ecoeducation

Department of Environment and Conservation

Sustainable forests

Student pre-excursion notes

1. About wood

Adapted from PRIMEFACT 541, May 2008, NSW Department of Primary Industries

Wood is an extremely important renewable, versatile and beautiful raw material. In Australia, about one cubic metre ($1m^3$) or one tonne of wood is used for every person each year.

Wood comes from living, growing trees and therefore is a renewable material. In many parts of Australia and other parts of the world, large areas of forest have been set aside to be managed primarily for the continued production of wood. Sustainable management of our forests, the primary source of the wood we use, ensures a continual supply of timber to meet present and future needs.

There are many different kinds of wood, produced by distinctive tree species. While all wood shares common features, wood from different trees has different end-use potential.

What is wood?

Wood comes from the trunk (main stem) of trees. A tree's stem serves two main purposes:

- to support the branches, leaves and flowers of the tree up into the light, holding these aloft and against buffeting from wind and storms
- to transport water and nutrients from the roots to the leaves and convey sugars and other compounds from the leaves to other areas of the living tree.

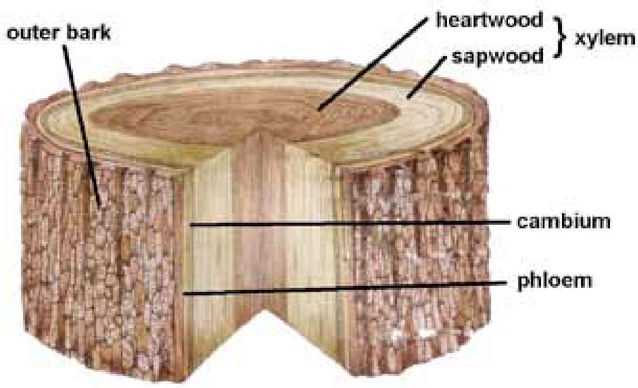
The cross-section of a tree trunk is made up of four principal layers. The outermost section is a ring of bark made up of two layers: an outer layer of dead corky material, the outer bark, and an inner layer of live bark, the phloem. The outer layer is made up of epidermal cells which protect the stem from damage or dehydration. The phloem transports sugars and other compounds made in the leaves to other living cells in the tree.

The next layer is the cambium, which usually feels slimy in a freshly cut stem. This thin layer is made of cells which produce phloem (to the outside) and xylem (to the inside).

The cambium is the only place in a stem where new growth takes place and its cells are constantly dividing to form new wood and new bark. As a result of the continual division of cells, the cambium layer slowly moves outwards as the tree increases in girth. As the tree expands in girth, the outer bark periodically splits or is shed and is replaced by the new outer layer.

Under the cambium, living xylem cells (sapwood) carry water and minerals from the roots to the leaves. Dead xylem cells make up heartwood which is the woody tissue (group of cells) that makes up the bulk of the stem.

Figure 1: Cross-section of a tree trunk



Different kinds of wood in a tree

Two kinds of wood are found in mature trees. When cross-sectioned, the central part of the wood (usually the bulk of the cross-section) is the heartwood. Around the heartwood, in a broad ring, lies the sapwood. It is paler in colour compared to the heartwood and is often whitish or cream in colour.

Heartwood consists of dead material. It helps support the tree and has no role in the growth of the tree.

Sapwood, on the other hand, is made up of living xylem cells which carry water and nutrients upwards from the roots.

New sapwood is formed by cambium cells as a tree grows. As new sapwood is formed, the innermost sapwood cells die and become heartwood. These cells slowly fill and become blocked with tannins, resins and other substances, making the wood darker in colour and, in some species, more resistant to decay and insect attack.

Annual rings

Trees that experience an annual growth pattern of slow and rapid growth rates are characterised by annual rings. Each ring represents one year's growth. Annual rings are found in most trees which originate in Europe and North America, where there are marked seasonal differences between warm and cold periods. By counting the number of annual rings it is possible to determine a tree's age.

In Australia, some native trees have annual rings, while others do not.

Growth rings are a feature of trees which grow in climates where growth virtually ceases for part of the year, such as during cold winter months. In spring, when these trees start growing again, wood is formed relatively rapidly and these earlywood cells tend to be large and thin-walled. Later in the season, as tree growth slows, the cells become smaller and thicker-walled. The larger thin-walled cells tend to be paler in colour than the smaller thick-walled cells. An annual ring is made up of these two layers – the layers of thin- and thick-walled cells.

Softwoods and hardwoods

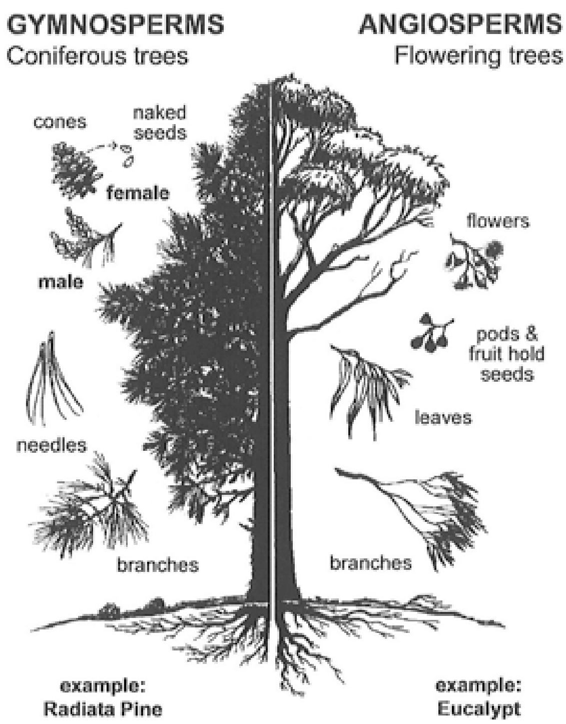
There are two main types of wood – softwood and hardwood. These terms refer to the water-conducting cells in a living tree from which timber comes and not to the density of the wood itself. The difference between the cells can be identified when timber samples are observed through a microscope or under a powerful magnifying glass.

In softwoods, the water-conducting cells are known as xylem tracheids and are tapered in shape, while in hardwoods these cells are tubular shaped and called xylem vessels.

Conifers are an example of gymnosperms, or cone-producing plants. All conifer species are softwoods, including radiata pine, an introduced pine species grown in softwood plantations in Western Australia.

Angiosperms are flowering plants. Eucalypts are an example of angiosperms and are also a native hardwood species. Balsa wood, although a 'soft' wood, is actually an angiosperm, and is therefore a hardwood.

Figure 2: Some differences between gymnosperms and angiosperms



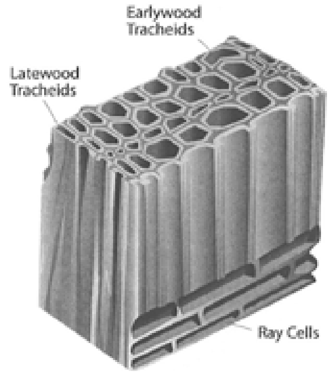
Softwood

The wood of gymnosperms is commonly referred to as softwood and occasionally as non-pored wood. An example of softwood timber is pine, sometimes also referred as whitewood.

The bulk of softwood is made up of long narrow cells, or tracheids, which fit closely together. The cell walls of tracheids are made of cellulose, and the centres are hollow. Tracheids lie alongside each other and another substance, lignin, is deposited between the touching cell walls. This helps to 'glue' and hold the tracheids firmly together. Conifer tracheids can be up to four millimetres long and serve to transport sap and strengthen the stem of the tree. Pits in the cell walls of the tracheids enable sap to pass from cell to cell as it moves up the stem.

