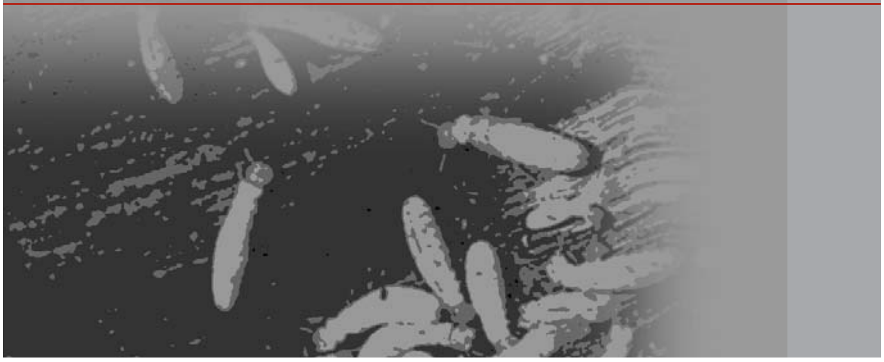


NSW Heritage Office

Wood preservation

Wood as a building material

Trees are either softwoods (gymnosperms or conifers) or hardwoods (angiosperms or flowering plants). Softwoods are not always softer than hardwoods. The Australian native cypress pine (*Callitris*) is a softwood of greater density and harness than many hardwoods, while balsa (*Ochroma*) is a hardwood.

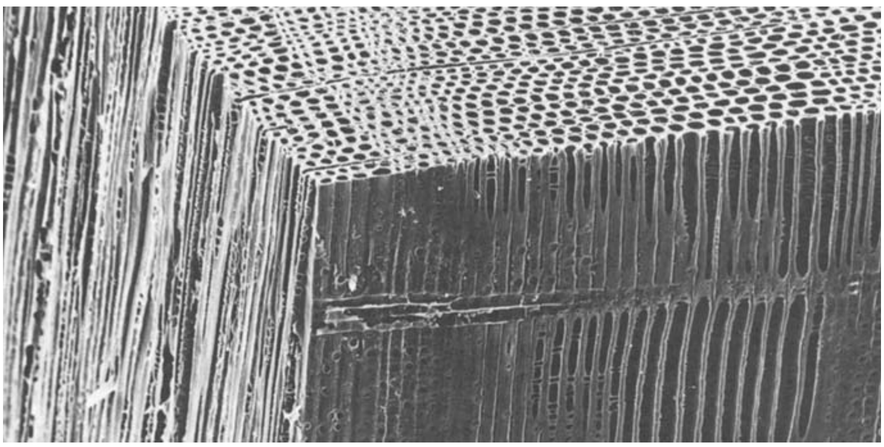
Wood structure

The microscopic structure of wood resembles a bundle of straws glued together; each straw represents a cell with a cellulose wall and a hollow centre (lumen), and lots of fine perforations through the walls. The cell walls are impregnated with lignin, a natural polymer that glues the cells together and gives wood its strength. Most cells are oriented longitudinally (parallel to the trunk of the tree), with some radially aligned.

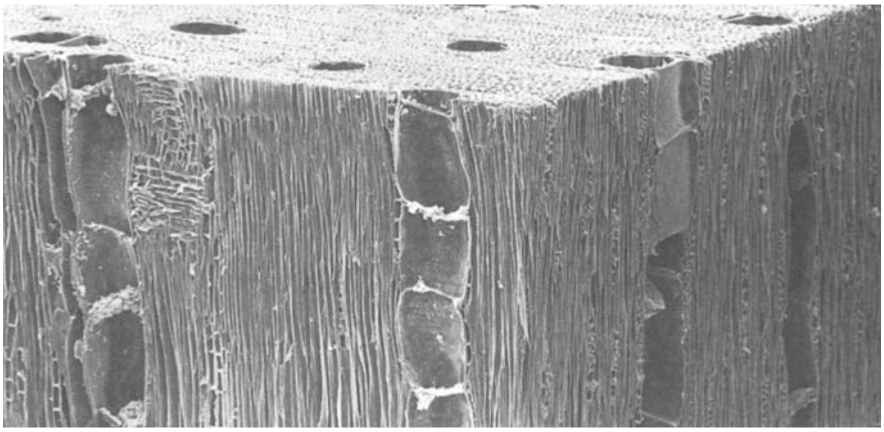
In softwoods the longitudinal cells (*tracheids*) provide both structural strength and transport of fluids, while in hardwoods these functions are performed by separate cells, *fibres* providing strength and *vessels* providing fluid transport. The presence of vessels is one distinguishing feature of hardwoods.

