other parts for wooden boats, roofing timbers, or speciality timbers for furniture and craft items. This can only practically be achieved by using a frame mill. Lay the log on its side with the curve either left or right. It may not be easy to position and fix normal slabbing rails onto a very curved log, in which case use long nails and string as when marking up extra long logs, and use a slabbing board, moving it as the cut proceeds. Then proceed with subsequent cuts as with a straight log.

Time and effort constraints

In each of the cases above, more time will be required per cubic metre of sawn timber produced than if milling logs within the range of optimum log sizes, and so the decision to cut will also depend on labour availability, etc. However, with this decreased efficiency, the fact that such logs are otherwise 'waste' and as such free should be taken into account. Also, once an operator has cut several such logs, the experience will mean less time is needed for similar logs in the future.

Improving output and quality

Per person - operator skill and knowledge

Freehand milling by an experienced operator, can produce high quality boards. However, farmers and 'part time' chainsaw millers are very unlikely to develop the skills required for freehand milling without many years' hands-on practice, and so some form of attachment will help in producing straight timber.

The skill of the operator is implicated in all aspects of improving output and efficiency, and a knowledgeable, conscientious, well-trained and motivated person will always achieve more. Some factors are hard to change, but improving working skills through training is possible, and likely to lead to immediate and measurable impacts. For example, this manual alone contains information that would assist in improving chainsaw safety, use and maintenance, increasing production and decreasing down-time, also selecting better logs, making more efficient cuts, possibly adding value to the timber and improving marketing.

Without special training, it is down to experience, built up gradually over time, enhanced also through talking to others working in the same field, sharing experiences and learning from each other.

Per team - milling system

Several saws will increase output, as will several people. However, working out the increased productivity in terms of income, related to the increased costs of machinery, maintenance, fuel and labour, is a complicated one and will vary widely from situation to situation. Having an additional smaller chainsaw is useful for clearing and even felling and cross-cutting operations, while leaving a big chainsaw attached to a frame, rail or carriage all day for milling. At least one other person is almost essential for moving logs and cut timbers, but also very useful in helping with felling, clearing, extraction, etc.

Several mills will also, obviously, increase total daily output if working side by side. It can be useful to have a small frame mill as well as a larger one if logs of very different sizes are to be milled. Several chainsaws will then also increase daily production by reducing time taken to change attachments in combination systems, such as using both a frame mill and a rail mill, allowing for more rapid production of edged timbers than using either type alone. Several manufacturers sell both, such as Granberg and Westford, but there are many other rail mills on the market, some with specific features that may be preferable.

Per chainsaw mill – choice and maintenance

The more powerful the chainsaw the higher the output, and double-ended bars with two power heads obviously increase production markedly. Keeping the chainsaw well maintained will also improve production in the long term by increasing its working life, and in the short and medium term by decreasing down-time. A well looked after chainsaw using the proper fuel and oils is much less likely to break down. Carrying the recommended tools and spares will also reduce down-time considerably. A sharp and well tensioned chain and a guide bar in good condition are especially important.

Choice of chainsaw, chain and mill type depends on a wide range of factors discussed earlier. If unaccustomed to the milling systems and equipment, it is possible that an inappropriate choice has been made and should be reconsidered. One choice may be to upgrade to a bandsaw mill, either by adding to an existing chainsaw mill or purchasing a new bandsaw or circular saw that is more suitable to the quantity, quality, size, species and location of sawlogs available.

Per tree - recovery

A common criticism of chainsaw milling is the wide kerf and thus reduced recovery per log as compared to band saws or circular saws. However, chainsaw mills do have the possibility of being able to mill logs unsuitable for conventional milling, and as such could process more of the tree than other sawmill types. It is suggested that calculations comparing systems should also include recovery data on a whole tree basis. In such cases, using more of the tree will increase the output, such as tops and branches, by milling short logs, small diameter logs, hollow logs or crooked logs. However, extra time is likely to be needed per cubic metre of timber produced from such logs, and special markets will be required for such pieces.