Australia has very few native softwoods. White cypress pine is an example of a native softwood growing in some parts of Australia. Softwood plantations of introduced (exotic) pine have been established in WA to meet community needs for softwood timber. Radiata and maritime pine (*Pinus pinaster*) are the main species grown in pine plantations in the south-west.

Figure 3: A close-up section of softwood



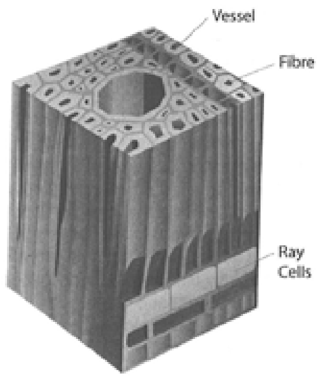
Hardwood

Broad-leaved trees, such as eucalypts and corymbias, are hardwood trees. Most Australian native timber trees are hardwoods. The wood of these trees is made up of two distinct types of cells – vessels and fibre cells.

Sap is carried upwards in large ducts known as vessels or pores. These start as wide cells with large cavities, arranged one above the other. In some cells the end walls break down to create long pipes running considerable distances. Vessels can usually be seen with the naked eye. Timbers with vessels are sometimes called pored timbers (hardwoods) and the arrangement of the vessels in a cross-section is a useful aid in identifying different timbers.

Strength in broad-leaved trees is imparted by other types of cells, called fibres. These are similar to conifer tracheids but are shorter in length (commonly about one millimetre long) and usually thicker walled. Fibres make up the bulk of the wood in broad-leaved trees. Like tracheids, the cell walls are made of cellulose and neighbouring cells are held together by lignin.

Figure 4: A close-up section of hardwood



Other wood cells

Among the other types of cells that occur in wood are ray cells. These store food in the stem and are found in all timbers. Unlike the other cells of sapwood which are arranged vertically, ray cells are arranged horizontally, extending radially outwards towards the bark. These cells give wood a distinctive sheen when it is radially split.

Often rays are only one cell wide and several cells high and quite difficult to see without a magnifying lens. However, in some trees the rays are very large and give the wood its characteristic patterns such as those seen in oaks and other timbers such as banksia and sheoak.

Properties of wood

Although the wood of all trees consists essentially of cellulose fibres held together by lignin, different trees produce woods with many different properties that make them suitable for different purposes.

The density of wood depends on the thickness of the fibre walls in relation to the size of the cells' hollow centres. Light timbers (for example balsa) have cells with very thin walls and a large hollow, while in contrast, dense timbers (such as ironbark) have cells with thick walls and a narrow hollow.

The colour of wood is determined by various substances, such as polyphenols, which are deposited in the cell walls. In most woods, the heartwood is distinctively coloured, commonly red, pink, brown or yellow and sometimes even black. While heartwood is usually evenly coloured, in some woods the colour is unevenly distributed, giving a streaky appearance that can be highly decorative (like walnut, for example). Some woods have a pale coloured heartwood not easily distinguished from sapwood.

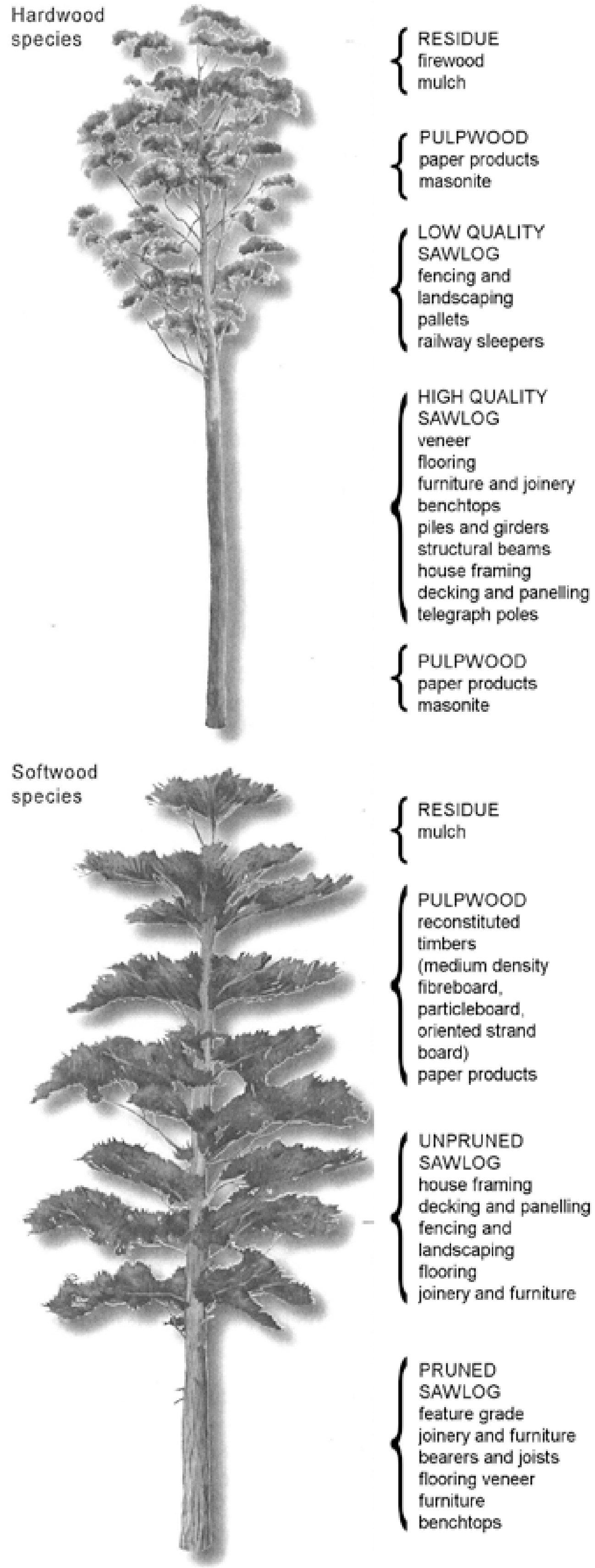
The figure or pattern of wood is the ornamental appearance produced by the interaction of such features as colour, the arrangement of the fibres, vessels, latewood and earlywood, and so on.

Other properties vary considerably between species and may effect the way the timber can be used. These properties include shrinkage as the wood dries, fibre length and the ratio between fibre length and hollow diameter (important when wood is used for paper making), hardness or resistance to marking, durability against attack by insects, fungi and other agents, strength properties that can vary markedly between seasoned wood (wood that has been dried) and green wood (wood with a high moisture content such as wood just cut from a living tree) and flexibility. Other important features that affect end-use potential are how dimensionally stable the wood is in its end-use application, the ability to absorb preservative treatment, ease of nailing, gluing and machining, and how well paint and other materials bond to the wood surface.

Uses of wood

The kinds of products that can be made from different types of wood is determined by the species and quality of timber grown. In many cases, wood properties and end-use potential improve with age, so it is not always possible to grow species in plantations and obtain the same end-use as is possible from wood from older trees from native forests.

