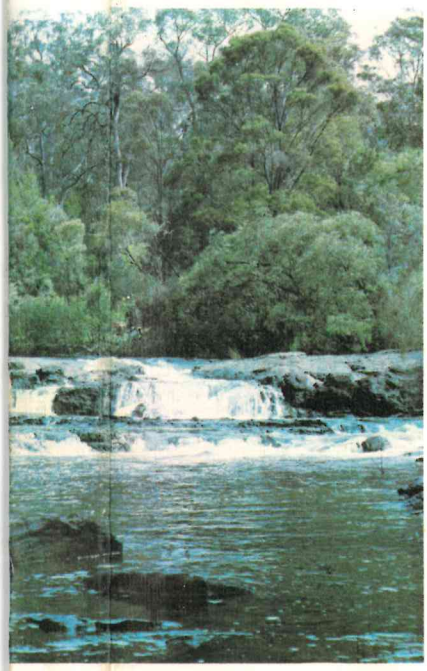
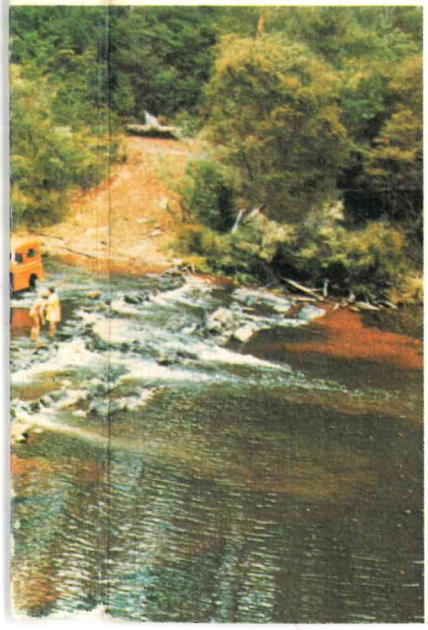
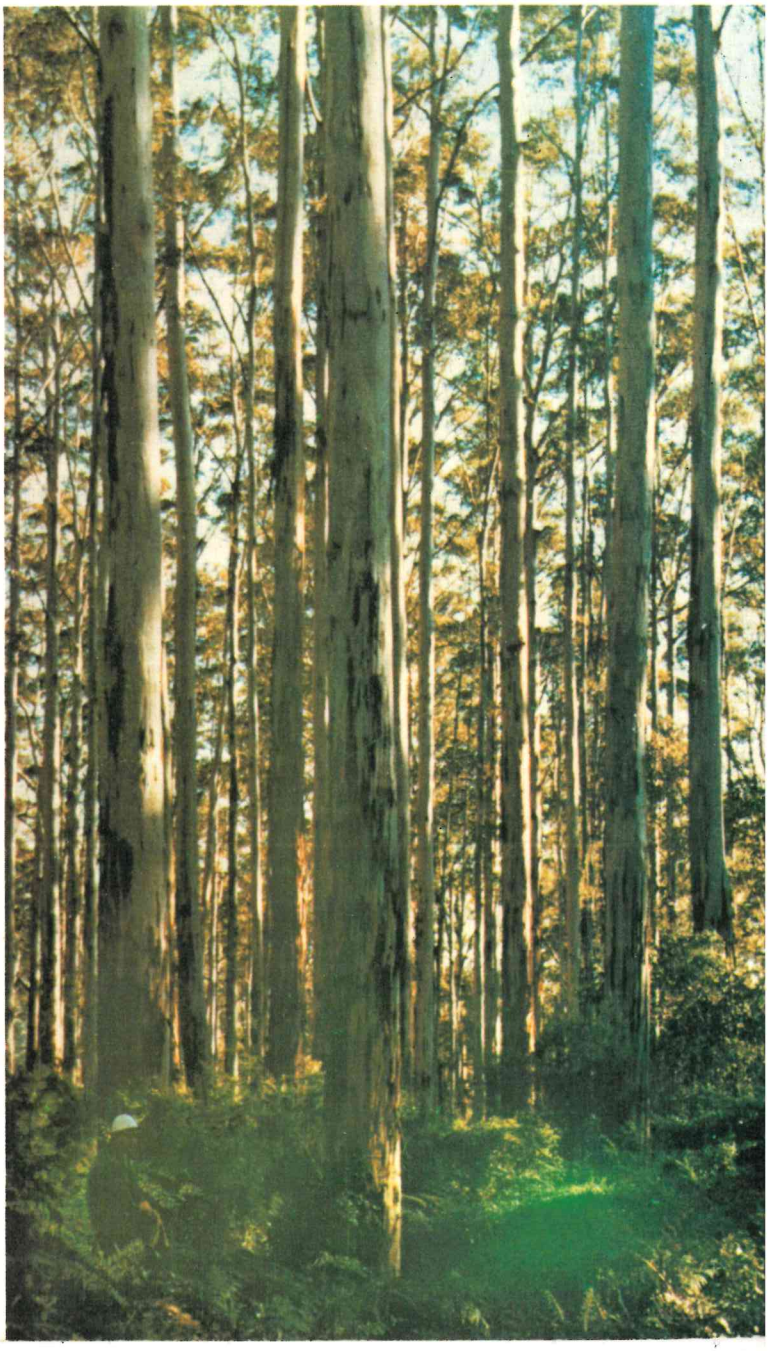
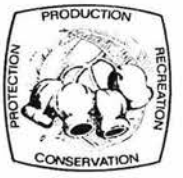
Forestry
in
Western Australia







FORESTRY IN WESTERN AUSTRALIA



Prepared Under the Direction of

B. J. BEGGS

Conservator of Forests

(1) – 2 57 20

PREFACE

"Forestry in Western Australia" was first published in 1957, revised in 1966, and now a third edition has become necessary. The numerous enquiries, both technical and general, received by the Forests Department show that the people of Western Australia are becoming increasingly aware of the importance of their forest heritage and of the necessity for its conservation, efficient management and multiple use.

By world standards the hardwood forests of this State are relatively limited, but while they have proved adequate for our past needs the time is fast approaching when growth in population, industrial expansion, and mining will impose considerable strain on the forest resource. Every endeavour is being made to anticipate these demands by improved methods of silviculture, protection and management, while the softwood plantation areas of the State are being currently increased at the rate of 6,000 acres (2,428 ha) *per year to achieve 250,000* (101,175 ha) *by the end of the century.*

"Forestry in Western Australia" has been prepared by officers of the Forests Department to provide, in some measure, an account of the practice of forestry in this State. For simplification scientific and technical terms have been avoided wherever possible so that the principles of forest management may be more readily appreciated by the layman.

More detailed information and any specific aspect of forestry not covered in this book is, of course, available by direct application to this Department.

Periodical revision of this publication will be made and any suggestions for its improvement will be appreciated.

Conservator of Forests

The third edition published in July 1971 has been reprinted without amendment.

CONTENTS

LIST OF COLOUR ILLUSTRATIONS

APPENDICES

In view of the forthcoming changeover to the metric system of measurement, figures in this bulletin are given both in standard units and their metric equivalents.

CONVERSION FACTORS USED IN THIS BULLETIN

LENGTH	1 centimetre = 0·3937 in. 1 metre = 3·281 ft. 1 metre = 1·094 yd. 1 kilometre = 0·621 mile 1 yard = 3 ft. = 36 inches	1 inch = 2·540 cm. 1 foot = 0·3048 m. 1 yard = 0·9144 m. 1 mile = 1·609 km. 1 mile = 1,760 yards = 5,280 ft.
AREA	1 cm^2 = 0·155 sq. in. 1 m^2 = 10·76 sq. ft. 1 $km.^2$ = 0·3861 sq. mile 1 hectare = 0·003861 sq. mile 1 hectare = 2·471 acres 1 sq. kilometre = 100 hectares	1 sq. in. = 6·452 cm^2 1 sq. ft. = 0·0929 m^2 1 sq. mile = 2·59 $km.^2$ 1 sq. mile = 259 ha. 1 acre = 0·4047 ha. 1 sq. mile = 640 acres
VOLUME	1 cm^3 = 0·061 cu in. 1 m^3 = 35·31 cu. ft. 1 m^3 = 0·706 loads* 1 litre = 61 cu. in. 1 litre = 0·2642 gal. (U.S.) 1 litre = 0·2200 gal. (Imp.) 1 litre = 1,000 cm^3	1 cu. in. = 16·39 cm^3 1 cu. ft. = 0·02832 m^3 1 load* = 1·416 m^3 1 cu. in. = 0·01639 litre 1 gal. (U.S.) = 3·785 litres 1 gal. (Imp.) = 4·546 litres 1 gallon = 4 quarts
MASS	1 kilogramme = 2·205 pounds 1 metric ton = 1·102 short tons 1 metric ton = 0·9842 long tons	1 pound = 0·4536 kg. 1 short ton = 0·9072 metric ton 1 long ton = 1·016 metric tons
PRESSURE	1 kg. per m^2 = 0·2048 lb. per sq. ft. 1 gr. per cm^2 = 0·0142 lb. per sq. in.	1 lb. per sq. ft. = 4·882 kg. per m^2 1 lb. per sq. in. = 70·31 gr. per cm^2.
DENSITY	1 kg. per m^3 = 0·06243 lb. per cu. ft.	1 lb per cu. ft. = 16·02 kg. per m^3
OTHER	1 m^2/ha. = 4·356 sq. ft./acre 1 m^3/ha. = 14·29 cu. ft/acre	1 sq. ft./acre = 0·2296 m^2/ha. 1 cu. ft./acre = 0·07 m^3/ha.

*This measure (1 load = 50 cu. ft.) is commonly used in the W.A. timber industry.

CHAPTER I

FORESTRY AND FOREST POLICY

Forestry

Forestry has been described as a science, an art and a business and may be defined as the human activity directed to the management, protection and utilization of forest resources. It concerns the yield of the land and is therefore a form of primary production dealing with a replaceable or renewable resource. It aims to regulate the present-day harvesting of the forest to ensure the continued availability of forest produce at a maximum level, in perpetuity. It is also concerned with improving the quantity and quality of forest resources to meet effectively the increasing demands of a rising population.

Utilization of produce was the first aspect of forests with which men were concerned, hence *Forest Utilization* is the oldest branch of forestry. Later, men began to notice that forests in the immediate neighbourhood of centres of civilisation were becoming depleted due to overcutting. Action taken to protect remaining areas from external exploitation resulted in the development of *Forest Protection*. Originally designed to guard against man's wastefulness, protection later extended to the preservation of forests against injuries by animals, insects, competing vegetation, wood-destroying fungi, fire and other destructive agencies.

With experience it was found that protection alone was not enough to safeguard the forests' resources. Laws were enacted to enforce more efficient control of cutting and to restrict it to the actual productive capacity of the forest.

Forest Management was evolved to meet the problem of calculating the annual or periodical growth and planning for its orderly utilization.

Even then the whole picture was not complete. Following cutting, it became evident that regeneration of the forest by natural seeding was not always adequate, and artificial aids became necessary to establish a satisfactory crop. Constant care and attention throughout the life of the trees was also found essential to produce the maximum growth of the type and quality of timber required by the community and thus *Silviculture* was developed. Silviculture is concerned with the regeneration and tending of forests from the seedling to the mature tree. In addition to the main branches of Management, Silviculture, Protection and Utilization, such fields as Policy, Mensuration, Soil Science, Surveying, Wood Technology, Recreation, Meteorology and Engineering are all necessary for the scientific management of forests. As an appreciation of the need for conservation and replacement of our forests arose, so Forestry developed as a science to deal with all aspects of the formation, treatment, and preservation of the forest environment. Forestry now stands as a profession requiring at least four years of intensive University training before the young forester is considered competent to begin his work in the forest.

Plate 1

Karri forest near Pemberton. Such scenic drives offer enjoyment to all.

The Value of Forests

The value of forests to the community can be grouped into four broad categories:

Productive

Protective

Recreational

Social

The Productive Function of Forests

In our daily lives we are surrounded by material produced from trees. From newspapers and books to the cardboard carton, through the long range of rayons, plastics and chemicals to the more obvious hardboard, chipboard, plywood and sawn timber, the basic raw material in each case is wood.

Wood has an outstanding characteristic—it is a renewable asset. With intelligent protection, management, and renewal of the forest resource, the world can be assured of continuous supplies of wood products. From time to time it is suggested that substitutes will steadily take the place of wood. However, careful analysis shows that while some uses for wood are replaced by other materials, new uses for wood are being developed. This is particularly so in the industrialised countries where big expansion in the use of pulpwood, plastics and synthetic fibres has caused an increase in the per capita, as well as the total consumption of wood.

Plate 2

A sawmill in the jarrah forest near Greenbushes. This is one of some 160 mills operating in the south-west of the State

A rough guide to a country's industrialisation can be gauged from its per capita consumption of sawn timber. Table 1 sets out these figures for the principal geographic regions of the world.

TABLE 1

Per Capita Consumption (Super Feet)*

Region	Sawnwood					
	Softwood		Hardwood		Total	
	1960	1968	1960	1968	1960	1968
North America	171	186	34	34	205	220
m^3	*·404*	*·439*	*·080*	*·080*	*·484*	*·519*
U.S.S.R.	174	169	31	30	205	199
m^3	*·411*	*·399*	*·073*	*·071*	*·484*	*·470*
Pacific Area	78	56	78	61	156	117
m^3	*·184*	*·132*	*·184*	*·144*	*·368*	*·276*
Europe	58	55	14	16	72	71
m^3	*·137*	*·130*	*·033*	*·038*	*·170*	*·168*
South America	10	11	17	16	27	27
m^3	*·024*	*·026*	*·040*	*·038*	*·064*	*·064*
Central America	10	11	4	5	14	17
m^3	*·024*	*·026*	*·009*	*·012*	*·033*	*·040*
Asia	8	9	4	5	12	14
m^3	*·019*	*·021*	*·009*	*·012*	*·028*	*·033*
Africa	3	1	3	3	6	4
m^3	*·007*	*·002*	*·007*	*·007*	*·014*	*·009*
World Average	38	36	10	11	48	47
m^3	*·090*	*·085*	*·024*	*·026*	*·113*	*·111*

* From F.A.O. Sources

This table shows the tremendous difference between the per capita consumption in the highly industrialised areas of Europe, North America and the U.S.S.R. compared to the less industrialised areas in Africa and Asia. As industrialisation increases in these countries, the demand for timber and forest products is bound to increase simultaneously.

For comparison, the Commonwealth and State consumption of sawn timber is outlined in Table 2.

It is due to the bolstering effect of these Australian figures that total consumption for the Pacific Area in Table 1 is so high. Tasmania even has a higher per capita consumption than North America and the U.S.S.R.

Apart from wood, forest products are important to several industries in the form of such resources as rubber, turpentine, tannin, cork, honey, edible fruits and seeds, medicinal oils, charcoal and carbon. In Western Australia, honey collection, charcoal iron, wood chemicals, tool handles and tannin extraction are examples of industries which are dependent on the forest.

TABLE 2

Per Capita Consumption of Sawn Timber for the Australian States for 1968

	Super Feet	M^3
Tasmania	219	*·517*
Western Australia	184	*·434*
Queensland	158	*·373*
Victoria	143	*·337*
New South Wales	137	*·323*
South Australia	133	*·314*
Northern Territory	86	*·203*
Australian Average	147	*·347*

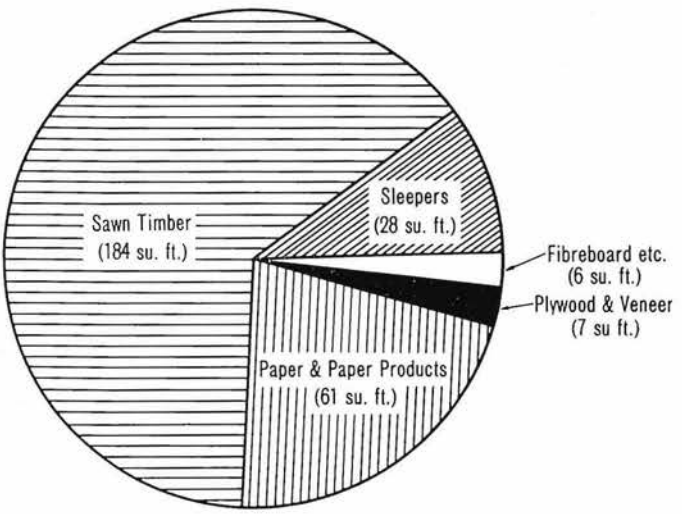


Plate 3

Diagram showing the per capita consumption in W.A. of the different categories of timber products—1967-68

The W.A. total per capita consumption in 1968 was 286 super feet (·675 m^3).

This is approximately equivalent to 65 cubic feet (1·83m^3) round log volume.

Wood is an indispensable part of the material structure on which our civilisation is based.

"From the cradle to the coffin we are dependent on wood."

The Protective Function of Forests

Forest vegetation is a vital factor in the regulation of stream flow, in the control of erosion, siltation, and other problems closely connected with water conservation. Destruction of forest vegetation on watersheds or the reduction of its effectiveness by fire or other agency will jeopardise water supplies and increase soil erosion.

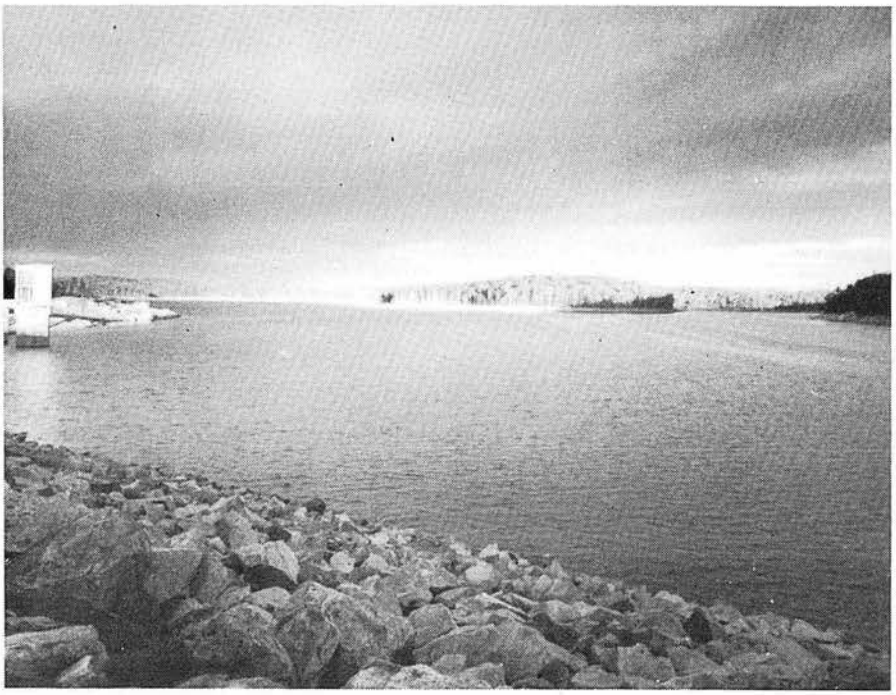


Plate 4

Serpentine Dam, at present the largest dam in the south-west of the State, obtains its water from a forested catchment

Western Australia has no extensive chains of high mountains to feed rivers and streams by melting snow. Only one-eighth of the State receives an average annual rainfall exceeding 20 inches (*51 cm*). Water is a major factor determining the extent to which agricultural and industrial development can be expanded and the degree to which population can be economically increased; therefore, it must be conserved. In this respect, forests on catchment areas play a major part. They promote infiltration of rainwater into the soil preventing excess surface run-off and they assist in regulating violent floods and controlling stream flow.

Forests also serve as windbreaks, reducing the velocity of air currents at the surface of the earth and protecting adjoining fields from searing winds. They provide shelter for crops, stock, game and birds. In general, forests tend to ameliorate extremes of climate.

Fire is a major problem in Western Australian forests because of our prevailing hot, dry summer. Hazard reduction by rotational burning under scientifically prescribed conditions is carried out to protect the forest, adjoining landholders, and small townships. Because not all of an area prescribed for controlled burning is actually burnt, the remaining pockets of unburnt country allow the forest to function as sanctuaries for native animals, while the burnt patches provide food for them as well as helping to regenerate indigenous wildflowers.

Plate 5

Removal of vegetative cover can lead to serious erosion. The photograph (1958) shows the results of overgrazing river flats in the East Kimberleys and consequent loss of grass, shrub and tree cover

Conspicuous examples are available of what may happen when the forests of a semi-arid country are removed. The Dustbowl area of America and the deserts and barren mountains of the Middle East and the North African coast bordering the Sahara Desert resulted from the destruction of forest cover in what were once prosperous regions. Nearer home, examples of overclearing are evident in the Mallee region of Victoria and some of Western Australia's agricultural areas.

The Recreational Function of Forests

Forests have a definite value in their contribution to national welfare as recreation grounds. Recognition of the value of forest land as a place to relax is indicated by the popularity of developed and undeveloped picnic areas throughout State Forests and the demand for the establishment of national parks and nature reserves in different parts of the State. A survey carried out by Forests Department officers indicated that in 1969 over 230,000 people visited State Forest areas within 35 miles (*56 kilometres*) of Perth. (See Chapter VI.)

The use of forests for recreation purposes is bound to increase as the population increases, becomes more mobile, and has more leisure time at its disposal.

Plate 6

Karri Oak picnic ground is one of several along the Rainbow Trail in the heart of the karri forest. Prepared by the Forests Department for the benefit of tourists such spots are becoming increasingly popular

The Social Function of Forests

Forests provide several fields of employment which can amount to a significant part of a nation's economy. Being mainly rural employment, which is labour intensive, this can greatly assist a policy of decentralisation. Many farmers are able to supplement their farm incomes by taking forestry jobs while developing their properties. The rural community in the south-west of Western Australia has closely followed this pattern of development. Employment is provided firstly by the forest services of forest management and general administration, which include such fields as raising and tending forest crops, fire control, research and utilization. It is estimated that every 25 acres (*10 ha*) of an intensively managed mature pine plantation can support one person in direct employment. Our slower growing natural forest does not involve such intensive working as this, but employment in these forests is still substantial under proper management. In addition, harvesting the crop and transporting it to the sawmill, pulping plant, or other processing factory requires labour, and labour is needed in the final step of transporting the processed raw material to market.

One classic example illustrating the employment which forests can create is provided by the intensive afforestation scheme in the Landes district of France in the 19th century. This area, previously a waste of windblown sand, increased its population

from 70,000 to over 300,000 in a period of 70 years, during which time 2,500,000 acres (*1,011,750 ha*) of forest were established and worked.

A recent trend in forestry and sawmilling operations is the emphasis on worker safety. This has reaped the double benefits of reducing injuries to forest workers and the cost of lost time accidents. Involvement in safe working methods is accepted as part of the forester's way of life.

Forest Policy

The history of forestry all over the world shows that in a young country, where there is a surplus of forests for the needs of the people, little thought is given to a forest policy. As the population grows, people become alarmed at the destruction of the forests and a policy for future control is formed.

Because forests are varied and the needs of communities served by forests differ, so the details of forest policies differ in any given situation. However, most countries have developed policies with much the same broad object of managing the multiple resources of their forests to best advantage for the future as well as the present.

This involves:

(a) Ensuring an adequate forest area for present and future demands.

(b) Protecting the present and future forest from injury by man, fire, pests and disease.

(c) Maintaining and improving the productivity of forests.

(d) Establishing forestry as a permanent rural industry growing and supplying forest products in perpetuity.

A well-managed forest may be likened to a bank account in which the forest itself and the forest soil represent the capital invested and held in trust, while the annual growth in timber (the increment of the forest) represents the interest earned. The fundamental idea of Forest Management is to harvest this increment only, and to preserve and improve the forest capital for increased future production.

This aim of a sustained yield to ensure the permanence of forest-based industries cannot be implemented without a sound policy. In Western Australia most of the forests belong to the State and are administered by the Government through its Forests Department.

Forest Policy in Western Australia

Forest Policy in Western Australia is carried out under the authority of the Forests Act which was passed in 1918 and deals amongst other things with forest area, finance, staff, working plans, and forest offences.

Forest Area: Under this Act, State Forest, once dedicated, can only be alienated with the consent of both Houses of Parliament. Over 4.4 million acres (*1.8 million ha*) of State Forest had been dedicated by 1970 and, in addition, 1.8 million acres (*728,000 ha*) had been gazetted as Timber Reserves. Of these Timber Reserves, only the 60,000 acres (*24,282 ha*) in the South-West are capable of producing millable timber and the balance consists chiefly of firewood forest in inland areas. However. 4.4 million acres

(*1.8 million ha*) is little enough area when it is realised that it is less than one per cent of the area of the State and that many countries have up to 30 per cent of forested land. The United States of America has 23 per cent of its area as forested land.

The area with sufficient rainfall to support forests is limited in Western Australia. and it is essential to make the best use of the forested land we do have. One way of doing this is to establish highly productive pine plantations to augment timber supplies from the jarrah and karri forests. By 1970 over 65,000 acres (*26,000 ha*) had been established and it is estimated that some 250,000 acres (*101,175 ha*) should be planted by 2000 A.D. to help the State remain self-sufficient with respect to timber supplies.

Finance: A forest crop matures only after a long period—not annually as with wheat and many other agricultural crops. A jarrah seedling growing today may take over a hundred years to reach harvestable size. It is essential therefore that finance is available in such a way that the work needed to protect and improve the forest can be regularly and continuously carried out. This is provided for in Section 41 of the Forests Act whereby nine-tenths of the nett forest revenue is available for forest protection and improvement. Loan money is also made available to develop plantations.

Staff: The Forests Act provides for the staffing of the Forests Department by allowing for a Conservator and a professional staff of fully qualified officers, as well as general division officers and wages employees. An important section of the staff is research workers engaged on forest improvement and protection projects.

Working Plans: One of the most effective means of controlling forest operations in Western Australia is through Working Plans. These may specify the quantity of forest produce which may be taken each year, the area from which it may be taken, the manner in which it may be taken, the silvicultural operations necessary to ensure the success of the next crop, and such other matters as the Conservator may think fit. A Working Plan must be approved by the Governor and can only be altered on the recommendation of the Conservator of Forests. The Working Plan is dealt with in more detail in Chapter VI on Forest Management.

Forest Offences: The Forests Act makes it an offence to do certain things which would prevent the State's forest policy from being effectively carried out.

For instance, it is an offence under the Forests Act to unlawfully remove forest produce from State Forest, Timber Reserves or Crown Land. Lighting fires in State Forest or timber reserves without carrying out certain conditions is also a forest offence.

Other offences are described in the Forests Act which also specifies the penalties applicable in each case.

Forest Economics

Timber exploitation began with the arrival of the first settlers in 1829. In 1836 the first exports of timber were recorded. The first sawmills appeared about the middle of last century. In 1970 approximately 163 mills were operating and more than 4,500 men were employed in the industry.

The peak years of production were 1913, 1926 and 1927, and following World War II, 1956 and 1966. In 1970, 45 million cubic feet (*1.3 million* m^3) of logs were obtained from our forests, 86 per cent from State Forests and Crown lands and the remainder from private property. The amount from private property is decreasing,

(down from 29 per cent in 1950 and 20 per cent in 1964 to 14 per cent in 1970) and this trend is expected to continue. The total demand for timber has two components, the per capita consumption and the total population.

The per capita consumption is usefully expressed as the log volume equivalent of the amount of sawnwood, plywood and veneer, fibreboard, sleepers, paper and paper products consumed per head of population. Plate 3 shows the components for W.A. in 1968, when the total per capita consumption was 65 cubic feet (*1.8 m^3*) equivalent log volume.

While the contribution of each component may vary with time the total per capita consumption in W.A. is expected to remain fairly constant.

At 65 cubic feet (*1.8 m^3*) per capita it is possible to predict the total timber demand for a given population.

The population of Western Australia reached one million in 1971 and is expected to be between 2.0 and 2.5 million by 2000 A.D. depending on the rate at which immigration and industrial expansion continue. At 65 cubic feet (*1.8 m^3*) per capita the total consumption will therefore be between 130 and 162 million cubic feet (*3.7* and *4.6 million m^3*). To meet this total demand, supplies can come from the native hardwood forest, pine plantations, and imports.

The hardwood forest can supply approximately 40 million cubic feet (*1.1 million m^3*) a year at the present level of utilization. With better sawn recovery, and the introduction of new uses such as chipwood for marri, the hardwood forest could supply over 65 million cubic feet (*1.8 million m^3*) per year by 2000 A.D. An increase of only two per cent in the recovery of our sawmills would mean the additional production of approximately one million cubic feet of sawn timber. This is by no means impossible. We have been in the position of a timber exporting country for many years, and in consequence have developed the bad habit of wasting timber, or discarding a piece we do not like because it is neither difficult nor expensive to obtain another length.

In addition if architects and builders take more care that the correct quality is used for different parts of a building, timber will be less costly to use and the timber available will go further. We tend to demand first quality timber for second rate purposes, and ask for one length of scantling where several short pieces are all that is required. We are reluctant to try smaller timbers or thinner floor boards.

In the long term, by making the forest more productive a greater supply will be available from the hardwood forest. A yield of 99 million cubic feet (*2.8 million m^3*) a year is possible if every acre is fully productive. This, however, will only be achieved after application of the forester's skills for many decades.

Pine plantations offer an extremely useful way of rapidly increasing the supply of timber. The planting rate in Western Australia has been stepped up from 2,700 acres (*1,100 ha*) in 1960 to 7,500 acres (*3,000 ha*) in 1969. A plantation area of 250,000 acres (*101,175 ha*) by 2000 A.D. is anticipated and this is expected to yield 50 million cubic feet (*1.4 million m^3*) a year. The yield in 1970 was approximately 3 million cubic feet (*85,000 m^3*). However, as the land suitable for planting pines is limited, a yield of 50 million cubic feet a year from 250,000 acres (*101,175 ha*) is the likely limit to the timber supply from plantations.

Importing timber and wood based products is another way of making up the demand. However, as this is costly and supplies may not always be available, it is highly desirable to keep this contribution to a minimum, except for specialty lines not readily available within the State.

The future and stability of the sawmilling industry and the associated financial benefit to the State are intimately bound up with a sound forest policy, maximum utilisation by the sawmiller and minimum wastage by the user.

CHAPTER II

THE FOREST ENVIRONMENT

Forest Botany

A Description of a Tree

A tree may be defined as a woody, erect growth having three readily distinguishable sections: the roots, the bole (stem or trunk) and the crown. The crown is supported by a single stem so that the height of the plant, when mature, exceeds 15 feet. This definition separates the tree from all other members of the plant kingdom in which it stands as the highest evolved form.

THE SECTIONS OF A TREE

The Root System

The roots constitute the underground portion of the tree and have two main functions: to support the stem and crown in their upright habit, and perhaps more important, to absorb from the soil the water and minerals required for plant nutrition.

Root types vary considerably from species to species and from tree to tree. They are governed mainly by two factors—(1) the particular nature of the species concerned, and (2) the soil type or rooting medium in which it is growing. Some trees possess an inherent capacity to send a tap root deep down into the soil. Other species favour shallow rooting and penetrate more in a lateral than in a vertical direction. Deep, well-drained soils favour tap root development, while shallow or waterlogged soils lead to a more lateral spread of the roots.

The nutrients in the soil water, when absorbed, are passed up, *via* the bole, to the crown to be converted into the food materials necessary to sustain life and growth.

Water absorption is carried out by the young fine rootlets and root hairs, the only part of the root system which has this property. These small absorbing ends have a short life and, once they have completed their work, break up and are replaced by the new rootlets formed at the growing tips. A layer of protective bark develops around the older non-absorbing roots, and they serve the dual role as a soil anchorage medium and as a pipeline to pass the root solutions taken up at the tips back to the stem and then up into the trunk.

Most root systems are extensively branched to permit the fine feeding rootlets to completely ramify through the soil in the search for water and mineral nutrients.

The Bole

The bole of the tree also carries out a twofold role in the life of the tree. It serves as a support to thrust the crown up and out into the light, and constitutes a conducting medium by means of which root solutions are passed up into the crown. The stem also allows the plant foods produced in the crown to return downwards to the other living parts of the tree.

All tree stems are woody and capable of radial growth. This allows the tree to grow in girth at the same time as it increases in height and width of crown. A sheath of bark completely encases the bole, protecting the vital conducting and growth tissues from external damage.

The size of a tree's bole depends to a large extent on its particular type, but it is also a reflection of the fertility of the site occupied by the tree. Karri has a bole length often exceeding 100 feet (*30 m*), while the woodland wandoo is normally found with a bole of approximately 25 feet (*8 m*). York gum and flooded gum are species which usually have very short boles.

Since the bole of the tree supplies the saw logs of commerce, this is the section with which foresters are primarily concerned. Trees in their young stages are often closely spaced to influence height growth and branch shed, forming a long, clean bole. Once maximum height is attained, however, the trees are thinned out. This allows the remaining trees more space for crown and root development and leads to more rapid increase in diameter growth.

WOOD

The body of a tree is made up of small cells composed of cellulose, the building material of plants. These cells are usually relatively short-lived and are rapidly replaced in function by new, younger cells put down for growth and expansion purposes. In the heartwood of the tree trunk, the majority of the cells have completed their living function and serve purely as mechanical support for the living parts. To facilitate this role, the cell wall normally undergoes chemical change and thickening, forming a much stronger unit.

A cross-section of a tree (Plate 4) shows the following well-defined features in succession from the outside to the centre:—

1. Bark, which may be divided into—
   (a) the outer, corky dead part that varies greatly in thickness with different species and with age of trees, and
   (b) the thin, inner living part.
2. Wood which in merchantable trees of most species is clearly differentiated into sapwood aind heartwood.
3. The pith, indicated by a small central core, darker in colour, which represents primary growth formed when woody stems or branches elongate.

Growth Rings

In the growing season the tree adds a layer of wood on the outside of that previously formed. If growth is interrupted annually by cold weather or dry seasons, the character of the cells at the end of each year's growth and the beginning of the next is sufficiently different to define sharply the annual layers or growth rings. (Plate 4). Consequently the age of such a tree may be determined by counting the number of annual growth rings at its base. In parts of the Tropics, where the growing season extends throughout the year, no well-defined annual growth layers are formed and it

is impossible, with any degree of accuracy, to tell the age of such trees. In eucalypts also it is generally difficult to determine the growth rings.

Sapwood and Heartwood

Sapwood contains living cells and plays an active part in the life processes of the tree. It is located next to the cambium and is the part of the tree that conducts the sap from the roots to the crown; it is also used for the storage of food. The sapwood layer may vary in thickness and commonly ranges from half to two inches. As a rule, the more vigorously growing trees of a species have wider sapwood layers.

As the tree grows the old sapwood is replaced by new rings and these old cells are altered to form heartwood. In the cavities of the heartwood various materials are deposited which frequently give a much darker colour to this wood. These infiltrations or materials deposited also make timber cut from it more durable when used in exposed conditions.

Medullary Rays

Another feature of wood which is particularly important in determining the "figure" of many woods are the medullary rays. These rays are observed on the cross-section as discontinuous radial lines. They vary in length and thickness with different species and serve, in the living tree, as a means of moving food radially across the wood tissues and as a food storage and waste depository area. Silky Oak, Banksia, Sheoak, and Oak, are some trees whose pronounced medullary rays produce a figure in wood highly valued for ornamental work.

The Tree Crown

The leaves of the crown form the factory area of the tree and the processes of food production, transpiration and respiration are all functions of the leaves. Seed for reproducing the species is also formed in the crown.

HOW A TREE LIVES AND GROWS

Tree Nutrition

Plants are the sustenance of all life on earth, for they alone are able to produce from simple, naturally occurring substances, the complex organic foods necessary for the life of organic cells. This process depends entirely on the action of sunlight on the green colouring matter (chlorophyll) of the leaves and is called photosynthesis. Animals require organic materials already formed and obtain them in solid food derived directly from plants or from other animals which have in turn fed on plants.

The basic elements required for food synthesis are drawn from two sources: the air and the soil. In all, nine elements—carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur—are required by all plants in fairly large quantities. These elements are referred to as the major elements of plant nutrition. Other elements such as boron, cobalt, chlorine, copper, iron, manganese, molybdenum and zinc are called the minor elements and are known to be essential for at least some plants, but are required in much smaller amounts. Of these elements, carbon in the form of carbon dioxide is taken from the atmosphere and all others are derived from the soil, in the form of mineral solutions in water.

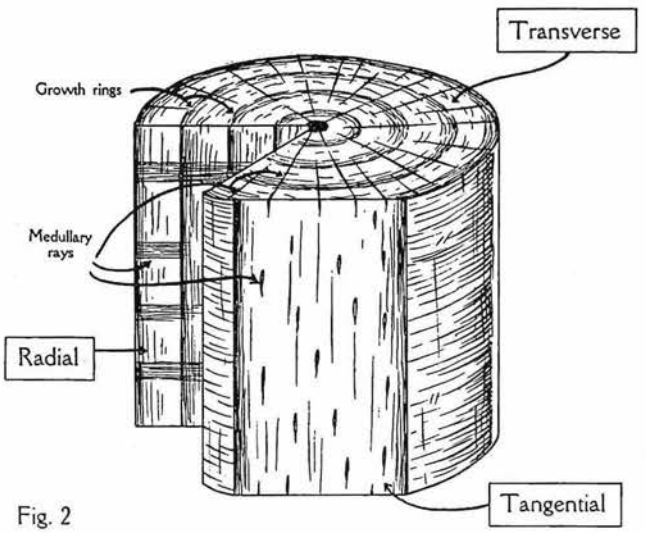


Fig. 2

Diagrammatic sketch of a cylinder of wood with transverse, radial and tangential sections exposed

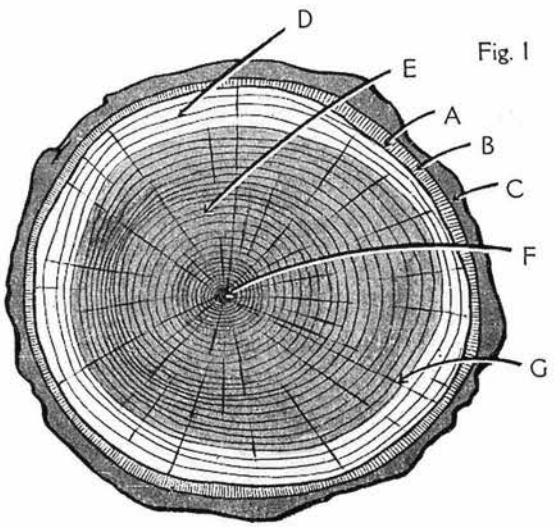


Fig. 1

Diagrammatic sketch of a transverse section of tree trunk

Plate 7

Diagrammatic sketches of wood sections. Figure 1 shows—A—cambium layer, B—inner living bark. C—outer protective bark, D—sapwood, E—heartwood, F—pith, G—medullary ray

A fertile soil will supply all the above major and minor elements and an infertile soil is deficient in one or more of them. The fertility of a soil is reflected in the health and vigour of the tree.

Many pines planted in Western Australia reflect soil deficiencies which have to be corrected by adding extra phosphorus in the form of superphosphate fertilizer or extra zinc in the form of a zinc sulphate spray to the foliage.

Photosynthesis

Photosynthesis is the production of organic foods from simple, naturally-occurring elements within the green plant cells in the presence of sunlight.

The raw materials of photosynthesis are water and carbon dioxide and the first known substances formed are simple carbohydrates, or sugars such as glucose, fructose and sucrose. Photosynthesis may be summarised as—

$$\text{Carbon dioxide from the air} + \text{water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{sugars} + \text{oxygen.}$$

Chlorophyll is not used up in the reaction; it acts merely as the trigger which sets off the process.

These sugars are converted into starches for storage in the tree.

Once manufactured, foods are passed down the branches and trunk, through the living inner bark (phloem). Here they are utilized to be absorbed by the tree for energy or converted to the higher organic forms such as carbohydrates, fats, proteins, vitamins, etc., necessary for life and cell production.

Phloem (living bark) tissue conducts the products of photosynthesis down from the crown to the living parts of the tree, while the sap from the roots is conveyed upward through the sapwood (xylem) of the tree. The two processes are opposite in direction.

Trees are killed by ringbarking because the phloem tissue is severed and the movement of food to the roots is prevented. Deeper ringing through the sapwood will also prevent the transference of water and minerals to the crown. Ringbarking thus kills a tree by starvation.

Transpiration

Another important function necessary to the life of the tree and occurring through the leaves in the crown is transpiration, or the expulsion of excess water from the tree into the atmosphere.

Less than 1 per cent of the water taken up by the roots and transported up to the leaves by the xylem tissue is used by the plant cells. The bulk of the water acts as a means of conveying the mineral nutrients, which are dissolved in it, from the soil to the leaves. Once the nutrients have been removed from the sap, the water is of no further use and must be removed from the plant to allow room for more sap to be moved up from the roots. This excess water is discharged into the atmosphere through special breathing pores, called stomata, in the leaves.

Through the stomata, carbon dioxide for photosynthesis is taken in, excess water in the form of vapour is evaporated and the exchange of gases necessary for respiration occurs.

Respiration

All plants breathe and respiration is just as necessary for plant life as it is for animal life. Plant respiration is also identical with animal respiration; oxygen is utilized and carbon dioxide is expelled. The energy required for this process is derived from some of the food materials supplied by photosynthesis.

The tree breathes through the leaves, the stomata providing the necessary communication between the plant and the atmosphere. Within the leaves small spaces between the cells serve as a channelway, connecting with the stomata. Each cell is therefore indirectly in contact with the atmosphere permitting the exchange of gases required in respiration.

A tree in which the energy built up in photosynthesis just balances that used in respiration will stay alive but will not grow. To encourage growth, conditions which favour maximum photosynthesis must be satisfied.

Respiration and photosynthesis then are two very different processes, both necessary for the life of the plant. Briefly, their differences may be listed as follows:—

Respiration

(1) Respiration is a continuous process, which functions night and day throughout the life of the plant.

(2) Respiration is necessary and common to all living cells, independent of their location or function.

(3) Respiration takes in oxygen from the atmosphere and expels carbon dioxide.

(4) Respiration uses up energy and plant food.

Photosynthesis

(1) Photosythesis occurs only in the presence of sunlight.

(2) Photosynthesis requires chlorophyll and thus only occurs in green cells.

(3) Photosynthesis uses carbon dioxide and water vapour and produces oxygen as a by-product.

(4) Photosynthesis provides food and the energy necessary for plant growth.

Reproduction

Nature makes plentiful provision for the preservation of the species and all trees, when they come to maturity, bear flowers. Within the flowers pollination occurs and in time they develop into fruit with seeds which fall to the ground and germinate to form new trees.

Jarrah flowers develop one year after the buds are first seen and are pollinated during the summer months. Twelve months after pollination, the fruit contains mature seeds. In the hot months of the summer the valves of the ripe fruit open while still attached to the tree and the seeds are allowed to drop to the forest floor. During their travel from the height of the crown to the floor, air currents may disperse the light seeds some distance from the mother tree. Many trees, such as the pines, have evolved wings on the seeds to allow for widespread dispersal once launched from the height of the tree.

On the forest floor the seed germinates when conditions of temperature, light and moisture are favourable to the establishment of the young seedling. Of the thousands upon thousands of seeds which germinate on every acre of forest soil, however, only a few survive competition from weeds, neighbouring trees and the long dry summer to eventually become a mature tree.

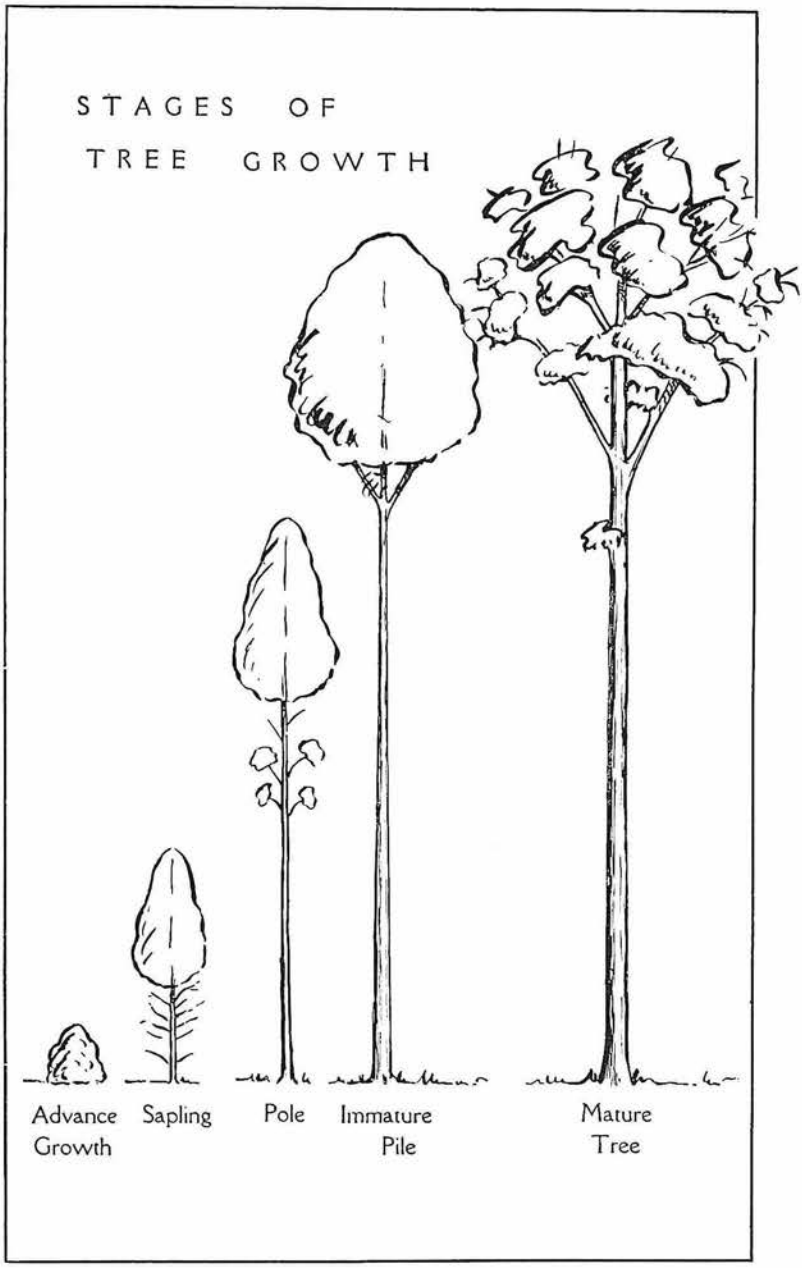


Plate 8

Illustrative stages showing the development of bole and crown throughout the life of a jarrah tree. From the small bushy advance growth stage to that of the mature tree required for sawmilling, a period of 150 years may elapse

The forester is largely concerned with providing the most suitable conditions for seed formation, seed shed, germination and successful establishment of the young seedlings to obtain adequate stocking throughout the forest area.

Besides reproduction by means of seed, many trees, like jarrah, are able to regenerate by shoots (coppice) which arise from the stump after the mother tree has been felled, or by suckers from the roots as with elms and figs.

Growth

Tree growth is carried out at three main growing regions. The root tips which grow generally downwards into the soil. The shoot tips which grow upwards. The third growing region of a tree is called the cambium, and is concerned with the growth in diameter of all woody parts of the tree. The cambium consists of a single layer of cells completely ensheathing the woody section of the tree, and is located immediately beneath the bark. From the cambium, cells are formed in two directions: new wood cells are formed on the inside, and new bark cells on the outside.

A tree grows by the formation of new cells rather than by the extension of existing cells. A tree grows in height by adding new cells upwards on top of the existing tip. A nail placed at the base of a tree will not move upwards as the tree grows, as is often believed; it will remain at the same distance from the ground throughout the life of the tree.

The Vegetation of W.A.

For over a century, in fact from the time when Dampier visited these shores, the unique flora of Western Australia has claimed the attention of botanists throughout the world. Only in South Africa and in South America do we find the native species so rich in vegetative and floristic forms.

The distribution of vegetation types in Western Australia is determined mainly by climate and to a lesser extent by soil type.

Climatically, three broad vegetation regions may be separated. These are a Northern Province, an area in the North and North-West of the State which receives a summer rainfall, a South-Western Province receiving a consistent reliable winter rainfall and a Central Province, a buffer region between the Northern and South-Western Provinces which receives an indefinite rainfall in either summer or winter.

The South-Western Province covers vegetative types which are typically Australian in character, a type familiar to most Southern Australians. The Northern Province, however, as well as containing an Australian flora, has some tropical species of Indo-Malayan origin. Eucalypts are present, so are Grevilleas, Hakeas and Banksias, yet in certain areas, particularly those of high rainfall and along the watercourses, tropical species are abundant.

In the Central Province grow species common to the South-Western Province, some species common to the Northern Province and also a definite characteristic scrub and steppe type vegetation of its own. Mulga bush is typical of a large section of this Province.

Within these Provinces, vegetative formations are separated both by local climatic and by soil factors. The accompanying vegetation map of the State (*Plate 9*) separates the following vegetative types:—

A.—Sclerophyllous Types (undergrowth of harsh leaved shrubs).

(1) Low rainfall tropical woodlands. Eucalypts are the dominant species.

(7), (8) and (9) Low rainfall temperate forests and woodlands with belts of sand heath and mallee. Eucalypts are the dominant species. This includes the salmon gum, wandoo, mallet and morrel woodlands. Type (8) is mainly sandplain.

(10) Sclerophyllous forest. Eucalypts are the dominant species. This type is the jarrah forest, including marri and blackbutt. It is one of the finest hardwood areas in the world.

(11) Temperate eucalpyt rain forest. Eucalypts are the dominant species. This type is the valuable and highly productive karri forest.

B.—Savannah Types. (Undergrowth herbaceous, principally grasses.)

(2) Savannah forest and woodlands. Eucalypts are the dominant species. Along the rivers, relatively dense forests of tropical species thrive.

(13) Savannah forest. Eucalypts are the dominant species. This is the coastal tuart formation.

(3) and (4) Savannah. In these areas are expanses of grassland, mainly of *Triodia* and *Themedia* species.

(5) Mulga bush.

C.—Treeless Regions

(6) Saltbush plain. The Nullarbor Plain.

(12) Desert with Spinifex and belts of low shrub.

The better known commercial forests of jarrah, karri and associated species are confined to that small fraction (2% of the total area) of the State which receives a reliable winter rainfall of 25 in. (*635 mm*) or better per annum, with wandoo extending eastward as open forest to areas of 20 in. (*508 mm*) rainfall.

Beyond the 20 in. (*508 mm*) rainfall limit, which lies some 50 miles (*80 km*) east of Perth, occurs the inland forest of open sclerophyllous woodland. Much of this land, down to 11 in. (*279 mm*) rainfall areas, has been cleared for agricultural purposes, forming the main wheat growing area of the State. Further east, in the Eastern Goldfields area, the open eucalypt forest has supplied valuable fuel and mining timber for the mining and grazing industries carried on within its precincts.

Northern and central areas are not a commercial proposition as far as the timber industry is concerned, but the local woodlands have played a major part in supplying timber and fuel used in the development of the country for grazing and mining purposes.

Western Australian Trees

The number and variety of native Western Australian trees is great, the eucalypts alone exceeding one hundred species. Only a few, however, are of commercial importance and the significance of the remainder is often overlooked. The prominence of the first half dozen species of importance in the timber trade is widely recognised for they produce timber of a quality highly regarded throughout the world. These species jarrah (*Euc. marginata*), karri (*Euc. diversicolor*), tuart (*Euc. gomphocephala*), wandoo (*Euc. wandoo*), marri (*Euc. calophylla*), blackbutt (*Euc. patens*) and red tingle (*Euc. jacksonii*) have played an important role in the development of the State, both from the point of view of supplying local timber requirements and in permitting a valuable export trade.

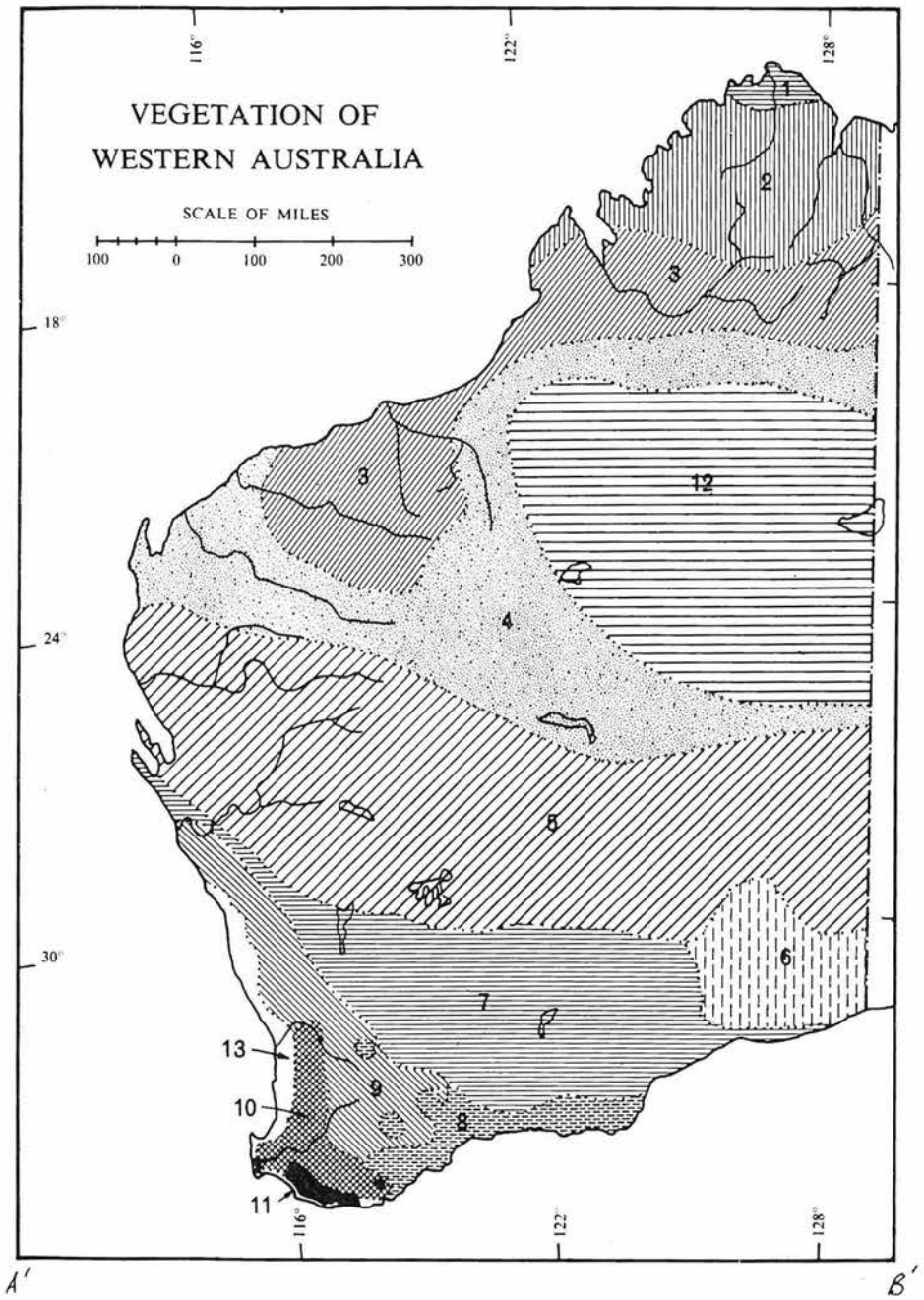


Plate 9

Map of W.A. showing vegetative formations. For description see text.
—"*By Courtesy of Royal Society of W.A*"

Plate 10

Coral-flowered Gum (*Eucalyptus torquata*)

In recent years, the minor Western Australian trees have received considerable attention. Such species as salmon gum (*Euc. salmonophloia*), the mallets (*Euc. astringens, Euc. gardneri,* etc.), morrel (*Euc. longicornis*), gimlet (*Euc. salubris*), coral-flowered gum (*Euc. torquata*) and others, typical of semi-arid to arid regions of the State are unique, in that they can attain a tree form in such low rainfall areas. Overseas attention has focused on these species with a view to afforestation in the drier regions of these countries, since usually no such comparable growth exists in semi-arid regions outside Australia. Many other of our minor species such as red-flowered gum (*Euc. ficifolia*), coral-flowered gum and fuchsia mallee (*Euc. forrestiana*), due to colour and diversity of blossoms, fruits, buds and leaves, are much sought after for ornamental planting.

The great majority of important trees of the State are of the evergreen, hardwood type and belong to the genus Eucalyptus. Natural softwoods are rare and confined almost exclusively to the genus Callitris, and are of no commercial value. Examples of such conifers are the Rottnest Island pine (*Callitris robusta*) and the Goldfields pine (*Callitris glauca*). Pine plantations observed in the metropolitan area and rural centres consist of exotic pines, that is, pine species introduced from other lands and not native to this State. These plantations are composed principally of *Pinus radiata,* a pine from the Monterey region of California, and *Pinus pinaster,* a species native to Mediterranean regions such as Portugal, Spain, Italy and France.

The value of tree growth in the Northern parts of the State is not generally appreciated by Southerners. Though not commercially important, these trees have proved invaluable in supplying local wood requirements for heating, fencing and building. Coolibah (*Euc. microtheca*), river red gum (*Euc. camaldulensis*) and several others are highly valued by the limited population of these outback areas.

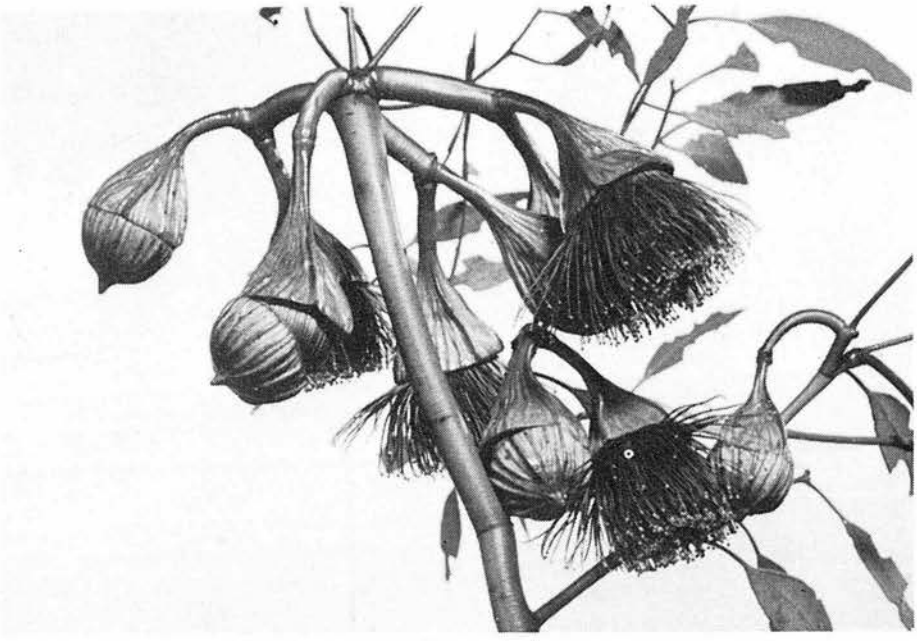


Plate 11

Pear-fruited Mallee *(Eucalyptus pyriformis)*

The following list includes the principal trees of the southern portion of the State:—

Trees of the Humid and Sub-Humid Zones

Bullich	*Eucalyptus megacarpa*
Flooded Gum	,, *rudis*
Jarrah	,, *marginata*
Karri	,, *diversicolor*
Marri	,, *calophylla*
Red-flowered Gum	,, *ficifolia*
Tingle, red	,, *jacksonii*
Tingle, yellow	,, *guilfoylei*
Tuart	,, *gomphocephala*
W.A. Blackbutt	,, *patens*
Wandoo	,, *wandoo (syn. redunca var. elata)*
Yate	,, *cornuta*
Bull Banksia	*Banksia grandis*
Karri Oak	*Casuarina decussata*
Menzies Banksia	*Banksia menziesii*
Native Pear	*Xylomelum occidentale*
River Banksia	*Banksia verticillata*
Rottnest Island Pine	*Callistris robusta*
Sheoak	*Casuarina fraseriana*
W.A. Peppermint	*Agonis flexuosa*
Warren River Cedar	*Agonis juniperina*

Trees of the Semi-Arid and Arid Zones

Blackbutt, Dundas	*Eucalyptus dundasii*
Blackbutt, Goldfields	„ *le souefii*
Blackbutt, yellow-flowered	„ *stricklandii*
Boongul	„ *transcontinentalis*
Coral-flowered Gum	„ *torquata*
Dundas Mahogany	„ *brockwayi*
Gimlet and Silver Gimlet	„ *salubris, Euc. campaspe*
Mallet, brown, white, etc.	„ *astringens, Euc. falcata,* etc.
Merrit	„ *flocktoniae*
Morrel, red	„ *longicornis*
Salmon Gum	„ *salmonophloia*
Swamp or Flat-topped Yate	„ *occidentalis*
York Gum	„ *loxophleba*
Goldfields Pine	*Callitris glauca*
Kurrajong	*Brachychiton gregorii*
Raspberry Jam	*Acacia acuminata*
Sandalwood	*Santalum spicatum*

This list includes the commonly known species. Appendix I provides a more complete list of the Eucalypts of Western Australia.

