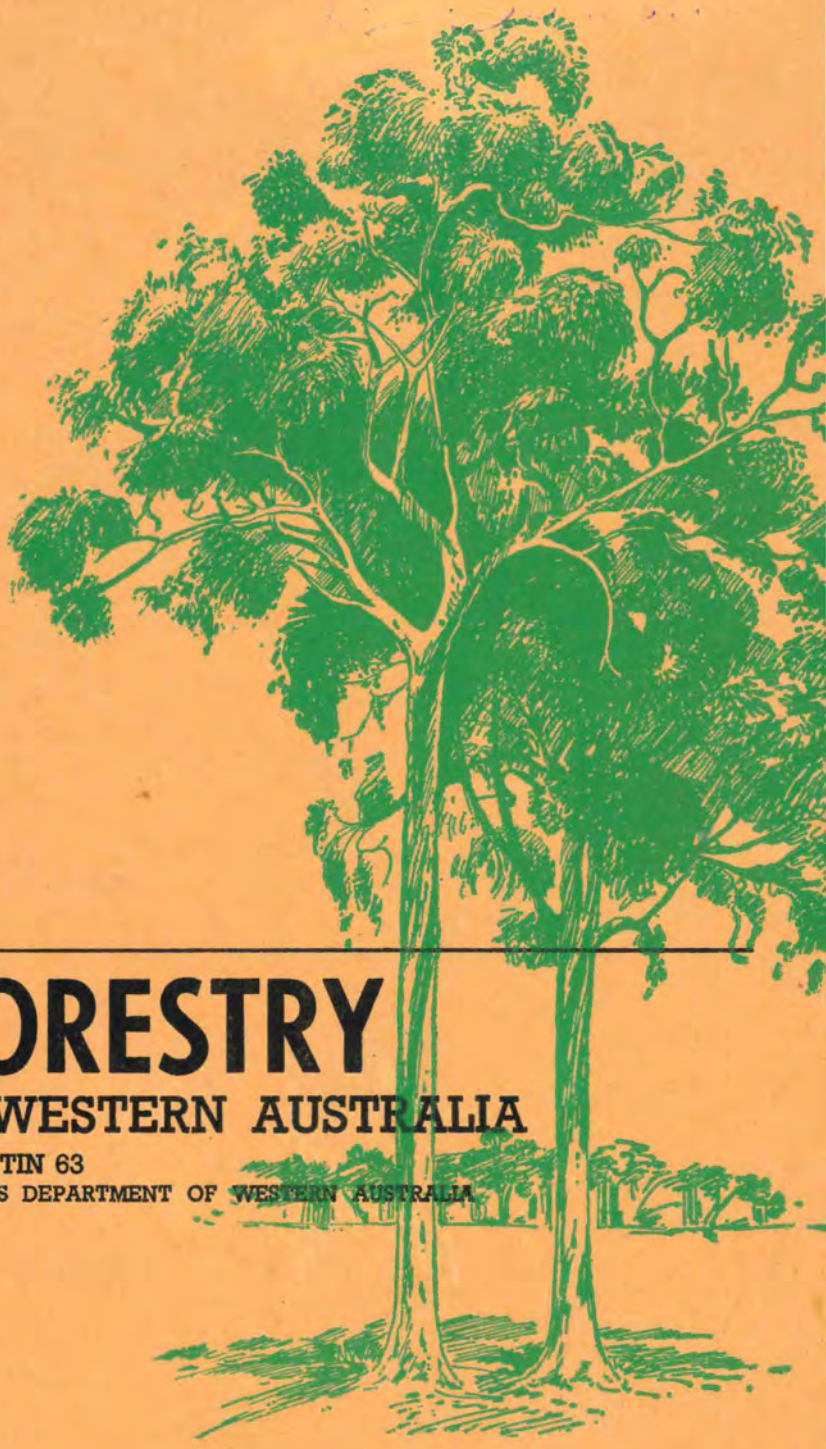

FORESTRY
IN WESTERN AUSTRALIA

BULLETIN 63

FORESTS DEPARTMENT OF WESTERN AUSTRALIA

FORESTRY
IN
WESTERN AUSTRALIA

Prepared Under the Direction of
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ERRATA

The Plate Index, as shown in Contents, has been deleted and the page number of the Subject Index should read 187.

Appendix VIII, page 178—Trees Suitable for Planting in Western Australia—should read Appendix VII.

PREFACE

"Forestry in Western Australia" was first published in 1957 and has been in such demand by the public ever since, that a new 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 forests of this State are relatively limited, but they have been adequate for the needs of our small population so far. Growth in population and industrial expansion over the new few years will impose additional pressures on our forest resources and every endeavour is being made to anticipate these demands by improved and intensified methods of silviculture, protection and management.

"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. Scientific and technical terms have been avoided wherever possible so that the publication can be easily read and the principles of forest management can be readily understood by the interested layman.

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

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

Conservator of Forests.

CONTENTS

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 produce. It concerns the yield of the land and is therefore, a form of primary production dealing with a replaceable or restorable resource.

Forestry aims at regulation of the amount of timber cut followed by the regeneration of cut-over areas to provide a new crop for the use of future generations. It is concerned with improvement in quantity and quality of forest produce grown on an area and the extension of forested areas to meet the demands of increasing population.

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

By degrees it was found that mere protection was not enough. Laws were enacted to enforce a more efficient control of cutting and to restrict it to the actual productive capacity of the forest. *Forest Management* was evolved to meet this problem of calculating the annual or periodic growth and planning for its orderly utilization.

Even then the whole picture was not complete. Following cutting it became evident that reproduction 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 maximum growth of the type and quality 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, Engineering, Mensuration, Soil Science, Surveying, Wood Technology, Meteorology and others, are all necessary for the scientific management of forests. As an appreciation of the need for conservation and replacement of our forest arose, so Forestry developed as a science to deal with all aspects of the formation, treatment and preservation of forest resources. Forestry now stands as a profession requiring at least four years of intensive technical training to University standard, before the young forester is considered competent to commence his work in the forest.

Plate 1.

Karri forest in the Pemberton area of W.A. Such scenic drives offer enjoyment to all.

THE VALUE OF FORESTS

Forests have four principal functions in the interests of the community. These are:—

(1) Productive.

(2) Protective.

(3) Recreational.

(4) Social.

(1) The Productive Function of Forests.

It is unnecessary to emphasise the importance of timber and other forest products in the general economy of a civilised country. Some material produced from trees is encountered on every hand. From the newspaper to the cardboard carton, from plywood to hardboard and through the long range of rayons and other synthetic fibres to plastics and the more obvious sawn lumber, the basic material is wood.

Its indirect use may be gauged by the need for nine cubic feet of timber to produce one ounce of gold and two cubic feet to produce one ton of coal.

Wood has one outstanding advantage. It is a replaceable asset. Its end is not in sight and if we deal wisely with this asset, the world should not go short. The suggestion has been made from time to time, that substitutes will steadily take the place of wood. This has been proved a fallacy on every occasion, for as fast as a substitute for wood is found in one direction, a new use for this basic raw material develops elsewhere. With the vast possibilities for expansion in the fields of pulpwood, plastics and synthetic fibres, the per capita consumption throughout the world will increase rather than decrease in the foreseeable future. In stable and well-developed areas such as Europe, the tendency is for the consumption of sawn timber to remain fairly constant, or to show a small but steady increase. The consumption of manufactured wood products, however, has approximately doubled during the decade 1950-60, and is likely to double again before 1975.

The per capita consumption of sawn timber may be taken as a rough criterion of a country's standard of living, and Table 1 below sets out these figures for the principal geographical regions of the world.

TABLE 1.

Per Capita Consumption (Super Feet).

Region	Sawnwood						Plywood		Particle Board		Fireboard	
	Softwood		Hardwood		Total*							
	1950	1960	1950	1960	1950	1960	1950	1960	1950	1960	1950	1960
Europe	52	58	11	14	67	75	1·5	2·8	....	1·8	1·0	2·2
U.S.S.R.	110	174	17	31	129	207	1·4	2·6	....	0·3	0·1	0·7
North America	206	171	45	34	252	206	8·9	20·4	....	1·2	4·5	6·5
Central America	11	10	5	4	18	16	0·1	0·5	....	....	0·1	0·3
South America	12	10	19	17	33	30	0·4	0·7	....	0·1	0·1	0·4
Africa	4	3	2	3	6	6	0·1	0·2	....	0·3	0·1	0·1
Asia	4	8	2	4	6	12	0·1	0·4	....	0·3	....	0·1
Pacific Area	81	78	92	78	178	166	3·2	4·7	....	0·5	3·4	5·8
World Average	33	38	9	10	44	49	1·0	2·2	....	0·4	0·5	0·9

* Includes sleepers.

This table shows the tremendous difference between the per capita consumption in the highly developed areas as compared with the newly emerging nations in Africa and Asia. The demand for timber and forest products in these less highly-developed regions, however, is bound to increase as the standards of living and industrialisation improve.

For comparison, the Commonwealth and State consumption is outlined in Table 2. It is due to the bolstering effect of these figures that the total for the Pacific Area in Table 1 is so high, and when looked at in isolation it can be seen that in general they rival, and in one case exceed, those of the two giants of the northern hemisphere: North America and the U.S.S.R.

TABLE 2.

Australian States—Per Capita Consumption of Sawn Timber in Super Feet (for the Year 1959-60).

Tasmania	271
Queensland	187
Victoria	184
South Australia	181
Western Australia	174
New South Wales (incl. A.C.T.)	153
Northern Territory	103
Commonwealth	175

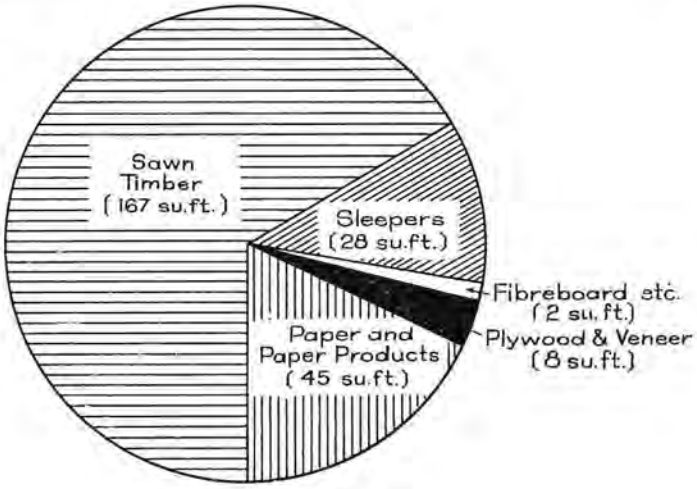


Plate 2.

Diagram showing per capita consumption in W.A. of the different categories of timber products—for the year 1961-62.

Apart from wood, which is the major Forest Product, forests supply a variety of minor products in the form of edible fruits and seeds, rubber, turpentine, tannins, honey, medicinal oils, etc. These often assume greater importance than timber in tropical regions. In Western Australia, honey collection, tannin extraction, charcoal-iron and wood chemicals are relatively important aspects of Forestry, though admittedly of far less significance than that of the major product, timber.

There is abundant support for the saying that from the cradle to the coffin we are dependent on wood. It is an indispensable part of the material structure on which our civilization is based.

(2) The Protective Function of Forests.

Forest vegetation maintained in an effective condition is a vital factor in the regulation of stream flow, in the control of erosion, siltation and other phenomena closely connected with water conservation problems. 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.

Forests promote infiltration of the rainwater into the soil preventing excess surface runoff. They assist in regulating the water supply by producing a more sustained feeding of springs, reducing violent floods and controlling the river and stream flow.

In this country, the problem of providing adequate water supplies to meet the industrial, domestic and irrigation needs of a growing population is a critical one, for water is the limiting factor determining to what extent agricultural and industrial development can be expanded, and the degree to which population can be economically increased.

Western Australia has no extensive chains of high mountains, such as are characteristic of other lands, to feed the rivers and streams by melting snow. We are dependent almost entirely on rainfall. Only one-eighth (12.6%) of the State receives an average annual rainfall exceeding 20 inches. Every effort, therefore, must be made to conserve water, and in this respect, forests on catchment areas play a major part.

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.

The importance of maintaining forests as sanctuaries to protect indigenous flora and fauna must also be recognised.

Glaring examples can be seen of what may happen when the forests of a country (particularly a semi-arid country) are removed. These are evident in Australia in the Mallee region of Victoria, in some of this State's agricultural areas, and, further from home, in the Sahara Desert, the Dustbowl of America and the deserts and barren mountains of the Middle East. In addition, the salting of farm lands and water supplies is another example of the damage which can result from the indiscriminate clearing of the forest.

(3) The Recreational Function of Forests

Forests have a definite, although intangible, value in their contribution to national welfare as recreation grounds for the people. In this country, recreational needs must be similarly catered for, and recognition of the value of public forest land as a source of relaxation is indicated by the demand for the establishment of National Parks in the different parts of the State. Their aesthetic appeal, and healthy and beneficial effect upon the human mind are factors which can only be valued spiritually. No balance sheet could define them in pounds, shillings and pence.

(4) The Social Function of Forests.

Socially, forests provide several fields of employment, the total of which is a significant factor in a nation's economy.

Primarily, employment is provided in general administration and forest management. Here are included the staffs of the Forest Services, and the labour required for the raising and tending of forest crops. It is estimated that one person could be directly employed for every 25 acres of an intensively managed pine plantation from the time of maturity. Our slower growing natural forest areas do not involve such intensive working as this but employment in these forests is still substantial under proper forest management.