Figure 5: Several different products are created from the different grades of timber within a single tree

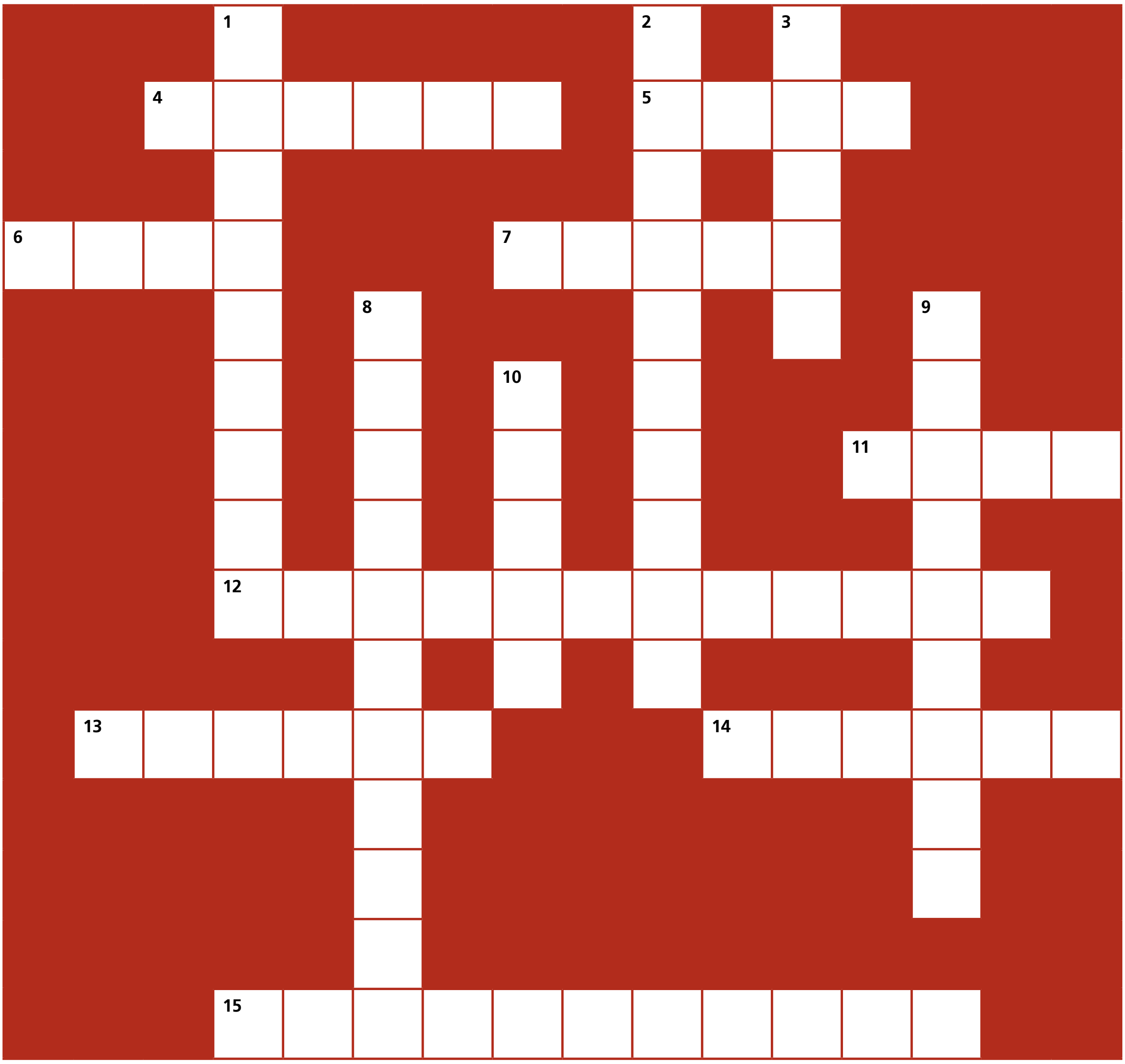


Major timber species

There are many species of tree grown in state forests and plantations of WA which are used for timber. However, few are used commercially because many are restricted to conservation reserves. A few of the most commercially important tree species grown in WA are:

- jarrah (*Eucalyptus marginata*) – the main native hardwood species harvested for timber which grows in the lateritic soils of south-west WA. The heartwood is dark red and relatively coarse in texture. The basic density of the timber is 670 kg/m^3. The timber is hard, strong and tough. The major uses for jarrah are for joinery, paneling and furniture and its excellent termite resistance means it is suitable for fencing. In the past the timber was used extensively for general construction, sleepers, poles and piles.
- radiata pine (*Pinus radiata*) and maritime pine (*Pinus pinaster*) – introduced (exotic) tree species originating from California and Mediterranean Europe respectively and planted in plantations in the south-west. *Radiata* is currently the more extensively planted species in WA, and is planted widely in other parts of southern Australia. Pines produce a non-pored softwood timber, pale to light brown in colour, with marked annual rings. The basic density of the timber is 380–480 millimetres. The timber is easy to work, making it a timber with low natural durability. It is used for joinery, flooring, panelling, building framework, packaging, paper pulp and particleboard manufacture. Round timber is preservative treated and used widely for fencing and poles.
- Tasmanian blue gum (*Eucalyptus globulus*) – extensive plantations have been established in the south-west on ex-farm land. It produces a yellowish-brown heartwood with a medium texture and distinct growth rings. The basic density is 540 kg/m^3. It is mostly used for export woodchips to produce pulp and high quality paper. Wood from blue gum from native forests in Victoria and Tasmania may also be used as general structural timber, flooring and furniture timber.
- sandalwood (*Santalum spicatum*) – a small parasitic tree growing in arid regions which establishes on the roots of other trees. It produces a yellow-brown heartwood with a distinctive fragrance. Its main use is for incense sticks in south-east Asian countries and the wood commands a very high price. It was WA's major export until gold was discovered in the 1890s. The timber makes very attractive inlays in parquetry, as well as being used for other craft items. The shavings are used for potpourri.
- karri (*Eucalyptus diversicolor*) – one of Australia's and the world's tallest hardwoods, karri is the second major native timber species in WA. Mature trees produce a hardwood that is pale pink to reddish-brown, though regrowth timber is a lighter colour. Its basic density is about 690 kg/m^3. Karri is now being used more extensively for flooring and panelling, and has potential for fine design furniture. It has been used extensively for general construction, shipbuilding, sleepers, guides or side beams in mines, structural plywood, roofing timbers and pulp and paper. Greater lengths are available than from any other WA hardwood.
- marri (*Corymbia calophylla*) – commonly referred to as redgum, marri is widely distributed in the south-west in the jarrah and karri forests. The heartwood is pale yellow to reddish brown with a basic density of 650 kg/m^3. Sawmill recoveries are low because of the extensive occurrence of kino or gum veins though there is an increasing market for feature grade timber for furniture use. The timber has been used in general construction, case manufacture, tool handles, sporting goods and oars, and for making paper.

Crossword - About wood



Across

4. Durable native timber
5. Tree food factory
6. Renewable material
7. Exotic softwood trees
11. Dead corky material
12. Source of timber in WA
13. *Corymbia calophylla*
14. Bark tissue
15. Able to keep in existence

Down

1. Broad-leaved trees
2. Crop of trees
3. Soft hardwood
8. Counted to discover the age of some trees
9. Support layer of a tree
10. Wood tissue

2. Forests, timber and climate change

Adapted from PRIMEFACT 688, October 2008, NSW Department of Primary Industries

The current challenge

Climate change is a current global challenge. The increase in carbon dioxide and other gases in the atmosphere have been associated with global warming or the greenhouse effect.