When cutting slabs, recovery can be very high if they are sold including edges with bark, so losing only the top and bottom side slabs and the kerf between each. However, when milling to smaller square edged dimensions, losses might be significant. Good marking up (see earlier) will help the operator decide what boards can be cut, and to make the most of the log diameter, increasing recovery. This is made much easier if there is a wide range of sizes that can be marketed, especially of small dimensions that can be 'squeezed in'. Reduced-kerf chains also exist, leaving a cut of 7 mm as compared to the normal kerf of 9 mm, increasing recovery (see Ripping chains), and would, for example, if cutting a dozen 2.5 cm boards from a single log, produce an additional board for 'free'.

Calculating recovery

In order to improve recovery it is necessary to be able calculate it. Recovery on a per log basis is the normal calculation, for which the log volume is needed. This is either stated as over bark or under bark. Under bark is a more useful measure and easy to see on logs, over bark is more often used with standing trees. If the log section is not round take the average diameter from the widest and narrowest points. Also, logs are rarely exactly cylinder-shaped, so it is more accurate to measure under bark diameter at both ends and take the average, before using the equation below. Use metric measures and fractions of a metre rather than centimetres (i.e. for 30 cm, use 0.3 metre) to calculate volume directly in cubic metres. Recovery is the percentage of the log that is turned into usable, marketable timber. Measure the volume of each piece of wood cut by multiplying the length, width and thickness, in fractions of a metre, to give a volume in cubic metres, adding them up to give the total volume of timber produced.

Log volume = (average diameter ÷ 4)
x (average diameter ÷ 4) x 3.142 x log length

Recovery percentage =
(volume of sawn timber ÷ log volume) x 100

4 From chainsaw to consumer

4.1 From stump to sale or stack

Extraction and transport

One of the great advantages of highly mobile chainsaw mills is the reduction of costs and equipment required by milling where the tree is felled, so avoiding log extraction. This also greatly reduces the potential environmental damage caused by the heavy equipment needed to extract logs. Indeed, chainsaw milling is used in some parts of the world partly as a result of the lack of road infrastructure, and the trees could simply not be milled by any other means, other than pitsaws. In these situations the sawn slabs or milled timber is commonly walked out either by hired labour or draft animals, to the nearest track or watercourse. Transportation of sawn timber to the market can often form a large percentage of the overall end cost, advantaging sellers close to markets. Timber may not necessarily be immediately sold, however, as it can also increase in value over time as it dries, or be further processed at the milling site or a nearby workshop into more valuable products.

Stacking

When storing or drying timber, a stable stack should be made. If boards are just piled on top of each other with no spacing they will not dry, leading to warping and fungal attack which reduces timber value. The correct stacking of timber allows timber to dry at the fastest rate whilst preventing distortion and degrading, by ensuring sufficient but not excessive air flows between the boards. The rate of airflow is controlled by the space between the boards, which are prevented from deforming or bending by the weight within and on top of the stack.

Boards of the same thickness should be made into a neat stack using bearers and stickers. Bearers are large pieces of wood with at least the top surface being flat, placed on the ground, on which the first board is laid. There should be over 20 cm clearance from the ground to allow moist air from the drying stack to circulate well. All bearers must be level with one another so that the boards are perfectly flat and straight. For species prone to twist, warp or distort, bearers and stickers placed above them should be 35-45 cm apart. Species not prone to such potential defects can have bearers and stickers up to 85 cm apart. Stack height varies, the wider it is the higher it can be, but too wide (i.e. over 1.5 m) and middle boards will not dry well.

Stickers are lengths of sawn wood all the same thickness (preferably planed), commonly 2-3 cm thick by 3-4 cm wide, flat and straight, and of lengths equal to or greater than the stack width. They should be made from stable dry wood. Care must be taken in choosing and cutting stickers as some types of wood stain the timber. The stickers must be placed between each and every board, each being exactly above the one below, and directly above the stack bearers. Stickers should always support the ends of the boards. Where boards of unequal length are to be stacked and stickered, start with the longest boards at the bottom and work upward, or place boards end to end, and subsequent stickers are placed where these short boards end.