Characteristics of the Genus Eucalyptus

The Eucalyptus derives its name from two Greek words which may be translated as "well covered"—a name applied to the little cap which protects the unopened flower, and one which aptly describes what is perhaps the leading feature of the genus. The most noticeable feature about a eucalyptus flower is the absence of both sepals and petals, and the presence of the bud cap or operculum which protects the stamens. The operculum usually falls off entirely as the flower expands, but sometimes remains hinged onto the calyx after the flower opens. These characteristics, together with the presence of the inferior ovary and the conspicuous stamens of indefinite number, serve to distinguish the genus *Eucalyptus* from all other flowering plants. The *Eucalyptus* is closely allied to the genus *Angophora,* which is found only in the Eastern States, in which there are petals which soon fall after expansion, and small but distinct calyx teeth. The calyx, although generally without lobes or teeth at all, has, in a few instances, small teeth, four in number, which are situated at or near the top of the calyx, and which appear to be the rudiments of sepals. The operculum takes the place of petals as regards their protective functions, but the filaments are the most conspicuous part of the flower, and being attractive, serve as petals in this respect. If, as is generally supposed, the Angophores are the ancestors of the Eucalypts, the operculum may have, at one time consisted of free petals. In some species of *Eucalyptus,* the operculum is double—the outer one falling off before the inner.

Eucalypts are all evergreen trees or shrubs, with the exception of one tropical tree which is deciduous, and another from the same latitude which is partially deciduous. They have simple leaves which usually have leaf stalks. The leaves are generally of a lance or egg shape. The venation consists of a midrib connected by fine secondary veins with a vein which runs close to the margin of the leaf (intra-marginal).

With few exceptions, the bracts and bracteoles so characteristic of other flowering shrubs and trees are absent from *Eucalyptus,* and, when present, are either rudimentary or fall before the flowering period.

P. KIMBER

Brown Thornbill (*Acanthiza pusilla*) at nest with young Fan-tailed Cuckoo (*Cacomantis pyrrhophanus*).

Bottom left: Rufous Tree-creepers (*Climacteris rufa*) at nest.

Bottom right: Rainbow Bird (*Merops ornatus*) at nest.

P. KIMBER

P. KIMBER

Yellow-tailed Thornbill or Tom Tit (*Acanthiza chrysorrhoa*).

P. KIMBER

Splendid Wren (*Malurus splendens*) beside nest.

P. KIMBER

Yellow Robin (*Eopsaltria griseogularis*) with young in nest.

P. KIMBER

Red-winged Wren (*Malurus elegans*).

Numbat or Banded Anteater (*Myrmecobius fasciatus*).

Short-nosed Bandicoot (*Isoodon obesulus*).

Purple-crowned Lorikeet (*Glossopsitta porphyrocephala*).

The Eucalypt Fruit

Eucalypt flowers differ from those of most other plants in that they have no obvious petals.

When flowering, the attractiveness of the blossom is derived from the numerous, conspicuous and often brightly coloured stamens.

The petals in the eucalyptus flower are replaced by the bud cap which protects the miniature stamens, dropping off when they mature.

The following illustrations show the method of fruiting and flowering of three different West Australian eucalypts.

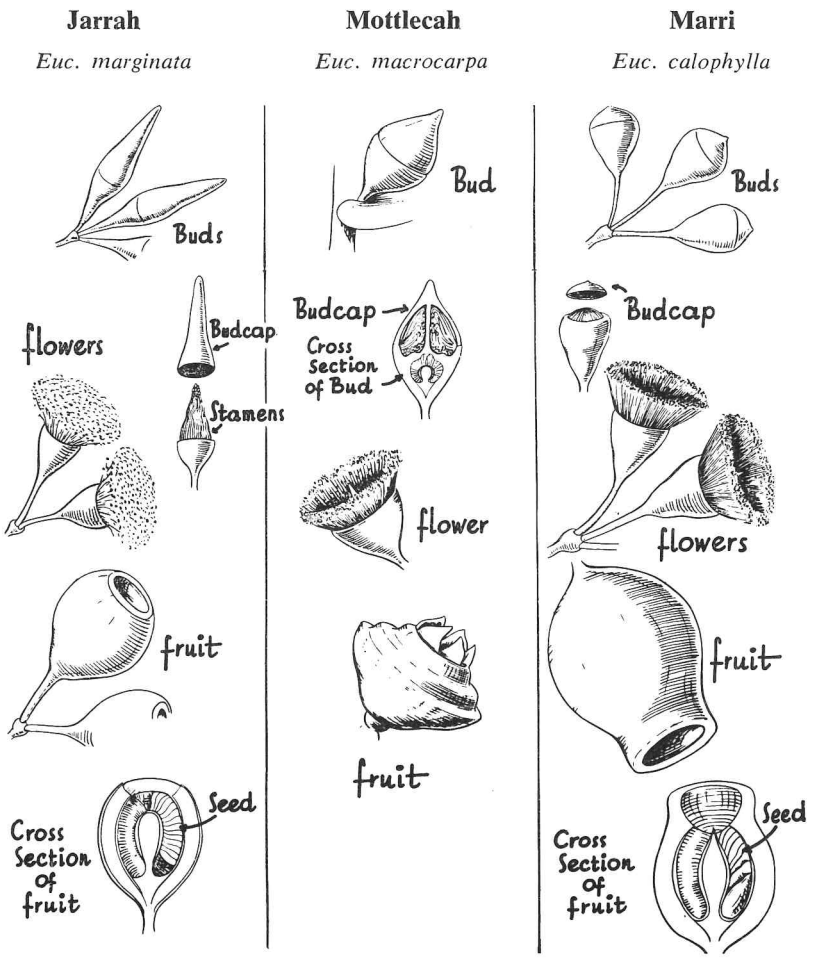


Plate 12

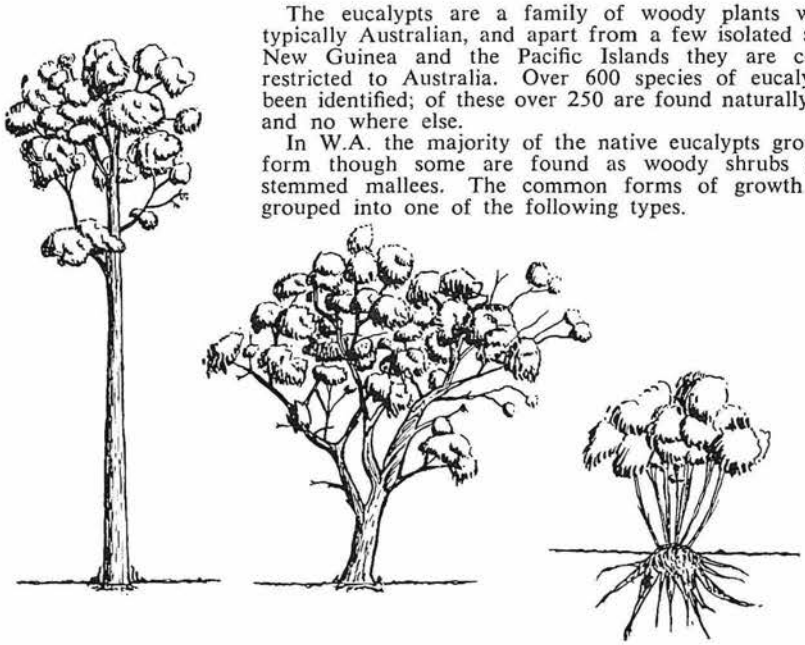
The flowering forms of three common W.A. eucalypts

Eucalypts are divided, as regards their habit, into Trees, Shrubs, Mallees and Marlocks. Trees are distinctive in habit, in that they possess a well defined trunk. Shrubs branch from the base, or close to the base; Mallees have a bulbous rootstock, either subterranean or half above the soil, from which arise stems (usualy four to eight in number) which are all about the same height. Typical mallees have a large woody stock. Marlocks, which may be called "sand plain mallees" have a smaller reduced stock, or become true shrubs. It is often difficult to distinguish between a marlock and a shrub, as intermediate forms occur, which may be one or the other. Trees and mallees, on the other hand, are quite distinctive forms of vegetation.

The Tree Form of the Eucalypts

The eucalypts are a family of woody plants which are typically Australian, and apart from a few isolated species in New Guinea and the Pacific Islands they are completely restricted to Australia. Over 600 species of eucalypts have been identified; of these over 250 are found naturally in W.A. and no where else.

In W.A. the majority of the native eucalypts grow in tree form though some are found as woody shrubs or many stemmed mallees. The common forms of growth may be grouped into one of the following types.



Long tapering bole with small crown. This type is characteristic of Karri, Jarrah and Blackbutt, the principal commercial timber producing species. Height growth is usually over 100 ft.

Short stocky bole with wide spreading shady crown. Height under 80 ft. This tree is characteristic of York Gum, Wandoo and Flooded Gum, found in farming areas.

Maximum height approximately 30 ft. Several stems arise from a single rootstock below ground. Mallees are typical of sand plains and many arid area species. Mottlecah is an example.

Plate 13

Three common habits of the eucalypts

The Forest

During the course of time the word "Forest" has altered in meaning as the social life of people has changed. The word, originally applied in feudal times to areas of land over which the King claimed exclusive rights of the chase, now refers to a wooded area or a collection of woods of large extent. To be precise, the F.A.O. has recently published the following definition for forests:—

> "Lands bearing vegetative associations dominated by trees of any size capable of producing timber or other forests products or of exercising an influence on the climate or on the water regime."

This is a very broad definition which, in Western Australia, includes not only the important jarrah, karri and tuart areas, but also the semi-arid and arid area woodlands in which wandoo, salmon gum, morrel, gimlet and mallet are prominent. It can be seen, therefore, that within the scope of the word "Forest" there are many forms.

Forests are primarily of two kinds, natural forests and artificial or planted forests. Jarrah and karri are examples of natural forests. The pine plantations around the Metropolitan Area and South-West are artificial forests.

Natural forests may be considered as managed or unmanaged, according to their treatment by man. An unmanaged forest is one which has received no attention from man except to regard it as a storehouse of timber to be cut down and carried away.

Plate 14

Virgin marri forest south of Pemberton

The managed forest, however, is one in which man has done much to control the utilization of the trees and to ensure their replacement and to maintain the forest as a vigorous producing unit.

The Distribution of Forests

Forest distribution throughout the world is determined by variations in climatic and soil conditions.

The commercial forests of this State occur principally in areas receiving a rainfall greater than 25 inches (*635 mm*) per annum in which the winter fall is reliable. Within this broad area of the South-West different forest types occur, according to the different requirements of their main species. The jarrah forest favours the well-drained lateritic soils of the Darling Scarp; tuart occurs only on the coastal plain limestone fringe, while karri requires particular soils of granitic origin in the cooler and better watered far-South.

Afforestation, or the creation of artificial forests (or plantations), is concerned with the planting of forests of a desired type on treeless areas, or to replace uneconomical tree growth on areas with suitable climate and soil.

The Composition of Forests

The forest is a community consisting of several component parts. Under forest conditions these components—vegetation, soil, animals, insects and birds—do not exist as separate entities. They live in an environment in which each is dependent on the others. Trees cannot grow satisfactorily unless certain soil and climatic factors are present, nor can they continue to reproduce and thrive unless animals, insects and birds are available to aid the process and maintain soil fertility.

The relationship which exists between the many individuals of the forest is intricate and usually varies from one type of forest to the next, for no two forests may be regarded as identical in all respects. It is necessary to understand the basic relationships which exist between the tree and its habitat, and this study of Forest Ecology is essential for successful forestry.

The Trees of the Forest

The trees in the forest form an entity within which they are mutually dependent but at the same time in competition with one another. Each requires a minimum allotment of light, space and soil nutrients for sustenance and growth; these factors varying with species and also with the age or stage of development of the particular tree. Some trees are light demanders in that they require plenty of light and space to mature and produce millable logs. The eucalypts are of this class. Jarrah seedlings will only develop to form a tree provided they are permitted a space in the forest canopy which allows ample light and area for development. Vigorous young jarrah saplings are rarely found growing in the shade or in close proximity to mature trees.

Other types of trees develop better under shade and are called shade tolerant. The English beech is the classical example of this. The sheoak and *Banksia grandis* provide the best examples of shade tolerant trees, which are not common in Western Australia.

Competition between trees for space, light and soil nutrients gives to the forest a distinctive structure in which the crowns of different species form successive layers or storeys. These canopy or crown levels are more distinctive in certain types of forest, the tropical rain forest in particular. In the jarrah forest, a reasonable example of these storied vegetation layers may often be found. Mature jarrah crowns form the upper

storey which may be generally divided into three separate regions, the top level of dominant trees, the general level of co-dominant trees and the lower level of dominated and younger tree crowns. Underneath this general canopy level is the understorey of suppressed trees, saplings, sheoaks and banksia. The lowest limit, or stratum, is classed as the ground flora and embraces the smaller shrubs, herbs and prostrate forms growing close to the ground.

This storied arrangement of the different types of vegetative growth has characteristics which are stable for a particular type of forest and is an aspect of importance to the forester when considering treatment methods most advantageous to tree growth.

The Forest Soil

The forest soil is second in importance only to climate as a factor determining the existence of forests. It often determines the nature and extent of the forests within a climatic zone and, in this State in particular, soil types may be broadly correlated with the forest types.

The soil provides a root anchorage for the trees and is a reservoir of the mineral nutrients necessary for the production of plant foods. It is not the inanimate and static medium it appears to the casual observer, but in reality, teems with a soil flora and fauna of its own. These organisms, most of them microscopic, play a very important part in aerating the soil and in making soil nutrients available for uptake by the plant roots. They are responsible for the breakdown of forest litter and its incorporation in the soil as humus.

Litter breakdown is a gradual transition in which the organic matter of plant debris is altered in composition and returned to the soil. Plant nutrients are released during the transformation and changed to a state available to the plant roots. By this process, the material built up by plants is never wasted but returned to the soil and again made available to the vegetation to sustain life and permit growth.

Under natural conditions there is a balance between the nutrients returned to the soil by litter decomposition and those utilized by the forest. Natural forest soils, in contrast to soils subjected to agricultural cropping, maintain their fertility under continued use.

When managing forests it is of prime importance that the nutrient balance be maintained, in the interests of soil fertility and sustained tree growth.

Managed and Unmanaged Forests

Possibly the idea of the cultivated forest is not entirely clear. One may ask just what advantages has a managed forest over a virgin forest if the latter is able to provide trees in perpetuity, maintain a stable composition and the soil fertility. It is not always realised that the virgin forest is not the most economical forest from man's point of view. Virgin forests have no normal succession of trees of all ages, but by virtue of their great age, usually contain a majority of overmature trees. Such trees lose more wood by internal decay each year than they are capable of putting on in their condition of poor vigour. Their large crowns overtop and suppress young trees and prevent germination of seed on the forest floor.

Managed forests, on the other hand, aim to have the optimum number of vigorously growing trees per acre. Once a tree slackens off in increment, it is removed to make way for more vigorous young ones coming on. All age classes of trees are represented in the forest so that as trees are cut for milling, others are available to produce a future final crop with a minimum lapse of time. Spacing between the trees is also controlled to permit an adequate area for growth of each member and the minimum of

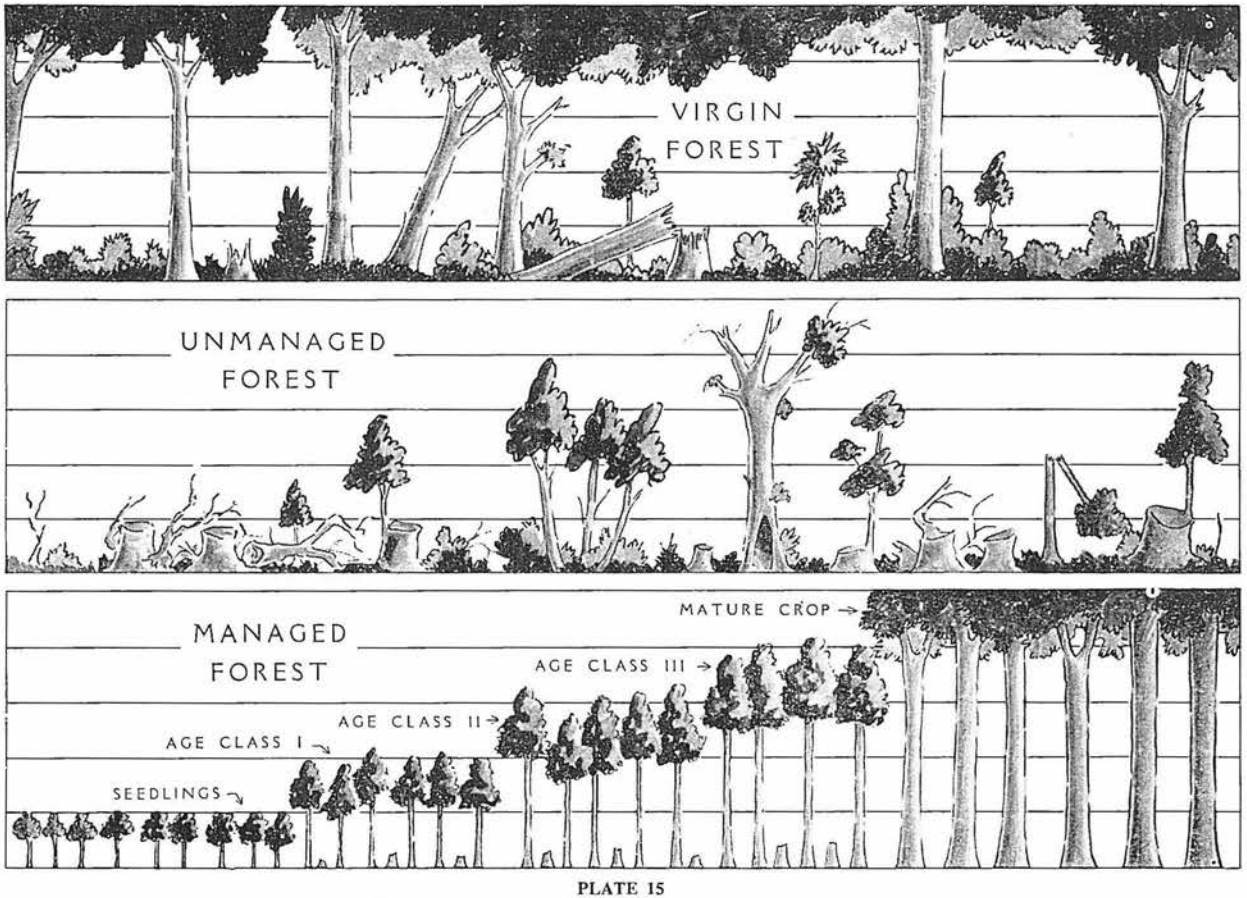


PLATE 15

Diagrammatic representation of a forest under management.
Virgin forest—mature to over-mature trees; very little regeneration present and frequent insect, fungi and fire damage.
Unmanaged forest—All good mill timber has been removed with subsequent damage to remaining stems. No provision for regeneration.
Managed forest—A regular succession of all age classes represented to provide regular timber crops in perpetuity.

competition from neighbours. Managed forests, therefore, are cultivated to produce the maximum amount of desirable produce while guaranteeing that there is always a crop ready to replace the one that is removed for utilization."

The Animals and Birds of the Forest (See also pages 41 - 45)

The forests of a country provide food and shelter for the many native birds and animals which have evolved to become a permanent part of the forest community. In Western Australia, this native fauna, completely at home in the virgin hardwood formations, has offered very few problems to foresters. Birds, by virtue of their feeding habits, are generally regarded as beneficial since they play a considerable part in keeping the insect population (usually a source of damage to timber) down to a minimum. As many as 83 birds have been recorded in and around the Dwellingup jarrah forest.

Introduced animals such as rabbits, sheep, cattle and goats, however, often cause considerable damage to the balanced state of a forest formation. These animals, by feeding on young shoots and trampling the soil, have the effect of reducing the regeneration potential of the forest. Over-grazing can eventually reduce forested lands to deserts.

Plantations of exotic species to which the natural fauna is not adapted, are often extensively damaged by animals and birds. The Black Cockatoo which damages growing tips and seeds in feeding from pine cones imposes a problem of control which has not yet been solved. Rabbits also cause extensive damage to pine nurseries and newly planted-out seedlings in some areas of the State.

Native animals and birds in natural forests, however, must be considered as a part of the forest complex to which, under normal conditions, they cause no great damage.

Insects and Fungi (See also Forest Pathology)

Insects and fungi are found in all forest formations. These, too, are part of the forest complex which must be considered by the forester. To all appearances a minor part of the complex, insects and fungi nevertheless play an important role in the forest. They can represent a source of damage to growing timber that is second only to fire.

However, not all insects and fungi are harmful. Some insects are pollinators and necessary for the reproduction of many plants growing in the forest, and soil insects and fungi are necessary for litter breakdown and humus formation.

Many fungi grow in association with tree and plant roots constituting mycorrhiza which is essential to the growth of such plants. This association of the lowly fungus with the highest forms of plant life is a remarkable example of symbiosis, or a mutually-advantageous relationship between two living organisms. Each of the participants in the union give and take some substance from the other. In the case of many trees, vigorous growth is not possible without this association with a certain type of fungus.

Pines in Western Australia require a mycorrhizal association and until this was realised, and the necessary fungi introduced, all attempts at pine nursery establishments resulted in failure. Little is known of the possibility of the W.A. eucalypts having mycorrhiza, but recent work seems to indicate a strong possibility in the case of jarrah.

The Forest Area

Of the total land area of 34,000 million acres (*13,770 million ha*), the world has 10,000 million acres (*4,000 million ha*) of forested land. This is separated as follows:—

Total forest area	10,000 million acres (*4,000 million ha*)
Accessible forest	5,000 million acres (*2,000 million ha*)
Forest being utilized	2,500 million acres (*1,000 million ha*)
Forest area under sound management	1,000 million acres (*400 million ha*)

It is estimated that a further area of 4,000 million acres (*1.6 million ha*) *of the* earth's original forest has been already destroyed by man's activity. This 30 per cent depletion of the original area provides a grave warning of what could be the fate of the present forests unless they are placed under wise and careful management.

As a result of a wise and far-thinking forest policy, Australia is fortunate in having substantial areas dedicated as State Forests or Timber Reserves to ensure the perpetual retention of our forest capital. Additional areas are retained by the Government under less secure tenure for the practice of forestry on a temporary basis. Table 3 below sets out in detail the areas reserved for forestry in Australia.

TABLE 3

Forest Reserves as at March 31, 1969
(Thousands of Acres)
(*Thousands of Hectares*)

State or Territory	Production Reserves (*a*)	Protection Reserves (*b*)	All Other Reserves	Total Area All Reserves
New South Wales	8,407 *3,402*	20 *8*	1,038 *420*	9,465 *3,830*
Victoria	5,669 *2,294*	499 *202*	151 *61*	6,319 *2,557*
Queensland	*8,927* *3,613*	2,343 *948*	—	11,270 *4,561*
South Australia	272 *110*	21 *8*	— —	293 *119*
Western Australia (*c*)	4,775 *1,932*	116 *47*	— —	4,891 *1,979*
Tasmania	4,537 *1,836*	234 *95*	— —	4,771 *1,931*
Australian Capital Territory	30 *12*	110 *45*	— —	140 *57*
Northern Territory	11 *4*	1,478 *598*	— —	1,489 *602*
Total	32,628 *13,204*	4,821 *1,951*	1,189 *481*	38,638 *15,636*

— Nil or negligible

(*a*) Land reserved for production of timber for commercial purposes.

(*b*) Land reserved principally for protection of other natural resources (e.g. parks, scenic areas, hills and water catchments).

(*c*) South-West zone only. There are a further 1,689,000 acres (*684,000 ha*) in the Eastern Goldfields region reserved for mining timber firewood and sandalwood requirements.

Included in the above areas dedicated to forestry are many plantations of native and introduced species. These are mainly softwoods of the Pinus species, but do include native softwoods such as hoop pine and kauri pine. Private enterprise is becoming increasingly attracted by the growing world demand for timber, particularly in the form of manufactured products such as paper pulp, plywood and particle board, and has already established a significant acreage of private forests in Australia.

Table 4 shows the area of plantations as at 31st March, 1969. Since that date there has been another planting in the winter rainfall areas and the total area of coniferous plus broadleafed plantations was in excess of 1 million acres by the close of 1969. A ceremony to mark the planting of the millionth acre was held in Perth in October, 1969, on the occasion of the 7th All Australian Timber Congress.

TABLE 4

Area of Plantations, coniferous and Broadleaved, as at 31 March 1969
(Acres)
(*Hectares*)

State or Territory	Coniferous						Govt. plus private	Broad-leaved (*c*)
	Government-owned			Private property (*b*)				
	P. radiata	Other species	Total	*P. radiata*	Other species	Total		
New South Wales	127,440	23,284	150,724	11,095	16,889	27,984	178,708	21,070
	51,613	*9,430*	*61,043*	*4,493*	*6,849*	*11,333*	*72,377*	*8,533*
Victoria	77,803	8,917	86,720	118,759	917	119,676	206,396	9,330
	31,510	*3,611*	*35,121*	*48,097*	*371*	*48,468*	*83,590*	*3,779*
Queensland	3,712	141,347	145,059	842	34,802	35,644	180,703	5,178
	1,504	*57,246*	*58,750*	*341*	*14,095*	*14,436*	*73,185*	*2,097*
South Australia	142,988	14,107	157,095	39,502	16	39,518	196,613	3,437
	57,910	*5,713*	*63,623*	*15,998*	*6*	*16,004*	*79,628*	*1,392*
Western Australia (*a*)	23,763	35,009	58,772	2,073	188	2,261	61,033	19,111
	9,624	*14,179*	*23,803*	*840*	*76*	*916*	*24,718*	*7,740*
Tasmania	35,338	424	35,762	14,764	3	14,767	50,529	809
	14,311	*172*	*14,483*	*5,979*	*1*	*5,980*	*20,464*	*328*
Australian Capital Territory	27,053	2,238	29,291	—	—	—	23,291	—
	10,957	*906*	*11,863*	—	—	—	*11,863*	—
Northern Territory	—	2,965	2,965	—	50	50	3,015	65
	—	*1,201*	*1,201*	—	*21*	*21*	*1,221*	*26*
Total	438,097	228,291	666,388	187,035	52,865	239,900	906,288	59,000
	177,429	*92,458*	*269,987*	*75,749*	*21,410*	*97,159*	*367,046*	*23,895*

— Nil or negligible.
(*a*) South-west zone only. Broadleaved plantations are mallet (*E. astringens*).
(*b*) Includes some preliminary figures.
(*c*) State-owned only.

Birds of the South-West Forests

(By C. F. H. Jenkins, M.A.)*

Anyone who has spent a few hours bird hunting in our south-west jarrah and karri areas will know that high, dense forests are not the best places to get a large tally of either bird species or individuals. In fact, many observers have commented upon the almost cathedral-like stillness which often pervades the densest forests. It is in the small clearings and along the forest streams that most of the birds will be found because of the varied habitat and food supply.

* Chief, Biological Services Division, Department of Agriculture, W.A.

At least four species of parrots are present in most areas of the south-west, and three are to be found nowhere else in Australia.

The Western Rosella (*Platycercus icterotis*) with its scarlet breast and yellow cheeks has close relatives in other States, but the Red-capped Parrot or Western Australian King Parrot (*Purpureicephalus spurius*) is quite unique. The rich purple underparts and the red markings on the head and beneath the tail make it one of our most handsome species. This bird has evolved in association with the south-west marri forests for the beak has a particularly long upper mandible which easily extracts the seed from the large woody "gum nuts". Unfortunately, the Western Rosella and the King Parrot have developed a taste for cultivated fruits and are regarded as pests by orchardists.

The parrots are the noisiest birds in the forest, and by far the rowdiest of all are the White-tailed Black Cockatoos (*Calyptorynchus baundini*). They occur only in south-west Australia and are rather irregular in their movements, touring the country in large screeching parties which feed on gum blossoms, nuts and insects, as well as apples and pine cones. The powerful bill of the cockatoo is well adapted for tearing the bark from the forest trees and removing the various insect borers which sometimes cause considerable damage, particularly to eucalypts and wattles. But, unfortunately, the bill is equally useful for shredding up pine cones and seed production is sometimes seriously affected.

Another noisy and irregular visitor to the forests is the Purple-crowned Lorrikeet (*Glossopsitta porphyrocephalus*). The call of the lorrikeet is always welcomed by the beekeeper as a sign that nectar-bearing flowers are about, and it is also probable that the birds help in the cross-pollination of the flowers as they move from one cluster of blooms to another.

The commonest parrot in Western Australia is the Twentyeight or Port Lincoln Parrot (*Barnardius zonarius*). The birds vary considerably in size and colour, according to the locality, and the call note also varies.

The forest birds of the south-west are large and predominantly green in colour, with a yellow collar and some red feathers at the base of the bill. The call can easily be syllabised as "twentyeight".

The wheatbelt birds are smaller and show increasing yellow on the underparts as one goes north. The call bears little resemblance to the "twentyeight" of the forest birds.

Amongst the smaller dwellers in the forest trees are the pardalotes or diamond birds, the western warblers, the thornbills or tits, and the sittellas or tree-runners. These are all insects eaters, but each species has its own particular method of seeking its prey.

The Yellow-rumped Thornbill or Tomtit (*Acanthiza chrysorrhoa*) is easily recognised by the canary-yellow patch above the base of the tail. This bird often feeds in small parties both on the ground and in the lower branches of the trees. Its duller relative, the Broadtailed Thornbill (*A. apicalis*), has a striped breast, a cocked-up tail and a rather persistent chatter. It feeds mainly amongst the twigs and leaves, often well above the ground.

The tiny Red-tipped Pardalote or Diamond Bird (*Pardalotus substriatus*) is much more often heard than seen, for in the springtime it keeps up a continuous call of "two two" as it climbs through the highest twigs, picking scale-like psyllids or lerps from the leaves.

Another tiny bird which is seldom seen, but whose activities affect many forest trees is the Flower Pecker or Mistletoe Bird (*Dicaeum hirundinaceum*). The male

is one of our most brilliantly coloured species with its steely black upper parts and bright red throat, breast and rump. The birds feed mainly on mistletoe berries and are instrumental in spreading seeds of the parasite from tree to tree.

The Western Warbler (*Gerygone fusca*) is a very small but active bird known to many children as the Sleepy Twit, because of its high-pitched, rather hesitant whistle. The Warbler often flutters at the end of a bough picking insects from the outer leaves and showing a characteristic white band near the end of its tail.

The Black-capped Sittella or Tree-runner *(Neositta pileata)* is a close relative of the European Nuthatch. It is an attractively coloured bird with a black head and an orange wing patch. The most outstanding feature is the relatively long bill, which turns distinctly upwards. The sittellas often hunt in small noisy parties and run spirally down the tree trunk using the upturned bill to probe every crack and crevice for hidden insects.

The Rufous Tree-creeper (*Climacteris rufa*) is another inhabitant of the thick forest areas. It is reddish brown in colour, rather larger than the Black-capped Sittella and has a characteristic highpitched call. It also runs spirally around the tree trunks looking for insects, but whereas the sittellas, as we have seen, usually work downwards, the tree-creepers usually work upwards, and so check cracks and hiding places which may have been missed on the downward run.

Amongst the most beautiful birds of the forest country are the robins and wrens. The Scarlet Robin *(Petroica multicolor)* with its brilliant red breast and white forehead is known to most people, but the more shy Western Yellow Robin (*Eopsaltria griseogularis)* is often overlooked. The canary-yellow of the underparts makes the bird easy to identify and its habit of clinging to the side of a large tree trunk is also characteristic.

Two wrens of the south-west forests are the Banded Blue Wren (*Malurus splendens)* and the Red-backed Wren *(Malurus elegans)*. Both like plenty of bushy cover and often nest in the tea-tree thickets which line the banks of forest streams.

Honeyeaters are amongst the most characteristic and specialised of Australian birds, and they are well represented in the forests. The long curved bill and brush tipped tongue are a special adaptation to assist birds in taking nectar and insects from native flowers. In some instances, the birds repay their hosts by carrying pollen from one bloom to another.

The largest and noisiest honeyeaters seen in the south-west are the wattle birds. The Red Wattle-bird (*Anthochaera carunculata*), so called because of the red fleshy wattle on the side of the head, is about the size of a small dove and has a hoarse coughing note. In company with the Little Wattle-bird (*A. chrysoptera*) is a frequent visitor to flowering plants, particularly banksias.

The smaller honeyeaters include the Brown Honeyeater *(Lichmera indistincta)*, which can be distinguished by its relatively long curved beak, small size, dull plumage and almost canary-like song. The Singing Honeyeater *(Meliphaga virescens)* which is rather larger, is greenish in colour, with a dark stripe through the eye. This species is common in suburban gardens. The New Holland Honeyeater (*Phylidonyris novae-hollandiae)* frequents the flowering eucalypts and banksias. It is frequently recognised by its black plumage, white face marks and yellow wing patches. A common species in the high tree tops, but one which is seldom seen at close quarters is the White-naped Honeyeater (*Melithreptus lunatus*). It may be distinguished from other common species by its small size and the conspicuous white crescent on the back of the neck.

Most of the honeyeaters mentioned may at times visit kangaroo paws and assist in cross-pollination.

The Western Magpie (*Gymnohina dorsalis*), the Squeaker (*Strepera versicolor*) and the Grey Butcher Bird (*Cracticus torquatus*) are widespread in the south-west, although the Magpie was scarce in the heavy forest regions prior to the general clearing for agriculture.

The Squeaker or Bell Magpie is about the size of a crow, but dark grey in colour with a light mark on the wings, which is quite conspicuous as the bird flies. The loud ringing calls of the Squeaker may be heard both in the forest and in more open country.

The Grey Butcher Bird is one of Australia's finest songsters and, unlike many other local birds, it calls strongly both in the spring and the autumn.

The Butcher Bird feeds on insects, lizards and small birds and often wedges its food under loose bark or into the fork of a tree, for later attention.

A comparative newcomer to the south-west forest is the Kookaburra (*Dacelo gigas*). Although most people regard the Kookaburra as a native, it was introduced from the Eastern States about the turn of the century. Liberations from the Zoological Gardens were made over several years and the birds quickly colonised the southern portions of the State.

Two species of doves, the Senegal Turtle Dove (*Streptopelia senegalensis*) and the larger Spotted Turtle Dove (*S. chinensis*) were also released about the same time as the Kookaburra, but although they spread to many country towns, they have shown little inclination to penetrate the forests.

Native Mammals of the South-West Forests

(By C. F. H. Jenkins M.A.)*

Most of our native mammals are nocturnal and so the existence of many species in a particular district may be overlooked unless dead bodies are seen on the roadside or specimens are brought home by the family cat.

EGG-LAYING MAMMALS OR MONOTREMES

Australia is famous for containing the only egg-laying mammals still surviving on the earth, and one of these is found in Western Australia. The Platypus is confined to the rivers of eastern Australia, but the Australian Spiny Anteater or Echidna (*Tachyglossus aculeatus*) is found all over the Commonwealth and is still moderately plentiful in the south-west of this State.

MARSUPIALS

The Western Grey Kangaroo (*Macropus fuliginosus*), recently shown to be a distinct species from the Grey Kangaroo of Victoria and New South Wales (*M. giganteus*), is still abundant in many areas of the south-west. The smaller brush Wallaby (*Wallabia irma*) is also widespread in the forest regions, but has disappeared from many of its former haunts.

The Quokka (*Setonix brachyurus*) has suffered severely in recent years, and although it was hunted for sport in the 1930's along many of the river thickets of the south-west, it is now very rare on the mainland, with its main strongholds on Rottnest Island and Bald Island.

---

* Chief, Biological Services Division, Department of Agriculture, W.A.

Two other wallabies, the Woilie or Brush-tailed Rat-Kangaroo (*Bettongia penicillata*) and the Tammar (*Thylogale eugenii*) have also declined in numbers in recent years. They both figured in the skin and hide trade in the 1930's, but now they survive in scattered areas only. Fortunately, the wandoo (white gum) woodlands of the Great Southern still support a reasonable number.

The Brush-tailed Possum (*Trichosurus vulpecula*) is still plentiful in many areas, but the nest building Western Ring-tailed Possum (*Pseudocheirus occidentalis*) with its white tipped tail, is a rarity.

Several species of bandicoots were once common in various parts of south-western Australia, but the Dalgite or Rabbit-eared Bandicoot (*Macrotis lagotis*) has disappeared and only the Short-nosed Bandicoot or Quenda (*Isoodon obesulus*) is common. The presence of this nocturnal feeder may be deduced from the conical diggings which may appear in the bush and even in home gardens, as the animals search for insects. The dark brown fur is coarse and bristly, and was never exploited by the "trade".

One of our most interesting mammals is the so-called Banded Ant-eater or Numbat (*Myrmecobius fasciatus*). It has reddish fur with several white bands across the back and rump. The name ant-eater refers to the fact that the creature feeds mainly upon termites or white ants which it unearths with its powerful claws. Although a true marsupial, the numbat lacks a well developed pouch, and the young are merely protected by tufts of long hairs as they cling to the mother. This animal is most commonly met within wandoo country around Pingelly, Narrogin and Kojonup.

The Chuditch or Western Native Cat (*Dasyurus geoffroii*) was once very common throughout the south-west and still persists in many timbered areas. It feeds upon insects, birds and other small creatures and used to rob the henroosts of the early settlers. As in other members of the marsupial cat family, the pouch is represented by two flaps of skin which afford but scanty protection to the naked young.

The tree climbing wambengers or native squirrels are still present in many areas, but because of their nocturnal habits they are seldom seen.

The Brush-tailed Wambenger (*Phascogale tapoatafa*) feeds upon various small creatures including birds, and like the larger native cat, it once caused trouble by robbing farm henroosts.

The so-called marsupial mice include two charming species—the Pigmy Possum (*Cercatetus concinnus*) which feeds mainly upon insects, and the Honey Mouse (*Tarsipes spenserae*) which takes insects and nectar from bush flowers. Both species are active mainly at night, but only too often they fall victim to the domestic cat.

RODENTS

A number of native rats and mice occur in Western Australia but the best known is probably the Western Water-Rat (*Hydromys fuliginosus*). It is found in most of our south-west streams, but because of its retiring habits, it is seldom seen.

It is a true rodent, but can be distinguished from the introduced rat, which may also frequent bush streams, by its much greater size, thick fur (once used commercially) and the fully furred white-tipped tail. In the early days the Water-Rat often used to rob the henroost, but its native food consists of gilgies and other water life.

Forest Conservation

For nearly 80 years the forests of Western Australia were exploited for their timber without any serious effort being made for replacement of the resource. Fortunately a small group of enlightened, far-sighted citizens realised that the resource was

not in fact "inexhaustible" and objected strongly to "mining" of the forest. It was through their efforts that the Forests Act, which aims at the conservation and regeneration of our native forests, was passed in 1918 and gazetted early in 1919.

Since the passing of the Act, conservation as practised by the Department, has not been the narrow concept of preservation, but rather the planned use and management of land, water, and their associated resources, for the provision of optimum social and economic returns.

The first step taken by the Department was the acquisition of prime forest for dedication as permanent State Forest. This was followed by measures to control exploitation so that only the forest increment was removed. Regeneration of cut-over areas then ensured that our forest resource would be with us in perpetuity.

Protection of the forest from fire was obviously necessary and an efficient fire control organisation has been developed. Not only are State Forests and timber reserves protected but a further two million acres of other Crown land and private property are given indirect protection, due either to their strategic significance in relation to State Forest or to their forest value.

Forest maps produced from aerial photographs, are of considerable value to Departmental research officers, C.S.I.R.O. and University staff, and amateur conservation groups studying ecology. In fact, these maps are the most suitable available basis for conservation studies in the high rainfall areas of the State. More recently, ecological site surveys linking vegetation with climate, topography and soil, provide a ready-made reference system for intensive studies of fauna and flora.

The Department has undertaken a number of major projects, some of which are, or were, not revenue producing. These include:—

Sand dune reclamation on areas along the South coast.

The establishment and maintenance of 56 arboreta scattered throughout the wheatbelt and the raising of tree seedlings for supply to farmers, Local Government authorities and other Government departments for shade, shelterbelt and ornamental purposes.

The protection of Dryandra Forest north-west of Narrogin, not only for timber requirements, but also as a habitat for the indigenous fauna, of which some species are quite rare.

The Native Flora Protection Act is administered by the Department and the Conservator is Chairman of the recently formed "Committee for Conservation of Road Verges".

Department officers have played and continue to play an active role on various bodies which are concerned with the conservation of natural resources. Some of these are:—

Western Australian Wild Life Authority

Reserves Advisory Council

Water Purity Advisory Committee

Soil Conservation Advisory Committee

Water Research Foundation of Australia.

Unfortunately the forest environment is seriously prejudiced by the over-riding powers of the Mining Act. However, following an enquiry into this Act early in 1970, firm recommendations were made by the Committee of Inquiry, which, if implemented, will provide valuable assistance in safe-guarding the forests in the future.

CHAPTER III

THE FOREST FORMATIONS OF WESTERN AUSTRALIA

The Jarrah Forest

Jarrah (*Eucalyptus marginata*) is the principal timber tree of Western Australia. Because of its resemblance to the well known Honduras timber "mahogany" it also was given that name by early settlers. It was recognised, however, that as the timber had so many fine qualities peculiar to itself, it warranted a distinctive name of its own and from about 1860 onwards it became universally known by its aboriginal name—"Jarrah".

Description of the Forest

Jarrah is a large tree, attaining under optimum conditions, a height of 100 feet (*30 m*) to 130 feet (*40 m*), with a straight bole of up to 50 feet (*15 m*) or 60 feet (*18 m*), and a diameter of 6 feet (*2 m*).

The bark is persistent, reddish-grey, stringy, flat and flakey, with small fissures running vertically. This bark renders jarrah distinct from other South-Western trees, except from Albany blackbutt (*Euc. staeri*), and red tingle (*Euc. jacksonii*), which trees also have fairly stringy barks, although less tough than that of jarrah.

The jarrah formation is a high forest with a small admixture of marri (*Euc. calophylla*) and blackbutt (*Euc. patens*); flooded gum (*Euc. rudis*) and bullich (*Euc. megacarpa*) occur in the gullies and flats. The understorey consists mainly of scattered sheoak (*Casuarina fraseriana*), bull banksia (*Banksia grandis*), and to a lesser extent, emu bush (*Persoonia spp.*). Below this understorey, blackboy (*Xanthorrhoea preissii* and *X. gracilis*) and zamia palm (*Macrozamia reidlei*) occur with grass trees (*Kingia australis*) on the poorer sandy types. The ground is covered with a wealth of shrubs and woody plants.

Although it lacks the aesthetic qualities of other forests, the jarrah formation is noted for its remarkable purity and the value and utility of the timber it produces. The prime belt has by far the least admixture of other species than any other Eucalypt forest in Australia of equivalent area, and it is considered to be one of the finest hardwood stands in the world.

Distribution

Jarrah was originally found scattered throughout the south-west of the State over some 13 million acres (*5.3 million ha.*) of country within the 25 in. (*635 mm*) to 50 in. (*1270 mm*) rainfall belt. The prime forest of some 4 million acres (*1.6 million ha.*) however, stretches from Chidlow's Well in the north, following the Darling Range to the extreme south of the State finishing just north of Albany. Most of this is now State Forest. The species is closely associated with soils of lateritic origin and the best existing forest areas occur on the lateritic gravels of the Darling Range where the rainfall exceeds 45 inches (*1143 mm*). However, jarrah attains its greatest size in the red loam soils of the deeply dissected river valleys. Most of these areas have been cleared of jarrah forest for other uses.

Plate 16

Mature jarrah forest near Dwellingup

Distribution is limited to the east and to the north by low rainfall and the species becomes progressively smaller as the rainfall decreases. Eastwards it gives way to wandoo (*E. wandoo*), powder-bark wandoo (*E. accedens*) and York gum (*E. loxophleba*). On the coastal strip west of the Darling Range it occurs in rather open formation as a tree of low height and poor form. Here it is associated with tuart (*E. gomphocephala*) which replaces the jarrah completely on the limestone ridges. In the extreme south of its range it is replaced by karri (*E. diversicolor*) and marri on the better soils, while on the southern plains it is a small, crooked tree and takes on a mallee form in the harsher environments.

Timber

Jarrah timber is dense, hard but fairly easily worked, of a red colour darkening with age to a rich brown with a beautiful grain, and takes a fine polish. It will be readily realised that there are few purposes for which jarrah cannot be used, when in addition to beauty of colour and grain, its strength, durability and an amazing resistance to fire are considered. Some trees possess a remarkable fiddleback figure referred to in the trade as "curly jarrah". For beauty of appearance as a furniture wood it has few rivals.

Weight per cubic foot (green)	73 lb. (*1168 kg/m*^{3})
At 12 per cent moisture	54 lb. (*864 kg/m*^{3})
Transverse strength	16,200 lb. per sq. in. (*1,139,000 gm. per sq. cm.*)
Tensile strength	15,500 lb. per sq. in. (*1,090,000 gm. per sq. cm.*)

Uses

In Western Australia jarrah is a veritable all-purpose timber. Despite its beauty as a furniture wood, it is used as a utility timber because of its strength, durability and availability. In the form of piles, stringers and decking it has been employed to such an extent that there is scarcely a wharf, pier or jetty in Western Australia which does not contain a high percentage of jarrah.

It is eminently satisfactory as a building timber, being used in the sawn state for stumps, joists, weatherboards, plates, studs, rafters, laths and shingles, while flooring, lining, frames, doors, windows, interior trim mantelpieces and other furnishings testify to the beauty and suitability of the dressed timber for high grade purposes. In large buildings jarrah makes excellent beams, columns and rafters, while as dadoes, panelling, partitioning, stair railing, counters and similar furnishings, it adds to the beauty of the interior. The pleasing figure of jarrah makes it eminently suitable for veneers and small quantities are now being used for this purpose.

Waste timber is universally used in the South-West as firewood, and jarrah forms the chief firewood supply of Perth.

The timber is quite durable and when used for posts or sleepers in contact with the ground it gives a long life of valuable service. The average life of jarrah sleepers in Australia is 20-35 years, depending on the locality in which they are used. Jarrah sleepers are readily accepted in many overseas countries and they contribute to a valuable export trade. In the London Underground they are still in use after 50 years of service.

Prior to the development of concrete and bitumen road surfaces, its durable nature permitted many famous thoroughfares throughout the world to be paved with jarrah blocks. Jarrah timbering employed in the first houses constructed in the Colony is still sound today and the post-and-rail fences erected by the early settlers are often still standing.

Flowering and Seeding

New fruiting buds appear in the axils of the leaves of the new summer growth in the December to March period, and if retained, they flower in the following November and December. From this flowering, the fruits mature to shed their seed in the following summer, two years after first formation of the bud.

Seed years, however, are not regular and heavy seeding occurs only once every four to six years. Scattered individuals can be found in seed every year, but in a general seeding, some 25 to 50 per cent of the stand will carry a heavy crop.

A marked crown degradation is noticeable during a heavy seeding. Copious flower bud formation is at the expense of the normal crop of leaf buds and when older leaves are shed the trees are left with extremely thin crowns. These normally rejuvenate during the summer after seeding.

The seed is black and three sided, and a little over an eighth of an inch in length. There are about 4,000 to the ounce (140 to the gram.) pure, or 1,000 with chaff.

Seed fall is brought about by the opening of the capsules in the hot dry weather of mid-summer. Dispersal distance is usually taken as the ground distance equivalent to the height of the tree.

Regeneration

Germination occurs in the cool, moist conditions of late May and June. Although many thousands of seedlings may appear on each acre at this time of the year, losses due to insects, fungi, and drought reduces the numbers by up to 95 per cent in the first year after germination. Mortality among the survivors continues for a number of years and a very small proportion of seedlings live to reach tree size.

A swelling forms at the base of the stem of the young seedlings. This swelling develops downwards as the seedling ages and forms a hardy, woody subterranean lump called the lignotuber. The leafy shoots of this plant grow very slowly in length but rapidly multiply in number to form a small bush. At the same time a large, deeply penetrating tap root is formed. This bushy form of jarrah becomes almost completely indestructible and is immune to fire. If the leafy shoots are burnt off, more arise from dormant buds on the lignotuber. If these shoots are not burnt off periodically they become moribund and the development of the plant is severely retarded. The jarrah bush appears to be quite incapable of developing into a sapling with a single upright stem until the lignotuber attains a diameter of about four inches, or until the shoots of the bush reach about two and a half feet in length and exceed six or seven in number. The period the plant takes to reach this stage varies considerably. Jarrah seedlings planted into ploughed soil where there is no competition will form a sapling shoot at from three to six years of age. Under normal forest conditions the period may extend to 15 years or more and on harsh, low quality forest sites this period of consolidation may exceed half a century.

Once a single leading shoot appears, it grows rapidly for the first few years, after which height growth slowly declines. A five-year old sapling shoot is likely to attain a height of 20 feet (*6 m*) or more, and at age 10 it will reach 30 feet (*9 m*) on a good site. For the first few years the sapling shoot is green and fleshy but by the time it is 5-8 years old thick bark is forming and it can withstand mild fires.

The impetus for the bushy plant to produce a dynamic sapling shoot arises from a reduction in competition. In the virgin forest this comes from the death of a large tree. Bushy plants, previously shaded by the tree, respond to the increased growing space available by forming sapling shoots. In managed forest similar conditions are created by the cutting of large trees for timber production.

Plate 17

An unthinned jarrah pole stand, 48 years old

Fire in the Forest

No account of the jarrah forest would be complete without some mention of fire. The whole forest community, including animals, plants and jarrah itself has developed in an environment which is subject to frequent burning. Botanically the jarrah forest community would be classed as a *fire-climax,* meaning that the plant species represented have reached a stable equilibrium with site conditions, and *particularly with fire.* Research workers have found sound evidence that the forest has been associated with fire for at least 7,000 years. The vast majority of plants in the forest, including wildflowers and jarrah itself, have certain adaptations that protect them from fire. In some cases fire is essential for their continued existence. Some instances of these adaptations can be cited.

The seed pods of some *Hakeas* and *Grevilleas* can only be opened and the seed released by the high temperatures of a fire. Nearly all the wattles (*Acacia spp.*) need treatment with temperatures around that of boiling water before they will germinate. A very high proportion of the plants in the jarrah forest have subterreanean woodstocks (or sheathed shoots in the case of plants of the lily family) from which new shoots are formed after a fire.

The Forests Department has learned by bitter experience the consequences of excluding fire from the forest, and the resultant build-up of leaf litter and dead plants. A succession of severe and uncontrollable wildfires in the period 1948-1950 followed 15 years of protection from fire.

We have then, a situation where the forest community needs fire for its continued health and existence. This is achieved by rotational burning over the forest floor every 3-5 years with carefully controlled fires in mild weather conditions. Rotational controlled burning nowadays replaces the lightning fires and aboriginal hunting fires of the pre-settlement era of the State.

Silvicultural Cutting for Regeneration

When sawmilling operations are about to commence on any specific area, an advance controlled burn is run through the area in cool weather to reduce the accumulated inflammable debris.

Next comes the operation of treemarking. Trees which are to be felled for sawmilling are marked by a forest officer. He blazes the tree to be felled and in a nick cut at the base, brands it with his treemarker's brand. This allows for the removal of mature or less vigorous elements of the old crop; and in the openings left by these trees the regrowth will become established.

The young, vigorously growing trees of the crop are retained in the forest to provide the mill logs of the future and the treemarker is careful to mark the old trees so that they will fall in the direction which will cause the least damage to those which remain.

Following the logging operation, tops (crowns) of felled trees are lopped flat and debris cleared away from the butts of good piles and poles. Finally, this debris is burnt in spring or autumn when minimum damage will occur to the remaining stand.

Full protection from fire must be afforded for a period of years until the openings have been satisfactorily stocked with young regrowth of sufficient height to permit the reduction of the fire hazard by prescribed light burning without incurring damage to the crowns. This period of complete fire protection may be from 8 to 10 years, by which time a total height well in excess of 20 feet (*6 m*) should have been attained.

Growth Rates

Although the growth rate of jarrah cannot compare with that of karri, it is nevertheless impressive when the harsh and impoverished conditions it grows under are taken into account. The average yield of sawlogs from the whole jarrah forest is in the region of 15 cubic feet per acre (*1.05 m^3/ha*) each year. There is a large difference in the rate of growth of the species between the relatively poor northern and eastern sectors of the forest and the prime forest area on the western edge of the Darling Range. In the former the trees may grow well under half an inch in girth (*13 mm*) each year and the annual timber yield per acre may be as low as five cubic feet (*0.14 m^3*). The prime forests of the high rainfall area produce more than 10 times this timber yield and individual tree growth may exceed three-quarters of an inch (*19 mm*) in girth a year.

The productivity of the jarrah forest is rapidly improving under the careful management regimes now practised. Protection from severe fires alone has resulted in a marked increase in production, and further gains can be expected from the large scale thinning operations of the last few years.

Other Trees of the Jarrah Forest

MARRI (*Eucalyptus calophylla*)

Introduction

Marri, a large and shapely tree, is the most widely distributed eucalypt in the south-west of Western Australia. The early settlers knew the tree as red-gum, no doubt because of the prevalence of a red gum or kino in the wood. The kino was often used as a tanning material. However, to avoid confusing the tree with the better known River Red Gum (*Euc. camaldulensis*), the native name of Marri was substituted for red gum some 50 years ago.

The tree is well known to the apiarist and farmer. In suitable seasons it gives a copious supply of nectar, usually flowering in the summer months of February and March. For the farmer its shapely form, dense crown and large white flowers make it an attractive and valuable shade tree.

The name calophylla signifies beautiful leaf, while children know the fruits as "hockey nuts".

Habit and Distribution

Marri has been recorded as growing near Port Gregory, some 40 miles (*64 km*) north of Geraldton; near Tinkurrin, 30 miles (*48 km*) east of Narrogin and as far as Cape Riche on the south coast. In the marginal areas, the tree is usually stunted.

In the prime jarrah forest, mature marri trees grow to over 100 feet (*30 m*) in height, with 40 to 50 feet (*12* to *15 m*) of bole and diameters at breast height of four feet (*1.2 m*) or more. In the wetter karri regions they frequently attain heights in excess of 150 feet (*46 m*) with a correspondingly greater bole length.

The largest tree recorded grows about two miles (*3.2 km*) west of Pemberton in a farmer's paddock, and has a height of 201 feet (*61 m*), a bole of 71 feet (*22 m*), a girth at breast height of 20 feet 10 inches (*6 m*) and a merchantable log volume of 1,215 cubic feet (*34 m^3*). A second large tree occurs some 20 miles (*32 km*) south-west of Collie with the corresponding measurements of 178 feet (*54 m*), 98 feet (*30 m*), 18 feet 10 inches (*5.4 m*) and 1,295 cubic feet (*37 m^3*).

Marri usually occurs in mixture with jarrah or karri and is not often seen in pure formation, although small pure stands do occur south of the Blackwood where the species reaches its best development. (See Plate 14.)

Growing in forests yielding high quality clear timber of jarrah and karri, marri until recently has been by-passed in logging. However, it is now coming into wider use following appreciation of its good properties.

Timber Properties

Marri is in the C.S.I.R.O. Strength Group B and the Durability Class 3.

In mature trees the heartwood is light brown and the sapwood varies in width from ½ to 1½ inches (*13* to *38 mm*). The grain is slightly interlocked and the wood is non-fissile, with a uniform medium coarse texture.

It is easily worked, but the prevalence of gum veins and the occasional loose ring has, in the past, inhibited its use as a saw timber. Nevertheless, it is stronger than jarrah, seasons with much less shrinkage than jarrah and karri and takes paint well. It is not difficult to nail and does not tend to split as much as some of the lighter eucalypts. One sawmill is now cutting only marri and producing mainly scantling.

It steam bends satisfactorily. Although better than karri, the timber is not as durable in the ground as jarrah.

Marri is of particular interest because it shows little decay or fibre breakdown, even in the heart of the tree. In wood-chip and pulp mills, this will enable the species to be chipped as a whole tree operation, avoiding costly segregation of faulty material. In this respect marri is unique among the hardwoods of Australia available for this purpose.

General Uses

Marri has adequate strength and durability for use as piles, sills and beams in bridge construction and it is satisfactory for marine piling where the hazard from marine borers is of low intensity. Preservative treatment makes marri suitable for use as poles, and a considerable number are now in use with the Postmaster General's Department. Experimental lots of sleepers have been used by the West Australian Government Railways, and they are also in use in New Zealand.

The timber is being used successfully for handles, shafts and oars, and for bats and other sporting goods. In the sawmilling areas it has been used quite extensively in cottage construction for framing, weatherboards, flooring and tile battens, and it is coming into more general use in this field in Perth. It is being used for the framing of flush panel doors and in select quality it would be excellent for furniture construction. It has also been found to make satisfactory fruit and beer cases.

W.A. BLACKBUTT (*Eucalyptus patens*)

Habit

Blackbutt is a tree which may attain a height of up to 150 feet (*46 m*), with a bole length of 40 to 50 feet (*12* to *15 m*), and a diameter, breast high, up to 6 feet (*1.8 m*). The bark is persistent, hard, fibrous, deeply fissured, and dark-grey in colour with an almost corky appearance.

In the forest, however, the bark on the lower portion of the trunk is usually blackened by fire, hence the name "blackbutt".

There are several other tree-species of lesser importance in Western Australia, especially on the Goldfields, known in their respective districts as "blackbutt". This indicates why a tree may need something more than its common or local name to distinguish it. (The trade name for the timber is Yarri.)

People unfamiliar with our forest trees sometimes experience some difficulty in distinguishing blackbutt from jarrah. The leaves, however, are smaller than those of jarrah and of a bluish-green colour. The fruits are somewhat smaller than the jarrah fruits, but the rim which forms the top margin of the fruit is quite narrow, and the ovary is slightly sunk and flatter.

Distribution

W.A. Blackbutt is not plentiful, but it is found in tree form in small patches in the gullies and pockets of alluvial soils throughout the prime jarrah forest region, and occurring with jarrah in some parts of the karri forest. A shrubby form is found as far east as Esperance, but is rare.

Timber and Uses

The timber is about the same weight and strength as jarrah, but of a pale yellow colour. It is almost identical in quality with jarrah and serves as a durable general purpose timber. The oak-like colour and hardness of the wood make it an excellent flooring and panelling timber. When available it is acceptable locally as a sleeper in the same class as jarrah.

SHEOAK (*Casuarina fraseriana*)

This tree grows to a height of 40 to 50 feet (*12* to *15 m*), with a bole 10 to 15 feet (*3.0* to *4.5 m*), and a diameter of 2 feet 6 inches (*0.75 m*). The bark is persistent, greyish and deeply channelled longitudinally.

The fruits of the sheoak are known as "cones". These, in the case of *Casuarina fraseriana*, are almost globular, about an inch in diameter, slightly flattened on top, and the valves, or openings which emit the seeds, are a light brown inside and open widely.

The wood is sound with broad medullary rays, which show up well and make the timber particularly beautiful when cut "on the quarter". It takes a good polish and is durable in service, and therefore makes an excellent cabinet wood. It splits well and was used almost exclusively in the early days of the Colony for roofing shingles. A shingle taken from one of the first houses to be erected in Perth (after 83 years' use) was found to be in a splendid state of preservation.

Sheoak has proved to be a first class cooperage timber and was formerly in high demand as a timber for keg and cask construction due to its relatively slight degree of shrinkage.

MINOR SPECIES

Two other species merit a mention due to their very attractive timbers. Both are relatively small trees, irregularly distributed throughout the forest. The timbers, therefore, are available only in small quantities.

