FOREST FOCUS

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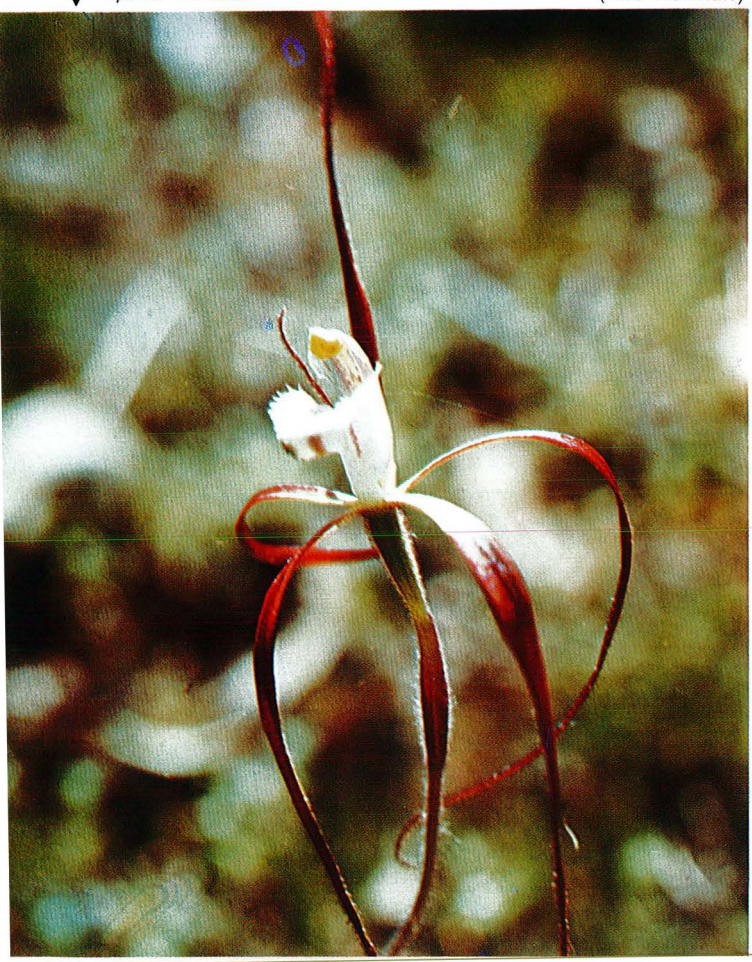
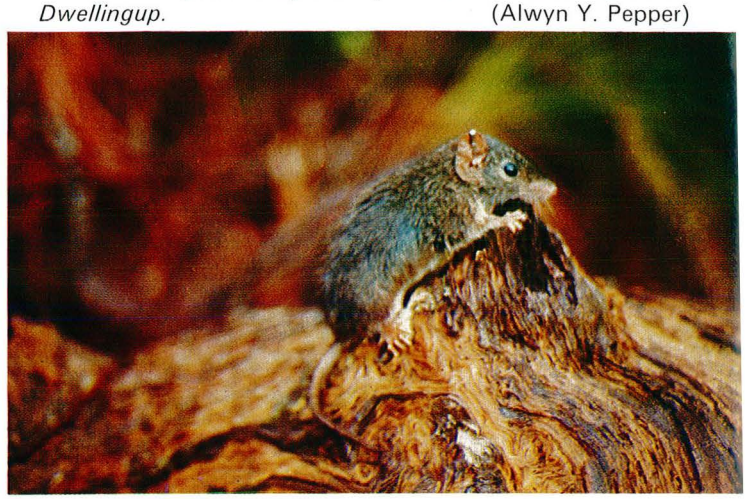
▲ *In heavily cut forests, regrowth from coppice or lignotubers has produced high quality pole stands.*

▼ *Spider orchid.* (Les Harman)



▲ *Blue Wren. Over 40 different species of birds have been observed in preliminary surveys in the jarrah forest near Dwellingup.* (Alwyn Y. Pepper)



▲ *The jarrah forest provides a habitat for many animals including this marsupial mouse.* (Les Harman)

▼ *Isopogon dubius.* (Les Harman)

▼ *Within an area smaller than most suburban gardens over 40 different plant species including many beautiful wild-flowers have been recorded.* (Les Harman)

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Front cover

High quality forest stand killed by P. cinnamomi. *In most dieback areas trees are salvaged before they deteriorate.* (Les Harman)

FOCUS on Jarrah dieback —a threat to W.A.'s unique jarrah forests

by Dr. S. R. SHEA

Its rugged, resilient appearance and apparent never-ending capacity to supply timber has perhaps caused many Western Australian's to be complacent about the jarrah forest. This forest, however, is now being attacked by a microscopic soil-borne fungus which has the potential to destroy it.

Phytophthora cinnamomi the organism which causes jarrah dieback can kill not only jarrah trees but the majority of species which grow in the forest. It is this almost total destruction that has led many plant pathologists throughout the world to recognise jarrah dieback as the worst plant disease ever recorded.

There is much evidence to suggest that the jarrah forest is one of the world's most unique forest ecosystems. Jarrah trees may attain a height of 56 metres and in some virgin forest areas on one hectare there is enough merchantable timber to provide wood for 29 average suburban homes or enough railway sleepers to build 2 kilometres of railway line.

Jarrah, however, is only one component of the ecosystem. Within an area smaller than the size of most suburban gardens it is not unusual to find over 40 different plant species from the delicate spider orchid to the bizarre blackboy. The forest provides a habitat for a variety of animals—many of which are unique to Western Australia—and in pre-

Phytophthora—"the plant killer"—has been aptly named. The microscopic fungus *Phytophthora cinnamomi* is very widely distributed within the state forests of W.A., causing a disease commonly known as "jarrah dieback", or "root rot". The disease has the potential to become one of the classic forest diseases of the world.

P. cinnamomi is of tropical origin and was first discovered in Java, in 1922, on cinnamon tree roots. It is now widespread throughout the world and has caused serious problems in forests, plantations, orchards, domestic gardens and nurseries.

The jarrah forest—your forest—is in great danger. Because of this, I have authorised that this issue of *Forest Focus* deal solely with this subject.

If you value the benefits these forests provide—timber, employment, fresh water, recreation and aesthetic values, a habitat for fauna and flora, to name some of the benefits to be derived, you will no doubt be keen to understand the nature of the disorder.

This issue aims to educate and seeks to gain your co-operation for the task, challenges and the changes which lie ahead.

B. J. Beggs.

Conservator of Forests

▲ *Jarrah may persist on the forest floor in this fire resistant lignotuberous stage for 20 years before growing into a tree.*

liminary surveys near Dwellingup over 40 species of birds have been recorded (see *Forest Focus* No. 7).