Growth rings are most apparent in some softwoods, where the *latewood* of the previous season differs greatly from the *earlywood* of spring. Latewood is harder, darker and denser than earlywood, because latewood cells have thicker walls and smaller-diameter lumens. While a growth ring usually represents a year's growth, climatic extremes and bushfires can disrupt normal growing patterns.

Scanning electron micrograph of a softwood, cypress pine, oriented as in the tree trunk. The top surface is cut horizontally across the tree, the right side is a radial face with two rays, and the left is a tangential face parallel to the growth rings.
Most cells are tracheids.
The scale bar is 500 µm (micron) – 0.5mm long.



Photograph by Peter Beutel and Roger Heady.



Photograph by Peter Beutel and Roger Heady.

Scanning electron micrograph of a hardwood, red cedar, oriented as in the tree trunk. The left side is a radial face showing an area of ray cells, and the right side is the tangential face. Note the large diameter vessels (pores) and the much smaller fibres. The relatively short vessel cells have small openings (pits) in the tissue between adjacent cells which allows fluids to pass. The scale bar is 0.5mm.

Sapwood and heartwood

A cross-section of tree trunk has *heartwood* (generally darker) in the centre, surrounded by a lighter rim of *sapwood* (much lighter in some eucalypts), and then the bark. Sapwood conducts fluid, but the heartwood is generally drier and is biologically dead. Metabolic by-products (*extractives*) are deposited at the sapwood/heartwood boundary, which expands as the tree grows. Extractives darken the heartwood and also make it naturally durable due to their toxicity to fungi and to some termites and borers.

Wood identification

The characteristic cell structure of different woods can be seen with the aid of a microscope, enabling the genus or species of tree to be identified from a 10mm cube. Correct identification allows accurate matching of colour and other physical properties in replacement timbers.

Wood density, hardness and strength

Cells of dense woods have small lumens and thick walls. When the wood is dry, the lumen is largely air, and the proportion of air to solid material is a measure of density. It ranges from 25%-30% for grey or yellow box (eucalypts), to about 70% for a low-density wood such as red cedar (*Toona australis*), and nearly 90% for balsa.

Hardness and strength generally increase with increasing density. Wood is very strong in tension, when measured along the grain, because of the long-chain cellulose molecules in the walls of the longitudinally arranged cells.

Extractives darken the heartwood and also make it naturally durable due to their toxicity to fungi and to some termites and borers.

Wood deterioration

There are four main agents of wood deterioration: fire, fungal rot, borers and termites. The effect of ultraviolet light is relatively shallow; it degrades exposed surfaces, turning them grey and weakening the surface cells.

Fire

Surprisingly, wood is not very flammable. It does not ignite readily, except in small twigs, or when very dry and at high temperatures. Large timbers char slowly and form a layer of charcoal which protects the wood beneath and slows the rate of combustion. Some timber structures may therefore remain serviceable after a fire.

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Fungal rot

All rotting of wood is caused by fungal attack. Fungi are minute organisms which live on and within wood and slowly digest the cell wall materials, leading to softening and decay. All forms of fungal rot – including brown rot, white pocket rot, soft rot, the simply named decay, and the confusingly named wet and dry rots – cause severe damage to timber in service and are often not discovered until the decay is well advanced.

Although fungal spores are common in the air, they cannot develop and attack wood unless it has a moisture content in excess of about 20% by weight. Dry wood will not rot. Preventing fungal attack is simply a matter of keeping wood relatively dry. This, of course, is easier said than done; some timbers, such as fence posts, are permanently damp and at risk. These should preferably be made from naturally durable timber. The sapwood of most species is not resistant to fungal rot.

To repair rotted structural timber, remove the visibly decayed zone together with any surrounding area affected, to be certain of removing all active fungi. Apply fungicides to the remaining timber as a precaution.

Recently, a solid form of fungicide based on boron and fluorine has been devised instead of the normal liquid or paste, and has proved effective in treating wooden transmission poles. Inserted as small rods into pre-drilled holes, the fungicide diffuses through the wood only when it becomes wet and fungal attack is likely. Fungicidal rods are suitable for these large-section timbers, but may weaken joints in smaller sections such as window frames.

