1.1 Sawmilling with chainsaws: a technical overview

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Freehand sawmilling with chainsaws is increasingly common in tropical forests and elsewhere, as chainsaws are now relatively cheap and widely available. The technique is especially suitable for exploitation of single trees by people living in or near forests who do not have the capital to invest in more expensive sawmilling equipment. Many of the people doing the sawing do not own the chainsaw they use; they hire, rent or borrow one, or use one as a paid labourer. Many of them save up in hope of one day becoming an owner-operator, or being able to buy and rent out a saw without having to do the hard work themselves.

The availability of chainsaws has been a boon to many people. Chainsaw millers in developing countries say they are better off than before they began using a chainsaw, when many did not have regular paid work.

However, besides issues related to illegal harvesting of timber, freehand chainsaw milling has a high risk of injury and fatigue. Safety clothing is rarely used in the tropics and even basic safety precautions are largely ignored. Removing chain depth gauges to increase cutting speed is common practice, but it increases the risk of chainsaw kickback, and other long-term health impacts from poor posture and high levels of vibration and noise.

THERE IS A CLEAR NEED TO ENSURE ADEQUATE TRAINING IN CHAINSAW USE AND MAINTENANCE, BOTH TO IMPROVE OPERATOR HEALTH AND SAFETY AND INCREASE EFFICIENCY.

Chainsaw milling attachments, which are commercially available and relatively inexpensive, greatly reduce these problems, and produce high-quality timber safely and efficiently. They are also especially suitable where trees are few or scattered, inaccessible, or have poor form or small size (Pasiecznik 2006). In addition, they can be more easily regulated than chainsaws (Pasiecznik 2007). However, they are hardly known and almost entirely unavailable in tropical forest regions.

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This article is aimed at those involved in making and implementing policies in the forestry and wood processing sectors, and companies involved in manufacturing and selling chainsaws, accessories and milling equipment. There is a need to ensure and promote adequate training in chainsaw use, make available appropriate safety and milling equipment, and develop markets for value-added end products.

A brief history of chainsaw milling

The first records of the use of toothed saws are from Egypt at least 5000 years ago. Long one- and two-handled saws became common tools for felling, cross-cutting and milling, and designs have changed little over time. The continued use of handsaws for sawmilling should not be underestimated, although they are being rapidly replaced by freehand chainsaws. The blade is used vertically, with logs that are either raised onto specially constructed frames, or more commonly as pitsaws, where a pit is dug under one end of a felled tree. The person on top of the log was once known as the top dog, and the one underneath, continuously covered in sweat and sawdust, the underdog, which is thought to be the origin of this word in English.

A revolution in sawmilling technology came with the invention of the circular saw blade in 1777, though more primitive versions were available before. It was not fully adapted for sawmilling timber until the early 1800s, coinciding with the invention of the first band saw. Both types of saw could be powered by water, though their evolution in the 1800s paralleled the rapid development of steam power applications.

However, no mill before 1900 could be described as portable. The advent of petrol-driven engines and the increasing demand for timber finally provided the incentive to develop appropriate machines for use within forests. Portable circular saws developed in the early 1900s, although these were made redundant by the arrival of the modern petrol chainsaw in 1929. The use of a continuously linked chain for cutting had been invented a century earlier in 1830 for cutting bones during surgery; it took 50 years to be adapted to cutting timber, and another 50 years of various unwieldy prototypes before Andreas Stihl came up with the chainsaw design that we recognize today.

Chainsaws were principally designed for felling and cross-cutting, and not for ripsawing (cutting logs into timber along the grain or length of a log). However, chainsaws were used in other types of less portable milling systems by the 1950s, if not earlier. The first milling attachments were frame mills; the Granberg Alaskan Mill (Granberg, USA) was commercialized in 1962, followed by the Gruminette (Zimmer, France) and others. These models have changed little in half a century. Around the same time, the first ripping chain specially designed for chainsaw milling was invented and patented. It is now manufactured by several companies, notably Granberg, Oregon and Stihl. Rail mills followed, such as the Mini Mill in 1973 (Granberg, USA) and the Beam Machine in 1982 (Quadra Tools, Canada). Carriage mills are the most recent development. They include the M7 (Logosol, Sweden) and the J100 (Jober, Canada), which use chainsaws or bandsaw cutting heads, and a bandsaw head powered by a single chainsaw engine (the Ripsaw, SIR, USA).