The productivity and diversity of the forest is all the more remarkable because it occurs in a very harsh environment. The laterite soils on which jarrah grows are infertile and dense, cemented sheet cap rock often occurs a few centimetres below the soil surface. These harsh soil conditions are not compensated by a favourable climate. Desert-like conditions prevail from December through to March. Fire is a natural factor of the environment with which the vegetation must contend, and the frequency and intensity at which it occurs would destroy many other types of forest. The jarrah forest is adapted to withstand severe fire and in fact some species, including jarrah, are stimulated by fire.

To survive and attain high productivity many of the components of the forest have evolved peculiar adaptations. Jarrah trees have adapted to the harsh, dry conditions by evolving a remarkable root system which penetrates the cap rock layer and extends often more than 15 metres to tap the water table deep in the soil profile. Banksia trees cope with the infertile soil by developing a special root to trap nutrients which are normally unavailable to plants.

The forest abounds with structures which have been developed to cope with fire. For example, jarrah trees commence their life in the form of a shrub which sprouts from a bulb-like fire-resistant structure called a lignotuber.

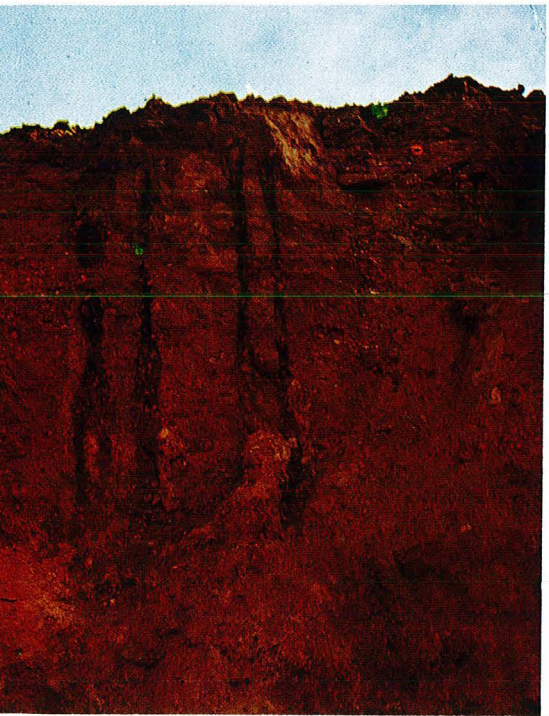
▲ *A banksia root which is adapted to extract phosphate from infertile soil.* (Les Harman)

All these adaptations are evidence that the jarrah forest is a specialised and finely balanced ecosystem. Unfortunately, its unique character, which results from its adaptation to this harsh environment, has made it extremely vulnerable to a new factor of the environment—*Phytophthora cinnamomi*.

The Disease

The first evidence of jarrah dieback is the death of members of the understory and shrub layer. Bull banksia (*Banksia grandis*) is one of the first trees to succumb. The leaves of banksia which have been killed by the fungus turn yellow, contrasting markedly with the dark green

▼ *Jarrah roots penetrating the dense cap rock of the laterite soil profile.* (Dr. Syd Shea)



▼ *Frequent fire is a natural factor of the jarrah forest environment.* (Les Harman)

forest vegetation. Deaths occur predominantly in autumn and to a lesser degree in late spring. Many other shrub and tree species such as zamia palm and blackboy are killed by the disease. In some diseased areas, however, susceptible species may persist for long periods after the fungus has been introduced.

Jarrah trees may not show disease symptoms for some months or even years after understory symptoms have been observed. The first symptom in jarrah is crown thinning. The trees "die back" from the branch tips, although death of branches is merely an indication of a damaged root system and does not indicate that the pathogen is present in the above ground part of the tree.

Some tree and shrub species are resistant to the disease. For example, marri, blackbutt and bullich have demonstrated their capacity to survive in diseased areas for many years and in some diseased areas marri has formed a woodland-type forest with a scattered shrub layer composed of resistant species. However, introduction of the fungus to a jarrah forest area will, on most sites, eventually result in the irreversible destruction of all but a few resistant species in that area.

In the latter stages of disease development jarrah dieback is easily recognised, but in the initial stages identification of infected areas may be difficult. Poor jarrah crowns or a single mortality in the shrub understory do not necessarily indicate that the fungus is present. However, patch dying in the understory layer particularly if banksias, zamia palms or blackboys are affected, usually indicates its presence.

The disease is not restricted to jarrah forest occuring on the Darling Ranges nor to the jarrah vegetation type. Poorer quality jarrah growing on the coastal plain is highly susceptible. Karri and wandoo forests, and the vegetation growing on the coastal limestones appear resistant. But banksia woodlands, a major vegetation type on the coastal plain, are highly susceptible to the fungus. The vegetation in

▲ *Banksias are highly susceptible and usually are the first species to die.* (Les Harman)

▼ *Zamia palm and blackboy killed by* P. cinnamomi. *A majority of the jarrah forest species including many wild-flowers are destroyed by the fungus.* (Les Harman)

▲ *Dieback of jarrah crowns resulting from fungal attack of the root system.* (Brian Stevenson)

▲ *Marri is resistant and some times forms a parkland forest in dieback areas.* (Les Harman)

many public reserves, parks, golf courses, farmlands and gardens has been destroyed or is being attacked by the fungus.

The Fungus

Fungi are lower forms of plant life. Some, like mushrooms, are readily visible to the naked eye at certain stages of their life cycle. Others such as *P. cinnamomi* can only be seen under the microscope. Some fungi are very beneficial as they break down dead plant material and in the process allow nutrients to be recycled. Others attack live plants and cause severe economic losses.

P. cinnamomi is recognised throughout the world as a major plant pathogen. It is a serious problem in the pine forests of south-east U.S.A., avocado orchards in California, pineapple plantations in Hawaii, and recently has been found to cause severe damage to some eucalyptus forests in eastern Australia. Over 400 plant species are attacked by this fungus including many horticultural species such as azaleas, camelias, plums and peaches.

Of all the areas in the world where this fungus has caused damage, the south-west of Western Australia is the most serious.