The harvesting of forest produce, an operation including logging, sawmilling, pulping, and other industries directly associated with the forest, requires further labour. Labour is also necessary to transport produce between the forest and processing centres where a further large number of workers are employed in those industries which convert the raw material from the forests into marketable goods.

Possibly the classic example illustrating employment created by forests is that concerned with an intensive afforestation scheme involving the Landes district of France in the ninteenth 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 of forest were established and worked.

In Australia, the number of persons now engaged in the forest services and in felling, hewing and delivering timber to market is 35,000, while a further 40,000 are employed in sawmills and plywood mills. Secondary industries using timber or other forest produce as a major raw material employ at least a further 35,000 persons. The majority of these workers are employed in rural areas, where forestry and the timber industry are often the mainstay of development and financial security.

FOREST POLICY

Forests are varied in their nature and serve the community in many different ways. The immediate objects of forestry and the means by which it is sought to achieve them are also varied and the setting out of the aims and the relationship of forestry to other forms of human activity make up that branch of Forestry known as 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. All civilized countries today have developed policies on much the same lines, with the object of using their forests to the best advantage, for the future as well as the present.

Forest Policy deals with the social and economic aspects of Forestry and is so designed that forests may, in the highest possible degree and the most economical manner, meet the demands made on them in the interests of the community as a whole.

The objects of Forest Policy are:—

(a) To ensure that there shall be an adequate forest area to meet present and future demands.

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

(c) To maintain and improve the productivity of forests.

Policy aims to establish Forestry as a permanent rural industry growing and supplying forest products in perpetuity.

A well managed forest may be likened to a banking 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) represents the interest earned. The fundamental idea of Forest Management is directed towards utilization of this increment only, while preserving and enhancing the forest capital for increased future production.

This idea of a sustained yield and the permanence of direct and indirect forest industries cannot be furthered without a sound policy on the part of the owners. In Western Australia most of the forests belong to the State and are administered by the Government through its Forests Department.

FOREST POLICY IN W.A.

In Western Australia the essentials of a good Forest Policy were provided for in the Forests Act, 1918. In this Act, provision was made for the dedication of State Forests which can be alienated only by agreement of both Houses of Parliament.

To date over four million acres have been dedicated as State Forest.

Apart from the area permanently dedicated as State Forest, approximately two million acres have been gazetted as Timber Reserves. Of these Reserves only the 60,000 acres in the South-West are capable of producing millable timber and the balance consists chiefly of firewood forest in inland areas.

Four million acres is little enough 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. In comparison, China has 240 million acres, and the U.S.A. 700 million acres.

It is essential therefore, that the best use must be made of our native forests and that other provisions are made to provide the extra timber which will be required by our ever expanding population.

To do this, pine plantations are being established to augment timber supplies from the jarrah and karri forests. Forty thousand acres have already been established, but it is estimated that at least 200,000 acres of plantation will be necessary to make this State self-supporting in the future.

Such is the first requirement of a Forest Policy—the dedication of a permanent forest area.

Secondly, a good forest policy must provide money and foresters to maintain and develop the forest. It must be remembered that a forest is a crop which matures only after a long period—not annually as with wheat and other grains. A Jarrah seedling growing today may take over a hundred years to reach millable size. It is essential that funds be arranged in such a way that permanent works and forest protection will be regularly and continuously maintained.

The Forests Act provides that nine-tenths of the nett forest revenue is available for forest replacement and improvement. In addition to this, loan moneys received are used to develop plantations.

Thirdly, a good Forest Policy must have specific authority for the application of this policy. In Western Australia this is covered by the Forests Act which provides for (inter-alia)—

(1) A Conservator and a Forests Department having a professional staff of fully qualified officers. The Conservator has wide powers in applying policy.

(2) The preparation and enforcement of Forest Working Plans which may specify—

(a) The maximum forest area from which forest produce be taken annually.

(b) The maximum quantity of forest produce that may be disposed of annually.

(c) The Silvicultural operations necessary to assure the regeneration of the best species of forest produce on areas which have been cut over, and

(d) Such other matters as the Conservator may think fit.

The Working Plans must be made at periods not exceeding 10 years. They must be approved by the Governor and can only be altered on the recommendations of the Conservator of Forests.

Working Plans are dealt with in more detail under the heading of Forest Management.

FOREST ECONOMICS IN W.A.

Timber is one of the most important primary products of this State, and we have been fortunate in having extensive forests of jarrah and karri, two of the world's most valuable hardwoods, provided for our use at no original cost.

Timber exploitation began with the arrival of the first settlers in 1829, and the first sawmills made their appearance about the middle of the last century. Approximately two hundred and twenty mills are operating at the present time and the industry employs more than 5,000 men.

During the past one hundred years the timber industry has generally prospered and has been a stabilizing force in the economy of this State and the mainstay of the ports of Busselton and Bunbury. The peak periods of production were in the years 1927 and 1928.

However, this peak was exceeded by the output in 1956 when 19,219,079 cubic feet of sawn timber came from our forests; about 75 per cent. of this from State forests and Crown lands and the remainder from private property. The amount from private property will dwindle as the years go by and is evidenced by a slight decrease from this source over the past 12 months.

With immigration and the great developments in both primary and secondary industries in this State, our population is expected to reach one million by 1980. What then will be the effect on our timber industry and our forest wealth?

At the present rate of consumption 22 million cubic feet of sawn timber will be required to provide our own needs. This is almost three million cubic feet more than our present total production. With a dwindling supply from

private property and even the complete cessation of exports, the State will still be in a serious position.

There are, however, several ways in which this leeway can be made up. Sawmillers must make every effort to increase their recovery from the logs which are available. Foresters must endeavour to improve annual growth by intensive silvicultural treatment of our higher quality hardwood forests: by removing useless trees, ensuring proper spacing and eliminating competition, the productivity of the vigorous retained growing stock can be almost doubled. Architects and builders must take more care that the correct quality is used for different parts of a building. Investigation of the present sizes of scantling, flooring, etc., is necessary to see whether timber can be saved in this way.

All these will help, but our major deficit can be made up in one of two ways—importation of our requirements or the production of fast growing exotic conifers in our own State.

Plate 3.

The Donnelly River Sawmill (Wheatley)—one of over 200 mills operating in the south-west of the State.

An increase of only two per cent. in the recovery of our sawmills would mean the production of one million cubic feet of sawn timber every year. 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.

We 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 loth to try smaller timbers or thinner floor boards. In fact, we have been thoroughly spoilt as timber users during the past 100 years.

About four million acres of forest country have been dedicated as State Forest by successive Governments for the production of timber for all time. The sustained yield figure at the present time is 40 million cubic feet of log timber a year. This is the amount actually being cut at the present time and cannot be greatly increased without inroads being made into our forest capital.

Further relief for the future lies in the use of the marri tree *(Eucalyptus calophylla)*. It is valuable timber which is at present not popular, but which has its uses in railway sleepers, building scantling, flooring and other purposes. Some 500 million cubic feet of usable marri logs are standing untouched in the forest today.

Importation of timber should not be thought of except for special purposes. It is expensive and supply is erratic.

Our salvation is the provision of pine plantations now so that they will be coming into production when the timber supply position is becoming acute in 20 or 30 years' time. Fast growing pines will yield at least 5,000 cu. ft. per acre in 40 or 50 years. With a planting programme of 2,000 acres a year and with thinnings at intervals during the rotation of the plantation, up to five million cubic feet of sawn pine could be produced each year.

With this in view, the Forests Department has already some 40,000 acres of plantations and every effort is being made to attain an immediate goal of 3,000 acres planted each year. Sawn timber from small early plantings is already being produced, and over 1,750,000 cubic feet was cut in 1964.

The future of the sawmilling industry and the timber requirements of the population are intimately bound up with a wise forest policy, maximum utilisation by the sawmiller, and minimum wastage by the user.

CHAPTER II

FOREST BOTANY

A DESCRIPTION OF A TREE
THE VEGETATION OF W.A.
WESTERN AUSTRALIAN TREES
THE GENUS EUCALYPTUS
THE FOREST

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, while the woodland wandoo is normally found with a bole of approximately 25 feet. 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 and 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, sulphur, phosphorus, potassium, magnesium and calcium 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 iron, manganese, molybdenum, copper, zinc and boron, 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.

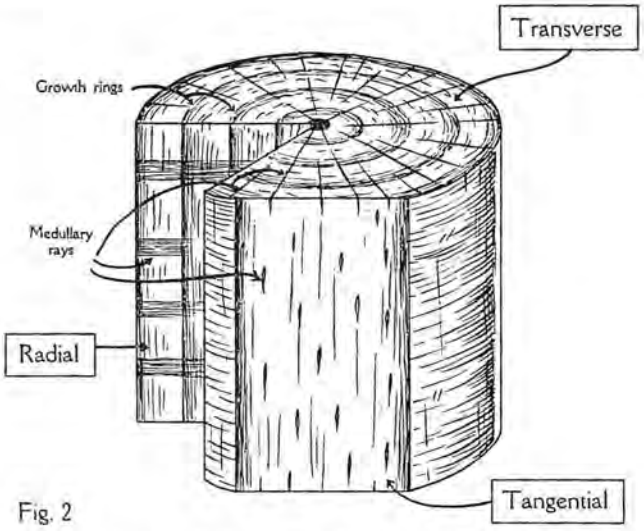


Fig. 2

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

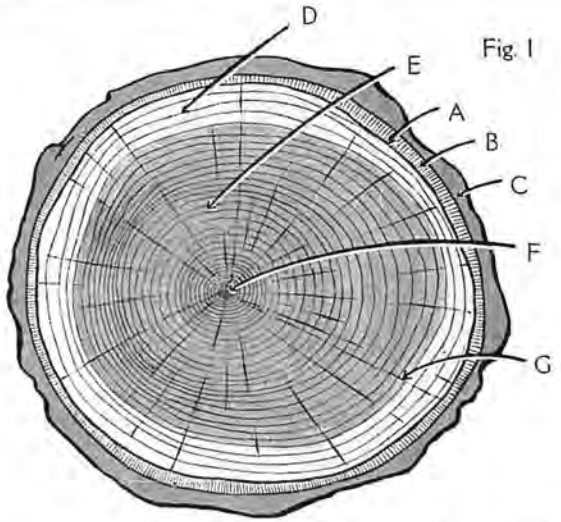


Fig. 1

Diagrammatic sketch of a transverse section of tree trunk

Plate 4.

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) Photosynthesis 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.

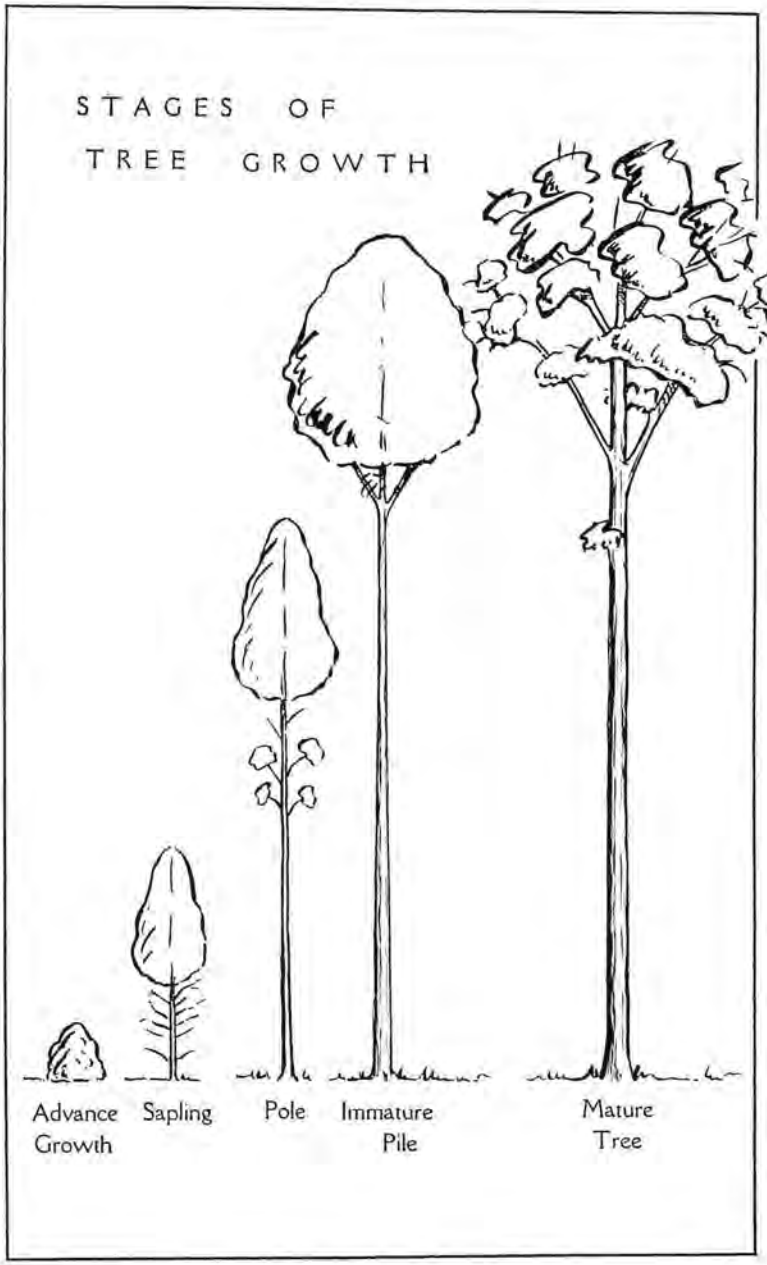


Plate 5.

