Small Scale Log Processing – Milling and Drying

Farm Forestry in the Adelaide Hills / Fleurieu Peninsula - Farm Forestry Note 10/05

This Farm Forestry Note provides a basic introduction to wood anatomy, portable milling and drying of timber. It will enable you as a tree grower to talk sensibly to a saw miller so you can organise the milling of a log or logs for your own use or sale.

Wood Anatomy

Hardwoods and Softwoods

The amateur timber enthusiast nearly always misunderstands the terms softwood and hardwood. They have a small part to do with the physical characteristics of the timber but actually relate to the botanical classification of the tree species.

Softwoods are botanically classified as gymnosperms that produce 'uncovered' seeds, usually contained in cone structures and largely represented by conifer species.

Hardwoods are classified as angiosperms and are flowering plants whose seeds are formed inside a ripening fruit and are represented by the broadleaved species.

It is for this reason that balsa wood, a very soft timber, is in fact botanically classed as a hardwood.

Sapwood and Heartwood

Heartwood is probably more aptly known as the 'true wood' and sapwood as the 'living wood.'

Sapwood is responsible for transferring substances required for growth to the growing tissues and for storing food reserves. It is unclear why sapwood is converted to heartwood but there appears to be a balance whereby adequate sapwood is maintained in the tree to support growth and redundant sapwood is converted to inert heartwood.

The major role of heartwood is for the structural support of the plant. During the conversion process the cells, previously able to transfer growth supporting substances, become blocked with tyloses, which are responsible for the colour and durability of the heartwood. In most species the transition zone is readily apparent by a distinct change in colour of the wood, although this may be difficult to observe in species with pale coloured heartwood.

As sapwood contains high levels of starches and sugars it is less durable and more susceptible to insect and fungal attack than is heartwood. The cells of sapwood are open so as to allow the conductance of growth substances around the tree, hence chemical preservatives are readily able to penetrate the sapwood. The blockages within the heartwood prevent preservative penetration thus thoroughly coating the outside of the heartwood with preservative is the best that can be done to protect it.

Juvenile wood

Juvenile wood is low quality wood that occurs in the centre of the tree when the tree is young. It is of low density, low strength and prone to warping. Juvenile wood is therefore not desirable for milling. As the tree ages the more mature characteristics of the wood that is laid down make it more suited to milling.

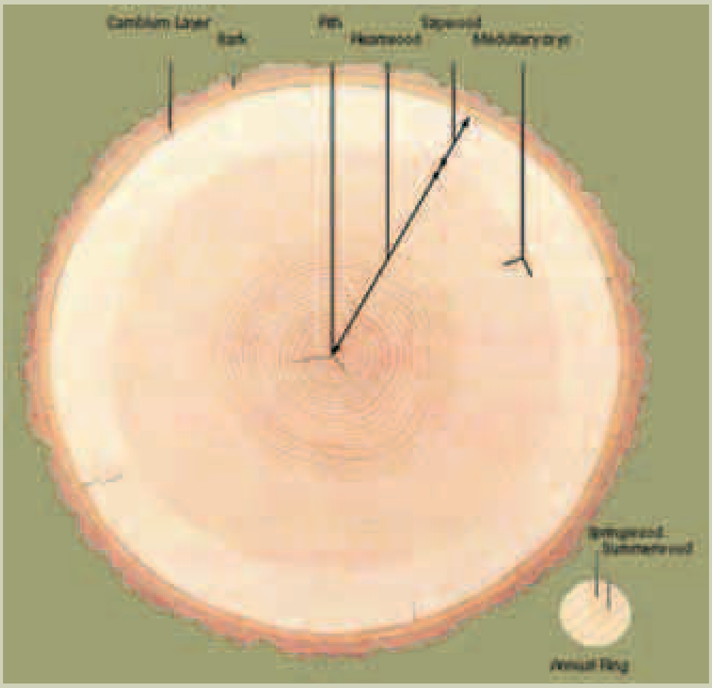
Earlywood and Latewood

The growth rings we see in wood are a result of the change from earlywood to latewood. The rapid flush of spring growth produces wood fibres that are short, fat and thin walled; termed earlywood. Slower growth over the rest of the year gives rise to narrower, longer, thick walled fibres; or latewood.

Growth stresses

Often growth stresses are common in logs and evidence themselves through splitting of the log, or more often bow, spring or splitting of cut boards due to distortion casued during sawing. Longitudinal growth stresses are common in hardwoods and can be particularly severe in Eucalypts. The stresses are often the most severe in small diameter logs.

As a tree grows wood cells are laid down over the outside of the existing wood.