P. cinnamomi occurs in the soil and roots in various forms which make up its "life cycle". The vegetative form of the fungus is called mycelium, which consists of microscopic tubular structures. During the asexual cycle of the fungus, which occurs only when the soil is moist and warm, sporangia are formed from the mycelium. Inside the sporangia a further spore type called a zoospore is formed, which on release can swim through wet soil. The fungus has the capacity to produce many sporangia from a small amount of mycelium and within each sporangia there are several zoospores. This process of zoospore production can occur in less than 48 hours and hence the fungus has the capacity to produce millions of spores in short periods from a small amount of mycelium. Two other spore types, a chlamydospore and a

▼ *In some diseased areas no regeneration of resistant tree species has occurred.* (Les Harman)

Many small woodlots in farms located on the coastal plain are being destroyed by the fungus. Note the distinct boundary between healthy and diseased forest.
(Les Harman)

sexual spore called an oospore, are produced by the fungus. These spores are relatively thick walled and permit the fungus to survive in soil indefinitely, even in the absence of host tissue, provided the soil is kept moist.

P. cinnamomi, principally during the zoospore stage, causes damage to plants by attacking their root systems. In some plants, as in the case of jarrah, only the fine feeder roots are attacked. Destruction of these roots prevents the plants from taking up nutrients and it slowly starves to death. In some jarrah forest species such as banksia, the fungus can also invade the large roots and death in these species is more rapid. Unfortunately, many of the specialised root structures which have evolved to cope with the jarrah forest environment, such as the specialised banksia root, are highly susceptible to the fungus. This not only makes these species highly susceptible, but it contributes to the spread of disease through the forest by providing a large food base for the fungus. It is somewhat of a paradox that the unique character of the jarrah forest has made it extremely vulnerable to *P. cinnamomi.*

Distribution and Spread

Jarrah dieback is widely distributed throughout the South-West. It is found from Gingin 60 km north of Perth to Mount Manypeaks 40 km east of Albany. The distribution of the disease has been mapped in state forest using aerial photographs, and ground and aerial surveys. Preliminary surveys, using the same techniques have recently been carried out to estimate the extent of the

Regrowth jarrah pole stand destroyed as a result of fungal attack on the root systems.
(Les Harman)

▲ *Fungal mycelium growing on a sterile, high nutrient medium.*
(Les Harman)

disease in national parks, crown land reserves and private property. The area affected by jarrah dieback in December, 1977, was:

State forest and timber reserves	220000 ha
National parks	3800 ha
Other crown land	56000 ha
	279800 ha

Private property figures have been excluded, as symptoms are not obvious on cleared farmland.

In *State forest* the area of dieback is increasing by about 16000 ha a year; and for *all crown land tenures* in the South-West is about 20000 ha a year.

The disease is not randomly distributed and its intensity varies with site and vegetation type. Jarrah forest growing on the fertile, red, loamy soils formed in the young, dissected river valleys on the western edge of the Darling Scarp appears to be particularly resistant to the disease. Forest growing on the laterite soils characteristic of the upland areas of the forest and the silty or sandy soils in the shallow valleys is susceptible but to different degrees. In lowland areas susceptibility is extremely high but uphill spread of the disease to the lateritic upland sites is generally very slow. A large proportion of the diseased forest area is restricted to the valley bottoms. The fungus, however, can rapidly destroy the vegetation on upland sites if infections are introduced at the top of the slope. If this occurs spores are rapidly distributed downslope in drainage lines.

Effects of Jarrah Dieback

The effects of any plant disease may be serious, but they are usually direct and definable, such as the diseases affecting cereal crops. Because it could destroy the total forest together with its multiplicity of values, the effects of jarrah dieback are more complex and in the long term potentially more serious than any other known plant disease.

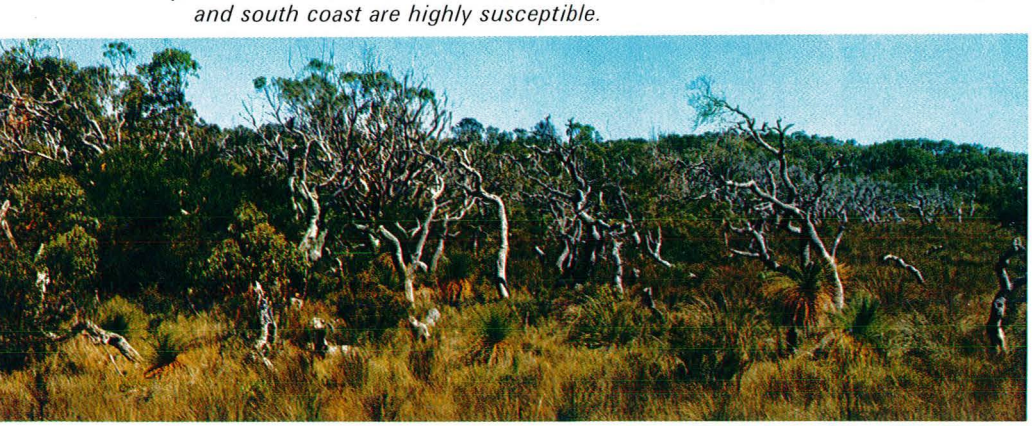
The Water Catchments. Catchments located within the jarrah forest currently supply over 80 per cent of the total water used in Western Australia. It is no accident that the major source of fresh water to meet current and future demands in southern W.A. is in forested catchments. Clearing of the forested areas to the east of the state forest has caused streams to turn saline. Research by the C.S.I.R.O. indicates that unless these areas are re-forested it could take up to 400 years before the streams become fresh.

Current research indicates there are large stores of salt in the soil in some catchments. For example, it has been estimated that there are 150000000 tonnes of salt stored in the soil and groundwater in the Wellington catchment. Paradoxically, the existing native vegetation is responsible for this large accumulation of salt. Over millions of years small quantities of salt contained in rainwater have been concentrated by the roots of the native vegetation. While this vegetation remains intact the salt is prevented from moving into the river systems and water in reservoirs remains relatively fresh. Disturbance of the vegetation by either man or disease in forest areas where salt accumulation has occurred will result in the release of salt into the weirs and reservoirs making the water unusable for either domestic or agricultural use.

The effect of jarrah dieback on water quality currently used is minimal as most of the seriously diseased forest occurs downstream from existing reservoirs or in areas which are not salt prone. However, in some areas the destruction of forest vegetation by *P. cinnamomi* has caused the streams fed from these areas to turn saline.

Timber Production. The most obvious and direct effect of jarrah

▼ *Banksia woodlands which are a major vegetation type on the coastal plain and south coast are highly susceptible.*



▼ Pinus radiata *growing in shelter belts on the coastal plain are being killed by the fungus, but the fungus has not caused any mortality in* P. radiata *plantations.*

dieback is its immediate and future impact on the milling industry. The long term future of any sawmill can only be assumed if the amount of wood cut each year is equal to that produced by the forest. As the area of forest affected by dieback increases and more forest becomes unproductive the size of this "allowable cut" will become less, forcing many mills to reduce in size, or even close down.