Native Pear (*Xylomelum occidentale*) is a small tree attaining a height of 20 to 25 feet (*6.0* to *7.6 m*) with a short bole, and a diameter of up to 12 inches (*30 cm*). The bark is persistent, grey or almost black and lightly fissured.

Native pear is to be found growing all along the sandplain country, between the Darling Range and the sea coast.

The tree yields a most ornamental dark brown wood, with a beautiful figure. It is light, and makes up into a very fine furniture wood. Finished with a wax surface it resembles moire silk. The tree being small, of poor form and frequently damaged by fire, the timber is never obtainable in large size or in commercial quantity.

River Banksia (*Banksia verticillata*) is a tree which reaches a height of 50 to 60 feet (*15 to 18 m*) with a bole of 15 to 20 feet (*4.5* to *6.1 m*), and a diameter of 2 feet 6 inches (*0.76 m*). The bark which is persistent, grey and completely fissured longitudinally, shows red when it is cut. The tree occurs along the larger rivers and streams in the South-West, and is rarely found growing far away from running water.

The timber is light-coloured with a particularly beautiful grain. The medullary rays are wide, so that when cut on the quarter it shows a beautiful oaklike figure much prized in furniture work. It is the lightest of the timbers of the State.

The Karri Forest

Karri is the Aboriginal name for the State's tallest trees and together with Mountain Ash and Alpine Ash of Victoria and Tasmania is credited with being one of the three tallest hardwood trees in the world. Its botanical name is *Eucalyptus diversicolor,* the specific name "diversicolor" referring to the difference in the shade of green between the upper and lower surfaces of the leaf. On days when the wind is strong enough to overturn leaves from their natural hanging position, the paler under surface contrasts strongly with the deeper green of the upper surface of the leaf.

Description of the Forest

Prime stands of karri constitute some of the most magnificent hardwood forests in the world. Long, straight boles, as much as 120 feet (*37 m*) to 160 feet (*49 m*) to the first limb, tower skywards supporting wide spreading crowns 60 feet (*18 m*) or more in diameter and total heights of 200 to 250 feet (*61* to *76 m*) are common. The tallest karri (measured in 1939) reached 286 feet (*90 m*) and had a butt girth of 24 feet (*7.3 m*)—truly a masterpiece of natural engineering combining symmetry and beauty with great strength and economy of material. The largest girth yet recorded is 40 feet 2 inches (*12 m*) at breast height.

The bark is smooth and greyish-white when old. However, in late summer this old bark splits and sheds in irregular patches exposing the new, fresh salmon-yellow bark beneath, so giving the stems a mottled appearance. Following severe fires, bark shed may be greater than normal resulting in stands of trees having uniform salmon-yellow bark. As the months pass, however, the colour gradually reverts to the original greyish-white.

Seen in the slanting rays of the morning sun, which illuminates the long, smooth straight boles against the bright green mass of the undergrowth, the karri forest presents a beautiful sight not readily forgotten. Care has been taken to reserve extensive areas in the virgin state, not only for reasons of conservation and recreation, but also to provide reference points for scientific ecological studies.

Plate 18

Virgin karri forest

257 20 – 4

Distribution

The karri forest occurs in the extreme south-west of the State in localities receiving a rainfall in excess of 40 in. (*1016 mm*) per annum. The main belt of forest lies south of a line drawn from Nannup in the north-west, through Manjimup to the Frankland River in the south-east, thence in a belt of decreasing width through to Denmark and Torbay, near Albany. Its western limit is a line south from Nannup, separated from the coast by a belt of coastal sand-dune country, varying in width from 2 to 10 miles (*3 to 16 km*).

A number of outliers from the main belt occur, the largest of which are:—

(1) A narrow coastal belt of some 75,000 acres (*30,000 ha*) on the strip of limestone soils between Karridale and Forest Grove.

(2) A patch of a few hundred acres on the northern slopes of the Porongorups, approximately 12 miles (*19 km*) east-south-east of Mt. Barker.

Within these distribution limits of nearly one million acres, the main commercial forest of about 300,000 acres (*120,000 ha*) spreads through the river systems. Of this, 170,000 acres (*69,000 ha*) are in pure stands, and 130,000 acres (*51,000 ha*) in mixture with marri, or more rarely, in mixture with jarrah or the Tingles (*Euc. jacksonii* and *Euc. guilfoylei*). Of the remaining 700,000 acres (*280,000 ha*) about 80 to 85 per cent is occupied by jarrah-marri forest, and the rest by wide, poorly drained flats carrying no native tree growth of commercial value.

Within its range, the actual distribution of karri is determined mainly by soil type.

Soils of the Karri Forest

Karri soils generally are acidic in reaction, with textures varying from fine sands to sandy loams derived from underlying granite gneiss. Such soils are of low nutritive value and have been proved deficient in trace elements such as zinc, copper, and cobalt.

The Timber and Its Uses

The timber of karri varies in colour from pale pink to reddish-brown and deep red and although closely resembling jarrah in appearance, is generally lighter in colour. A common test to distinguish between jarrah and karri is to burn a splinter of sound truewood—avoid sapwood and brittle heart. Jarrah burns to black charcoal, but with karri the red-hot coal continues to glow until a true white ash is produced.

The timber of karri is hard, stiff and tough, and considerably stronger than Douglas Fir and English Oak. It has exceptionally good bending properties.

Weight per cubic foot (green)	72 lb./cu. ft. (*1200 kg/m³*)
At 12 per cent moisture	57 lb./cu. ft. (*912 kg/m³*)
C.S.I.R.O. strength group rating	B

Karri is rated as durability class 3 by the Division of Forest Products, C.S.I.R.O.

The uses of karri wood material are numerous. The strength and stiffness of the timber, combined with the extraordinary long, clean lengths which may be obtained, render it unsurpassable for superstructural work. It is possible to secure karri in larger sections and longer lengths than any other known hardwood. In beams, rafters, tile battens, columns, roof trusses, warehouse floor joists, and other members where strength is the essential factor, it gives satisfaction. It may be mentioned that, in one of the mills in the karri forest, the roof was carried by two trusses with a common tie beam consisting of a piece of 12 in. x 12 in. (*30 cm* by *30 cm*) karri,

80 ft. (*24 m*) in length. In many instances karri has replaced oregon for scaffolding planks, where its greater strength has more than offset the increase in weight. In bridge construction it is used for half caps and decking. The timber is highly prized for transmission line crossarms, and is also used in coach, waggon and motor body building.

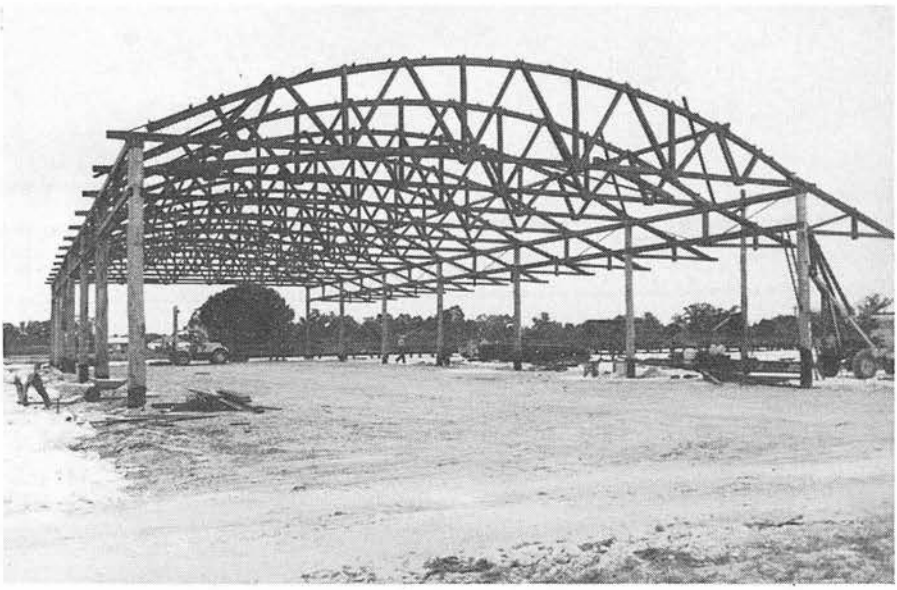


Plate 19

Thirteen karri bowstring trusses were used in the construction of this sawmill near Welshpool. The carved sections are of laminated construction and each truss spans 18.9 m with a 3.7 m cantilever. The round posts are jarrah.

In the gold mines of Western Australia, karri is used for many purposes, while large quantities have been exported to Johannesburg where its use is particularly favoured in gold mines as cage guides or "sliding" beams. Reports show that, under conditions of heavy wear, it has a much longer life for this purpose than pitch pine and other timbers previously used.

Large quantities of karri have been used for many years by the Postmaster General's Department for telephone crossarms, and these have given good service. With the setting up of a 1,000 pounds per square inch (*70,300 gr./cm²*) pressure impregnation plant at Pemberton, crossarms are now being treated with 3 per cent pentachlorphenol in oil, and give excellent service. Since its inception not one failure of a crossarm in service has been reported. The hazard from termite and fungus attack in a crossarm is low, but the oil impregnation is worthwhile in reducing the weather checking that can occur in a hot, dry climate. Treated karri crossarms are now used throughout Western Australia and are exported to other States.

In 1944 the plywood industry was established in Western Australia using selected karri logs. Although used initially for all classes of plywood, especially 3-ply, the main use of karri veneer today is for multi-ply waterproof sheets. This type of product is in great demand for concrete form work, because of its great strength and resistance to wear. Karri plywood is also used for truck flooring, and any requirement where strength is an important factor.

Karri has become increasingly popular as a flooring timber, with regular exports of the finished product to the eastern States of Australia, Darwin, the United Kingdom, New Zealand and Greece.

A recent addition to the export market is its use as slats for refrigeration rail-cars in the United States of America. This commodity is usually supplied by the Philippines and South America.

Until partially replaced by cartons, fruit cases were produced annually to carry the apple crop to England. Karri has also been used for wine vat and cask manufacture and for wood pipes and flumes. The last section of karri pipe in the Goldfields Water Supply Scheme pipeline was removed in early 1971—still in good condition.

Karri is on Lloyd's list of shipbuilding timbers and, before the days of steamships, vessels built wholly of this timber were constructed in Western Australia. At Hamelin Harbour, from which the produce of the early Karridale sawmills was exported, quite a fleet of large lighters built entirely of karri was employed. In shipbuilding in later times, the wood had been used largely for keelsons, and the long lengths obtainable are regarded by shipbuilders as an added advantage for this work.

Despite difficulties encountered in gluing, karri shows promise for use in long span laminated beams.

Recent trials have indicated that round karri poles can be successfully impregnated with creosote by "Boultonizing", a process which displaces the green sap with preservative without requiring the pole to be dried beforehand. Previously, drying of poles has been accompanied by excessive checking. Should artificial durability be imparted to karri poles free of excessive checking, then the ready availability of long transmission poles, 55 feet and more in length, from thinnings in even-aged regrowth stands, promises to solve a serious problem of supply of this commodity for the State.

As early as 1923 paper was produced from a mixture of 70 per cent karri and 30 per cent imported sulphite pulp. In recent years trials have indicated that satisfactory pulp can be produced from karri, particularly from young thinnings, and also from sawmill waste.

The sap is strongly acid and readily corrodes iron in exposed positions. When nailed green, galvanised iron nails should be used.

When in full flower, the karri forest is one of the most prolific honey yielders known, contributing about 25 per cent of all table honey produced in W.A. From 400 to 600 lb. (*181* to *272 kg*) of the finest quality honey may be harvested from each hive.

The Protective and Recreational Functions of the Forest

Apart from its more obvious value as a wood producer, the karri forest, even more than adjacent forest communities, has the capacity to trap and regulate the heavy concentrated winter rainfall. Streams of fresh water, free of contamination by silt or salt, flow the year round. In a dry country such as Australia, fresh water, suitably stored, is of vital importance for domestic, industrial and rural usage. It will not be long before all such streams are utilised for these purposes. It is noteworthy that streams which originate further inland from the forest belt, yet flow through it (*e.g.*, Warren, Frankland, Kent Rivers), have become progressively more salty with agricultural development in the upper reaches, whereas those confined to forest catchments (Donnelly, Barlee, Treen) have maintained their freshness.

Being the only temperate eucalypt rain forest in W.A. it is logical that it be used for recreation, not only during the hot summer months, but also in springtime when the ground flora bursts into flower. Many thousands of visitors annually appreciate

Plate 20

" The Cascades ", a favourite tourist spot near Pemberton, is typical of scenes to be found along the permanent freshwater streams which arise in nearby State forest

the cool green gullies, and fish for native marron and introduced trout in the streams. Birdlife is prolific and kangaroos, emus and brush wallabies are often seen.

The Forests Department in the past has provided a number of tourist facilities, either independently, under Treasury grant, or in conjunction with the Pemberton National Parks Board. These include development of access and provision of picnic spots in the karri forest, such as the Rainbow Trail, the Cascades, One-Tree Bridge and developments in the Beedelup, Warren and Pemberton National Parks.

Departmental lookouts such as Gloucester Tree and Diamond Tree attract a high volume of tourist attention and Gloucester Tree is manned for part of the tourist season, outside the normal fire season, for the benefit of tourists.

Flowering and Seeding Habits

Unlike jarrah and marri, which have a reserve lignotuberous stage between seedling and sapling, karri must rely upon its seedlings to develop directly into tree form.

Hence its natural regenerative process relies wholly on seedfall, detailed knowledge of which is essential for silvicultural operations.

The normal seed cycle from bud initiation to mature seedfall takes 4 to 5 years. Flowering takes place in mid-cycle at 2½ years from bud initiation. With minor exceptions all trees progress through the cycle in unison. Hence seed is available in the forest only at the end of each 4 to 5 year cycle. It follows that regeneration operations utilising natural seedfall can only take place at periodic intervals, usually for two years out of every five. Bumper seed crops seldom follow one another, but usually occur once a decade.

Seed Supplies

Dominant trees are the best seed source for the 120,000 seeds per acre (*49,000 ha*) required for adequate natural regeneration. Sampling shows that seed is dispersed indiscriminately with equal amounts being distributed under the crowns and out to a distance equal to half the tree height; about half this number reaches distances equal to the total tree height.

Seed collection for artificial regeneration is done in association with trade cutting, following the testing of sample capsules for high quality seed of above average yield. About one ton of green capsules yields 11 lb. of pure seed (*5 kg to one metric ton*), averaging 330,000 per pound (*150,000 per kilogram*). The seed constitutes only about one-sixth of the material extracted from the capsules, and the balance is worthless chaff.

Natural Regeneration

In order to prepare a clean seed-bed, burning is carried out at a time when the seed supply—as determined by sampling and testing—is adequate for karri regeneration. Burning before the seed is ripe encourages the weeds to establish first, and burning after seedfall incinerates the seed on the ground. Burning helps to ripen the seed in the capsules and promotes seed-shed; it also removes competing scrub and stimulates the early development of karri seedlings.

The seed germinates after the opening rains in autumn and early winter. Leaf mould, litter and ground vegetation hinder establishment of the seedlings, but the bare mineral soil exposed by the controlled burning becomes carpeted with seedlings.

In cutover stands of karri, three dominant trees per two acres will provide the 120,000 seeds per acre (*49,000 ha*) required for satisfactory regeneration. From this seed shed between 500 and 3,000 seedlings per acre (*200* and *1200/ha*) are established.

The effect of the ashbed resulting from the burn is quite remarkable in ensuring the obsolute dominance of karri over the weeds. At the centre of a two-year-old ashbed, karri seedlings may be 10 to 12 feet (*3* to *4 m*) in height, compared with 1 to 2 feet (*0.3* to *0.7 m*) in height off the ashbed. Vigorous sapling stands can then completely dominate the site and attain 80 to 90 feet (*24* to *27 m*) height growth in 20 years.

Artifical Regeneration

Proven methods of artificial regneration have been adopted by the Forests Department, so that areas not satisfactorily stocked with natural regeneration may now be restored to full productivity.

Seed is very sensitive to site influences and direct seeding to date has proved unreliable and expensive. Broadcast seeding requires four to eight times as much seed as spot seeding and sixty times as much as for the production of nursery plants.

Plate 21

A 40-year-old stand of karri regrowth resulting from clear-cutting and regeneration treatment

Transplanting suitably-sized natural regeneration (15 in.) (*38 cm*) or of open-rooted nursery plants (6 to 8 in.) (*15* to *20 cm*) gives more certain establishment than does seeding. A handful of equal amounts of nitrogen and phosphate fertiliser next to the planting hole has the effect of producing more rapid and uniform growth in transplanted seedlings than in naturally regenerated seedlings. The shoots of karri seedlings which have been transplanted without fertiliser die back for two-thirds of their height after planting; development is retarded in the early stages and restricted subsequently by weed growth, and the leading side shoots are commonly forked and malformed. On the other hand, karri seedlings fertilised at the time of transplanting produce vigorous leading shoots and a rush of height growth which quickly dominates the competing ground vegetation.

Silviculture

Karri thins itself moderately well, naturally. The dominant saplings race ahead in height growth, develop larger crowns and overcome their neighbours in the struggle for light, space, and soil nutrients.

The initial establishment of 120,000 or more seedlings per acre (*49,000 ha*) would, under natural conditions of height growth and fire, be reduced to 1,000 (*400*) trees at 10 years and 500 (*200*) at 20 years. Roughly half of these would by this time be dominated.

Except on an experimental scale, no artificial thinning treatments have been carried out in the karri forest. This practice would prove uneconomic at the present stage. Should a pulp industry develop, a large amount of raw material could become available in the form of thinnings from stands 10 to 30 years of age.

The oldest stands resulting from Departmental regeneration work date from 1929, but valuable information has been obtained from areas of natural regeneration at Karridale, now aged 70 to 80 years, and also from old farm properties, one of which dates back to 1872.

Measurements of sample plots laid down in these areas indicate that karri will produce from 75 to 150 cubic feet of wood per acre per annum (*5* to *10* m^3/ha) on favourable sites.

Judicious use of controlled fire in sapling stands does not appear to have any adverse effect on tree growth. The critical bark thickness to insulate the cambium from the radiant heat of fire is 0.4 to 0.7 in. (*10* to *18 mm*). This critical point usually occurs where the stem is at least three inches in diameter. Vigorous dominants develop a thick fire-resistant bark near the butt and can survive all but the hottest fires.

Regeneration Systems Employed

The earlier regrowth stands from 1929 to 1938 were produced under a clear-felling system in which marketable timber was felled with no attempt to preserve smaller immature trees. Many of these were smashed in felling operations. Marri trees were ringbarked, and the understorey scrub felled, and the whole burnt by a fierce fire in a good seed year. A dense and uniform crop of seedling regeneration came from seed provided by non-marketable karri trees left in the stand. These latter were subsequently ringbarked to save the growing stock from competition.

In 1938 this method was replaced by a silvicultural operation known as the Selection System, a modified form of treemarking under which the over-mature and mature karri trees were removed for sawlogs under the direction of a forest officer, with the aim of retaining undamaged the maximum number of immature trees. Standard treemarking was introduced into the karri forest about 1949. Under this system the

forest officer marks the trees to be removed, and also indicates the direction in which they are to be felled in order to avoid damage to growing stock. (See Plate 58.)

Since 1968 the system has changed again, reverting to a clear-felling system which produces an even aged stand similar to those produced from 1929-1938. The main objection to the earlier clear-felling was the unavoidable waste of smaller immature trees. Over the past decade a market for smaller scantling sizes, boards, etc., has enabled the utilization of a greater proportion of these smaller trees previously wasted. The manifest advantages of a clear-felling system are: simplified management and protection, more efficient extraction, and less complex regeneration procedures. The main difference between the present clear-felling system and the initial one is that great care is now taken to retain the biggest and best trees as seed trees and not rely on unmarketable trees as previously. Once regeneration is established seed trees are removed.

Other Important Species of the Karri Forest

On the south coast, in the vicinity of Walpole, is a small pocket of country which has the mildest climate of the whole State. Within its confines are a number of eucalypts deserving of special note—the Tingles and Red-flowered Gum. These are all endemic, *i.e.*, they are native to this area and nowhere else.

RED TINGLE (*Eucalypt jacksonii*)

Red Tingle is one of the world's big trees. Though not as tall as karri, it attains larger girths, often being heavily buttressed. Diameters of 15 feet (*4.6 m*) at 5 feet (*1.5 m*) from the ground are found, and one tree measured 66 feet (*20 m*) in circumference at the base. Heights rise to 230 feet (*70 m*), but are more commonly 180 feet (*55 m*).

The bark is persistent, grey-brown in colour, and longitudinally fissured in the "stringybark" fashion. Except for its size, red tingle closely resembles jarrah in general external appearance. However, the heavy undergrowth and denser crowns are more typical of the moister karri type forest.

Distribution

The total occurrence is no more than 15,000 acres (*6,000 ha*) and is bounded by the Kent River to the east, the Deep River to the west, and to the north by a line approximately 10 miles from the coast. Annual rainfall is 50 inches (*1270 mm*) or more; summer rainfall is 12 to 14 inches (*305* to *356 mm*), distinctly higher than elsewhere in the south-west. It commonly occurs in mixed stands with karri, marri and yellow tingle, but pure stands of limited extent are found.

Timber

The timber is red-brown in colour and closely resembles jarrah, but is lighter in weight. Limited supply has prevented its wider use for general framing and structural purposes. Some fine examples of its use in furniture and panelling exist. Used as a sleeper, it has a service life of 20 years under South-West conditions. It suffers from "collapse" if not carefully seasoned.

The importance of conserving this rare species is more important than promoting its utilization. All the best stands are now either in State Forest or National Park.

YELLOW TINGLE (*E. guilfoylei*)

In size, form, and general appearance of bark and bole, yellow tingle and jarrah are very similar. Both resemble red tingle also, except that the latter is taller and more massive. Yellow tingle attains a height of 80 to 120 feet (*24* to *36 m*) and a diameter at breast height of three to four feet. Apart from the yellow colour of its wood, the most obvious characteristic used to distinguish the tree from red tingle is the flat, strap-like peduncle of its fruit. Jarrah fruit are bigger and shaped differently from either red or yellow tingle.

Distribution

Yellow and red tingle occur together, but the yellow extends considerably further to the west, north and east.

Timber

The timber is yellow in colour, hard, dense and durable. Having a wider occurrence than red tingle, availability is better. In limited numbers it is accepted as a sleeper with jarrah, and is considered of equal durability and utility. It does not suffer from "collapse" during seasoning.

For some years the existence of another Tingle having characteristics of both red and yellow tingle has been known. Although its form and appearance closely resembles red tingle, the wood is yellow, and its distribution is more that of yellow tingle. The buds and fruit are different from both, as is the glaucous nature of its juvenile foliage. Recent investigations suggest that sufficient differences exist for it to be named a third Tingle species.

RED-FLOWERED GUM (*Eucalyptus ficifolia*)

The brilliant vermilion stamens of this tree have made it famous and it is widely planted as an ornamental in Australia and overseas. Its natural occurrence is confined to the same south coast pocket as the tingles. However, it does not intermingle with them, but grows on coarse sandy soils in several small patches; one in sight of the coast near Peaceful Bay, and others twelve to sixteen miles inland directly to the north. The first recorded sighting of *E. ficifolia* was further west at Broke Inlet. However, it has not been seen there since.

Considerable variation in flower colour is found: vermilion, crimson, orange and pink. Trees of outstanding colour have been identified and tagged in the field. Seeds have been collected from each tree, raised in the nursery and planted out in orchard form in a safe area within State Forest. The survival of this irreplaceable genetic material is thus favoured.

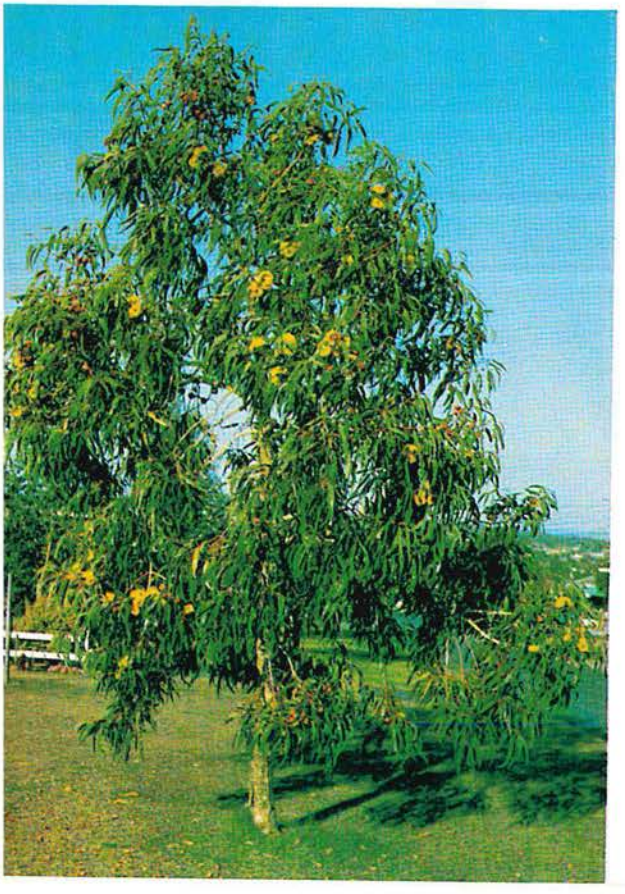
In Western Australia cultivated specimens are prone to attack by fungal canker, which also affects marri but less severely. It is hoped that resistant strains may eventually be found.

Eucalyptus ficifolia and *Eucalyptus calophylla* (Marri) are both bloodwoods and are closely related. However, *E. ficifolia* has smaller more rigid leaves, a characteristic umbrageous shorter form, coloured flowers, and slightly different fruits.

W.A. PEPPERMINT (*Agonis flexuosa*)

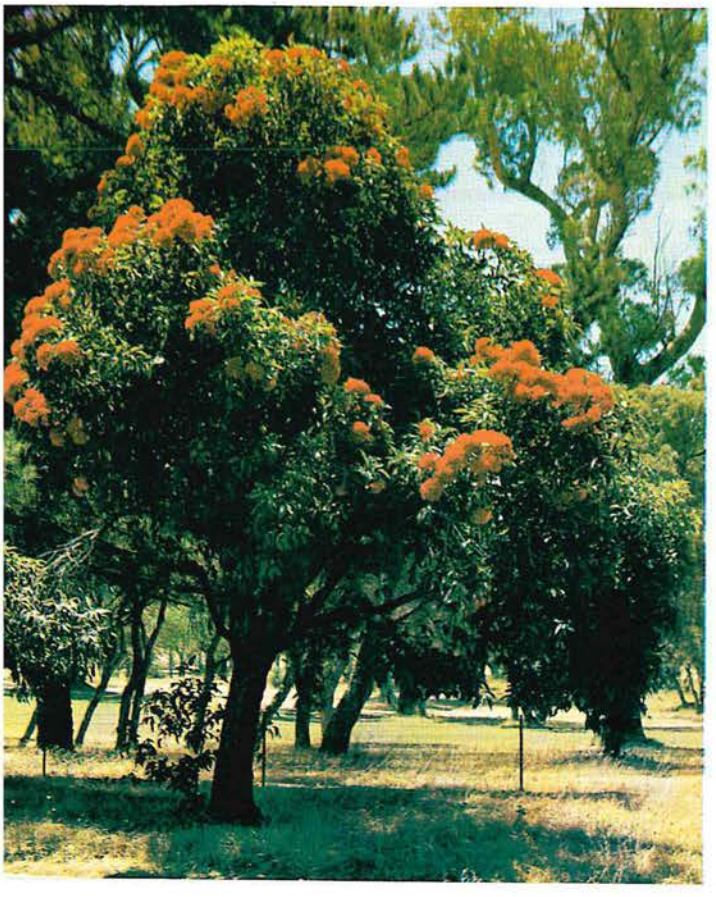
Peppermint is a common understorey tree along the banks of streams and in damp, sandy situations throughout the karri forest and further north, particularly in

Illyarrie (*E. erythrocorys*).



Mottlecah (*E. macrocarpa*).

Red-flowered gum (*E. ficifolia*).



Karri trees, particularly after bark-shed in late summer, form one of the world's most magnificent and scenically beautiful hardwood forests.

association with tuart. Though the timber makes fine panelling and has good strength qualities, irregular form limits its usage. Its umbrageous, sometimes weeping habit, the pleasing appearance of its light green foliage, its peppermint scent, and the clean carpet of leaf litter formed beneath the crowns, create an ideal environment for summer campers. The trees are commonly left standing singly and in groups for stock shelter, and have been planted extensively as street trees, particularly in the Perth Metropolitan area.

WARREN RIVER CEDAR (*Agonis juniperina*)

Warren River Cedar is confined to the higher rainfall karri area. It commonly occurs in permanently damp situations alongside streams and surrounding swamps, often in association with peppermint and river banksia.

The wood is light brown to yellow in colour, has good strength and working properties, and has been used for handles and boat building. However, limited availability and the vulnerability of the standing tree to attack by a large borer have restricted its use.

The Tuart Forest

Description of the Forest

Tuart (*Eucalyptus gomphocephala*) occurs in an open formation which particularly over the southern portion of its range, approaches typical savannah forest conditions. The undergrowth is scanty, consisting chiefly of trailing legumes such as Hardenbergia, Kennedya and Hovea, but there is, however a well developed understorey of small trees which afford shade. The ground covering consists of grasses and herbs which dry off in the summer. This forest is the only forest formation in the southern portion of the State which has a ground covering partially of grass, a factor typical of savannah formations generally.

Peppermint (*Agonis flexuosa*), attaining heights of up to 30 feet (*9 m*) is the principal understorey species in the south, while *Banksia menziesii, Banksia grandis, Banksia attenuata, Casuarina fraseriana,* black wattle and spearwood (*Kunzea evicafolia*) predominate in the north.

The tuart normally grows in a pure stand, but can nevertheless be found associating with other eucalypts, particularly towards the outskirts of the stand. Marri is a common species throughout the entire range of the forest, and jarrah occurs in patches but never attains any great size. Flooded gum (*Euc. rudis*) and yate (*Euc. cornuta*) are also found on the swampy flats in the south.

Tuart, the principal species of the formation, attains heights of up to 120 feet (*36 m*). It is more umbrageous than jarrah, but the trunk is usually not as straight. Bark is persistent, rough, light grey in colour—a bark typical of the "Box" group of eucalypts more common to the Eastern States.

Distribution

Tuart is confined to limestone formations which stretch in scattered lines from Lake Pinjar southward along the coast as far as Sabina River, some three miles east of Busselton. Curiously enough, it is not found elsewhere in the State, although limestone occurs all round the coastline.

The tuart belt is separated from the seaboard by an extensive system of sand dunes, and from the Darling Range (which runs parallel to and at an average distance of 20 miles from the coast) by the lateritic foothills which claim the jarrah as their principal tree. This belt is some 150 miles (*240 km*) in length and 5 to 10 miles (*8* to *16 km*) in width.

Rainfall throughout is approximately 30 inches (*762 mm*) per annum, but, the prime area of forest is found towards the southern limits where the rainfall increases to about 40 inches (*1016 mm*).

The best tuart is to be found between Capel and the Sabina River. Over 6,000 acres (*2400 ha*) of tuart country in this locality has been reserved as a State Forest.

Soils

Tuart is only found on limestone outcrops and the yellow to brown sands associated with them on this coastal tract.

Timber and Uses

The timber is a pale yellow in colour, very hard and dense with a strong interlocked grain—a characteristic which makes it ideal for use where strains or abrasions are encountered. For this reason it is largely employed in the construction of railway wagons, and formerly it was used extensively for the pins supporting telegraph insulators. The timber is reasonably termite resistant and even stronger than that of the wandoo and makes a very attractive floor.

The area of prime tuart forest is of very limited extent, and the timber growing in State Forests is reserved for Government requirements.

Weight per cubic foot (green)	78 lb. (*1250 kg/m*^{3})
At 12 per cent moisture	64 lb. (*1025 kg/m*^{3})
Transverse strength	17,900 lb. per sq. in. (*1,258,000 gr/cm*^{2})
Tensile strength	16,500 lb. per sq. in. (*1,160,000 gr/cm*^{2})

Flowering and Seeding

A general seed year occurs only at intervals of from five to eight years. Buds form in March to April, flowers the following March to April, and seeds the next year in the same month. Dispersal is very good, but seed is often retained another year. A fire assists in obtaining a general seedfall.

Regeneration

The establishment of seedlings is a haphazard process of which the story is only partly known. Very little regeneration is found in the tuart forest and has not been apparent for many years.

Seedlings generally die before they reach any appreciable size, and those that survive do so on an ashbed where a heavy pile of debris or a log has been burnt. Limited research indicates that the story is more complicated than this.

Nursery stock planted on sites where they are free from competition from established trees have developed quite satisfactorily.

Only one small sawmill is in operation in the tuart forest. It is controlled by the Forests Department, regulating the cutting of this valuable timber to the rate of growth. The small area of good tuart forest has been declared State Forest and is now under fire protection and silvicultural treatment.

Plate 22

Cut-over tuart forest near Ludlow

YATE (*Eucalyptus cornuta*)

Yate grows to a height of 50 to 70 feet (*15-21 m*) with a bole of 25 to 35 feet (*7.6 m-10.7 m*), and a diameter of three feet (*0.9 m*).

The bark is persistent, dark, rough, and of dirty, untidy appearance on the trunk; it peels off the branches, often hanging down in strips, leaving the branches white like those of karri. It occurs at Busselton, Donnelly River coast, Lake Muir, and in the Mount Barker district.

The timber is light-coloured and of exceptional strength; probably the strongest timber in the world—the results of one test for tensile strength and breaking load was 17½ tons per square inch, which is 3½ tons less than that usually specified for wrought iron of ordinary quality.

Weight per cubic foot (green)	79 lb. (*1264 kg/m³*)
At 12 per cent moisture	71 lb. (*1136 kg/m³*)
Transverse strength	21,500 lb. per sq. in. (*1,512,000 gr/cm²*)
Tensile strength	24,200 lb. per sq. in. (*1,702,000 gr/cm²*)

Yate was used generally for wheelwright work, but now the supply of this timber is practically negligible.

The Wandoo Woodland

Description of the Woodland

Wandoo (*Eucalyptus wandoo; syn. redunca var. elata*) is a smooth barked tree which often grows to a height of 100 feet (*30 m*) with a bole length of 30 to 40 feet (*9-12 m*) and a breast height diameter of 4 feet (*1.2 m*). Under forest conditions, however, the height is generally between 70 and 80 feet (*21* and *24 m*) with a 20 to 25 foot (*6* to *8 m*) bole and a breast height diameter of 2 to 3 feet (*0.6* to *0.9 m*).

The bark is smooth, yellowish-white in colour with purple-grey patches of more persistent bark. On a mature tree the bark is about 1 inch in thickness and decorticates in patches.

The tree closely resembles *Eucalyptus accedens* (Powderbark Wandoo) both in appearance and silvicultural characteristics, and often the two species are found growing in mixture. A point of distinction is that the bark of mature trees of *Eucalyptus accedens* bears a fine, white powder which may be rubbed off with the hands. Furthermore, the operculum or bud cap of the wandoo is long and tapering, while that of the powder bark is blunt. In the young stages the two species may be readily separated by the differences in juvenile leaves.

Another tree which closely resembles wandoo is the recently named *Eucalyptus laeliae*. This new species was earlier confused with powderbark wandoo but differs from it in that the buds and fruits are much smaller and, in particular, the startling white bark persists to the smallest branches. Furthermore it occurs in small pure stands only on laterite-free soils in drainage lines of the Darling Range. The specific name refers to "Laelia", one of the vestal virgins, and is obviously related to the virgin whiteness of the bark.

Unlike the jarrah, karri and tuart formations, the wandoo forest does not present a uniform woodland. Rather does it form a series of associations in which the tree takes a leading part. It does not grow in close formation but in an open savannah woodland or sclerophyll woodland in which there is wide spacing between the trees. Within these areas wandoo occurs both as a pure stand and in mixture with jarrah, marri or powderbark wandoo.

Throughout the range of wandoo, york gum (*Euc. loxophleba*) is found in association, but not as a mixture with it, the separation of site being determined mainly by soil factors. In the centre and to the east of its range wandoo associates with the mallets (*Euc. astringens, Euc. gardneri, Euc. falcata*). Yate (*Euc. cornuta*) and swamp yate (*Euc. occidentalis*) occur in association with wandoo towards the limit of its range where its quality is poor. Flooded gum (*Euc. rudis*) is also found with wandoo along some gullies.

Distribution

Wandoo is a native of the south-west of Western Australia and is generally found between the 15 and 20 inch (*381* and *508 mm*) rainfall limits. It extends as far north as Mt. Lesuer (Jurien Bay) where it occurs in small pure stands, but reaches its maximum development in the vicinity of Bindoon from whence it deviates to form two areas, one on either side of the Darling Range.

Wandoo on the western side of the range is not extensive and exists mainly as odd clumps of trees along the foothills of the scarp.

On the east of the Darling Range it encroaches well into the jarrah forest along the gullies.

The prime wandoo woodland occurs from Bindoon to Boddington, either in broad gullies or on low ridges. Extending south from Boddington, the quality of the stands fall off until it reaches the southern limit in the Stirling Ranges.

The eastern limit of the species extends from Hyden northwards and eastwards almost to Bullabulling where it occurs in mallee form.

Soils of the Wandoo Woodland

The surface layers of typical wandoo soil are dark brown loamy sands or sandy loams containing some gravel. Occasionally in the bottom of a valley the texture of the surface soil becomes a clayey loam. Usually clay occurs at a shallow depth in wandoo soils, varying from six inches to almost four feet, depending on the slope of the land.

Surface drainage in wandoo soils is fair only, and down the profile the drainage can be poor.

Timber

Wandoo timber is light brown to light yellowish brown in colour. It is fairly close-textured with a wavy or interlocked grain, with which some figure may be associated. It is one of the heaviest eucalypts and one of the most durable of Australian hardwoods. It is very hard, exceedingly strong and stiff, and very tough. With hand tools, it is somewhat heavy to work, but it performs satisfactorily in machining.

Weight per cubic foot (green)	80 lb. (*1281 kg/m³*)
At 12 per cent moisture	68 lb. (*1089 kg/m³*)
Transverse strength	16,100 lb. per sq. in. (*1,132,000 gr/cm²*)
Tensile strength	16,500 lb. per sq. in. (*1,160,000 gr/cm²*)

Uses

Wandoo is best suited for purposes where strength and durability are of importance. It is used in considerable quantities for sleepers, being recognised as one of Australia's best sleeper timbers. It is a first class structural timber and used in the construction of

Plate 23

Open wandoo wocdland east of Mundaring

bridges and wharves for beams, girders, joists and storey posts. For railway purposes it is used for truck under-frames and has proved eminently satisfactory for top planks in truck sidings where it is subject to heavy service conditions. In earlier days it was highly prized by the wheel-wright trade for naves, shafts, cogs, spokes and felloes.

It is particularly suitable for flooring subject to heavy wear and in building construction where durability, strength, or hard wearing qualities are desired.

A remarkable quality of this timber is that, when used in conjunction with steel, there is no chemical action between the wood and the metal. Bolts have been taken from under-frames of trucks after 20 years' use and found to be quite as clean as when put there, while the auger marks were still visible in the holes.

The wood and bark of wandoo contain a high percentage of usable tans which are extracted by digesting the chipped material in large vats. A wide range of commercial tan products are derived from the extract liquor.

The wandoo areas form an important part of the honey industry in W.A. due to the heavy nectar production in seed years. Wandoo honey is a light coloured highly palatable product which has a big internal demand from honey connoisseurs. In addition, the winter flowering habit of wandoo north of Bindoon is a valuable supply for the off-season sustenance of apiaries.

Silviculture

The formation of the bud, fruit and seed of wandoo follows a similar pattern to jarrah.

For an average season, new leaf growth begins in January and reaches a maximum during February. In conjunction with leaf formation, new flower buds form in the axils of the leaves. Many of these buds do not mature further.

Twelve months later during February when the buds have fully developed, flowering occurs. These flowers set and require a further twelve months after flowering for the seed present in the capsules to ripen. The fruit capsules do not remain on the tree for long after ripening.

From the first formation of the bud it requires two years to obtain the ripe seed which is generally shed while the fruit is still held on the crown. After a ground fire a heavy fall of seed will result.

Wandoo has a periodicity of general seed years which is about once in every three years. Flowering throughout the forest does occur every year, but to a limited extent.

Present observations indicate that under natural conditions wandoo seed will only germinate satisfactorily on an ash bed.

As with jarrah, the aerial shoot from the germinating seed of wandoo does not grow immediately to form one erect stem. Several shoots develop to assume a low bushy habit and the plant enters into a resting period during which the ligno-tuber increases in diameter. Approximately ten years after germination, the ligno-tuber which has grown to about three inches in diameter, puts forth one single vigorous shoot from the bushy advance growth to assume dominance and develop into a sapling.

Following germination, a light fire does little damage to regeneration due to the etablishment of the vigorous ligno-tuber below ground level. Intensive fires, however, may be the cause of lack of advance growth under virgin wandoo forest. In areas where there have been severe fires, a marked effect on the soundness of the timber in mature trees is apparent. Wandoo burnt at the butt, or with a dry side, is usually not suitable for milling.

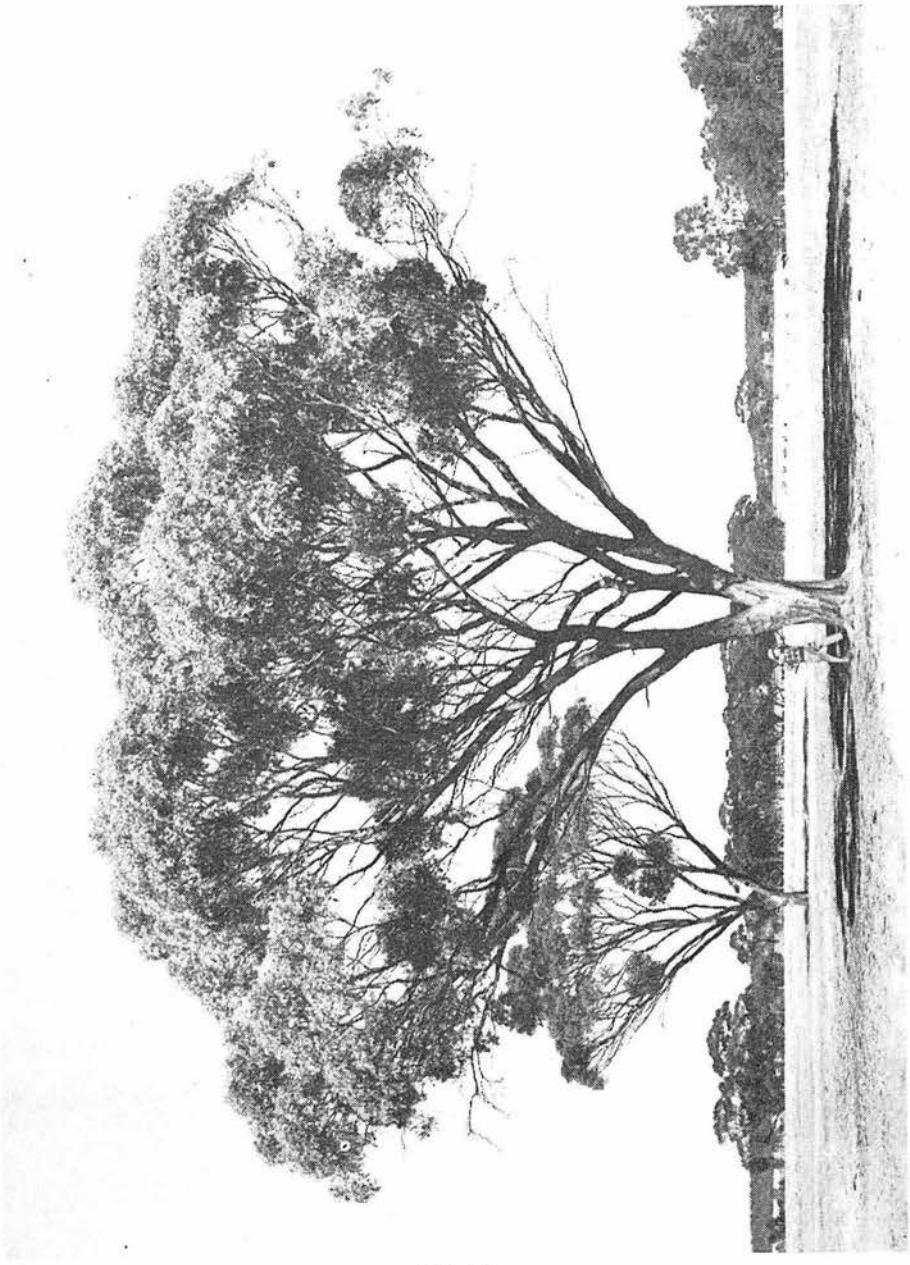


Plate 24

York Gum *(Eucalyptus loxophleba)* near Brookton. Background trees on the river bank are flooded gum. *(E. rudis).*

Other Trees of the Wandoo Woodland

YORK GUM (*Eucalyptus loxophleba*)

York gum may grow to a height of 40 to 60 feet (*12 to 18 m*) with length of bole of 10 to 15 feet (*3.0 to 4.6 m*), and a diameter of 18 to 24 inches (*46 to 61 cm*).

The bark is rough, persistent and varies from a light to a dark-grey in colour. The inside of the bark is reddish. Branches are more spreading than is the case with most eucalypts.

The wood is yellow-brown in colour, dense, hard, heavy, with an interlocked grain very suitable as a mallet, nave or maul timber. It may be worked to exhibit a beautiful figure.

Weight per cubic foot (green)	77 lb. (*1234 kg/m³*)
At 12 per cent moisture	67 lb. (*1073 kg/m³*)
Transverse strength	14,500 lb. per sq. in. (*1,019,000 gr/cm²*)
Tensile strength	13,000 lb. per sq. in. (*914,000 gr/cm²*)

York gum grows in open or savannah forests in the 20 inch (*508 mm*) rainfall belt and is most common around Bolgart, Toodyay, Northam, York and from Narrogin to Broomehill. Its presence is regarded by farmers as an indication of good agricultural soil for wheat growing, and also good grazing country for sheep.

FLAT-TOPPED YATE (*Eucalyptus occidentalis*)

Flat-topped yate is a tree which may attain a height of about 70 feet (*21 m*) with a trunk of up to 20 inches (*51 cm*) in diameter and a rough, grey, flaky-fibrous bark covering the whole of the trunk and the lower parts of the main branches. The branches have a smooth yellowish-grey bark and are usually wide spreading giving the crown of the tree a typically broad and flat appearance, hence the name of "flat-topped" yate.

The timber is pale in colour, hard, and somewhat straight-grained, something like that of yate but inferior in strength and durability.

The bark contains a relatively high percentage of tannin, but as yet the tree has not been economically exploited for tan bark, nor is it considered likely to be so in the future.

Sometimes called swamp yate, it occurs in poorly drained areas such as alluvial flats and the margin of swamps and lakes in the Wagin, Dumbleyung, Katanning and Cranbrook districts. From here it extends almost to the south coast and eastwards to Esperance and beyond.

RASPBERRY JAM (*Acacia acuminata*)

Jam occurs as a small tree 15 to 25 feet (*4.6 to 7.6 m*) in height with a short bole up to 12 inches (*30 cm*) in diameter.

The wood is heavy and very durable; in the agricultural areas jam posts have a service life of 40 years. The grain, like its Victorian sister, the blackwood, is very beautiful and is much prized for cabinet work. The jam tree is regarded by farmers as an indication of good wheat-growing and sheep-raising land, and is therefore being rapidly destroyed in the course of clearing operations.

The name "raspberry jam" arises from the strong scent, resembling that of pressed raspberries, which is characteristic of the wood.

Plate 25

Raspberry Jam (*Acacia acuminata*) trees in a reserve near Williams

The Mallets and other Tannin Trees

Tannins are a valuable commodity which have the ability to convert hides to leather, making them resistant to exposure to air, moisture, temperature change and bacterial attack. They are also useful as a basic ingredient of ink, as an astringent in medicine, and as a dispersant to control the viscosity of mud in oil-well drilling.

In recent years, synthetic materials have largely replaced leather for many of its traditional uses. Nevertheless, the demand for natural tanning materials continues but on a very much reduced scale.

The tannins of the State occur in the following forms—

(a) In the bark—e.g. Brown mallet (*Eucalyptus astringens*)

(b) In the kino (or so-called gum), as in Marri (*Eucalyptus calophylla*).

(c) In the wood, as in Wandoo (*Eucalyptus wandoo*).

Of these the best known are brown mallet bark and the wood of wandoo (already described).

The Mallets

In Western Australia the common name "mallet" is applied to four species of eucalypts:—

Eucalyptus astringens—Brown mallet.
Eucalyptus gardneri—Blue mallet.
Eucalyptus falcata—White mallet.
Eucalyptus spathulata—Swamp mallet.

All produce bark with a high tannin content, brown mallet being of most economic importance and swamp mallet, which is of limited extent, the least important.

Description of the Mallet Areas

The mallets are smooth-barked trees, the brown and blue (refers to leaf colour) having bronze-coloured bark when freshly exposed in mid-summer. The colour gradually changes to dark-grey as the year progresses. White mallet has a light-grey to pale bronze bark. Bark thickness near the base varies from one-quarter inch (*6 mm*) on young trees to over ½ inch (*13 mm*) on large isolated trees. However, bark on the limbs seldom exceeds one-quarter inch (*6 mm*) in thickness.

The growth habits of the mallets vary considerably, ranging from typical tree form to mallee form. As trees, they have more-or-less straight boles, 6 feet to 20 feet (*1.8 m to 6.1 m*) long, while total heights attained are: brown, 60 feet (*18 m*); white, 35 feet (*11 m*); blue, 30 feet (*9 m*); and swamp mallet, 30 feet (*9 m*).

Brown mallet reaches the greatest size. Large trees are seldom seen these days but trees 70 feet (*21 m*) in height, two feet six inches (*76 cm*) breast height diameter with a bole of 20-30 feet (*6-9 m*) were not uncommon in the natural state.

Mallet regenerates prolifically after a fire and forms dense groups of regrowth. Similar dense groups occur under plantation conditions. Unless these are thinned, growth stagnation occurs which results in delayed production of bark of economic value. Given ample space, the mallets under favourable conditions develop into attractive ornamental trees.

The mallets are all extremely fire-tender but managed to survive for untold centuries in areas subject to periodic heavy fires. When they regenerate after a fire they are commonly associated with a dense growth of poison plants. After some 12 to 20 years these plants die and disintegrate leaving a comparatively clean floor which will not

readily carry a fire except under severe weather conditions. With the increase in fire frequency associated with settlement, mallet groups were generally not able to remain unburnt until the clean floor stage was reached and many of them were destroyed.

Distribution

The four species occur between York and Mt. Barker, on the Great Southern Railway, and south-eastwards to Ravensthorpe.

To the east of the 25 inch (*635 mm*) isohyet, the jarrah forest gives place to wandoo woodland and further east the wandoo gradually merges into the low rainfall temperate woodlands of salmon gum and morrel, with belts of mallee and heath. In these two latter woodland types, mallet occurs in colonies ranging in area from one to 200 acres (*81 ha*).

Brown, blue and white mallet attain their best development on well-drained, elevated land on the laterite breakaways and on the scree below them, occasionally extending for some distance into the more level adjacent country of the new plateau.

Brown mallet predominates in the western portion of the range, but proceeding eastwards the proportion of white mallet increases until it becomes the major species. These two species may occur in pure formation, in mixture, or in association with other species such as *Euc. redunca* and *Euc. accedens*. Blue mallet is a minor species occurring with white and brown mallet but seldom forms the predominant species of the mixture.

Swamp mallet occurs on loams in low-lying situations. It attains its best form in the southern wheat belt between Katanning and Ongerup.

Utilization

The economic importance of mallet arises from the tannin which occurs in the bark, particularly that of brown mallet which is recognised as one of the richest natural tanning materials in the world and has been used in the manufacture of leather for over 60 years. This bark, which contains from 40 to 57 per cent tannin, is stripped from the tree during the winter and spring months, i.e. from May to November. After air-drying it is chipped into small pieces about one inch in length and in this form is used for making tan "liquor" in the leather industry.

Brown mallet timber has been tested and found to be almost as tough as American hickory and has a higher static strength than that species; on the other hand it is stiffer and considerably heavier than hickory. Mallet should make a satisfactory substitute for hickory for all but the most exacting purposes. It has been used on a semi-commercial scale for the manufacture of tool handles, and only the lack of adequate supplies of mature trees has prevented a more widespread use for this purpose. This dense timber has a very low shrinkage and no difficulty is experienced in air drying. The wood is very hard, it machines well and appears to bend very well when steamed.

In recent years brown mallet has, on occasions, been used as a mining timber in sizes from 3 inch (*7.6 cm*) crown diameter upwards.

There is no quantitative data for the other mallets, but like brown mallet they are excellent fuels and are used as a farm timber in their respective localities.

The history of the tan bark industry in this State is one of destructive exploitation. Beginning early in the present century, an export market of 138 tons (*140 metric tons*) in 1903 rose to 20,700 tons (*21,030 metric tons*) in 1905. A rapid decline of production followed as mature mallet trees were destroyed by stripping, by fire, or by removal during the clearing of land for agriculture.

The economic importance of the bark resulted in the Department establishing 19,000 acres (*7,689 ha*) of brown mallet plantation between 1927 and 1960. Unfortun-

Plate 26

A plantation of brown mallet (*Eucalyptus astringens*) at Dryandra north-west of Narrogin. Mixed wandoo and powderbark wandoo may be seen to the right of the road.

ately, the market has declined to the extent that the last effective commercial bark stripping for tannin occurred in 1969 and the industry would need an increase both of demand and price to become viable again.

Silviculture

With the exception of the mallee forms, all species of mallet are fire tender and do not coppice. However, the trees commence to bear fertile seeds at about six to eight years and regeneration is generally copious following a fire, but sparse, even after trade cutting, if the area is unburnt.

The procedure followed in the artificial regneration of brown mallet was to remove all marketable timber from an area, clear-fell the remainder and, after it had dried, burn in late summer. Sowing was carried out as soon as possible after burning to take advantage of the early winter rains. Small spots about 12 in. (*30 cm*) in diameter at about 6 ft. (*1.8 m*) intervals were lightly cultivated with small hand hoes and a pinch of seed dropped on each (about ½ lb. (*227 gr*) of seed per acre was used). The seed was then lightly covered and compacted by light pressure from the planter's foot.

Best results were obtained when the intensity of the heat from the fire was sufficient to kill scrub and weed growth and to partly sterilise the soil. In addition, the mineral salts in the ash made available by the fire may have been a contributing factor. The success of planting was affected to some extent by the season and the intensity of the fire, but mainly by the suitability of the site, as indicated by the original vegetation.

Owing to the use of impure brown mallet seed, both blue and white mallet appeared in minor proportions in the plantations showing that they can be established in the same manner as brown mallet.

Trials have shown that white mallet will succeed on laterite sites considered too poor for brown mallet. On the better sites the latter is undoubtedly the most desirable species, with a potentially high yield of quality tans.

All species have for several years been regularly raised under nursery conditions in various forms of containers—principally earthenware flower pots, but also in tubes and in metal or wooden trays 4½ in. (*11.4 cm*) in depth, allowing 5 sq. in. (*32 sq. cm*) per plant. Their production has presented no serious difficulty except under the more humid conditions near the coast. Nursery stock of brown mallet planted on well prepared sites in Western and South Australia and Victoria have attained heights of nine feet and over in three years.

However, trees established by direct sowing in plantations where they are subject to competition from established vegetation are slower in their development and sites are considered of first quality when annual height increment is 18 inches or more. The rate of growth of the edge trees—the roots of which have access to cleared and cultivated firebreak strips—is considerably greater than that of trees less favourably situated within the compartment.

Other Tannin Trees

Tannins in the Bark: Three other trees provide tan bark of fair quality but inferior to the brown, blue and white mallets. They are:—

Flat-topped Yate — *Eucalyptus occidentalis.*
Dundas Mahogany — *Eucalyptus brockwayi.*
Dundas Blackbutt — *Eucalyptus dundasii.*

The last named two occur in the Norseman district.

Marri Kino or Gum: Investigation proceeded for a number of years into the suitability of marri kino as a source of tanning materials. As yet this kino has not been used commercially because of difficulties involving its insolubility and colour, but it has been definitely established that the extracts from it are very suitable for tanning heavy leather.

Wandoo Wood Extract: Both the wood—and bark—of wandoo and powderbark wandoo contain a high percentage of usable tans which are extracted by digesting the chipped material in large vats. A large plant has been operating at Toodyay for some years providing extract for the local market and for export.

The districts in which wandoo occurs are being rapidly developed for agriculture and much of the timber utilized by the factory would otherwise have been destroyed.

Forests and Woodlands of the semi-arid and arid regions of W.A.

Distribution

These forests, or woodlands, cover a region roughly rectangular in shape, bounded on the north by the 25° parallel of latitude and on the east by the 125° meridian of longitude. The south western boundary is the 20 in. (*508 mm*) isohyet and the southern boundary (from a point about 70 miles (*113 km*) east of Albany) is the south coast.

The region falls naturally into two distinct zones, the boundary between which approximates to about the 9 in. (*229 mm*) isohyet. The southern zone is characterised by Eucalypt woodland and the northern by Acacia (Mulga) bush. To the east at about the 8 in. (*203 mm*) isohyet the eucalypt zone meets the Nullabor Plain.

The Eucalypt Zone

This is spread over an area of approximately 156,000 square miles (*404,000 sq. km*). Over one quarter of this, in the higher rainfall (western and southern) portions of the zone, has been cleared for agriculture.

A large proportion (probably two thirds) of the balance is naturally treeless.

Whilst this zone forms one broad climatic type, a number of sub-zones can be recognised, viz:—

(1) 15-20 in. (*381-508 mm*) Annual Rainfall.

The principal species are wandoo, york gum and the mallets (already described under their respective sections). This is a mixed farming zone and has been mostly cleared for agriculture.

An easterly extension of this zone which forms a narrow strip of some six million acres in extent adjoins the south coast and extends eastwards to about 120 miles (*193 km*) beyond Esperance. This extension consists largely of sandplain and mallee and is at present being rapidly developed for agricultural purpcses.

(2) 11-15 in. (*279-381 mm*) Annual Rainfall.

Principal species are Salmon Gum (*Euc. salmonophloia*), Gimlet (*Euc. salubris*), and Morrel (*Euc. longicornis*). Other less common species in this region are Salt River Gum (*Euc. sargentii*), Merrit (*Euc. flocktoniae*), and Swamp Mallet (*Euc. spathulata*). The sub-zone coincides with what is now the wheatbelt and only fragments of the original forest remain. Some mining timber and firewood for the pumping stations on the Goldfields pipeline were obtained from the forests of the wheatbelt but generally the original trees were felled and burnt in the process of agricultural development.

(3) Below 11 in. (*279 mm*) Annual Rainfall.

This sub-zone lies to the east of the agricultural areas and extends thence eastwards for a distance of nearly three hundred miles. Its northern limit is about fifty miles (*80 kg*) north of Kalgoorlie and its southern limit some sixty miles (*96 kg*) south of Norseman.

A wide range of species occur and include—Morrel, Merrit, Salmon Gum, Gimlet, Silver Gimlet (*Euc. campaspe*), Goldfields Blackbutt (*Euc. le souefii*), Boongul (*Euc. transcontinentalis*), Coral-flowered Gum, (*Euc. torquata*), Dundas Mahogany (*Euc. brockwayi*) and Dundas Blackbutt (*Euc. dundasii*).

Salmon Gum, Morrel and Dundas Mahogany attain heights of seventy feet or more but the other species vary in height from thirty to about fifty feet (*9-15 m*).

This inland woodland played an important part in the State's development by providing fuel and mining timber in enormous quantities for the goldmining industry. For approximately 40 years mining operations on the Golden Mile depended solely on wood fuel for their power. During the 1930's a change was initiated with the introduction of oil fuel on two mines and this trend continued until about 1960 when wood fuel was entirely displaced by oil on all mines. It is estimated that the total firewood consumed by the goldmining industry since its inception is of the order of thirty million tons (*30.5 million metric tons*).