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These cells produce a tension stress along the grain and a compression stress across it. Each new layer compresses the older layer it overlays along the grain (longitudinally), reducing the tension it carried but placing it under compression.

These stresses cause the young outside wood to contract while the inner wood expands, causing the timber to bow towards the bark when the log is milled.

Distortion of the log during sawing results in sawing inaccuracies, reducing productivity and product recovery.

The most promising solution may be to relieve the stress evenly around the log, releasing many boards simultaneously in a multiple saw operation or in a single saw operation by rotating the log as subsequent boards are cut off.

How much wood do I have? – Log volume

The volume of a log can be estimated using either of the following two formulae, both utilising simple measurements of the log.

Huber's Formula

Measure the length of the log in metres. Measure the underbark diameter of the log at its midpoint.

Calculate the sectional area of the log for the measured diameter.

Sectional area = π . (Diameter/2)^2

Volume m^3 = sectional area midpoint of log . log length metres

Smalian's Formula

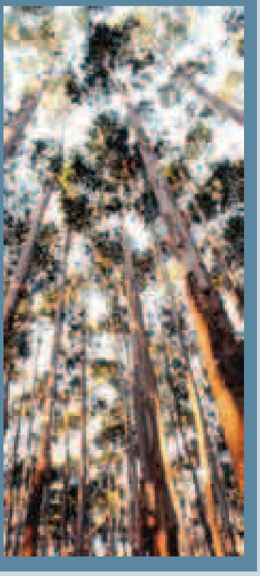
Measure the length of the log in metres. Measure the underbark diameter of the log at its ends.

Calculate the sectional area of the log for the measured diameter.

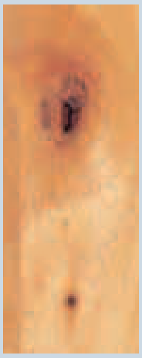
Sectional area = π . (Diameter/2)^2

Volume m^3 = (sectional area large end + sectional area of small end) /2 . log length

Measuring at the midpoint of the log is usually more accurate however often it is impractical either because it is difficult to remove the bark or the midpoint is inaccessible, as in a stack of logs or where the log is heavy or embedded in the ground.



Major types of degrade in logs & milled boards



Knots

Knots result when branches grow off the main trunk. If large enough they will reduce the strength of boards as well as detract from the appearance value of the wood (except in cases where knots are made a feature of the timber). Knots surrounded in bark are 'encased' and these may drop out leaving a hole in the board. This occurs when a branch dies and is not shed from the tree as the tree continues to grow.

Gum or resin pockets

These are cavities in the wood, which in softwoods contain resin, and in hardwoods; gum or kino. Unless large they will not impact on the strength of the timber but rather its appearance. Generally they occur as a protective response to injury or stress of the tree.

Checks, splits and shakes

Checks are cracks in the surface of the timber and normally occur as a result of stresses as the wood dries. Checks affect appearance rather than strength unless they extend from one surface of the timber to another in which case they will reduce strength and are known as *splits*. A *shake* is a split that has occurred by severe stress in the growing (caused by wind) or harvesting (felling) process.

Pith

Pith is the first formed wood at the growing tip of the tree and is confined to the centre of a log. It is weak, differing in structure to the wood subsequently formed in the tree, and difficult to finish. In pine timber it can be prominent as a brown line of soft material running the length of boards.

Wane and want

A wane edge occurs where a board is cut adjacent the outside of the log and the board therefore does not have a full cross-section, an edge is missing as a rectangular cross-section is cut from a round profile. Want is where the missing cross-section is not due to the board coming from the outside of the log but due to mechanical damage of the log or faulty sawing.

Rot

Primary rot is fungal decay of the tree before milling.

Cup, bow, spring and twist

These defects normally arise in the drying process or due to growth stresses in the log and affect the straightness of sawn boards. These defects generally have little impact on the strength of the boards but rather present difficulties in obtaining straight and square faces to work with.