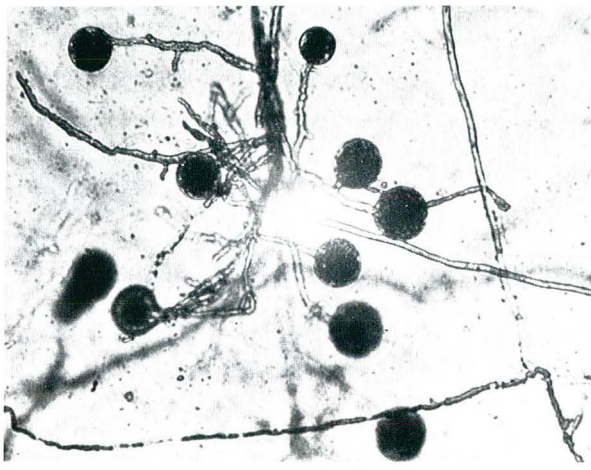
Conservation. The effect of jarrah dieback on forest flora and fauna has not been widely appreciated. Many trees and shrubs of the forest which are renowned for their beautiful flowers are affected. Susceptible plants include species of *Banksia, Persoonia, Adenanthos, Podocarpus, Leucopogon, Dryandra, Xanthorrhoea* and *Casuarina*. Certain vegetation types, particularly those occurring in lowland areas such as the *Banksia littoralis* dominant understory type, are in danger of extinction. The loss of individual plant species extends beyond that species because in an ecosystem, living organisms are dependant on one another. For example, Forest Research Officer Per Christensen (*Forest Focus* No. 10) has documented the role of *Banksias,* one of the trees most susceptible to *P. cinnamomi,* in providing food and shelter for many of the small animals and birds inhabiting the forest.

"For example, the red wattle bird, the little wattle bird, the yellow-winged or new holland honeyeater, together with the closely allied white-cheeked honeyeater, the western spinebill, the tawny-crowned honeyeater, the white-naped honeyeater, and the brown honeyeater are some of the honeyeaters commonly associated with banksia flowers, particularly on the south coast. Other birds such as the silvereye and the black cockatoos also feed on the nectar of the banksia flowers. The latter also frequents the banksia belts at a later date when the seed ripens. Birds come not only to seek nectar but also for the numerous wasps, moths, butterflies, beetles and ants attracted to the flowers. At night boobook owls and bats feast on moths attracted to the nectar. At this time another small creature, the tiny noolbenger or honey possum, emerges to feed on the pollen and nectar of the flowers. This animal is almost entirely adapted to a diet of nectar and banksias are one of the main species it frequents.

"The equally tiny dormouse or pigmy possum also frequents the banksia groves at flowering time. They live mainly on an insect diet and have been observed to breed at the time of the banksia flowering on the south coast. Their tiny nests and those of the noolbenger are often found inside rotted out hollows in the trunks of the banksia."

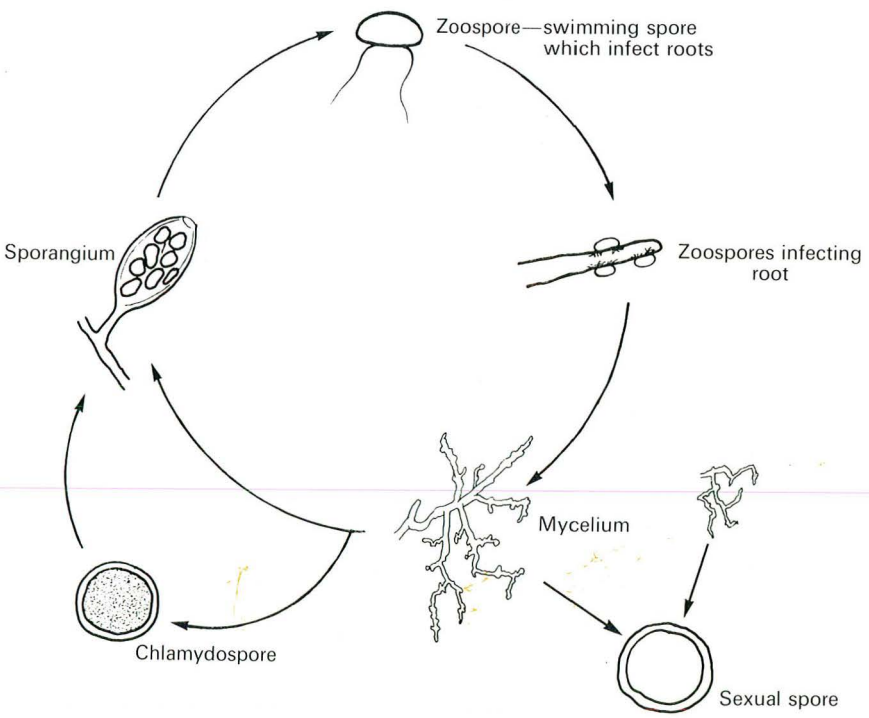
Recreation. Apart from its water, timber and conservation values the jarrah forest is being increasingly used for outdoor recreation. During

▲ *Sporangium: zoospores are formed in this structure and on release swim to roots.* (Les Harman)



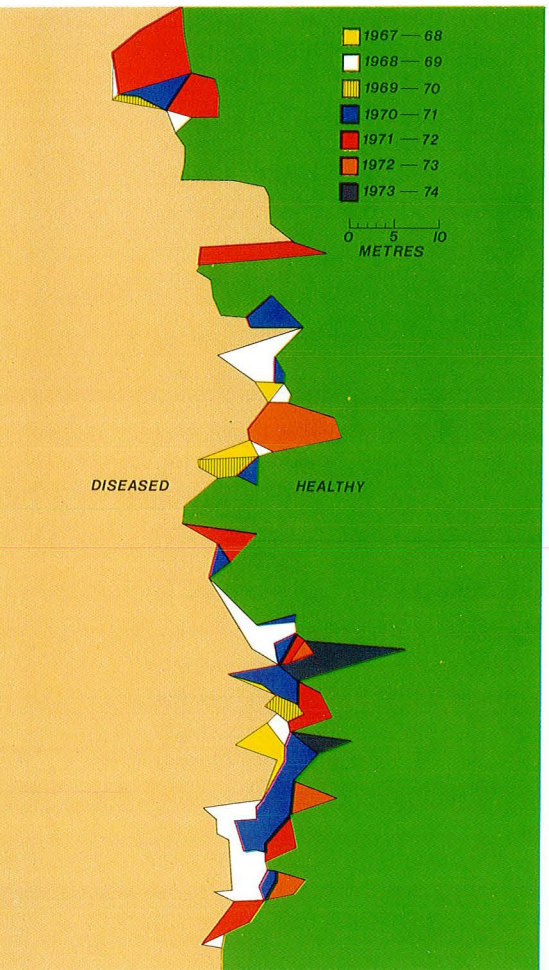
▲ *Chlamydospore: these spores allow the fungus to survive in soil provided it is moist.* (Les Harman)