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 6)* 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 eucalypt 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 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 25in. or better per annum, with wandoo extending eastward as open forest to areas of 20in. rainfall.

Beyond the 20 inch rainfall limit, which lies some 50 miles East of Perth, occurs the inland forest of open sclerophyllous woodland. Much of this land, down to 11 inch 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. jacksoni)* 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.

In recent years, the minor Western Australian trees have received considerable attention. Such species as salmon gum *(Euc. salmonophloia)*, the mallets

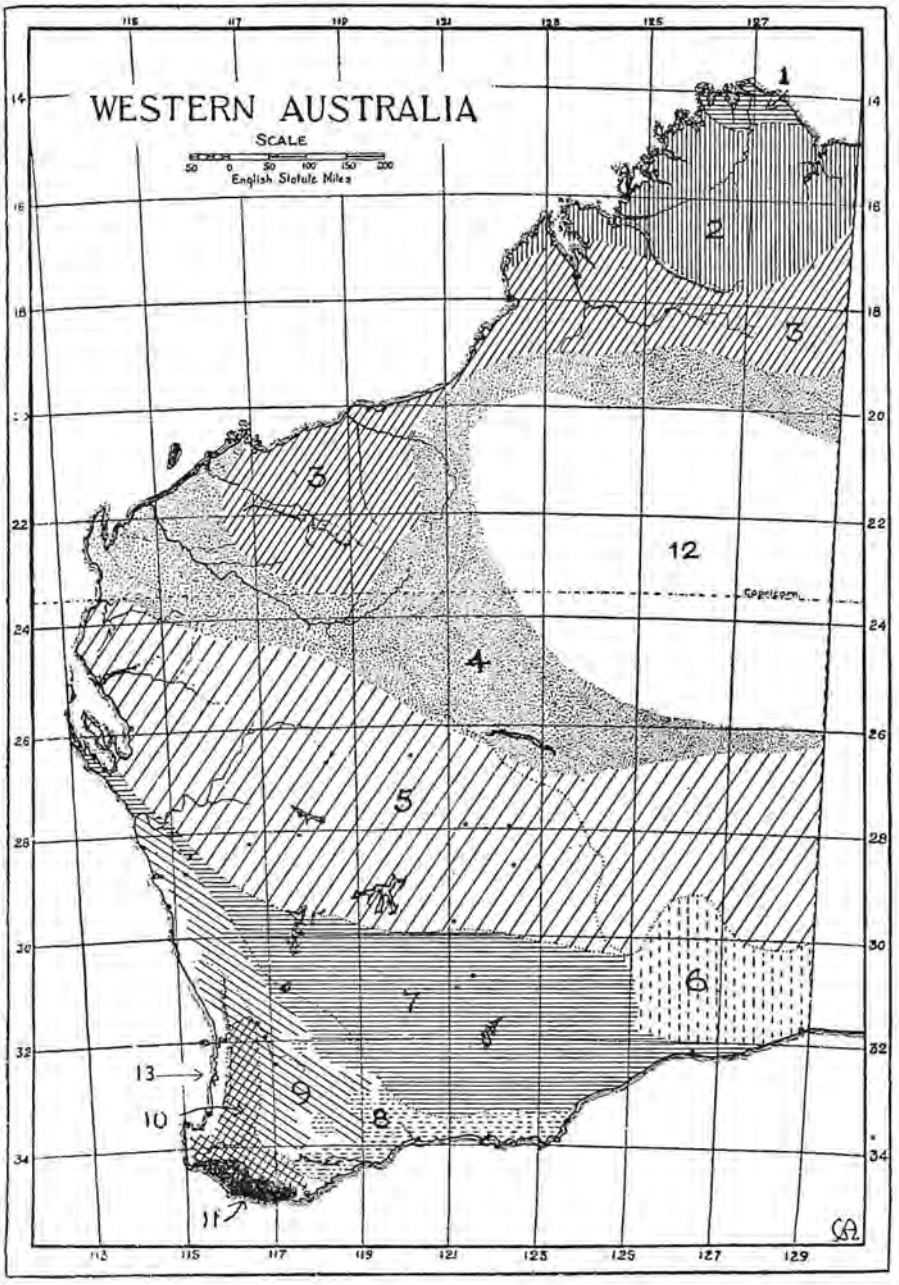


Plate 6.

Map of W.A. showing vegetative formations. For description see text.

—"By Courtesy of Royal Society of W.A."

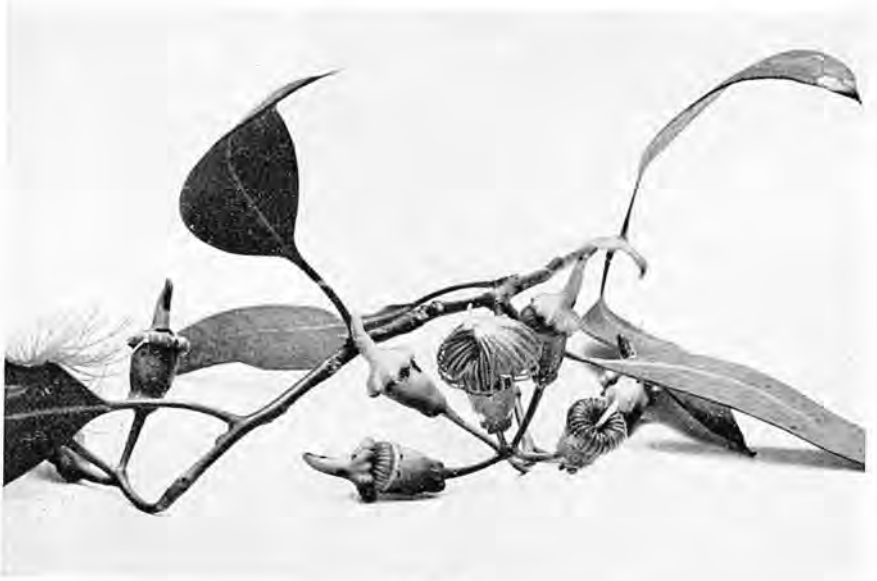


Plate 7.

Coral Gum *(Eucalyptus torquata).*

(Euc. astringens, Euc. gardneri, etc.), morrel *(Euc. oleosa var, longicornis)*, gimlet *(Euc. salubris)*, coral 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 focussed 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 flowering gum *(Euc. ficifolia)*, coral 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. Blackheart *(Euc. microtheca)*, river red gum *(Euc. camaldulensis)* and several others are highly valued by the limited population of these outback areas.

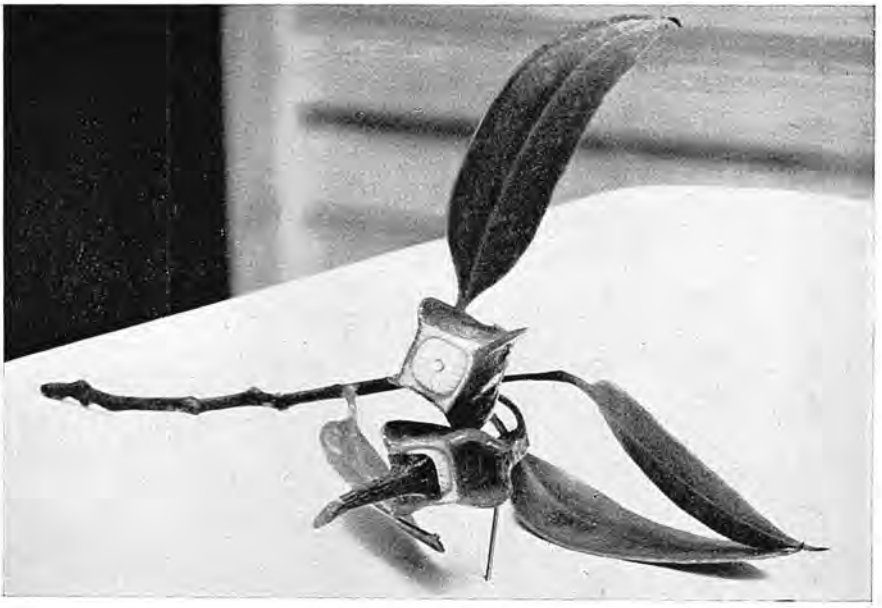


Plate 8.

Fuchsia Mallee *(Eucalyptus forrestiana).*

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

Common Name	*Scientific Name.*
Jarrah	*Eucalyptus marginata*
Karri	„ *diversicolor*
Tuart	„ *gomphocephala*
Wandoo	„ *wandoo*
Marri	„ *calophylla*
Blackbutt	„ *patens*
Yate	„ *cornuta*
Red Tingle	„ *jacksoni*
Yellow Tingle	„ *guilfoylei*
Red Flowering Gum	„ *ficifolia*
W.A. Peppermint	*Agonis flexuosa*
Warren River Cedar	„ *juniperina*
Native Pear	*Xylomelum occidentale*
River Banksia	*Banksia verticillata*
Sheoak	*Casuarina fraseriana*
The Mallets	*Eucalyptus astringens, Euc. falcata, etc.*
York Gum	*Eucalyptus loxophleba*
Swamp or Flat-topped Yate	„ *occidentalis*
Salmon Gum	„ *salmonophloia*
The Gimlets	„ *salubris, Euc. campaspe*
Red Morrel	„ *oleosa var. longicornis*
Dundas Mahogany	„ *brockwayi*
Goldfields Blackbutt	„ *le souefii*
Grey Gum	„ *griffithsii*
Redwood	„ *oleosa var. glauca*
Merrit	„ *flocktoniae*
Yellow-flowered Gum	„ *stricklandi*
Coral-flowered Gum	„ *torquata*

Kurrajong	*Sterculia gregorii*
Goldfields Pine	*Callitris glauca*
Raspberry Jam	*Acacia acuminata*
Sandalwood	*Santalum spicatum*
Flooded Gum	*Eucalyptus rudis*
Bullich	„ *megacarpa*
Bull Banksia	*Banksia grandis*
Menzies Banksia	„ *menziesii*
Karri Oak	*Casuarina decussata*
Rottnest Island Pine	*Callitris robusta*

This list includes the commonly known species. Addendix 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 of *Eucalyptus*, 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 of *Eucalyptus* 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.

The *Eucalyptus* 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. Eucalypts 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.

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 (usually 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.

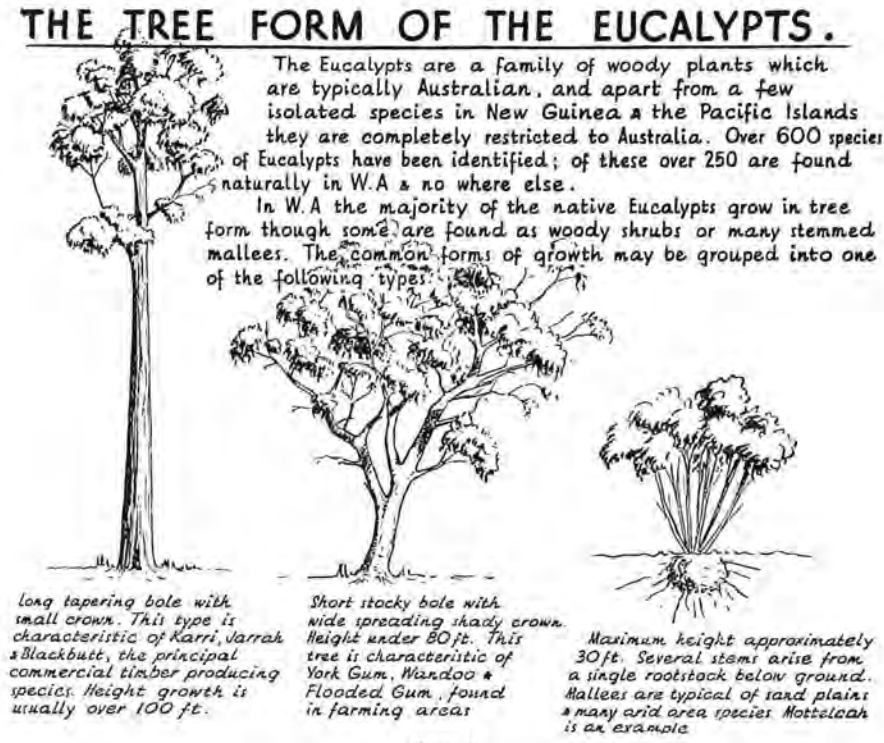


Plate 9.

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

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 & often lightly coloured stamens.

The petals in the Eucalypt 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 & flowering of three different West Australian Eucalypts.