Log grading

Definition of sawlog:

A sawlog is defined as any length of a log of merchantable species which:

- is at least 2.7m in length
- has a small end diameter (measured under bark) of 25cm or greater
- does not have sweep or crook which exceeds one-fifth of the diameter along a
- 2.4 m straight edge
- is of grade D standard or better

Definition of Hardwood sawlog grades for Victoria (these can be used as a general guide in SA)

A-Grade

Any sawlog with a minimum small end diameter under bark of 50cm which has no defective quarters and maximum defects on exposed ends of:

- *one-quarter diameter lengths of all gum vein or gum pockets*
- *light stain*

In addition:

- *maximum angle of sloping grain of 1:10 along the length of the sawlog*

B-Grade

Any sawlog with a minimum small end diameter under bark of 35cm which has maximum allowable defects on exposed ends of:

- *one quarter diameter length of loose gum veins/ pockets and shakes*
- *one diameter length of tight gum vein more than 3mm in width*
- *two diameters length of tight gum vein less than 3mm in width light stain*

In addition:

- *1:10 angle of sloping grain along the sawlog axis*
- *a maximum of one defective quarter along the length of the sawlog*
- *a maximum of 105cm squared of pipe in an exposed end*

C-Grade

Any sawlog with a minimum small end diameter under bark of 30cm which has maximum allowable defects ofon esposed ends of:

- *one diameter length of loose gum veins/pockets and shakes*
- *seven diameters length of tight gum vein more than 3mm width*
- *unlimited lengths of tight gum veins less than 3mm width*
- *dark stain*

In addition:

- *maximum sloping grain angle of 1:8 along the length of the sawlog*
- *maximum of two defective quarters*
- *maximum of 112cm square of pipe in an exposed end*

D-Grade

Any sawlog with a minimum small end diameter under bark of 25cm which has maximum allowable defects on exposed ends of:

- *two diameters length of loose gum veins/pockets or shakes*
- *10 diameters length of tight gum vein more than 3mm width*
- *unlimited length of tight gum vein less than 3mm width*
- *dark stain*

In addition:

- *maximum sloping grain angle of 1:8 along the length of the sawlog*
- *maximum of three defective quarters*
- *maximum of 120cm square of pipe on exposed ends*

Sawing

The most basic interpretation of sawing is to reduce a log of circular cross-section to rectangular sectioned pieces. To do this is in itself not difficult but to do it with minimal waste and with maximum value recovery requires a wealth of practical experience and knowledge. Saw milling is an art!

Portable and Industrial Milling

Industrial milling operations require high volumes of wood of uniform log dimension. They are characterised by very high levels of capital investment in equipment, high rates of production and require that you the grower have sufficient volume of log available to justify the cost of undertaking an industrial harvesting operation.

Portable milling operations see a trade-off between productivity and capital outlay. The relatively low productivity of portable sawmills means the production of industrial wood products may be difficult to achieve competitively. The most viable prospect for farm foresters thus exist to value add by conducting low volume high value operations.

Advantages of portable sawmills:

- Able to supply niche markets not serviced by larger industrial processors
- Value adding for the small grower come processor
- Return of unwanted residues (bark, edgings, sawdust) to the site, retaining nutrients on site
- Flexibility of milling operations
- Breaking down logs to recoverable timber thus reducing transport costs
- Allow operations to occur in inaccessible sites
- Allows recovery of small volumes of timber economically

Portable mills do have a number of disadvantages:

- Relatively low productivity
- High labour requirement
- Involve heavy manual handling operations
- Working environment may not conform to industry occupational health and safety standards
- The dimensional accuracy and surface finish are likely to be more varied

Types of saw used

Numerous portable sawmills are available, including chainsaw, horizontal bandsaws, and single and twin circular saws through to the more complex units with moving carriages on which the log is placed and moved through the saw.

Chainsaw mills – are cheap, labour intensive, give a low percentage recovery of material and give relatively poor accuracy of cut.

Horizontal bandsaws – give a high recovery of material (narrow saw cut and accuracy), are able to cut wide logs but require two passes to produce dimensional timber, they lack automation and the blades require frequent setting and sharpening.

Circular saws – produce dimensional timber with two passes, have a wider saw cut than bandsaws and are labour intensive as they have a low level of automation.

Twin circular saws – high productivity, able to cut dimensional timber in a single pass but they have a relatively wide saw cut.

Single man bench saws – these are high productivity mills that have systems that reduce labour and manual log handling but they are expensive and less portable.

In general the more expensive the mill, the higher the level of automation and productivity.

The amount of timber recovered from a log varies considerably depending on:

- the size and quality of the log
- the type of saw it is milled with
- the milling technique used
- the drying and grading of the timber.

Typically between 40 and 70% of the theoretical log volume is recovered by milling. Maximum productivity is achieved by minimising both wastage and the number of saw cuts and by ensuring products are accurately sawn.

The sawing operation can be divided into two stages:

- Breaking the logs down into manageable sizes
- Resawing these pieces into final product dimensions – edging and docking

Debarking

Before beginning to mill a log it is wise to remove the bark as it may pick up dirt during logging, transporting and handling. Debarking will clean the log and reduce saw tooth wear and damage. Sharp saws are more efficient cutters, giving not only better rates of production but also more accurate cutting.