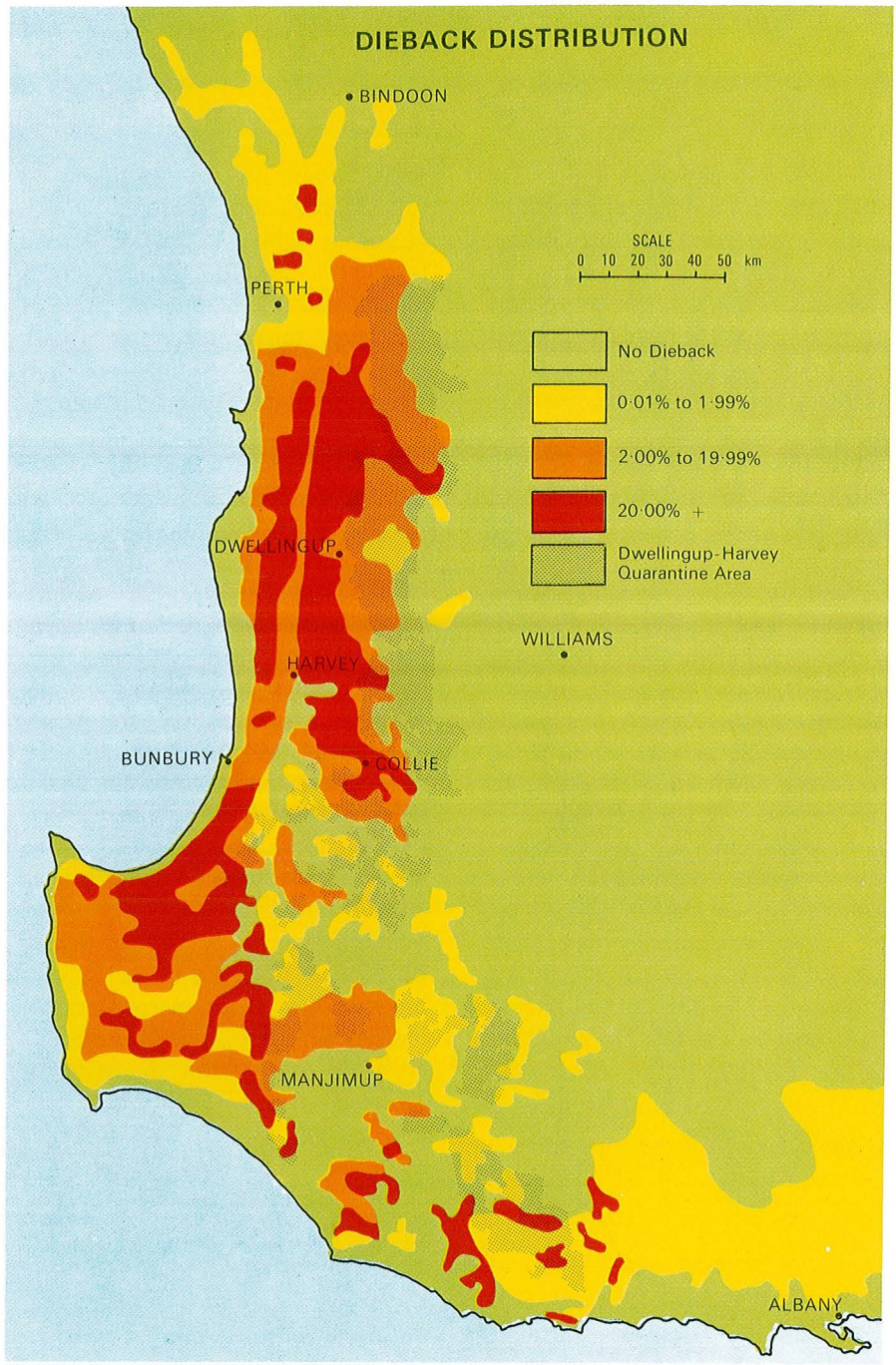
▼ *Life cycle of* Phytophthora cinnamomi.



▲ *Almost all the vegetation in this picture is highly susceptible to* P. cinnamomi *and is in danger of becoming extinct.* (Les Harman)

▼ *Spread of the disease upslope as measured by symptoms in the understory. The rate of spread of the disease is slow if spread by man is eliminated.*





▼ *Destruction of the jarrah forest by either clearing or jarrah dieback has caused the development of salt patches and the salination of streams in some eastern valleys.*

The conservation value of this "A" Class reserve near Pinjarra has been completely destroyed by P. cinnamomi. (Les Harman)

a forest recreation survey, it was found that on one weekend 750 people visited one picnic site located near Dwellingup. Much of the appeal of the forest to those who visit it is destroyed by jarrah dieback.

Research

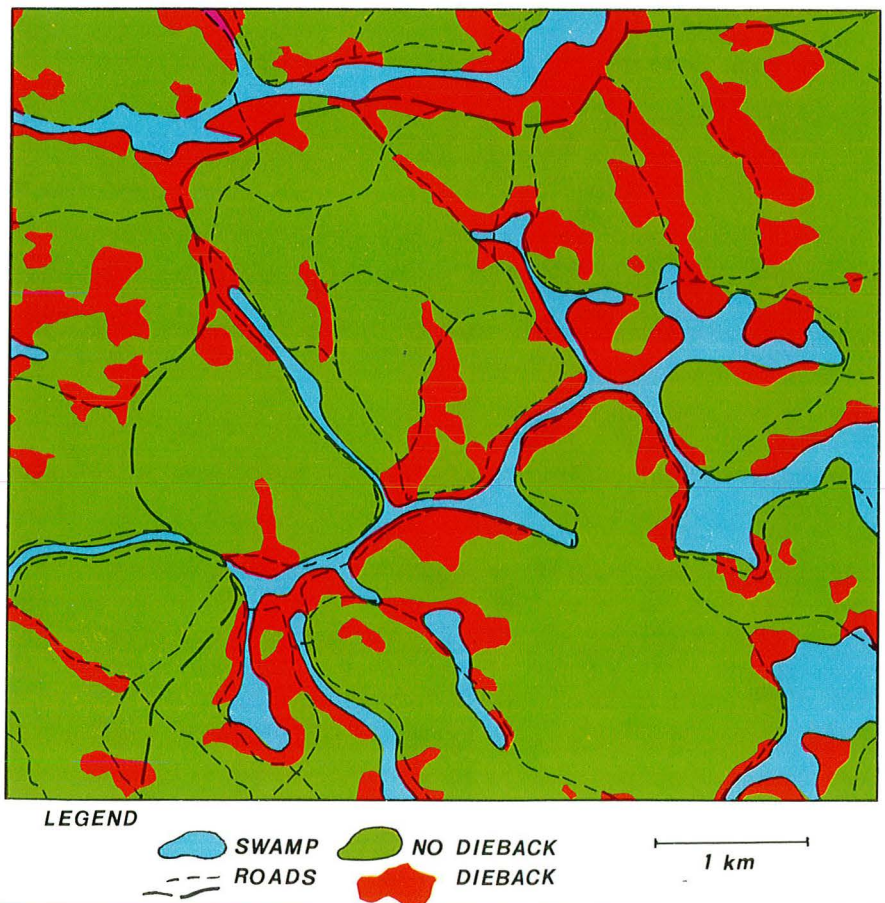
Jarrah dieback was first described prior to World War II but it was very restricted in area and the small areas of dead forest were assumed to be caused by fire. After 1945, following the large-scale introduction of mechanical earth-moving equipment, the disease became more widespread and a number of investigations were carried out in an attempt to find a cause. It was not until 1965, however, that Mr. Frank Podger of the Commonwealth Forest Research Institute, identified *Phytophthora cinnamomi* as the causing agent.