Forests and forest products play a vital role in using and reducing these greenhouse gases, which influence the greenhouse effect.

The greenhouse effect explained

The greenhouse effect occurs naturally. A combination of gases in the Earth's atmosphere are known as greenhouse gases. These include carbon dioxide (CO_2), methane (CH_4), water vapour and nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). These gases form a shield around the Earth.

Sunlight passes through the Earth's atmosphere and is reflected back into space. Some of this reflected light will be trapped by the greenhouse gases. This is the greenhouse effect, a natural process that maintains an average temperature of 16°C on Earth and ensures the survival of plant and animal life.

If there were no greenhouse gases in Earth's atmosphere the environment would be similar to that of the moon where there is no evidence of life.

Only about one per cent of the Earth's atmosphere is made up of naturally occurring greenhouse gases. If this fine balance of gases is thrown out, there could be significant effects on Earth. These could include increases in the average temperature, changes in the world's rainfall pattern and vegetation cover, and rising sea levels from melting ice caps.

Greenhouse gas emissions have increased due to human activity since the industrial revolution started in the 1800s. These activities include the burning of fossil fuels, increased mining and the clearing of forested land for agriculture and housing. Carbon dioxide is the main greenhouse gas produced from these activities. Scientists believe carbon dioxide levels increased by 25 per cent between 1900 and 1985.

Use of carbon dioxide in forests

Plants carry out a process called photosynthesis in which carbon dioxide in the air is absorbed through their leaves and, with energy from the sun, is used to make food. As part of this process, the carbon is stored or 'fixed' within the stems, leaves and branches of the plant and oxygen is released into the air. This is often called 'sequestration'. Fifty per cent of the dry weight of plant biomass is carbon. One tonne of carbon represents 3.67 tonnes of carbon dioxide. The carbon dioxide is only released into the atmosphere when the plant is burnt or decomposes.

Carbon credits

In NSW, carbon credits are recognised reductions or absorptions of carbon relative to the normal way of doing things. A carbon credit is equivalent to one tonne of carbon dioxide (CO_2). Within NSW carbon credits from eligible forests may be created by accredited entities under the NSW Greenhouse Gas Reduction Scheme (www.greenhousegas.nsw.gov.au).

Companies or individuals creating more carbon certificates than they need can sell the extra certificates to carbon emitters who need to reduce their greenhouse gas emissions. As yet there is no similar scheme operating in WA.

The role of planted forests

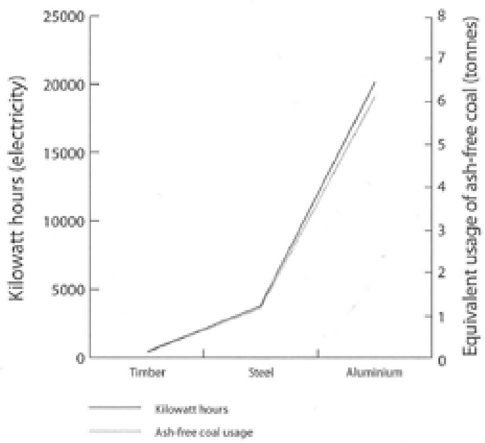
New pine and eucalypt plantations in WA are established on existing cleared land. The larger the area of plantations established and the faster they grow, the more carbon dioxide will be removed from the atmosphere, thus reducing the imbalance in the greenhouse effect.

The advantages of using timber

Timber and other wood products store the carbon dioxide they absorbed when they were growing trees. The carbon stored in the timber will not be released even when a tree has been harvested and processed into timber products.

Plastics (derived from petrochemicals) and metals such as steel or aluminium actually produce greenhouse gases during their manufacture. Even the process of extracting raw materials from the ground, such as bauxite for aluminium, results in greenhouse gas emissions.

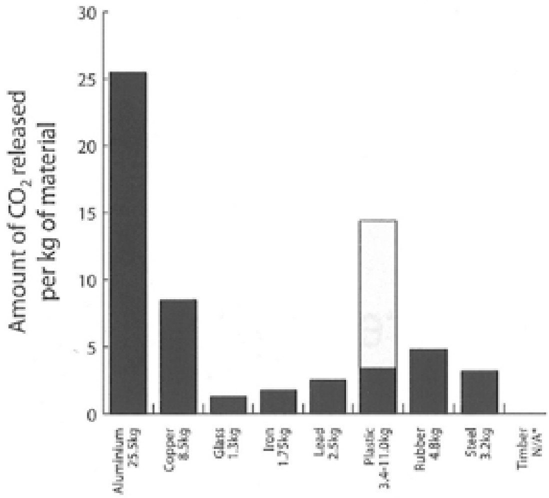
Figure 1: Comparison of energy usage in production of building materials (producing one tonne of each)



The figure above shows it takes far less energy to produce timber than it does to produce steel or aluminium for use as building materials.

Energy is equivalent to electricity. The main source of electricity in WA is coal. Coal is formed from dead plant matter after millions of years of heat and compression. Coal therefore contains large amounts of carbon, which is released into the air when it is burnt to make electricity. So, the less electricity used, the less carbon dioxide released into the atmosphere.

Figure 2: Amount of carbon dioxide released during manufacture of different materials

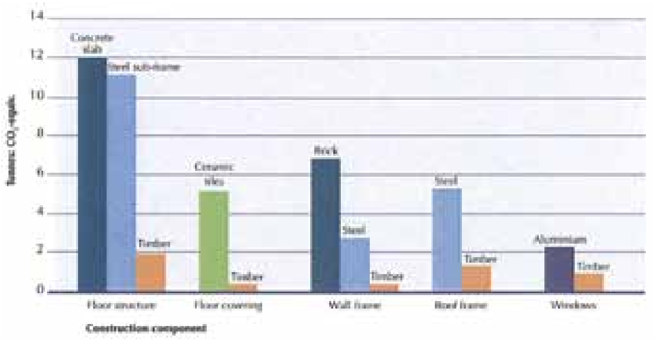


* Timber contains stored carbon dioxide from the atmosphere. Although some carbon dioxide is released during the milling of timber, the net effect is that 8.3kg of carbon dioxide is actually absorbed during both the growth and processing of timber and no carbon dioxide is produced.

** Carbon dioxide emissions for plastic production depend on the type of plastic. This range is represented by the grey bar.

The Cooperative Research Centre for Greenhouse Accounting studied the greenhouse implications of substituting forest products for alternative materials in house construction. By choosing wood products wherever possible, greenhouse gas emissions equivalent to up to 25 tonnes of carbon dioxide per house could be saved. This is because wood requires much less energy in its manufacture than competing materials and also because it continues to store the carbon sequestered by trees.

Figure 3: Greenhouse gases emitted in the manufacture of building materials used in a range of construction for a single storey house in temperate Australia



(Source: Inwood International Magazine, Issue 55, February–March 2004)

Forests and forest products have an important role to play in reducing greenhouse gases. Mature forests are important storehouses of carbon and younger, regrowth forests and plantations actively take in large amounts of carbon dioxide from the air and store carbon in their wood fibres. Timber products not only require far less energy to produce than alternatives such as steel and aluminium, but also act as a long-term storage for carbon.