Logs are most easily debarked when green. This can be done by hand with a sledge hammer or the back of an axe. For smaller logs, rolling with a tractor wheel will readily crack the bark allowing it to be peeled off. If large numbers are to be debarked then specialised equipment may be required.

Methods of sawing

Backsawing - produces boards with faces tangential to the growth rings (the grain runs along the boardface). High-grade timber can be cut from faulty logs and the 'flat' grain wears well in flooring. Drying problems can occur, but in species not prone to cell 'collapse,' but in which there are growth stresses, back sawn boards may give less 'spring.'

1. Live Sawn

2. Radial Sawn

3. Quarter sawn

Live-sawing - (flat sawing) is the simplest and cheapest method, requiring less handling of the log. Here the log is reduced to boards by successive cuts along the log. This produces wide boards, with little waste, which is of particular importance with small logs. Variations of this pattern may be used, but live sawing effectively produces a mixture of back-sawn and quarter-sawn products from the log.

Radial-sawing – a new approach to the utilisation of fast grown, short rotation, small diameter hardwood (a small end diameter of more than 20cm is otherwise needed). This approach uses a circular saw to cut wedges of timber from the outside to the centre of the log. This overcomes some of the stress relief problems associated with the milling of small sized hardwood. Sawn wood recovery can be higher when compared with the conventional 50% or less for small diameter logs. Products include weatherboards, fencing materials, flooring and decking. Quarter and back sawn boards are readily cut with single and twin circular saws whereas chainsaw, horizontal bandsaw and bench saw systems require frequent turns of the log.

Quarter-sawing - is the best method for species that have high tangential shrinkage in drying. The log is sawn by cutting across the growth rings (the grain runs across the board face). This enhances the decorative properties of some species and the boards are not as prone to cupping or checking during drying. Quartersawn boards expose fewer gum veins and shrink less in width.

Should I saw parallel to the bark or the centre axis of the tree?

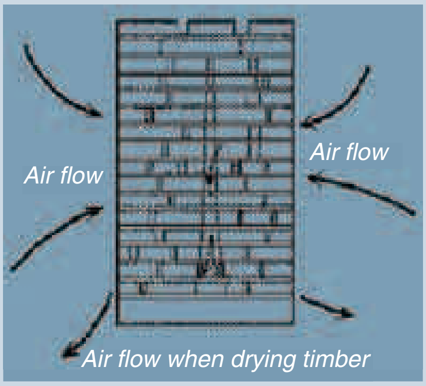
Taper-sawing (parallel to the bark) will recover more of the sound wood from the outer section of the log and leave the central knotty, juvenile wood core as waste. Split taper sawing involves sawing parallel to the central axis of the log.

Drying timber

Drying is an essential element of preparing your timber for final use and further value adding your timber.

Reasons for drying

- to achieve stability; prevent shrinkage, splitting, checking, warping
- to achieve greater stiffness and strength
- to allow penetration of preservatives
- to obtain a surface finish that will accept paint, polish or glue
- to protect against decay



Air flow when drying timber

Moisture contents

- Green timber can have up to 130% moisture content as that of a live tree
- Air drying brings this back to 10 to 25% moisture content – this is of course ambient temperature and humidity dependent
- Kiln dried timber can reduce the moisture content to less than 12%

The time taken for timber to dry will depend on the initial moisture content, species, dimensions of the board and differences in wood anatomy. A moisture meter should be used to check the degree of seasoning the timber has undergone.

Once cut the harvested log begins to lose moisture. The fibre saturation point is reached when the free water within the cells is lost, corresponding to moisture content of about 30%. At this stage only the bound water in the cell walls remains. When this bound water has dried to a level in equilibrium with the surrounding air the wood is seasoned.

A moisture gradient develops between the outside of the wood which dries more quickly and the inside layers, this results in stresses as the outside tries to shrink which may result in surface checks, splits or honeycombing. The degree of shrinkage in timber varies with the plane considered so that tangential to radial to longitudinal shrinkage, is in the order of 100:50:1.

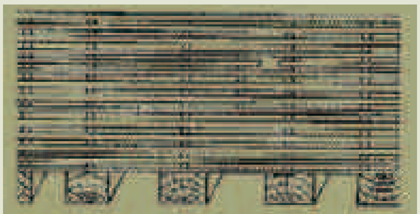
For this reason a slower more controlled drying regime will result in less drying induced degrade.

Shrinkage on drying is inevitable but sound drying practices will reduce the degrade that occurs.

Collapse is a form of drying degrade many eucalypts are prone to. It results in an undulating or washboard appearance of the wood. A steam reconditioning treatment will return the board to its original shape and appearance however internal checking or honeycombing may remain.