Research is currently being carried out by a variety of organisations. An intensive programme is carried out by the W.A. Forests Department at its Dwellingup Research Station and the department also provides funds for research scholarships at the Western Australian and Australian National Universities. The Commonwealth's Forest Research Institute is maintaining a research station at Kelmscott which is primarily involved in jarrah dieback research and more recently the C.S.I.R.O. has initiated an investigation into the disease. The research programme being carried out in W.A. is only part of world-wide research into the fungus.

The development of methods to control the disease is hindered by its widespread nature in a forest which has a relatively low value per unit of area. In the horticultural situation it is possible, although expensive, to reduce the impact of the fungus by the use of fungicides and other intensive cultural treatments. In a forest such methods are impractical. Hence, research has been directed to evolving techniques to prevent the introduction of the fungus into uninfected areas, and changing the environmental conditions in the natural forest to make it resistant to the disease rather than attempting to eradicate the fungus.

Although *P. cinnamomi* can cause destruction of the forest on most sites, susceptibility varies markedly. **Recognition of this variation and the identification of the factors responsible for it have provided some hope that the disease may be controlled in the short term by forest hygiene**

Distribution of disease in badly affected forest. Note that infections are primarily restricted to low-lying moisture-gaining sites.



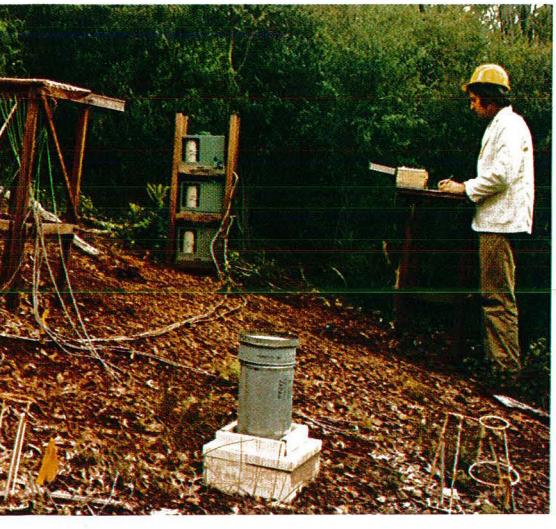
Golf course vegetation killed by P. cinnamomi. (Les Harman)

▲ *Pigmy possum on banksia flower.* (Bert Wells)

▲ *Destruction of vegetation could seriously affect the habitat of animals such as the Honey and Pygmy possums, and birds like the New Holland honeyeater.* (Bert Wells)

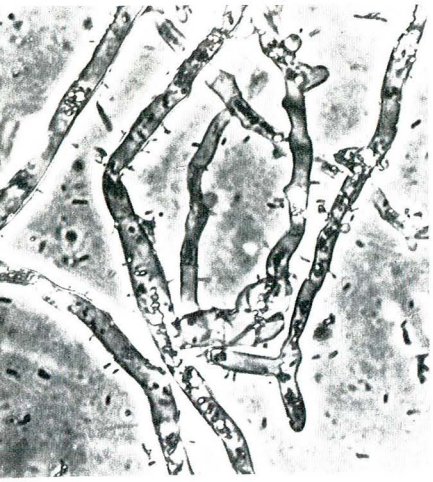
▲ *Honey possum on bottlebrush.* (Bert Wells)

▼ *Forests Department dieback research at Dwellingup includes detailed monitoring of the soil environment under different vegetation types to determine their susceptibility to the fungus.* (Les Harman)



techniques and in the long term by manipulation of the forest vegetation.

Detailed measurements of the soil environment on various sites within the forest have shown that lowland sites are highly susceptible because they are water gaining, but on the freely drained upland sites where jarrah grows best, the soil environment is only marginally suitable for the fungus. Over a period of eleven years measurements of the spread have shown that provided contaminated soil is not carried on to upland sites the natural extension of the disease from the lowlands is very slow. Current research indicates that it may be possible to increase the resistance of the upland sites by promoting a dense understory vegetation. Marked changes in the understory and shrub layer of the forest can be achieved relatively cheaply by altering the frequency and intensity of prescribed burning.



▲ *Soil bacteria attacking* P. cinnamomi. *Recent research indicates that on some sites disease may be biologically controlled.* (N. Malajczuk)

New lines of research are constantly being explored. On some jarrah forest sites the fungus is unable to become active because it is being attacked by other micro-organisms. **It is possible that with further research these natural antagonists may be used to achieve biological control of the disease.**

In areas where the fungus has already destroyed the forest there is little hope that the natural forest will ever be re-established. For these areas trials are being carried out with alternative tree species. Over 50 tree species with known commercial potential have been tested in the field and laboratory for resistance to *P. cinnamomi*. Three species of pine and at least eight eucalypts have been able to survive in the presence of the fungus and also grow on jarrah forest sites.

Trials are continuing and over 250 hectares of dieback-affected forest are being planted each year. In salt-prone catchment areas which are affected by jarrah dieback it will be necessary to replant with trees which have a deep root system so that the discharge of salt into reservoirs can be prevented.