In addition to the principal woodland types described, there are associated with them the following non-forest areas which occur throughout the whole eucalypt zone:—

(a) Mallee—Mallee is a term used in describing a considerable number of the eucalypts which have the common characteristics of large persistent rootstock and a number of stems. They attain various heights up to 30 feet (*9 m*), depending on the species and the locality. A limited amount of small-dimension firewood is obtained from this forest, while the "mallee root" is particularly prized for domestic firewood. Pure mallee always occurs on sandy loams, but isolated patches intrude into other forests types and into the sand plains. A number of species which occur as trees under one set of conditions take mallee form under less favourable conditions.

(b) Sandplain (Scrub Plain)—This formation carries no timber of economic value and is a sub-type in which the eucalypts do not predominate. The chief genera represented are Acacia, Grevillea, Hakea and Casuarina.

(c) In addition to the above, there are several sub-types of no economic importance, e.g. lake country consisting of actual lakes and treeless flats adjacent to them, and low hills of wind-blown sand bordering the lakes.

The Mulga Zone

In this zone the eucalypts, although still represented, form only a minor part of the bush which is an almost pure Acacia association. The acacias have vertical leaf-like phyllodes of a blue-grey hue and the general appearance of the mulga is drab and dull. The most outstanding species are:

Mulga (narrow, medium and broad leafed forms) .... Acacia aneura
Hop bush mulga .... Acacia craspedocarpa
Bowgada .... Acacia linophylla
Curara .... Acacia tetragonaphylla
Minerichi .... Acacia grasbyi
Sugar brother .... Acacia brachystachya

Associated with the acacias are a number of minor genera; viz., hakeas, eremophilas, cassias, brachychiton, etc.

At intervals of many miles, large watercourses occur throughout the mulga zone and in the beds and on the banks of these there are strips of River Gum *(Eucalyptus camaldulensis)*. This tree has played quite a considerable part in the development of the mining industry in the northern goldfields, but it is not sufficiently plentiful or of good enough quality to supply the requirements of the mines after they have passed through the early stages of development.

Silviculture of the Inland Woodlands

Eucalypt Woodland: The recent history of the goldfields woodlands has been one of exploitation. Trade cutting was followed by natural regeneration, in parts heavy, elsewhere meagre, but seldom absent. The forester's part has been to protect this second growth from indiscriminate cutting, at least until such time as it is sufficiently mature to provide seed for a third crop. Owing to the sparse nature of the ground cover, extensive fires do not occur and hence fire protection is not necessary.

Cutting has been practically on a clear felling basis, the only trees excluded from the operations of licensees being those of under five inches *(12.7 cm)* diameter at six inches *(15.2 cm)* from the ground. Actually, scattered over-mature trees unfit for mill

Plate 27

Salmon Gum (*Eucalyptus salmonophloia*) bordering the Great Eastern Highway and railway reserve west of Cunderdin.

logs and too tough to split for firewood were left and these assisted, to a limited extent, in providing seed for the second crop. Much of the seed, however, came from the trees which had been felled and many of the seedlings became established either among the leaves of the parent or in slight depressions—particularly in the wheel ruts made by drays etc.

The Goldfields' eucalypts are seldom without seed—seed usually remaining in the tree for two summers after maturing; hence it is not unusual to find on one tree two crops of ripe seed. The older seed vessels usually open while the third crop is ripening. A limited proportion (seldom more than 10 per cent) of the stumps left after the trade cutting, coppice, but coppicing is confined almost entirely to stumps which are favourably situated to receive additional moisture or are protected by tall shrubs of the understorey. During particularly dry seasons both seedlings and coppice growth may be absent.

Mulga Bush: Further problems arise in dealing with the mulga bush. The understorey is sparse and if too much of the cover is removed, wind erosion is liable to occur, and because growth rates are very slow—on trees of 3 inch (*7.6 cm*) diameter it is less than 1/5th of an inch (*5 mm*) in girth per annum—restocking is a very slow process. The majority of the acacias in the association possess marked value as top feed for stock, while the timber—being fungus and termite resistant—is eminently suitable for fencing and other requirements on the sheep stations. The Forests Department, therefore, is called upon here to safeguard and reconcile the conflicting claims of the miner, the firewood cutter and the pastoralist.

In order to safeguard mulga stands, firewood cutters are required to confine their cutting to the denser patches and leave at least seven living trees over four feet (*1.2 m*) in height per square chain on the areas cut over.

The Principal Goldfields Trees

SALMON GUM (*Eucalyptus salmonophloia*)

In the forest or woodland areas of what is now the wheatbelt, salmon gum trees of 80 to 100 feet (*24* to *30 m*) in height with boles of 40 feet (*12 m*) and 2½ to 3 feet (*0.8 to 0.9 m*) in diameter once occurred. In more easterly forests now remaining, trees of these dimensions are seldom, if ever, seen.

The crown is umbrella-shaped and somewhat thin-foliaged, but the burnished or lacquered appearance of the leaves is a feature possessed by few other trees. The bark is smooth throughout and rather thick and friable. The gleaming salmon-coloured bark and bright shining leaves make it the most conspicuous tree in the savannah forest.

The wood is deep red when freshly cut, reddish brown when dry and exceedingly dense and strong. It has been used extensively for mining and farming purposes.

Weight per cubic foot (green)	70 lb. (*1,121 kg/m³*).
At 12 per cent moisture	66 lb. (*1,057 kg/m³*).
Transverse strength	20,100 lb. per sq. in. (*1,413,000 gr/cm²*)
Tensile strength	19,200 lb. per sq. in. (*1,350,000 gr/cm²*)

The tree usually occurs in pure stands forming open woodland formations on red loamy or light clay soils but is sometimes mixed with gimlet, morrel and other species.

THE GIMLETS

The gimlets are small trees with a maximum height of 40 ft. (*12 m*). The bark is smooth, thin and reddish-brown in colour and the trunk, especially in young trees, is fluted or spirally twisted. This longitudinally-twisted characteristic of the stem is responsible for the vernacular name of the tree.

Gimlet *(Eucalyptus salubris)* is the best known of the gimlets, occurring over a wide range which includes the greater part of the wheatbelt (where it is now rare), the Eastern and Dundas goldfields and for many miles eastwards from Kalgoorlie.

It occurs in pure formation—usually on heavy clay loams in low lying areas—but is also found associated with salmon gum over more extensive areas. The salmon gum —gimlet association was regarded as an indication of the best agricultural land and little of it now remains uncleared throughout the wheatbelt.

Silver Gimlet or Silver-topped Gimlet (*Eucalyptus campaspe*) has a more restricted range. Starting near Coolgardie it extends eastwards to Kalgoorlie and at least one hundred miles beyond and also south to the Eyre Highway. It receives its name from the blue-green leaves and the silvery-powdered twigs and capsules. However, there are many specimens which show charactertistics intermediate between the two species.

A somewhat similar tree (*Euc. annulata*) which occurs in the south-eastern wheatbelt and thence eastward to Norseman is also known in the districts where it occurs as "gimlet".

The timber of common gimlet is hard and tough and has been used extensively in the round (as poles) for building and mining purposes. The silver gimlet, although useful in very small sizes for firing sticks in the mines, soon develops a hollow trunk as it grows larger and is thus of limited use even as firewood. The two gimlets as well as *Euc. annulata* are all quite suitable for planting in parks, gardens and streets but they require good loam soil and it is inadvisable to endeavour to grow them in poor soil.

RED MORREL (*Eucalyptus longicornis*)

Both Red Morrel and Black Morrel (*Eucalyptus melanoxylon*) are well-known trees of the wheatbelt. The former is larger and more widely distributed and may attain heights of up to 90 feet (*27 m*) in the wheatbelt but somewhat less further east. It occurs throughout the whole of the wheatbelt and its eastern fringes as far as the goldfields. On the other hand black morrel occurs in a more restricted area from Westonia to Bullabulling. Although somewhat similar in appearance, the two can be distinguished fairly easily. The wood of the red morrel is red, the under-bark pink and the bark on the upper branches reddish-grey. The wood of the black morrel is dark brown, the under-bark yellow and the bark on the upper branches silver-grey with darker patches.

The bark on the trunk of both species is rough, grey in colour and persistent for almost the whole length of the bole. Both trees grow in a belt of country having an annual rainfall ranging between 10 and 12 inches (*25-30 cm*).

The following are the physical characteristics of red morrel:—

Weight per cubic foot (green)	73 lb. (*1,169 kg/m³*)
At 12 per cent moisture	64 lb. (*1,025 kg/m³*)
Transverse strength	16,900 lb. per sq. in. (*1,188,000 gr/cm²*)
Tensile strength	18,000 lb. per sq. in. (*1,266,000 gr/cm²*)

Red morrel is used both as a mining timber and for firewood; black morrel is suitable for firewood only.

Plate 28A

Young gimlet (*Eucalyptus salubris*) north of Westonia.

Plate 28B

Below. Mature gimlet in a paddock near Kellerberrin. Note the heavy, almost 'corkscrew' fluting of the stem and main branches —hence the name 'gimlet'.

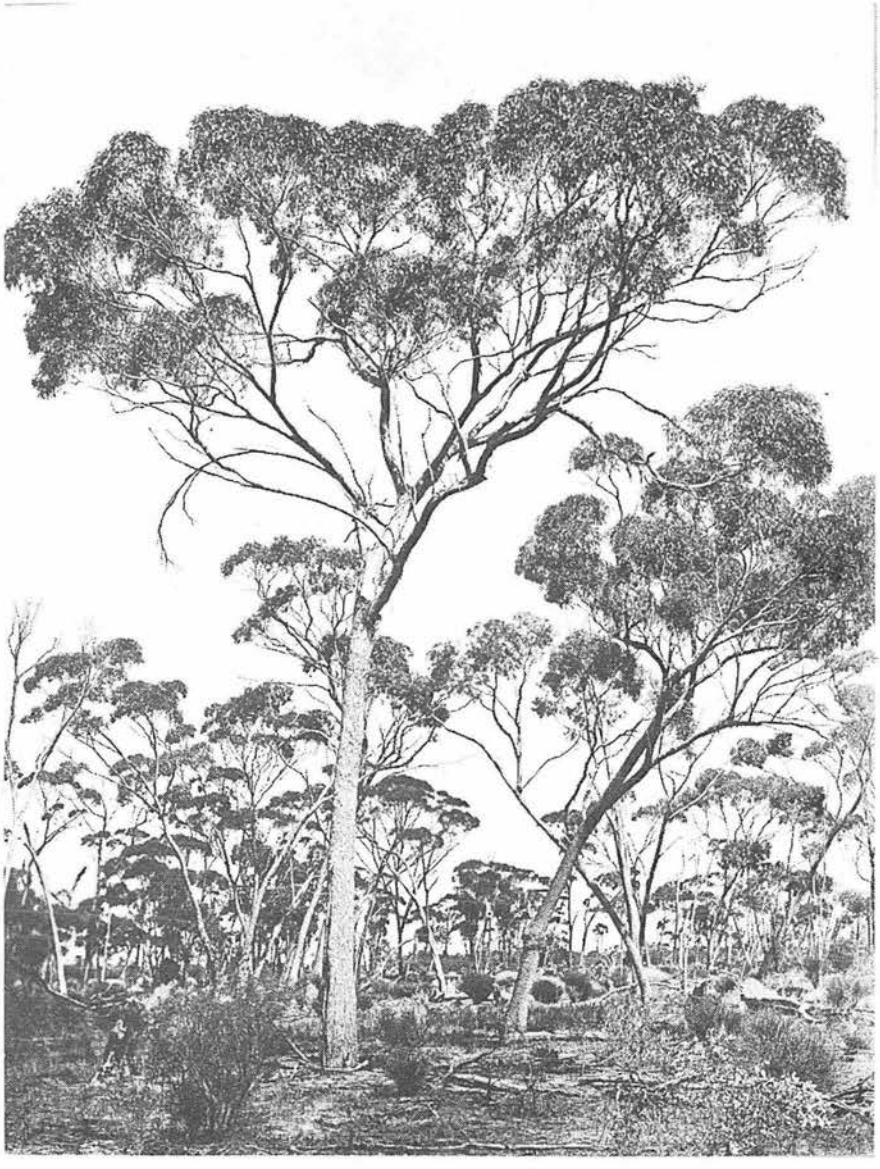


Plate 29

Morrel (*Eucalyptus longicornis*) showing the open nature of dry area woodlands

DUNDAS MAHOGANY (*Eucalyptus brockwayi*)

This tree is indigenous to the Norseman district where it grows to a height of up to 80 feet (*24 m*), and has a broad crown of lustrous green foliage and a smooth-barked trunk up to 2½ feet (*76 cm*) in diameter.

Resembling the salmon gum in general appearance, the tree may be distinguished in the field by a paler-coloured bark and deeper green crown. The bark when cut is blood red and sticky to the touch.

Dundas mahogany commonly occurs in the Norseman district, growing on the greenstone formation of the area. Its associates are salmon gum, morrel, merrit and Dundas blackbutt.

Eucalyptus brockwayi is very suitable for planting as a shade tree in agricultural areas.

GOLDFIELDS BLACKBUTT (*Eucalyptus le souefii*)

Eucalyptus le souefii forms a tree of 30 feet to 40 feet (*9* to *12 m*) in height. This tree has a dark-brown flaky bark for two feet to six feet (*0.6* to *1.8 m*) in height at the base of the trunk, which is otherwise smooth and greyish-brown in colour. This dark bark at the base of the trunk is responsible for the tree's common name.

Blackbutt timber is light brown and very dense. It is used in small sizes as mining timber—chiefly as "pass logs"—but since it becomes hollow as it approaches maturity the larger trees are usually suitable only for firewood. It has quite a wide range, extending from some 50 miles (*80 km*) north of Kalgoorlie to some 50 miles (*80 km*) south of Norseman and from Coolgardie eastwards for about 150 miles (*241 km*).

Two other Goldfields' species (*Euc. clelandii* and *Euc. stricklandii*), which have dark rough bark on the lower portion of the trunk, are also known locally as "blackbutt".

BOONGUL (*Eucalyptus transcontinentalis*)

Bongul reaches its best development on the Goldfields where it attains heights of 30 to 50 feet (*9* to *15 m*) and has a smooth white bark and rather spreading crown. The bluish green leaves lack the sheen of salmon gum and in spring the tree produces heavy crops of nectar-bearing blossom, light yellow in colour. In recent years apiarists have periodically moved their bees from the coast to feed on the nectar produced by this and other Goldfield trees.

The wood is reddish in colour, fairly tough and in the past was used by natives for making spears.

Euc. transcontinentalis also occurs in the wheatbelt and in all southern States of Australia except Tasmania. However, in these places it is a mallee with a rough bark.

CORAL-FLOWERED GUM (*Eucalyptus torquata*)

Coral-flowered gum occurs as a small tree of 20 to 25 feet (*6.0* to *7.6 m*) with widely spreading branches and dull, dark grey-green leaves. The bark is persistent, dark grey or almost black, longitudinally fissured and friable.

Inflorescences are produced in abundance. The striking red and yellow buds are followed by attractive pink blossoms. Under natural conditions flowering is confined mainly to the spring months, but under cultivated conditions a greatly extended flowering period may occur.

Buds and fruits are quite unique in form, in that both the base of the capsule and the operculum are distinctly ribbed, while the latter terminates in a beak some half inch (*12.7 mm*) in length. (*See Plate 10.*)

The distribution of the species extends from the Eastern to the Dundas Goldfields and its occurrence is almost invariably on rising ground, in gravelly soil.

KURRAJONG (*Brachychiton gregorii*)

Kurrajong grows to 25 feet (*7.6 m*) in height with a thick, straight trunk and widely spreading dense branches. The bark is rough and persistent, and light grey in colour. The wood is spongy and the cambium ring yields a strong fibre.

Kurrajong is an excellent shade tree, being very densely branched. The leaves are divided into finger-like segments, and the flowers are greenish red and broadly bell-shaped. The species occurs freely throughout the Goldfields, particularly in the "mulga" area. Initial growth rate is very slow.

Stock are very partial to its foliage, so that it needs protection until it has attained a considerable size.

GOLDFIELDS PINE (*Callitris glauca*)

This native conifer may attain a height of 30 feet (*9 m*) with more or less spreading branches which give it a cedar-like appearance. The leaves are bluish-green, the bark almost black and fibrous. This tree is very much like its sister the Rottnest pine (*Callitris robusta*), and occurs on the margins of salt lakes. Its timber is resistant to termite attack, which makes it valuable as a fence-post timber.

SANDALWOOD (*Santalum spicatum*)

At the present time this species may be found growing as a small tree to a height of 12 to 16 feet (*3.7* to *4.9 m*) with a diameter of six to eight inches (*15* to *20 cm*). Before it had been so extensively exploited, specimens reaching a height of 25 feet (*7.6 m*) with a diameter up to 12 inches (*30* cm) were common in the areas of better rainfall which are now cleared and cultivated for the production of wheat crops.

In the early days of the State the habitat of sandalwood extended as far west as Northam. In those days, the tree played an important part in the development of Western Australia. It always commanded ready money by reason of its value as an article of export to China, where it is highly prized and used for ceremonial purposes. The tree has now practically ceased to exist in the wheatbelt and present supplies are often hauled 100 miles (*161 km*) or more to the railway lines running to goldmining centres of the interior.

The wood is light-yellow in colour, and the heartwood is strongly aromatic. It is this latter property which led to its extensive use by the Chinese in the manufacture of "Joss Sticks" for burning in religious ceremonies. In addition, sandalwood is popular for fancy and carved woodwork, and the making of trinket boxes and a host of other small articles.

Sandalwood oil obtained from this species is of fine quality and valued for use in soaps, perfumes and for medical purposes.

257 20 – 5

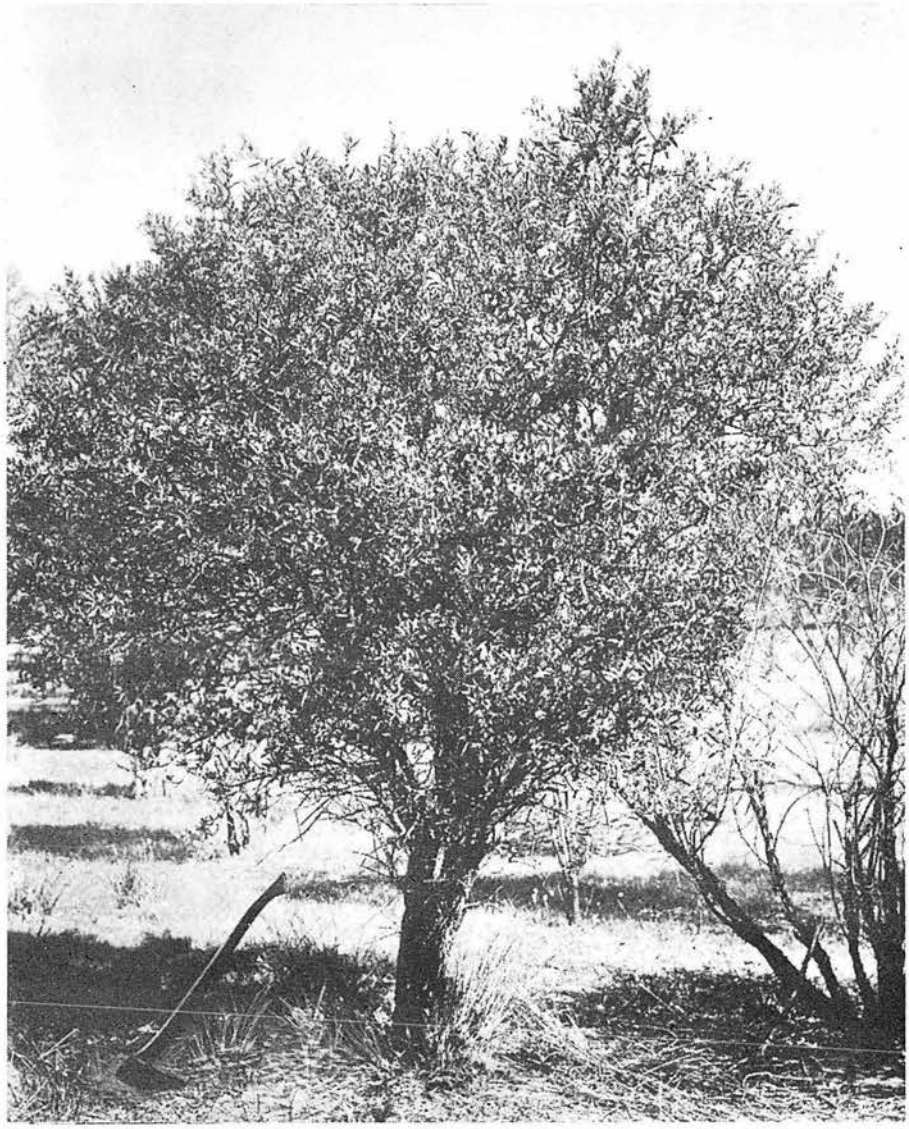


Plate 30

Sandalwood *(Santalum spicatum)*

Eucalypts—A Simplified Key to 17 W.A. Trees

Identification of eucalypts is often not a simple task and a single characteristic is rarely sufficient for the purpose.

Over 600 species and variations have been named. Many different eucalyptus species have similar characteristics, and even the identifying characteristics on one particular tree or trees of the same species can vary greatly; e.g., *E. loxophleba* (York Gum) in the key.

A positive identification can generally result only from the careful consideration of a number of features possessed by an individual tree. The most helpful of these are the general size and form; the nature of the bark on the trunk and branches; the adult leaf characters, including venation and oil dots; juvenile leaf forms; flower colour type and size, shape and structure of buds and fruits. Where naturally occurring plants are concerned, the geographical location and habitat can be of great assistance in their identification as many species are strictly limited in their distribution.

Example for using simplified key:

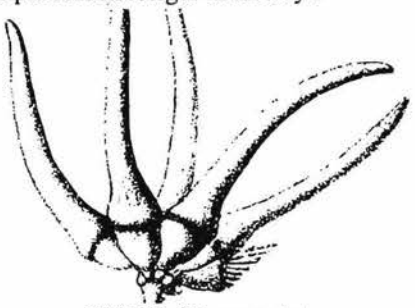
Assuming we have a tree with a smooth, greyish-white bark, large fruits and exsert valves.

Under the major heading "Bark smooth", the specimen fits into the *colour* of bark category *greyish-white*. The large fruit and exsert valves would then place the specimen into the first of the next two categories, which means that it is *E. megacarpa,* or Bullich.

Explanatory Notes

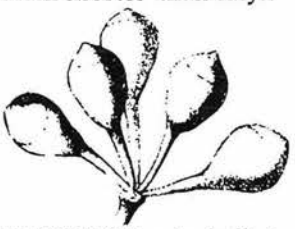
Eucalypt buds consist of the *operculum* which protects the developing stamens and which is eventually shed as these mature; and the *calyx* which develops into the fruit.

Operculum longer than calyx



YATE *(E. cornuta)*

Operculum shorter than calyx



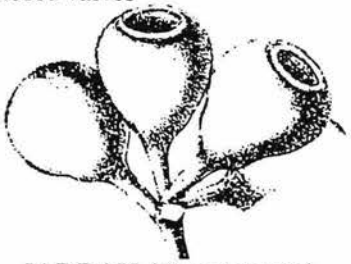
MARRI *(E. calophylla)*

When the seeds are ripe, the valves in the fruit open and the seeds are released. The valves may either be *exsert* or *enclosed.*

Exsert valves

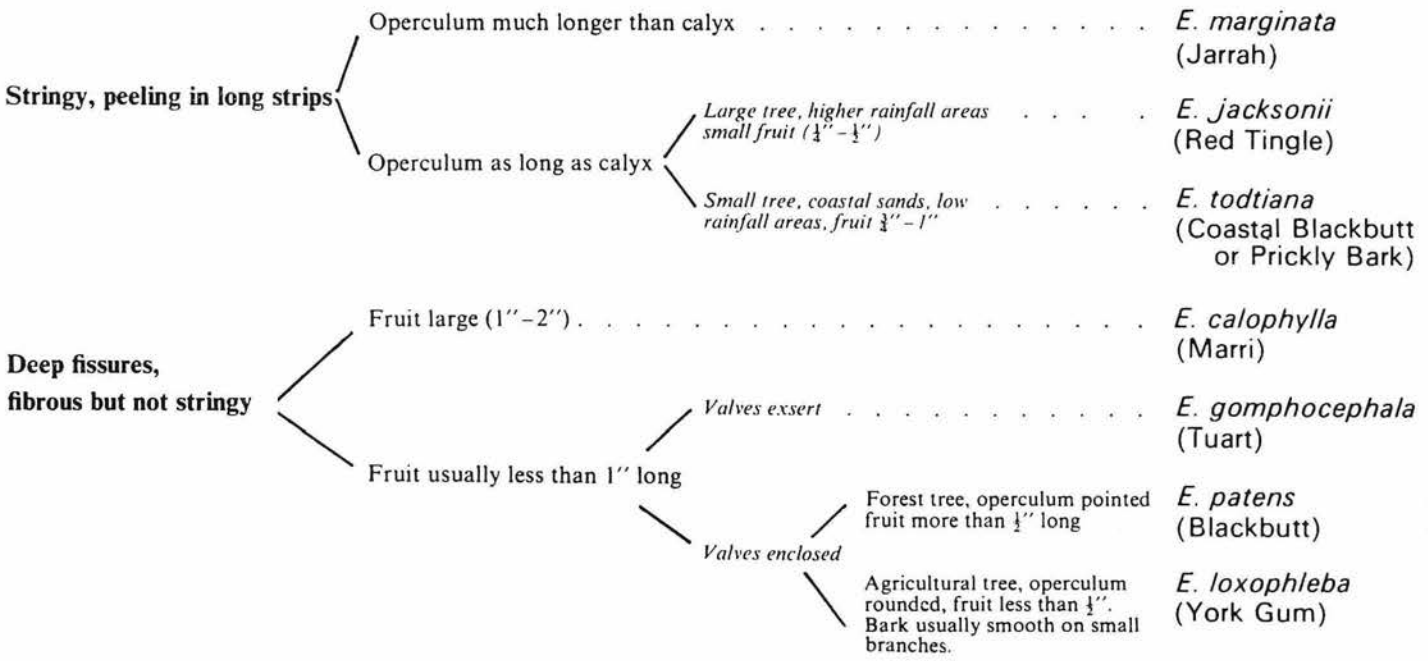
BROWN MALLET *(E. astringens)*

Enclosed valves

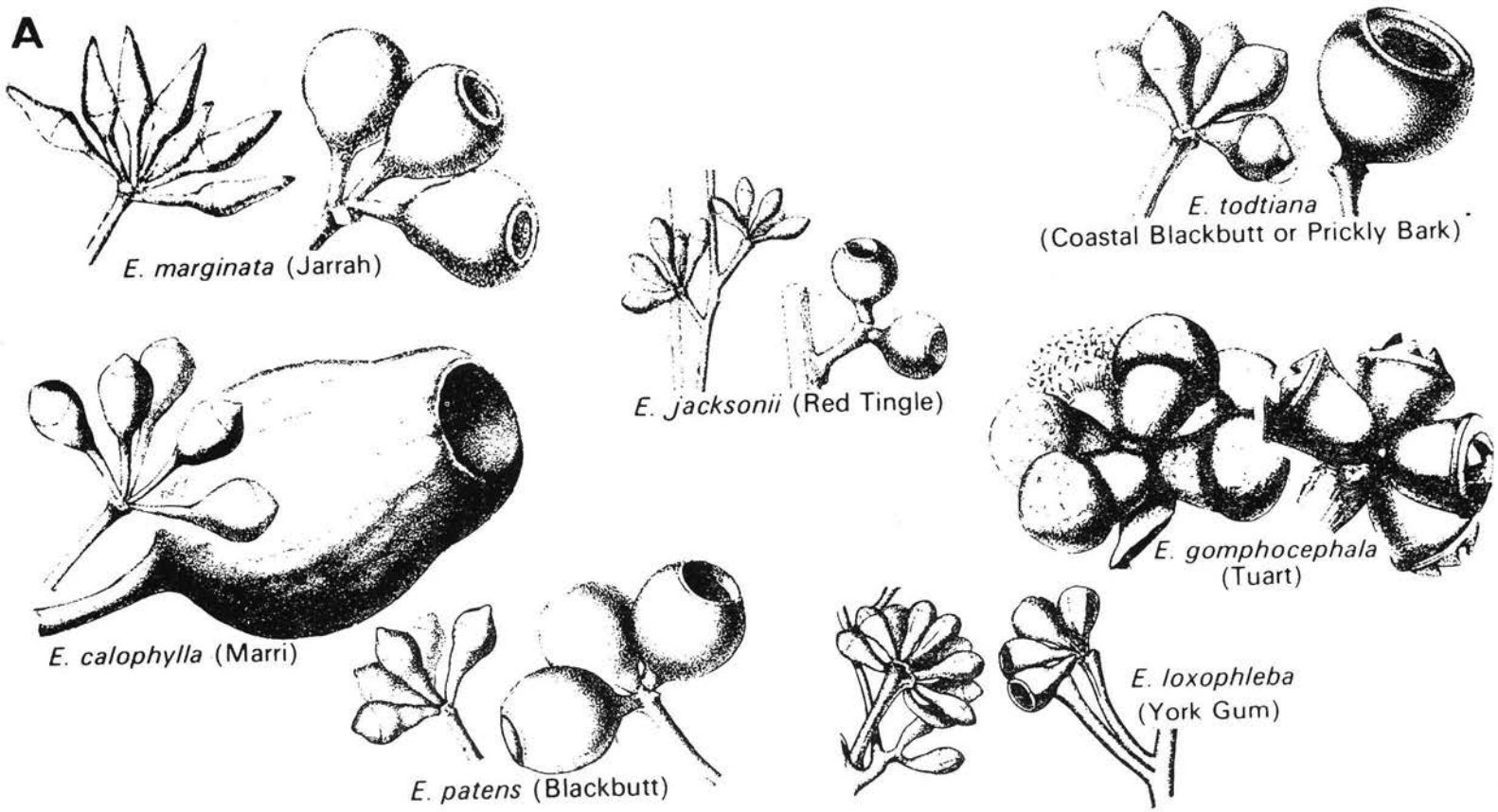


JARRAH *(E. marginata)*

A
BARK THICK, ROUGH AND PERSISTENT



ALL ILLUSTRATIONS OF BUDS AND FRUITS ARE DRAWN TO ACTUAL SIZE



BARK SMOOTH

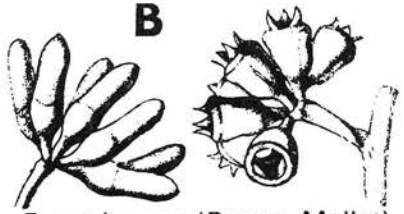
B

Bronze or pink	Operculum much longer than calyx	*Bark light bronze*	*E. astringens* (Brown Mallet)
		Bark deeper bronze, stem and branches often have corkscrew twist	*E. salubris* (Gimlet)
	Operculum as long as calyx, buds and fruits very small		*E. salmonophloia* (Salmon Gum)
Greyish-white	Fruit large (longer than 1″), valves exsert		*E. megacarpa* (Bullich)
	Fruit less than 1″ long, valves enclosed		*E. diversicolor* (Karri)
Yellowish-white	Operculum shorter than calyx		*E. accedens* (Powderbark Wandoo)
	Operculum longer than, or as long as calyx		*E. wandoo* (Wandoo)

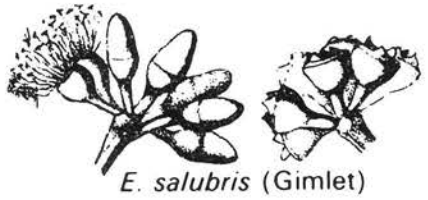
BARK ROUGH ON TRUNK, SMOOTH ON LARGER BRANCHES

C

Operculum much longer than calyx (4-5 times); distinctive beaked fruit	*E. cornuta* (Yate)
Operculum much longer than calyx (2-3 times), slightly ribbed, bell shaped fruit	*E. occidentalis* (Flat-topped Yate)
Operculum bluntly pointed, slightly longer than calyx	*E. rudis* (Flooded Gum)
Operculum shorter than calyx	*E. loxophleba* (York Gum)

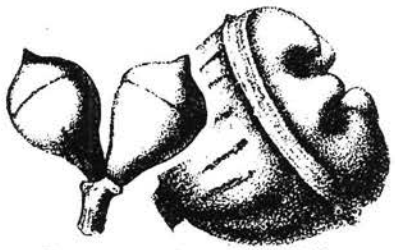


E. astringens (Brown Mallet)



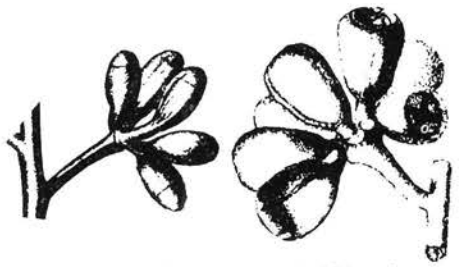
E. salubris (Gimlet)

E. salmonophloia (Salmon Gum)



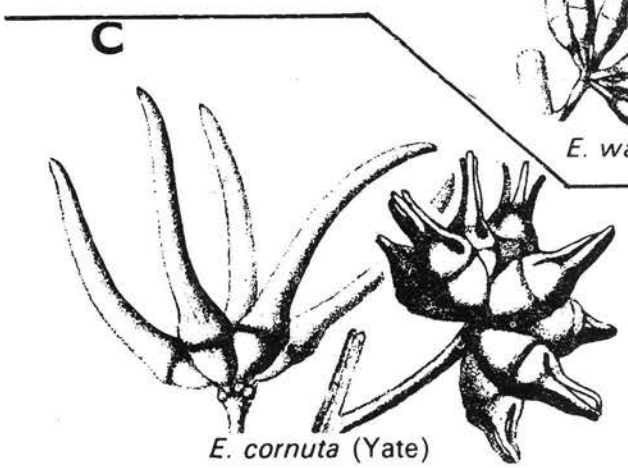
E. megacarpa (Bullich)

E. diversicolor (Karri)



E. accedens (Powderbark Wandoo)

E. wandoo (Wandoo)



E. cornuta (Yate)

E. occidentalis (Flat-topped Yate)

E. rudis (Flooded Gum)

CHAPTER IV

FOREST PROTECTION

Fire Protection
Forest Pathology
Insect Pests of Forests

Forest protection is the work of safeguarding the forest against various injurious agencies. It is one of the most important tasks facing the forester for unless damage of natural and man-made origin is checked, and where possible, eliminated, all other forest improvement methods can only be partially successful.

The destructive agents which cause damage in the forest are many, but man, fire, insects, fungi and animals are the most important. The damage caused by such agents may vary from the loss of a single tree by windthrow or the degrade of timber products due to insect boring, to the total destruction of thousands of acres of timber by a single severe fire.

In Western Australia, fire is the greatest single factor threatening the timber crop and the first major work of the Forests Department has been to provide fire protection to the State's forest area.

Fire Protection

White man first saw the forests of Western Australia as mature to over-mature, stabilised virgin stands in which the ground flora was completely suppressed and controlled by the dominant tree growth. The general impression he gained was of a relatively open and clear forest floor beneath a closed, shady canopy of trees.

Such forest carried little fuel on the ground to feed big, hot fires and as a result, the frequent fires which occurred, probably lit by natives or lightning, burnt quietly and slowly over the sparse litter of the forest floor, causing little damage to the tree trunks and crowns.

With early sawmilling practice the situation changed drastically. Rapid and excessive exploitation removed most of the large trees, opening up large gaps in the canopy to let in sunlight which favoured the excessive growth of scrub and understorey species.

Logging debris such as discarded logs, branches, leaves and bark also accumulated on the forest floor to add to the scrub fuel. This, due to man's careless handling of fire, resulted in large fierce fires which caused great damage to standing trees and young regeneration.

The natural condition of the forest had been changed by almost a century of uncontrolled exploitation when the Forests Department first took steps to organise against uncontrolled fires.

Fire Damage

Direct fire damage in its most severe form results in a serious scorching of the surface soil and humus layer and the killing of all plant life. As a general rule the resistance of a tree to bole damage is directly related to its bark thickness. Young trees are therefore most susceptible to fire damage.

Plate 31

The remains of a jarrah forest devastated by fire following logging operations in the early part of the century when protection from fire was not practised

Fires may kill trees outright or they may scorch part of the stem and crown. In such cases the tree may become dry-sided. These areas of dead wood crack open reducing the saw-log quality and allowing the entrance of harmful fungi and insects which in turn reduce the log quality further. Repeated heavy fires retard the growth rate and deform the shape of the bole.

Apart from damage to the standing trees, removal of the forest canopy and the ground vegetation favours excessive run-off of surface water, sheet flooding, and a decrease in the permanence and purity of streams dependent on the forested catchment area. Recreational and scenic values are also affected by unrestricted fires and in many instances both man and animals have faced death in a forest conflagration.

Uncontrolled fires are always destructive and occasionally disastrous. They are a major cause of timber damage and loss within the forest and present a menace to successful forest management.

Fire Prevention

All fire protection is based on a sound policy of fire prevention. The aims of fire prevention are to reduce the chances of a fire starting and to make provision in advance to reduce rates of spread of those that do start, making them more easily controlled by the suppression forces.

Education: Since over 90 per cent of fires in Western Australia are man-made, the achievement of the first aim mentioned depends on educating the public to take care with fires, and enforcing laws of the Bush Fires Act which stipulate the sensible use of fire. The laws provide penalties for those who refuse to follow them.

Road signs, newspaper articles, radio talks, television films, pamphlets and pictures are widely used to bring home to the public the danger from uncontrolled fires.

The Bush Fires Act restricts all burning between October 1, and May 31, in the following year and places a complete prohibition on burning for specified periods within these dates unless by permit for special purposes.

Below are listed the main conditions of the Act under which burning may be undertaken.

Any person wishing to burn must:—

(1) Give at least four days' notice in writing of his intention to burn to be delivered to all the following:—
    (a) Each adjoining owner or occupier.
    (b) The Secretary of the Local Authority.
    (c) A Bush Fire Control Officer of the Local Authority.
    (d) A Forest Officer, if the land is within two miles (*3.2 km*) of a State Forest.

(2) The notice must contain full particulars of the locality of the bush to be burned and must give the dates of the day or days when the burning will be done. These dates must not be more than 28 days from the date of the notice.

(3) Written permission to burn must be obtained from a Bush Fire Control Officer, or if there is no control officer appointed, from the Secretary of the Local Authority. The permit issued may contain further conditions or requirements stipulated by the issuing officer and these must be complied with.

(4) The area to be burned must be surrounded by a firebreak which has been ploughed or cleared of all scrub, stubble or inflammable material to a width of at least 10 feet (*3 m*) or such other width as is specified by the Bush Fire Control Officer in the permit to burn.

(5) At least three men must be constantly in attendance from the time the fire is lit until, in the opinion of a Bush Fire Control Officer or Bush Fire Brigade Officer, it is safe to leave.

(6) The fire must not be lit on a Sunday.

(7) The fire must not be lit on a day when the fire hazard forecast by the Perth Weather Bureau for the locality is "dangerous".

Further important provisions cover the formation of Bush Fire Brigades and allow for the appointment of Bush Fire Control Officers who have wide powers under the Local Authority to deal with matters pertaining to both controlled and uncontrolled fires.

Controlled Burning: The second aim of fire prevention, which is to reduce rates of spread of wild fires, is achieved by hazard reduction using "Controlled Burning". This involves the use of low intensity, mild fire within predetermined boundaries to remove or reduce the easily lit part of forest fuel such as leaves and twigs lying on the ground. Fire of this type does not damage the trees and can be achieved for

Plate 32

Aerial incendiary operation—with the priming and timing device in the foreground. On the flight deck are the pilot and a forestry officer who does the plotting and navigating

quite extensive periods in spring and shorter periods in autumn, when the temperatures are reasonably low and the fuel quite moist. Controlled burning is now practised throughout State forests on a 4-6 year rotation, except in those areas which have been recently regenerated and saplings are too young. The volume of fuel in the forest is thus prevented from building up to a point at which if a fire started during dangerous fire weather, control would be virtually impossible.

Fuel reduction by controlled burning is carried out for the following reasons:—

(1) Rotational controlled burning to obviate the buildup of fuel over large areas.

(2) Protection of high value areas such as towns, mills, schools or plantations by buffer areas.

(3) Isolation of specific high risk areas such as roads and railways where fires frequently start.

(4) Burning for silvicultural reasons such as top disposal, to clean up debris of tree tops after logging operations, and to provide ash beds for seedling establishment.

(5) Preparation for increased risk in an area and improvement of access, as in the case of advance burning before a sawmill operates in an area.

(6) Subdivision of high value areas such as plantations into blocks surrounded by burnt country so that should a fire start it can be contained within a reasonable area and so minimise losses.

Whatever the reason, all burning must be programmed and each Division must prepare a prescribed burning plan at the beginning of each financial year showing proposed burning and the priority for each area.

Following this, each area proposed for burning is closely examined and described. Objectives of management such as community protection, timber production, conservation of flora and fauna, public recreation and water catchment protection then determine the acceptability, timing and intensity of fire which is prescribed for that area.

Extensive research has identified the relationship of fire behaviour to weather, fuel and forest conditions so that prescriptions can be applied with reasonable accuracy and reliability.

Controlled burns are ignited by lighting parallel lines of spot fires spaced so they will link by late evening on the day concerned. For many years this lighting was done by crews of men walking through the forest. However, in 1965 information obtained from fire behaviour studies permitted the development of the technique of aerial ignition. Trials carried out in conjunction with the Council for Scientific and Industrial Research resulted in a major breakthrough in prescribed burning of inaccessible areas and provided an efficient tool for the undertaking of large-area burns under ideal conditions.

A semi-automated machine mounted on a twin-engine aircraft is used to prime and eject tiny incendiary capsules at regulated intervals as the aircraft flies parallel flight lines over an area of forest. The aircraft flies at about 3-500 feet *(91-152m)* above the tree tops using radio beams at the end of each flight line to keep on track. The beacons are mounted in light 4-wheel drive vehicles which are also equipped to locate start and finish points on progressive flight lines. Ground crews are dispersed around the area to ensure the fire is confined to the prescribed area.

Plate 33

Prescribed burning by aerial ignition near Shannon River. To ensure control each area to be burnt is surrounded by tracks and edge-burnt well before aerial ignition is carried out—this is illustrated by the lack of fire adjacent to the track. The lighting pattern is parallel strips of spot fires lit across the wind. Weather conditions are chosen to produce low intensity fire indicated by the white, thin smoke.

The aircraft, beacons and suppression crews can communicate with each other using VHF radio and are directed by the controller—usually the Divisional Forest Officer. Areas of up to 30,000 acres *(12,000 ha)* can be safely burned in one day using this new development. The advent of aerial ignition has made intensive protection possible for the whole of 4.5 million acres *(1.8 million ha)* of State Forest.

Fire Weather Forecasting

The prediction of "fire behaviour," for either controlled burning or suppression, depends essentially on interpretation of weather as it affects fuel conditions and fire intensity.

As early as 1934 a Fire Weather Station was established at Dwellingup where investigations correlated the combined effect of weather elements with the moisture content of half inch diameter *Pinus radiata* rods, which were in turn shown to be representative of the forest fuel inflammability or fire hazard. This then, provided an ignition source is present, defines the likelihood of a fire starting.

Later studies in the 1960's used this measure of fuel moisture content together with wind and fuel quantity to predict rate of fire spread and related fire behaviour characteristics. This is known as the fire danger.

To aid the forecasting of these factors other weather stations were established through the forest areas at Pemberton, Dryandra, Ludlow and Margaret River. In addition simple instruments for temperature, humidity, rain and wind measurement are maintained at most forest settlements and fire lookout towers.

Close co-operation is maintained with the Meteorological Bureau, to whom weather telegrams are despatched at 9.00 a.m. and 3.00 p.m. daily during the fire season, from Dwellingup, Pemberton and Dryandra.

The Bureau passes a forecast by telephone to Como at 4.00 p.m. each day of, expected cloud, rain, wind strength, direction and changes, maximum temperature, minimum relative humidity and fire hazard for the next day. These are transmitted over the Department's radio system at 4.15 p.m.

At 7.30 a.m. each morning weather reports are received from forest stations and with any revised information from the Bureau are used to check and modify the forecast made on the previous afternoon. The latest forecast of weather, fire hazard and fire danger is then transmitted from Como at 7.45 a.m. with a view to having this information available in the field before gangs leave each headquarters for work.

Should weather be suitable for controlled burning, gangs will be directed to those areas where prescriptions require the type of fire behaviour predicted.

If conditions are unsuitable for controlled burning, the degree of fire danger forecast and local knowledge of the location of heavy fuel and high risk areas, will determine the disposition of forces to combat any uncontrolled fire should it occur.

Detection

Fire weather forecasting and the prevention measures outlined above are systems which aim firstly at preventing fires from starting, and secondly, at restricting those fires which do occur, to a limited area. Rapid fire detection and subsequent suppression measures are necessary to locate and to stop the fire as quickly as possible, thus restricting damage to a minimum.

Fire detection entails the actual sighting and locating of the fire. Detection methods vary in different countries, but the major system employed in Western Australia depends on the use of skilled observers working from specially constructed

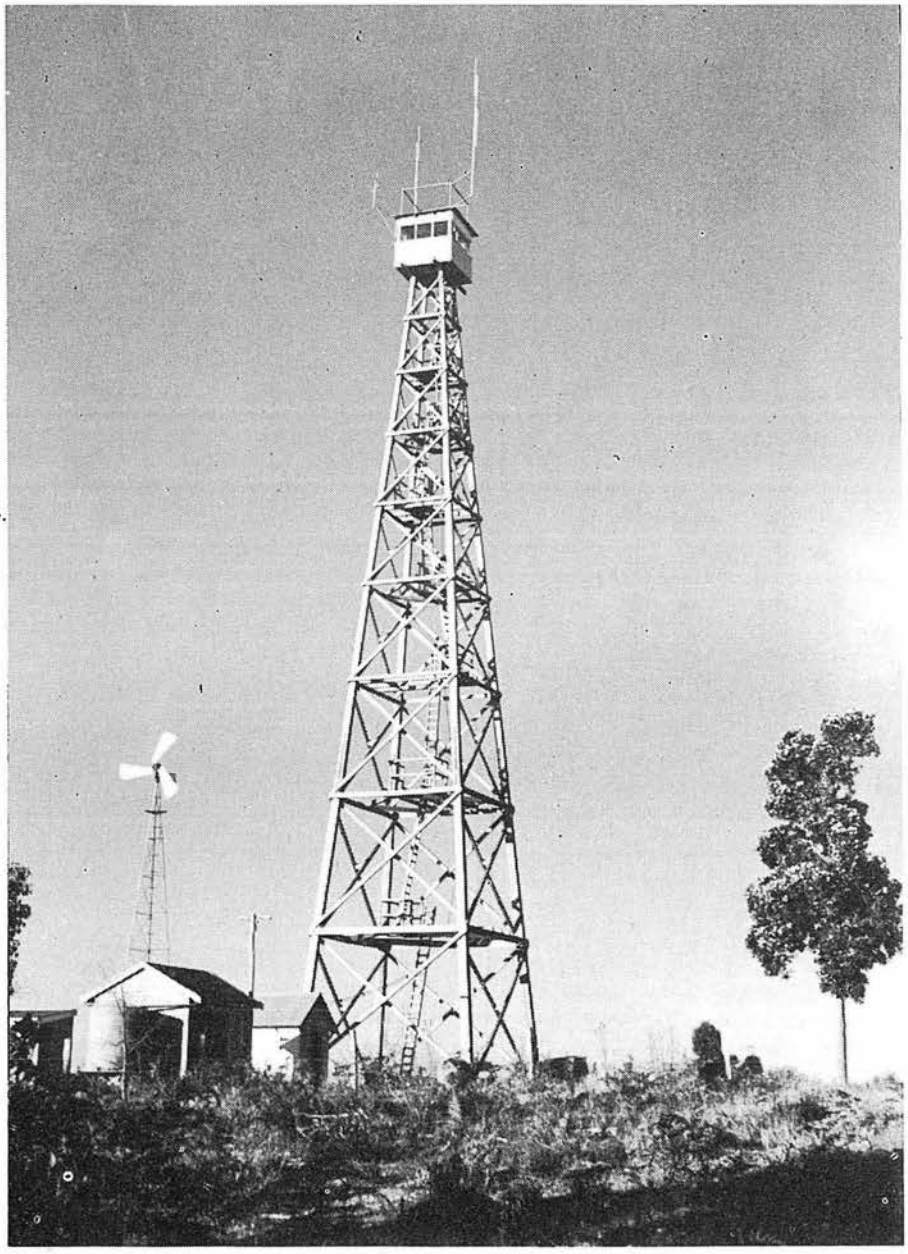


Plate 34

A wooden fire lookout tower 140 ft. high erected for fire detection purposes. This particular tower also acts as a repeater station in the overall telecommunications network

Plate 35

Gloucester Tree fire lookout with its cabin perched 200 feet up in the branches of a karri tree

lookout towers established throughout the forest. The towers vary from simple structures on high ground to wooden trestle towers up to 140 feet *(43 m)* in height, or cabins built in the tops of tall karri trees. The tallest fire lookout is Gloucester Tree, 200 feet *(61 m)* in height, which is situated two miles *(3.2 km)* from Pemberton. It was named after the Duke of Gloucester who witnessed some of the early work in preparing the tree for the cabin.

The lookouts are manned continuously from early morning till evening throughout the fire season, and aided by powerful binoculars, observers scan the tree tops for the warning signs of smoke. Each tower is equipped with direction-finding equipment and a properly orientated plan of the country to enable the bearing of a fire to be plotted simply and rapidly. As soon as the faintest wisp of smoke is sighted a bearing is taken and the district office immediately notified by telephone or radio.

Lookouts are so placed that whenever possible, the forest is under observation from at least two towers. On receiving bearings of smoke from two towers, it is a simple matter in the district office to plot the cross-bearings and pinpoint the fire.

Occasionally, due to poor ground visibility, the towers must be supported by secondary detection systems. The most important of these is aircraft spotting. During periods of poor visibility and in particular after lightning storms a forest officer is sent up in a light aircraft to spot fires. If he sights smoke he notes its position relative to tracks and creeks, etc., and plots it on a map of the forest which shows all these features. He then radios the position of the smoke to the Divisional Headquarters.

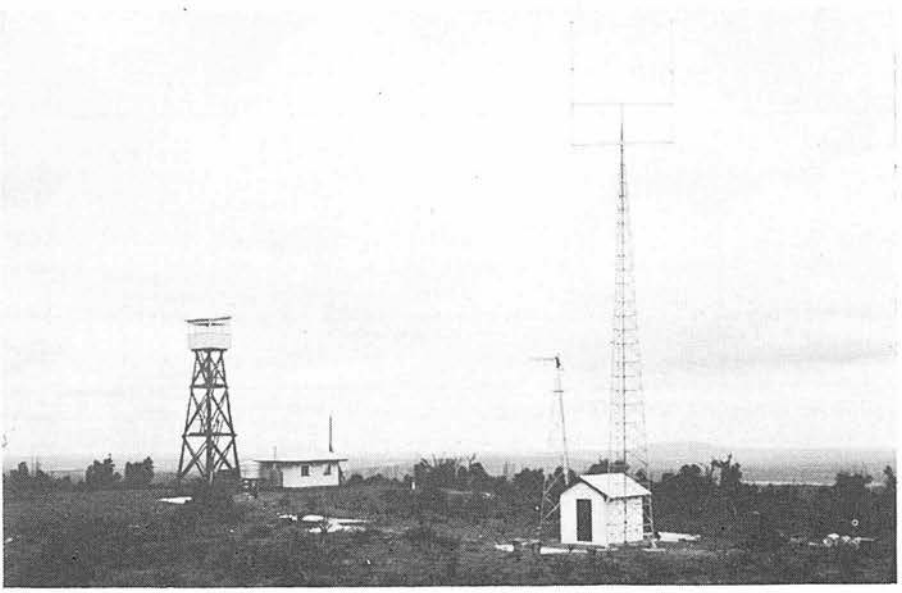


Plate 36A

The V.H.F. radio repeater station installation on Mt. Wells east of Dwellingup showing the windcharger for charging batteries, the fire lookout and the towerman's hut

Plate 36B

A radio message is received at Divisional Headquarters

Ground observation from hill tops, or reconnaissance through the forest by vehicle, are other secondary detection methods used on occasions.

Communications

Detection is the initial function which brings a fire suppression crew into action. All moves which follow on from the actual detection to the final extinction of a fire depend largely on the efficiency of communications, access and equipment.

The public telephone system provides the means of communication for most administration purposes, connecting all divisions, and some fire towers. This inter-divisional system is supported by High Frequency radio for Fire Control purposes and where the P.M.G. network is unable to meet demands.

Within each Division and between adjacent divisions there are again two systems of communications. The first of these is single line, earth return, telephone maintained by the Forests Department. Over 2,500 miles (*4,000 km*) of line link Divisional Headquarters, fire towers and smaller forest settlements. Replacements of this system by radio telephone has been started as advantage is taken of efficiency and economy provided by modern technological advances. The second internal method of communication uses Very High Frequency radio signals to link headquarters, fire towers and mobile transceivers fitted to vehicles or in portable packs. This is a most reliable, simple and flexible system and has allowed major advances in fire control organisation.

Access and Equipment

Rapid suppression is dependent on suitable access throughout the forest permitting the speedy movement of men and equipment to the site of a fire. Over 15,000 miles *(24,000 km)* of forest roads have been built to allow manpower and even the heaviest of fire equipment to be moved to most areas with the minimum of delay.

The first mobile fire fighting unit used by the Department was a light duty outfit consisting of a utility fitted with several packsprays, a 33 gallon (*150 litres*) tank of water, fire rakes, crosscut saws, axes, waterbags and emergency rations. This outfit carried a gang of four men.

This was replaced by a 2-3 ton truck carrying 200 gallons (*909 litres*) of water and a power pump used either to deliver the water or replenish it from static water supplies developed through the forest. These trucks carry the additional equipment of earlier models and are equipped with chain saws. The chain saw is an important unit at the fire edge to fell trees burning too high up to be reached by pumpers.

The 2-3 ton outfit was augmented by the heavy duty unit capable of delivering up to 200 gallons (*909 litres*) of water per minute. It is a 4-7 ton truck, frequently with four-wheel drive carrying a specially constructed slip-on unit of a 600 gallon (*2,728 litres*) tank and power pump. They may pump direct from natural water supplies or pick up water with their own pump and carry it to a fire.

Recently the functions of personnel carrier and heavy duty unit have been combined on the one prime mover, producing economy and added efficiency. This unit has now been adopted as the standard fire truck for the Department.

Apart from the hand tools such as rakes, shovels and axes which are standard equipment for all fire gangs, light bulldozers are valuable for constructing fire lines. When required at the scene of a fire they are transported on the back of 7-ton trucks. In the dense undergrowth of the karri forests large bulldozers are frequently essential, together with the specialised transporters they require. Rubber-tyred tractors with blades are beginning to replace small bulldozers at jarrah forest fires as they are more mobile and require no additional transporter.

But in the more open forest, gangs of men with hand tools still represent the most important fire fighting units. The reason, of course is that men can be moved to a newly reported fire much faster than machines and if need be, can carry out all facets of suppression unaided. Early attack while the fire is small is the essence of fire suppression.

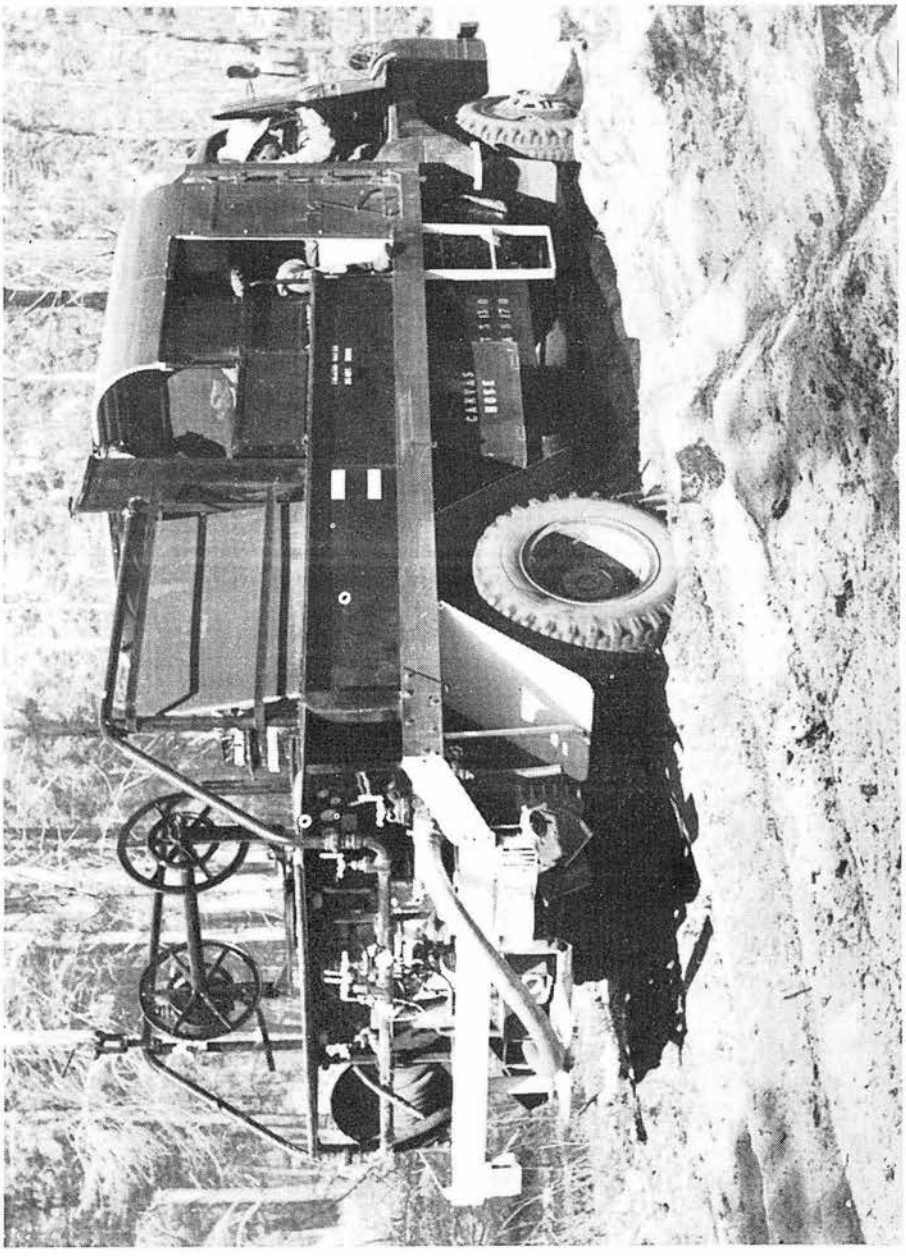


Plate 37

The dual-purpose gang truck combines the fire fighting qualities of the old "heavy duty" outfit and the mobility of the normal gang truck

Plate 38

A fire-control gang "knocking down" a small fire with packsprays and rakes

Fire Suppression

Fire suppression is the process of actually extinguishing the fire. It is the culmination of events leading from rapid detection, communication with the district office, and despatch of crews to the scene of the fire. Perhaps the most valuable weapon of suppression is the speed and efficiency of those operations which occur between the commencement of a fire and the arrival of the suppression crew, for the difficulty and labour involved in extinguishing a fire grows out of all proportion with the increase in extent of a perimeter of the fire.

Fire suppression is a three-stage operation entailing "knocking down" the running fire, "mopping up", and final patrol. From present knowledge of fire behaviour supported by data from fire research work, despatcher tables have been prepared based on how fast the fire is spreading and the delay between detection and attack of the fire. When a fire is reported, local knowledge of weather, fuel and forest type together with information on access routes and crew location are applied to the tables and a suppression force despatched which is reasonably assured of early success.

In the high value pine plantations this process is varied slightly to provide even greater certainty of rapid control. All divisional forces within two hours' travel of a plantation are immediately despatched on detection of a fire in a plantation area and this action is initiated by the code words "Red Action" transmitted over all communication channels. This code is used to ensure brevity and speed of message dissemination.

Whether the fire attack is with packsprays and rakes, or bulldozers and power pumpers, the aim is to "knock down" the flames by cooling with water or removing the fuel it is about to burn.

After the fire has been knocked down or satisfactorily checked, the arduous job of putting it out (mopping up) commences.

A break, cleared to mineral soil is constructed around the whole burnt area by hand tools and/or bulldozer, to prevent further spread. Every burning tree close to the edge of the fire which could throw sparks into the unburnt country is either put out or felled. Every log and stump burning close to the cleared break is extinguished with water, completely covered with earth or cut off and rolled in onto the burnt country.