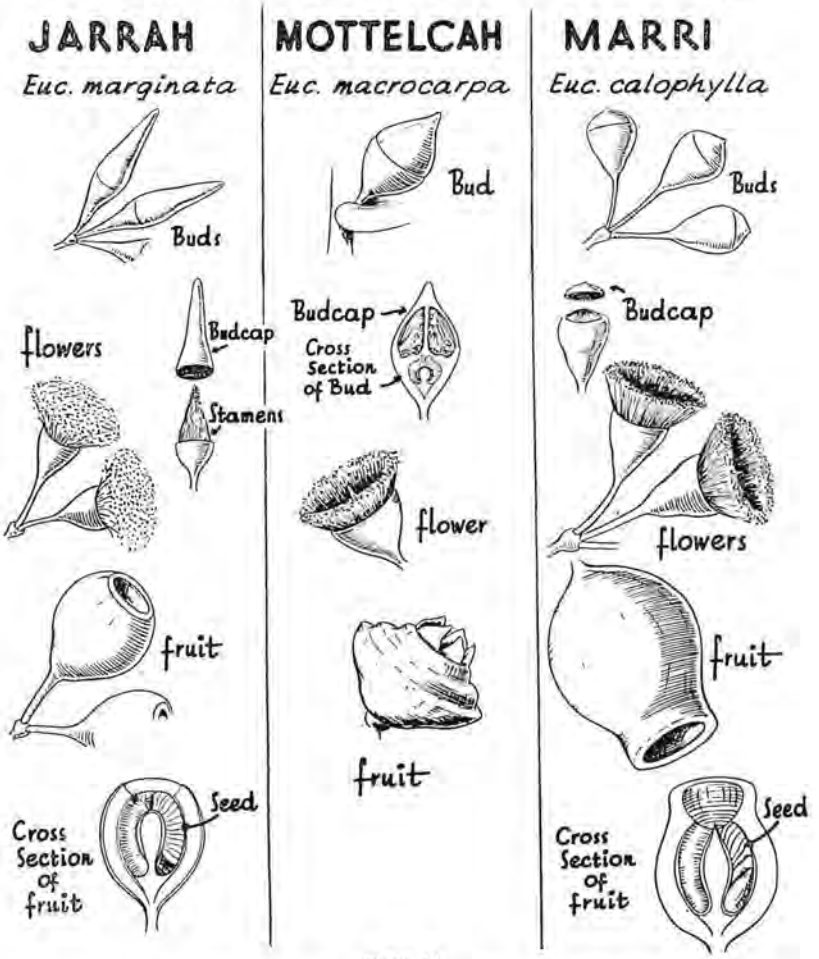


Plate 10.

The flowering forms of three common W.A. eucalypts.

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 forests or unmanaged forests, 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. 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 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.

Mottlecah, or Rose of the West *(Eucalyptus macrocarpa)*.

Marri *(Eucalyptus calophylla)*.

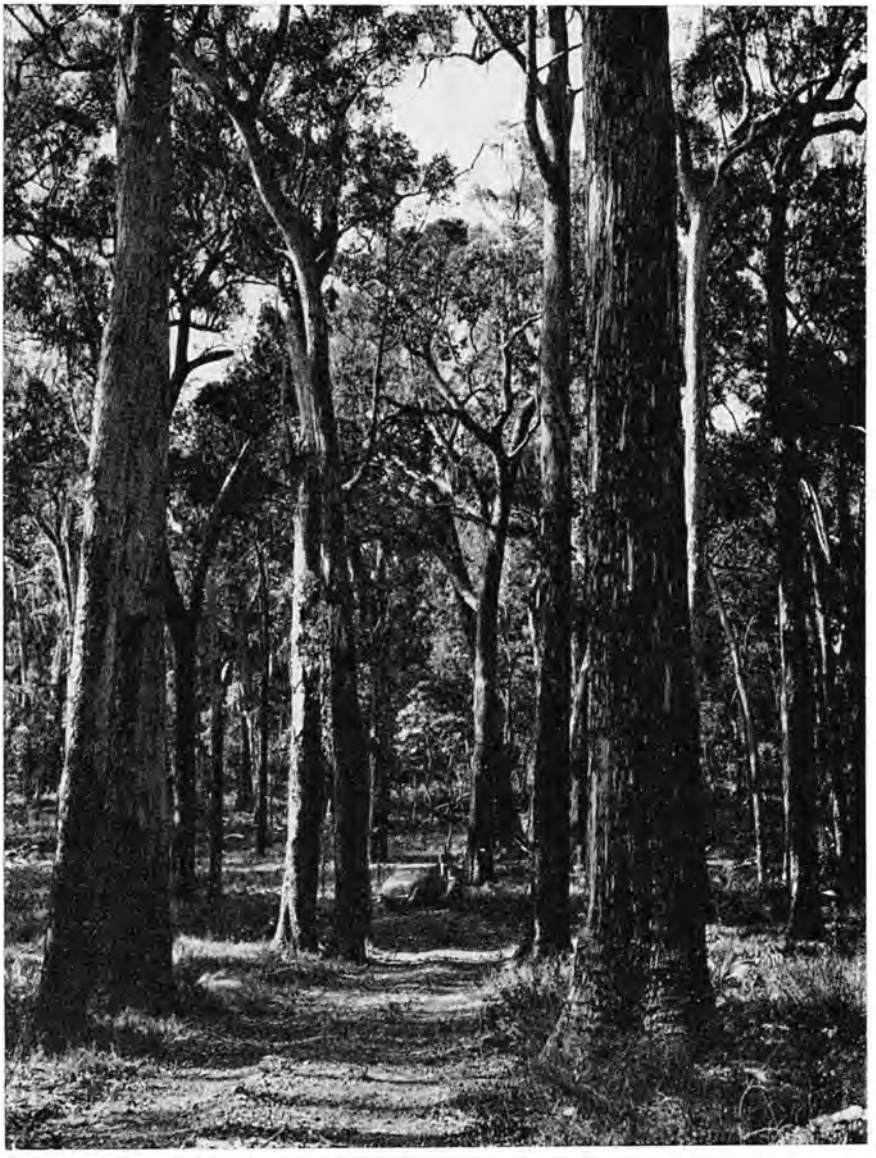


Plate 11.

Mature jarrah forest.

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 the dominant trees, the general level of the co-dominant trees and the lower level of the 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 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.

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.

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.

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

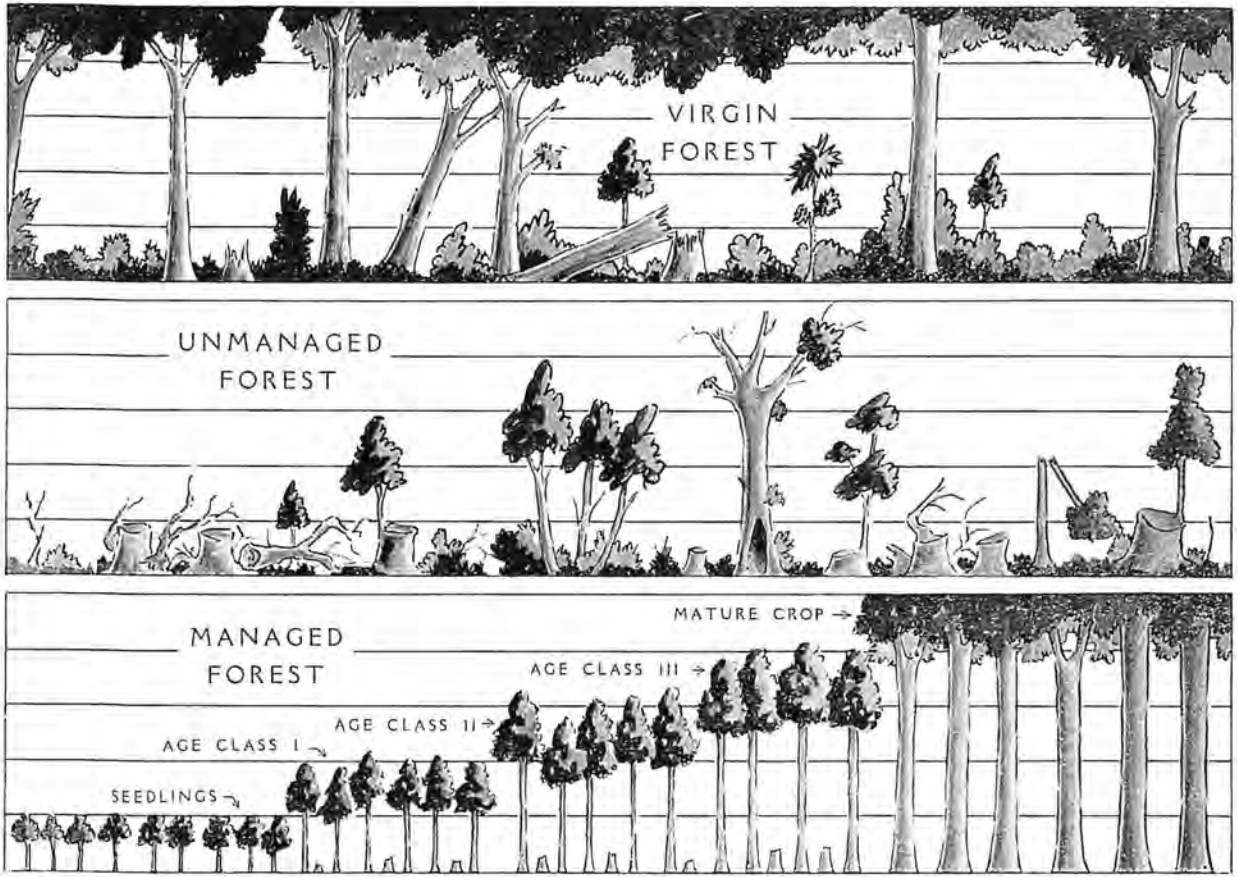


Plate 12.

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.

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, the world has 10,000 million acres of forested land. This is separated as follows:—

Total forest area	10,000 million acres.
Accessible forest	5,000 million acres.
Forest being utilized	2,500 million acres.
Forest area under sound management	1,000 million acres.

It is estimated that a further area of 4,000 million acres 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 practise of forestry on a temporary basis. Table 3 below sets out in detail the areas reserved for forestry in Australia.

TABLE 3.
Area of Forest Reservations as at 30th June, 1963 (Acres).

State/Territory	State Forests	Timber Reserves	Other Reserves of Forestry Value	Total
New South Wales	6,723,785	1,371,376	....	8,095,161
Victoria	4,870,111	861,276	368,000	6,099,387
Queensland	5,474,291	2,619,080	946,590 (*a*)	9,039,961
South Australia	279,860	956	470,100 (*b*)	750,916
Western Australia	4,454,309	1,839,351	776,697 (*c*)	7,070,357
Tasmania	2,287,050	137,218	1,217,146 (*d*)	3,641,414
Australian Capital Territory	—	—	131,000 (*e*)	131,000
Northern Territory	—	9,422	2,393,600 (*f*)	2,403,022
Total	24,089,406	6,838,679	6,303,133	37,231,218

— Nil or negligible. (*a*) Includes national parks 911,252 acres, and scenic areas 35,338 acres. (*b*) Includes some flora and fauna areas. (*c*) Timber reserves under the Land Act. (*d*) Includes 612,000 acres of pulpwood concessions on Crown lands, 370,375 acres of exclusive forest permits on Crown lands and 234,771 acres of scenic reserves (forested). (*e*) Forest land not specifically reserved. (*f*) Includes fauna and flora reserve, Coburg Peninsula 473,600 acres; Land within welfare reserves 1,100,000 acres; Land covered by pastoral lease 820,000 acres.

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 below lists the areas of both public and private plantations established up to September, 1963.

TABLE 4.

Area of Plantations, Coniferous and Broadleaved as at 30th September, 1963 (Acres).

State/Territory	Coniferous							Broad-leaved
	Government-owned			Private Property			Govern-ment Plus Private	
	P. radiata	Other Species	Total	*P. radiata*	Other Species	Total		
New South Wales	79,458	20,091(*a*)	99,549	10,657	14,791(*d*)	25,448	124,997	*
Victoria	44,443	10,043	54,486	*	*	75,000†	129,486	*
Queensland	2,237	101,125	103,362	*	*	7,970	111,332	1,430
South Australia (*b*)	112,704	9,904	122,608	*	*	39,750	162,358	*
Western Australia	14,828	24,434	39,262	1,200	170	1,370	40,632	*
Tasmania	17,917	431	18,348	7,108	—	7,108	25,456	*
Australian Capital Territory	24,130	2,238	26,368	—	—	—	26,368	*
Northern Territory	—	251(*c*)	251	—	23	23	274	*
Total	295,717	168,517	464,234	*	*	156,669	620,903	*

* Not available. — Nil or less than half the appropriate unit. † Estimated.
(*a*) Includes 3,791 acres of hoop, bunya and kauri pine. (*b*) Excludes the 1963 plantations.
(*c*) Cypress pine (*Callitris intratropica*). (*d*) Chiefly *P. elliotii*.

CHAPTER III.

THE FOREST FORMATIONS OF WESTERN AUSTRALIA

THE JARRAH FOREST.

THE KARRI FOREST.

THE TUART FOREST.

THE WANDOO FOREST.

THE MALLET AREAS.

FORESTS OF THE ARID AND SEMI-ARID INLAND.

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 to 130 feet, with a straight bole of up to 50 feet or 60 feet, and a diameter of 6 feet.

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 the Albany blackbutt *(Euc. staeri)*, and the red tingle *(Euc. jacksoni)*, 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 13,000,000 acres of country within the 25 to 45 inch rainfall

Plate 13.

Jarrah forest showing the large straight boles and typical stringy bark of the species.