Boards without the support of stickers will naturally deform, therefore the more likely the timber species is to deform, the closer the stickers should be. The thinner the sticker, the slower rate of drying. Thin stickers (e.g. 12 mm) are necessary for thick boards or species prone to checking (cracks and splits in the face of the board), casehardening (exterior of the board is normal but the inside has checks) or with low humidity and high temperatures. Protection from hot dry winds is recommended.

Thicker stickers (e.g. 4 cm) lead to quicker drying times and so can be used for timber species that dry well without deformation or faults such as a number of softwood species or where humidity is high (above 80%). Stacks should be protected from excessive direct sunlight which leads to top layers drying too quickly, and from rain which leads to slower drying. Best results are achieved by using evenly distributed weights on top of the stack or tight strapping of the whole stack. For large logs cut through and through (or live sawn), an alternative stacking method is sometimes used, called stacking in the 'boule'. This means that the boards are stacked and stickered in the order they were cut, so the stack looks like the log from which it was cut.

4.2 Adding value to timber

Drying

There are number of defects that can occur during drying, some of which are avoidable, by correct stacking for example. Good timber drying is a skill but no secret, and one of the most overlooked aspects of timber conversion. Poor drying can turn a valuable stack of timber into a worthless pile of warped or crooked boards if done incorrectly. Whole books are written on this subject (see Further reading), and it is not in the scope of this manual to cover such topics, but it is hoped that its importance will be suitably acknowledged. Air drying is the simplest, cheapest but longest method, by just leaving stacked timber for up to a year, depending on board thickness and weather conditions, but this will often only reduce the moisture content of the timber to 20%, where for indoor carpentry, lower moisture contents down

Kilning

Kilns speed up the drying process and produce timber with consistent moisture content often below 10%, but this requires energy, and they cost money to buy and operate. The market conditions for timber will determine the moisture content sellers should aim for. In many cases and for stable species, building timbers often need little or no drying, whereas timber for furniture or low humidity environments (e.g. flooring in an air conditioned or centrally heated houses) needs to be kiln dried to as low as 8% for some markets. Solar kilns have been developed and are very suitable for tropical countries as the only energy required other than the sun is a little electricity to operate a thermostatically controlled fan. Made of plastic sheeting on a simple metal frame they are also relatively cheap to purchase or make.

to 12% are generally preferred. Some species of timber that are very prone to deformation or internal growth stresses, especially some fast grown eucalyptus species, need very carefully drying and steam re-conditioning to release internal board stresses, and so steam kilns or reconditioning rooms are needed to achieve good results.

Defects in dried timber occur, other than internal growth or other stresses, because the moisture in the middle of the board cannot escape quickly enough though the outer layers of the board. Generally, moisture escapes most easily from the ends of boards following the grain, and least easily across annual growth rings. This excessive moisture loss from the ends of boards that can lead to cracking can be reduced by coating them with wax or other non-staining moisture barriers. The basis of efficient, low defect drying of timber is to match the ability of the board to release its internal moisture to the rate of moisture loss from the surface. As boards are variable, a conservative approach is needed to keep defect losses to a minimum. Once defects occur, it is often impracticable or impossible to reverse.

Further processing

There is a range of specialised equipment available for secondary processing of sawn timber, such as table saws, edgers, moulders, finger jointers, etc. The cost of these machines tends to increase as productivity increases. Choice concerning their purchase could follow similar lines as for sawmill selection, with, for example, chainsaw milling attachments available at low cost that can edge and plane timber, and many simple hand tools are also available that can fulfil these functions at a low capital cost, but with a correspondingly low processing rate, the optimum being affected by estimated throughput. In such cases, profits may be maximised if the sawmiller can provide exactly the required size and finish of timber for the end-user without excessive capital outlay or labour costs, and supply at a price acceptable to the user. Such value adding may, however, be opposed by timber traders who may see this as a threat to their buying and selling. Thus if chainsaw millers or tree owners are to be involved in further processing they may also need to market their own produce and carry out some 'market research' (or just 'asking around') to work out how to obtain better prices and from whom. National forestry services may be able to provide up to date information on general market prices for common sizes of timber of different species, to help decide what species to cut into what sizes and for selling where, if there is a choice.