When the fire is considered safe, a patrol is left on the area, and the gangs and equipment return to headquarters for overhaul, refuelling and a general refitting ready for the next call.

The patrol, equipped with a light unit and radio, remains until the fire is completely safe; a period often entailing stand-by for several days.

Usually with efficient detection, reporting and despatching, most fires in State forests are brought under control when small.

Forest Pathology

Introduction

Forest Pathology may be defined as the science that deals with diseases of forest trees, forest stands and forest products.

Fungi and insects, after fire, are considered to be the two most important damaging agents which can cause loss of production in a forest. Both are responsible for a serious loss of timber each year, a loss which though quite obvious, is difficult to assess in monetary values.

FUNGAL DAMAGE TO TREES AND TIMBER

Fungi can work against forest management in two ways. Firstly, there are fungi which attack seeds, seedlings or the growing tree and cause death of the plant or degrade of the timber it contains. Secondly, certain fungi act on the timber once it has been sawn, seasoned and placed in service, causing degrade of furniture or quality articles and loss of strength in structural timbers.

When dealing with the forest fungi, it is usual to separate them into three broad groups for convenience in classification. These groups are as follows:—

(1) Fungi attacking nursery plants and young trees.

(2) Fungi attacking wood in the mature, immature and over-mature tree.

(3) Fungi which attack forest products or wood once it has been sawn and seasoned.

These fungi do not always belong exclusively to the one group; that is, they do not always act in one capacity and not the others. Usually this is so, but many fungi may be found attacking wood in two situations, and perhaps three. *Polyporus eucalyptorium* for instance, is active in the growing tree and also against timber in service or on the ground.

FUNGAL DISEASES IN THE NURSERY

Damping-off Fungi

Two genera of fungi, *Pythium* and *Phythophthora* may cause considerable losses in nursery stock in certain years.[1]

These fungi attack and may kill the germinating seedling before it emerges from the soil, a disease condition known as pre-emergence damping-off. Later, the same fungi may attack plants which have already emerged, by breaking down or softening the stem just at the soil surface level, causing the plant to topple and die (post-emergence damping-off).

The activity of these fungi is favoured by moist, crowded conditions in the nursery and high soil acidity.

Control measures aim to improve soil conditions, and in this respect the use of a pine sawdust mulch has been successful. When damping-off is prevalent seed dusting with fungicidal powders provides some control for the pre-emergent stage and an early application of soil drenches (e.g. Cheshunt mixture) are often effective once the seedlings have emerged.[2]

JARRAH DIEBACK

The jarrah forest in this State is threatened by a serious disease locally known as jarrah dieback. This disease ultimately results in the complete death of the jarrah trees and most of the associated shrub and understorey species. It is caused by a microscopic soil-borne fungus called *Phytophthora cinnamomi.*

RECOGNITION OF DISEASED AREAS (SYMPTOMS)

The first signs of the disease are observed in the understorey layers of the forest where bull banksia (*Banksia grandis*), blackboys (*Xanthorrhoea preissii*) and zamia palms (*Macrozamia reidlei*), yellow and die.

The jarrah trees show the effects at a later stage—often after all of the banksia understorey has died.

The symptoms in jarrah are a thinning of the leaves and a dying back of the tree's branches. This die-back becomes progressively more severe until the tree succumbs.

Diseased areas spread outwards slowly and gradually enlarge. The rate of increase is quite variable depending on the forest type, the site and the season. Some native species, notably marri (*E. calophylla*), W.A. blackbutt (*E. patens*), bullich (*E. megacarpa*) and wandoo (*E. wandoo*), are resistant to the disease and continue to grow within the affected areas.

THE FUNGUS

The soil fungus *Phytophthora cinnamomi* causes serious disease in many plant crops. The list of affected plants numbers over 400 species and includes such plants as azaleas and camellias, peach, plum, avocado, pineapple, oak, cypress, eucalypts and pines. This fungus is widely distributed overseas.

---

[1] Other genera which may cause disease in nurseries include *Fusarium*, *Rhizoctonia* and *Macrophomina*.
[2] Soil sterilisation with formalin and methyl bromide has successfully reduced the incidence of this disease in eucalypt and pine nurseries.

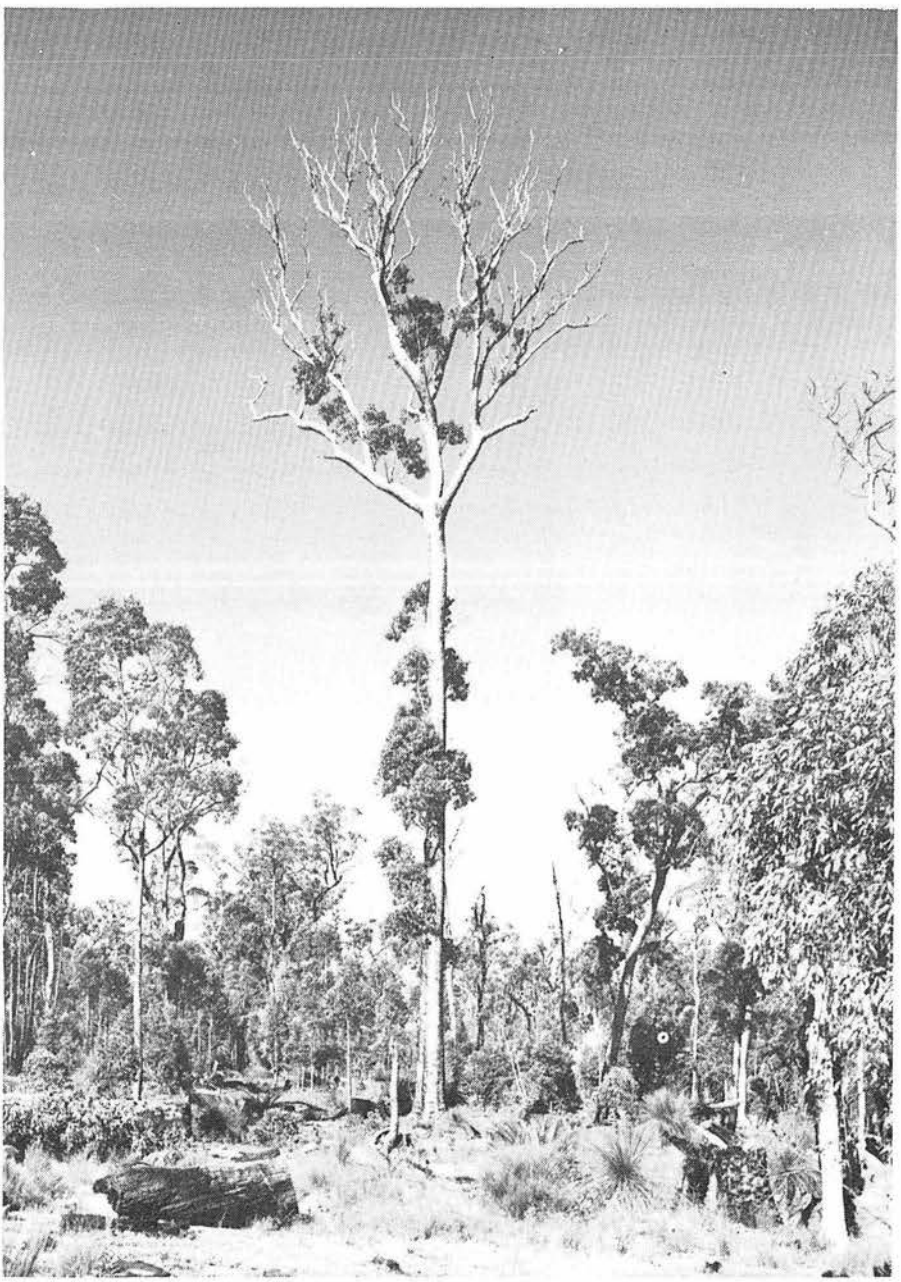


Plate 39

Typical "dieback" symptoms in a jarrah tree near Dwellingup

In affected plants, many of the small feeder roots are blackened and dead. The loss of these rootlets reduces the uptake of moisture and nutrients, resulting in the eventual death of the plant.

P. cinnamomi belongs to the group of fungi known as the water moulds and requires wet soil conditions for the best development of its three spore stages: *Sporangia* (which release mobile swimming spores) and the resistant spore forms *Oospores* and *Chlamydospores*. All of these spore forms are ultimately dependent on the vegetative mycelium which feeds on the plant's root system.

This fungus has been recognised as causing the death of a range of coniferous species particularly *Pinus radiata* planted in shelterbelts in New Zealand.

Available evidence suggests that extensive deaths in shelterbelts of *Pinus radiata* along the coastal plain south of Perth may be attributed to this fungus.

CONTROL

Mapping from aerial photographs indicates that less than 5 per cent of the forest area is affected by dieback. The best method of control is to prevent the spread of the fungus from the diseased areas into the 95 per cent of the forest which is still healthy.

Under favourable conditions, small clods of diseased soil can initiate a new centre of infection. Spread of the fungus, if unaided by man is slow; but man, with his ability to transport large quantities of soil over great distances, in a very short period

Plate 40

Logging and roading equipment can carry large quantities of infected soil adhering to the chassis and wheels or tracks and so spread the jarrah root rot disease

of time, is the most efficient carrier of this disease into healthy areas. Large volumes of soil are constantly being moved within the forest area on bulldozing, logging and road-building equipment and it is these units which constitute the greatest source of danger.

An intensive education programme of all forest users is well under way. With the full co-operation of the sawmilling industry, logging prescriptions aimed at minimising the artificial spread of the fungus on infected machinery have been drawn up and are being implemented in all major permits.

Hygiene logging involves the segregation of logging areas and of logging routes into "healthy" and "diseased". To reduce artificial spread of diseased soil into healthy forests, operations in the two areas are kept entirely separate. Infected equipment is thoroughly washed if transfer to a healthy area becomes necessary. Forest roads are relocated to bypass diseased areas. New gravel pits are located in healthy forest, "diseased" gravel pits are closed. Where possible, the entire logging operation is concentrated on the diseased areas in order to minimise timber losses through degrade. This sanitation programme is working well, but it is obvious that the co-operation of all parties involved will be essential for its continuing success.

In localised and high value crops (e.g., nurseries and orchards), control may be achieved by soil sterilisation, fumigation or the use of fungicides. Due to the high cost of treatment, this approach is impractical on a forest scale and could only be used in very limited areas. However, physical barriers such as ditching and poison-band killing, draining of susceptible sites and replanting with resistant species have been used to control the natural spread of the fungus within the forest area.

It is important that the diseased areas which are currently unproductive should be replanted to a timber crop. Tree species which offer commercial potential in the jarrah forest environment have been tested for resistance to the disease in both glass-house and field trials. Over fifty species of eucalypts and pines have been tested to date and a number of these show considerable resistance to the fungus. Extensive field trials of these species have been established in dieback areas. So far *Pinus pinaster* and *Eucalyptus microcorys* show the greatest promise. The oldest plantings of *P. pinaster* in a dieback area were established in 1950 and this species has grown in the diseased areas for twenty years without any ill effects.

THREAT TO OTHER FOREST TYPES

Work to date indicates that karri (*E. diversicolor*), marri (*E. calophylla*), wandoo (*E. wandoo*) and blackbutt (*E. patens*), the other important timber species in Western Australia, are resistant to this disease. The local plantations of *Pinus pinaster* and *Pinus radiata* also appear to be safe from the effects of the fungus.

DECAY IN WOOD

Decay or rot in wood is caused by some species of fungi. The fungal *hyphae* (or thread-like strands) which cannot usually be seen by the naked eye unless they occur in a closely-woven feltlike mass known as *mycelium*, feed on the substances composing the cell walls of the wood. They use certain constituents of the cell walls, neglecting others, with the result that the cell walls are broken down, the wood being thus greatly weakened and more or less destroyed. It is the breaking down of the wood and the change in its physical and chemical properties that is termed "decay".

Dry wood cannot decay because there must be about 20 per cent moisture in the wood before rot can begin. On the other hand completely saturated wood cannot decay because air is essential for fungal growth and activity. Decay of the standing

Plate 41

Species trials to rehabilitate " diseased " areas
Top—Pinaster Pine (*P. pinaster*)
Bottom—Tallowwood (*Euc. microcorys*)

tree is therefore restricted to the heartwood or deadwood part of the tree which is not completely saturated with water. Decay of wood in service is not likely to occur if the wood is properly seasoned and maintained at a low moisture content.

Most fungi in this group attack the mature heartwood causing either "cubical rot" (so-called because the decayed wood breaks into cube-like formations), or "straw rot" (in which case the decayed wood resembles old straw, both in colour and texture).

WOOD ROTS IN W.A.

Cubical rot is the commonest rot found in Western Australia. It bears a resemblance to the co-called "dry rot" of the old world. In contrast to the "dry rots" of the Northern Hemisphere, which continue their destructive action after the log has been sawn and the timber put into use, the common rots of Western Australian forest trees are confined almost entirely to the living tree and die as soon as the log is sawn and the wood has dried out.

Fungal attack is conveniently classed as either primary or secondary.

Primary attack is that on the growing tree.

Secondary attack is that on the completely dead tree, the log on the ground or timber once it has been sawn and put into service.

Unfortunately, some fungi are both parasitic and saprophytic, that is to say, primary and secondary. The outstanding example of this in Western Australia is the *Polyporus australiensis,* a fungus which can be found fruiting freely on living trees as well as on dead logs and stumps.

Initial investigations into wood rots in this State provided the following information:—

(1) Most of the fungi attacking the State's trees were identified.

(2) Most of these fungi were found to be primary attackers only.

(3) These primary fungi die sooner or later after the timber is milled.

(4) One fungus in particular, *Polyporus australiensis* which attacks karri, marri, tuart and sometimes wandoo and other trees, is both primary and secondary.

(5) The fungi which seriously affect jarrah and most other timber having a high moisture content when in or on the ground in Western Australia are mainly saprophytic species, and not primary rots which have extended after cutting of the tree.

(6) As already mentioned *P. cinnamomi,* the Dieback fungus, kills the tree by attacking the roots. It *does not* attack the above-ground parts and *does not* affect timber quality.

PRIMARY ATTACKING FUNGI

The following fungi are important in this State:—

Polyporus eucalyptorum (Column Rot or Heart Rot)

This fungus causes the column or heart rot which is the most common and important rot in the main jarrah forests where it does a tremendous amount of damage in the bole of the living tree.

Polyporus eucalyptorum will attack most eucalypts, including jarrah, marri, W.A. blackbutt, tuart, wandoo and flooded gum, and has also been known to attack other genera such as Casuarina. Its activity produces a brown cubical rot which is usually

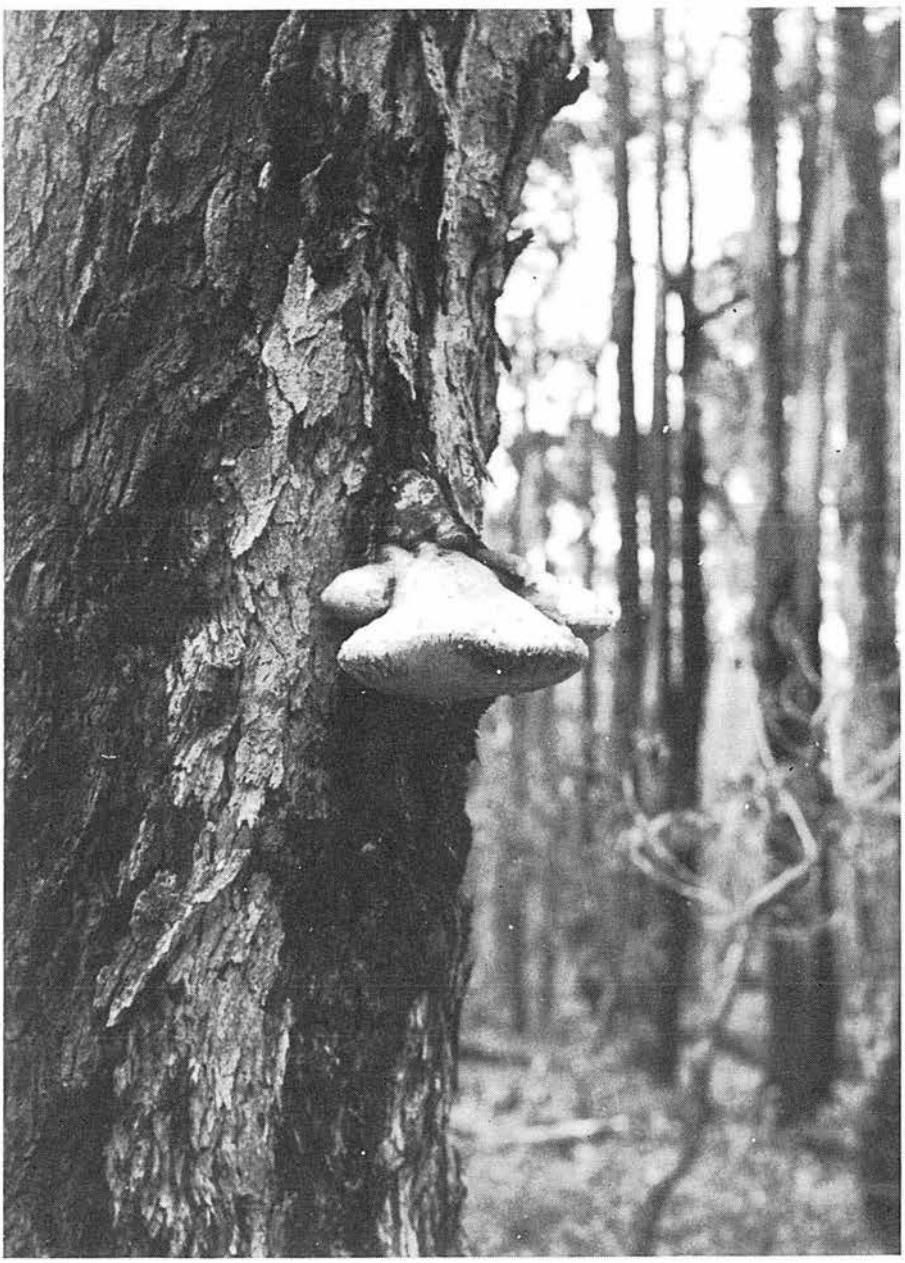


Plate 42

A bracket fungus on a marri tree indicates extensive internal infestation

associated with a quantity of mycelium, often in white sheets. This mycelium consists of a mass of fungal hyphae or threads which, with the aid of chemical processes, enter air pockets, penetrate sound wood and break down the wood cell structure. The mycelium attacks the bole and limbs of a tree and may sometimes be found in the larger roots.

The fruiting body (or sporophore) is conspicuous in the jarrah forest in winter, usually emerging from a knot, knothole or other blemish in the bole of the tree, in the form of a whitish bracket about six to twelve inches (*15-30 cm*) across and five to six inches (*13-15 cm*) thick.

As the name polyporus implies, this sporophore has numerous small holes or pores on the underside. From these pores the dust-like spores are dropped to the wind currents and widely dispersed. The few spores that find knotholes or other blemishes on trees germinate and the fungal hyphae enter the heartwood to continue the life cycle. This process of spore distribution applies to many fungi.

Polyporus pelles (Pocket Rot)

Polyporus pelles is a bracket fungus which, in the jarrah forest, has a sporophore about 3 to 4 inches (*7.6-10.2 cm*) across and an inch or more in thickness. The top of the fresh sporophore rather resembles a furry skin.

This fungus is responsible for the brown cubical pocket rot which is common in jarrah, particularly in the Eastern section of the forest.

Polyporus gilvus (White Pocket Rot)

This is another bracket fungus known to attack jarrah, marri, sheoak and other trees. It causes a whitish rot which is usually associated with a good deal of white mycelium.

The sporophore is a rough, irregular and knobby bracket usually 3 to 6 inches (*7.6-15 cm*) across and half as thick. Successive sporophores formed each year are persistent and 3 or 4 may be found superimposed upon each other; a feature common also to the genus *Fomes*.

Polyporus gilvus is not as common as *P. eucalyptorum* or *P. pelles*.

Poria mollusca (Jarrah Straw Rot)

The rotting action of this species causes the decayed wood to resemble old straw, both in texture and colour. The rot is often found associated with pinholes (the small tunnels caused by the pinhole borer) a fact which seems to indicate that borers may be responsible for much of the spread of this rot.

So far, fruiting bodies of this species have not been found or reported in the forest.

Fomes (Straw Rot and Honeycomb Rot)

Fomes rimosus and *Fomes robusta* are found on wandoo, jam, casuarina and other trees. The sporophores are hard, woody, hoof-shaped brackets, brownish in colour and about 2 to 4 inches (*5-10 cm*) across. They are persistent and it is common to find several superimposed one upon the other.

Fomes rimosus is fairly common on wandoo, where it causes a white honeycomb rot in the bole or limbs. It dies after the timber is cut and drying out.

A *Fomes*, as yet unidentified, which has a smaller sporophore usually emerging on the upper limbs is thought to cause the common yellowish straw rot in wandoo. This rot also dies soon after the timber is partly dried.

Pleurotus estreatus (Straw Rot in Peppermint)

The mature peppermint tree is almost invariably attacked by this bracket fungus, which causes a straw rot. The sporophore emerges from any blemish in the bole to form a yellowish bracket from 4 to 14 inches (*10-35 cm*) across and ½ to 1 inch (*13-25 mm*) thick.

SECONDARY ATTACKING FUNGI

Coniophora cerebella (Dry Rot)

In England, Europe, America and other places, dry rot causes considerable damage to buildings. This fungus is rare in Western Australia and is not often found excepting in old timber stacks where moist conditions have favoured its development. In this State the fungus is responsible for a brown cubical rot.

So far as is known, *Coniophora cerebella* is a secondary rot which rarely fruits. The brown mycelial threads, sometimes found on the ground underneath an old, damp timber stack, bear a superficial resemblance to a spider's web.

The name "dry rot" refers to the fact that this fungi often appears to operate on completely dry timber under completely dry conditions. This is not so; all fungi require moisture to function. *Coniophora cerebella*, however, produces long and branching threads of mycelium which carry water some distance to the site of attack and thus often appear to attack completely dry wood. With the aid of the water carried along its threads, the fungus attacks dry timber not in contact with the ground.

Dry rot is a serious fungus under any conditions which assist its growth. It is fairly common in some of the Eastern States where it is said to cause jarrah to disintegrate rather rapidly.

Stemphilium (Wet Rot)

Stemphilium is the fungus which attacks jarrah and other timbers at or near ground level. It is commonly found softening the face of the wood in contact with the ground, working in slowly from the outside.

Stemphilium is a secondary attacker which forms a thin cubical rot if the decayed wood is permitted to dry out. This fungus does not produce a sporophore but grows its spores directly on the wood.

Trametes lilacino-gilva

This secondary fungus occurs widely throughout Australia and is found attacking dead wood of many species. It is severe on karri and may also be found on marri, yarri, banksia and others. The rot produced is brown-coloured and cubical in appearance, usually associated with a good deal of whitish mycelium.

The sporophore is a thin, leathery, pored bracket, 1 to 4 inches (*25-100 mm*) across and ¼ inch *(6 mm)* or so in thickness; pale brownish on top and lilac coloured beneath.

Polyporus tumulosis (Log Rot)

This fungus commonly attacks large jarrah logs, causing a brown cubical rot.

A large mass of mycelium, called a false sclerotium is developed underground and may wrap up stones and gravel until it weighs perhaps half-a-hundredweight *(25 kg)*. From this mycelium mass, and usually following a bush fire, mushroom type sporophores up to six inches (*15 cm*) in diameter are formed.

Polyporus mylittae (Blackfellow's Bread)

Polyporus mylittae is somewhat like *Polyporus tumulosis* in its habits. It forms a true sclerotium up to 50 pounds *(23 kg)* or so in weight which, when cut, resembles tapioca pudding. Reputedly eaten by the natives, it is tough and tasteless, but the natives may have found some satisfactory method of treatment to make it palatable.

In Western Australia the sclerotium has been found attached to the underside of karri logs.

Lentinus dactyloides

Lentinus dactyloides is only known as a secondary fungus occurring in the dry inland of Australia. It has been known to attack karri sleepers in South Australia.

Trametes cinnabarina

This fungus is very common on dead wood, particularly the dead sapwood. Its activity is not very destructive in eucalypts and it is restricted completely to the dead sapwood region. On a pine log it soon penetrates the wood which will show a pink colouring many inches deep. Provided conditions remain favourable, the entire pine log is soon destroyed in the manner of a straw rot.

As a rule the sporophore takes the form of a thin leathery bracket but may appear as a flat surface attached to the top of pine stumps. The colouring, normally scarlet underneath, is often scarlet all over when occurring on pine stumps. In such a case, too, it may measure a foot *(30 cm)* across. Usually this fruiting body is less than six inches *(15 cm)* wide and about ¼ inch *(6 mm)* thick.

Polystictus versicolor

Somewhat similar in habit to *Trametes cinnabarina,* the sporophore of *Polystictus versicolor* is a thin leathery bracket, often fan shaped, from 1 to 6 inches *(2-15 cm)* across and 1/16th to a ¼ of an inch *(1-6 mm)* thick. The upper surface is marked with beautiful concentric zones of various colours. Sometimes the brackets are found massed one above the other.

Ceratostomella and Penicillium spp. (Blue Mould)

This fungus attacks pine shortly after it is fallen whether it is left as a log or sawn. It appears as a blue stain and reduces the value of the sawn product by affecting the timber's appearance. Rapid conversion and seasoning are necessary to avoid attack by this fungus. The sawn timber is treated with pentachlorphenol or else it may be kiln dried immediately after milling.

PRIMARY AND SECONDARY ATTACKING FUNGI

Polyporus australiensis (Karri Cubical Rot)

Polyporus australiensis causes decay in karri, marri, tuart, wandoo, yellow tingle and several other eucalypts. Dead wood in both the log and the mature tree is attacked, producing a brown cubical rot with a white mycelium. It is severe on karri timber in contact with the ground but works slowly on tuart and wandoo.

The sporophores, which have a strong musty smell, can be found during many months of the year, sometimes on the bole of a tree, but more often on old logs or stumps. They are usually from 5 to 15 inches *(13-38 cm)* across, 5 to 6 inches *(13-15 cm)* thick and of the bracket form.

Commonly these fruiting bodies are bright orange on the underside and contain internally an orange coloured pigment which has, on occasions, been used fairly successfully as a dye. The colouring is less vivid in spring than in autumn and the fruits are smaller. South of Cape Naturaliste, colourless specimens can be found on marri trees.

Armillaria mellea (Root Rot)

This fungus is commonly associated with marri with which it may even live without harmful effects. The fungal threads attack the living cells of many plants including citrus trees, tree lucerns, Victorian ti-tree and pine seedlings. The fruiting bodies are like small slender mushrooms and arise in groups. They are gilled and because of their colouring are known as "honey fungus".

Sporotrichum destructor (Red-flowered Gum Canker)

Sporotrichum destructor is a parasitic fungus which attacks the living cells of marri and red-flowered gum. It is fairly common on marri and kills the individual limbs attached, but is seldom severe enough to kill the whole tree. In King's Park and many other areas, red-flowered gums have been killed by it.

The fungus penetrates the bark and sap, works around the limb inside the bark while at the same time causing the bark to open up for a few inches along the grain, exposing whitish mycelium which usually becomes stained with sap or gum.

Fistulina hepatica (Liver Fungus)

This fungus is probably of little economic importance. It is found on jarrah and is said to occur on oak in England.

The sporophore, which has a superficial resemblance to *Polyporus pelles* is usually five to six inches *(13-15 cm)* wide and two inches *(5 cm)* thick. It is brownish to liver-coloured with a reddish flesh, has a reddish juice and is edible.

Fistulina hepatica is often associated with pencilled jarrah, the pencilling being caused by the fungus and appearing as an excess of kino in the medually rays. Apparently it is not responsible for decay, or at least not directly. In blackbutt trees pencilling of timber is often found to be associated with some other rotting fungi.

TIMBER GRADING

Under Forests Department Grading Rules any rot in timber was not acceptable prior to 1948. Once it became apparent that the three commonest rots in jarrah trees *(Polyporus eucalyptorum, P. pelles* and *Poria mollusca)* ceased to extend soon after the timber was cut it was considered reasonable to accept, for most purposes, limited amounts of these primary rots in timber.

It is still necessary to ensure—

(a) that the cavity caused by the decay and incipient decay is not large enough to impair the serviceability of the timber;

(b) that the presence of the decay does not cause the loss of timber orders.

Subject to adequate control over these points, Grading Rules were amended in 1948 to allow the acceptance of "minor pockets of primary rot" in most classes of jarrah timber.

A similar arrangement was later made to cover blackbutt and tingle. Wandoo is attacked chiefly by *Fomes* which also dies soon after cutting. Since this timber is used chiefly in local trade where its great durability is appreciated, something more than "minor pockets" are accepted by the consumers.

Greater care is taken in karri as it is commonly attacked by *Polyporus australiensis* which often continues to extend after the timber is put into use.

Apart from air and warmth, all fungi require moist conditions, and are therefore of far less economic importance in the dry inland parts of Australia than they are in the higher rainfall areas.

In general, the detrimental effects of wood rotting fungi can be greatly reduced by adequate seasoning, design and building practice.

Insect Pests of Forests

By C. F. H. JENKINS, M.A. & S. J. CURRY, M.A.†*

Compared with most agricultural crops the forests of South Western Australia experience little damage from insect pests. A wide range of insects is associated with our native plants, but the relatively natural conditions under which the forests have been maintained have helped, no doubt, to stabilise changes in insect populations.

LEAF-EATING AND BUD-DESTROYING INSECTS

Jarrah Leaf Miner: Many types of insects feed upon the leaves and buds of forest trees, but the one which causes the most conspicuous damage is the Jarrah Leaf Miner *(Perthida glyphopa)*.

This small native moth, belonging to the family Incurvariidae, causes widespread damage during the winter months, primarily to Jarrah *(Eucalyptus marginata)* and Flooded Gum *(E. rudis)*, although about ten other species of eucalypt may sometimes be affected.

The moth lays its eggs in the leaves and the larvae tunnel through the leaf tissue forming reddish-brown blotches. When the larvae emerge they cut typical oval-shaped holes in the leaf and these holes together with the larval mines produce an overall effect on the tree similar to leaf scorch due to fire. The foliage is replaced during spring and early summer and the tree appears to completely recover from the attack. However, successive infestations may adversely affect the vigour of the tree and reduce its growth.

Some control of the population is exercised by parasitic wasps, predatory birds and ants while a proportion of the jarrah trees are resistant to attack. Systemic insecticides have proved effective for small scale control but are too costly for use on a large scale.

The Gum Leaf Skeletonizer (Roeselia lugens), also known as the Brown Leaf Moth is much less common than the Jarrah Leaf Miner, but spasmodic outbreaks of the caterpillars sometimes cause extensive damage. The caterpillar is a woolly bear type, reddish brown in colour, with long grey hairs.

Caterpillars of the Tussock Moth, the Bag-Shelter Moth and the Case Moth sometimes cause severe leaf damage. *The Tussock Moth* caterpillar *(Orgyia athlophora)* gets its name from the dense brush-like tufts of bristles which stand out from the main hairy covering of the body.

The Bag-Shelter Caterpillar or Processional caterpillar (*Ochrogaster contraria*) is well known to most country residents. The strings of trailing caterpillars never fail

* Chief, Biological Services Division, Department of Agriculture, W.A.
† Forest Entomologist, Department of Agriculture, W.A.

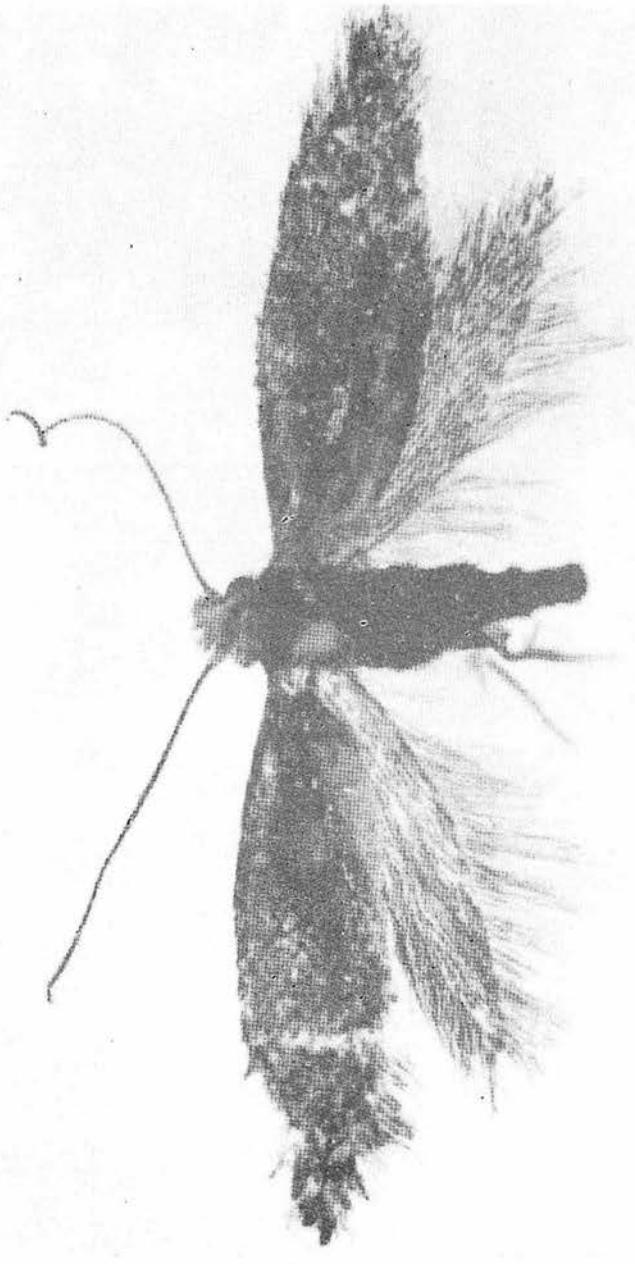


Plate 43

Jarrah Leaf Miner—an adult moth (dorsal view; magnified 16 times)

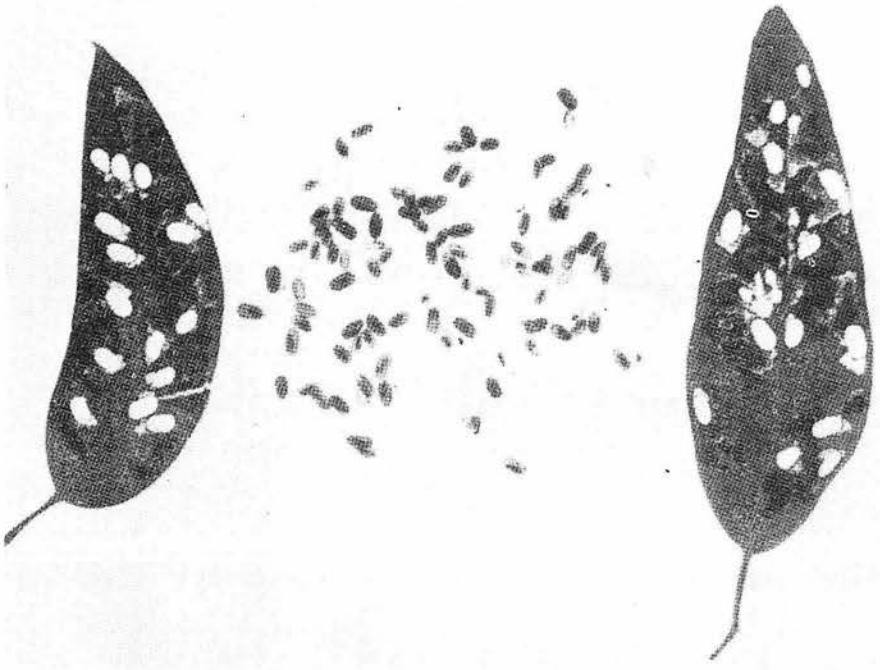


Plate 44

Jarrah leaves showing typical damage caused by larval galleries and the oval holes produced when the larvae drop out of the leaves in cases—shown separately between the leaves

to arouse attention, and the large silken bags hanging from defoliated trees are a feature of many roadsides. The hairs of many insects are highly irritating to some people and bushmen usually treat the homes of the bag-shelter caterpillars with respect.

The outstanding feature of *Case Moth* caterpillars is that they build silken coverings within which they live—rather like a snail in a shell. The construction of the shelter varies according to the species and the material available. Some like the Leaf Case Moth *(Hyalarcta huebneri)* cover the outside of their silken bag with bits of leaves, while others such as the Lictor or Faggot Case Moth *(Clania ignobilis)* use lengths of thin twigs. The larvae of the Ribbed Case Moth *(H.nigrescens)* on the other hand, construct a greyish silken bag conspicuously ribbed but quite devoid of decoration or extra covering.

The case moths have a wide host range but damage is usually restricted, for, as in the Tussock Moth, the females of the Case Moth are wingless and after hatching, the tiny caterpillars lower themselves on silken threads from the parental shelter and may be scattered by the wind.

The Steel-Blue Sawfly: The caterpillar-like grubs of the Steel-blue sawfly *(Perga sp.)*, often known as "Spitfires", may cause severe defoliation of individual trees or limbs but these insects are much less troublesome in Western Australia than in parts of the Eastern States. The eggs are laid in the tissues of a gum leaf and as

the larvae grow they congregate on the twigs in clusters which may reach the size of a small football. The insects spread out to feed on the foliage during the night, but cluster again with the approach of daylight.

Many types of beetles feed on native plants, but the rounded leaf-cutting beetles or chrysomelids, and the snouted weevils or curculionids are amongst the commonest and most destructive.

The Red-Legged Weevil (*Catasarcus rufipes*) feeds on a wide range of both native plants and cultivated shrubs.

SAP SUCKING INSECTS

Many species of sap sucking insects occur in the south-west forests, including the well-known cicada and the smaller cicadellids or leaf hoppers, but these are not considered of major importance.

Native aphids are very poorly represented in Australia, the only one reported in Western Australia being *Anomalaphis comperi.* The *Woolly Pine Aphis* or Pine Adelgid *(Pineus pini)* is the only introduced species of importance. This insect with its white waxy covering is heavily attacked by ladybirds and other natural enemies.

Sap sucking coccids which include scale insects and mealy bugs are represented by some very interesting species. The genus *Apiomorpha* produces various types of woody galls, some of which look very like the fruits of a eucalypt, while others may be almost circular and larger than a golf ball.

The leaf insects or psyllids are small sap sucking insects which attack a range of native trees and shrubs. Although some of them construct galls, and others are naked throughout life, most of them spend their immature stages under a waxy or sugary covering. One of the commonest type of lerp insects found in Western Australia, *Creiis periculosa,* is associated with Flooded Gum (*Eucalyptus rudis*). The mussel-shaped, flat scales may almost cover both sides of the leaves and the damage may produce heavy defoliation.

One of the most puzzling features about the psyllids is that attacks appear to be increasing in intensity and that more and more tree deaths can be attributed to this cause. The psyllids are of course native insects and their association with eucalypts has been of very long standing. It would seem, therefore, that some fundamental changes in the environment must have contributed to the lack of balance now existing between the tree and its parasite. Such a change could have been brought about by clearing and agricultural development, and in the irrigation areas the change of water table could have played a part. Many insectivorous birds such as pardalotes, thornbills, tree tits and even "twenty eight" parrots are known to feed on lerp insects and their sugary scales, and so a reduction in bird life could be yet another contributory factor.

WOOD BORING BEETLES

The Bardee: One of the best known of our wood boring insects is the so-called bardee. This creamy white, apparently legless grub, is the immature stage of a long thin Cerambycid or Longicorn beetle. There are many different species, but all are characterised by the very long feelers or antennae.

The beetle lays its eggs on the bark and the tiny spindle-shaped grubs bore down to the sapwood. Here they feed and tunnel about in all directions producing a network of scroll-like markings packed tightly with a mass of sawdust-like frass. When fully fed the grubs bore several inches straight into the solid wood and pupate.

Although often found in dead or dying trees, bardees are not always the cause of death. Healthy trees are usually able to withstand an appreciable amount of insect attack, but sickly trees seem to be particularly attractive to wood borers. It follows then that in many cases, heavy borer infestation may be of secondary importance as far as tree decline is concerned.

One species, *Phoracantha impavida* attacks young tuart, sometimes in association with a Cassid borer *Culama sp.* which also bores under the bark. The borers tend to ringbark the stem and this no doubt accounts for the unexpected death of some young trees and the dead upper branches of many older trees.

Tuart Bud Weevil (Haplonyx tibialis): The tuart bud weevil is a native insect which, as its name implies, is associated almost entirely with tuart. Because of its small size and retiring habits the insect is rarely seen, but its presence can be easily detected by the carpet of twigs and buds around infested trees.

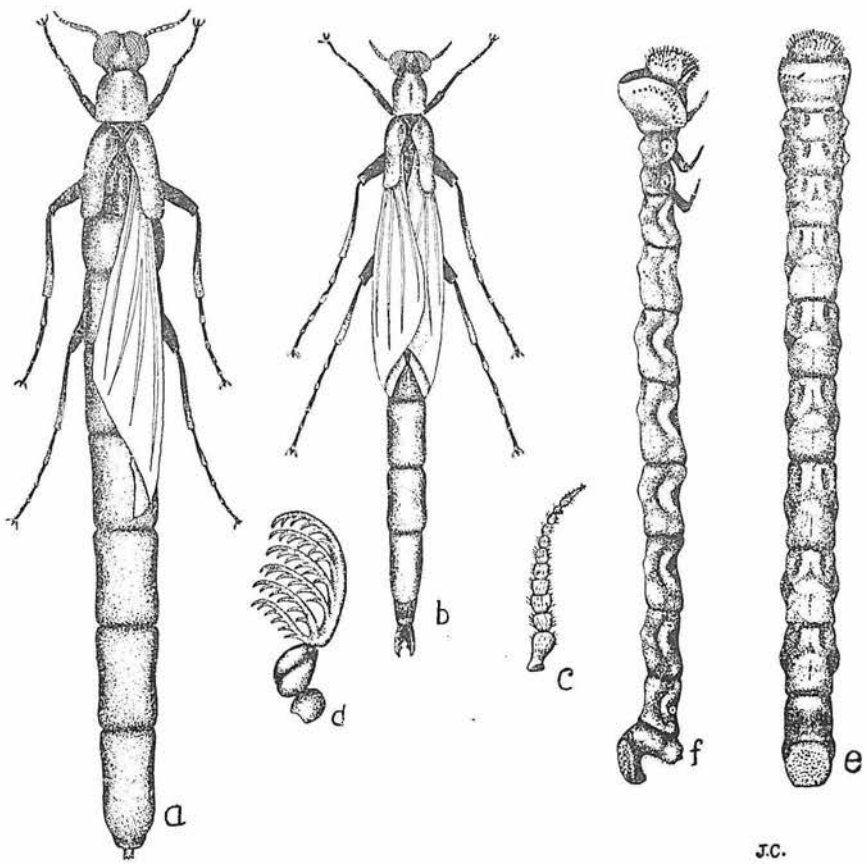


Plate 45

Pinhole Borer (*Atractocerus kreuslerae*)
a. Female, enlarged 5 times; one wing removed to show segments
b. Male, enlarged 5 times
f. and e. two views of a larva, enlarged

The female chews a hole into the cap of an unopened flower bud and deposits its egg. The grub which develops eats its way down to the base of the bud and pupates there. The adult weevil then cuts its way from the base of the now empty flower bud.

Although the eggs are deposited while the buds are still growing on the tree, the beetle either chews off the clusters or ringbarks them soon after laying, so that they fall to the ground. Unfortunately, the weevils often cut off many more buds than are actually used in egg-laying. In a season when the insects are prevalent, overall blossoming can be seriously affected, with consequent reduction in the yield of seed and honey from tuarts.

Gregarious Gall Weevil (Strongylorrhinus ochraceous): Large stern galls are produced by several species of Eucalyptus including karri, tuart and flooded gum following oviposition by this weevil. Attacked stems swell as the insects develop and may be sufficiently weakened by the cavities produced when the beetles emerge, to break during strong wind.

Pinhole Borers: The only pinhole borers found so far in the south-west of the State belong to the beetle family Lymexylidae, of which the commonest species appears to be the *Eucalypt Pinworm (Atractocerus kreuslerae)*. Several eucalypt species are attacked by these borers, including jarrah, karri, tuart, wandoo and W.A. blackbutt. The beetles occur in most forest areas and appear to be most common in badly fire-damaged sites, although rarely is there a high incidence of attack.

Considerable damage can result from concentrated larval boring, if the galleries become large enough to cause some reduction in timber strength, and rejection of apparently sound logs may result. No parasites or predators have been discovered and the only feasible method of control appears to be to reduce external bark damage to a minimum and so lower the incidence of attack.

Bark Beetles: Three introduced species of bark beetles *(Fam. Scolytidae)* have been found in Western Australia. The two species of European origin, *Hylastes ater* and *Hylurgus ligniperda,* are of minor importance but the Five-Spined Bark Bettle *(Ips grandicollis),* which is of North American origin has caused considerable mortality in drought affected *Pinus radiata* plantations near Adelaide.

Since its later introduction into Western Australia it has spread to nearly all pine plantations and is found attacking recently felled logs, and unhealthy and dying trees affected by fire, disease or drought.

There are no effective parasites or predators, the only natural control of the population being due to fungal and bacterial infections of the hibernating insects. Improvement of tree vigour and thus resistance to attack, can be achieved by correct plantation thinning, and some control of beetle populations can be obtained by burning trash and dead or unhealthy trees. Protection of logs can be achieved by insecticidal spraying, but rapid utilization after felling is more effective in preventing deterioration.

Sirex Wasp: Sirex Wasps *(Siricidae)* known also as Wood Wasps and Horntails show a preference for egg-laying into unhealthy trees of the genus *Pinus,* and the resulting larvae can cause considerable damage and the ultimate death of the tree. One species, *Sirex noctilio,* from Southern Europe, has become established in New Zealand, Tasmania and Victoria and has caused serious damage to pine plantations, particularly under-thinned *Pinus radiata.* Despite efforts to control its spread by the destruction of infested trees and the introduction of parasitic wasps and nematodes, infestation is advancing westwards towards South Australia, and it remains a potential threat to our pine plantations. Various Sirex species have been intercepted at Fremantle and dealt with by quarantine authorities.

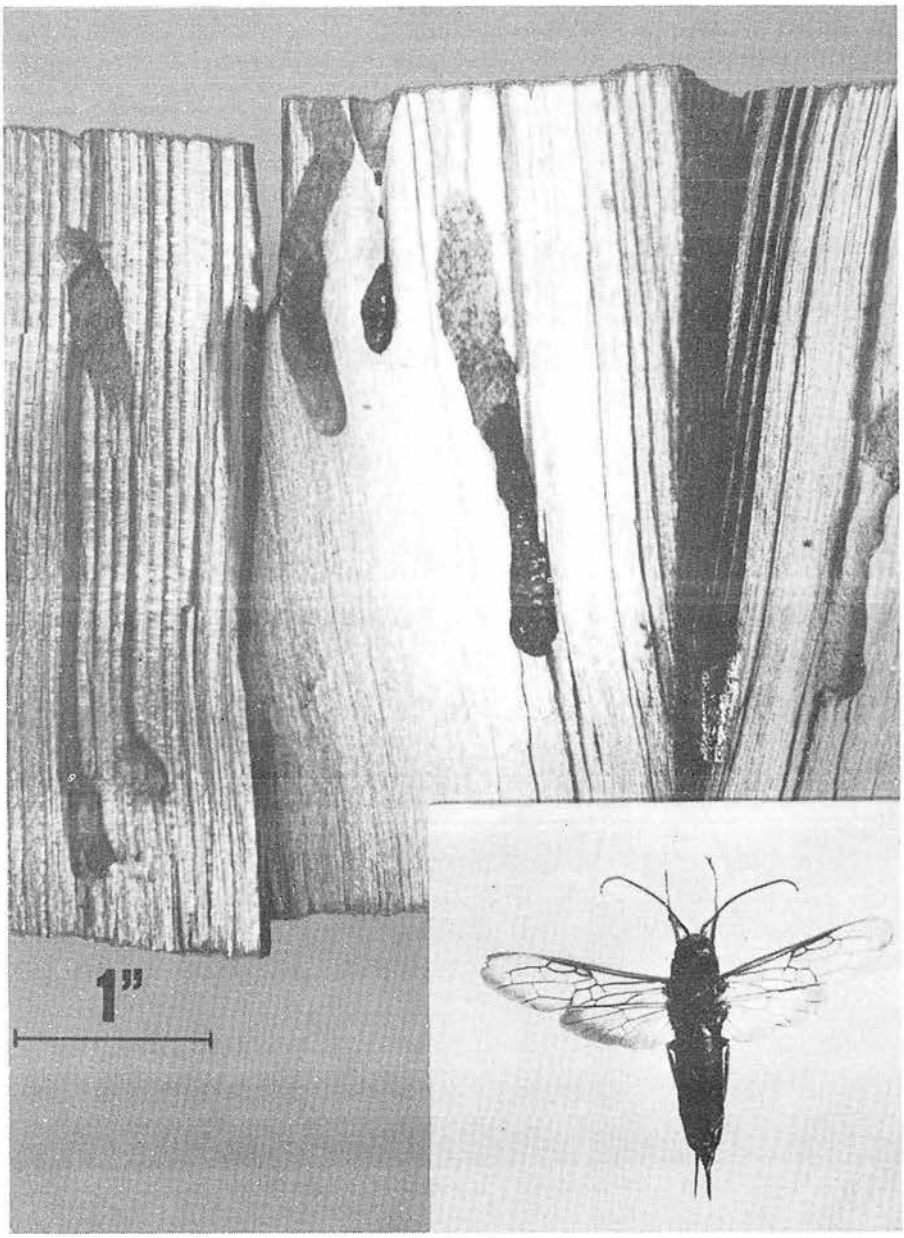


Plate 46

Damage done to the wood by the tunnelling of sirex larvae. Inset: an adult female wasp (*Sirex noctilio*). The female is about an inch long and steel blue in colour, while the male is slightly smaller and distinguished by an orange-coloured, black striped abdomen

WOOD BORING MOTHS

Two families of wood boring moths are common in the south west forests, the *Cossidae* or *Goat Moths* and *Hepialidae* or *Swift Moths.* These are small to very large moths whose larvae tunnel in the wood of various native trees, including the eucalypts and acacias. Many of these moths have a life cycle of more than 12 months and the larger species may produce extensive tunnels half an inch or more in diameter. The white fleshy caterpillars (witchetty grubs) which sometimes reach six inches in length, were prized as food by the aborigines.

Karri trees from pole size to maturity may suffer damage by cossid larvae of the genus *Xyleutes*; this can result in reduction of timber quality.

FAUNA ON THE FOREST FLOOR

Termites: A wide range of mites, insects and other invertebrates contribute towards the breakdown of the ground litter which accumulates under forest trees. Amongst the most important destroyers of wood are the termites and, although serious pests in structural timber and sometimes in standing trees, they are important scavangers in the forest.

The most destructive local termite in buildings and fences is *Coptotermes acinaciformis* and this species is also common in the bush. In Eastern States forests it has been associated with considerable damage to standing trees, but causes less damage in Western Australian forests.

CHAPTER V

PINE PLANTATIONS IN WESTERN AUSTRALIA

Introduction

The continent of Australia has no natural forests of pine. A few timbers such as hoop pine, bunya pine and cypress pine are commonly referred to as pines, but they are not true pines and are not now of high importance in the economic field of providing large quantites of softwood needed by Australia.

Western Australia, particularly, is deficient in softwoods, and has, perforce learnt to use eucalypt hardwoods for many purposes for which softwoods are used in other parts of the world. Normally about 80 per cent of a country's requirements are softwood, but in Western Australia the position is reversed and over 90 per cent of hardwoods are used.

The position with respect to future supplies has been under review for a considerable time, and because of the demands of an ever-increasing population, has led to the formation of plantations of introduced pines which have the ability to reach maturity in a relatively short time. These plantations will provide the timber necessary to avoid large scale importation of the State's requirements in the future.

The Need for Pine Plantations

The population of Western Australia passed one million in late 1970, and is expected to reach two million before the end of the century. Per capita consumption of wood and wood products is expected to remain fairly constant at approximately fifty cubic feet (*1.4 m^3*) per annum. The State's requirement for wood products is therefore expected to double by the year 2000 A.D.

Production from the existing forests will not be sufficient to supply this requirement and it is calculated that at least a quarter of a million acres (*100,000 ha*) of pine plantation will be needed by this time, to supplement our timber supplies.

Forests Department Policy on Pine Plantations

The Forests Department today has some 70,000 acres (*28,000 ha*) (August, 1970) of pine plantation and a planting programme of 6,000 acres (*2,400 ha*) per annum. It aims to establish 240,000 acres (*97,000 ha*) by 2000 A.D.

Western Australia has no indigenous commercial softwoods and the plantation establishment programme is based on a policy designed to:—

(1) Provide wood for the demands of a future increased population.

(2) Establish a better balance in the proportion of softwood and hardwood utilised within the State.

(3) Prevent future dependence on wood imports to satisfy local demands.

Early Problems

Today's plantations and the current techniques of large scale pine planting in a difficult environment have been achieved as a result of over 70 years of endeavour with varying fortunes. Many obstacles were overcome by dint of thorough investigation and trial. The notable increases in planted areas in recent years were made possible by the solving of numerous problems by early West Australian foresters.

Plate 47

A 30-year-old *Pinus radiata* plantation near Mundaring Weir

The successful investigations carried out include work on selection of species and strains, soils and site selection, nursery techniques and mycorrhiza, ground preparation and planting methods, fertilisers and minor elements.

The following notes outline the development of our current plantation practices.

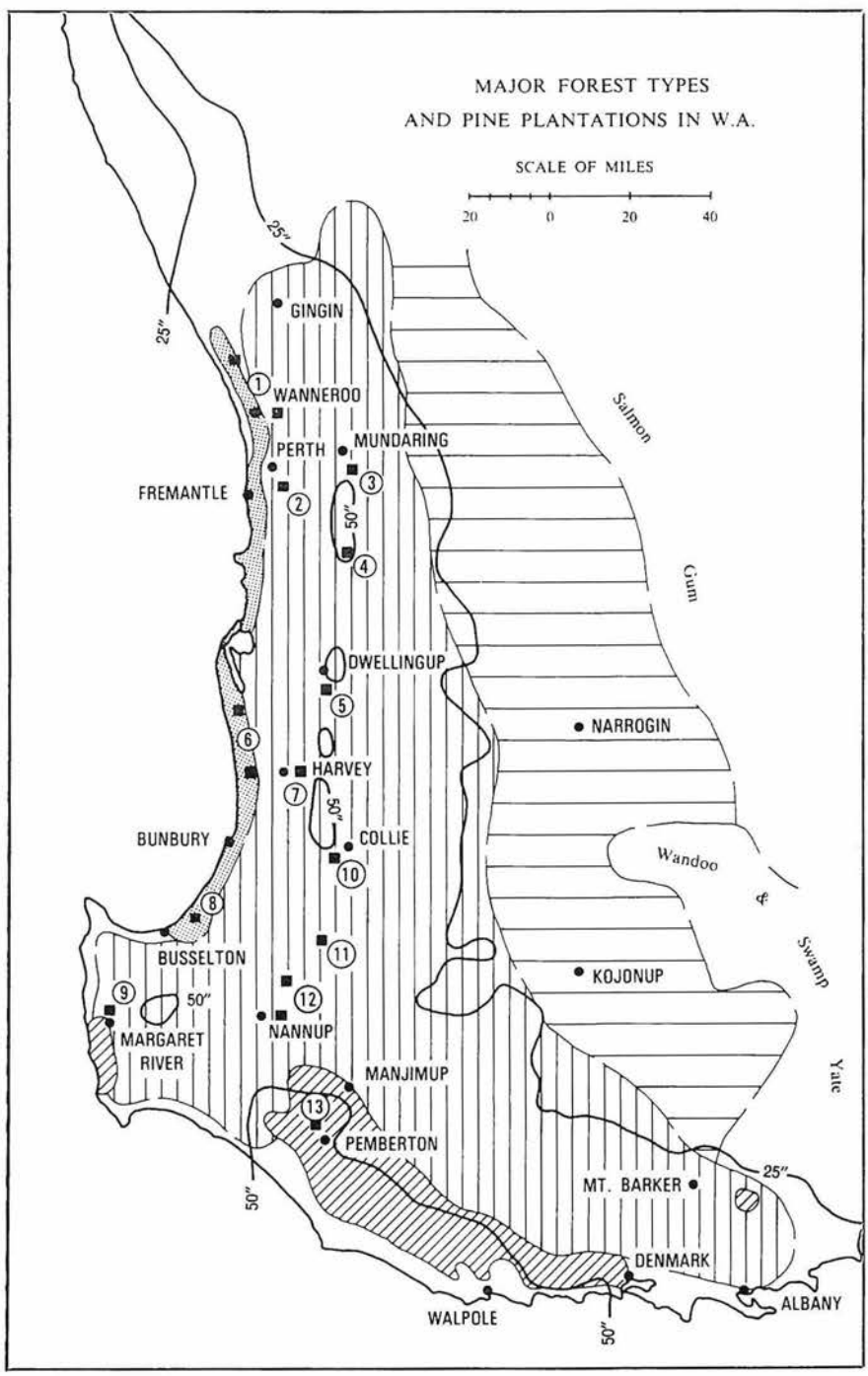
Selection of suitable species

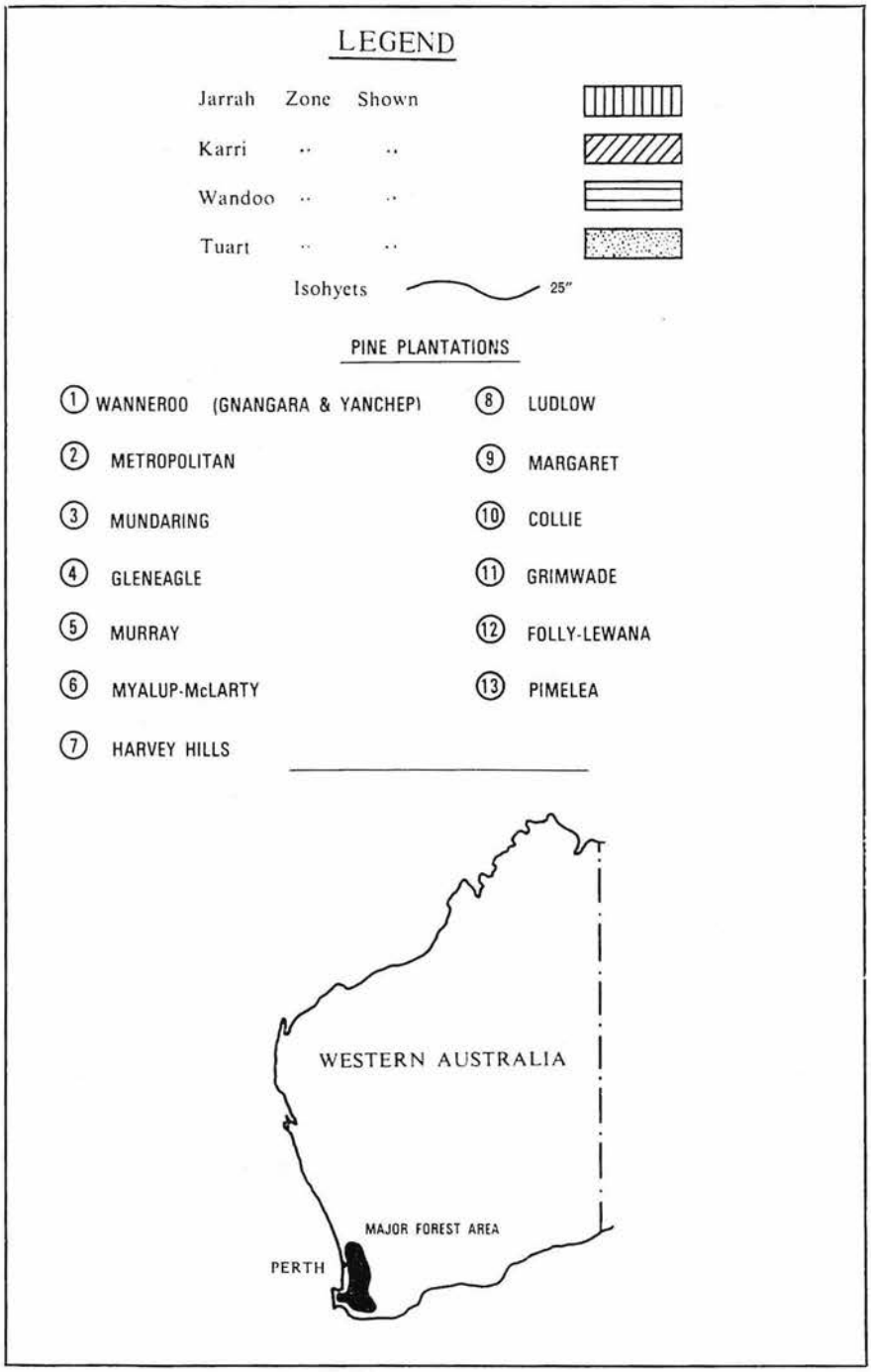
The first trial plantings made in 1897 on coastal sand dunes near Bunbury were a failure. It was a matter of experiment to find species which were suitable to West Australian climatic and soil conditions.