Typical decay pattern of cubical brown (fungal) rot.

Photograph by David Young.

Borers

Damage to timber by wood borers is generally minor and rarely needs treating. However, some borers can cause considerable destruction. Knowing the difference can save unnecessary treatment.

Most borers are beetles with a four-stage life cycle beginning with eggs, which are laid in the vessels or in cracks in the wood surface. These hatch into the larval or grub stage, which burrow into the wood, producing a network of galleries which may considerably weaken the timber. Adults develop from a pupal stage, burrow out of the wood and fly off to breed. The exit or flight holes of the adult are generally the first signs that borers are present, often with a fine dust (frass) which is borer excrement.

When evidence of borers is discovered three questions should be answered:

Is it still active? If not, control measures will be required.

What type of borer was or is responsible? Some are benign.

What is the extent of damage and are structural repairs required?

Some of the more important borers found in Australian building timbers are:

Most borers are beetles with a four-stage life cycle beginning with eggs, which are laid in the vessels or in cracks in the wood surface.

Powderpost beetles (Lyctids) attack only the sapwood of some hardwoods. They are so common that susceptible timber is generally attacked in the first few years of service. Since sapwood is generally only a small proportion of a timber section (it is limited by law in New South Wales and Queensland), lyctids generally cause little structural damage, even if most of the sapwood has been thoroughly burrowed. Powder-post beetle damage can be found years after the attack has ceased, and, although initially alarming, once positively identified it rarely requires further action.

The name ***Furniture beetles*** (Anobiids) suggests a preference for furniture, but these beetles can also attack flooring and framing timbers. They mainly attack the sapwood of softwoods, preferring old, well-seasoned timbers such as baltic pine, and damp humid conditions such as poorly ventilated floors. Furniture beetles are a hazard to old buildings and active infestations must be treated. The loose frass they produce is gritty like fine salt, unlike that of powderpost beetles, which is compacted in the galleries and is fine and powdery.

Pinhole borers infect only green timber and standing trees, and die out as the wood dries. All the damage they do is done before normal use of the wood, so no action is required. Common among the pinhole borers are the ambrosia beetles whose galleries have a characteristic dark stain.

The ***European house borer*** (*Hylotrupes bajulus*) is an introduced pest which is occasionally found in imported timber. It attacks the sapwood of seasoned softwoods and can cause major structural damage. Quarantine controls apply to imported timber to prevent further infestations.

Control measures for active borer infestations include spraying, coating and injection of insecticides, and fumigation with toxic gases, sometimes of complete buildings. Handling and applying the chemicals involved needs specialist skills.

Termites found in firewood. Never stack firewood against walls! The dark-headed termites are soldiers and the white ones are workers. Identification of termite species is generally based on the shape of the head and pincers (mandibles) of the soldiers.

Photograph by Peter David Young.

Termites

Unlike borers, termites are a major hazard to wooden building structures and contents. Often incorrectly called white ants, termites are social insects living in colonies numbering more than a million. Mature colonies have three main types of termite: reproductives, soldiers and workers.

Wood-eating termites are classified according to their living and feeding habits: dampwood, tree-dwelling, subterranean and drywood termites. The last two are the most common types found in buildings.

Subterranean termites

Subterranean termites live largely underground, building their nests in old tree stumps and root systems. Some forms build prominent nest mounds which may be up to three metres high. From the nests, tunnels or galleries radiate outwards to sources of food, which may be trees, fallen logs, posts, or stumps of timber buildings. Subterranean termites need a dark, moist environment, such as a poorly ventilated or drained subfloor area, and cannot survive for long in the open, sunlit air.

Termites can extend their tunnel system above ground by constructing shelter tubes of mud in search of more food. These tubes may run up the side of a building pier or stump or over the base of masonry walls to a timber floor above. From the flooring, termites may invade wooden components throughout a building, including the roof framing. The first sign of activity is often the collapse of floorboards.

Termite control

Good building construction incorporates termite shields (ant caps) on stumps and piers. These are not intended to prevent termites entering the timber above, but to slow them down and force them to build shelter tubes out and around the shields, where the tubes can easily be seen.