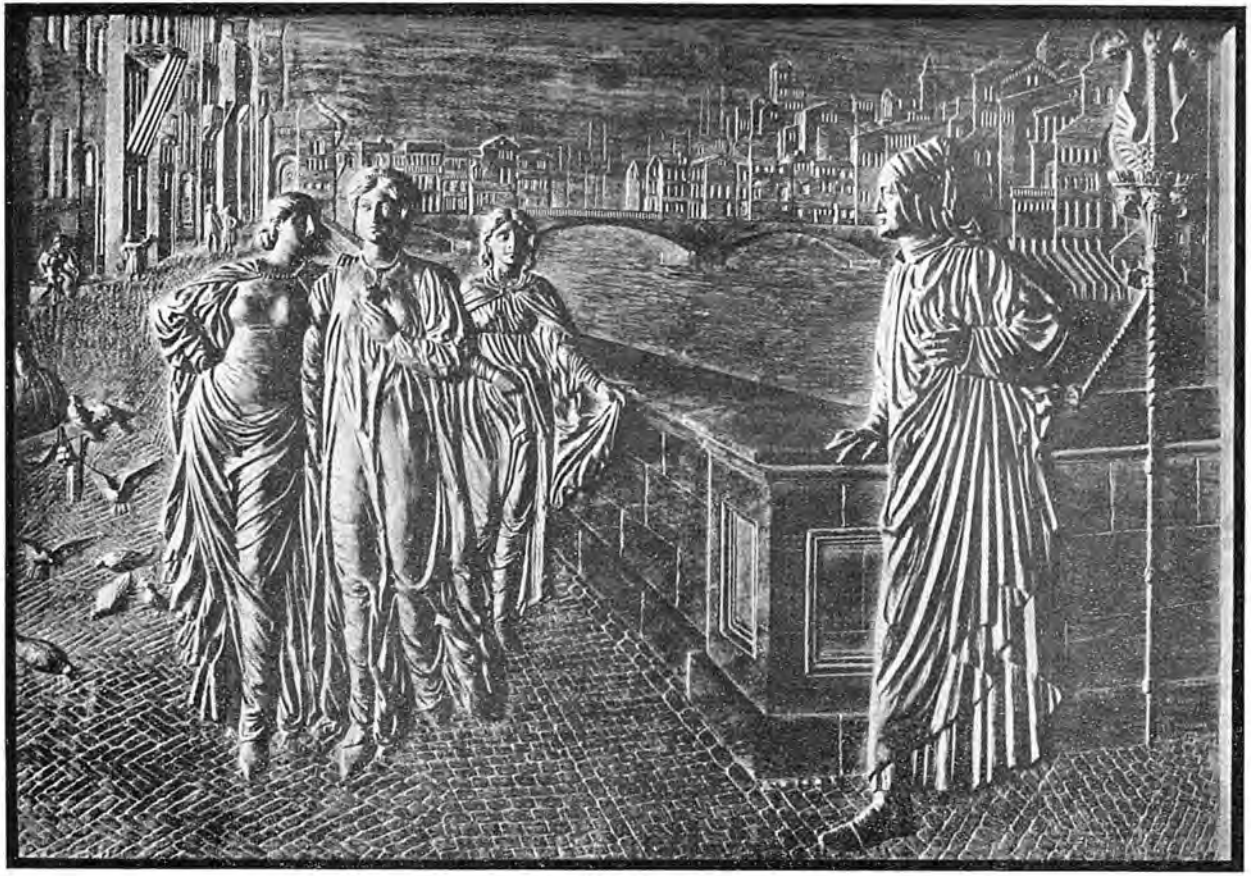


Plate 14.

Jarrah panel—Dante and Beatrice, as carved by William Howitt of Perth, W.A. This work fully illustrates the use of jarrah as a high quality timber.

belt. The prime forest of some 4,000,000 acres, however, stretches from Chidlow's Well in the north, along the Darling Range to the extreme south of the State, in the neighbourhood of Albany. Most of this is now State Forest. The species attains its largest proportions between the Murray and Warren Rivers, becomes smaller to the east of the Kent River, is reduced to typical mallee form on the mountains of the Stirling Range, and small, crooked trees on the plains to the south.

As one passes eastward from the prime timber belt, the jarrah becomes progressively smaller, giving way to Wandoo *(Euc. Wandoo)*, Powder Bark Wandoo *(Euc. accedens)* and York Gum *(Euc. loxophleba)*. On the coastal strip west of the Darling Range it occurs in rather open formation as a tree of low height growth and poor form. Here it is associated with Tuart *(Euc. gomphocephala)*, which on the limestone ridges replaces the jarrah completely. In the extreme south of its range it is replaced on the better soils by karri *(Euc. diversicolor)* and marri *(Euc. calophylla)*.

Jarrah reaches its optimum development on the deep, well-drained gravel on the slopes of the laterite-capped ridges of the Darling Range.

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.
At 12 per cent. moisture	54 lb.
Transverse strength	16,200 lb. per sq. in.
Tensile strength	15,500 lb. per sq. in.

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 consist of 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 mantlepieces 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.

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.

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, and in a general seeding, some 25 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 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 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 a ground distance equivalent to the height of the tree.

Regeneration.

Germination occurs in May and June after the first winter rains, and the young seedling establishes itself during the wet winter. The intensity of germination may be as high as 500,000 per acre.

As a result of the activities of natural parasites, intense root competition and an extremely hot and dry summer climate only a minute proportion of the germinants survive past the first and second summers.

Those which do survive consolidate their position and ensure their survival by the formation of ligno-tubers at the base of their stems. From these ligno-tubers a number of dwarf shoots arise but there is no immediate development of a sapling. After the ligno-tuber has attained a diameter of about four inches a single leader shoot may get away from the bushy growth to form a sapling. This initial development stage may cover several decades.

Once a single leading shoot makes its appearance, the young sapling continues to grow normally unless subject to attack by insects or frost. After four years, excepting where situated in the middle of a heap of debris, the "advance growth" will recover from almost any fire.

The species is relatively tolerant and a young tree will grow up under limited shade.

In its virgin state the forest carried a very high proportion of over-mature large sized trees whose age has been estimated variously as between 300 and 600 years. Because of their great age, a long period of decline of perhaps 50 years or more before death was probably the rule, and this had the effect of providing an opening of the canopy and a long regeneration period during which the new crop of advance growth could become established under the parent stand.

In the small openings caused by the death of individual trees in the virgin forest there was no lack of regrowth and the stand was characterised by small

Plate 15.

Falling a large jarrah tree with a power drag saw—one of the earliest forms of mechanised falling. This method has now been superseded by the use of chain-saws, as shown in Plate 53. Note also that the operator is not wearing a safety helmet.

healthy juvenile groups of 3 to 20 co-dominant stems scattered throughout the extent of the forest.

Fire in the Forest.

Evidence indicates that fire has always been a factor of the jarrah forest environment. It is also considered that in certain instances, moderate fire is beneficial in the forest. Fire protection, aimed at lightly burning the area at intervals to prevent any build-up of litter and debris which would ultimately result in a severe fire, has so far proved to result in no detrimental effects to the growing stock and soil, provided burning is carefully regulated during cool weather.

Plate 16.

A jarrah regrowth stand 2 years after thinning operations and silvicultural treatment were carried out.

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 saw-milling 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 for the future and the tree-marker 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 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 of 20 feet should have been attained, with the height of the lower level of live crowns being above 12 feet.

Growth Rates.

The growth of jarrah is extremely slow when compared with some of the introduced pines. On the best sites 0.75 inches in girth per year can be achieved and about 18 inches in height. On the lower site qualities growth is even slower and an annual average for the whole prime forest region is 0.6 inches in girth or a wood production of 10-30 cubic feet per acre. Some improvement in volume production, however, will take place under careful management when regular thinnings and removals will ensure that only the longest boles (that is, those trees capable of putting on the greatest volume) will be retained as the final crop trees. Protection from severe fires will also serve to increase the low annual growth rate of the present day forests.

OTHER TREES OF THE JARRAH FOREST.

MARRI. (*Eucalyptus calophylla*).

Habit.

This tree attains a height of 90 to 130 feet, with a length of bole of 40 to 50 feet, and a diameter of 6 to 7 feet. The bark is persistent and of a hard, rough, irregularly furrowed appearance. In young trees the bark is light grey in colour and friable. In older trees the bark is brownish, dark grey and rather flaky and frequently stained to a reddish hue by the kino which exudes from the tree. Branches are widely spreading and for this reason it makes a very good shade tree. A pink flowered variety has attained some popularity as an ornamental tree.

Distribution.

Marri occurs throughout the jarrah belt but like blackbutt, is to be found generally on the better alluvial soils in the valleys between the laterite-capped ridges. Marri soil is considered, from an agricultural point of view, a degree better than jarrah soil which is usually of low value for farming. It is also found mixed with karri over the karri forest area. Eastward it extends into the drier areas slightly beyond the Great Southern Railway.

Timber.

The timber is light brown in colour, easily worked but its quality is degraded by excessive pockets and rings of gum (kino). Sound marri timber may be used for all purposes where strength and elasticity are required. Marri has not been extensively used as sawn timber, although the general indication is that the heartwood is quite durable.

Marri fence posts have a service life of 19 years under Western Australian conditions and tests are at present under way to determine the service life of untreated marri sleepers. In 1912 sleeper tests were conducted at Albany, Kalgoorlie, Geraldton and Cue with powellized marri sleepers to indicate an average service life of 25 years. The powellizing process was a preservative treatment consisting of boiling the green timber in open vats containing molasses and arsenious oxide.

Uses.

Marri has been used to a limited extent for weather-boards and building scantling, case manufacture, general mill work and waggon stock. As a timber it is inferior to jarrah and with the latter available at competitive prices it is unlikely that marri will be in any great demand.

The marri is also well known to the apiarist, giving a copious supply of nectar in suitable seasons. It flowers in the summer months, usually in February and March, but may continue until April or May.

On account of its singularly attractive habit of growth and dense crown, and the large white or pale pink flowers, the tree is of considerable value to the farmer and country dweller as a shade tree.

The name "calophylla" signifies beautiful leaf.

BLACKBUTT *(Eucalyptus patens).*

Habit.

Blackbutt is a tree which may attain a height of up to 150 feet, with a bole of 40 to 50 feet, and up to 6 feet in diameter. 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 at least five other tree-species of lesser importance in Western Australia, several of them 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.

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.

Blackbutt is not plentiful, but is to be 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.

Weight per cubic foot (green)	69 lb.
At 12 per cent. moisture	54 lb.
Transverse strength	14,200 lb. per sq. in.
Tensile strength	15,700 lb. per sq. in.

NATIVE PEAR *(Xylomelum occidentale).*

Habit.

This is a small tree attaining a height of 20 to 25 feet with a short bole, and a diameter of up to 12 inches. The bark is persistent, grey or almost black, and lightly fissured.

Native pear is to be found growing all along the sand plain country, between the Darling Range and the seacoast.

Weight per cubic foot (green)	56 lb.
At 12 per cent. moisture	46 lb.
Transverse strength	7,700 lb. per sq. in.
Tensile strength	7,000 lb. per sq. in.

The tree yields a most ornamental and 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).*

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

Banksia verticillata yields a light-coloured timber 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.

Weight per cubic foot (green)	59 lb.
At 12 per cent. moisture	35 lb.
Transverse strength	10,300 lb. per sq. in.
Tensile strength	8,000 lb. per sq. in.

The timber is in short supply and of very limited availability.

SHEOAK *(Casuarina fraseriana).*

This tree grows to a height of 40 to 50 feet, with a bole 10 to 15 feet, and a diameter of 2 feet 6 inches. 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.

THE KARRI FOREST

Karri is the aboriginal name for the State's tallest tree, *Eucalyptus diversicolor*. This latter or specific name refers to the changes in the colour of the bark during the different seasons of the year.

Description of the Forest.

Prime stands of karri forest constitute some of the most magnificent hardwood stands in the world and are really a most impressive sight. Long straight boles of up to 120-160 feet before the first side limbs are reached tower skyward, supporting a wide, spreading crown of 60 feet or more. The bark is smooth greyish-white when old. In late summer, this old external bark splits and decorticates exposing a new, fresh, salmon-yellow coloured bark beneath. Bark shedding is irregular over the surface of the stem, resulting in a mottled appearance with mingled patches of greyish-white and salmon-yellow. Following severe fires, the outer bark shed may be more extensive than normal, giving a uniform stand of salmon-yellow colour, which gradually bleaches to a greyish white as the months pass. Seen with the slanting rays of the morning sun piercing the dew spangled vegetation, the karri forest presents a beautiful sight not readily forgotten.

The individual karri tree is a masterpiece of natural engineering in its great strength, symmetry and beauty, combined with economy of material. Trees up to 286 feet in height with girths at breast height of 24 feet have been measured. Girths of up to 38 ft. 6 in. have been measured on shorter trees. This tree is equalled or surpassed in size and beauty by only one or two other species, namely the mountain ash eucalyptus of the Eastern States, and the master of them all, the mighty sequoia of North-Western American coastal regions.

Distribution.

The karri forest occurs in the extreme South-West of the State in localities receiving a rainfall in excess of 40 in. per annum. The main belt of karri forest lies South of a line drawn from Nannup in the North-West through Manjimup to the Frankland River in the South-East, and thence in a belt of decreasing width through to Denmark and Torbay. 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 2-10 miles.