Marketing

The most critical aspect of profitably producing sawn timber is marketing and sales. Small sawmillers all over the world tend to forget this aspect, concentrating on what they feel more comfortable with, sawmilling. Entrepreneurs or merchants, again throughout the world, fill this gap between the market need and sawmillers' product. Further reading is recommended including general sources on marketing theory. Some general concepts should be considered:

1. The closer the timber product meets end users needs the better the profitability. This may mean adding value.
2. Commodity products, e.g. standard size building timbers are more prone to competition on price from imports and large sawmilling companies or substitution with competing materials (concrete, stone, steel, bamboo, etc.). In contrast, niche markets can command price premiums, e.g. curved sections of timber for furniture or boat building (crooks and knees) cut from bent trees, as there maybe no other suppliers or alternate materials.
3. Information about markets and customer needs reduces the risk of unsold or unmarketable timber and increases the potential for better prices and returns.
4. Fewer merchants or traders between the producer and end user improves returns as fewer people need to make a profit, but may be impractical for small producers.
5. Better communications or infrastructure between producers and distant buyers means the less 'local' (often lower) prices will be. Conversely, poor communications in markets with limited supplies of sawn timber can lead to locally higher prices.
6. Quality sells, or rather, sells better. This can be as simple as ensuring boards are of even thickness or by matching customer performance requirements, e.g. for strength or termite resistance, to species that match those characteristics.

The market for sawn timber is very variable, with boards of 2.5-5.0 cm thickness being most commonly sold. Straight edged boards will probably fetch a higher price than 'through and through' boards, i.e. those with bark on one or both edges. However, cutting boards for specific end products will fetch the highest prices. For example, talking to a local furniture maker may lead to a deal for timber of certain dimensions, which can be cut by chainsaw where the tree

has fallen, giving the best price per cubic metre available.

Studies have indicated that 90% of timber used by furniture and flooring makers is less than 10 cm wide and less that 1.5 m long, therefore avoiding the problem of what to do with non-standard sizes especially short lengths. Preparing timber 'blanks' for a pre-determined market is one way to maximise the profits and minimise waste from 'farm-sawn' timber. In such cases, profits may be maximised if the sawmiller can provide exactly the required size and finish of timber for the end-user without excessive capital outlay or labour costs, and supply at a price acceptable to the user. An example for the first point could be that there is a strong demand and a high price paid for a door of a local design. To satisfy this market need, the timber seller could do one or all of the following; dry their timber and sell to the door maker, cut the timber to the size of door timbers and sell to door maker, mould their timber to door design requirements and sell to the door maker, or make and sell the doors himself.

For sawmillers with limited cash reserves or where costs need to be kept to a minimum, including the amount of timber stocked or drying, the options for increasing profitability are limited as they need to sell quickly without incurring additional costs. In these situations, supplying local markets by 'farm gate sales', cutting green timber to customers orders and selling to merchants are usually the only options. Nevertheless, the other 'rules of thumb' are still opportunities to be considered.