Two main user groups practise chainsaw milling today:

- The first group is forest-dependent people living in or near natural forests, mainly in moist tropical and sub-tropical regions. They usually mill freehand, part time or full time, and mainly but not exclusively, for local, national and regional markets.
- The second group includes woodworkers, artisans, hobbyists and farmers, living in, near to or far from forests, mostly in temperate and subarctic regions, milling part time only, with frames or other attachments, mainly but not exclusively for their own use. The latter are largely responsible for the development of chainsaw milling attachments, which have the potential to greatly improve the livelihoods of the former.

Chainsaws and accessories

Chainsaws

Chainsaws cost US$200–2,000 and are manufactured by many companies. Stihl and Husqvarna tend to dominate the global market, although a large number of other makes are widely used in specific countries or regions, but rarely seen elsewhere. Operators prefer chainsaws with a capacity of at least 50 cubic centimetres (cc) for milling freehand or with milling attachments, costing at least US$500. Smaller chainsaws can be used, but they have a much reduced cutting rate. A rule of thumb is that the size of the chainsaw engine in cc should be greater than the log diameter in cm. Chainsaws of 90 cc are preferred by regular chainsaw millers. 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); costing US$1,000 or more. For freehand milling in tropical forests, even larger chainsaws are common, such as the Stihl MS076 (111 cc), MS880 (122 cc) and 090; costing US$1,500 or more.

Chains

To increase cutting speed in freehand chainsaw milling, depth gauges are commonly filed down or cut off. This, however, increases vibration, the chance of kickback, operator injury and wear of the bar and chainsaw. Instead of modifying the chain, regular chisel chains can be used. Reducing the angle of the top plate from the usual 30 degrees to 0–15 degrees increases the smoothness of the cut and thus board quality. These are called ripping chains; they can be purchased (Table 1) or regular chains can be filed down as required. The Granberg ripping chain has an additional feature whereby half the teeth are reduced to "scorers," further increasing board finish and cutting speed. Reduced-kerf chains are also available, such as the Micro-Lite (Oregon) and PMX (Stihl), for use with special thinner "picco" bars. These decrease the width of each cut to seven mm from the usual nine mm, reduce fuel use and increase cutting speed, but are more likely to break and should not be used with large chainsaws.

Table 1. Chainsaw mill and accessory manufacturers and suppliers and factory gate prices

Model	Manufacturer	Cost (US$)	Web site
Rail mills			
Beam Machine	Quadra Tools, Canada	40	www.beammachine.com
Boardmaster	Hud-son, USA	40	www.hud-son.com
Mini Mill II	Granberg, USA	80	www.granberg.com
Lumbermaker	Haddon Tools, USA	90	www.haddontools.com
TimberJig	Logosol, Sweden	170	www.logosol.com
Micro-Mill	Accutech, Canada	200	www.accutechinnovations.com
Headcutter	Big Foot Tools, USA	210	www.bigfoottools.com
EDM Tracer	Schroeder, USA	240	www.loghelp.com
Miter Mill	Accutech, Canada	600	www.accutechinnovations.com
Big Mill Basic	Logosol, Sweden	750	www.logosol.com
Frame mills			
Alaskan Small Log Mill	Granberg, USA	140	www.granberg.com
Alaskan Mark III 24"	Granberg, USA	180	www.granberg.com
Slabbing Mill 24"	Westford, Australia	290	www.eftelcorporate.com.au/~jemal
Stihl LSG 450	Logosol, Sweden	360	www.logosol.com
Alaskan Mark III 84"	Granberg, USA	390	www.granberg.com
La Gruminette	Zimmer, France	420	www.zimmersa.com
Slabbing Mill 66"	Westford, Australia	430	www.eftelcorporate.com.au/~jemal
Big Mill LSG Pro	Logosol, Sweden	500	www.logosol.com
Stihl LSG 600	Logosol, Sweden	520	www.logosol.com
Alaskan Mark III C2	Granberg, USA	640	www.granberg.com
Carriage mills			
"Make your own"	Procut, Canada	1,000	www.procutsawmills.com
Rail Mill	Westford, Australia	1,140	www.eftelcorporate.com.au/~jemal
J100 Jobber	Jober, Canada	1,500	www.jober.qc.ca
Baby Bug 10XB	Wood Bug, Canada	1,560	www.woodbug.com
Chain Saw Mill	Hud-son, USA	1,800	www.hud-son.com