The well known *Pinus radiata* (the "remarkable pine") which had been so successful in South Australia and other parts of the world is extremely demanding as to site in Western Australia. It was found that it will grow well only on deep, fertile, loamy soils in a rainfall of at least 30 inches (*762 mm*). *Radiata* has become an important species in W.A. but it can only be grown on carefully selected sites following intensive soil survey.

Many other species were tried and it was found that *Pinus pinaster* was outstanding in its ability to grow on the poor sandy soils which are available in quantity to forestry in Western Australia.

There are several geographic races of *P. pinaster* as the species occurs naturally over a wide range of situations in southern Europe. Of these several races it was found by trials that the *P. pinaster* from the forests of Leiria in Portugal was outstandingly superior under West Australian conditions. Since 1940, only the Leirian strain has been used in establishment of our *P. pinaster* plantations.


MAJOR FOREST TYPES
AND PINE PLANTATIONS IN W.A.
SCALE OF MILES
20 0 20 40
25"
GINGIN
WANNEROO
PERTH
MUNDARING
FREMANTLE
50"
Salmon Gum
DWELLINGUP
NARROGIN
HARVEY
BUNBURY
COLLIE
Wandoo & Swamp Yate
BUSSELTON
KOJONUP
MARGARET RIVER
NANNUP
MANJIMUP
PEMBERTON
MT. BARKER
DENMARK
ALBANY
WALPOLE


LEGEND
Jarrah Zone Shown
Karri
Wandoo
Tuart
Isohyets
25"
PINE PLANTATIONS
① WANNEROO (GNANGARA & YANCHEP)
② METROPOLITAN
③ MUNDARING
④ GLENEAGLE
⑤ MURRAY
⑥ MYALUP-McLARTY
⑦ HARVEY HILLS
⑧ LUDLOW
⑨ MARGARET
⑩ COLLIE
⑪ GRIMWADE
⑫ FOLLY-LEWANA
⑬ PIMELEA
WESTERN AUSTRALIA
MAJOR FOREST AREA
PERTH

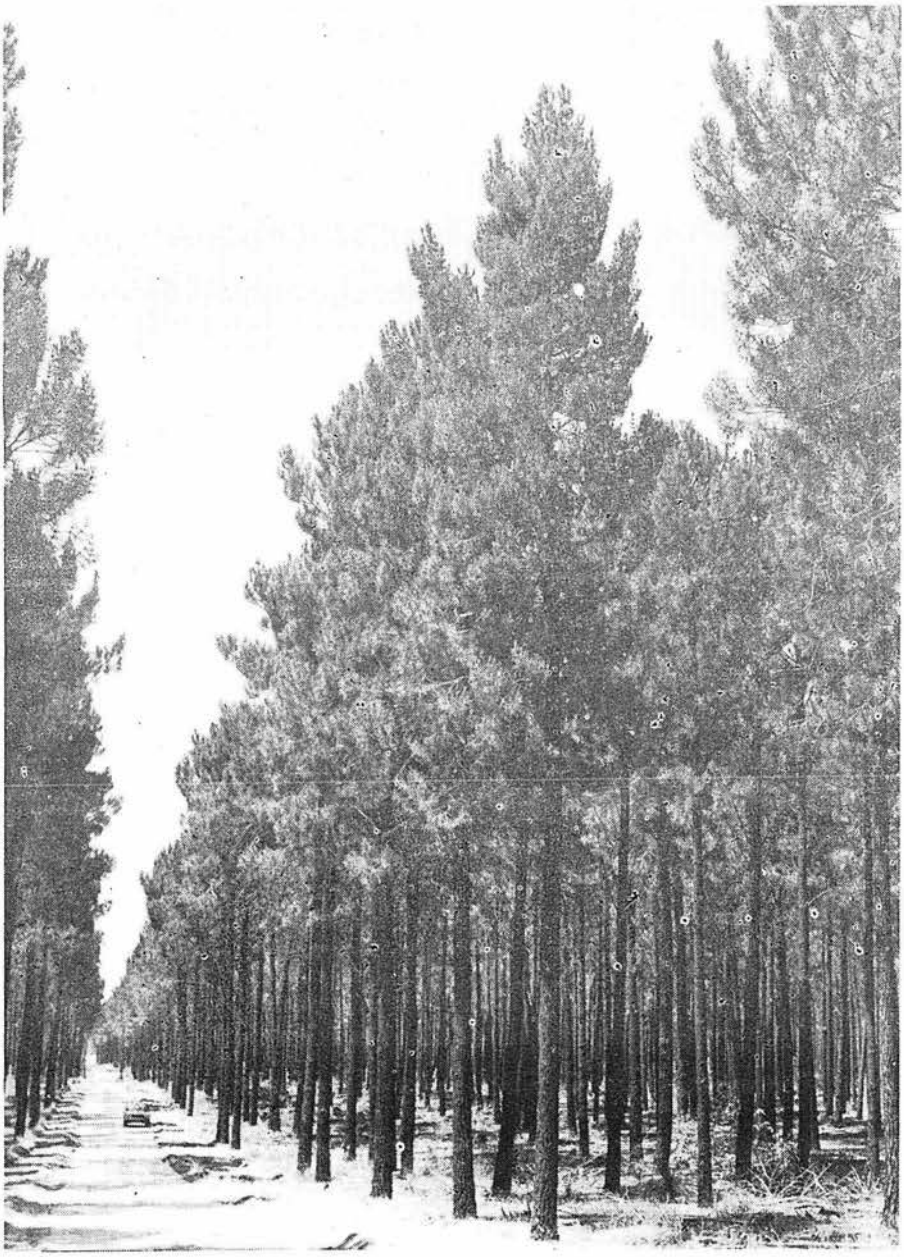


Plate 48

A 38-year-old *Pinus pinaster* plantation at Gnangara on the coastal sands north of Perth

These two trees, *Pinus radiata* and *Pinus pinaster* have been adopted as the major species for plantation use in Western Australia. *Pinus radiata* is much more productive, with faster growth rates than *pinaster* but it does require first class soil. Availability of suitable soil places a limit on the amount of *radiata* planted and for this reason our plantations of *radiata* are scattered through the south west portion of the State. *Pinus pinaster* on the other hand grows well in very poor soils and is planted extensively on the coastal sand plain close to Perth.

Pine Seed

Our supplies of seed for the plantation programme are currently obtained from South Australia (*P. radiata*) and from Portugal (*P. pinaster*).

When seed is received, the details of seed origin are checked and recorded. The seed is cleaned, graded, dried and then stored in airtight containers in a special low temperature store room. Germination tests are carried out on samples of each seed lot. Prior to sowing the seed is treated by a process called "stratification" to ensure prompt and even germination. This involves soaking the seed for periods up to seven days followed by further cold storage in a damp condition for three to five weeks. Before despatch to the nurseries the seed is again dried and dusted with fungicide.

Tree Breeding

It has been demonstrated that the quality and vigour of pine trees can be greatly improved by selective breeding. A tree breeding programme was commenced in 1957 to produce trees of improved form, vigour and timber quality in both *P. pinaster* and *P. radiata*. Surveys of several thousand acres of local plantation produced 16 trees of *P. pinaster* of the very best quality for breeding. Additional breeding material has also been obtained from the native forests in Portugal.

Superior trees of *P. radiata* have similarly been selected for breeding from local, Eastern States and New Zealand plantations. Seed orchards have been established by grafting from select trees and, in the near future, will provide seed of greatly improved genetic quality for our future pine plantations.

Nurseries

Pine plantations are established by planting out one year old seedlings which are raised in nurseries.

Before large scale planting could take place more problems had to be solved in nursery techniques under Western Australian conditions. Early attempts to raise pine seedlings in nurseries proved a failure. Research into the matter established that certain fungi, one, of the puff ball type and another, similar in habit to the mushroom, were a necessary presence in the soil for healthy pine growth. Only when an association exists between these mycorrhizal fungi and the roots of the pine, is satisfactory growth achieved. In other lands, where pines occur naturally, this fungus is present in the soil, but it was found necessary in W.A. to inoculate new nurseries with the soil fungus.

The seed is sown during August. The nursery beds usually consist of 6 rows about 8 inches (*20 cm*) apart and the rate of sowing is designed to give 10 seedlings per foot (*30 cm*) of row.

Plate 49

The pine nursery at Hamel, 1970. Up to 7 million pine seedlings are planted each year

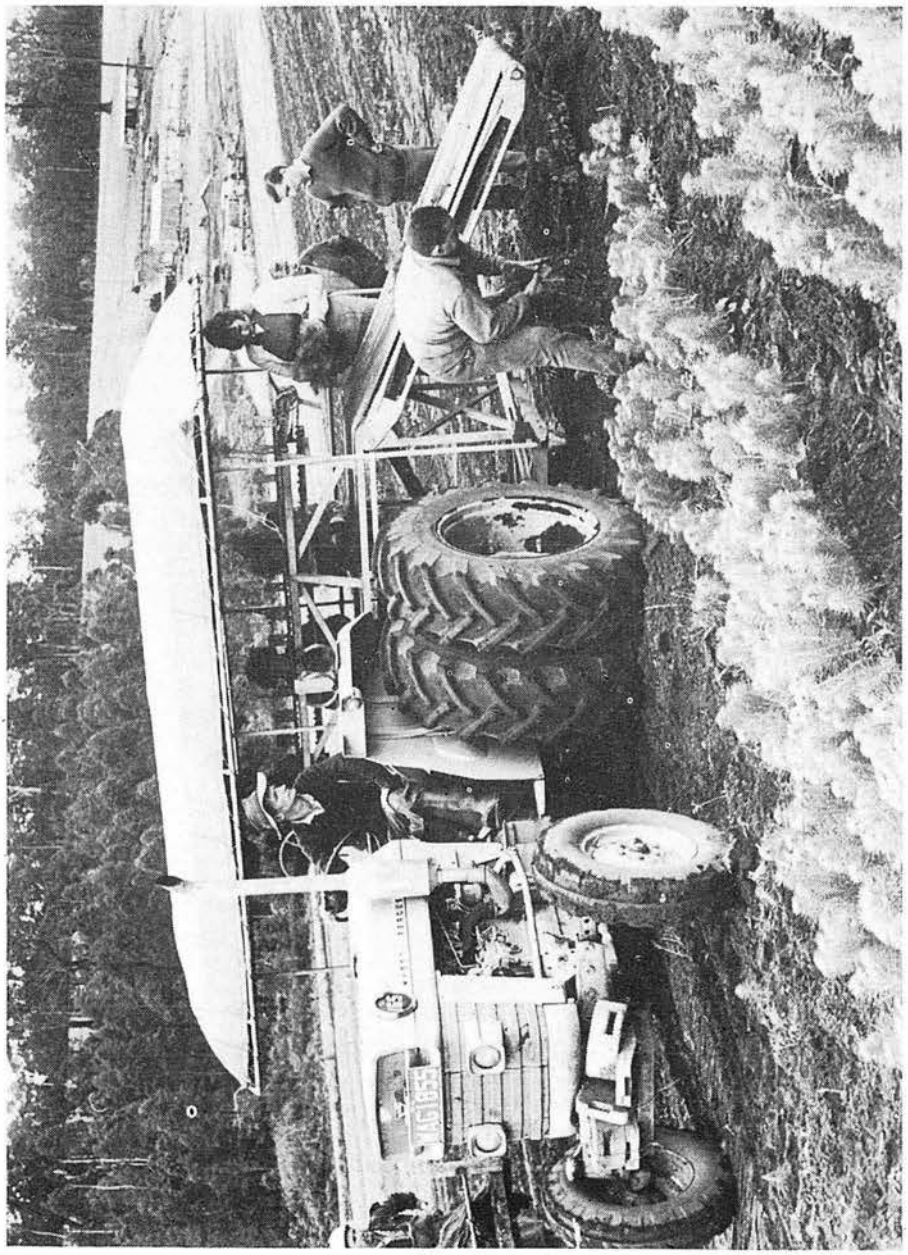


Plate 50

A mobile pine sorting and bundling table in the Nannup nursery. After root cutting the lifted pines are placed on an endless belt, sorted, counted, bagged and transported to the field for planting. The unit is capable of handling 13,000 plants an hour

All operations in the nursery are mechanised as far as possible and the layout of the nursery is therefore designed to provide the longest possible length of bed for economical use of machinery.

The major problems in the nursery are the control of weeds and "damping off" fungi. The soil is often sterilised prior to sowing to kill the harmful fungi and some of the weed seeds. Special chemical weedicides are also used both before and after sowing to eliminate weeds. Attacks of "damping off" in the young seedlings are treated with a fungicide drench.

Nurseries are generally worked on a three years cycle rotating the pines with green crops which are ploughed in to maintain the soil organic matter and structure. Current investigations aim at developing techniques of mulching with sawdust or adding organic matter in the form of peat to obviate the need for costly and wasteful green cropping.

Nurseries are watered through the summer and the plants are lifted for planting in the field during June and July of the following winter.

Ground Preparation for Plantation Establishment

In early attempts at pine establishment the methods which were used in Europe were tried. Partial clearing and direct sowing of the pine seed results, in the West Australian climate, in almost complete failure. Experience showed that very thorough

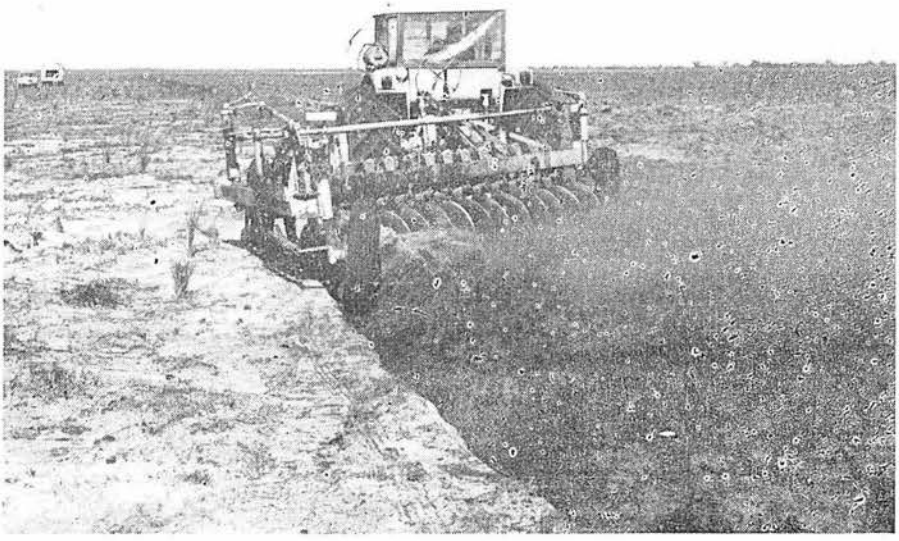


Plate 51

Ploughing prior to planting in the coastal sands north of Perth. It is this bare country, so unattractive for agricultural purposes, that produces pine plantations of the quality shown in Plate 48

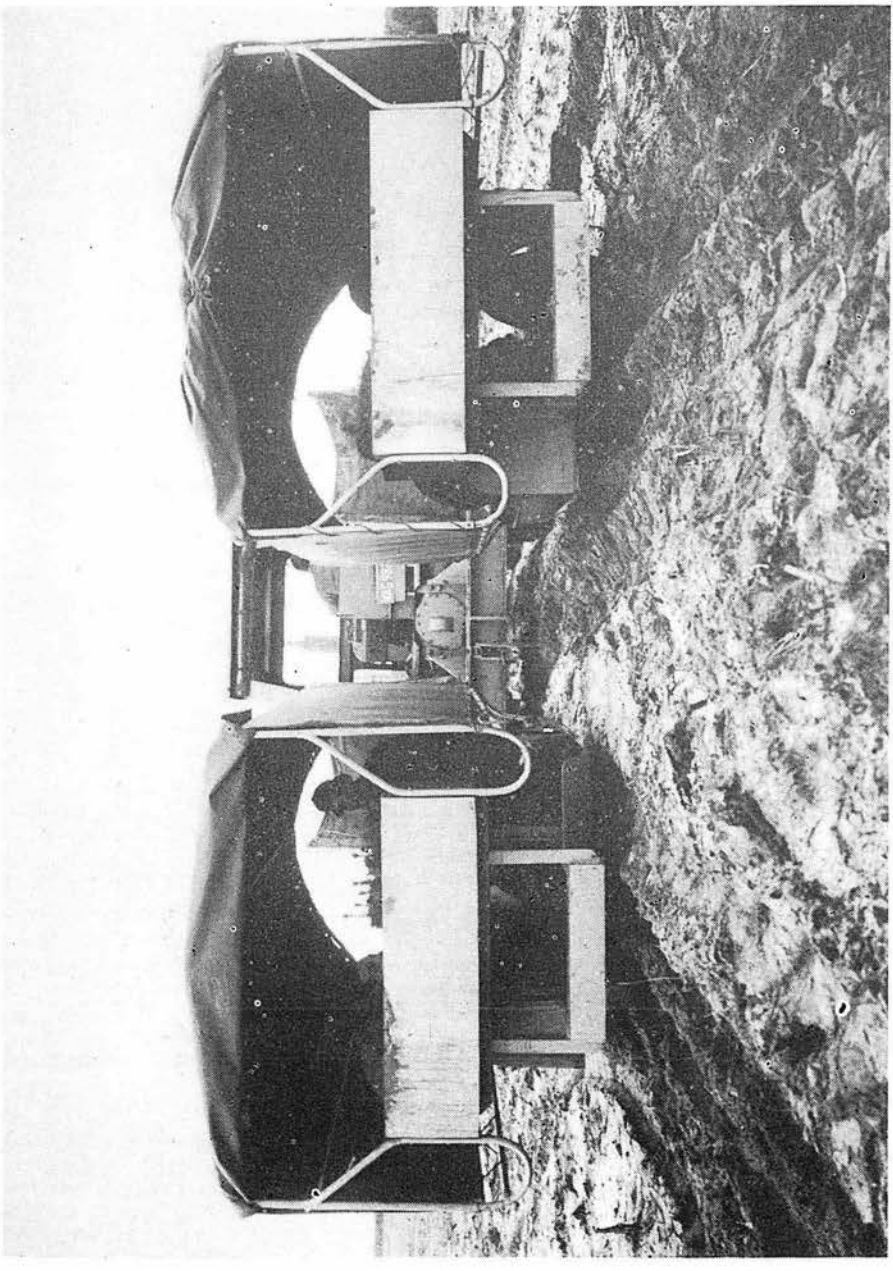


Plate 52

Paired pine planting machines operating on the coastal plain north of Perth

site preparation with complete clearing and either ploughing or spraying with weedicides to eliminate competition from the native species, is essential.

Clearing is carried out by bulldozer. In heavily timbered country, after utilisation of all saleable timber, the trees are pushed down and windrowed for later burning. In lighter forest on the coastal plain, clearing is by "chaining". Two large bulldozers with a heavy chain between them pull down the native timber. This is left to dry out for at least one summer before being burnt.

The final clearing consists of burning up the remaining debris and eliminating the scrub regrowth. Regrowth is controlled either by deep ploughing, on the sand plain, or by spraying with weedicides, on the steeper country.

Planting

The planting of the prepared areas takes place in June and July following satisfactory rain, and is carried out either by means of special tractor-drawn planting machines in suitable country or by hand planting in the steeper and rocky areas. The young trees are generally planted at a spacing of 8 ft. x 6 ft. *(2.4 m x 1.8 m)* or 910 per acre *(2,249 ha)*. The reason for this seemingly close spacing are many, but principally it is to ensure that straight trees with small branches are formed. Also, this close growth enables the young trees to quickly form a canopy over the land and eliminate competition from the natural growth of the original vegetation. Another reason is that, from the original large number of trees planted, a good selection can be made of trees which are to be kept as the final crop.

Application of Fertilisers

Greatly increased growth rates can be obtained in some case by applying artificial fertilisers to the pines.

For example, *P. pinaster* will make little or no growth on the infertile sands of the coastal plain unless phosphorus (in the form of 2 ozs. *(57 gr.)* of superphosphate per tree) is added immediately after planting. Subsequent broadcast applications of superphosphate are needed to keep the trees growing at the optimum rate.

The application of phosphatic and nitrogenous fertilisers to *P. radiata* and *P. pinaster* has been shown to be very beneficial in other situations and large scale trial work is continuing so that timing and rates of application can be defined more closely.

Of the minor or trace elements, the addition of zinc has been shown to be essential, in some areas, for the continued health and growth of the pines.

Tending the Plantation

Planting the young pines does not complete the operation of plantation establishment, for care or tending must take place after the initial planting. Coppice or "sucker" growth of natural plants in the early years can cause competition with the young pines, and unless treated may cause the failure of the area. The coppice and other unwanted species are either slashed, hormone sprayed or ploughed-in one or more years after planting, to allow the pines to take possession of the site, after which time no further natural vegetation will appear.

Pruning

Pine trees in their natural state produce side branches, which unlike the eucalypts are persistent and do not fall off when they die. To produce clear timber the operation of pruning is carried out and these limbs are removed either by skilled axemen, by

Plate 53

Another view of the pine planting machine. A ploughshare between the wheels opens a furrow into which the pine seedling is placed; the angled rubber wheels behind the operator's hand then squeeze the earth around the erect seedling and a measured dose of fertiliser is added as the seedling emerges from the tamping wheels.

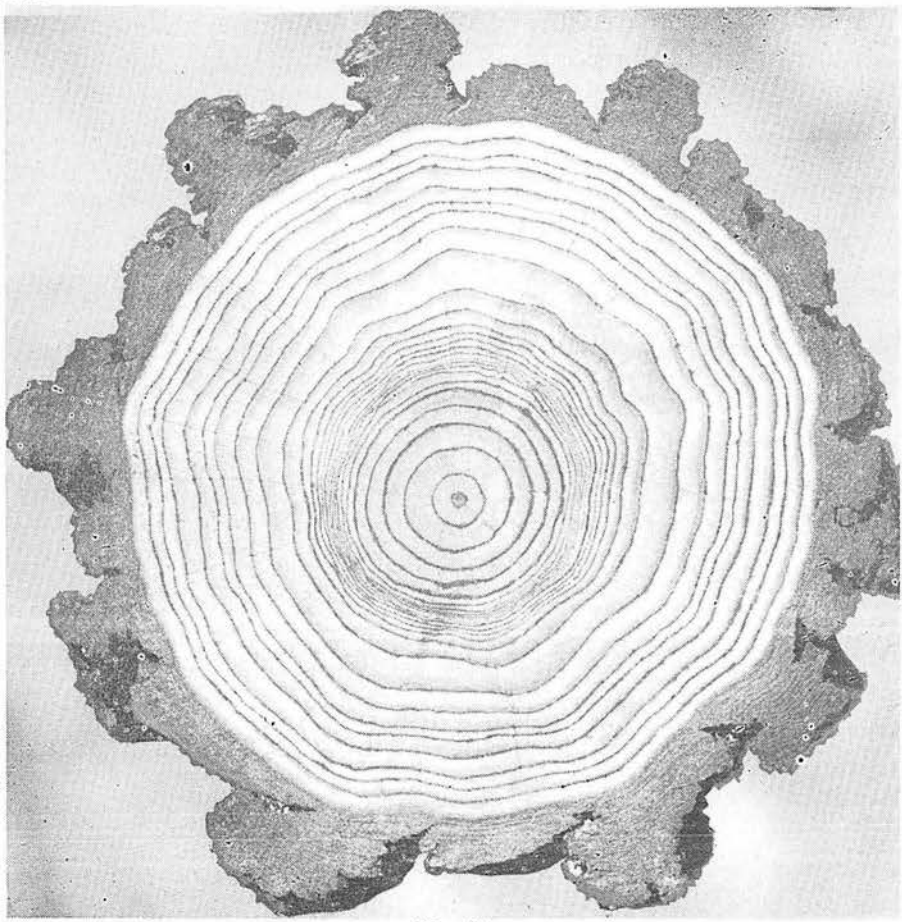


Plate 54

The effect of superphosphate fertiliser in pine plantations. When applied to this tree at age 16 years, superphosphate produced the increased growth shown by the greater width of the outer rings

cutting with long-handled secateurs or by the use of a pruning saw. The trees can then increase in volume without having to enclose the dead side branch which results in knotty timber.

Pruning is carried out in two or more stages. Trees which are selected for the final crop are high pruned to 15 feet *(4.6 m)* or more. It is important that this operation is carried out when the trees are small so that the "Knotty core" is kept to a small diameter, preferably no more than 6 inches *(15 cm)*.

Thinning

As the trees develop it is necessary to remove part of the stand to allow the remaining trees room to grow. The number of trees is reduced successively by selection "thinning" in which the poorer trees are removed.

Thinning aims at maintaining maximum growth on the final crop trees which are selected early in the life of the stand. The thinnings are usually sold and provide a useful intermediate yield from the plantation.

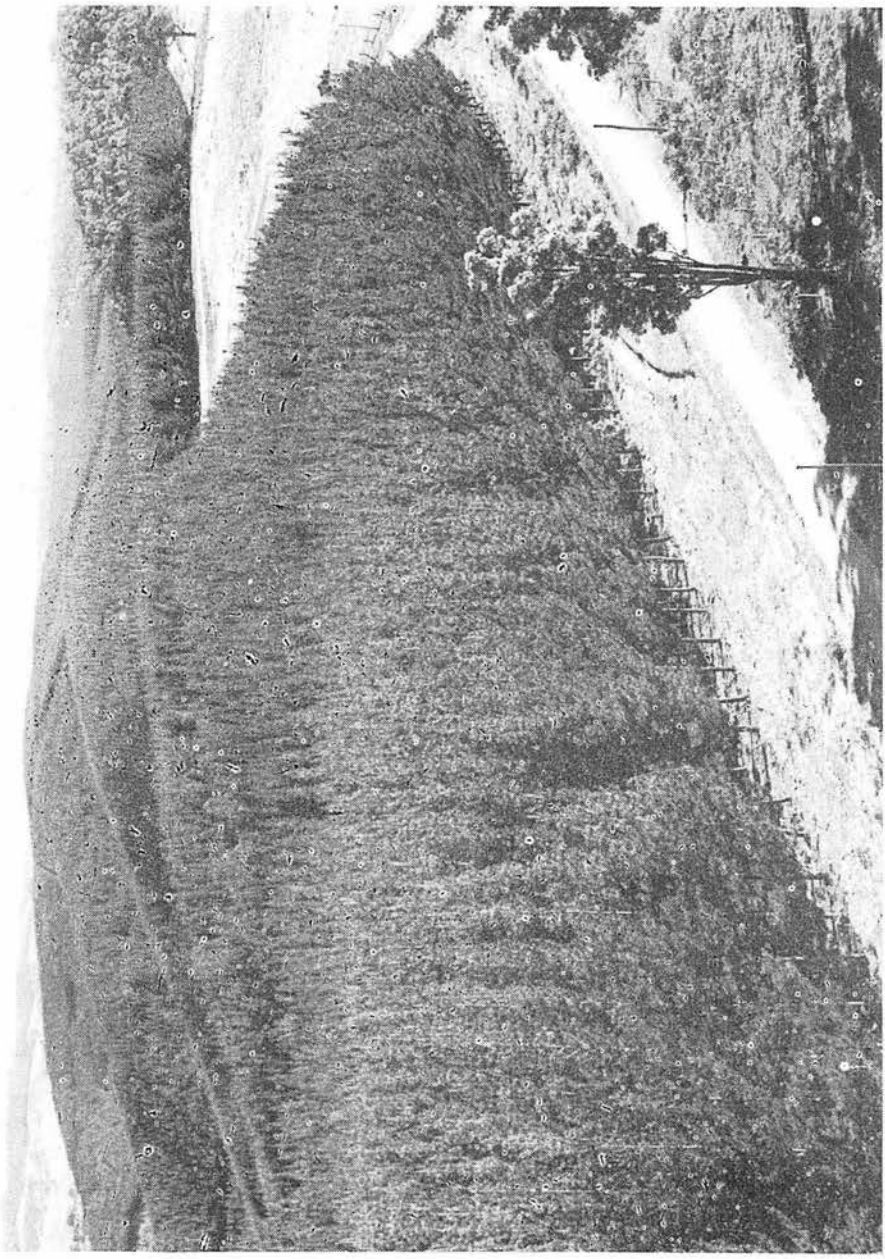


Plate 55

A general view of the *P. radiata* plantation at Milward near Nannup. The pines in the foreground are barely 11 years old

The rotation length or age at clear falling varies with species, situation and market opportunities. Forestry is a continuing process and when the mature trees are finally felled, a new crop of young pines is established on the site.

Fire Protection of Plantations

Pine plantations represent a large capital investment and they are very susceptible to fire. The risk of fire is ever present each summer in West Australia and accordingly, a great deal of planning and effort is expended in reducing the fire risk and maintaining an efficient fire control system. Fire breaks and roading systems are established and maintained. Prompt fire detection is ensured by a system of fire lookout towers, and an efficient fire fighting organization of trained men and modern equipment is constantly ready to deal with fires in the forest.

Pine plantations produce a heavy accumulation of inflammable litter. This litter can be removed and the fire hazard greatly reduced without damage to the trees by careful controlled burning during the winter months. Hazard reduction by controlled burning of strategic buffer zones is carried out in many of our plantations.

Forest Pests and Diseases

Pines are subject to many diseases and damaging insect pests, notably Sirex Wasp *(Sirex noctilio)* and the leaf cast disease caused by *Dothistroma pini.* Fortunately in Western Australia our plantations are very free of disease, no doubt due to our isolation and to vigilant plant quarantine precautions. Careful tending to maintain the trees in a vigorous condition is also a safeguard against disease.

Plantation Management

Management of pine plantations like any other forestry project requires long term planning as well as day to day organisation.

Working Plans are prepared for each plantation centre. These plans present a description of the plantation resources and define planting programmes and silvicultural schedules for the tending of the stands. Thinning schedules are drawn up presenting forecasts of future timber production.

CHAPTER VI

FOREST MANAGEMENT

Forest management is the application of business methods and technical forestry principles to the operation of a forest estate according to the policy of the owner of the forest.

The Forests Department of Western Australia has the exclusive control and management of the State Forests of Western Australia, where forest management takes into account the multiple use of all forest resources which include timber, water, recreation and wildlife. All foresters look on State Forest not as a great reserve in which trees should be hoarded for the future, but as a productive unit from which the annual production of multiple resources can be harvested for public use, replaced and ultimately increased by good management. Whether the forest concerned is State owned or privately owned, forest management is a business. As such, technical knowledge and managerial ability must be used to manage the forest for the maximum benefits of the State as a whole.

The Development of Forest Management in Western Australia

In the years up to 1918 the forest area was largely unmapped, had few tracks. was ravaged by wildfires and subjected to uncontrolled exploitation. After the passing of the Forests Act in 1918 the Forests Department began to develop roads in the forest for fire protection and survey purposes, to control exploitation and to ensure orderly harvesting of the forest crop as a self perpetuating asset for the benefit of future generations.

In addition, mapping and assessment was commenced in order to obtain estimates of the volume of marketable timber in the forest. Using this information, management plans were prepared for the maintenance of existing sawmills and the introduction of new ones.

Management plans for all areas are now combined into a document known as the general working plan for the hardwood forest, and under Section 31 of the Forests Act, this has the effect of a law governing operations on a forest area.

A general working plan is also prepared for pine plantations and this follows the principles described for the hardwood forest.

Forest Inventory

Any form of continuous management of a forest area requires a large amount of varied and usable information. In Western Australia information about the forest itself, excluding research data, is obtained from forest inventories compiled mainly with the assistance of photo mapping at two field centres called Working Plans Offices.

Computer processing of field data has allowed more useful information to be made available more quickly and more economically than ever before.

Air Photos

The most important advance in the field of forest inventory to date has been the use of air photos. Before World War II it is estimated that over 100,000 man-miles (*160,000 man-kilometres*) were walked classifying and measuring the forest. Since World War II classification of the forest into different types according to

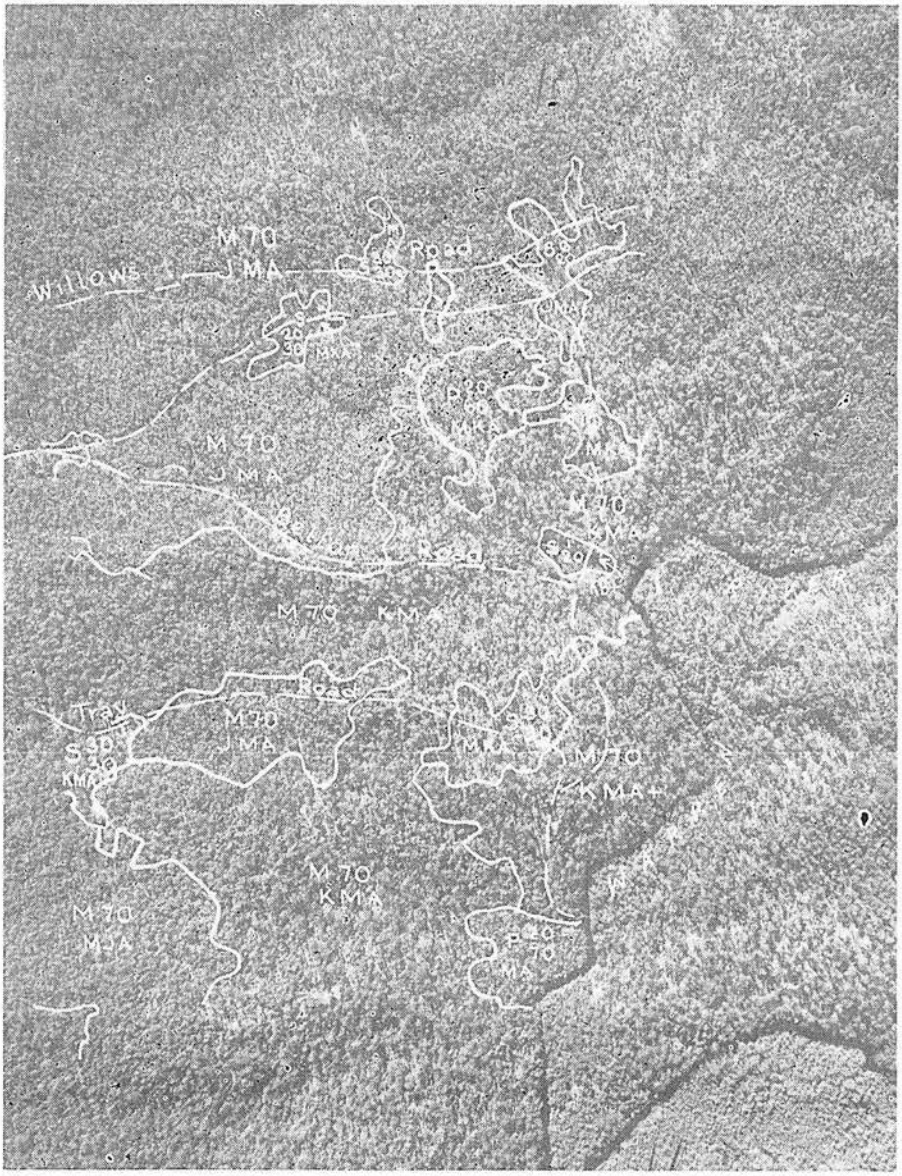


Plate 56

Part of an interpreted aerial photograph. The photo has been marked to differentiate species and stocking. Thus—J. indicates Jarrah, M—Marri and K—Karri; M70 signifies mature with 70 per cent. crown cover; A, B indicate height class and S refers to sapling forest, etc.

species, crown density and stand height has been carried out with the aid of air photos.

Photographs have given more complete information of the location, nature and extent of forest areas than the previous method, while at the same time, costly and tedious field work has been reduced.

It is also possible in some cases to measure stand volumes directly from air photos and this can reduce field work even further.

An experienced interpreter using aerial photographic interpretation (A.P.I.) techniques can locate stands which have been cut over, regenerated, fire damaged, affected by disease, or recently roaded. All this information can be plotted easily with the aid of modern mapping equipment and made available for forest management purposes.

Research is being carried out to improve the value of air photos by determining the most suitable combination of film, filter, scale of photography and the most suitable season of the year for detecting any activity in the forest.

Assessment

Sample plots are measured by two-man teams in both native hardwood forests and pine plantations. One per cent or less of the total forest area is actually measured, but as the location of the plots is selected in a statistically sound way using air photo type maps, a desired level of precision can be achieved.

In the hardwood forest, assessment plots are generally rectangular 20 chains (*400 m*) by 1 chain (*20 m*) (2 acres) (*0.8 ha*) in size. They are located by chain and compass survey and every tree on the plots is carefully measured.

Standards of assessment are controlled from the two field Working Plans Offices. Estimates of marketable volume are continually checked and in this way the quantity of timber available to any sawmill can be determined quite realistically. Data is recorded on specially designed field sheets from which skilled girls prepare punched cards at a computer centre. When the cards for all the plots in an area have been prepared they are processed by a computer programme written by a forester to produce the required final information.

In plantation assessment the basic procedure is similar to that for hardwoods except that trees to be measured at each sample point are selected in a special way called angle count sampling.

Working Plans Branch

The Working Plans Branch is responsible for providing basic information needed in the preparation of both the hardwood and softwood working plans.

Using assessment information obtained from the field teams, growth rate information from permanent plots, and records of all earlier forest operations, the working plans branch is able to prepare new information and to revise old volume estimates so as to balance estimated growth against the rate of timber harvesting operations. In this way it is possible to calculate the amount of timber which can be supplied continuously from a particular area of forest.

This technical work needs information from many sources and knowledge of the most modern methods to enable the manager to practise competently the science and art of forestry.

The Working Plan

The Working Plan describes the way in which the forest area is to be managed to fulfil the policy requirements of the Forests Department, within the framework

Plate 57

A hardwood assessment team measuring a karri tree

of State Government Policy. The plan must be flexible enough to cope with the differences in climate, topography, and forest types which occur over the 4.6 million (*1.9 million ha*) acres of State Forest in Western Australia.

To do this the forest has been divided into 15 administrative divisions each of about 300,000 to 400,000 acres (*120,000* to *160,000 ha*) which in turn consist of about 30 forest blocks, each approximately 10,000 acres (*4,000 ha*) in area.

Inventory information is collected on the basis of these forest blocks and proposals are drawn up to utilise the timber on them. So that the forest resources are never depleted, cutting is regulated to ensure that the volume removed is equivalent to the growth put on by the forest. This is the same thing as removing only the accumulated interest from a bank account each year, so that the capital in the bank account is never reduced. In the forest this "sustained yield" approach to forest management ensures a regular supply of timber and provides the basis for a stable forest industry.

However, the timber marketing situation is continually changing, new logging and sawmilling techniques are being developed from time to time and new inventory information is constantly providing better figures, consequently the Working Plan is reviewed at five to ten-yearly intervals to take into account this continually changing pattern.

ASPECTS OF FOREST MANAGEMENT IN WESTERN AUSTRALIA

Control of Sawmilling Operations

Following recommendations laid down in the Working Plan a sawmill is granted a permit to cut a specified quantity of timber each year.

The forester then prepares a logging plan to provide this timber from the forest in such a way that a future crop will always be available and that no uncontrolled cutting of the forest occurs.

Each tree that the forester considers can be safely removed by the sawmill is marked with a distinctive brand which also indicates the direction in which the tree should be felled. This system ensures that immature and vigorous trees are not cut and that felled trees do the least possible damage to the remaining crop.

Where timber is required for purposes other than sawmilling, such as mining timber, poles, piles and firewood, the same manner of regulation is applied, ensuring that these operations do not destroy young trees.

Collection of Royalty

All timber removed from the forest is subject to a fee or "royalty". Records of all timber removed are carefully kept and each month the sawmiller submits to the Forests Department a list of the logs he has taken from the forest and for which he subsequently pays royalty. The money collected in this way forms the major part of Departmental revenue and is spent on the protection and regeneration of existing forests and the development of new forests to meet the future needs of the State.

Regeneration of the Forest

The forester must replace all trees removed from the stand with vigorous young saplings, thus leaving the stand in a more productive condition after the logging and regeneration operations than it was beforehand.

In the jarrah forest a "top-disposal" burn, lit under appropriate weather conditions, is used to remove the debris from tops of trees felled during logging and

Plate 58

Vigorous 4¼ years-old karri regrowth west of Manjimup

Plate 59

A 95 year old regrowth stand of karri. Most of the dominant trees are over 90 inches in girth

this allows any advance growth present to develop freely. Before the top-disposal burn, tops and other inflammable debris are cleared away from the boles of standing trees so as to avoid damaging them during the burn.

Regeneration of karri stands is obtained from natural seedfall. After the trade cut, scrub is rolled flat and all unwanted trees are felled. This debris is then burnt at a time when seed has ripened in the crowns of specially selected seed trees. The seed is released by the heat from the burn and falls onto the ash beds produced from the burnt debris, where it germinates after the first winter rains. Once adequate germination has been obtained the seed trees are also felled, leaving the area completely free for the subsequent development of the seedlings into plantation-like stands of even aged trees. Sometimes when inadequate natural regeneration is obtained, seedlings are planted in unstocked areas to ensure that a fully stocked stand will be obtained.

Regeneration is one of the most satisfying operations to a forester who can see that by the use of his skilled training and experience a new crop of vigorously growing young trees has been added to the forest.

Roadmaking

The Forests Department has constructed a continuous network of roads and tracks throughout the forest to provide access for fire control and logging operations.

Arterial all-weather roads provide the major systems, followed by sub-arterial roads, forest tracks and firelines, the standard of construction varying according to the planned use of the road.

The greater the development in any area, the more intensive has been the road system, and at the present time there are over 16,000 miles (*256,000 km*) of roads and tracks servicing the forest areas of Western Australia.

A fleet of machines is maintained to keep pace with new road construction and maintenance of existing roads, and of course to provide transport and equipment for all other operations in the forest.

Mapping

All those forest areas in Western Australia which have been developed to any extent are now covered by detailed maps. As new information becomes available, old maps are amended and new maps are prepared by the drafting branch of the Forests Department.

Many of the earlier maps were prepared from ground survey, using a theodolite for arterial roads, and compass and chain for forest tracks. Nowadays most maps are prepared from air photos using precision built Swiss photo plotting equipment which requires only a small amount of ground control work.

Housing

The Forests Department has found it necessary to establish settlements so that the skilled officers and employees needed for forest operations, and particularly for fire fighting, can be housed at strategic centres and be readily available in an emergency.

The settlements contain over 500 houses as well as offices, workshops, garages and in some cases research stations. These provide the necessary facilities for maintaining Departmental equipment and for carrying out scientific investigations into many of the biological and technical problems confronting the forester.

Jarrah Dieback

The soil-borne fungus *Phytophthora cinnomomi* is the casual agent of the disorder known as jarrah dieback. It destroys the fine feeding roots of a wide range of hosts besides jarrah, gradually depriving them of access to moisture and nutrients until they die. By 1970 approximately 5 per cent of the forest area was affected by this disorder. (See Chapter IV—Forest Pathology.)

Physical control being too expensive, the Forests Department is using hygiene measures to reduce the rate of spread of the disease. This involves such controls as the segregation of operations in affected forest from operations in unaffected forest: washing down vehicles which do have to go into unaffected areas: not using gravel from an affected area for roading purposes. All the hygiene measures are designed to prevent the transport of fungal spores to unaffected areas and so reduce the rate of spread of the disorder to minimal proportions. Its success depends on the necessary controls being strictly observed at all times. The excellent co-operation given by the sawmilling industry and other forest users so far, indicates that this is possible.

Logging priorities in areas with dieback, are prepared so that severely affected stands are cut first, then those not so severely affected. Stands not affected are logged last, again observing strict hygiene measures.

Once an area is logged it is replanted with species resistant to *Phytophthora cinnamomi* such as *Pinus pinaster* and *Eucalyptus microcorys*.

Recreation

With an increasing population which is more mobile and has more leisure than ever before, the use of forest areas for recreation is also increasing. It has been estimated that in 1969 over 230,000 people visited State Forest areas within 35 miles (*56 km*) of Perth.

The Forests Department welcomes responsible visitors to the forest, and in conjunction with the National Parks Board and other bodies, has developed a number of scenic drives, picnic spots, walking trails and ornamental plantations for public use throughout the forest.

Selected areas of virgin forest have been set aside for scenic as well as for scientific purposes, and in a number of places, special management prescriptions have been introduced to preserve the beauty of the forest for all to enjoy, without conflicting with the productive role of the forest.

The only things required of visitors to the forest are that they enjoy the forest environment as responsible citizens taking particular care with camp fires, avoiding damage to wildflowers and wildlife or to essential telephone lines and fire lookouts upon which the safety of the forest depends.

Co-ordination of Forest Management in Western Australia

The forest organisation in Western Australia covers a wide area and because of this, groups of three divisions with their respective Divisional Officers are controlled by Inspectors who are in turn responsible to Superintendents for all matters of field administration, execution of management plans, works programmes, and allocation of finance to meet these programmes.

Plate 60

Part of the Gleneagle picnic ground on the Albany Highway, 33 miles from Perth. Stone fireplaces, rustic tables and chairs and litter bins are provided by the Forests Department

The money available for forest management is mainly derived from the sale of log timber together with Government grants for additional works such as special road construction, pine plantation establishment, or development of tourist facilities. The amount of work which can be done each year depends upon the amount of finance available. Annual works programmes are drawn up according to the priorities set down in the Working Plan. Working Plans must therefore be sufficiently flexible to take efficient advantage of the actual amount of money which is available for each year.

Each division keeps records of works' progress and costs to enable total expenditure to be kept within specified limits, and prescribed quantities of work to be achieved.

In addition, records are kept of areas of treated forest, areas of forest that have been cut over, areas of top-disposal burns, areas regenerated, areas control-burned, areas assessed, new roads constructed, and any other activities which are important to forest management.

CHAPTER VII

HARVESTING AND MARKETING OF FOREST PRODUCTS

(Utilization)

Utilization of the forest resource concerns the harvesting and subsequent treatment of forest produce to provide marketable material, and is another important branch of forestry. It is the end towards which all the art and science of management, protection and silviculture are directed.

Utilization of the State's forests to supply timber for local and export requirements is one of the oldest aspects of the State's economy. The capacity of our hardwood forests to produce the durable, reddish, mahogany-like timber later to be known as jarrah, was an early realisation in colonial days, and its subsequent exploitation did much to aid initial development of the State.

FOREST PRODUCTS

The major forest product in this State is sawn hardwood timber obtained from mature trees of jarrah, karri, wandoo, marri and W.A. blackbutt. These hardwoods have been used for practically all purposes in this State—even for uses where softwoods would be more suitable.

Western Australia, of necessity, imports softwoods and softwood products, and this position will remain until sufficient areas of our ever increasing pine plantations reach merchantable size.

There are, however, many other products such as poles, piles, fence posts, particle board, plywood, charcoal, honey, boronia blossom etc. which in themselves are vital to our economy, but whose value is considerably less than that of the major forest product—sawn timber.

Building Timbers

This is the avenue of greatest sawn timber consumption, and dwelling construction is by far the most important consumer within this group. Sawn timber is used for the numerous purposes of framing, flooring, lining, panelling, joinery, etc.

Jarrah, karri and wandoo are eminently suited for such purposes and widely used.

Constructional Timbers

Under this heading are included round and sawn timbers, generally of large cross section.

Girders are the elite production of the hardwood forest. Demanding qualities of length, strength, straightness and a reasonably high degree of durability, karri is the ideal girder timber and consequently much in demand.

Large beams of long span can also be produced by gluing many layers of boards together. This material is called "glulam".

Sleepers

Western Australian hardwoods have established a wide reputation for the excellent railway sleepers that have been exported. This export trade was reduced of necessity during the war, but has since revived.

Since the lifting of export restrictions in 1957, overseas markets have accounted for some 80 per cent of the Australian export sleeper trade. South Autralia and the Commonwealth Railways have absorbed large quantities as also have the iron ore railways in recent years.

Wandoo is considered to be the finest sleeper timber in Australia. Jarrah also forms an excellent sleeper, high in strength and durability. Karri sleepers are not as durable as the wandoo and jarrah yet are suitable in drier areas where susceptibility to fungal rot and termite attack is not the major factor to be considered. Preservation by pressure treatment may open up a wider field for this and other species in the future.

Piles and Poles

Piles and poles are also elite products of the forest which must satisfy certain specifications of length, straightness, girth and durability. Jarrah is an excellent pole and pile timber because of its durability in the ground and reasonably high resistance to marine borers. Wandoo is classed as the most durable timber for poles found in the State, but is not so readily available as jarrah. Young marri, with its fairly high proportion of sapwood and its inherent strength qualities, is a suitable pole timber if treated with preservatives under pressure. Karri is also very suitable when treated. A pressure treatment plant at Picton near Bunbury is now producing large quantities of treated poles for use in telephone line construction. (See Plate 70.)

Fence Posts and Mining Timbers are largely obtained from the local forests adjacent to the industries concerned. Western Australia is very fortunate in that timber requirements for the mining industry, important to State development were very suitably met by species growing in the inland forests.

Jarrah splits well and is very durable in the ground and is widely used as a fencing timber. Wandoo is excellent for strainer posts, but is difficult to split into the smaller sizes most suited to fencing.

Manufactured Wood Products

Under this heading are included cases and crates, boxes, barrels and casks, furniture, matches, boats, caravans, etc.

Jarrah, karri, marri and W.A. blackbutt fill most State demands, but certain timbers must be imported to fulfil some specific requirements. For example, furniture demands a variety of timbers of set qualities of figure, weight and colour, often characteristic of tropical timbers. Manufacturing needs are highly selective in many instances but jarrah has wide application for furniture use. Softwood timbers, however, are often more suitable for boxes and crates, paper, etc.

Plywood Production

The plywood industry in Western Australia has made remarkable progress in recent years. An importing State in 1956, we now export considerable quantities of plywood, mostly to the Eastern States. Local pine logs (in increasing quantity) and karri are used for peeling, but imported hardwood logs, mostly from Sarawak, form the main bulk of supplies at present.

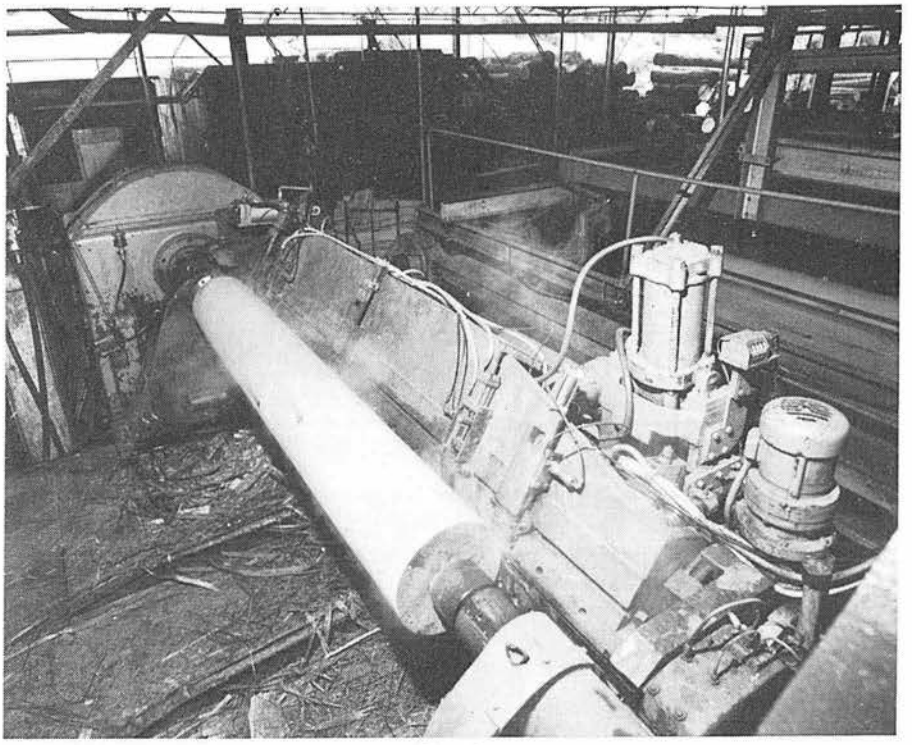


Plate 61

A partly peeled plywood log in a modern lathe in a suburban factory.

Plywood is the wood composite produced by cross-banding three, five or seven layers of veneer face to face with glue. The wood veneer is obtained from the log in long sheets produced by peeling on a lathe.

This product of wood is becoming increasingly popular in modern use. The desirable characteristics of ply—large surface area with no splitting or shrinking tendencies—are associated with a high recovery from the log.

Chipboard Production

A new industry producing chipboard from pine thinnings has recently been started in the Metropolitan area. This material consists of fine flakes which are lightly coated with glue, distributed over a forming trough then pressed between hot platens to form a dense sheet with similar properties to solid wood. The removal of a large volume of small-sized logs from the Metropolitan pine plantations for chipboard will result in the more complete utilization of each tree felled.

Charcoal Iron Production

Another interesting industry is the production at Wundowie of a high grade iron, using charcoal instead of coke.

The charcoal used in the smelting process is carbonised from waste wood left after all merchantable timber has been obtained from the logs by a modern sawmill. When

the mill logs have been removed from an area, the remaining unmerchantable trees are also felled and converted by firewood cutters into sizes suitable for charring in the retorts.

The by-products of wood carbonisation—acetic acid and methyl alcohol—are also separated and marketed.

Sandalwood

The sandalwood tree is a root parasite which once was widespread over the drier areas of the State. It has been extensively exploited, the wood fetching a high price from India and China where it is used in Joss Sticks for religious ritual. When burnt the wood is strongly aromatic. The wood is also favoured for ornamental carving.

Although all readily available supplies have been cut out, wood from more remote areas maintains a reduced but steady export trade to Asian countries.

Honey

Honey is another useful commodity obtained from our forests.

Karri honey is the most important. It is a high grade product, clear, light in colour, and with a delicate flavour and excellent consistency. The karri forests contribute about 25 per cent of all the table honey produced in this State.

Jarrah is not highly regarded as a nectar yielding tree. The coastal stands produce fairly large quantities of a somewhat dark-coloured and strongly flavoured honey more suitable for blending than for use in its natural state.

Tuart honey is light in colour, with a pleasing flavour and fine grain when candied.

Tannin

The actual tannin potential of Western Australian trees is treated in detail in Chapter III.

A plant is at present operating at Toodyay, to produce a tannin extract from the wood of the wandoo tree. This product, named Myrtan, is readily absorbed by the leather industry overseas, and is also used as a constituent of drilling mud used for oil exploration.

As far as possible, all sawmilling timber which can be utilized is removed from an area before the bush operations for the extract plant commence. Most of the remaining timber, including the larger branches, is removed to the factory where it is hogged (or chipped) into small pieces.

The hogged material is fed into vats where the water soluble tans are removed and concentrated to give a high quality tanning extract. The wood residue from the vats is used as a fuel to provide steam for the plant.

Marri is a tree with potentialities for producing tannin, but as yet extraction from this species is considered uneconomical.

Considerable tannin exploratory work has also been carried out with karri.

HARDWOOD LOGGING OPERATIONS

The operations concerned with the harvesting of the tree crop, are conveniently considered under the headings of logging operations—including felling of trees and the snigging and hauling of log material to the mill—and the final processes which convert the log into marketable material—milling, seasoning and preservation.

Plate 62

Felling a large karri tree (24 ft. 10 in. *(7.4 m)* girth) with a chainsaw

Felling

To operate a sawmill on logs obtained from State Forest or Crown lands, it is necessary to have a sawmilling permit. The area over which the mill is permitted to cut is set out in the permit.

In most permit areas, the treemarking system applies. Only trees marked by an officer of the Forests Department may be felled, and those retained produce the crop for the next cutting. Marking is normally by means of two blazes: one on the trunk to permit the faller to locate the tree and another, consisting of an axe-cut in the foot of the tree, which is stamped with a hammer brand to identify the tree marker and authority for marking. In addition to indicating to the faller that the tree is to be felled, the hammer brand shows the direction in which the tree is to be felled. The treemarker thus endeavours to protect, as far as possible, standing trees and regeneration from damage by the falling tree.

Recently, a system of cull felling was introduced in the karri forest. Broadly, the system aims at "proving" all trees of doubtful quality and felling useless trees with sufficient crown vigour to occupy effective growing space, thus making way for the establishment of a new crop.

Until about 1950 the axe and crosscut saw were exclusively the tools used by the faller to fell and prepare the tree for transport to the mill. The axe was employed to cut a scarf into the front of the tree and to trim off the side limbs. The crosscut saw was used on the back of the tree, opposite the axe scarf, to 'back" the tree down and to cut the trunk into suitable log lengths.

For a few years the axe and crosscut saw were replaced by the motor-powered circular saw which found widespread application to all but very big trees such as are found in the karri forest. These large trees were felled in the old manner, but power dragsaws were used to crosscut the bole into suitable log lengths.

After trials with a chain saw operated by two men, the industry now uses, almost universally, the one-main chain saw for the bush operations of felling and crosscutting. These saws, which are available in various sizes, cut by special teeth fitted on a power-driven chain, and are capable of felling trees ranging in size from small pines to large karri up to 25 feet (*7.6 m*) in girth.

Snigging and Loading

Once the log has been prepared by the faller, it is ready for transport to the mill. In some cases, logs are loaded on to a motor truck at the stump, but generally they are pulled (or snigged) to a central dump (or landing) for loading on to a motor truck.

Crawler tractors are used extensively to snig logs from the stump to the loading ramps. Where large logs are being snigged a logging arch is often used which enables the front end of the log to be raised from the ground, thus making snigging easier and reducing the amount of dirt and small stones picked up by the log. One of the disadvantages of the trailing logging arch is that in manoeuvering it into position, damage may be done to valuable regrowth.

In areas where logs are somewhat smaller and rather scattered, the recent introduction of fast moving, rubber-tyred units which both snig and load has proved successful. Loading ramps are not required for these units as they load directly onto logging trucks. The lifting and placing of logs is by hydraulic control and this means the minimum impact damage to logging trucks. Another advantage of these units is their ability to travel at 20 m.p.h. (*32 km.p.h.*) unloaded, so that a low loader is not required, as with crawler tractors, to move them from place to place.