Control of Jarrah Dieback by Forest Hygiene and Quarantine in State Forest

The major means by which *P. cinnamomi* is spread through the forest results from the activities of man. Unaided movement of the fungus uphill or on a flat surface is less than a few centimetres a year. The fungus can survive and may be carried in less than one gram of moist soil and this amount of infected soil is sufficient to initiate a new diseased area. Any activity in the forest which involves movement of soil can cause the disease to be spread distances measured in terms of kilometres in one day.

Once new infections are established on uphill sites, disease spread downslope is rapid and over a period of years most vegetation downslope of the new infection will be destroyed. **Therefore prevention of artificial spread is the greatest single step which can be taken to control jarrah dieback.**

Reduction of artificial spread by forest hygiene techniques, although difficult, is not impossible despite the insidious nature of the fungus. *P. cinnamomi* cannot be transmitted in the atmosphere and although it will survive in moist soil for long periods it is rapidly killed when the soil is dried. Although only small quantities of infected soil are required to initiate new dieback areas in the field situation, the probability of this happening with small quantities of soil is low. Most of the spread in the forest has resulted from moving large quantities of soil like that adhering to bulldozers or moved in road building operations.

During the summer months the soil on all but the low-lying swampy sites is too dry for the fungus to survive and the chance of spreading during this period is low. Artificial spread of the disease can be markedly reduced by restricting activity in healthy forests to the summer months and washing down vehicles

▲ *Eight-years-old Tasmanian blue gum* (E. globulus) *trees which were planted on dieback sites.* (Les Harman)

▼ *Three-years-old dieback resistant trees which were direct seeded on to dieback site. Low cost methods of rehabilitation such as this are necessary if the large area of affected forest is to be rehabilitated.* (Les Harman)

▼ *The use of infected gravel as road building material was a major cause of disease spread in the past.* (Govt. Photographer)

◀ *Laboratory testing of soil carried on logging equipment which had been working in a dieback area showed that it contained* P. cinnamomi. (Govt. Photographer)

▲ *Large-scale operations involving soil disturbance, such as bauxite mining, cause artificial spread of the fungus.* (Les Harman)

▼ *The fungus could be readily carried in soil adhering to the wheels of trail bikes.* (Les Harman)

◀ *Washing down vehicles before they enter healthy forest reduces the risk of disease spread.* (Les Harman)

whenever they move from diseased to healthy forest.

Distribution of the disease within the forest was considered when implementing the hygiene programme. A total of 720000 ha, 40 per cent of State forest, has now been gazetted as quarantine area. The first section gazetted was 499000 ha of northern jarrah forest to the east of the badly diseased area near the Darling Scarp. The second section comprised 211000 ha mainly of jarrah forest in the southern region of State forest south of a line approximately between Nannup and Bridgetown.

Entry by vehicle to this quarantined area will be permitted only in special circumstances and a permit is required. The legislation provides heavy penalties for infringements to the Act. Almost all forest activities involving vehicular movement, such as logging, are restricted to the western edge of the forest which is badly affected by dieback.

The stringent quarantine:

- Permits the identification of affected areas in the high quality forest zone;
- Provides time in which to introduce a logical basis for implementing hygiene measures;
- Provides time to develop work methods so that multiple-use management may be continued;
- Effectively curtails artificial spread in not yet hopelessly infected susceptible forests where disease is a threat to management objectives.

The co-operation of everybody who uses the forest, whether for work or recreation, is essential if jarrah dieback is to be controlled. Information on forest hygiene and quarantine procedures can be obtained at any Divisional Office.

Control of Jarrah Dieback Outside State Forest

Control of the disease in national parks and reserves, crown lands, farmland and golf courses, can only be achieved by reducing artificial spread. In home gardens fungicides may give some control. On the deep sands on which most homes in suburban Perth are located infections generally remain localised. Therefore the best method of control is prevention of the spread of contaminated soil.

In badly affected areas the aesthetic value of the destroyed natural vegetation may be at least partially recovered by planting resistant trees and shrubs. A list of trees and shrubs which are resistant to the fungus is provided opposite.

Conclusions

P. cinnamomi is a new and devastating factor of the environment in the south of Western Australia. Unchecked, the disease could eventually result in the irreversible destruction of the majority of the jarrah forest and many other vegetation types occurring in the area. It is a complex problem but there is some hope that a method of controlling the disease will be discovered. Control by hygiene and quarantine, however, is the only method in the short term which will ensure that the priceless value of the forest will be conserved for future generations.

Back cover

The productive capacity of the jarrah forest is illustrated by this virgin stand. (Les Harman)

A selection of species resistant to *Phytophthora cinnamomi*

R. J. EDMISTON

SHRUBS

Aucuba japonica var. *variegata* (2 m). Evergreen attractive shrub with variegated foliage requires a semi-shaded position.

Berberis thunbergii var. *atropurpurea* (2 m). Thorny, hardy deciduous shrub grown mainly for the attractive purple foliage which changes to deep crimson scarlet in autumn.

Buddleia davidii (4 m). Tall, upright semi-deciduous shrub producing long spikes of blooms during the summer and autumn. Available in a range of colours.

Coprosma repens (syn. *Bauerii*) (Mirror plant) (2 m). Attractive hardy, evergreen shrub, available also in variegated foliage forms. Suitable for seaside or inland planting.

Cordyline australis (Cabbage tree) (3 m). Hardy, evergreen plant with attractive strap-like foliage radiating from a central cluster. Used extensively as pot plants or for feature gardens. Suitable for seaside or inland planting. Will withstand dry conditions.

Cytisus scoparius var. *andreanus smithii* (Broom bush) (2 m). Hardy, evergreen small-leafed shrub with bronzy yellow and crimson pea-shaped flowers. Other varieties should also be resistant.

Dodonaea viscosa var. *purpurea* (Purple-foliaged hop bush) (2 m). Hardy, evergreen purple-foliaged plant with insignificant flowers followed by flat-winged capsules.

Euonymus japonica (1-2 m). Hardy, evergreen shrubs. Available in variegated forms.

Forsythia intermedia (3 m). Deciduous shrub covering its stems with bright yellow, narrow-petalled flowers in spring.

Hebe speciosa syn. *Veronica imperialis* (1 m). Hardy, evergreen shrub with racemes of magenta coloured flowers.

Hibiscus syriacus (3 m). Deciduous shrubs with attractive flowers available in a range of colours.

Hoheria populnea var. *alba* variegated (variegated N.Z. Lace Bark) (3-4 m). Deciduous shrub with the attractive foliage margined creamy-white. A form with central variegation is also available.

Hydrangea hortensis (2-3 m). Deciduous shrubs with large flower heads usually pink but changing to blue in acid soils.