Certification

Traceability is an increasing concern especially for timber exported to developed countries, where consumers and governments are beginning to demand information on exactly where wood comes from and how and by whom it was processed. Certification is a means of guaranteeing this, and is also a relatively recent way to sometimes achieve a better price by gaining access to specialist markets. The objective is to ensure that the wood sold has been legally obtained, comes from sustainably managed sources and has passed through a transparent and reliable 'chain of supply'. In Europe, North America and elsewhere, consumers are willing to pay a higher price for goods that they know have come from sources that are sustainably managed. To be 'certified' involves contacting one of the many available 'certifying bodies' that can be reached directly or via a local or national organisation such as the forestry department, chamber of commerce, etc. The constraint is that there is a cost paid for certification often on a per hectare basis, so the more land to be certified, the cheaper per hectare it becomes, and it is likely that forming a 'producers association' could be the only economical way for small producers and processors to achieve certification. It also usually needs professionals to organise and operate the certification system, and essentially, the advice often given is 'don't do it unless your profitable market or potential market requires it'.

5 Additional Information

5.1. Further reading

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LANTRA. 2003. Felling Small Trees Workbook. Technical Awards. LANTRA Awards, Stoneleigh, Coventry, UK. 32pp.

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Oregon. 2004. Saw chain, guide bar and drive sprocket maintenance and safety manual. Oregon, Portland, USA. 98pp. (pocket-sized booklet, free via www.oregonchain.com).

Stewart M, Hanson I. 1998. On site processing for farm forestry. RIRDC Publication No. 98/79. RIRDC, Australia.184pp. http://www.rirdc.gov.au/pub/shortreps/sr38.htm.

Stihl. 2004. Chain Saw Safety Manual. Stihl, UK. 29pp. http://www.stihl.co.uk/pdf/chainsaw.pdf.

Selected additional websites

Make your own chainsaw mill
www.backwoodshome.com/articles/tresl39.html
www.eddiem.com/projects/csmill/mill.htm
www.stewardwood.org/resources/DIYchainsawmill.htm

Ripping chains
www.chainsawsforsawmills.com/sawchains.htm

Discussion forum
www.woodweb.com/KnowledgeBase/KBPPSawmilling.html

Timber drying
www.laymar-crafts.co.uk/linkr.htm
www.ca.uky.edu/agc/pubs/for/for55/for55.htm
www.mtc.com.my/publication/library/drying/contents.html
http://sres.anu.edu.au/associated/fpt/drying/solar.html
www.cays.com.au/aes/html/bsk.htm

5.2. Chainsaw mill manufacturers

Accutech Innovations

Products: Micro-Mill, Miter Mill
Address: 2189 Woodglen Crescent
Burlington
Ontario L7L 6G9
Canada
Tel/fax: +1 905 315 9363 / 315 8238
Email: admin@accutechinnovations.com
Website: www.accutechinnovations.com

Big Foot Tools

Products: Headcutter
Address: 3725 West Russell Road
Las Vegas
Nevada 89118
USA
Tel/fax: +1 702 565-9954 / 579 9046
Email: sales@bigfootsaws.com
Website: www.bigfoottools.com

EcoSaw

Products: Chainsaw mill
Address: Manor Farm
141 Martells Road
Brierfield, NSW 2454
Australia
Tel/fax: +61 2 6655 2720
Email: sales@ecosaw.com
Website: www.ecosaw.com

Granberg International

Products: Alaskan Mark III,
Small Log Milling Attachment,
Alaskan Mark III C2,
Mini Mill II
slabbing rails, ripping chains, bars,
various accessories
Address: PO Box 2347
Vallejo
California 94592-0347
USA
Tel/fax: +1 707 562 2099 / 562 2094
Email: granberg@aol.com
Website: www.granberg.com

Haddon Tools

Products: Lumbermaker
Address: 21967 West Vernon Ridge Drive
Mundelein
Illinois 60060
USA
Tel/fax: +1 847 566 5030 / 566 5034
Email: info@haddontools.com
Website: www.haddontools.com

Hud-Son Forest Equipment Inc.

Products: Chainsaw Mill, Boardmaster
Address: PO Box 345
8187 State Route 12
Barneveld
New York 13304
USA
Tel/fax: +1 800 765 7297 / 315 896 2627
Email: info@hud-son.com
Website: www.hud-son.com

Jober BLC International Ltée.