Woodworkers' Sawmill	Logosol, Sweden	2000	www.logosol.com
Woodbug 20XB	Wood Bug, Canada	2,260	www.woodbug.com
SM2186 Chainsaw Mill	Lennartsfors, Sweden	2,310	www.lennartsfors.com
M7 Sawmill	Logosol, Sweden	2,400	www.logosol.com
Chainsaw mill	EcoSaw, Australia	3,500	www.ecosaw.com
Milling accessories			
Winch	Westford, Australia	30	www.eftelcorporate.com.au/~jemal
Supplemental oiler	Granberg, USA	50	www.granberg.com
Helper handle	Granberg, USA	50	www.granberg.com
EZ slabbing rails	Granberg, USA	140	www.granberg.com
Bar Stinger (handle)	Schroeder, USA	170	www.loghelp.com
Double-ended bars	Granberg, USA	230	www.granberg.com
Weatherboard guide	Westford, Australia	180	www.eftelcorporate.com.au/~jemal
Log Wizard debarker	Log Wizard, Canada	290	www.logwizard.com
Log House molder	Logosol, Sweden	1,450	www.logosol.com
The Ripsaw	SIR, USA	1,590	www.ripsaw.com
Ripping chains			
Granberg chain	Granberg, USA	—	www.granberg.com
Granberg-type chain	Laser, Canada	—	www.lasersales.org
Various, + Micro-Lite	Oregon, USA	—	www.oregonchain.com
Various, + PMX	Stihl, Germany	—	www.stihl.com

Source: Pasiecznik et al. (2006). This table compiles all the commercially available chainsaw milling equipment identified in 2006. It is arranged in approximate retail price order by mill type, but gives no indication of quality, technical characteristics or maximum/minimum log size that can be sawn. The author has no commercial interest in any of the makes/models listed.

Oil

Two-stroke oil should be added to fuel at a ratio of approximately 1:25 (i.e., 200 cl of oil per 5 litres of fuel). However, some operators add at least twice this amount, believing that it increases efficiency; in fact, it significantly increases overall running costs (Pasiecznik and Carsan 2006). Oil is also required as a chain lubricant. Special synthetic chain oils are not commercially available in many countries or are prohibitively expensive. Used engine oil is sometimes used, but the small particles of metal it contains can damage the oil pump. The best alternative is any type of vegetable oil, the thinner the better, that is locally available, relatively cheap and biodegradable.

Chainsaw milling attachments

The following is a summary description of equipment that is currently commercially available, classified into frame mills, rail mills and carriage mills. For more information on chainsaws, accessories and different mill types, see Pasiecznik et al. (2006), and/or the companies' websites included in Table 1 of mill manufacturers.

Frame mills

Frame mills cost US$140–640. They are probably the best known and most commonly available of all chainsaw milling attachments. Often called Alaskan mills or slabbing mills, they are also referred to by the manufacturer's name, especially where these are used exclusively, such as Granberg, Logosol or Stihl mills or frames. Frame mills are simple guides that are fixed parallel to the chainsaw bar. They are used with the bar and frame positioned horizontally for "live," "slab" or "through and through" sawing, and can be adjusted to cut various thicknesses. They are made of square tubular steel or aluminium, with or without rollers. Some manufacturers produce various sizes to accommodate different lengths of chainsaw bar, and the corresponding log diameters. In using a frame mill, operators must use slabbing rails, slabbing boards or similar attachments when making the first cut.