Plate 63

Cross-cutting a karri log with a chainsaw

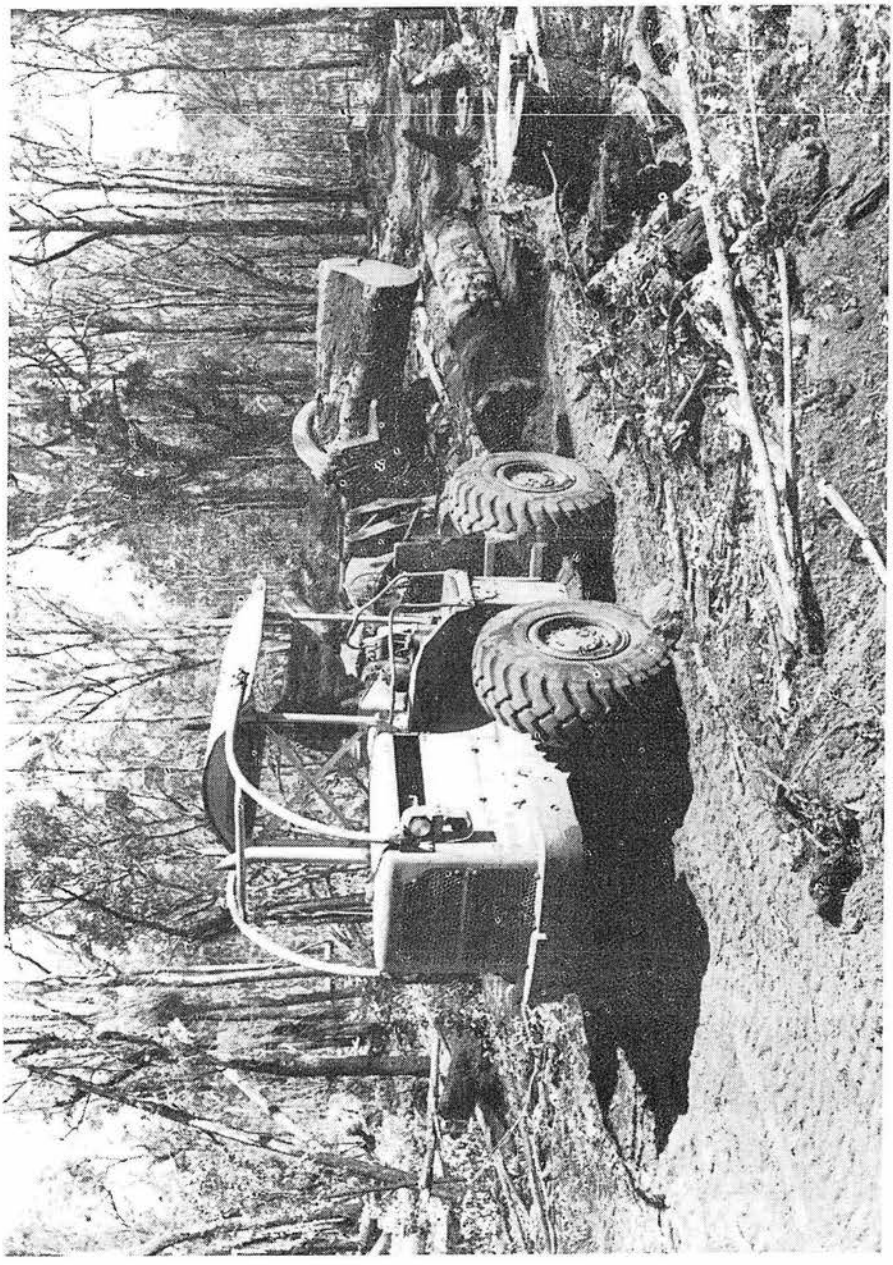


Plate 64A

A rubber-tyred logging machine snigs two jarrah logs and carries one in the forks

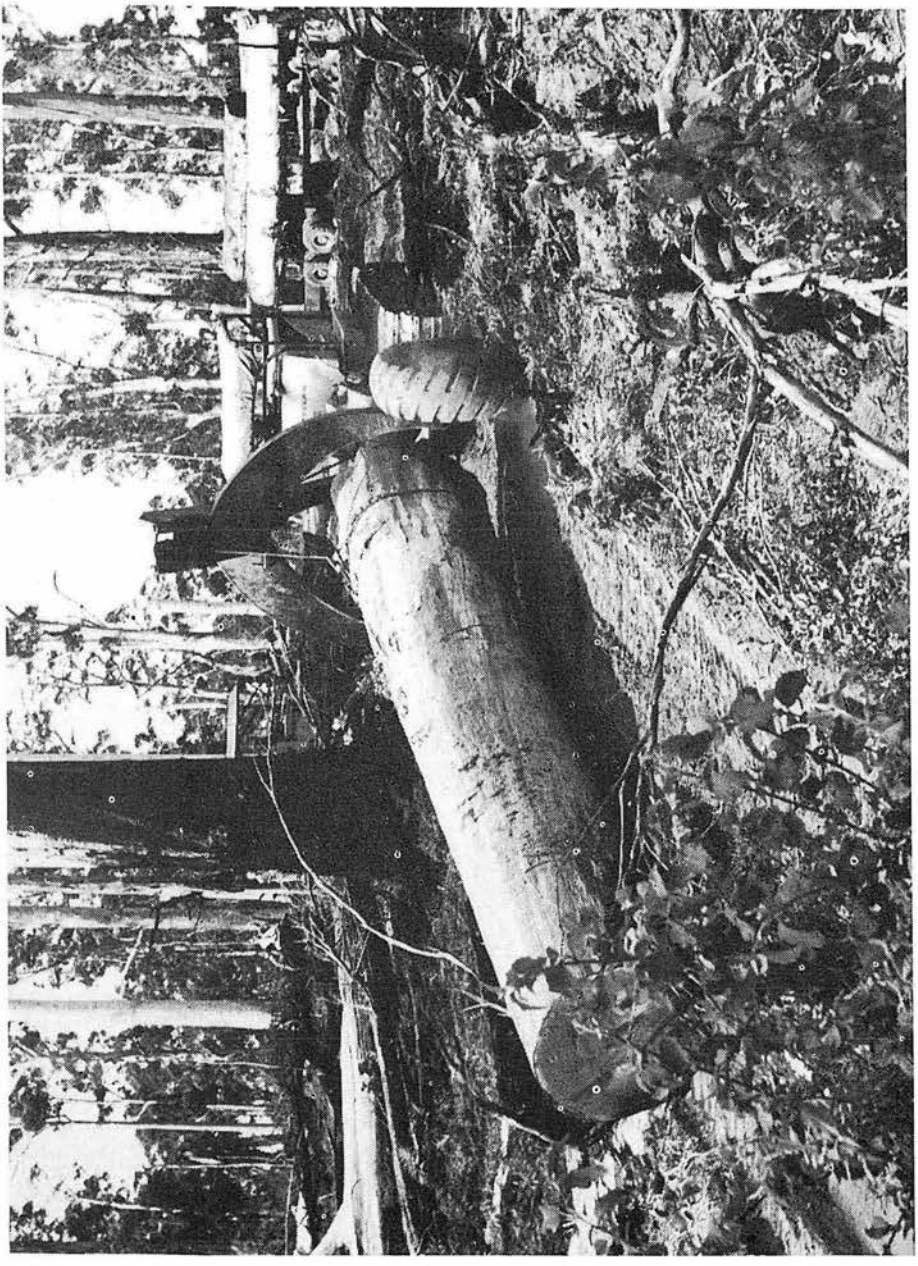


Plate 64B

A rubber-tyred logging arch holds the " nose " of a karri log clear of the ground as a crawler tractor hauls it to the bush landing

Plate 65A

The rubber-tyred logger uses its hydraulically operated forks to load a jarrah log on to a log truck

Plate 65B

In the karri forest the same operation is carried out by crawler tractor fitted with a dozer blade and forks. Here it "end for ends" a long karri log on to the jinker of the waiting log truck

The development of the four-wheel drive crane-trucks, commonly referred to as a "jib" or "quad", has revolutionised the snigging and loading of the smaller logs of the wandoo and marginal jarrah forests. The crane is powered by a winch driven by a power take-off from the engine, permitting small logs to be lifted at the stump, carried to the waiting haulage truck and loaded into position. This system does away with the need for a landing, and is extremely useful where log timber is scattered.

Bush landings are built-up ramps which allow logs to be rolled up the sloping ramps on to the back of a haulage truck. The earlier practice of using petrol winches in the jarrah forests and steam winches in the karri forest has largely ceased. The blade of a bulldozer is now commonly used for loading from ramps in both the jarrah and karri forests. However, some petrol winches are still in use, and of course the rubber-tyred units previously mentioned, which do not need ramps.

Hauling

In the earlier days of the industry, steam locomotives were used almost exclusively to transport logs from the bush landing to the mill. This method has been completely replaced by the use of motor logging trucks. Avantages of road transport over rail transport are—

(1) steeper grades can be worked;

(2) the sphere of operations can be changed quickly and with little expense;

(3) generally, the construction of suitable haulage roads presents no problems as gravel is readily available.

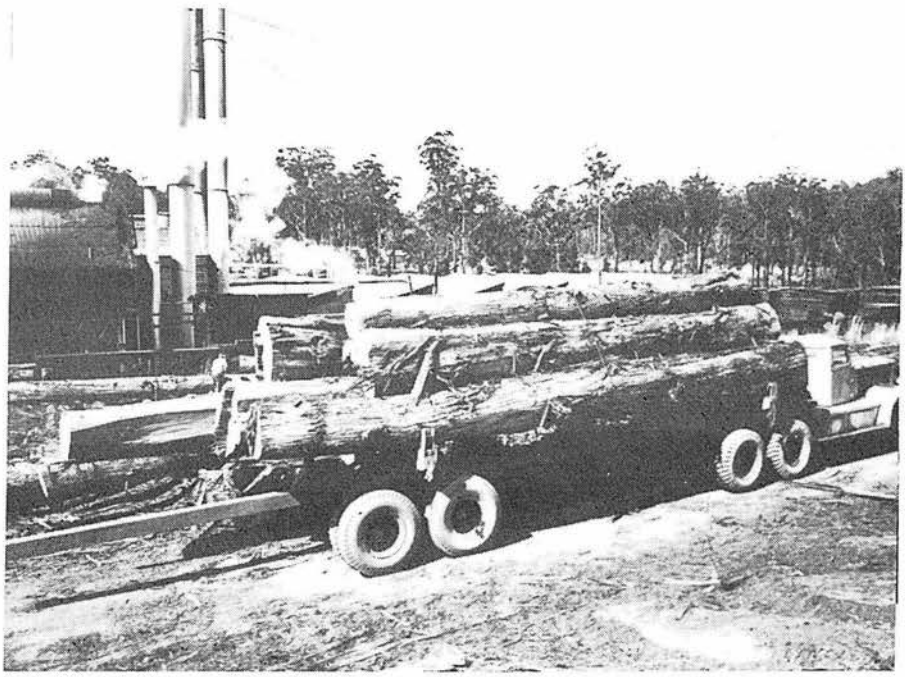


Plate 66

A log truck loaded with jarrah logs about to be unloaded at the mill landing—Wheatley

Other systems of log transportation employed overseas, for various reasons have not been employed in Western Australia. In the United States of America and Canada, it is common practice to float the logs down the streams to the mill. This system could not be used in this State because of the lack of suitable waterways. Other popular systems employing high-lead ground lines for haulage are only suitable in rugged terrain with a high volume of timber per acre. This condition is not met in Western Australia.

SAWMILLING

Timber milling is concerned with the conversion of logs into sawn products suitable for marketing.

Mills, in general, fall into two classes:—

(1) General purpose mills cutting scantling, railway sleepers and crossings, flooring and joinery stock etc.

(2) Special mills, usually small. These include the railway sleeper mill, the hardwood case mill and the pine mill.

General Purpose Mills vary in size. In the past, large mills employing 50 or more men under the mill roof were common. Nowadays, the larger mills average about 25 men under the mill roof, medium-sized mills about 15 and the remainder below 15, and as low as four.

Earlier mills were usually erected on sloping sites close to a good supply of water. Sloping sites permitted the use of gravity for easier movement of timber through the mill and water was necessary for the boilers, as all mills were steam powered. Wood fuel for the boilers was obtained from waste accumulated in milling.

Present-day mill design tends to select a reasonably flat site—for proper drainage a slope of about 1 in 40 is desirable—and mechanical means are employed to move the timber through the mill. A sloping site leads to difficulties with the handling and stacking of the timber produced.

Wherever possible, S.E.C. power is used for mills of all sizes. Electricity has the advantage of ease of transmission within the mill, compared with the belt drive of the steam or diesel-powered mill.

The basic operations involved in a general purpose mill are as follows:—

For convenience, the logs are brought into the mill in multiple lengths whenever possible. The first operation is to crosscut the logs into the most suitable lengths for the orders held by the sawmill or to obtain maximum recovery.

Following crosscutting the log passes to the breaking-down unit which, as the name implies, is designed to cut the log into suitable baulks or flitches for handling through the mill. The breaking-down unit consists of two circular saws, mounted verticall one above the other to enable cutting of large girth logs, or a single large bandsaw is used. Logs are moved through and past the saws on a power driven carriage which now has no rider on it and is completely controlled by the sawyer through push buttons.

From the breaking-down unit, the flitches pass to the saw benches. These vary in number with the size of the mill. A small mill may have a main bench (or No. 1) and one other small recovery bench subsequent to breaking down. In this case, the No. 1 bench has to do most of the cutting to size.

Large mills may have as many as three or four benches following the breakdown unit, together with the necessary docking saws. In this case, the No. 1 bench produces any material of large section, also carrying out the flitching for the next bench. The No. 2 benches do the resawing and are commonly referred to as board benches. No. 3 bench produces smaller recovery lines and some scantling.

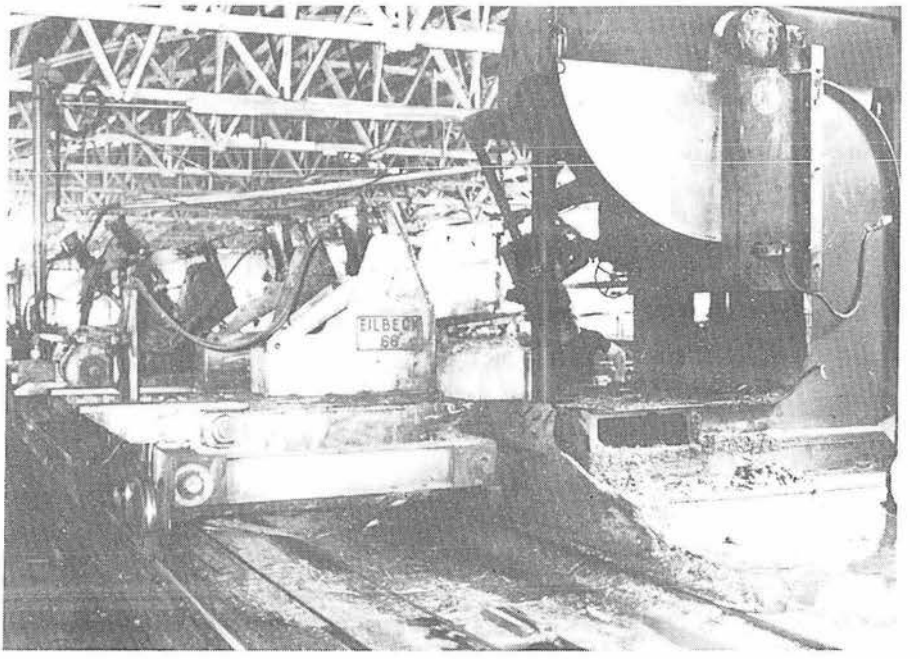


Plate 67

A bandsaw is used to " break down " this jarrah log into smaller sections. Note the " riderless " log carriage.

The Sleeper Mill falls into the small special group. Most of these mills cut timber only for railway sleepers, though some small scantlings, fence posts or pickets may be recovered from edgings.

Sleeper mills normally have a crude breaking down unit followed by one saw bench. Logs are cut to a neat length in the bush thus eliminating the need for a docking saw at the mill. Many early sleeper mills did not even have a breakdown unit. The log was "spotted" on the landing; that is, a flat face was cut with a broad-axe, and all the cutting was then accomplished on one bench. This method of handling gave rise to the name "spot mill".

All sleepers produced in Western Australia at present are sawn. Prior to World War II the sleeper hewer was a familiar figure in the bush, and at one stage all sleepers were hewn. Now the work is exclusive to the mills, and not even one sleeper hewer's permit is on issue at the present time.

The Hardwood Case Mill operates usually on short logs of poorer quality, producing small sawn boards for the different types of boxes and cases required by the community. However, in recent years the larger general purpose mills have produced most of the hardwood case requirements and case mills are now few in number.

Pine Mills which cut thinnings from plantations have increased in importance over the last decade. There are two broad types, the case mill and the general purpose mill. At present, about half of the sawn pine production is in the form of cases for the packing of a wide range of items from canned and bottled goods to crayfish tails and fruit. The general purpose mills produce larger dimension material for use in shelving, furniture making, lining board and for constructional purposes. Present indications are that there will be a steady increase in demand for local sawn pine in the future.

SEASONING OF TIMBER

For timber to be a satisfactory material in use, it is essential that its properties be stabilised as far as possible. The most important factor affecting the stability of timber in use is the fluctuation of its moisture content, as regards both initial drying from its green condition and subsequent atmospheric variations.

Seasoned timber is stronger than green and is less subject to "movement", decay, sap stain and attack by insects. It is also lighter in weight, a most important point when freight and handling costs are considered.

In addition, dry timber is necessary for most end uses because green timber cannot be satisfactorily painted or glued or treated with preservatives.

Seasoning entails the drying of timber to the stage where its moisture content is in equilibrium with that of the surrounding atmosphere. During this process appreciable shrinkage takes place but after seasoning, movement is slight and is in harmony with the cyclic changes from summer to winter. This cyclic change can be noticed in the boards of a polished floor.

Timber, particularly boards, may be dried under natural conditions by strip-stacking in the open air (air-drying) or artificially in specially designed kilns (kiln-drying).

Air-drying: Material to be dried is strip-stacked in large yards or open sheds exposed to the wind. Good air circulation is of prime importance and the stacks must be raised off the ground, with adequate space between them, and the yard must have thorough drainage and be so placed as to avoid obstruction by large buildings and tall trees. Under these conditions the time taken to properly air-dry local hardwoods may range from 12 months to two years depending on the size of the stock and the climate experienced. In modern mills, softwoods are usually kiln-dried straight off the saw.

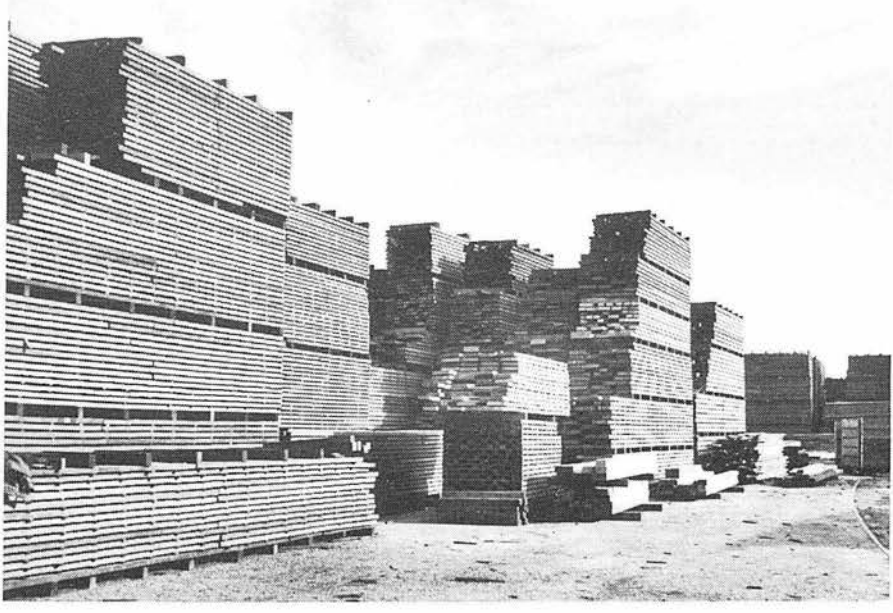


Plate 68

Sawn timber stacked for air-drying. Proper air circulation is essential for good drying and the prevention of fungal attack

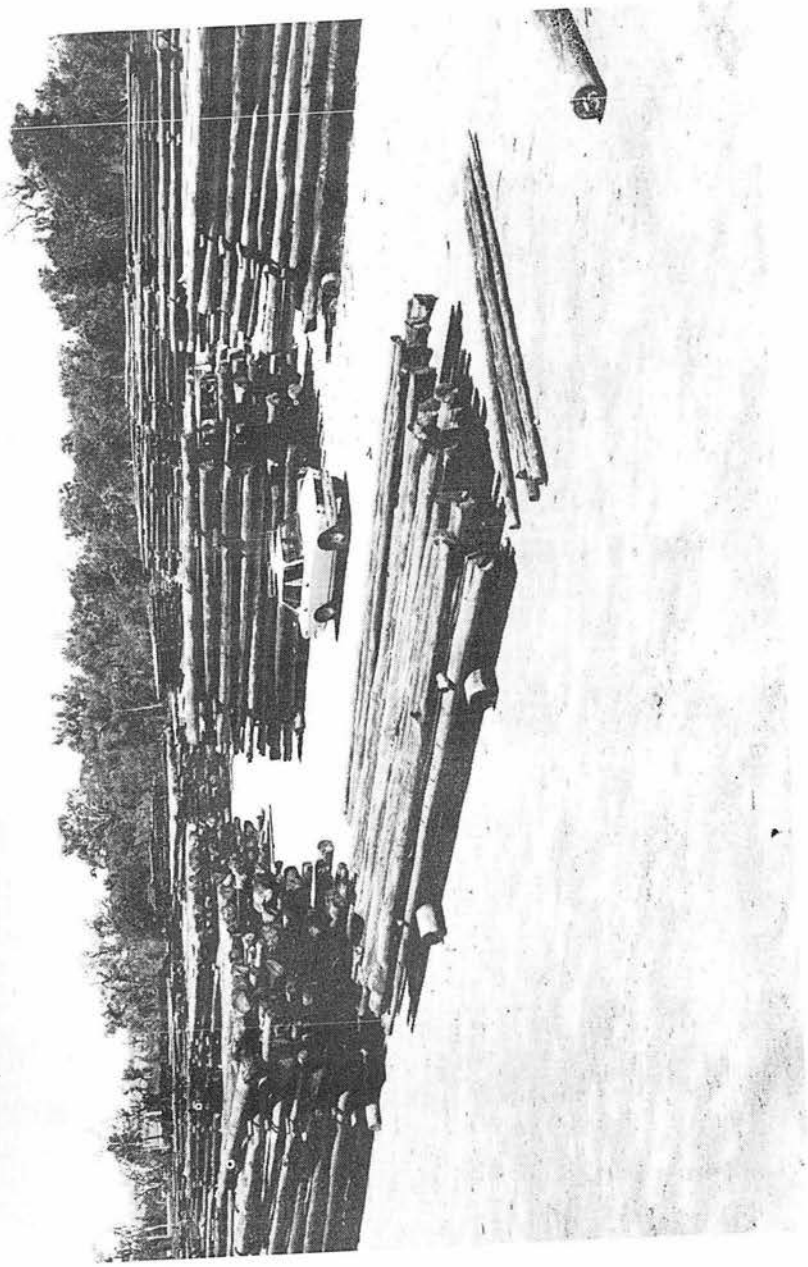


Plate 69A

Poles stacked for air drying prior to preservative treatment

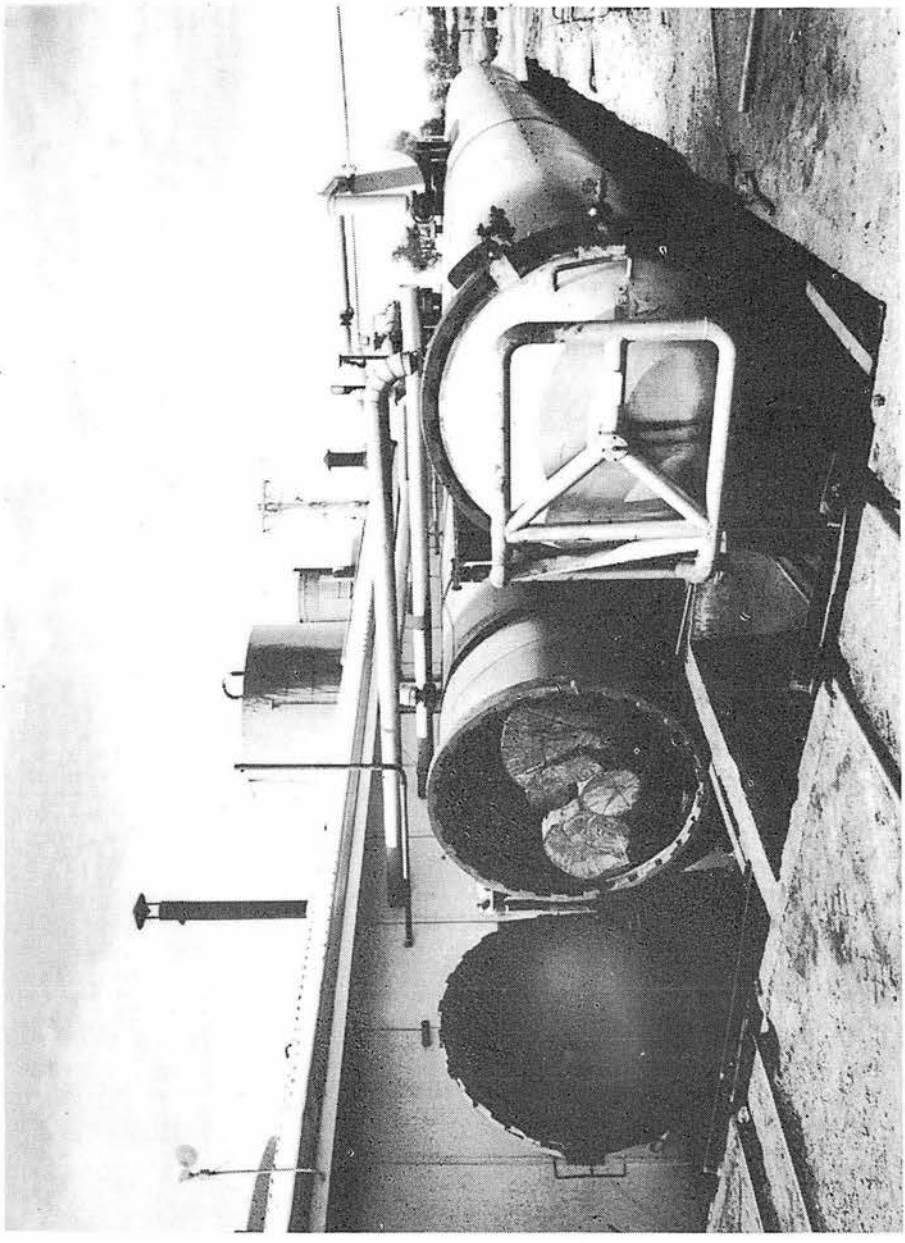


Plate 69B

The poles are treated with preservative at a pressure of 200 lb/sq. in. (14,000 gr./cm²) in these cylinders

Kiln-drying: To reduce the time factor involved in air seasoning, it is common practice to-day to partly air-dry hardwoods, then complete the drying in specially designed kilns. For boards 1 in. (*25 mm*) thick this final stage takes only seven days, as compared with 12 months if left in the open.

The principle of the timber kiln is to apply, according to prescribed schedules, controlled heat, moisture and air circulation by the use of steam pipes and large electric fans. The strip-stacked timber is placed in the kiln, an initial steaming given to make the wood pliable and heat applied from steam pipes. Large reversible fans control the circulation of the air.

Timber handling in seasoning yards is done mostly by forklift and straddle trucks. For this reason the yards should be reasonably level, at the same time allowing for proper drainage.

Chemical Seasoning: Normal drying processes applied to larger cross-sectional hardwoods remove moisture more rapidly from the outer layers of wood than from the inner core. The resulting stresses from shrinkage of the outer layers can lead to surface checking and end slitting. Recent investigations have shown that by soaking the timber in concentrated solutions of common salt or urea, a more even rate of drying may be obtained and the development of checks and splits avoided. This method of seasoning is, at present, employed mainly for special items,—e.g. the production of mallet heads where checks and splits are not acceptable.

PRESERVATION OF TIMBER

Wood preservation includes all practices, direct and indirect, designed to reduce deterioration of wood products caused by biological attack, (fungi, termites, borers, marine organisms) or by other agencies such as fire and weathering.

The need for preservative treatment is growing, due to resistant species becoming less readily available and a considerable proportion of our timber needs are being met by non-durable hardwoods and softwoods. For example, in Western Australia, Marri (*Eucalyptus calophylla*) poles—once considered of little value—are now, following preservative treatment, used extensively as telephone poles through the South-West. Similarly, pine fence posts, treated under pressure with preservatives, are being used in farming areas where naturally durable posts are not readily available. Karri telephone line cross-arms are also treated under very high pressure using a pentachlorphenol preservative in furnace oil.

There are two main types of preservative:—

(1) Water-borne—e.g. multi-salt compounds of copper, chrome, and arsenic, usually applied under pressure; sodium pentachlorphenate used in dipping green timber to prevent blue mould or "sapstain"; and ammonium phosphate compounds for fireproofing.

(2) Oily types—e.g. creosote and pentachlorphenol in furnace oil. The oily types are particularly useful in reducing "weathering".

Various treatment processes are in use:—

(i) Diffusion treatment in which chemicals penetrate into the green (or wet) timber by slow molecular movement from aqueous solution. The process may be accelerated by heating, but does not require the application of vacuum or pressure.

(ii) Hot and cold bath treatment is in fact a form of pressure treatment in which dry wood is heated in the preservative to expel air and then allowed to cool in the preservative thus replacing the expelled air. Oils and certain water-borne solutions may be used. Fence posts are often treated in this way.

(iii) Pressure treatment in which preservative oils or water-borne solutions of preservative salts are forced into dry timber under pressure with or without the use of heat and vacuum.

(iv) Sap replacement in which green, freshly barked posts have their ends set in a tub of water-borne preservative and proceed to suck it up just as flowers in a vase take up the water.

(v) Boultonizing in which green round or sawn timber is boiled in an oily preservative to expel the sap and then pressure is applied to the liquid to force it into the now-empty cells.

For the preservation of the sapwood of round poles and the sawn timber of Pinus radiata, a pressure of 200 lb. sq. in. (*14,000 gr/cm²*) is usually applied. The heartwood of eucalypts is particularly difficult to treat and penetration of preservative is low. The treatment plant for sawn karri applies pressure up to 1,000 lb. sq. in. (*70,000 gr/cm²*) and was the first commercial plant in the world to use such high pressures. Portable plants using only 50 lb. sq. in. (*3,500 gr/cm²*) have been designed to fill local needs where the establishment of high pressure plants is not economically justified.

Apart from the use of chemical preservatives there are several simple precautions which can be observed to prevent deterioration of timber.

Fungi: As fungi prefer moist conditions and will not develop where the moisture content of the wood is below 20-25 per cent, dry timber quickly and keep it dry in use by designing structures to exclude water.

Insects: For termites use barriers such as metal caps (ant-stops), damp courses and frills to cut off access from the ground. Soil treated with dieldrin, aldrin, creosote, etc. is an effective barrier, and this method is now widely used.

Lyctus (Powder Post Borer): The grub of this beetle attacks only the sapwood of those hardwoods which have a high starch content. Therefore use an immune species; heartwood only; or preservative-treated timber.

Marine Borers: Use either a resistant species such as jarrah or timber which has been heavily impregnated with preservative.

Weathering: Where timber is exposed to frequent changes of surface temperature and moisture, application of oily compounds reduces surface breakdown.

PINE HARVESTING AND MARKETING

As indicated elsewhere in some detail the early attempts to establish pine plantations in Western Australia were fraught with difficulties deriving mainly from soil nutrient deficiencies. It was something of a milestone when the first pine logs were sold in 1927, however it was not until another eighteen years elapsed that net pine log revenue exceeded the level of $10,000. By this time, at the end of World War II, some plantations were overdue for thinning but the long standing hardwood industry could not be persuaded to handle small pine logs. Early marketing was difficult as these logs were suitable only for the box and case trade. In order to secure the necessary thinning of plantations the Forests Department set up small sawmills at a number of plantation centres and marketed through the main distributors in the timber trade. Sales steadily increased and in 1955 total log production reached 709,000 cubic feet (*20,000 m³*), returning a net revenue of $94,392.

At this time the case trade in the Metropolitan area also expanded and drew increasing quantities of pine logs from plantations close to the city and from the coastal plain at Gnangara, some fifteen miles to the north.

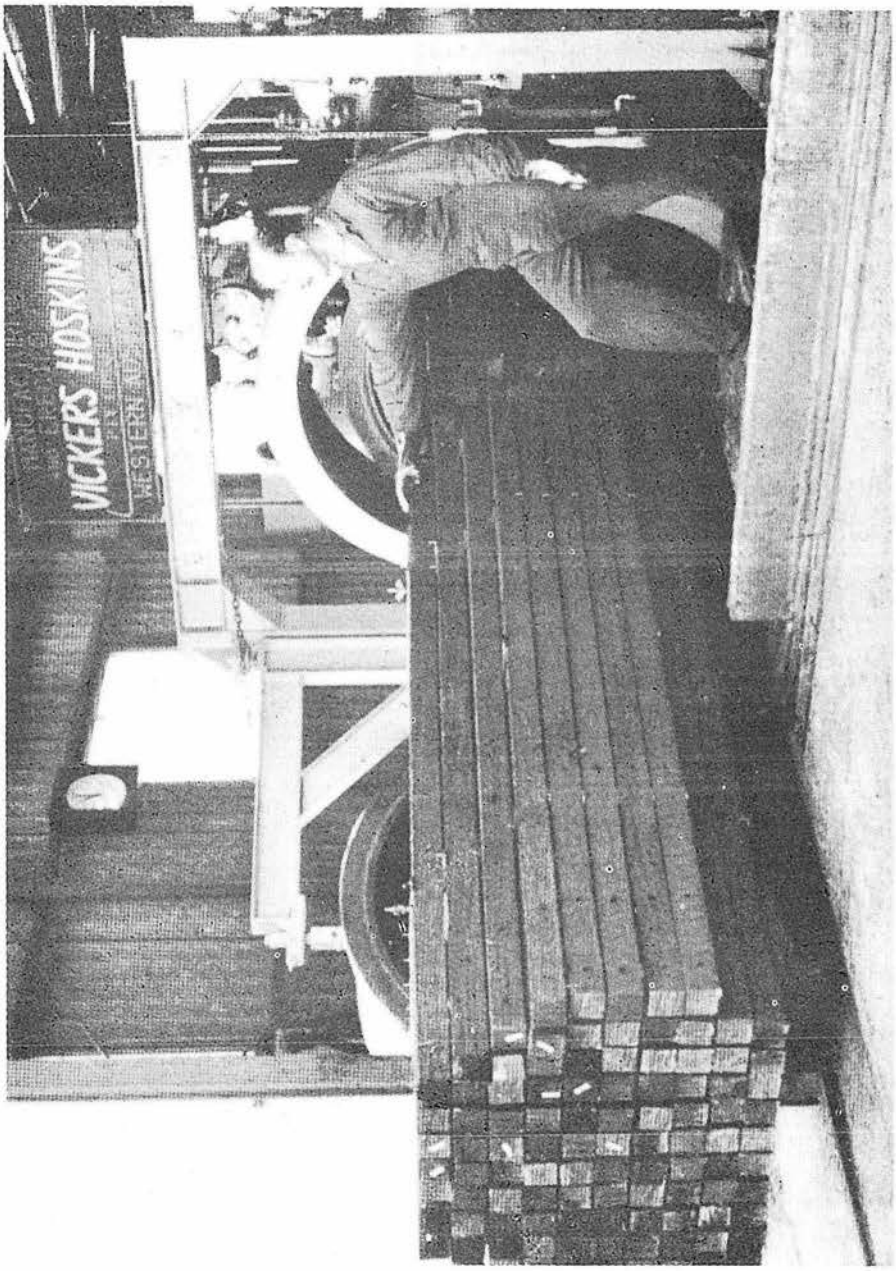


Plate 70

Karri crossarms entering the cylinder in which they will be subjected to high pressure preservative treatment

The plantation at Mundaring Weir began to yield larger logs from later thinnings as did plantations in the South-West. Pine sawmills were able to produce general purpose board sizes suitable for furniture and cupboard framing, fittings and linings. The plywood industry, initially based on karri and imported log timbers, drew increasing quantities of the larger logs for peeling for plywood production.

Annual volume production now approaches 3 million cubic feet (*80,000 m^3*) and net revenue exceeds $250,000.

Note: Annual cost of plantation establishment and maintenance exceeds $1 million.

In 1969 the demand for pine boxes, cases and industrial packaging was still maintaining consistent production levels in face of stiff competition from other packaging media such as cartons and plastic containers. The local product was also successfully meeting competition from large scale pine producers in New Zealand and South Australia.

The future supply of small-sized pine logs is expected to be absorbed by the particle board and paper pulping industries. In 1970 the established factory capacity for particle board production in Western Australia was considerably in excess of both current board demand and supplies of raw material. The industry is geared to develop as rapidly as these limiting factors will allow.

It has become clear that although there will always be a demand for quality timber the greatest demand will be for reconstituted wood—chips, flakes or fibres compressed and bonded into sheets of uniform density which can be supplied to meet specifications in a wide range of size and thickness. This is not only advantageous to builders and specifiers but enables the economic conversion of large volumes of wood which are below sawlog size or quality.

The development of techniques for production of high quality waterproof particle board and plywood has further extended the market for local softwoods. The particle board industry in Australia is intensely competitive and more than half of the industry's output in Western Australia is marketed in other States while a small but growing export market is developing.

Other small, but none the less important, uses for plantation pine are for fence posts, pearling poles, wood wool and Christmas trees. Wood preservation plants are in operation at Bunbury, Perth and Manjimup for the impregnation of wood under pressure with preservative chemicals such as creosote and C.C.A. (copper, chrome, arsenic) salts. Pine so treated becomes equally as durable as our most durable hardwoods. The Metropolitan plant also treats sawn pine for construction uses such as housing and cooling towers for electricity generating stations. Pearling poles have been produced for some years now for the construction of cultivation rafts for the culture pearl industry at Kuri Bay. Wood wool is increasingly used for the production of cement based wall and ceiling boards.

An interesting recent development is the production of "Glulam"—the fabrication of large glued and laminated beams capable of providing clear spans of up to 300 feet (*91 m*).

Pine logging, once a close-to-nature operation of man with axe and bow saw, and of man with horse (for snigging)—in quietness broken only by the ring of the axe, the swish of the falling tree, or man's command to his horse—has now, of neccessity, become highly mechanised. Chain saws roar and tractor log loaders shuttle between stump and motor trailer. Sophisticated mechanical equipment has been specially designed for pine logging and already in Australia we have a pine harvesting machine which shears off the tree at ground level, lifts it bodily on to a horizontal carriage, removes limbs and top in one rapid operation and tips the log into a carrying tray. The days of mechanical harvesting in our pine forests are now with us.

Plate 71

A Massey-Ferguson Treever operating in the Gnangara *P. pinaster* plantation. Operated by one man, the machine in a given time handles a greater volume of small pine logs than the two and sometimes three crane trucks previously used

Plantation establishment in Western Australia is based on a policy designed to—

(1) Provide wood for the demands of a future increased population;

(2) Establish a better balance in the proportions of softwood and hardwood used within the State.

(3) Prevent future dependence on wood imports to satisfy local demands.

The present planting rate will achieve the establishment of 250,000 acres (*101,175 ha*) of plantation by the year 2000. By that time our plantations will each year be capable of yielding thirty million cubic feet (*850,000 m^3*) of softwood logs. In a State which has no natural supply of softwoods the ratio of softwoods to hardwoods will then be 3:4 and eventually the production from man made forests will exceed the output of our native forests.

This is the success story of the Monterey Pine (*Pinus radiata*) a storm twisted poor relation in its native California, but the backbone of all softwood plantings in Australasia. New Zealand long ago, and Australia recently, achieved one million acres of exotic plantations—mainly in *Pinus radiata* which owes its success not only to its remarkable rate of growth but to its remarkable adaptability as a tree and its remarkable versatility as a timber. It has, in fact, long been known in many places as "Remarkable Pine".

CHAPTER VIII

FOREST RESEARCH

REVIEW OF PAST WORK

Research has always been an integral part of forestry in Western Australia. Even as early as the 1920's officers of the Department made important discoveries in the field of pine nutrition on poor sites, which has received world-wide recognition. The work of the Department on the control of bushfires, which has been in progress for several decades, is also widely known.

Due to shortage of trained staff, research lagged behind forest management in the years following World War II. However, several contributing factors led to a rapid build-up of research activities in the 1960's. These included the recognition of the seriousness of the jarrah dieback disorder and the identification of its cause, the expansion of pine planting under the Commonwealth Softwood Agreement, and the change-over from complete fire protection to hazard reduction by controlled burning. The expansion of research to meet these challenges has been made possible by increased availability of suitably trained staff and improved financial provisions for staff and equipment.

Plate 72

The Institute of Forest Research and Protection at Como

ORGANIZATION OF RESEARCH

The research branch now comprises 14 university-trained officers and 38 assistants. There is a central Institute of Forest Research and Protection at Como in the metropolitan area, which co-ordinates research activities and provides supporting services in soil and plant tissue analysis, pathology, statistical analysis and automatic data processing. In addition, it carries out research into the jarrah dieback disorder, seed storage, pelleting and germination, and litter decomposition under forest stands.

The associated research outstation at Wanneroo concentrates on various aspects of *Pinus pinaster* silviculture, such as tree breeding, site selection and nursery and plantation techniques.

The research station at Dwellingup was primarily established to investigate silviculture and protection of the jarrah forest. Topics under study include the establishment of regeneration and its subsequent tending, fire protection, control of jarrah dieback disorder and rehabilitation of affected areas.

Similarly the chief function of the Manjimup research station is the investigation of karri silviculture and protection. At present the main topic under study is the regeneration of cut-over stands, from seed production to tending of regenerated areas. The protection of these denser, moister forests against fire damage is also being closely investigated.

Plate 73

Neave's Road scion arboretum near Wanneroo showing the difference in shoot growth between the two rows of clones (grafts from two different superior or " plus " pine trees). The arboretum facilitates controlled pollination

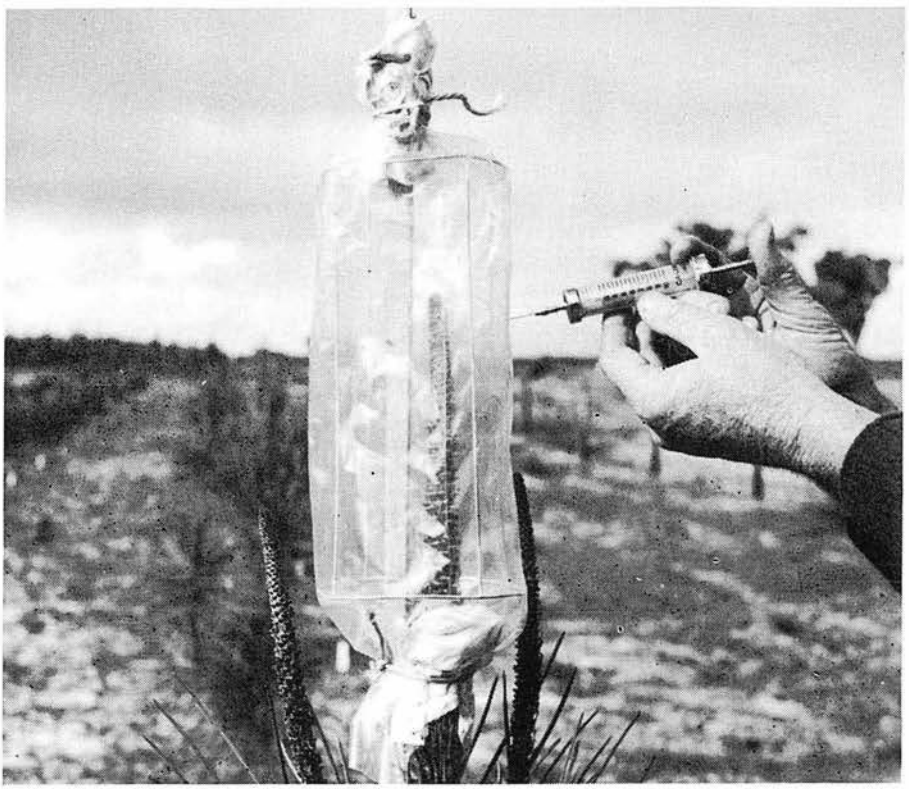


Plate 74

Controlled pollination of a selected scion of *P. pinaster*. The shoots are protected by sausage skin casing to prevent pollination by undesirable strains and selected pollen dust is injected by a hypodermic syringe

The associated outstation at Collie is engaged in the study of tree-breeding and plantation establishment of *Pinus radiata*.

CO-OPERATION WITH OTHER ORGANIZATIONS

In addition to the research activities described above the Department co-operates with several organisations on topics of common interest. It provides financial support and/or field assistance to the C.S.I.R.O. Divisions of Soils and Forest Products. It co-operates with the Commonwealth Forestry Research Institute and the Universities in the study of the jarrah dieback disorder, in the latter case by the financing of scholarships at post-graduate and post-doctoral levels. Co-operation with other state forestry services is chiefly through the Research Working Groups, which provide periodic opportunity for specialists in the various branches of forestry research to exchange information and discuss common problems.

ACHIEVEMENTS

Tree Breeding

Following earlier studies of the relative merits of the various races of *Pinus pinaster*, tree breeding within this species is focussed on the Leirian race, which

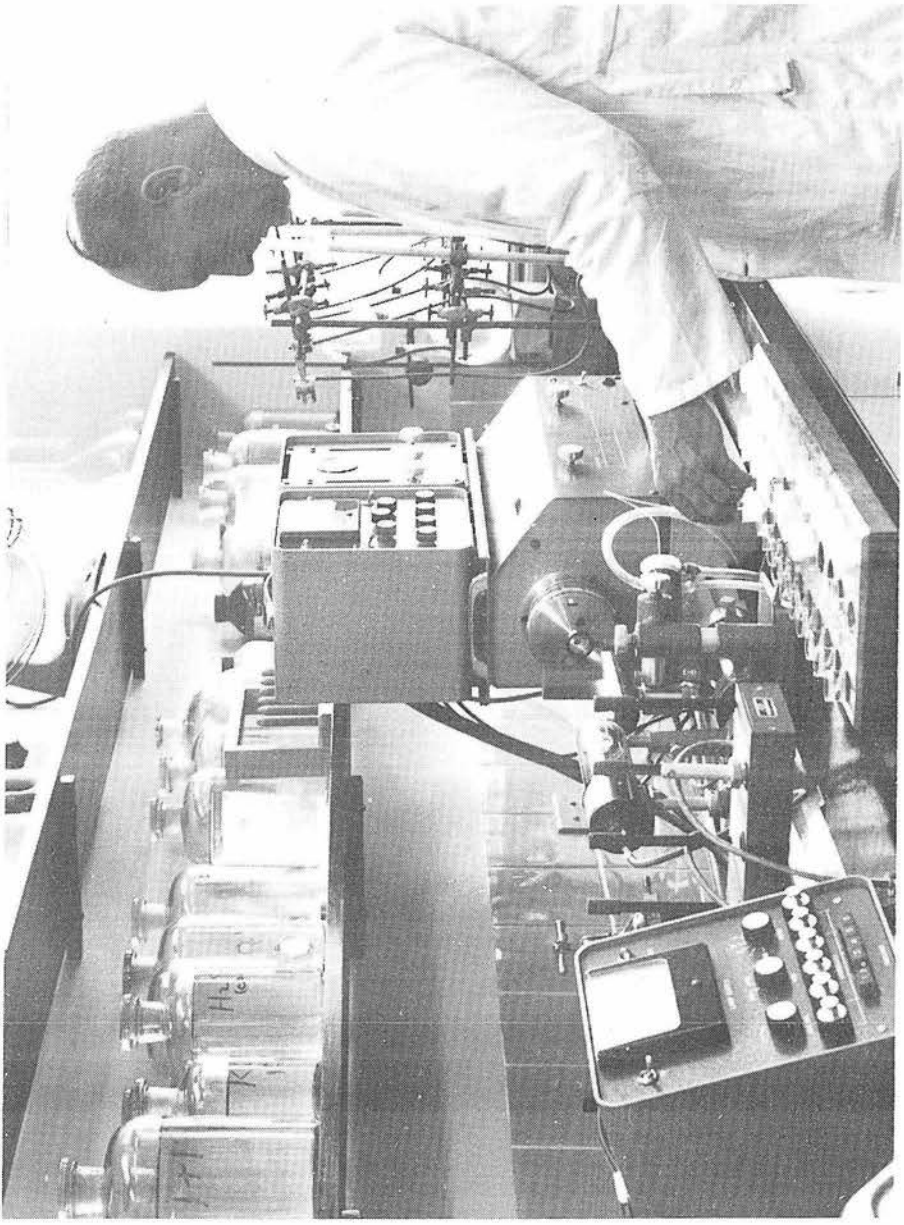


Plate 75A

In the laboratory—zinc analysis with the Atomic Absorption Spectrophotometer

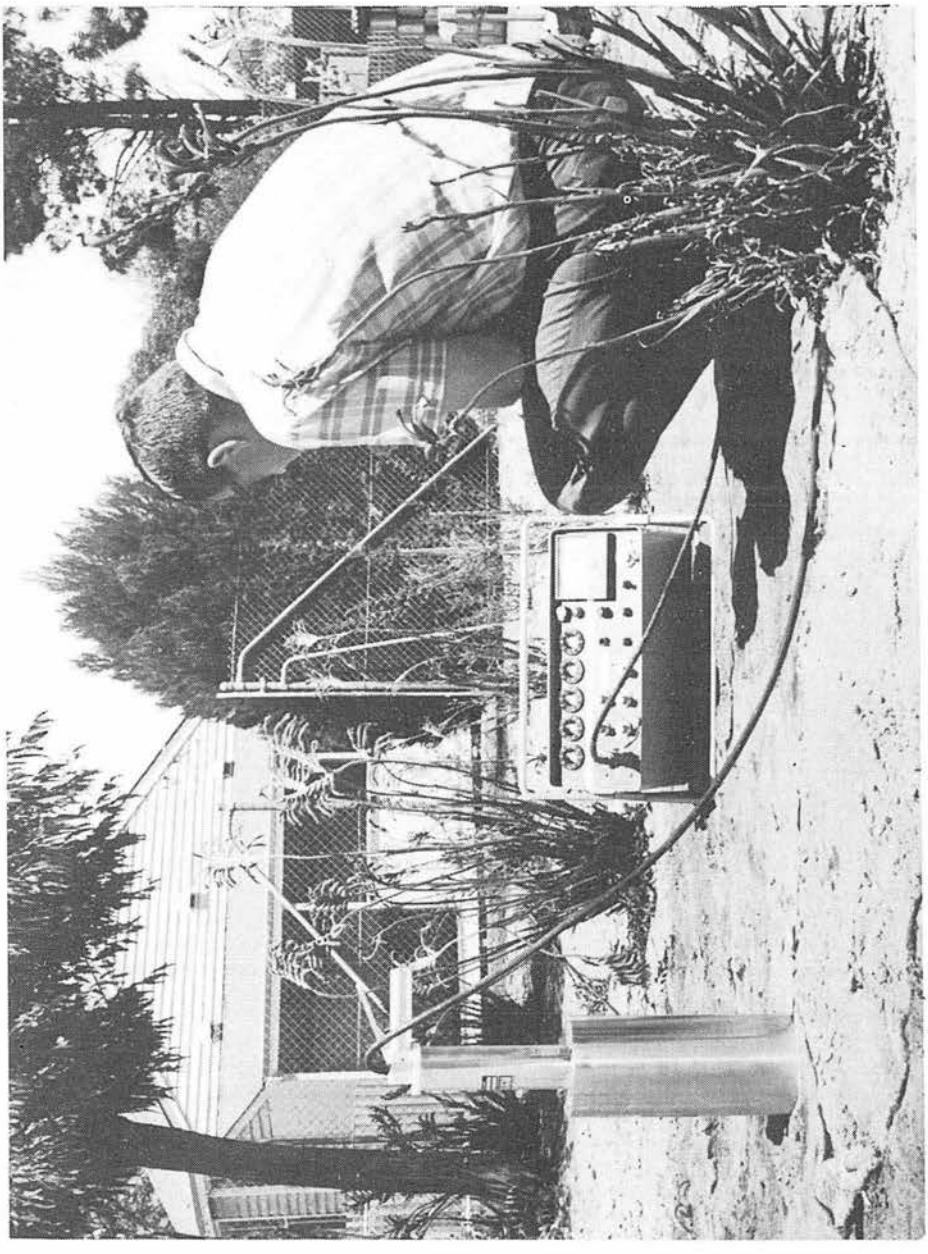


Plate 75B

In the field—a nuclear probe being used to measure soil moisture

was found to be the most vigorous one under local conditions. Scion arboreta and seed orchards have been established, within which have been brought together superior trees from both the local plantations and the forest of Leiria in Portugal. Numerous progeny trials, which will make possible the final selection of parents for future plantations, are under way.

The breeding of *Pinus radiata* is less advanced due to a later start. Nevertheless, seed orchards have been established concurrently with progeny testing, utilizing superior trees from New Zealand and Eastern States, as well as from local plantations.

Nursery Techniques

The nursery technique for *Pinus pinaster* has been revised in order that the increased demand for planting stock can be met. Improvements in maintenance of soil fertility, disease prevention and weed control have resulted in more reliable and cheaper seedling production.

A similar revision of nursery techniques for *Pinus radiata* is nearing completion. It is also concerned with maintenance of soil fertility and weed control.

Site Selection

A method of site selection based on natural vegetation has been developed for the northern coastal plain. It has made possible the avoidance of sites on which the survival, growth or form of pines would be unsatisfactory. Similar studies are nearing completion in the northern jarrah forest, where the situation is rather complex. Experiments have been established to study the improvement of initially unsuitable sites by mounding, drainage and fertilizer application.

Tending of Plantations

On the fertile sites normally planted with *Pinus radiata* vigorous growth of weeds creates a serious problem in newly established plantations. Research is being carried out into controlling the weeds by application of weedicides, applied at different seasons at various quantities and concentrations, both before and after the planting of the pines. Many satisfactory results have already been obtained.

Pruning and Thinning of Plantations

The purpose of these operations is to improve the size and quality and hence the value of the logs produced in plantations. In pruning studies the timing of the pruning, the size of the knotty core and the height of the pruned section of the bole are being investigated. In thinning studies reduction of the original stand to a specified density is being related to the vigour, form and health of the remaining trees, and to the yield of timber both from the thinning operations and the final harvesting. Results of these investigations point to the desirability of early heavy thinning in order to produce large, healthy trees in the shortest time. On steep slopes with shallow soil, and on sands underlaid by limestone, the danger of drought deaths is an additional reason for early thinning. The connection between stand density, interception of rain, rewetting of soil and drought occurrence is being investigated by use of rain gauges, stem flow gauges and a neutron probe moisture meter.

Litter Decomposition

The study of litter decomposition under exotic pines and native hardwoods indicates that the slower decomposition in the former is due to markedly lower number of soil micro-organisms. The rate of decomposition is also influenced by stand density and past history of litter burning.

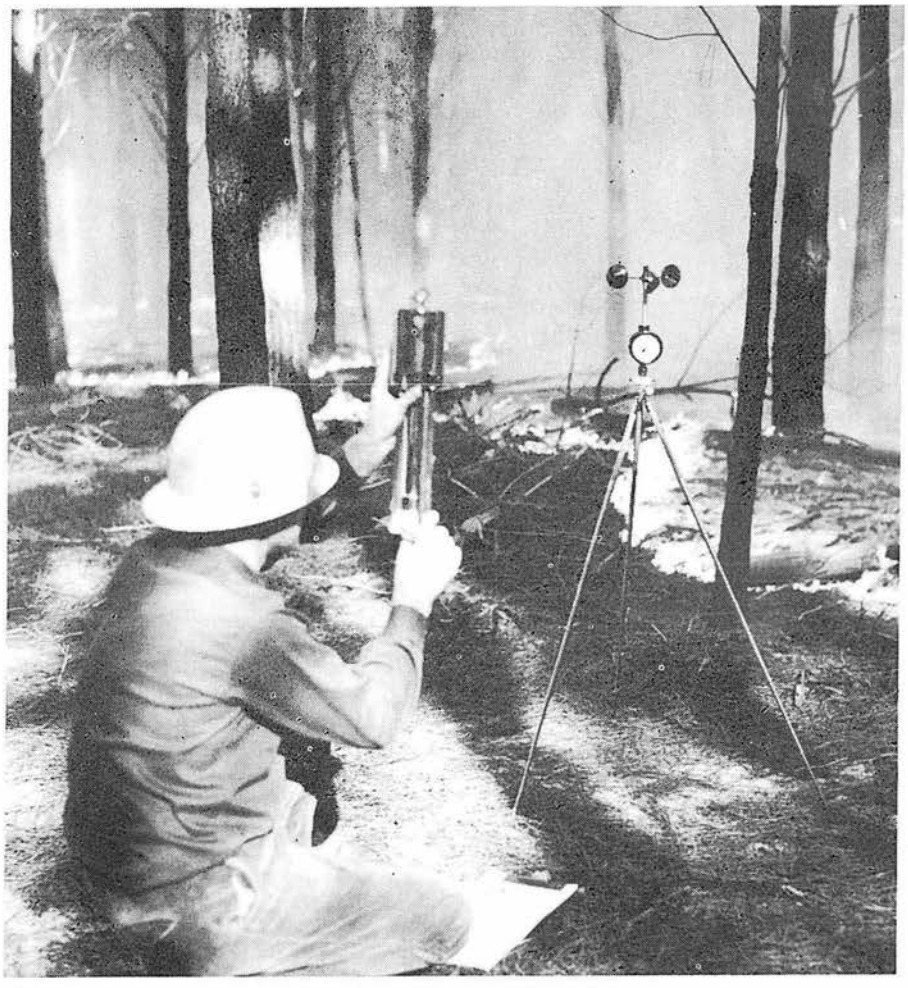


Plate 76

A careful record of prevailing weather conditions is required when experimental fires are lit in pine plantations. Here a fire research officer takes measurements of temperature, relative humidity and wind speed during burning trials in a stand of *Pinus pinaster*

Fire Behaviour

Studies of the behaviour of forest fires under varying weather conditions and varying amounts and types of litter have been completed for jarrah and *Pinus pinaster* and investigations are now being undertaken on the karri forest. In all cases, the amount of litter accumulated has been related to the density of the stand and number of years without fire. The ultimate aim of these studies, already partly achieved, is the reliable prediction of fire behaviour to facilitate controlled burning and fighting of wildfires. A method of carrying out controlled burning by dropping incendiaries from a light aircraft has been developed.

Fire Damage

The effect of fire intensity on the degree of damage to the crowns and boles of young hardwood and pine trees has been investigated, and recommendations made of safe conditions for controlled burning. More recently, studies have commenced on the effect of fires on wildflowers and native animals.

Jarrah Silviculture

The aim of studies in this sphere has been the determination of the optimum conditions for the natural regeneration of jarrah forest. This involved investigation of environmental conditions and of optimum stand density, and included manipulation of the stand density through removal of unwanted or defective trees by the use of arboricides.

The logical final step in this research, the adaptation of research findings to the intensive management of high quality jarrah forest, has already been initiated.

Jarrah Dieback

Investigations in both the field and laboratory have shown that the organism causing this disorder, the fungus *Phytophthora cinnamomi,* requires certain conditions for maximum activity. These conditions are:— adequate, but not excessive, moistness of the soil and moderately high soil temperature. The length of the season favouring the activity of the pathogen varies according to the slopes. The initial spread is strongly related to soil pattern, because soil carried about by trucks and bulldozers is the chief means of its distribution.

Rehabilitation of the affected areas requires screening of exotic tree species to find those capable of withstanding the attack by *Phytophthora,* and preparation of the site to favour establishment of resistant species. Numerous species have been tested and many of these have been found to be resistant. The establishment methods tried range from direct sowing of seed after minimum of site preparation, to the planting of nursery-raised seedlings following thorough clearing and ploughing.

Karri Silviculture

Because karri is by far the most vigorous native hardwood species, every effort is being made to ensure satisfactory regeneration of cut over areas. Thorough study has been made of its flowering and seeding patterns, so that maximum use can be made of good seed years. Detailed study has also been made of seed germination and establishment and growth of seedlings. In order that karri can be established even in years of poor seed production, and on areas on which it regenerates poorly, various methods of artificial regeneration, such as direct sowing of pelleted seed, transplanting of wildings and planting out of nursery-raised seedlings, have been attempted, many of them with considerable success. Attention is now being turned to the tending of successfully regenerated areas.

THE FUTURE OF FORESTRY RESEARCH

The development of forestry must keep pace with the overall development of the State, in particular the increasing industrialization and rapid population growth. Although the total area of the State is large, the area with adequate rainfall and mild temperatures, is quite small. It is in this region that the residential development and recreational activitites will be concentrated. The State Forests are also concentrated in this region. For this reason, they must be managed to provide maximum benefit to the people.