Products: J100 Jobber
Address: 15 Boulevard JF Kennedy
Suite 7 St-Jérôme
Québec J7Y 4B4
Canada
Tel/fax: +1 450 431 2727 / 431 2727
Email: jober@jober.qc.ca
Website: www.jober.qc.ca

Laser Sales Inc.

Products: Ripping chains, bars
Address: 1717 Oxford St. E
London
Ontario N5V 2Z5
Canada
Tel/fax: +1 519 452 0501
Email: sales@lasersales.org
Website: www.lasersales.org

Lennartsfors AB

Products: SM2186 Chain Saw Mill
Address: Lennartsfors 1
SE-672 92 Årjäng
Sweden
Tel/fax: +46 573 39200 / 30035
Email: info@lennartsfors.com
Website: www.lennartsfors.com

Logosol AB

Products: TimberJig, Big Mill Pro LSG, Stihl LSG 450, Stihl LSG 600, M5 Sawmill, M7 Sawmill, Log House Moulder, Stihl ripping chains, picco bars, various accessories
Address: Industrigatan 13, SE-871 53 Härnösand, Sweden
Tel/fax: +46 611 18285 / 18289
Email: info@logosol.se
Website: www.logosol.com

Log Wizard

Products: Log Wizard debarker, Log Master
Address: Box 3299, Spruce Grove, Alberta T7X 3A5, Canada
Tel/fax: +1 780 960 2727 / 960 2767
Email: info@logwizard.com
Website: www.logwizard.com

Oregon Cutting Systems Group, Blount Inc.

Products: Ripping chains, bars
Address: 4909 SE International Way, PO Box 22127, Portland, Oregon 97269-2127, USA
Tel/fax: +1 503 653 4706
Email: technicalservices3 @oregonchain.com
Website: www.oregonchain.com

Procut Portable Sawmills

Products: Make your own saw mill plans
Address: 9975 Old Summit Lake Road, Prince George, British Columbia V2K 5T1, Canada
Tel/fax: +1 250 962 0866
Email: sawmill@telus.net
Website: www.procutsawmills.com

Quadra Tools

Products: The Beam Machine
Address: Box 16, Quathiaski Cove, British Columbia V0P 1N0, Canada
Tel/fax: +1 250 384 9210
Email: tedmat@shaw.ca
Website: www.beammachine.com

Schroeder Log Home Supply Inc.

Products: EDM Tracer II
Address: PO Box 864, Grand Rapids, Minnesota 55744, USA
Tel/fax: +1 800 359 6614 / 755 3249
Email: info@loghelp.com
Website: www.loghelp.com

Southeastern Industrial Resources Inc.

Products: The Ripsaw (chainsaw bandsaw)
Address: PO Box 266, Grant, Alabama 35747, USA
Tel/fax: +1 256 728 3070 / 728 3071
Email: sir@scottsboro.org
Website: www.ripsaw.com

Westford Enterprises

Products: Slabbing Mill, Rail Mill, winch, weatherboard guide
Address: 5 Forge Street, Welshpool 6106, Western Australia, Australia
Tel/fax: +61 8 9350 5555
Email: jemal@vianet.net.au
Website: www.eftelcorporate.com.au/~jemal

Woodbug Small Log Sawmill Ltd.

Products: Woodbug, Baby Bug
Address: Box 138-1435 West Road, Heriot Bay, British Columbia V0P 1H0, Canada
Tel/fax: +1 250 923 7773 / 923 4413
Email: susy@woodbug.com
Website: www.woodbug.com

Zimmer SA

Products: La Gruminette
Address: Domain de la Bruyère, 57690 Zimming, France
Tel/fax: +33 3 87 90 30 22 / 87 90 36 06
Email: zimmer@zimmersa.com
Website: www.zimmersa.com