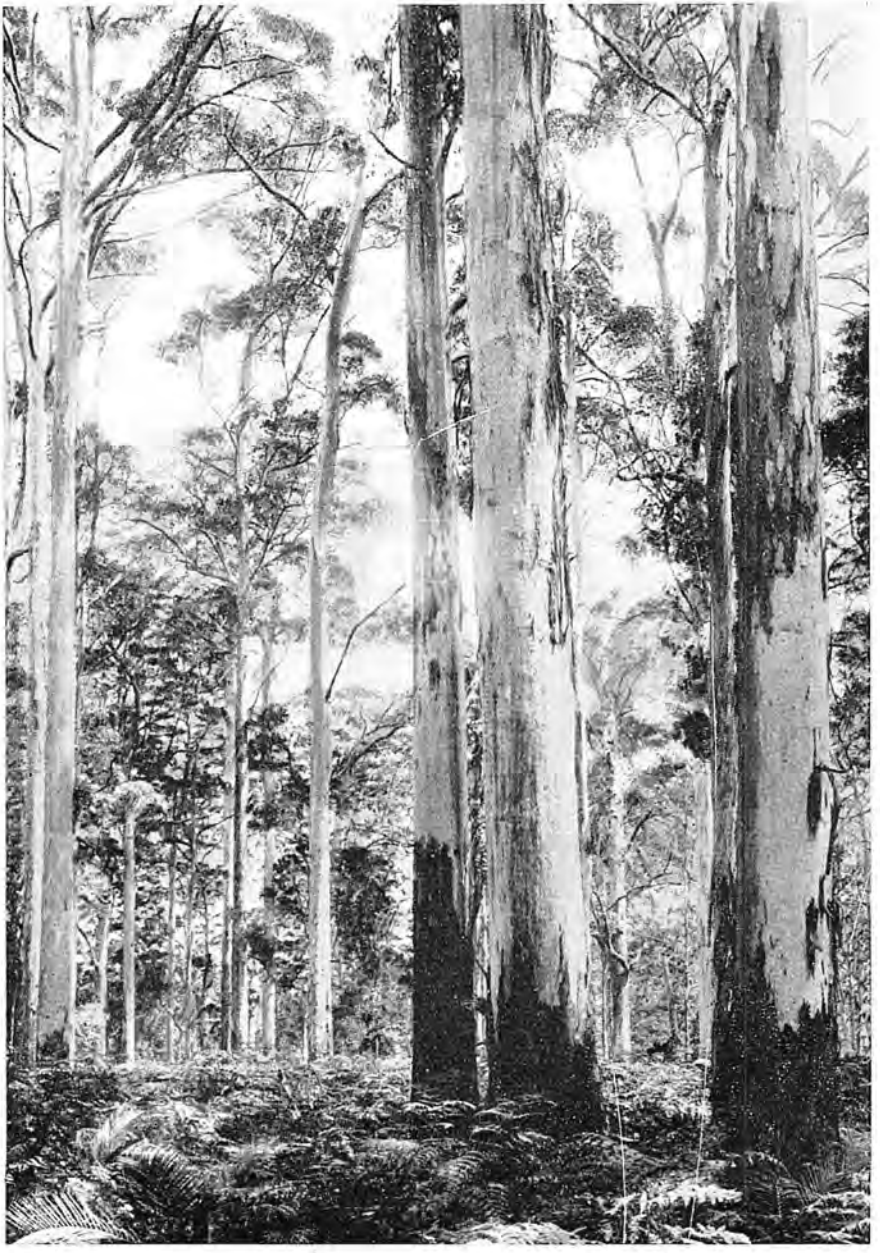


Plate 17.

Karri forest—note the long, clean boles with the typical "gum" bark.

Two outliers from the main belt occur, namely—

(1) a narrow belt of some 50,000 acres over the strip of coastal limestone between Karridale and Forest Grove, together with small patches along inland gulleys, extending as far North as Margaret River; and

(2) in the Porongorups, approximately 12 miles South-East of Mt. Barker, where a small patch of a few hundred acres of karri occurs.

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

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

Soils of the Karri Forest.

Karri soils generally are acidic in reaction, with textures varying from fine sands to sandy loams derived from under-lying granitic rocks. Such soils are of very low nutritive value by recognised agricultural standards. They have also been proved deficient in trace elements such as zinc, copper and cobalt.

Timber.

The timber of karri varies from pale pink to reddish-brown and deep red in colour and closely resembles jarrah in appearance, although generally lighter in colour. A common test to distinguish the two is to burn a splinter of the sound truewood—avoid sapwood and brittle heart. Jarrah burns to a 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, heavy, stiff and tough, and considerably stronger than Douglas Fir and English Oak. It is an exceptionally good bending timber.

Weight per cubic foot (green)	72 lb./cu. ft.
At 12 per cent. moisture	57 lb./cu. ft.
Transverse strength	19,200 lb. per sq. in.
Tensile strength	18,750 lb. per sq. in.

Karri is rated as durability class 3 by the Division of Forests Products, C.S.I.R.O. For this reason it is not recommended for sleepers without satisfactory preservative treatment. Prior to World War II, "powellised" sleepers were used with success in the Trans-Australia line, but this special arsenical treatment has been discontinued.

Uses.

The uses of karri are numerous. The strength and stiffness of the timber, combined with the extraordinarily 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, columns, warehouse floor joists, and other members, where strength is the essential factor, it gives every satisfaction. It may be mentioned that, in one of the mills in the karri forest the roof is carried by two trusses with a common tie beam consisting of a piece of 12 in. by 12 in. karri, 80 ft. 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 cross-arms, and is also used to a considerable extent for coach, wagon and motor body building.

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 as guides or sliding beams. Reports have shown that, under conditions of heavy wear, it has a much longer life for this purpose than pitch pine and other timbers previously tested.

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 pressure impregnation plant at Pemberton, crossarms are now being treated with 3 per cent. pentachlorphenol in oil and are expected to give even better service. 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 being used throughout Western Australia and are being 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

Plate 18.

Thirteen karri bowstring trusses were used in the roof construction of this new sawmill built at Welshpool. The curved sections are of laminated construction, and each truss spans 62 feet clear and has a 12 foot cantilever. The round posts are of jarrah.

Plate 19.

Karri bud development, showing the flowering stage in mid-Autumn, 2¼ years after the buds are first formed.

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.

In recent years it has become increasingly popular as a flooring timber in the Eastern States of Australia, where attractively packaged supplies from Western Australia are readily available.

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.

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 has been used largely for keelsons, and the long lengths obtainable are regarded by shipbuilders as an added advantage for this work.

The timber has been pulped successfully on an experimental scale and as early as 1923 a paper was produced from a mixture of 70 per cent. karri pulp and 30 per cent. imported sulphite pulp.

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

Flowering and Seeding Habits.

The length of the floral cycle from bud initiation to seed maturity is normally four years.

Flowering usually occurs at 2¼ years (see Plate 19) but this can vary from under 1½ to over 2½ years.

From a moderate crop of buds, a co-dominant tree will bear well over one quarter of a million flowers, but only about 50,000 seeds may be expected from this tree.

The flowering period usually lasts two or three months, although occasionally it may spread over a period of more than two years in some stands. In general, heavy blossom occurs at intervals ranging from four to seven years.

When in full flower, the karri forest is one of the most prolific honey yielders known, contributing about 25 per cent. of all the table honey produced in Western Australia: 400 to 600 lb. of the finest quality honey may be harvested from each hive.

The immature seed capsules are located amongst the thinned out oldest leaves, as shown in Plate 20A. Following flowering, the seed crop ripens over one full winter. When the old leaves are cast and the capsules exposed, seed maturity is assured.

Seed shed occurs in the summer at the end of the fourth and fifth years of a cycle. Usually two consecutive years' seed, adequate for natural regeneration, are followed by intervals of from two to four years without seed.

Seed Supplies.

Dominant trees are the best seed source for the 120,000 seeds per acre 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 a distance 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 1 ton of green capsules yields 11 lb. of pure seed, averaging 330,000 per pound. 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.

Plate 20A.

Karri seed capsules (fruit) at different stages of maturity: the fruit among the leaves is still immature, while that exposed at the base of the leaves has already reached maturity.

Plate 20B.

Mature karri seed capsules, showing seed dissemination from 4 year old fruit on the dead branchlets and 5 year old fruit on the green branchlets.

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

The effect of the ashbed following the burn is quite remarkable in ensuring the absolute dominance of karri over the weeds. At the centre of a two year old ashbed karri seedlings may be 10-12 feet in height, as compared with 1-2 feet in height off the ashbed. Vigorous sapling stands can then completely dominate the site and attain 80 to 90 feet height growth in 20 years.

Artificial Regeneration.

Proven methods of artificial regeneration 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.

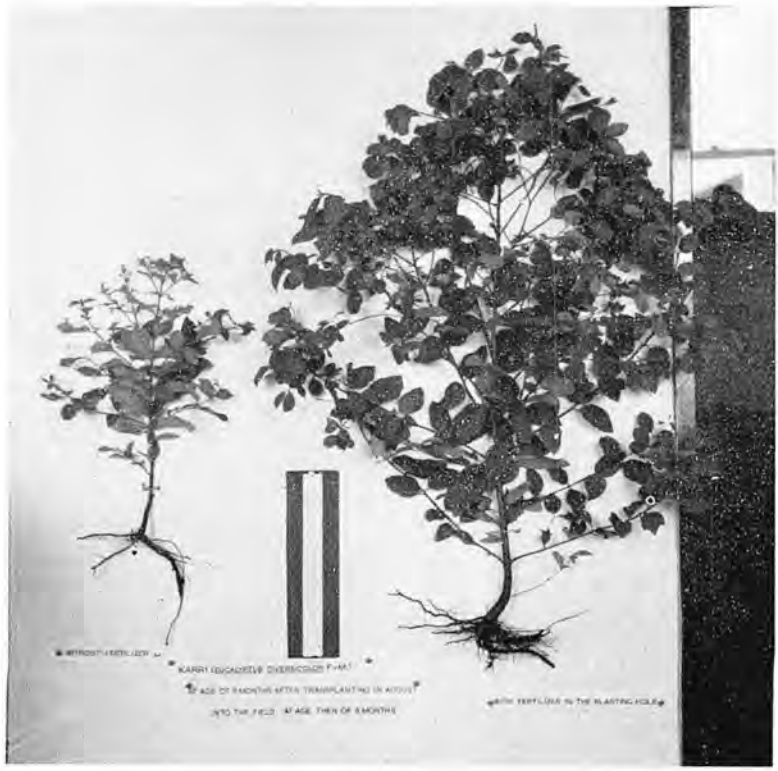


Plate 21.

Open-rooted karri transplants—both plants are 9 months old, but the one on the left was planted without fertiliser, while that on the right had 2½ oz. of fertiliser at time of planting.

The transplanting of suitably-sized natural regeneration (15 in.) or of open-rooted nursery plants (6-8 in.) 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 in transpanted seedlings growth that is more rapid and uniform than that of 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 a vigorous leading shoot and a rush of height growth that quickly dominates the competing ground vegetation. See Plate 21 for a comparison of two equal aged transplants with and without fertiliser.

Silviculture.

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

A seedling establishment of 20,000 or more per acre under natural conditions of height growth and fire would be reduced to 1,000 trees at 10 years and 500 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 60-70 years, and also from old farm properties, one of which dates back to 1872.

Measurement of sample plots laid down in these areas indicates that karri will produce from 75 to 150 cubic feet of wood per acre per annum 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 in. to 0.7 in. 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 1936 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 1936 this method was replaced by a silvicultural operation known as the Selection System, a modified form of treemarking under which the overmature and mature karri trees were removed for sawlogs under the direction

Plate 22.

Thirty-five year old stand of karri regrowth near Pemberton, resulting from clear-cutting and regeneration treatment.

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.

Investigations have confirmed previous opinions that the quality and vigour of the individual trees should determine the intensity of trade cutting. The desirable objective at present is to retain not less than one-third of the marketable trees, to serve as a source of seed for the next crop. The tops and limbs left from the trade cutting can be cleared away from the remaining trees and burnt along with the accumulated debris on the forest floor, which serves the dual purpose of cleaning the stand and helping to ripen the seed in the canopy above.

OTHER IMPORTANT SPECIES OF THE KARRI FOREST.

RED TINGLE TINGLE *(Eucalyptus jacksoni)*.

Red tingle is one of the largest trees in the State. It grows to form a tree of up to 230 feet in height with a long bole which may attain a diameter of 15 feet at a height of 5 feet from the ground. The base of the trunk is often buttressed, one tree measured being 66 feet in circumference at the base. More often it is found growing up to a height of 180 feet with a diameter of 10 to 13 feet.

The bark is persistent, grey-brown in colour, with longitudinal fissures and is not unlike jarrah bark in general appearance. The tree closely resembles the jarrah and blackbutt but is much larger than either.

Although not as tall as the largest karri trees, the red tingle is certainly the largest in girth of any of the eucalypts in Western Australia.

Distribution.

Red tingle forms high and dense forest in the 50 inch rainfall zone between the Bow, Frankland and Deep Rivers. It does not extend far inland. The tree is usually associated with yellow tingle, karri and marri and is found in almost pure stands or as scattered trees in the karri forest.

Timber.

The timber closely resembles jarrah but is lighter in weight. Up to the present it has not been put to any extensive use but appears to be eminently suitable for furniture and other purposes where lightness, strength and appearance are required. It should also be a good structural timber and its lightness and the ease with which nails can be driven without splitting the wood will render the small sizes particularly valuable for fruit and other cases. Used as a sleeper timber, red tingle has a service life of 20 years under South-Western conditions.

Weight per cubic foot (green)	60 lb.
At 12 per cent. moisture content	48 lb.
Transverse strength	14,200 lb. per sq. inch.
Tensile strength	15,680 lb. per sq. inch.

As this valuable timber is only found growing on a comparatively small area, it is important that it should be reserved, and the timber used only for the high-grade purposes for which it is eminently suited. All prime tingle forest has been dedicated as State forest.

Plate 23.