Further reading

TimberCam, a timber carbon accounting model developed by NSW DPI
http://www.dpi.nsw.gov.au/forests/info/timbercam

Intergovernmental Panel on Climate Change
www.ipcc.ch

United Nations Framework Convention on Climate Change
http://unfccc.int/2860.php

Greenhouse Gas Reduction Scheme
www.greenhousegas.nsw.gov.au

Australian Government Department of Climate Change
www.greenhouse.gov.au

Temperatures rise in the global greenhouse by Gribbin, J, *New Scientist* 110 (1508): pp.32–33.

'Greenhouse gases: evidence for atmospheric changes and anthropogenic causes' in Pearman (ed.) Greenhouse, E. J. Brill Publishers, Leiden, p.752.

'Organic matter accumulation in a series of Eucalyptus grandis plantations' in *Forests Ecology and Management* 17: pp.231–242.

Timber in building construction ecological implications, Lawson, W.r, University of NSW, 1996.

Questions - Forests, timber and climate change

1. The greenhouse effect is a natural phenomenon, so what's the problem?

2. Name some greenhouse gases. Which of these can be reduced by forests?

3. Draw a diagram to explain the greenhouse effect.

4. How do people enhance the greenhouse effect?

5. Why can regenerated forests be referred to as carbon sinks?

6. What is a carbon credit?

7. Explain the different roles that young and mature forests play in reducing greenhouse gases.

8. What are the advantages for climate change in using timber as a building material?

9. What could you do to reduce the amount of carbon dioxide produced and already in the atmosphere?

10. Use Figure 3 from the worksheet to calculate the difference in carbon dioxide emissions between a house constructed entirely from timber than one which has a concrete floor, brick walls, a tiled floor, a steel roof frame and aluminium window frames.

11. Use the internet or other means to research four other ways in which you could design a house to reduce greenhouse gas emissions over the life of the house.

3. Forests and forestry in WA

Adapted from PRIMEFACT 687, April 2008, NSW Department of Primary Industries

Why do we need forests?

Forests have always been valuable to humans, providing shelter and protection, fuel and building materials, and a source of many foods and drinking water. As civilisations developed, forests were sometimes seen as obstacles standing in the way of progress and future development, occupying the land needed for farming and urban development. Vast areas of the world's forests and woodlands have been cleared to make way for these activities.

Today, the most pressing long-term effects of extensive forest clearing are soil erosion, in particular the irreplaceable loss of valuable topsoil, siltation of rivers and other water courses, shortages of timber and the loss of unique wildlife. After two centuries of European settlement, Australia provides many examples of the ill effects of forest clearing, mainly for agriculture but also for cities and towns.

We are just as dependent on forests as past generations. Forests produce timber and other materials, protect water catchments and provide habitat for wildlife. They also provide places for recreation, purify the air we breathe and the water we drink and provide breathtaking vistas and areas of natural beauty.

Most of Australia's remaining forested areas are managed by national or state agencies. Publicly owned forests in WA are managed as state forests, national parks, nature reserves, community conservation areas, water catchment reserves, vacant Crown land and state recreation areas. The forest areas we have today in Australia exist because they were reserved for timber and other values. State forests in WA are managed to ensure that forests will continue to exist and provide their many benefits and values. Within these forests large areas of special conservation value are reserved, forming an important part of the WA reserve system.

Today around 17.6 million hectares of forests and woodlands remain in WA and there is about 400,000 hectares of plantation forests. In the south-west of WA the Department of Environment and Conservation (DEC) manages approximately 2.46 million hectares of state native forests. These forests are dominated by eucalypts unique to the south-west.

What do we get from state forests?

Ecologists throughout the world agree that reservation is a crucial technique for conserving ecosystems. WA's forest reserve system contains more than a million hectares in national parks, conservation parks, nature reserves and other reserves.

This system of reserves will protect and maintain the full spectrum of biodiversity:

- forest communities
- individual species
- genetic diversity within species
- habitat
- evolutionary processes
- ecological support systems.

In areas of state forest where activities such as wood production and mineral production are permitted, biodiversity can be maintained by complementary management outside reserves.

The identification and protection of special zones and corridors along streams and roads and around wetlands, heaths, woodlands and rock outcrops ensures that multiple-use forests can maintain a rich assemblage of plants and animals that complements biodiversity conservation in other reserves.

Timber from state forests is used in: home construction for framing, flooring and weatherboards; furniture, tools and toys; railway sleepers; bridge girders; wharf piles; poles to support our telephone and electricity wires; fence posts; props for underground mining and pulpwood for paper and building boards – to name just a few.

Other products obtained from state forests include fuel wood, essential oils for medicinal and industrial use, charcoal, seeds, wildflowers and honey.

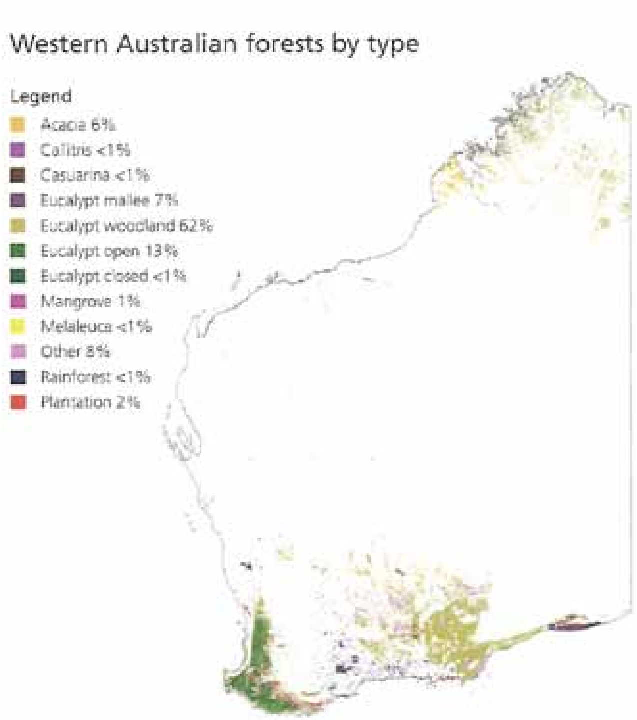
Forests absorb carbon dioxide emissions from the atmosphere and use the carbon to make sugars and complex molecules like cellulose and lignin – forming wood, branches, roots, leaves and bark. About half a tree's dry weight is carbon. If a forest is planted on cleared grazing land, the growing trees dramatically increase the total carbon stored on the land.

Forests also play an important role in water catchments. Most of our rivers in the south-west have at least part of their headwaters in state forests. From these forests comes water that is used for town and rural supplies. Forests filter rainwater and run-off entering watercourses, ensuring good water quality.

State forests also have aesthetic value, contributing to the attractive landscape and rural scenery of WA.

Furthermore, state forests provide many recreational opportunities. Forest roads give access to areas of natural beauty and to scenic lookouts. Picnic areas, camping sites, walking and riding trails, forest drives and other recreation facilities have been installed in many state forests for the enjoyment of the public.

What kinds of forests and woodlands do we have in Western Australia?



Forests and woodlands contain hundreds of different species of plants and animals that have adapted over time to their particular environmental conditions. It is the mix of plants (the trees and the understorey plants) growing in an area which define the forest type of the area. Many forest types can be recognised in WA.

Many different species of trees occur in state forests including more than 200 species of eucalypt, nearly 400 species of acacia (wattles), and over 600 species of Proteaceae.

Different tree and understorey species have their own particular growing requirements, such as soil type, water and nutrients, climate, position (aspect) and fire regime. As a result, each species is found in certain places – some species are widespread, while others are restricted to defined areas.