5.2. Chainsaw mill manufacturers (continued)

	Model	*Manufacturer*	*Cost (US$)*	*Website*
Rail mills				
1.	Beam Machine	Quadra Tools, Canada	40	www.beammachine.com
2.	Boardmaster	Hud-son, USA	40	www.hud-son.com
3.	Mini Mill II	Granberg, USA	80	www.granberg.com
4.	Lumbermaker	Haddon Tools, USA	90	www.haddontools.com
5.	TimberJig	Logosol, Sweden	170	www.logosol.com
6.	Micro-Mill	Accutech, Canada	200	www.accutechinnovations.com
7.	Headcutter	Big Foot Tools, USA	210	www.bigfoottools.com
8.	EDM Tracer	Schroeder, USA	240	www.loghelp.com
9.	Miter Mill	Accutech, Canada	600	www.accutechinnovations.com
10.	Big Mill Basic	Logosol, Sweden	750	www.logosol.com
Frame mills				
11.	Alaskan Small Log Mill	Granberg, USA	140	www.granberg.com
12.	Alaskan Mark III 24”	Granberg, USA	180	www.granberg.com
13.	Slabbing Mill 24”	Westford, Australia	290	www.eftelcorporate.com.au/~jemal
14.	Stihl LSG 450	Logosol, Sweden	360	www.logosol.com
15.	Alaskan Mark III 84”	Granberg, USA	390	www.granberg.com
16.	La Gruminette	Zimmer, France	420	www.zimmersa.com
17.	Slabbing Mill 66”	Westford, Australia	430	www.eftelcorporate.com.au/~jemal
18.	Big Mill LSG Pro	Logosol, Sweden	500	www.logosol.com
19.	Stihl LSG 600	Logosol, Sweden	520	www.logosol.com
20.	Alaskan Mark III C2	Granberg, USA	640	www.granberg.com
Carriage mills				
21.	‘Make your own’	Procut, Canada	1000	www.procutsawmills.com
22.	Rail Mill	Westford, Australia	1140	www.eftelcorporate.com.au/~jemal
23.	J100 Jobber	Jober, Canada	1500	www.jober.qc.ca
24.	Baby Bug 10XB	Wood Bug, Canada	1560	www.woodbug.com
25.	Chain Saw Mill	Hud-son, USA	1800	www.hud-son.com
26.	Woodworkers’ Sawmill	Logosol, Sweden	2000	www.logosol.com
27.	Woodbug 20XB	Wood Bug, Canada	2260	www.woodbug.com
28.	SM2186 Chainsaw Mill	Lennartsfors, Sweden	2310	www.lennartsfors.com
29.	M7 Sawmill	Logosol, Sweden	2400	www.logosol.com
30.	Chainsaw mill	EcoSaw, Australia	3500	www.ecosaw.com
Milling accessories				
31.	Winch	Westford, Australia	30	www.eftelcorporate.com.au/~jemal
32.	Supplemental oiler	Granberg, USA	50	www.granberg.com
33.	Helper handle	Granberg, USA	50	www.granberg.com
34.	EZ slabbing rails	Granberg, USA	140	www.granberg.com
35.	Bar Stinger (handle)	Schroeder, USA	170	www.loghelp.com
36.	Double-ended bars	Granberg, USA	230	www.granberg.com
37.	Weatherboard guide	Westford, Australia	180	www.eftelcorporate.com.au/~jemal
38.	Log Wizard debarker	Log Wizard, Canada	290	www.logwizard.com
39.	Log House molder	Logosol, Sweden	1450	www.logosol.com
40.	The Ripsaw	SIR, USA	1590	www.ripsaw.com
Ripping chains				
41.	‘Granberg chain’	Granberg, USA	-	www.granberg.com
42.	Granberg-type chain	Laser, Canada	-	www.lasersales.org
43.	Various, + Micro-Lite	Oregon, USA	-	www.oregonchain.com
44.	Various, + PMX	Stihl, Germany	-	www.stihl.com

N.B. This compilation of chainsaw milling equipment is arranged in approximate retail price order by mill type, but without any indication of quality, technical characteristics or maximum log size sawn.