Already increasing demands are being made on forest areas for water, recreation and wildlife conservation. These can be, to a large degree, reconciled with the production of wood, which has been the main function of these forests in the past. It is intended to study the implications of this multiple use concept, particularly in areas nearer to Perth, where the pressure is greatest. Using the classification of sites as a basis, the degree of conflict and the possibility of reconciling alternative forms of forest land use will be examined. Attention will also be given to those forms of land use which are not reconcilable with forestry, such as agriculture and mining, by examining the broad and long term advantages and disadvantages to be derived from them, of the costs involved in rehabilitation of areas mined by open-cut methods and of cleared marginal or unproductive agricultural land.

Increased attention will also be given to the efficiency of forest management. Recently developed techniques employing electronic computers, such as simulation and optimization, will be used to evaluate management alternatives and to determine the financial feasibility of new methods developed through silvicultural research.

(8) —257 20

CHAPTER IX

TREE PLANTING IN WESTERN AUSTRALIA
BORONIA
SAND DRIFT RECLAMATION

Tree Planting in Western Australia

In many parts of the State, particularly in the semi-arid agricultural areas where extensive clearing of the native vegetation has taken place, there is a great need for suitably placed trees for shade, windbreak and ornamental purposes. To aid people who wish to improve conditions in rural areas, the Forests Department maintains nurseries from which they may obtain small trees of suitable hardy species at reasonable cost. A seed store is also maintained to supply seed for those who desire to raise their own trees. This store also plays an important role in supplying seeds of Western Australian trees to overseas countries.

Forests Department Tree Nurseries

In 1896 a nursery for the propagation of commercial timber trees for government plantations was established at Guildford. However, conditions there proved

Plate 77

Potted seedlings in the shade house at Hamel Nursery. Particular care is taken to control "damping-off" fungi which could cause extensive deaths in a large concentration of plants such as this (see also Chapter IV)

unsuitable, and in 1897 a site was selected near the small Hamel siding on the South Western Railway, two miles (*3 km*) south of Waroona. The area selected was portion of the old de Hamel Estate and included a large area of rich alluvial soil through which runs the south branch of Samson's Brook.

Many fine trees and shrubs established very early in the nursery's existence still survive. Among the most outstanding are the Norfolk Island Pines, now well over 100 feet (*30 m*) in height, the camellia bushes over twenty feet high and a number of plants of the New South Wales waratah. Of particular interest is a huge specimen of cork oak, now over 64 feet (*19 m*) in height and 12 feet (*4 m*) in girth, from the butt of which strippings of commercial cork have been made. A small plantation of pines planted at the beginning of the century is probably the oldest commercial plantation in the State.

Although the nursery was established primarily to supply commercial timber trees for Departmental plantations, its functions were soon extended to the raising of ornamental trees for supply to the Education Department for planting in school grounds, to local authorities for street and park planting and to other public bodies and charitable institutions. This range was gradually extended to include landholders who required trees for shade and shelter for stock, for ornamental planting on farms, and for farm woodlots.

Up till 1916 all trees were supplied free of charge, but the demand became so great, and the system so abused, that in 1917 it was decided to make a charge for the trees to cover the cost of raising them. At about the same time, in agreement with private nurseries in the metropolitan area, it was decided that no further shrubs would be raised at Hamel, and that the trees would not be supplied to private persons resident within the metropolitan area.

Earlier figures are not available, but since 1925 the annual distribution of trees from Hamel has ranged from 30,000 in the depression years to 314,000 in peak years, with a total distribution since that year of over five million trees covering seventy-five different varieties.

Owing to its situation in the heavy rainfall area of the South West, conditions at Hamel were found to be unfavourable for the raising of trees suitable for planting in the low rainfall areas of the wheatbelt. To meet this demand, the Department established another nursery at Kalgoorlie in 1947. After functioning for seven years this nursery was transferred to the Narrogin district.

The aim of the Forests Department has been to provide from its nurseries hardy trees for every site and purpose. While species from overseas or from the Eastern States have figured largely in the Hamel stocks, those found most suitable for the wheatbelt and which have been raised at Narrogin have been mostly our own Western Australian trees. These latter provide an outstanding variety of form, growth habit and leaf coloration, and many bear blossoms of outstanding beauty.

The eucalypts, so typically Australian, which constitute the bulk of the trees distributed from the nurseries, possess that rather uncommon combination of fast initial growth and long life, and moreover exhibit a great deal of adaptability which enables many of them to thrive over relatively wide ranges of soil and climate.

In order to test species for suitability in the arid and semi-arid zones of the State and to demonstrate the value of tree planting in these areas, the Forests Department

Plate 78
Trays of young eucalypt seedlings at Hamel nursery ready for despatch to buyers after being " hardened " in the open

has, since 1949, maintained a programme of arboreta establishment throughout the farming areas. Fifty-six arboreta have now been established comprising some 9,000 trees of many different species. The arboreta cover a wide area, ranging from Yuna in the north to Kalgoorlie and Esperance and Boxwood Hills in the south. This work has enabled the Department to assess which are the most suitable trees for planting in different localities and has been an invaluable aid to our advisory service. A number of pamphlets have been prepared setting out lists of suitable species with descriptions, and advice on planting and care of trees.

Few would question the desirability of establishing trees within the agricultural zone, particularly on the naturally treeless land which has figured so largely in recent agricultural development schemes. Because of the patient and painstaking work in this field over many years, the Forests Department is in a position to offer sound advice on questions of tree planting in these areas.

Following the success of this work in the southern half of the State, a Forester was seconded late in 1963 to investigate and promote the growing of trees for amenity purposes in the rapidly developing north-western areas. This project has developed considerably and has received excellent support from the expanding communities of the townships and from the mining companies. The Department of the North-West has now taken over the scheme which is operated from Broome.

Boronia

Introduction

The *Boronias,* surprisingly perhaps, are members of the same family of plants (*Rutaceae*) as the orange, lemon, lime and other citrus fruits, and in the karri forest forest region the Crowea and Hazel (*Chorilaena sp.*). All have the aromatic attribute which is one of the characteristics of the family and many are rich in oil.

In Western Australia there are 48 species of boronia, most of which occur in the south-west, while a few are found at higher altitudes in the tropical north. The various members may have yellow, blue, white, pink (such as *B. heterophylla*) and red or purple blossoms, but undoubtedly the most popular is the Scented or Brown Boronia (*Boronia megastigma*) which is renowned for its delightful perfume.

Occurrence

Brown boronia, which is endemic to the State, occurs naturally in sheltered, wet, acid sites scattered over some 10,000 square miles (*25,900 sq. kilometres*) of the higher rainfall areas of the extreme South West. Its habitat is approximately bounded by a line sweeping north-easterly from Busselton through Ludlow and Wellington Dam to Mount Ross some 20 miles (*32 km*) north of Collie. There the line turns S.S.E. through Kulikup to Unicup, thence veers E.S.E. to pass through Mount Barker and finish at the Kalgan River north-east of Albany. The coastline forms the remaining southern and south-western boundaries.

Within these limits, some 250 known locations of boronia, covering a total area of approximately 1,000 acres (*405 ha*) have been recorded in State Forest.

History of Exploitation

Major Lockyer, who founded Albany in 1826, is said to have collected seed of brown boronia and despatched it to Kew Gardens. The sale of bunches of blossom began about 1900 and in 1909 seed for propagation was collected for sale to Victoria at 5/- per ounce.

The first permit to gather blossom for distillation and subsequent use in the perfumery trade appears to have been issued in 1925 where areas 20 miles (*32 km*) on either side of the railway line between Cranbrook and Albany were involved. The following winter over 32,000 lb. (*14,500 kilos*) of petal were picked for this purpose. Since then the quantities obtained have been irregular, varying from 244 lb. (*111 kg*) in 1950, *Nil* in 1953, to amounts ranging in the last five years from 3,300 lb. (*1,500 kg*) to 6,800 lb. (*3,080 kg*).

Sprays for decorative purposes are sold in the shops and streets of Perth and large towns, and in 1969 a total of 11,259 lb. (*5,107 kg*) (estimated 5,500 lb. (*2,495 kg*) of blossom) was consigned by rail for this purpose. It is probable that considerable quantities were also transported by road and the demand for boronia in this form could well increase.

Most of the seed collected is exported to Victoria and New Zealand, local requirements being insignificant. The annual demand for seed is currently about 100 lb. (*45 kg*) of brown boronia, 34 lb. (*15 kg*) of red (or pink) boronia (*B. heterophylla)* and 6 lb. (*3 kg*) of yellow boronia (*B. purdieana*). Red boronia is to be found in the Walpole, Denmark and Albany districts, but yellow boronia has a relatively wide distribution on the deeply leached grey sands to the north of Perth.

Survey of the Boronia Resource

Over the years, land clearing for agriculture has destroyed many areas of boronia and, recently, public concern was expressed that increased exploitation by pickers and, perhaps, damage by fire, could be threatening Western Australia's resources of brown boronia. As a result the Forests Department, in 1969, arranged for a survey to assess the situation.

All the evidence from the investigation suggests that *rational* picking does not appear to threaten survival but, without burning, brown boronia has a life span of only seven to ten years before it is suppressed by longer-lived and more vigorous scrub. It would seem, therefore, that periodic burning (after flowering and seeding) is essential for the continued reproduction of the species.

Much more work has yet to be done by the Department on the fire ecology of boronia and several other species of wildflowers, and the complex nature of the research is planned to continue for several years.

Sand Drift Reclamation

The loose sandy nature of the central and south-west coastline of Western Australia renders it particularly susceptible to wind erosion. From Shark Bay to Eucla the coastline is unstable and any factors such as fire or over-grazing which destroy the vegetation cover will start the sand moving.

Sand drifts in this area may range in extent from a few acres to many square miles. It is probable that the dunes have always been a feature of the coastal belt, but their formation has undoubtedly been accelerated since the country was occupied by white man. Some of the huge dunes facing the Southern Ocean, particularly the one lying between the mouths of the Warren and Donnelly Rivers, were engulfing karri forest 200 feet (*61 m*) high. Other troublesome dunes occurred near Augusta, Boranup, Swanbourne and the Greenough River.

Sand Dune Fixation

It is of interest that the first challenge to tne wind and "sea sand" was made in 1892 by the sawmilling firm of M. C. Davies and Sons of Karridale. They imported "Marram Grass" from South Africa and planted it on the Boranup sand dunes. In a relatively short time the drift was stopped and the dunes have remained stable ever since.

Marram grass was again used in 1919, 1920 and 1924 to 1927 to fix coastal dunes near Cottesloe and Swanbourne, work on the latter (100 acres) (*40 ha*) being done by the Forests Department. In 1936 the Department was again responsible for checking the advance of a 1,000 acre (*405 ha*) dune which was threatening the flow of the Warren River. The whole surface of the dune was planted with marram grass and no further encroachment took place.

From 1937 to 1939 further plantings were made on sand drift areas north of the mouth of the Warren River (Yeagerup) and along the coastline between Cowaramup and Augusta. During World War II small areas were dealt with at Point Peron, Garden Island and Rottnest Island.

Marram grass is the outstanding medium used for stabilising sand dunes in this State. It is easy to establish and extremely hardy within the 20 inch (*508 mm*) isohyet and will thrive on any sand not containing more than 60 to 70 per cent of

calcium carbonate in the form of shell particles. Unfortunately certain Rottnest Island sands and similar lime sands at Greenough River and Mahomet Flat near Geraldton contain up to 98 per cent calcium carbonate and some other fixing medium is necessary.

In 1965 representatives of the Department of Agriculture, the Forests Department and one of the large oil companies joined forces in an attempt to stablise sand dunes near Lancelin. The technique involved planting some 15,000 seedlings—mostly acacias with some pines and eucalypts—and then spraying the dunes and the plants with a bituminous type emulsion to temporarily bind the soils until the plants developed. The experiment was, not unexpectedly, a complete failure.

While the Forests Department was separately engaged in sand dune reclamation for many years, this work has now been taken over by the Soil Conservation Branch of the Department of Agriculture.

CHAPTER X

TRAINING IN FORESTRY

The steadily increasing population and the consequent rise, both in living standards and in the overall level of industrialisation have imposed enormous demands on the State's limited forest resources; thus increasing the need for efficient and far sighted management.

Forestry, as a supplier of the raw resource wood for timber and paper products, and as a means of conserving some of the State's greatest assets in the form of wildflowers, wildlife and water is a profession that has become vital to the community and the need for an increased number of highly trained foresters is increasing.

The staff in the forest service of this State is grouped into a Professional Division staffed by University graduates and a General Division staffed by field officers, recruited from the Department's own employees or graduates from the departmental cadet training school.

Training Officers for the Professional Division

Prior to the establishment of a Forestry School in Canberra in 1926, the Professional Division was staffed by foresters who had received their training overseas, or who were graduates from the University of Adelaide. In 1928 the first Western Australian graduates from the Canberra Forestry School returned to take up duty with the Department. In 1965 the Forestry School was incorporated into the Australian National University in Canberra. Renamed the Faculty of Forest Science, it raised theoretical training in forestry to a new level by offering both graduate and post-graduate courses. A similar course is also available at the University of Melbourne.

The training of professional foresters embraces a four year university course, leading to the degree of Bachelor of Science in Forestry. The first year is spent at the University of Western Australia, to give students a background in science. Practical experience in forestry is gained during the vacation periods by working for the Forests Department. The next three years of training are spent at the Australian National University in Canberra. This part of the course includes field trips to the major forest areas in the Eastern States.

SYLLABUS—UNIVERSITY OF W.A.

Botany 10
Geology 10
Chemistry 12
Mathematics 12 or Physics 11

SYLLABUS—AUSTRALIAN NATIONAL UNIVERSITY

Year 1

Environmental Factors
Tree Physiology
Ground and Aerial Surveying

Year 2

Forest Organisms and Communities
Forest Entomology and Pathology

Indigenous Silviculture
Wood Science
Mensuration

Year 3

Plantation Silviculture
Utilization of Forest Products
Forest Management and Administration
Forest Economics and Policy
Conservation, Multiple Use and Resource Management

This training scheme is expensive, and would be prohibitive to most private students from this State. To overcome this problem, financial assistance, in the form of a cadetship offered by the Forests Department is awarded to students attempting a B.Sc. (Forestry).

Following satisfactory completion of the University Course, the graduate is appointed to the position of Assistant Divisional Forest Officer with the Forests Department.

The majority of professional foresters are employed in an administrative capacity over some particular forestry district, and as such are called upon to supervise or assist in all district forest management work. This work involves silvicultural operations to encourage tree growth and regeneration; protection from wild fires, injuries, insects and fungi; treemarking for sawmilling operations; assessment of the timber growing stock; the felling, logging and delivery of logs to the timber mills, survey for roads, fire-lines and plantations; the location, construction and maintenance of forest roads; the use and maintenance of earth-moving and logging machinery; and the handling of forest labour. Administration may embrace both hardwood and softwood forests or may specialise in one or the other.

Certain foresters with a particular aptitude for the work are employed full time on such specialised aspects as soil survey and analyses, timber utilization, fire protection, assessment of resources, air-photo interpretation, management and growth studies, and pure scientific research.

The Field Cadet Training Scheme

While the administration and technical direction of the Forests Department has always been under the auspices of the professional foresters appointed under the Public Service Act, provision was made for the appointment under the Forest Act of a field staff. Officers of this staff are trained to implement and supervise the many aspects of forestry, which fell under the overall direction of professional foresters.

Since its foundation in 1918 the Forests Department has recruited the bulk of its field staff from amongst its own employees who show an aptitude for implementing the principles of forest practice, and the management of men and machines. However, the Forests Department, realising the important role that education in new forest techniques plays in modern forestry has, over the past two decades, recruited the majority of field staff from its own Field Cadet School. Education of field staff has also been undertaken; the Department conducting refresher courses to keep its staff up to date.

A Field Officer training scheme was commenced in 1952 with the establishment of the Cadet Training School at Dwellingup. Rebuilt in 1958 it offers accommodation for 16 cadets, a lecture room, a store, a kitchen and a recreation room. The school

is staffed by professional and field officers, who by the use of modern teaching aids present a diverse syllabus which gives a broad coverage of all the aspects of forestry. The purpose behind the formation of the school was the training of foresters who were well versed in modern forest practice ,and who had a sound knowledge of forestry in W.A. The training period is for two years and places strong emphasis on the practical aspects of forestry. In 1969 the course was modified to include a higher theoretical content in the syllabus, and in 1970 was incorporated with the Mount Lawley Technical College. Cadets now spend the first year of training at Mount Lawley Technical College, followed by one year at the Forestry School. Cadetships, awarded by the Department during the two year training period are available to students 16 years of age, holding a Junior Certificate or an Achievement Certificate of a high enough level to obtain entry into a Technical College.

SYLLABUS—MOUNT LAWLEY TECHNICAL COLLEGE

English Expression
Horticultural Botany
Forest Science
A—Physics, Chemistry, Meteorology, Fire Behaviour
B—Botany, Dendrology, Soil Science and Geology
C—Entomology and Pathology
Forest Calculations
Forest Statistics
Vehicle and Equipment Maintenance
Forest Surveying and Mapping

SYLLABUS—DWELLINGUP FIELD CADET SCHOOL

Forest Administration
Wood Technology
Silviculture
Mensuration
Experimental Method
Forest Engineering
Utilization of Forest Products
Fire Control
Man Management and Safety
Conservation and Recreation
Forest Management and Economics
Forest Administration

Graduates from the W.A. Field Cadet Scheme are appointed as Forest Guards with the Forests Department. From this position they can rise with diligence, length of service and satisfactory qualification through the ranks of Forest Ranger, Assistant Forester, Forester, District Forester and Senior Forester.

Apart from the Field Officer Training Scheme, the Forests Department conducts training schemes for apprentice motor mechanics, technical assistants and draftsmen.

Further Information

Interested persons requiring further information about forestry as a career are invited to inquire at the head office of the Forests Department in the R. & I. Bank Building (4th floor) Barrack Street, Perth.

CHAPTER XI

SAFETY IN FORESTRY

Since the early part of this century the economic and human costs of accidents in industry have attracted attention to methods of prevention. In more recent years prevention measures for industrial accidents have become well understood and clearly defined. The activities by which prevention is achieved have been grouped under the title of "Safety" which in general terms has been defined as "the control of men, machines, materials and work methods to provide a working environment in which people will not be injured or property damaged".

Forestry, however, due to its variety of operations, and to the largely uncontrollable, natural environment in which they are carried out, has long been recognised as one of the most difficult fields in which to apply the principles of Safety.

The passing of the Timber Industry Regulation Act in 1926 was the first evidence of Forests Department activity in the field of safety. This Act gave the Conservator of Forests legislative powers and responsibilities to record and investigate accidents, and to secure safe working conditions, in the sawmilling industry.

Initial precautionary measures were directed mainly at guarding unsafe equipment but the hazards of sawmill and forests continued to claim victims with little evidence of decline, until the last decade when management techniques were applied which had been designed to implement the aims of the original legislation.

In 1959 the Minister for Labour directed Government Departments to examine their accident records and prevention methods. As a result, a committee of senior officers was formed in the Forests Department and they initiated the first formal attempts at accident prevention within Departmental operations.

They instituted detailed accident recording and met regularly to examine causes and prevention methods. In time, similar committees were formed in each field division. There was, however, only minor success from these moves and it became clear that something more was needed.

It was in 1965 that representatives of both Forests Department and sawmilling industry, heard expounded the modern principles of accident prevention together with the management techniques which were being used to achieve spectacular success in preventing accidents elsewhere in the world. This was presented at a number of schools held by the National Safety Council for accident prevention training of supervisors.

Within the Forests Department a safety programme was planned and undertaken with the aid of National Safety Council staff. All officers and overseers were given formal coaching in the various techniques used to achieve accident prevention; policy in this field was defined, and an officer was seconded from fire control duties, given ten weeks schooling by the National Safety Council and charged with the exclusive responsibilities of training and field promotion of the safety campaign.

The sawmilling industry developed parallel schemes and accident frequency began a steady and continuing decline.

The associated graph illustrates Forests Department statistics for Disabling Injury Accidents per million man hours worked and the resulting number of man days lost during the years to 1970.

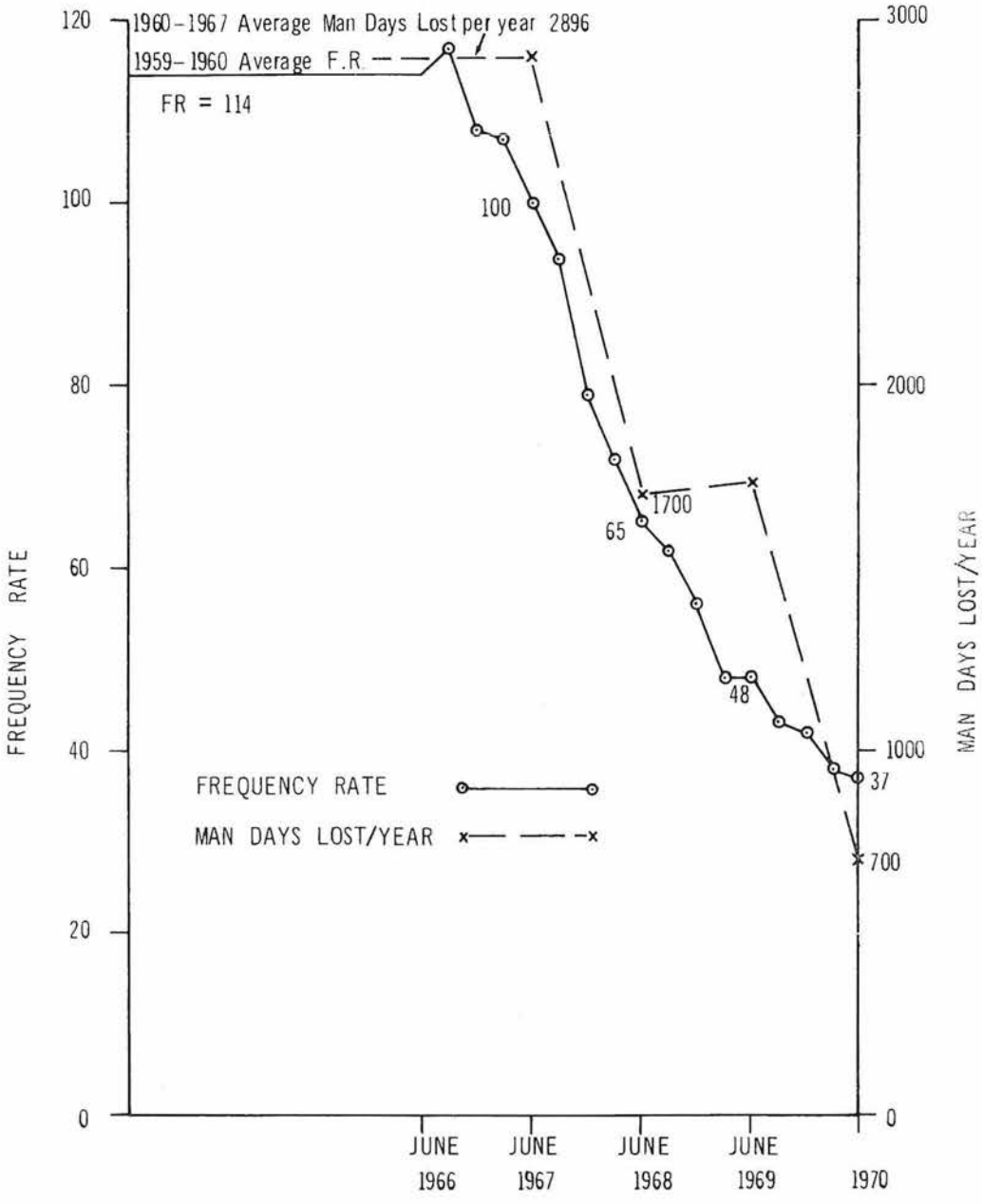


Plate 79

The above graph clearly demonstrates the spectacular improvement in the safety record in recent years

The saving of 10 man-years in 1969-70 compared to the years prior to 1967 is a measure of the economic and human benefits derived. Industry figures are following the same trend as those of the Department with a reduction by 1970 of 65 per cent in the number of Disabling Inquries per year. National Safety Council Awards for fifty and one hundred thousand hours worked free of Disabling Injury have been won by several Forests Department field divisions and various sawmills. The number of accidents is becoming steadily less and it is obvious that the full measure of success from the Safety campaign in the Forests Department and the Timber Industry is yet to be realised.

APPENDIX I

W.A. EUCALYPTS—LIST OF COMMON NAMES

Standard Common Name	Botanical Name	Other Names
Albany Blackbutt	*Euc. staeri*, Maiden	
Apple Gum	*Euc. pruinosa*, Schau.	Silver-leaved Box
Bald Island Marlock	*Euc. lehmannii*, Preiss	Middle Island Mallee
Bara Gum	*Euc. gongylocarpa*, Blakely	Marble Gum, Desert Gum
Bastard Bloodwood	*Euc. zygophylla*, Blakely	
Bell-fruited Mallee	*Euc. preissiana*, Schau.	
Blackbutt (W.A.)	*Euc. patens*, Benth.	
Black Morrel	*Euc. melanoxylon*, Maiden	
Blue Mallet	*Euc. gardneri*, Maiden	
Blue Snap and Rattle	*Euc. calycogona*, Turcz.	Gooseberry Mallee, Red Mallee
Boongul	*Euc. transcontinentalis*, Maiden	
Brown Mallet	*Euc. astringens*, Maiden	
Bullich	*Euc. megacarpa*, F. Muell.	
Cleland's Blackbutt	*Euc. clelandii*, Maiden	
Coarse-leaved Mallee	*Euc. grossa*, F. Muell., ex Benth.	
Coastal Blackbutt	*Euc. todtiana*, F. Muell.	Prickly-bark
Coastal Moort	*Euc. platypus*, Hook, var. *heterophylla*, Blakely	
Coolibah	*Euc. microtheca*, F. Muell.	Threaded Blackheart, Flooded Box
Coral-flowered Gum	*Euc. torquata*, Luehm.	Coral Gum, Coolgardie Flowering Gum
Darwin Box	*Euc. spencerana*, Maiden	Grey Box, Black Box
Darwin Stringybark	*Euc. tetradonta*, F. Muell.	Stringybark
Desert Blackbutt	*Euc. intertexta*, R. T. Baker	Western Red Box
Dundas Blackbutt	*Euc. dundasii*, Maiden	
Dundas Mahogany	*Euc. brockwayi*, C. A. Gardn.	
Flat-topped Yate	*Euc. occidentalis*, Endl.	Swamp Yate
Flooded Gum	*Euc. rudis*, Endl.	Moich
Four-Winged Mallee	*Euc. tetraptera*, Turcz.	Square-fruited Mallee
Fuchsia Mallee	*Euc. forrestiana*, Diels	
Ghost Gum	*Euc. papuana*, F. Muell.	Tropical Gum, Cabbage Gum, Desert Gum
Gimlet	*Euc. salubris*, F. Muell.	
Goldfields Blackbutt	*Euc. le souefii*, Maiden	Le Souef's Blackbutt
Goldfields Sand Mallee	*Euc. eremophila*, (Diels) Maiden	
Grey Gum	*Euc. griffithsii*, Maiden	
Gungunnu	*Euc. caesia*, Benth.	Gungurru
Illyarrie	*Euc. erythrocorys*, F. Muell.	
Island Bloodwood	*Euc. nesophila*, Blakely	
Jarrah	*Euc. marginata*, Sm.	
Karri	*Euc. diversicolor*, F. Muell.	
Kimberley Hills Gum	*Euc. cliftoniana*, W. V. Fitz.	
Kingsmill's Mallee	*Euc. kingsmillii*, Maiden & Blakely	
Kruse's Mallee	*Euc. kruseana*, F. Muell.	Book Leaf Mallee
Lemon-flowered Gum	*Euc. woodwardii*, Maiden	
Macarthur River Box	*Euc. tectifica*, F. Muell.	
Mallee Snap and Rattle	*Euc. celastroides*, Turcz.	Mirret, Mealy Blackbutt
Marri	*Euc. calophylla*, R. Br.	Redgum
Merrit	*Euc. flocktoniae*, Maiden	

Standard Common Name	Botanical Name	Other Names
Micum	*Euc. pallidifolia*, F. Muell, Syn. *E. brevifolia*, F. Muell.	Mountain White Gum
Moort	*Euc. platypus*, Hook.	Round-leaved Moort
Morrel (Red)	*Euc. longicornis*, F. Muell.	Morrel
Mottlecah	*Euc. macrocarpa*, Hook.	Rose of the West
Mountain Marri	*Euc. haematoxylon*, Maiden	Mountain Redgum
Open-fruited Mallee	*Euc. annulata*, Bentham	
Pale Bloodwood	*Euc. terminalis*, F. Muell.	Long-fruited Bloodwood, Kulcha
Pear-fruited Mallee	*Euc. pyriformis*, Turcz.	
Poot	*Euc. decipiens*, Endl.	Redheart
Powderbark Wandoo	*Euc. accedens*, W. V. Fitz.	
Red-flowered Gum	*Euc. ficifolia*, F. Muell.	Red Flowering Gum
Red-flowered Moort	*Euc. nutans*, F. Muell.	
Red Morrel	*Euc. longicornis*, F. Muell.	Morrel
Red Tingle	*Euc. jacksonii*, Maiden	
Redwood	*Euc. oleosa var. obtusa*, C. A. Gardn.	
Ridge Gum	*Euc. alba*, *Reinw.*	
River Gum	*Euc. camaldulensis*, Dehn.	River Red Gum
Rose Mallee	*Euc. rhodantha*, Blakely & Steedman	
Salmon Gum	*Euc. salmonophloia*, F. Muell.	
Salmon-bark Wandoo	*Euc. lane-poolei*, Maiden	
Salt River Gum	*Euc. sargentii*, Maiden	
Scarlet Pear Gum	*Euc. stoatei*, C. A. Gardn.	
Silver Gimlet	*Euc. campaspe*, Moore	Silver-topped Gimlet
Snap and Rattle	*Euc. gracilis*, F. Muell.	
Southern Cross Mallee	*Euc. crucis*, Maiden	
Swamp Mallet	*Euc. spathulata*, Hook.	
Tuart	*Euc. gomphocephala*, A. DC.	
W.A. Blackbutt	*Euc. patens*, Benth.	Blackbutt
Wandoo	*Euc. wandoo*, Blakely syn, *redunca*, Schau. var. *elata*, Benth.	Whitegum
Weeping Gum	*Euc. sepulcralis*, F. Muell.	
White Bark	*Euc. apodophylla*, Blakely & Jacobs	
White Mallee	*Euc. erythronema*, Turcz.	Red-flowered Mallee
White Mallet	*Euc. falcata*, Turcz. var. *ecostata*, Maiden	
Woollybutt	*Euc. miniata*, A. Cunn. ex Schau.	Melaleuca Gum
Yate	*Euc. cornuta*, Labill.	
Yellow-flowered Blackbutt	*Euc. stricklandii*, Maiden	Strickland's Gum
Yellow Tingle	*Euc. guilfoylei*, Maiden	
York Gum	*Euc. loxophleba*, Benth.	
Yorrel	*Euc. gracilis*, F. Muell.	

APPENDIX II

ALPHABETICAL LIST OF WESTERN AUSTRALIAN EUCALYPTUS TREES

Euc. accedens, W. V. Fitz.
Euc. alba, Reinw.
Euc. apodophylla, Blakely & Jacobs
Euc. argillacea, W. V. Fitz.
Euc. astringens, Maiden
Euc. brachyandra, F. Muell.
Euc. brevifolia, F. Muell.
Euc. brockwayi, C. A. Gardn.
Euc. caesia, Benth.
Euc. calophylla, R.Br.
Euc. camaldulensis, Dehn.
Euc. campaspe, Moore
Euc. celastroides, Turcz.
Euc. clavigera, A. Cunn.
Euc. clelandii, Maiden
Euc. cliftoniana, W. V. Fitz.
Euc. collina, W. V. Fitz.
Euc. confluens (W. V. Fitz.), Maiden
Euc. cooperiana, F. Muell.
Euc. cornuta, Labill.
Euc. corrugata, Luehm.
Euc. decipiens, Endl.
Euc. dichromophloia, F. Muell.
Euc. diversicolor, F. Muell.
Euc. drummondii, Benth.
Euc. dundasii, Maiden
Euc. erythrocorys, F. Muell.
Euc. falcata, Turcz.; var. *ecostata*, Maiden
Euc. ficifolia, F. Muell.
Euc. flocktoniae, Maiden
Euc. foelscheana, F. Muell.
Euc. gamophylla, F. Muell.
Euc. gardneri, Maiden
Euc. gomphocephala, A. DC.
Euc. gongylocarpa, Blakely
Euc. gracilis, F. Muell.
Euc. grandifolia, R. Br.
Euc. griffithsii, Maiden
Euc. guilfoylei, Maiden
Euc. haematoxylon, Maiden
Euc. houseana, (W. V. Fitz.) Maiden
Euc. intertexta, R. T. Baker
Euc. jacksonii, Maiden
Euc. laeliae, Podger & Chippendale
Euc. lane-poolei, Maiden
Euc. latifolia, F. Muell.
Euc. le souefii, Maiden
Euc. lirata (W. V. Fitz.), Maiden
Euc. longicornis, F. Muell.
Euc. marginata, Sm.
Euc. megacarpa, F. Muell.
Euc. melanophloia, F. Muell.
Euc. melanoxylon, Maiden
Euc. microtheca, F. Muell.
Euc. miniata, A. Cunn.
Euc. mooreana (W. V. Fitz.), Maiden
Euc. mundijongensis, Maiden
Euc. nesophila, Blakely
Euc. occidentalis, Endl.
Euc. oleosa, F. Muell.
Euc. oligantha, Schau.
Euc. pallidifolia, F. Muell.
Euc. papuana, F. Muell.
Euc. patens, Benth.
Euc. perfoliata, R. Br.
Euc. platypus, Hook.
Euc. platypus, Hook., var. *heterophylla*, Blakely
Euc. pruinosa, Schau.
Euc. ptychocarpa, F. Muell.
Euc. pyrophora, Benth.
Euc. wandoo, Blakely, syn.: *redunca*, Schau; var. *elata*, Benth.
Euc. rudis, Endl.
Euc. salmonophloia, F. Muell.
Euc. salubris, F. Muell.
Euc. sargentii, Maiden
Euc. sepulcralis, F. Muell.
Euc. setosa, Schau.
Euc. spathulata, Hook.
Euc. spencerana, Maiden
Euc. staeri, Maiden
Euc. stoatei, C. A. Gardn.
Euc. striaticalyx, W. V. Fitz.
Euc. stricklandii, Maiden
Euc. tectifica, F. Muell.
Euc. terminalis, F. Muell.
Euc. tetrodonta, F. Muell.
Euc. todtiana, F. Muell.
Euc. torquata, Luehm.
Euc. transcontinentalis, Maiden
Euc. woodwardii, Maiden

Trees which occasionally take on a mallee form—

Euc. astringens, Maiden
Euc. celastroides, Turcz.
Euc. cornuta, Labill.
Euc. decipiens, Endl.
Euc. diptera, Andrews
Euc. falcata, Turcz.
Euc. flocktoniae, Maiden
Euc. gardneri, Maiden
Euc. gracilis, F. Muell.
Euc. marginata, Sm.
Euc. megacarpa, F. Muell.
Euc. oleosa, F. Muell.
Euc. salubris, F. Muell.
Euc. spathulata, Hook.
See also Mallees occurring as trees.

ALPHABETICAL LIST OF MALLEES AND MARLOCKS

Euc. angulosa, Schau.
Euc. angusta, Maiden
Euc. angustissima, F. Muell.
Euc. annulata, Benth.
Euc. buprestium, F. Muell.
Euc. calycogona, Turcz.
Euc. comitae-vallis, Maiden
Euc. conglobata (R. Br.) Maiden
Euc. crucis, Maiden
Euc. decurva, F. Muell.
Euc. diptera, Andrews
Euc. doratoxylon, F. Muell.
Euc. dumosa, A. Cunn.
Euc. ebbanoensis, Maiden
Euc. eremophila, Maiden
Euc. eremophila var. *grandiflora*, Maiden
Euc. erythronema, Turcz.
Euc. erythronema, var. *marginata*, Benth.
Euc. eudesmioides, F. Muell.
Euc. ewartiana, Maiden
Euc. falcata, Turcz.
Euc. foecunda, Schau.
Euc. forrestiana, Diels
Euc. goniantha, Turcz.
Euc. grossa, F. Muell.
Euc. herbertiana, Maiden
Euc. incrassata, Labill.
Euc. jutsonii, Maiden
Euc. kalganensis, Maiden
Euc. kingsmillii, Maiden & Blakely
Euc. kruseana, F. Muell.
Euc. lehmannii, Preiss
Euc. leptophylla, F. Muell.
Euc. leptopoda, Benth.
Euc. macranda, F. Muell.
Euc. macrocarpa, Hook.
Euc. micranthera, F. Muell.
Euc. nutans, F. Muell.
Euc. occidentalis, Endl. var. *stenantha*, Diels.
Euc. odontocarpa, F. Muell.
Euc. oldfieldii, F. Muell.
Euc. oleosa, F. Muell.
Euc. orbifolia, F. Muell.
Euc. pachyloma, Benth.
Euc. preissiana, Schau.
Euc. pyriformis, Turcz.
Euc. redunca, Schau.
Euc. redunca, var. *melanophloia*, Benth.
Euc. redunca, var. *oxymitra*, Maiden
Euc. rhodantha, Blakely & Steedman
Euc. sheathiana, Maiden
Euc. tetragona, F. Muell.
Euc. tetraptera, Turcz.
Euc. uncinata, Turcz.
Euc. websteriana, Maiden
Euc. xanthonema, Turcz.
Euc. youngiana, F. Muell.

Mallees which sometimes have a tree form

Euc. annulata, Benth.
Euc. conglobata, (R.Br.) Maiden
Euc. diptera, Andrews
Euc. doratoxylon, F. Muell.
Euc. eremophila, Maiden
Euc. eudesmioides, F. Muell.
Euc. falcata, Turcz.
Euc. lehmannii, Preiss
Euc. leptophylla, F. Muell.
Euc. oleosa, F. Muell.
Euc. platypus, Hook.
Euc. spathulata, Hook.
See also list of trees sometimes occurring as Mallees.

APPENDIX III

SUMMARY OF EXPORTS OF FOREST PRODUCE SINCE 1836

Year	Timber			Year	Timber			Wood Manufactures	Tanning Materials	Essential Oils
	Cub. ft	M³	Value £		Cub. ft.	M³	Value £	Value £	Value £	Value £
1836 (*a*)	10,000	*283*	2,500	1901	7,150,600	*202,505*	572,354	....	....	....
1837	....	....	....	1902	6,256,750	*177,191*	500,533	....	....	....
1838	....	....	....	1903	7,748,450	*219,436*	619,705	....	859	....
1839	....	....	....	1904	8,072,300	*228,608*	654,949	....	32,876	....
1840	....	....	....	1905	8,709,500	*246,653*	689,943	....	154,087	....
		....	....	1906	(*c*) 8,830,700	(*c*) *250,085*	708,993	....	140,720	....
1841	....	....	....	1907	(*c*) 6,409,550	(*c*) *181,518*	511,923	....	98,773	....
1842	....	....	....	1908	(*c*) 9,869,509	(*c*) *279,504*	813,591	....	79,934	....
1843	....	....	....	1909	(*c*) 10,830,450	(*c*) *306,718*	867,419	....	59,633	....
1844	(*b*)	(*b*)	163	1910	(*c*) 12,074,100	(*c*) *341,939*	972,698	....	93,733	....
1845	....	....	....							
1846	2,550	*72*	255	1911	(*c*) 12,449,500	(*c*) *352,570*	986,341	....	83,470	....
1847	12,200	*346*	1,120	1912	(*c*) 11,297,100	(*c*) *319,934*	903,396	....	49,004	....
1848	3,350	*95*	333	1913	(*c*) 13,619,850	(*c*) *385,714*	1,089,481	....	47,377	....
1849	....	....	....	1914 (*d*)	(*c*) 6,279,750	(*c*) *177,843*	502,152	....	18,197	777
1850	10,500	*297*	1,048	1915 (*e*)	(*c*) 9,968,500	(*c*) *282,308*	808,392	....	6,127	381
				1916	5,432,100	*153,837*	441,991	....	10,208	1,102
1851	1,250	*35*	268	1917	3,890,650	*110,183*	310,893	....	18,959	2,060
1852	7,050	*200*	806	1918	3,436,250	*97,315*	274,141	....	16,886	3,995
1853	52,200	*1,478*	5,220	1919	4,135,750	*117,124*	332,584	11,535	18,875	3,987
1854	58,500	*1,657*	7,023	1920	5,055,300	*143,449*	465,731	21,935	22,121	3,704
1855	76,900	*2,178*	12,076							
1856	70,500	*1,997*	9,671	1921	9,816,250	*277,996*	1,137,819	24,916	23,073	10,017
1857	69,200	*1,960*	9,449	1922	8,309,750	*235,332*	1,041,047	22,248	13,328	6,878
1858	29,250	*827*	2,340	1923	7,911,310	*224,048*	997,454	12,377	21,161	20,075
1859	67,350	*1,907*	6,051	1924	11,126,861	*315,113*	1,367,517	11,505	29,606	39,877
1860	54,800	*1,552*	4,932	1925	11,844,303	*335,431*	1,477,997	13,298	40,136	42,057
				1926	12,001,384	*339,879*	1,522,958	10,072	15,056	47,819
1861	27,750	*786*	2,497	1927	12,580,262	*356,273*	1,651,149	8,727	15,818	26,544
1862	68,800	*1,948*	7,151	1928	10,384,784	*294,097*	1,265,383	7,783	27,662	39,131
1863	32,900	*932*	2,963	1929	7,635,237	*216,230*	960,435	6,603	35,850	63,307
1864	58,300	*1,651*	5,508	1930	6,579,743	*186,338*	807,425	4,687	40,628	77,510
1865	183,950	*5,210*	15,693							
1866	85,650	*2,426*	6,849	1931	4,127,856	*116,901*	507,382	26,615	35,333	56,170
1867	56,750	*1,607*	4,541	1932	3,062,673	*86,735*	361,700	85,488	42,016	59,301
1868	8,000	*227*	638	1933	2,235,540	*63,310*	262,617	80,332	33,352	26,331
1869	179,900	*5,095*	14,273	1934	4,060,830	*115,003*	487,248	76,107	20,904	26,720
1870	157,200	*4,452*	17,551	1935	5,326,117	*150,836*	636,466	65,494	15,284	35,363
				1936	5,598,180	*158,540*	697,522	50,665	12,237	27,526
1871	218,500	*6,188*	15,304	1937	5,673,903	*160,685*	699,684	52,338	14,491	38,185
1872	37,000	*1,048*	2,590	1938	7,545,744	*213,695*	932,420	47,934	13,865	35,128

1873	68,150	*1,930*	4,771		
1874	345,600	*9,787*	24,192		
1875	342,350	*9,695*	32,965		
1876	219,050	*6,204*	23,743		
1877	336,150	*9,520*	26,979		
1878	580,900	*16,451*	63,902		
1879	627,250	*17,764*	69,742		
1880	662,550	*18,763*	66,252		
1881	792,750	*22,451*	79,277		
1882	936,500	*26,522*	93,650		
1883	997,000	*28,235*	79,760		
1884	861,700	*24,403*	68,936		
1885	848,150	*24,020*	67,850		
1886	626,150	*17,733*	50,902		
1887	354,800	*10,048*	28,384		
1888	525,570	*14,884*	42,060		
1889	788,500	*22,330*	63,080		
1890	1,172,200	*33,197*	82,052		
1891	1,273,950	*36,078*	89,179		
1892	1,082,650	*30,661*	78,419		
1893	512,950	*14,527*	33,888		
1894	1,063,700	*30,124*	74,804		
1895	1,255,250	*35,549*	88,146		
1896	1,545,600	*43,771*	116,420		
1897	2,393,300	*67,778*	192,451		
1898	4,086,150	*115,719*	326,195		
1899	6,913,550	*195,792*	553,198		
1900	5,725,400	*162,143*	458,461		
1939	5,704,250	*161,544*	722,310	43,518	17,842	25,550
1940	5,049,585	*143,004*	634,859	62,796	19,485	47,736
1941	6,091,187	*172,502*	790,876	74,935	13,686	59,867
1942	5,244,634	*148,528*	700,474	64,454	6,986	74,904
1943	3,516,566	*99,589*	605,327	32,426	1,598	70,523
1944	3,645,354	*103,236*	613,994	25,324	1,294	72,704
1945	2,851,475	*80,754*	570,028	27,307	2,795	103,055
1946	3,373,025	*95,524*	722,061	2,618	4,872	128,050
1947	3,458,628	*97,948*	865,255	13,118	12,056	151,768
1948	3,584,405	*101,510*	1,099,073	6,572	9,556	116,465
1949	3,198,212	*90,573*	993,152	6,639	5,112	75,395
1950	2,857,946	*80,937*	974,493	13,525	8,243	78,550
1951	2,342,492	*66,339*	918,485	25,101	16,581	125,833
1952	2,373,553	*67,219*	1,032,909	47,689	19,120	119,109
1953	3,965,188	*112,294*	2,074,421	120,095	34,136	70,852
1954	3,858,956	*109,286*	2,248,320	59,360	80,248	55,273
1955	3,477,249	*98,476*	1,935,019	79,893	37,338	80,882
1956	4,568,024	*129,367*	2,818,716	119,459	554,760	90,928
1957	4,684,017	*132,651*	3,256,719	78,934	588,544	58,993
1958	5,572,681	*157,818*	3,875,705	39,762	337,655	101,814
1959	6,461,535	*182,991*	4,373,218	41,612	259,046	52,843
1960	6,133,240	*173,693*	4,160,354	20,549	366,606	63,905
1961	5,533,847	*156,719*	3,838,387	25,305	201,957	95,475
1962	5,660,937	*160,318*	3,993,663	194,380	281,364	81,506
1963	5,484,259	*155,314*	3,966,697	255,190	254,726	70,402
1964	5,266,329	*149,142*	3,686,732	272,187	322,916	88,666
1965	4,716,296	*133,566*	3,545,627	523,596	326,156	76,019
			$	$	$	$
1966	2,431,248	*68,853*	4,361,278	1,365,441	289,841	314,817
1967	4,898,421	*138,723*	7,467,696	1,335,872	262,808	269,044
1968	2,986,211	*84,569*	4,947,595	3,016,850	N.r.s.	280,806
1969	3,052,796	*86,455*	4,984,098	3,802,927	N.r.s.	267,565
1970	3,399,534	*96,275*	5,661,547	3,906,699	N.r.s.	317,553
Total	471,347,667	*13,349,126*	203,415,770	19,261,795	10,925,265	7,311,809

(*a*) The exports up to the year 1834 consisted only of supplies to shipping of which no record is kept.

(*b*) Not available.

(*c*) Approximate figures only.

(*d*) Six months ended 30th June.

(*e*) Year ended 30th June from 1915 onwards

(*f*) Excludes casks (principally empty returns) previously recorded in this item from 1946-1966 inclusive.

(*g*) Includes items for which the quantity in M^3 is not available from 1951 onwards.

N.r.s.—Not recorded separately.

APPENDIX IV

SUMMARY OF IMPORTS OF TIMBER, FURNITURE, TANNING MATERIALS AND ESSENTIAL OILS, SINCE 1848

Year	Timber, Wood-ware, etc.	Tanning Materials	Essential Oils	Year	Timber, Wood-ware, etc.	Tanning Materials	Essential Oils
	£	£	£		£	£	£
1848	464	....	....	1900	56,266	1,416	1,105
1849	....	....	....	1901	80,134	1,740	1,546
1850	189	....	....	1902	97,810	3,418	1,751
1851	3,216	....	....	1903	102,383	3,556	1,348
1852	2,479	....	....	1904	157,856	1,322	2,122
1853	790	....	....	1905	98,494	582	1,592
1854	831	....	....	1906	95,229	1,412	1,915
1855	1,464	....	....	1907	122,016	2,767	1,549
1856	1,124	....	....	1908	93,205	2,392	4,584
1857	744	....	....	1909	90,502	4,129	4,033
1858	1,528	....	....	1910	171,280	3,531	3,686
1859	690	....	....	1911	152,133	2,912	4,938
1860	2,005	....	....	1912	167,244	3,089	4,598
1861	1,459	....	....	1913	202,640	2,651	5,392
1862	1,920	....	....	1914	78,736	629	2,823
1863	1,568	....	....	1914-15	107,763	2,082	4,988
1864	894	....	....	1915-16	76,849	3,313	4,788
1865	548	....	....	1916-17	75,681	2,848	3,848
1866	1,442	....	....	1917-18	58,305	2,020	4,358
1867	1,727	....	....	1918-19	62,824	1,181	4,168
1868	1,451	....	....	1919-20	100,083	3,748	10,043
1869	1,408	....	....	1920-21	171,654	*4,899	6,106
1870	1,518	....	....	1921-22	92,448	5,865	6,577
1871	736	....	....	1922-23	109,428	6,991	4,033
1872	1,660	....	....	1923-24	133,983	2,790	3,301
1873	1,008	....	....	1924-25	161,893	2,670	4,429
1874	1,774	....	....	1925-26	144,989	5,826	4,449
1875	2,707	....	....	1926-27	162,193	8,971	4,254
1876	3,098	....	....	1927-28	183,196	9,648	6,955
1877	2,036	....	....	1928-29	241,601	6,894	4,413
1878	2,947	....	....	1929-30	197,532	10,825	3,980
1879	2,340	....	....	1930-31	76,533	4,145	3,160
1880	3,061	....	....	1931-32	164,496	4,705	3,505
1881	3,639	....	....	1932-33	197,916	4,903	3,421
1882	3,692	....	....	1933-34	183,944	4,310	3,888
1883	6,667	....	....	1934-35	211,056	4,076	5,040
1884	2,930	....	....	1935-36	228,451	5,401	3,921
1885	11,479	....	....	1936-37	257,164	5,267	4,810
1886	17,888	....	....	1937-38	270,126	4,777	6,560
1887	8,136	....	....	1938-39	254,315	3,974	7,014
1888	4,461	....	....	1939-40	259,399	6,802	23,027
1889	7,686	....	....	1940-41	249,111	3,798	32,399
1890	14,979	....	....	1941-42	283,611	15,846	33,828
1891	18,406	....	....	1942-43	163,480	6,250	47,718
1892	26,713	....	....	1943-44	149,928	7,883	68,871
1893	14,493	....	....	1944-45	148,838	9,264	75,449
1894	17,964	....	....	1945-46	†219,466	19,573	56,295
1895	47,128	....	....	1946-47	386,465	12,395	78,091
1896	5,381	....	....	1947-48	345,508	8,019	96,769
1897	164,552	....	....	1948-49	470,755	8,662	42,926
1898	55,566	....	....	1949-50	521,815	24,923	51,197
1899	45,689	....	....	1950-51	640,059	21,147	161,358
				1951-52	1,037,499	18,494	167,697
				1952-53	509,667	21,493	69,804
				1953-54	923,367	45,202	58,019
				1954-55	816,052	27,395	76,464
				1955-56	839,581	27,315	131,758
				1956-57	830,700	35,403	99,863
				1957-58	873,520	28,310	101,680
				1958-59	815,300	9,365	62,983
				1959-60	895,845	14,608	74,199
				1960-61	1,203,641	12,621	60,942
				1961-62	1,236,106	13,853	130,876
				1962-63	1,978,937	9,868	63,739
				1963-64	1,903,772	19,412	37,494
				1964-65	2,289,999	21,677	69,741
					$	$	$
				1965-66	4,856,090	60,963	132,862
				1966-67	6,458,909	68,928	191,796
				1967-68	8,135,532	75,657	143,696
				1968-69	8,731,114	109,905	206,309
				1969-70	10,968,170	153,169	293,845
				Total	91,807,979	1,673,128	5,244,076

* This and subsequent years include tanning extracts, not previously recorded.

† This and subsequent years include values for furniture, bamboo, cane, etc., not previously included.

SUMMARY OF LOG VOLUMES PRODUCED IN WESTERN AUSTRALIA SINCE 1829

Year	* Crown Land		Private Property		Totals		Year	* Crown Land		Private Property		Totals	
	Cubic Feet	M³	Cubic Feet	M³	Cubic Feet	M³		Cubic Feet	M³	Cubic Feet	M³	Cubic Feet	M³
1829-1916	....	....	....	....	663,267,850	*18,784,136*	1939 (*c*)	29,247,650	*828,293*	11,086,000	*313,956*	40,333,650	*1,142,249*
1917 (*a*)	19,665,550	*547,513*	2,144,500	*60,732*	21,477,600	*608,245*	1940 (*c*)	27,660,100	*783,334*	9,139,550	*258,832*	36,799,650	*1,042,166*
1918 (*b*)	7,665,550	*217,088*	504,950	*14,300*	8,170,500	*231,388*	1941 (*c*)	28,089,200	*795,486*	10,289,000	*291,384*	38,378,200	*1,086,870*
1919 (*c*)	19,987,050	*566,033*	3,390,450	*96,018*	23,377,500	*662,051*	1942 (*c*)	26,636,650	*754,350*	5,633,400	*159,538*	32,270,050	*913,888*
1920 (*c*)	28,292,200	*801,235*	5,762,900	*163,205*	34,055,100	*964,440*	1943 (*c*)	23,604,900	*668,491*	4,322,950	*122,426*	27,927,850	*790,917*
1921 (*c*)	29,308,950	*830,029*	7,018,450	*198,763*	36,327,400	*1,028,792*	1944 (*c*)	22,252,500	*630,191*	4,456,200	*126,200*	26,708,700	*756,391*
1922 (*c*)	36,122,400	*1,022,986*	15,640,150	*442,929*	51,762,550	*1,465,915*	1945 (*c*)	21,970,000	*622,190*	4,309,550	*122,046*	26,279,550	*744,236*
1923 (*c*)	26,807,300	*759,183*	9,867,050	*279,435*	36,674,350	*1,038,618*	1946 (*c*)	21,126,500	*598,302*	5,482,350	*155,260*	26,608,850	*753,562*
1924 (*c*)	42,004,450	*1,189,566*	9,342,800	*264,588*	51,347,250	*1,454,154*	1947 (*c*)	21,918,550	*621,583*	7,831,950	*221,801*	29,780,500	*843,384*
1925 (*c*)	43,832,900	*1,241,348*	18,142,250	*513,789*	61,975,150	*1,755,137*	1948 (*c*)	22,251,350	*630,158*	8,871,900	*251,252*	31,123,250	*881,410*
1926 (*c*)	48,823,750	*1,382,689*	25,037,600	*709,065*	73,861,350	*2,091,754*	1949 (*c*)	20,261,800	*573,814*	9,814,300	*277,941*	30,076,100	*851,755*
1927 (*c*)	46,887,600	*1,327,857*	31,356,100	*888,005*	78,243,700	*2,215,862*	1950 (*c*)	21,081,150	*597,018*	9,932,650	*281,293*	31,013,800	*878,311*
1928 (*c*)	42,781,250	*1,211,565*	23,334,450	*660,832*	66,115,700	*1,872,397*	1951 (*c*)	25,391,450	*719,086*	10,713,050	*303,394*	36,104,500	*1,022,480*
1929 (*c*)	32,289,750	*914,446*	11,098,950	*314,322*	43,388,700	*1,228,768*	1952 (*c*)	28,942,550	*819,653*	11,938,300	*338,093*	40,880,850	*1,157,746*
1930 (*c*)	31,654,150	*896,446*	11,653,600	*330,030*	43,307,750	*1,226,476*	1953 (*c*)	34,223,400	*969,207*	13,021,400	*368,766*	47,244,800	*1,337,973*
1931 (*c*)	18,822,600	*533,056*	12,148,500	*344,046*	30,971,100	*877,102*	1954 (*c*)	37,485,950	*1,061,602*	13,562,000	*384,076*	51,047,950	*1,445,678*
1932 (*c*)	11,742,850	*332,558*	4,115,950	*116,564*	15,858,800	*449,122*	1955 (*c*)	37,467,650	*1,061,084*	15,195,450	*430,335*	52,663,100	*1,491,419*
1933 (*c*)	13,165,650	*372,851*	2,456,650	*69,572*	15,622,300	*442,423*	1956 (*c*)	39,811,350	*1,127,457*	13,773,350	*390,061*	53,584,700	*1,517,518*
1934 (*c*)	21,263,100	*602,171*	6,330,400	*179,277*	27,593,500	*781,448*	1957 (*c*)	39,426,100	*1,116,547*	11,585,350	*328,097*	51,011,450	*1,444,644*
1935 (*c*)	27,458,250	*777,618*	11,451,750	*324,314*	38,910,000	*1,101,932*	1958 (*c*)	39,069,500	*1,106,448*	12,397,450	*351,096*	51,466,950	*1,457,544*
1936 (*c*)	31,400,600	*889,265*	13,436,150	*380,512*	44,836,750	*1,269,777*	1959 (*c*)	40,533,471	*1,147,908*	13,756,198	*389,576*	54,289,669	*1,537,484*
1937 (*c*)	31,703,850	*897,853*	15,902,200	*450,350*	47,606,050	*1,348,203*	1960 (*c*)	38,882,028	*1,101,140*	12,017,553	*340,337*	50,899,601	*1,441,477*
1938 (*c*)	31,737,450	*898,805*	15,928,950	*451,108*	47,666,400	*1,349,913*	1961 (*c*)	37,752,774	*1,069,159*	10,818,790	*306,388*	48,571,564	*1,375,547*
							1962 (*c*)	39,243,552	*1,111,377*	9,789,268	*277,232*	49,032,820	*1,388,609*
							1963 (*c*)	38,671,715	*1,095,183*	9,831,552	*278,430*	48,503,267	*1,373,613*
							1964 (*c*)	39,431,089	*1,116,688*	10,220,000	*289,430*	49,651,089	*1,406,118*
							1965 (*c*)	41,430,800	*1,173,320*	9,815,867	*277,985*	51,246,667	*1,451,305*
							1966 (*c*)	42,224,817	*1,195,807*	10,105,791	*286,196*	52,330,608	*1,482,003*
							1967 (*c*)	40,941,527	*1,159,464*	9,967,907	*282,291*	50,909,434	*1,441,755*
							1968 (*c*)	43,485,765	*1,231,517*	8,060,784	*228,281*	51,546,549	*1,459,798*
							1969 (*c*)	40,385,056	*1,143,705*	5,676,938	*160,771*	46,061,994	*1,304,476*
							1970 (*c*)	39,597,323	*1,121,396*	6,203,619	*175,686*	45,800,942	*1,297,082*
							Total	....	....	....	....	2,922,566,004	*82,767,071*

* Includes State Forest Timber Reserves, Crown Land and Private Property (Timber Reserved). Estimated.
(*a*) Year ended 31st December.
(*b*) Six months ended 30th June.
(*c*) Year ended 30th June.

APPENDIX VI

PROPERTIES OF TIMBERS—SUMMARY

Timber		Weight, lb./cub. ft.		Per cent, Shrinkage, Green to 12 per cent. M.C.		Bending Strength at 12 per cent. M.C.	
Standard Trade Common Name	Standard Trade Reference Name	Green	12 per cent. M.C.	Radial	Tangential	*Modulus of rupture	*Modulus of elasticity
						lb./sq. in.	lb./sq. in.
Jarrah	*Euc. marginata*	73	51	5·3	7·9	16,200	1,880,000
Karri	*Euc. diversicolor*	72	57	5·1	10·1	19,200	2,760,000
Tuart	*Euc. gomphocephala*	78	65	4·0	7·0	18,100	2,370,000
Wandoo	*Euc. wandoo syn. redunca var. elata*	80	69	2·5	3·5	20,600	2,420,000
Brown Mallet	*Euc. astringens*	70	61	4·4	7·1	26,000	2,680,000
Blackbutt (Yarri)	*Euc. patens*	70	53	3·5	6·9	14,300	1,850,000
Yellow Tingle	*Euc. guilfoylei*	74	62	....	....	19,400	2,820,000
Red Tingle	*Euc. jacksonii*	60	48	5·7	9·9	14,200	1,950,000
Marri	*Euc. calophylla*	76	52	3·6	6·9	18,200	2,410,000
Sheoak	*Casuarina fraseriana*	60	46	1·2	4·5	12,000	1,356,000

* Detailed information regarding the properties of W.A. timbers is available in the " Handbook of Structural Timber Design ", Division of Forest Products, C.S.I.R.O., Melbourne, Technical Paper No. 32, and also in Technical Papers No. 13 and 25.

APPENDIX VII

PLATE INDEX

APPENDIX VIII

SUBJECT INDEX

(8)—75592

257 20/6/74—2M—O WILLIAM C. BROWN, Government Printer, Western Australia