Rail mills

Rail mills cost US$40–240. They are the cheapest and most simple type of mill, comprising of a small attachment that fixes onto the chainsaw bar and rides along a rail attached to the length of the log. They help chainsaw millers make straight cuts through a log, usually vertical. Some models require the bar to be pre-drilled to allow the attachment to be bolted on, in other models the attachment simply clamps on. Rails may be specially supplied metal units (strips, bars, angle iron, etc.) or pieces of wood, typically in common sizes such as 10 by 5 cm or 15 by 5 cm (4 by 2 inch or 6 by 2 inch), for nailing or screwing on to the log. Some rail mills have additional features such as an ability to set the chainsaw at angles other than 90 degrees (vertical), or to cut mitres, control the depth of cut or cut curved lines. They allow operators to produce custom timber, and many models have been specially designed for making log cabins and timber-frame housing.

Carriage mills

Carriage mills cost US$1,000–3,500. The chainsaw is fixed on or into a carriage that rides along a frame or set of rails. Most carriage mills make horizontal cuts, though some make vertical (or near-vertical) cuts. These mills are larger, heavier, more expensive and require more set-up time than the rail or frame mills, but they increase productivity, reduce muscular stress and strain, and entirely eliminate the risk of accidents. When assembled, carriage mills cannot be carried by a single person, however, and share many similarities with portable band saw and circular saw mills. Several models of carriage mills have specially designed band saw heads that can be used instead of a chainsaw.

When chainsaw milling makes sense

The few studies comparing chainsaw milling with portable bandsaws and circular saws have identified conditions where milling logs with chainsaws is the most appropriate; some have also compared freehand milling with the use of milling attachments. Criteria that need to be considered are available capital, availability of sawmilling equipment, site accessibility, labour considerations, desired productivity and end products (Pasiecznik et al. 2006). Additional criteria include environmental considerations and operator health and safety.

Table 2 presents a review of results from studies on productivity and timber recovery from freehand milling and chainsaw milling with attachments. Although figures vary greatly, there appears to be an increase in timber recovery when using milling attachments, especially carriage mills. Productivity (per working team) was potentially higher with freehand milling, though carriage mills were comparable, and rail and frame mills were the least productive.

Table 2. Productivity and timber recovery from freehand chainsaw milling and chainsaw milling with attachments

country	notes	productivity m3/day	recovery %	source[1]
Freehand chainsaw				
Brazil	Various hardwoods	4.8	41–61%	D'Oliveira et al. 1998
Guyana	Various hardwoods	4.2	10–25%	Grisley 1998
Indonesia	Various hardwoods	2.0	<5%	Roda 2005
Philippines	Coconut	1.5	27%	Arancon 1997
Guyana	Locust and greenheart	1.2–1.8	19–22%	Clarke 2005a
DR Congo	Grevillea and eucalyptus	0.8	37–55%	Samuel, Pasiecznik and Fehr 2007
Ghana	Various hardwoods	—	40%	Tropenbos 2003
Kenya	Grevillea	—	28–39%	Onchieku 2001
Frame and rail mills				
Kenya	Granberg Mark III — grevillea	1.45	45–55%	Samuel, Pasiecznik and Fehr 2007
Australia	5 assorted mills (mean)[2]	1.1	35%	Stewart and Hanson, 1997
DR Congo	Stihl LSG 450 - Grevillea/eucalyptus	1.0	41–54%	Samuel, Pasiecznik and Fehr 2007
Mexico	Rail mill (unspecified)	1.0	40%	Richards et al. 2001

USA	Granberg Mark III – oak	0.6–1.2	—	Henderson and Krier, 1997
Kenya	Granberg Mark III - Prosopis	0.27	25%	Samuel, Pasiecznik and Fehr 2007
Australia	Frame and rail mills	—	55%	Smorfitt et al. 2004
Carriage mills				
Sweden	Logosol M7 – softwood	2.3—3.5	50—60%	Company website
Canada	Procut "make your own"[3]	1.8—3.6	—	Company website
UK	Jonsered 600+[4] — Douglas fir	1.6—2.9	26—66%	Jones, 1998
Canada	Procut "make your own" — softwoods	1.2—2.4	—	Company website
UK	Jonsered 600+[4] – oak	1.1	56%	Jones, 1998
New Zealand	FRI mill – rimu	1.0	52%	James, 1985
Canada	Procut "make your own" — hardwoods	0.6—1.2	—	Company website