Cut over karri forest east of Pemberton, illustrating the mixture of size classes found in a managed forest, and which is one of the aims of the selection system.

YELLOW TINGLE TINGLE *(Eucalyptus guilfoylei)*.

Yellow tingle attains a height of 80-120 feet and a diameter of three to four feet. The bark is much the same as blackbutt, persistent, closely fibrous and stringy except on the branchlets. Yellow tingle resembles jarrah in general appearance but the bark is less rough. The fruits are also smaller, narrower, and more contracted at the top, or pear shaped.

Timber.

The timber is yellow in colour, exceedingly hard and dense and very durable. It is used for railway sleepers which have a service life of 25 years in Western Australia. It has qualities somewhat similar to tuart but is straight grained.

Weight per cubic foot (green)	74 lb.
At 12 per cent. moisture content	62 lb.
Transverse strength	19,400 lb. per sq. in.

Yellow tingle grows in the same district as the red tingle and forms a lower storey to the latter. Isolated specimens may be found near Denmark.

RED FLOWERING GUM *(Eucalyptus ficifolia)*.

Eucalyptus ficifolia is a tree indigenous to Western Australia, and is found growing on a very restricted area near the mouth of the Bow River in the extreme south-west. This is a particularly handsome tree, and both here and in the Eastern States is very much used for ornamental planting. It is one of the most attractive of the eucalypts; the flowers are of gorgeous colour and stand out strikingly among the dark green foliage. A canker disease has severely attacked specimens planted in Perth and was responsible for the death of most of the trees which formed a very attractive avenue in King's Park, Perth.

Eucalyptus ficifolia is closely related to *Euc. calophylla*, but is a quite distinct species. It does not attain the large proportions of marri, has smaller, more rigid and deeper green leaves, flowers of a brilliant vermillion or sometimes crimson, slightly different fruits, and brown winged seeds.

W.A. PEPPERMINT *(Agonis flexuosa)*.

This tree grows to a height of about 30 feet, and has rather a drooping habit. An ornamental and shade tree, it has much to recommend it, proving successful for street planting purposes in Perth. The leaves are long and narrow, and of a pale green. The flowers, which are white in colour, are situated in small clusters at the bases of the leaves. The leaves also have a characteristic scent of peppermint.

In its natural state *Agonis flexuosa* is found as an understorey tree in the karri and tuart forest, particularly the latter.

WARREN RIVER CEDAR *(Agonis juniperina)*.

Agonis juniperina is a tree growing to a height of 50 feet with a diameter of two feet six inches. It is found only in karri country, alongside the running streams and rivers, usually associated with river banksia and peppermint. The bark is persistent, brown, fibrous, and spirally fissured.

The tree may be distinguished from the W.A. peppermint by its much smaller leaves, which are about a quarter of an inch long, and by the flowers being in small dense clusters near the ends of the branches.

The wood is light brown or yellow in colour. It is very strong, and most suitable for axe handles and other uses where hickory or ash is generally used.

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, 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 attaining 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. 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 the limestone formation, and on this formation it stretches 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 coast line.

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 in length and 5 to 10 miles in width.

Rainfall throughout is approximately 30 inches, though the prime area of forest is found towards the southern limits where the rainfall increases to about 40 inches.

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

Soils.

Tuart is only found on limestone in 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 desirable 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.

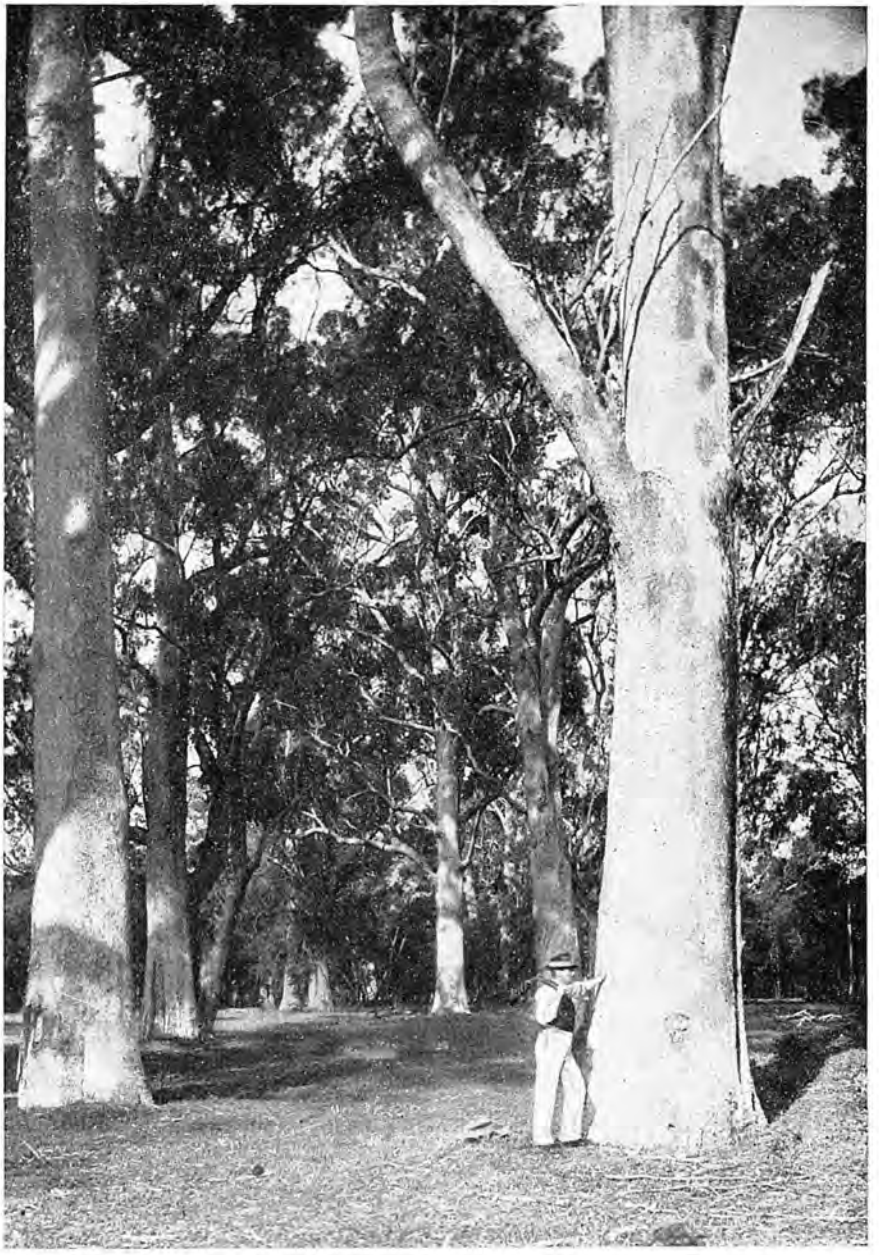


Plate 24.

Tuart *(Eucalyptus gomphocephala)* forest near Busselton.

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.
At 12 per cent. moisture	64 lb.
Transverse strength	17,900 lb. per sq. in.
Tensile strength	16,500 lb. per sq. in.

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 getting a general seeding down.

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.

YATE *(Eucalyptus cornuta).*

Yate grows to a height of 50 to 70 feet, with a bole of 25 to 35 feet, and a diameter of three feet.

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 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.

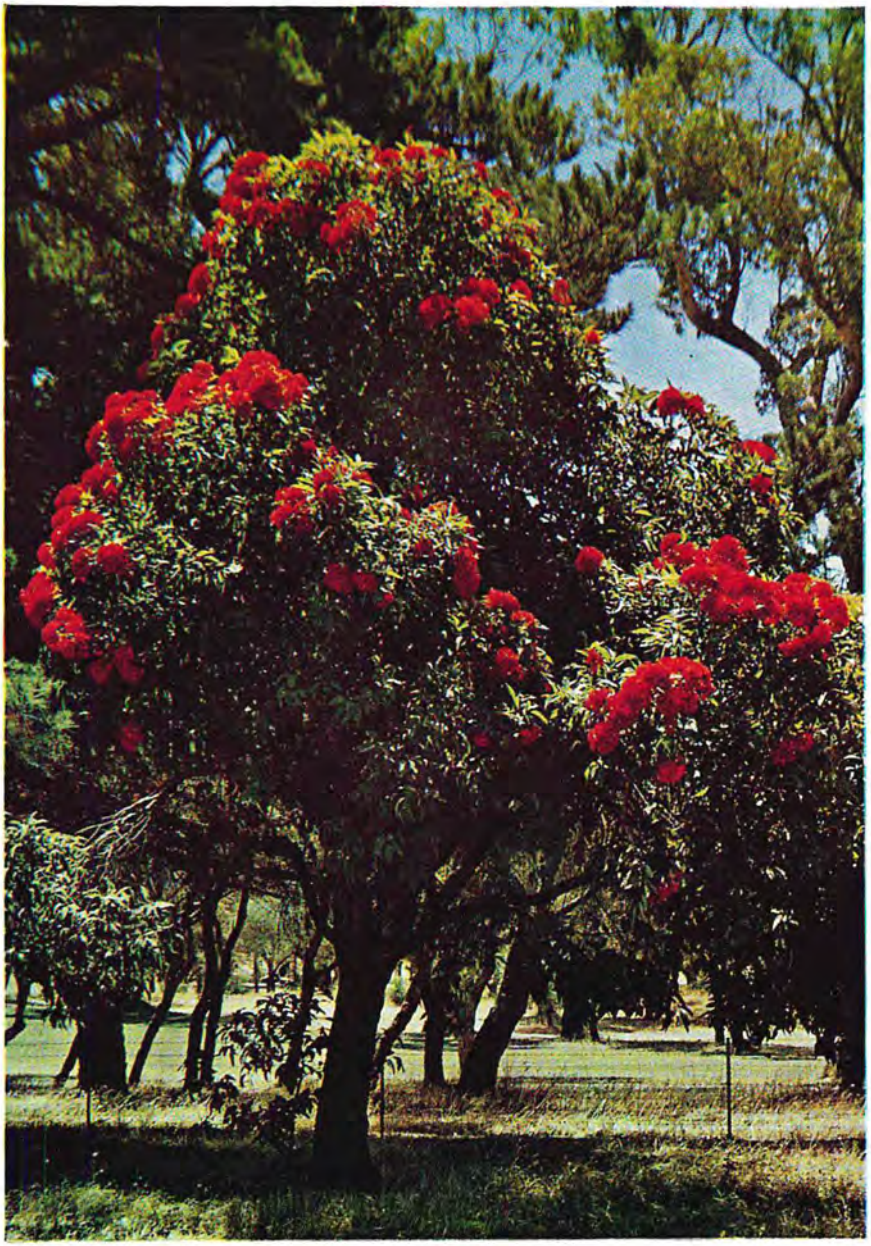
Weight per cubic foot (green)	79 lb.
At 12 per cent. moisture	71 lb.
Transverse strength	21,500 lb. per sq. in.
Tensile strength	24,200 lb. per sq. in.

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

THE WANDOO FOREST

Description of the Forest.

WANDOO *(Eucalyptus wandoo; syn. redunca var. elata)* is a smooth barked tree which often grows to a height of 100 feet with a bole length of 30 to 40



Red Flowering Gum *(Eucalyptus ficifolia)*.

Christmas Tree *(Nuytsia floribunda)*.

feet and a breast height diameter of 4 feet. Under forest conditions, however, the height is generally between 70 and 80 feet with a 20 to 25 foot bole and a breast height diameter of 2 to 3 feet.

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* (powder bark 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.

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 open savannah woodland type forests in which there is wide spacing between the trees. Within these forests, wandoo occurs both as pure forest and also in mixture with poor class jarrah, stunted marri and powder bark wandoo. Usually, it is found growing on lower lying country than the above three species, but on the middle and upper slopes of gently undulating country wandoo occurs in mixture with them.

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 30 inch rainfall limits. It extends from as far north as Moora, reaching its maximum development in the vicinity of Toodyay from whence it deviates to form two areas, one on either side of the Darling Range.

Wandoo on the west side of the range is not extensive and exists mainly as odd clumps of trees along the foothills of the Darling Scarp

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

The prime wandoo forests occur from Boddington to Toodyay, either in broad gullies or on low ridges. Extending south from Boddington, the quality of the forest falls off until it reaches the southern limit of its distribution in the Stirling Ranges.

Soils of the Wandoo Forest.

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.

Plate 25.

Wandoo *(Euc. redunca var. elata)*. Two fine open-grown specimens. The taller tree is 91 ft. high with a 48 ft. bole.

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.
At 12 per cent. moisture	68 lb.
Transverse strength	16,100 lb. per sq. in.
Tensile strength	16,500 lb. per sq. in.

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) and is in great demand for poles. It is a first class structural timber and used in the construction of 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, and from it various implements are made.

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 of wandoo is unusual in that it contains a high percentage of tannin. This is extracted by cooking the chipped wood in large vats and evaporating the liquors to a heavy black viscous extract.

Natural Regeneration.

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 establishment 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.

Timber Production.

Volumes of utilisable timber produced per acre in the wandoo forest are very variable. They may vary from one load per acre to up to 20 loads per acre. Good wandoo forest is considered to carry at least 8 loads of merchantable timber per acre.

OTHER TREES OF THE WANDOO FOREST.

YORK GUM *(Eucalyptus loxophleba)*.

York gum may grow to a height of 40 to 60 feet, with length of bole of 10 to 15 feet, and a diameter of 18 to 24 inches.