How are state forests managed?

State forests in WA are managed for multiple use on an ecologically sustainable basis. That is, they are managed in such a way as to conserve the forests, preserving unique flora and fauna species and their habitats, and also ensure the continued supply of timber and other products, while providing clean water and many recreation opportunities.

Values and uses of forests include:

- Aboriginal and other cultural heritage sites
- aesthetic views
- conservation of ecological communities
- water supply
- beekeeping
- bush foods and medicines
- education
- fuel wood
- recreation
- timber supply
- wildlife conservation
- carbon sequestration
- salinity control.

Managing a state forest requires extensive planning and assessment of all activities. Forest activities that impact on soil, water and flora and fauna populations, distribution and habitats are carefully planned and monitored.

Professional foresters, ecologists and other scientists and experts manage state forests in WA. They have the task of planning, implementing, monitoring and reviewing all forest activities and impacts, to ensure that all the competing uses and values of the forest are balanced and maintained.

DEC and the Forest Products Commission (FPC) manage forests by:

- planning – including timber harvesting plans, road construction, recreation areas, hazard reduction burns and forest reserves
- supervising – all activities that disturb the forest
- assessing and managing – forest growth, pests and diseases, regeneration, impacts on the forest environment, flora and fauna populations.

Forest assessments conducted as part of the Regional Forest Agreement (RFA) process identified areas of high natural, cultural and Indigenous value. Areas of high value have been incorporated into the forest reserve system into conservation reserves (including national parks).

The forestry activities carried out in a state forest are governed by laws, standards, codes of practice and conditions set and agreed by the state government and acknowledged by the federal government. Authorisation for these activities is granted through the Forest Management Plan (FMP), prepared by the Conservation Commission of Western Australia, approved by the Minister for the Environment, regulated by DEC and implemented by FPC.

Useful resources

Conservation and Use of Western Australian Forests, Underwood and Bradshaw (ed.), The Institute of Foresters of Australia (Pub.), 2000

Forest Products Commission
www.fpc.wa.gov.au

Department of Environment and Conservation
www.dec.wa.gov.au

Department of Sustainability, Environment, Water, Population and Communities
www.environment.gov.au

Conservation Commission of Western Australia
www.conservation.wa.gov.au

Questions - Forests and forestry in WA

1. What two activities have resulted in the clearing of large areas of forests?

2. What do people depend on forests for?

3. List 10 uses of timber obtained from WA's state forests.

4. Explain the role forests play in reducing greenhouse gas emissions.

5. How do landowners and the community benefit from planting forests?

6. Name two areas excluded from timber harvesting in WA.

7. Besides forest products, what are forests valued and used for?

8. How many species of tree can be found in WA's native forests and what are some of the main groups of trees?

9. What are the three main species of native hardwoods harvested for producing timber in WA's south-west forests?

10. State forests are managed for multiple use on an ecologically sustainable basis.
    a) What is meant by 'multiple use'?
    b) Explain the term 'ecologically sustainable'.

4. Timber harvesting in native state forests

Adapted from PRIMEFACT 693, October 2008, NSW Department of Primary Industries

Forest management

There are about 2.6 million hectares of native forests in the south-west of WA of which about 90 per cent is on public land. These forests are managed for multiple values on an ecologically sustainable basis. That is, they are managed in such a way as to conserve the forests, preserving unique flora and fauna species and their habitats, and also ensure the continued supply of timber, water and other products.

Managing WA's public forests is the responsibility of three government agencies:

- The Conservation Commission of Western Australia (CCWA) in which the public forests are vested. The CCWA is responsible for preparing management plans and for monitoring and auditing their implementation.
- The Department of Environment and Conservation (DEC) manages lands on behalf of the CCWA and prepares draft management plans for the CCWA, including the Forest Management Plan (FMP). The FMP is the framework DEC uses to manage activities in state forests. This includes setting management standards and supervising and monitoring their implementation.
- The Forest Products Commission (FPC) is responsible for managing the harvesting, regrowing and sale of timber according to the requirements of the FMP.

Ecologically sustainable forest management

Ecologically sustainable forest management (ESFM) is the guiding philosophy for forest conservation and management. The forest is managed to maintain ecological processes and biodiversity while seeking to optimise the benefits to the community from all uses of the forest, both now and into the future. Within publicly owned native forests, around 50 per cent is set aside permanently from timber harvesting as part of a comprehensive, adequate and representative (CAR) reserve system, and is managed primarily to conserve environmental, biodiversity and recreation values. About another 12 per cent of the forest is included in smaller reserves such as road, river and stream reserves which ensure diversity in forest structure at the landscape scale and help to connect the larger reserves.

Outside the CAR reserve system, values such as forest plants and animals, water quality and Aboriginal and other Australian cultural heritage are also protected through a rigorous process of planning, approvals and prescriptions that are required by legislation, the FMP and codes of practice.

The FMP exists predominantly for the forest areas of DEC's Swan, South West and Warren regions. The FMP provides the strategic framework for the management of planted and native forests until 2013. The FMP shows how DEC and FPC implement sustainable forest management and is used to inform policies, procedures and guidelines in areas such as fire management, soil and water protection and conservation of flora and fauna.

Regulations for timber harvesting

Timber harvesting in WA is strictly controlled by the *Forest Management Plan 2004–2013* (FMP), which is monitored by the Conservation Commission and was assessed by the Environmental Protection Authority.

In WA, all old-growth forest is excluded from timber harvesting where it is either protected in the conservation reserve system or in areas referred to as informal reserves.

Timber harvesting is excluded from 1.38 million hectares of national parks, nature reserves, conservation parks, forest conservation areas and informal reserves. Under the FMP, about 850,000 hectares, or approximately 38 per cent of the total forest area, is available for sustainable timber harvesting, following Conservation Commission requirements and contemporary silvicultural practices to ensure sustainability for future generations.

Each year, only a small percentage (about 0.5 per cent) of native state forests in WA is harvested. Timber production is conducted on a sustained yield basis with the amount of timber allowed to be harvested per year set out in the FMP.

FPC also applies strict environmental controls to ensure the state's forest assets are protected. FPC's environmental management system, procedures and controls are externally audited and independently certified under an internationally recognised standard, ISO 14001.

All areas which are harvested by FPC are regenerated to provide bush habitats and timber resources for the future.

The harvest plan

Harvesting plans draw together specialist information on soil and water, threatened species, Aboriginal and non-Aboriginal heritage, silviculture (the care and cultivation of trees), road construction and maintenance, and inventory data (information on the numbers and types of trees in the area). The information is condensed into a succinct plan, including detailed maps developed using a geographic information system (GIS). All annual harvest plans are available for the public to view on FPC's website.

DEC is responsible for developing rolling three-year indicative timber harvesting plans, showing where harvesting is allowed to take place within the next three years. These three-year timber harvest plans are also made publicly available. From these, FPC prepares its annual harvesting plans.

It is essential that FPC staff, contractors and operators follow the site-specific conditions set out in a harvest plan as well as observing the guidelines, manual and procedures developed by DEC as required under the FMP, and codes of practice for operations.

The harvest plan contains detailed maps which outline the areas to be excluded from harvesting such as undisturbed vegetation around streams, drainage lines and road corridors, to protect environmental values, and clearly shows the area where timber harvesting is permitted.