Source: adapted from Samuel, Pasiecznik and Fehr 2007

1. For source references, please refer to Samuel, Pasiecznik and Fehr (2007), Table 1.2 (page 8).
2. Including: Granberg Mark III, Westford Rail Mill, Beerwah Ripper Mk IV, MacQuarrie Chain Mill, Logosol.
3. Using a Stihl 090, one man helping, averaged over seven years (www.procutportablesawmills.com/production.htm).
4. Now marketed as the Lennartsfors SM 2196.

A study in DR Congo (in Samuel, Pasiecznik and Fehr 2007) compared the economic viability of producing timber freehand and with a frame mill. It found that, although timber from a frame mill was of higher quality, that there was no local market for such timber, and the price premium that could be obtained in the non-local market was largely spent on transport. Although frame mills had a higher rate of recovery, logs were abundant, and thus there was little motivation for using milling attachments in the region. The literature on this topic is sparse, however, and more site-specific research is required in various forest and non-forest regions.

Each milling attachment has its own advantages in different situations. Table 3 summarizes these related to the type of timber required and logs available. Rail mills provide a simple means for an infrequent user to guarantee a straight board, and are used for edging timber or producing beams. These mills can be purchased very cheaply (less than US$50), but there are benefits in using a rail and frame mill in combination. Frame mills have a wide range of uses, are able to process both very small and very large diameter and even crooked logs, and they are also relatively cheap and very efficient with medium-size logs. Although the Gruminette and Westford Slabbing Mill have certain advantages, Granberg's range of frame mills generally offers a good choice at a reasonable cost.

Carriage mills such as the Jober J100, Logosol M7 and the two Woodbug mills are very efficient in processing large numbers of small-diameter logs, such as forest thinnings.

Table 3. Suitability of chainsaw milling techniques for different products and types of logs

	freehand milling	rail milling	frame milling	carriage milling
Type of timber produced				
Slabs	√	√	√	√
Edged timber	√	√	√	√
Quartersawn boards	x	x	x	√
Extra long lengths	√	√	√	x
Type of log to be milled				
Small diameter logs	x	x	√	√
Short logs	√	√	√	√
Crooked logs	x	x	√	x
Tapered logs	√	√	√	√
Oversized logs	√	√	x	x
Side slabs	x	x	√	x
Defective logs	√	√	√	√
Speciality cutting	x	√	x	x
Various				
Portable by one man	√	√	√	x
Approximate mill cost (US$)	0	40–240	140–640	1,000–3,500

Source: adapted from Pasiecznik et al. 2006

Chainsaw attachments can also cut firewood into timber (e.g., Pasiecznik and Harvey 2006, poster No. 6), and process logs that static sawmills and larger portable sawmills would not accept. Logs as small as 30 cm long and 15 cm in diameter can be milled, making it possible to produce marketable timber from branches, bent, damaged or undersized logs, off cuts, reclaimed building timber, and street and fence trees likely to contain nails.

Conclusions

There is a clear need to ensure adequate training in chainsaw use and maintenance, both to improve operator health and safety and to increase efficiency. Training should be provided through widely accessible courses, and should make available appropriate safety and milling equipment, including the range of attachments discussed above. Initial courses undertaken in Kenya indicate that there is a great interest in them — operators

were willing to pay for training — with potential benefits to be gained. Economic, social and environmental advantages would all increase with further investment in providing improved skills and better equipment to chainsaw operators. Such training should be included as a requirement in all timber certification schemes as a start, and expanded accordingly.

For more information

See http://chainsaw.gwork.org for many publications detailing the chainsaw milling technologies covered in this article, resulting from a DFID-funded project and related activities. The chainsaw milling manual (Pasiecznik et al. 2006) is the definitive and independent guide to the equipment described and their use. It is summarized in a series of eight A4 posters; these, along with the manual, are available from the website in English, French and Spanish. They are supported by an economic and policy case study from East Africa (Samuel, Pasiecznik and Fehr 2007), a series of four policy briefs, and additional articles and training course reports.

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