Air drying

Air-drying is cheap but the rate of drying and the final moisture content is at the mercy of the weather.



Example of drying stack formation

General guidelines are:

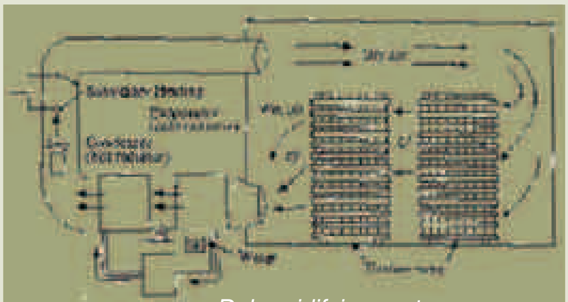
- don't make the stacks too large, approximately 1m wide and no more than 2.5 metres high
- make sure the foundations are level
- orientate the stacks so that the prevailing wind will flow through the stack
- paint the ends of the boards with bitumous paint or wax to prevent excessive drying
- to provide space for air circulation and to help keep the boards flat and straight, the layers of stacked boards should be separated by stickers. 20mm high and 30mm wide. They should be aligned vertically in the stack and spaced every 450 to 900mm apart, depending on the species and the thickness of the boards
- a stack should contain one thickness of board only but can accommodate varying length and width boards
- the board ends should finish flush to avoid distortion and thus waste of the overhanging ends
- a cover or roof for the stack is required and should ensure that rain falls clear of the stack
- the roof should be weighted down and weight applied to the stack to maintain timber in good shape as it dries

Kiln drying

Kilns with artificial heating and humidity control allow for a more controlled and rapid drying process. They require higher levels of technical skill and greater capital investment and are only warranted if you are milling sufficient volume or high value timber or if you are further value addign and processing your timber, for example making furniture. Conventional kilns are expensive and for small-scale production dehumidification and solar kilns are better alternatives.

Solar kilns are claimed to offer significant energy savings through the use of a "hot-house" principle for drying. In many cases the solar system can be supplemented with a conventional heating system to provide a more constant environment and to reduce drying times.

Dehumidification systems utilise the heat pump principle of air conditioners and use low temperatures for drying (< 50°C). Warmed air evaporates moisture from the timber, which is then condensed and removed. The heat generated in condensing the moisture is used to reheat the air stream that passes over the timber and so the cycle continues. Drying by this means is energy efficient, low cost and easy to operate but slower than conventional kiln drying.



Dehumidifying system

Microwave drying systems have not been fully developed but appear to provide very quick drying with little degrade. At this stage due to the lack of availability of industrial scale components microwave drying is restricted to the craft wood market with conventional domestic microwave ovens.

Occupational health and safety issues

Saw milling is an inherently risky task and special attention should be given to health and safety issues.

The most obvious danger comes from the saw blade itself. To say it is important to avoid contact with the saw blade is perhaps an understatement. It is recommended that the blade is guarded and that where possible the saw is operated from the non-cutting side.

Moving logs and sawn boards will require some heavy lifting. Where possible lifting equipment should be used to prevent personal injury.

Noise levels in milling operations are very high and proper hearing protection must be used.

Similarly sawdust can cause respiratory and eye problems so eye and respiratory protection should be used.

Further References

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P.R Bird 2000 Farm Forestry in Southern Australia – A focus on clearwood production of speciality timbers

List of Millers and Portable Millers

Millers

D Keatley, Pebbly Range Rd, Tungkillo, 5236	Ph. 8538 7119	Mb. 0412 844 682
Roger Kowald, Mt Torrens, 5244	Ph. 8389 4221	
Phil Walsh, Mt Crawford	Ph. 8524 6183	
Log Saw, Ranns Rd, Uraidla, 5142	Ph. 8390 3135	
Peter Waller, Aldgate, 5154	Ph. 8339 2736	

Contract milling

Mt Compass Sawmills, Bill Dalitz, Sandmine Rd, Mt Compass	Ph. 8556 8230	
The Original Scrub Giant P/L, Chris Brookes, Victor Harbor	Ph. 8552 6691	Mb. 0421 179 914
Log Saw, Neil Mullard, Uraidla	Ph. 8390 3135	
Steve Gardner, Macclesfield	Ph. 8388 9036	Mb.0407 716 890
Norwood Saw Works, Grant Stott	Ph. 8362 2946	
Roger Kowald, Mt. Torrens	Ph. 8389 4221	
Wes Seeliger, Eden Valley	Ph. 8565 3226	

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