Guidelines that are applicable to available harvesting areas or 'coupes' include:

- pre-disturbance checklist requirements, which ensure that all values present in the area are identified prior to harvesting so that site specific sensitivities can be managed
- road management plan, to identify roads which heavy vehicles are permitted to use
- Phytophthora (dieback) disease management guidelines to outline the hygiene management practices to be applied to the area
- soil management guidelines outlining the timing of harvest activity to minimise damage to the soil during harvesting and measures to ensuring protection of the soil from compaction and erosion
- silviculture guidelines outlining the silvicultural system to be applied, including the requirements to retain habitat elements in every coupe, regeneration and rehabilitation requirements following harvesting.

Harvesting the forest

Harvesting of forest products is carried out by trained contractors engaged by FPC. Harvesting contractors are required to fell trees, prepare and extract log products to roadside landings and load and cart logs to FPC's customers, and must adhere to codes of practice. Some mill customers require logs to be debarked or chipped prior to delivery.

Contractors must work to strict rules and guidelines which focus on accountability, safety, environmental safeguards and proper use of trees felled. These guidelines are contained in a number of publications, including the *Contractors' Timber Harvesting Manual* and the *Safety and Health Code for Native Forest/Hardwood Logging and Plantation Logging*.

The most common products sold include sawlogs (large, medium and small; high quality and low quality), chiplogs (karri), firewood/charcoal logs, poles (for powerlines and bridges), and logs for fencing purposes. Tree species harvested mainly include jarrah, karri and marri, and small quantities of blackbutt, wandoo and sheoak.

FPC also engages consultants from time to time to provide specialist advice or services and engages other contractors for works such as road construction and maintenance, establishment and tending of plantations, carting and application of fertiliser to plantations by ground and by air, carrying out post-harvesting treatment of native forest areas, and supply of various materials, such as fertiliser and drainage pipes.

FPC is responsible for selling logs and other forest products either by state agreements, contracts or auction.

How is harvesting carried out?

Before any trees are cut down, a supervising forest officer from FPC walks through the forest and uses paint or tape to mark the trees to be retained and the reserve boundaries specified in the harvesting plan, as well as conducting other pre-harvesting checks.

Trees are often felled using a mechanical harvester, and less often now by chainsaw, with the operator removing the limbs and head of the tree where it has fallen. A forwarder or skidder then takes the log to a landing, or log dump. The logs are then sorted and graded by a qualified log grader before being hauled by truck to a timber mill.

In the cooler months following harvesting, post-harvest burns are carried out to promote regeneration and reduce the fire hazard.

To ensure compliance with the FMP and appropriate regulations, harvesting operations are continually supervised and monitored by FPC staff. Supervising officers oversee operations, mostly on a daily basis, and DEC officers make spot visits to harvesting operations to ensure that the standards are correctly applied.

Effective management of operations and training and supervision by FPC and DEC minimises incidences of non-compliance with operational conditions, however where they do occur DEC may issue Management Letters (MLs) or Work Improvement Notices (WINs) to specify appropriate remedial action.

Certification

Third-party certification of sustainable forest management has developed around the world in response to markets demanding that imports of timber products are independently certified under an internationally recognised, accredited standard.

Certified forestry operations have to meet strict requirements which show that the practices are sustainable and legal. Unfortunately, large areas of forest around the world are being managed badly, particularly in developing countries with poor systems of law enforcement or insufficient national wealth to fund high-quality forest practices. Forests are simply exploited for wood with little thought to sustainable forest management principles.

FPC is certified to the Australian Forestry Standard (AFS), which has been recognised and endorsed by the world's biggest network of forest certifications systems, known as the Programme for the Endorsement of Forest Certification (PEFC).

FPC is also certified to ISO14001:2004 – Environmental Management System (EMS), the international standard for environmental management systems.

Questions -Timber harvesting in native state forests

1. What is the aim of native state forest management?

2. What is meant by natural values and services to the community?

3. Define ecologically sustainable forest management (ESFM).

4. What is a harvesting plan and how is it created?

5. What is done to minimise the environmental effects of timber harvesting?

6. Who ensures compliance with regulations for timber harvesting?

7. How is harvesting carried out?

8. When and why are harvesting sites burnt?

9. What trees or other plants are always left when a site is harvested, and why?

10. What is the purpose of forestry certification?

5. Silviculture in the jarrah forest

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What is silviculture?

Silviculture is the science, art and practice of controlling the establishment, growth, composition, health and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

Silvicultural systems are developed for forests after initially considering the life history and general characteristics of the tree species. Once these aspects are understood, the broad range of forest values such biological diversity, ecosystem health and protection of soil and water resources can be further considered to design systems that deliver a range of objectives. No single system is appropriate to all situations.

Multiple-use forest, state forest and timber reserves have a number of sometimes-competing objectives. Silvicultural practice aims to provide a balance between all of the objectives while ensuring that our forests are managed sustainably.

Competition

A major component of many silvicultural practices is an understanding of competition for water and nutrients both for individual trees and whole forest stands. Competition between trees is measured in terms of the density of trees in a particular stand of forest. Jarrah is a very persistent species and can survive at high levels of competition, however density affects the growth rate of individual trees, the stand as a whole and other components of the forest such as understorey, general health and water production.

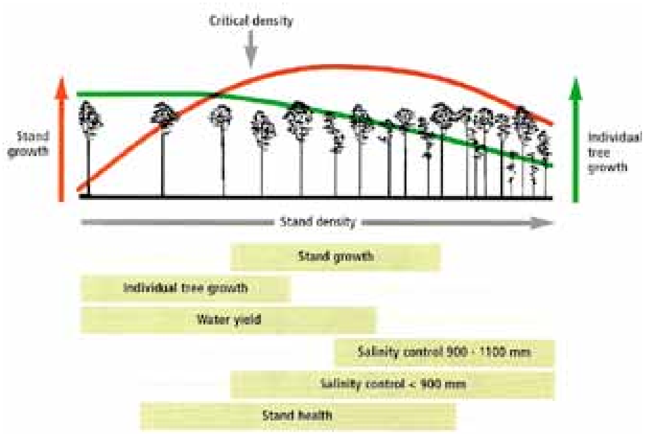
Density measurements in forests are expressed as basal area (BA) in units of m^2/ha, which is the total cross sectional area in square meters of all the tree trunks in one hectare. Density may also be expressed as a stocking of trees in units of 'stems per hectare' (spha).

When the stand density is low and the forest canopy is relatively open, trees do not compete with each other for water and nutrients and grow relatively freely. Low stand density facilitates higher catchment water yield. When stand density is too high, trees compete with each other and may be in a permanent state of stress.

The point at which trees begin to compete for resources and the growth of stand volume begins to slow is known as critical density. The exact point at which this occurs will vary according to soil type and rainfall. In the western jarrah forest, critical density is at about 8–10m^2/ha, in the eastern forest where soil quality is poorer and there is less rainfall, this value is about 6m^2/ha.

The ideal range of stand densities for the production of timber in the western jarrah forest occurs between 10 and 25m^2/ha. A basal area of 10m^2/ha equates to about 300 spha of trees with a trunk diameter at breast height (dbh) of approximately 20 centimetres and a basal area of 25m^2/ha equates to about 125spha of 50 centimetres dbh trees. At lower densities individual tree growth may be greater, however less volume of timber will be produced from each hectare. At higher densities total growth is suppressed by competition.

Figure 1: The range of stand densities most suitable for different management objectives



Growth stages of a jarrah tree

Following germination, *seedlings* develop rapidly. They must extend their root systems quickly to survive the first summer drought and are vulnerable to grazing by both vertebrates and invertebrates. Seedlings in the open will develop much faster than those shaded by mature trees.