Juniperus sabina (1 m). Semi-prostrate vigorous conifer suitable for banks or large rockeries, foliage green.

Juniperus sabina squamata var. *meyeri*. Similar to above with bluish-green foliage.

Lonicera nitida (Honeysuckle) (2 m). Evergreen shrub with small creamy-white flowers.

Magnolia liliflora var. *nigra* syn, with *Magnolia soulangeana* var. *nigra* (2-3 m). Attractive deciduous shrub with the flowers a dark purple on the outside and pale purple within. Require a semi-shaded position and an acid soil.

Nerium (Oleander) (6 m). Hardy, evergreen shrubs available in a range of colours.

Phormium tenax (N.Z. flax) (2-3 m). Evergreen, hardy plant with stemless leaves arising from the base. Available in green, purple or variegated forms. Adaptable to most situations.

Photinia glabra var. *rubens* (2-3 m). Hardy, compact, evergreen shrub, the new growth being a burnished coppery red.

Pittosporum eugenioides (3-5 m). Hardy, evergreen shrub or small tree with pale green foliage. The variegated form makes an attractive contrasting plant in the garden.

TREES

Acer negundo (Box elder) (15 m). Deciduous tree suitable for growing in cool situations.

Angophora costata (Smooth-barked apple) (20 m). Attractive evergreen tree resembling the eucalypts in appearance but differing in having opposite leaves and no operculum to the fruit.

Cupressus arizonica var. *bonita* (Arizona cypress) (5-9 m). Attractive, hardy pyramidal conifer with glaucous foliage.

Cupressus torulosa (Bhutan cypress) (9 m plus, depending on situation). Tall, conical, attractive specimen tree with drooping bluish-green branchlets.

Eucalyptus accedens (Powder-bark wandoo) (20 m). Smooth barked tree with a dense spreading crown and a white or sometimes salmon powder covering the bark.

Eucalyptus astringens (Brown mallet) (21 m). Upright tree, bronze coloured bark, dark green leaves, umbrella crown.

Eucalyptus botryoides (False mahogany) (18 m). Broad leaves, heavy crowned. Bark rough, dark grey.

Eucalyptus calophylla (Marri) (27 m). Heavy crowned attractive tree with rough, flaky persistant bark.

Eucalyptus calophylla var. *rosea* (Pink-flowered marri) (12 m). Broad leaves, dense crown, pink blossoms.

Eucalyptus camaldulensis (River gum) (27 m). Fast growing tree, bark white or grey and smooth. Crown dense, sometimes with a weeping habit.

Eucalyptus citriodora (Lemon scented gum) (18 m). Attractive stately tree with smooth white bark. Foliage not dense.

Eucalyptus cladocalyx (Sugar gum) (21 m). Large spreading crown and clean, smooth bark. Fast growing.

Eucalyptus cladocalyx var. *nana* (Dwarf sugar gum) (9 m). Fast growing, smooth bark, shiny green foliaged crown.

Eucalyptus falcata (White mallet) (8 m). Attractive small tree with smooth yellowish-white bark.

Eucalyptus forrestiana (Fuchsia mallee) (6 m). Attractive mallee, capsules at flowering time bright red, clustered and pendulous, stamens yellow.

Eucalyptus gardneri (Blue mallet) (10 m). Large dense crown, leaves bluish green, bark smooth and grey brown.

Eucalyptus globulus (Tasmanian blue gum) (30 m). Fast growing, large pendulous leaves.

Eucalyptus kruseana (Book-leaf mallee) (6 m). Unique appearance. Leaves small, round, sessile and bluish. Flowers yellow in spike-like arrangements.

Eucalyptus laeliae (Darling Range ghost gum) (18 m). An attractive heavy crowned tree with startling white powdery bark.

Eucalyptus maculata (Spotted gum) (30 m). Smooth, mottled bark, attractive crown, fast growing.

Eucalyptus megacarpa (Bullich) (24 m). An attractive tree with smooth white to yellowish-white bark. Prefers a swampy situation.

Eucalyptus melliodora (Yellow box) (30 m). Moderately dense crown with bluish-green drooping foliage.

Eucalyptus microcorys (Tallow wood) (24 m). Fibrous bark, light tan to brown. Rather pyramidal crown.

Eucalyptus occidentalis (Flat-topped yate) (18 m). Tall tree, umbrella crown. Bark on trunk rough and dark, on limbs grey and smooth.

Eucalyptus patens (Blackbutt) (30 m). Rough furrowed persistent bark with fine bluish-grey foliage.

Eucalyptus platypus var. *platypus* (Moort) (6 m). Densely foliaged small tree or mallee with round, shining, dark green foliage.

Eucalyptus resinifera (Red mahogany) (30 m). Heavy crowned ornamental shade and shelter tree.

Eucalyptus robusta (Swamp mahogany) (15 m). A spreading tree with a heavy crown of dark, glossy leaves.

Eucalyptus rudis (Flooded gum) (15 m). Short boled, spreading tree with rough grey persistent bark. Suitable only for very wet areas.

Eucalyptus saligna (Sydney blue gum) (30 m). Smooth bluish-white bark and dark green leaves.

Eucalyptus salmonophloia (Salmon gum) (24 m). Handsome tree. Bark smooth, salmon coloured. Dense crown with shiny leaves.

Eucalyptus sideroxylon (Mugga ironbark) (18 m). A fine shade and shelter tree.

Eucalyptus spathulata (Swamp mallet) (8 m). Small tree or mallee with smooth, bronze coloured bark. Leaves very narrow.

Eucalyptus wandoo (15 m). Fairly dense spreading crown. Bark smooth and light coloured. Foliage bluish-grey.

Eucalyptus leucoxylon rosea (Pink-flowered yellow gum) (9 m). Ornamental tree with attractive red blossoms.

Liquidambar styraciflua (Sweet gum) (12 m). Deciduous tree of pyramidal habit and dense maple-like foliage. The autumn tonings of yellow, gold and wine are at their best in cold districts.

Pinus elliottii (Slash pine) (20 m). Hardy tree, suitable for ornamental, shade or windbreak purposes.

Pinus pinaster (Maritime pine) (20 m). Hardy shelter tree with a dense spreading crown.

Pinus taeda (Loblolly pine) (20 m). Hardy shelter tree with a dense crown.

Populus nigra var. *italica* (Lombardy poplar) (25 m). Stately columnar deciduous tree. Suitable for open areas only.

Quercus palustris (Pin oak) (15 m). Deciduous tree with thin, glossy, green, deeply lobed leaves. Brilliant red autumn foliage in cool climates.

Salix alba var. *tristis* (White willow) (23 m). Deciduous tree with bright yellow drooping branches.