For many years the standard barrier against termites has been insectidal chemicals sprayed into the soil around piers and stumps and against the base of masonry walls. Organochlorines, once commonly used for this purpose, are being phased out around Australia owing to their high toxicity and persistence in the environment. In NSW they have been illegal since 1 July 1995. Less hazardous chemicals (organophosphates) can still be used, but require frequent reapplication.

Unlike borers, termites are a major hazard to wooden building structures and contents.

Physical barrier systems are an alternative to chemicals. Two types now in use are stainless steel mesh and crushed granite screenings. The holes in the mesh and between the granite particles are too small for termites to crawl through, and the steel and granite are too hard for the termites to chew. Though principally designed for use in new buildings, these methods may have some applications in protecting existing buildings.

Investigation reveals the extent of damage due to termite activity.

Photograph by Bruce Edgar.

When termites are discovered

If active termites are discovered they should not be disturbed. Cover any breach in their shelter tubes with mud, and seal breakthroughs into galleries in timber sections immediately with masking tape or similar adhesive. Then seek specialist advice from someone with appropriate skills (such as an entomologist) to identify the termite species and hence likely nesting habits.

If the nest can be located (relatively straightforward for mound-building species) it should be destroyed or treated. Colonies whose nests cannot be located are best treated with arsenic dust, a slow-acting poison that is carried back to the nest by foraging termites and will slowly kill the whole colony. Household insecticides may kill termites locally but are most unlikely to reach the nest and eradicate the colony.

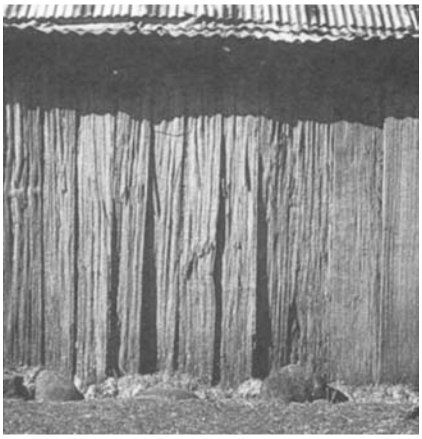
Arsenic dust is highly toxic and should only be handled by someone with appropriate training. After treatment the building should be carefully monitored for signs of termite activity. Once activity is extinct the damaged timbers should be conserved or replaced, and consideration given to the installation of some form of barrier.

Drywood termites

Unlike subterranean termites, drywood termites do not require continuous contact with the ground, as they can obtain moisture from the wood in which they feed and live. Native drywood termites are found in northern Australia, where the climate and wood are wetter; here they can be a problem for buildings. More significant are several introduced species, particularly the West Indian termite, which has been found in several places between Sydney and Brisbane. Whereas subterranean termites produce a dusty frass, drywood termites have distinctive faecal pellets. They are usually treated by fumigating the whole building with methyl bromide, a procedure requiring specialist advice and skills.

Arsenic dust is highly toxic and should only be handled by someone with appropriate training. After treatment the building should be carefully monitored for signs of termite activity.

This wall may be picturesque, but it is decaying rapidly due to build-up of soil. Grass against the slabs promotes fungal rot and risks termite attack.



Photograph by Peter David Young.

Preventive conservation

Keep it dry!

Keeping wood in buildings dry will significantly reduce the risk of:

- swelling and shrinkage cracking
- fungal rot
- attack by termites and some borers.

Ensure that roof drainage, guttering and stormwater disposal systems are working properly, that there are no plumbing leaks, and that any surface water is drained well away from walls. Underfloor spaces should be kept well ventilated.

Keep it coated

Coatings such as paints, varnishes, waxes and oils are the principal means of controlling swelling, as well as protecting and enhancing timbers. Most coatings act as barriers and prevent water penetration into the porous cellular structure of wood. End grain, a cross-section through the original fluid transport system of the wood, is especially vulnerable and requires thorough coating. However, no coatings are totally impermeable to air or water vapour and so moisture can still enter and leave the wood slowly. Small checks or splits in paint coatings are a sign that the wood is swelling and shrinking excessively and that repainting is needed.

Regular maintenance inspections

Wooden items need regular maintenance, and should be inspected every six months. Look in subfloor spaces for signs of rot and termites in the flooring and framing. In roof spaces, look for evidence of leaks that may promote fungal growth. Any sign of breakage or distortion of roof structures should be investigated by a structural engineer. Check external paint finishes for splitting or cracking that may indicate water penetration to the wood beneath.

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