Within one to three years the seedling begins to form a small swelling at the base of the stem known as a *lignotuber*. The lignotuber contains many dormant buds and holds a store of nutrients which makes the seedling less vulnerable to fire and grazing.

When the shoot is damaged by either fire or grazing, multiple shoots grow from the lignotuber to form what is known as *seedling coppice.* The lignotuber continues to grow while the shoots form a 'bush' growing little in height. When the lignotuber and root system reach a critical size, the tree is capable of relatively rapid growth into a sapling and is known as a *ground coppice.* It is thought to take approximately 20 years for a seedling to reach this stage of development.

All of the regeneration stages are collectively known as the *regeneration pool.*

When overstorey competition is reduced, ground coppice is 'released' and develops into *saplings* up to about 15 centimetres diameter at breast height (dbh), poles (up to about 45 centimetres dbh) and finally into larger, mature trees.

Silvicultural systems

In addition to thinning, silvicultural systems are broadly divided into systems designed to create even-aged stands (clearfelling) or uneven-aged stands (selection systems). The difference in these latter two approaches is the size of the gap in the canopy created by harvesting and the size of the patches of regeneration which occur.

The jarrah forest is naturally a mosaic of different stand structures so the silviculture is dominated by selection systems, with the gaps created by harvesting generally being 10 hectares or less. Field observation must be employed to determine the most appropriate silvicultural treatment for each stand within the forest mosaic.

Commercial harvesting may be supplemented by non-commercial thinning – the removal of non-saleable trees to improve the growth and health of the remaining trees.

Various forms of 'overwood retention'—keeping some older trees or patches of forest—is also used to provide older elements of the forest for purposes such as a seed source, wildlife habitat and aesthetics.

When a tree is removed from a stand in the jarrah forest it is done for one of the following reasons:

- to improve the health and growth of the remaining trees (thinning, no regeneration required)
- to reduce competition to allow lignotubers to develop into saplings (gap creation – remove the overstorey)
- to reduce competition to allow seedlings to develop into lignotubers (shelterwood – partial removal of the overstorey to allow regeneration to establish and develop).

Only one of these is done in any patch at one time and the patches must be large enough to remove the suppressive effect of surrounding larger trees and to minimise the chance of future felling of these trees to damage the new growth.

Promoting growth

Tree growth is promoted by thinning the regrowing forest. Tree diameter is an important factor in sawlog production. Not only must the tree reach a minimum size before it produces a sawlog, but with a bigger diameter, there is less waste in producing sawn timber and defects in the log can be more easily tolerated.

Potential crop trees are identified that are most likely to provide good quality sawlogs during the next harvest. The maximum number of crop trees required is based on the number the stand can support before growth suppression occurs.

Pole stands may be thinned to approximately 250 spha with a follow-up thinning to 125 spha as the stand matures.

Thinning may be done by non-commercial removal of trees which are not suitable as crop trees (culls), or by removing trees commercially which have already reached sawlog size. Culls do not contain saleable timber but do provide other forest values so only those which are directly competing with crop trees are removed.

Regeneration release

Regeneration release involves removing competition from overstorey trees by creating a gap. This allows for the rapid growth of existing regeneration. Gaps are harvested when the trees are in the mature to senescent development stage, when the tree crowns are no longer able to expand to occupy the space made by removal of individual trees. Gaps are only created where there is an adequate regeneration pool.

Trees which are of sawlog size are removed and sold and some cull trees are also removed. Some potential crop trees and habitat trees will be identified and protected during harvesting.

Regeneration establishment

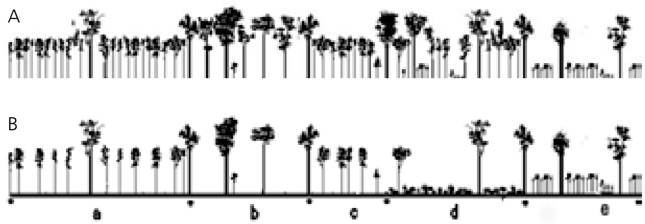
Where the regeneration pool is considered inadequate to regenerate and the forest is in the mature to senescent development stage, the shelterwood system is used to encourage regeneration establishment.

Shelterwood harvesting is also done to allow regeneration but is carried out when there are not enough trees at ground coppice or sapling stage. The aim is to reduce competition from overstorey while also maintaining some forest cover to provide a seed source and maintain a forest environment for aesthetic, salinity management and wildlife purposes.

Understorey trees and plants also compete with tree seedlings so a proportion of the understorey is removed either by fire or by machines to increase the chances for seedling survival. A balance is struck between maintaining the diversity of understorey plants and the requirements of tree seedlings, allowing them to compete effectively with other germinating understorey plants.

Examples of appropriate silvicultural practices

The diagram below shows the range of stand structures that may be found in the jarrah forest as a result of past forestry practices, and the silvicultural treatment that would be applied to each.



a) Large groups of pole-sized trees resulting from removal of groups of mature trees. This stand would be thinned to promote growth of crop trees.

b) Groups of mature trees retained during the previous harvest which may have been too small at the time. If the lignotuber pool is inadequate, this would be cut to 'shelterwood'. It would be partially harvested while retaining some trees as a seed source as well as to provide habitat and shelter while seedlings develop.

c) Small groups of pole-sized trees resulting from the removal of several mature trees. This stand would also be thinned.

d) Multi-aged stand resulting from selective removal of single trees. Gap creation would be carried out to allow lignotubers to develop into saplings. Existing saplings and poles may be damaged from the harvesting of large trees.

e) Large groups of saplings with habitat trees retained. These are not treated now but thinned at a later date as saplings develop into poles.

Fire also plays a role in each of these treatments. Fire may be used for fuel reduction, to stimulate germination of seed, to stimulate development of lignotubers and to temporarily alleviate understorey competition.

Fire may also be used prior to harvest for additional purposes such as making it easier to identify lignotubers and/or for improved access and safety.

Habitat

All silvicultural systems used in the jarrah forest include the retention of habitat trees and logs during harvesting to ensure animals have sufficient places to live and nest into the future.

Primary habitat trees are large trees with existing hollows that animals can use immediately and into the short term. Secondary habitat trees are smaller trees that may not have hollows now, but will develop hollows in the future when the primary habitat trees die and fall over. Habitat logs on the forest floor are dead and fallen trees that provide homes for small mammals and reptiles

Questions - Silviculture in the jarrah forest

1. What is silviculture?

2. List three possible objectives of silvicultural practice.

3. Explain what is meant by 'critical density' in a stand of forest.

4. What is the difference between gap creation and selection systems?

5. What is the purpose of each of the following silvicultural treatments?
   a) thinning
   b) gap creation
   c) shelterwood

6. What are four uses of fire in silviculture?

7. What silvicultural treatment (thinning, gap creation or shelterwood) would be used in each of the following stands of trees?
   a) Large groups of pole-sized trees remaining as a result of mature trees being harvested.
   b) A stand consisting mostly of mature trees where the lignotuber pool is inadequate for regeneration.
   c) A stand of trees of different ages with a good pool of lignotubers.

8. What is meant by:
   a) a cull tree?
   b) a habitat tree?

9. What is the approximate number of trees aimed for at time of harvest to get maximum timber production in a jarrah forest?

10. What is meant by a 'regeneration pool'?