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.
At 12 per cent. moisture	67 lb.
Transverse strength	14,500 lb. per sq. in.
Tensile strength	13,000 lb. per sq. in.

York gum grows in open or savannah forests in the 20 inch rainfall belt. It is most common around Bolgart, Toodyay, Northam, York, 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.

THE SWAMP, OR FLAT-TOPPED YATE *(Eucalyptus occidentalis)*.

Swamp yate is a tree which may attain a height of about 70 feet with a trunk up to 20 inches 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 usually spread 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.

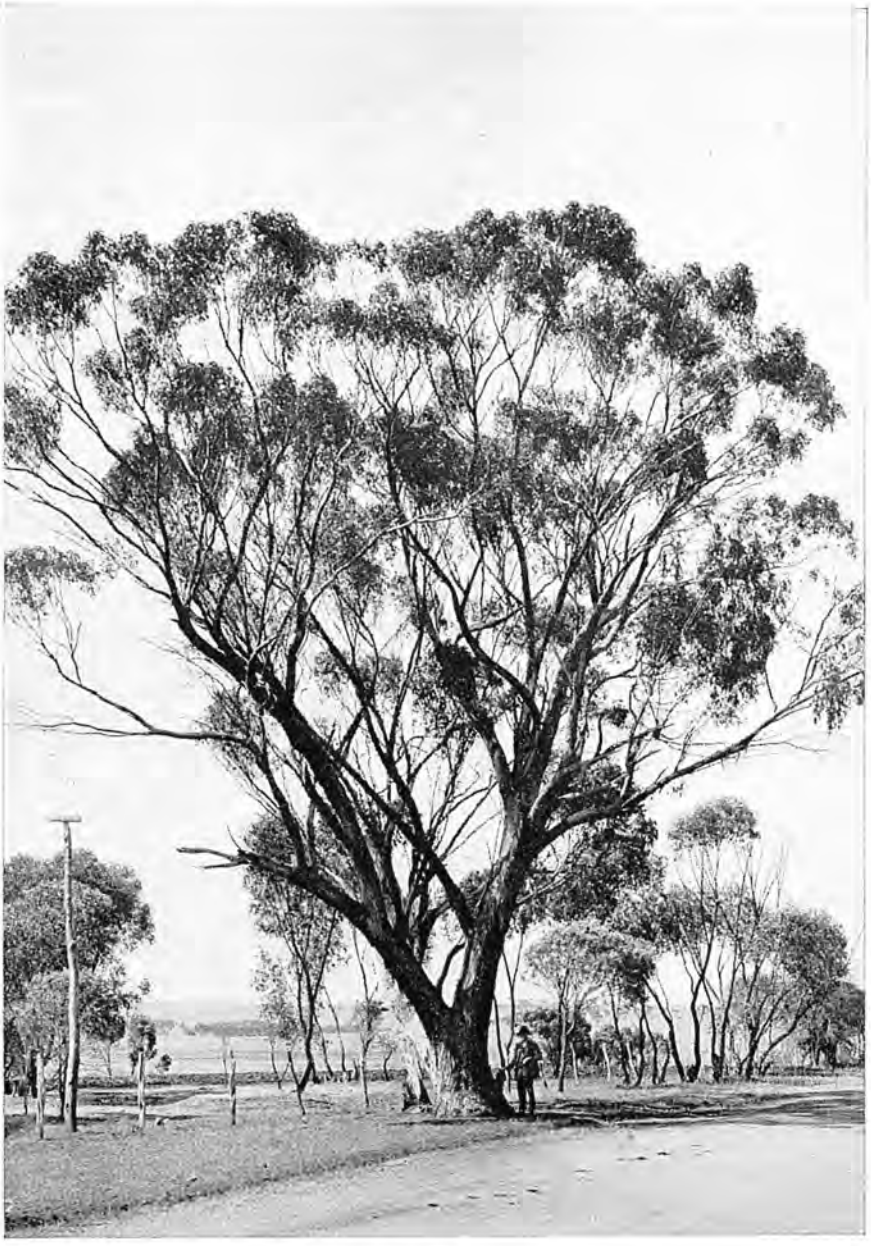


Plate 26.

York Gum *(Eucalyptus loxophleba).*

Plate 27.

Raspberry Jam *(Acacia acuminata).*

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.

Swamp yate 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 in height with a short bole, and up to 12 inches 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.

THE MALLET AREAS

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,

which are readily distinguishable from other Eucalypts associated with them. These four species occur in a fairly distinct zone. They all produce bark with a high tannin content, the brown being the most important of the group economically and swamp mallet, which is of limited extent, being the least important.

Description of the Mallet Forest.

The mallets are smooth barked trees, the brown and blue (which refers to leaf colour) having a bronze coloured bark when freshly exposed in mid-summer but gradually changing to dark grey as the year progresses. The white mallet has a light grey to pale bronze bark. Bark thickness near the base varies from ¼ inch on young trees to over ½ inch in large isolated trees. However, bark on the limbs seldom exceeds ¼ inch in thickness.

The habit of growth of the trees varies considerably from typical tree form to mallee form. As trees with single more-or-less straight boles from 6 feet to 20 feet in length, heights attained are: brown 60 feet, white 35 feet, blue 30 feet and swamp mallet 30 feet.

Brown mallet reaches the greatest size. Large trees are seldom seen these days but trees of 70 feet in height, two feet six inches breast height diameter with a bole of 20-30 feet 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 heavy periodic fires. When they regenerate after a fire they are commonly associated with a dense growth of poison plants. After from about twelve to twenty 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 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 isohyet, the jarrah forest gives place to savannah forest of wandoo *(Euc. wandoo)* and further east the wandoo savannah gradually merges into the low rainfall temperate forests and woodland of salmon gum and morrel, with belts of mallee and heath. In these two latter types of forest the mallet forest occurs in colonies ranging in area from 1 to 200 acres.

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

The 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 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

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 was experienced in air drying. The wood is very hard, it machines well and appears to bend very well when steamed.

During recent years brown mallet has been used as a mining timber in sizes from 3 inch 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 economic importance of mallet has arisen from the tannin which occurs in the bark. The bark after stripping and air drying is chipped into

small pieces about one inch in length and in this form it is used for making tan liquor in the leather industry. The bark of *Euc. astringens*, which is the most important species, contains from 40 to 57 per cent tannin. The bark was for many years in considerable demand overseas and was the subject of an extensive export trade. However, heavy exploitation of the natural stands which are mostly privately held has reduced readily available supplies while a depressed price resulting from a reduced demand has deterred bark strippers from operating. As a consequence, although a market still exists tonnages exported in recent years have been small.

The mallet bark is obtained by stripping the bark during the winter and spring, i.e. from May to November. The tree is of course killed in the process.

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 artificial regeneration of brown mallet was carried out for over 30 years (from 1927-60), and 19,000 acres of plantation were established. The procedure 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. in diameter at about 6 ft. intervals were lightly cultivated with small hand hoes and a pinch of seed dropped on each (about ½ lb. 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 be 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 the 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, returning a somewhat higher yield of better quality bark.

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. in depth, allowing 5 sq. in. 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 has attained heights of nine feet and over in three years.

However, trees established by direct sowing in the 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.

The rate of allowable stripping from the plantations has been calculated on a sustained yield basis, and is of the order of 400 tons of bark per annum.

FORESTS OF THE SEMI-ARID AND ARID REGIONS OF WESTERN AUSTRALIA.

DISTRIBUTION.

These forests 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. isohyet and the Southern boundary (from a point about 70 miles east of Albany) is the South Coast.

The region falls naturally into two distinct forest zones, the boundary between which approximates to about the 9 in. isohyet. The Southern Zone is characterised by Eucalypt forest and the Northern by Acacia (Mulga) forest. To the east at about the 8 in. isohyet the Eucalypt Zone meets the Nullarbor plain.

THE EUCALYPT ZONE.

This is spread over an area of approximately 156,000 square miles. 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 subzones can be recognised, viz.:—

(1) (20-15 in. 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 east of Esperance. This extension consists largely of sand plain and mallee and is at present being rapidly developed for agricultural purposes.

(2) (15-11 in. Rainfall).

Principal species are Salmon Gum *(Euc. salmonophloia)*, Gimlet *(Euc. salubris)*, and Morrel *(Euc. oleosa var longicornis)*. Other less common species in this region are Salt River Gum *(Euc. sargenti)*, Merrit *(Euc. flocktoniae)*, and Swamp Mallet *(Euc. spathulata)*. This sub-zone coincides with what is now the wheatbelt and only fragments of the original forest area 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. 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 north of Kalgoorlie and its southern limit some sixty miles south of Norseman.

A wide range of species occur including the following:

Salmon Gum *(Euc. salmonophloia)*.
Morrel *(Euc. oleosa var longicornis-syn. Euc. longicornis)*.
Gimlet *(Euc. salubris)*.
Silver Gimlet *(Euc. campaspe)*.
Goldfields Blackbutt *(Euc. le souefii* and also *Euc. clelandi)*.
Merrit *(Euc. flocktoniae)*.
Coral Flowered Gum *(Euc. torquata)*.
Boongul *(Euc. oleosa var glauca-syn. Euc. transcontinentalis)*.
Dundas Mahogany *(Euc. brockwayi)*.
Dundas Blackbutt *(Euc. dundasi)*.

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.

This inland forest played an important part in the State's development by providing fuel and mining timber in enormous quantities for the goldmining industry.

For approximately forty 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 has been estimated that the total firewood consumption by the goldmining industry since its inception was of the order of twenty-five million tons.

In addition to the principal forest types described, we have 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, 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 both 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) *Sand Plain (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.

MULGA ZONE

In this zone the eucalypts, although still represented, form only a minor part of the forest which is an almost pure Acacia association. These 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 tetragonophylla.*
Minerichi	*Acacia grasbeyi.*
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 *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.

The recent history of the goldfields forest has been one of exploitation. Trade cutting has been 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 unnecessary.

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

Further problems arise in dealing with the mulga forest. The understorey is sparse and if too much of the cover is removed, wind erosion is liable to occur, while owing to the very slow growth rates (on trees of 3 inch diameter it is less than $\frac{1}{2}$ of an inch 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 4 ft. in height per square chain on the areas cut over.

THE PRINCIPAL GOLDFIELDS TREES.

Plate 28.

Salmon Gum *(Euc. salmonophloia)*, a tree of wide range throughout the inland areas in the southern portion of the State.

In the forest areas of what is now the wheatbelt, salmon gum trees of 80 to 100 feet in height with boles of 40 feet and 2½ to 3 feet in diameter occurred. In the more easterly forests now remaining trees of these dimensions are seldom if ever to be seen.

Plate 29.

Gimlet *(Euc. salubris).*

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.
At 12 per cent. moisture	66 lb.
Transverse strength	20,100 lb. per sq. in.
Tensile strength	19,200 lb. per sq. in.

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

The gimlets are small trees of a maximum height of 40 ft. 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.

Common gimlet occurs over a wide range which includes the greater part of the wheatbelt (where it is now rare), the Eastern and Dundas Goldfields and eastwards for many miles 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.

The silver topped gimlet 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 characteristics 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 is the larger and more widely distributed of these two. It attained heights of up to 90 feet in the wheatbelt and somewhat less further east. While red morrel occupies a range covering almost the whole of the wheatbelt and eastwards to the Goldfields, the black morrel occurs in a more restricted area from Westonia to Bulla Bulling. Although somewhat similar in appearance, the two can be distinguished fairly easily. With red morrel the wood is red, the under-bark pink and the bark on the upper branches reddish grey. With black morrel the wood is dark brown, the under-bark yellow and the bark on the branches silver-grey with darker patches.

Plate 30.

Morrel *(Euc. oleosa var. longicornis)*. This photo also shows the open nature of the dry area forests.

The bark of both species is rough, grey in colour, and persistent for almost the whole length of the main trunk. The morrels occur in a rainfall belt of about 10 to 12 inches per annum.

The following are the physical characteristics of red morrel—

Weight per cubic foot (green)	73 lb.
At 12 per cent moisture	64 lb.
Transverse strength	16,900 lb. per sq. in.
Tensile strength	18,000 lb. per sq. in.

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

DUNDAS MAHOGANY *(Eucalyptus brockwayi)*

This tree is indigenous to the Norseman district where it grows to a height of up to 80 feet, with a broad crown of deep lustrous foliage and a smooth barked trunk up to 2½ feet 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.

The Dundas mahogany occurs freely in the Norseman district, growing on the greenstone formations 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 in height. This tree has a dark-brown flaky bark for two feet to six feet 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 fifty miles north of Kalgoorlie to some fifty miles south of Norseman and from Coolgardie eastwards for about 150 miles.

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

BOONGUL *(Eucalyptus oleosa var glauca)*.

This species was previously known as *Eucalyptus transcontinentalis*. On the Goldfields it occurs as a tree which attains a height of 30 to 50 ft., has a white smooth bark and a rather spreading crown. The leaves are bluish green and lack the sheen of the salmon gum. It occurs in the wheat belt as a mallee with a rough bark.

The flowers are light yellow in colour and in recent years these have provided a good source of nectar for the bees which are periodically taken to the Goldfields by apiarists from the coastal areas of the State.

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

CORAL FLOWERED GUM *(Eucalyptus torquata)*

Coral flowered gum occurs as a small tree of 20 to 25 ft. 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 in length. (See plate 7.)

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 *(Sterculia gregorii)*

Kurrajong grows to 25 ft. in height with a thick straight trunk and widely spreading dense branches. The bark is rough and persistent, and of a light grey 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.

THE GOLDFIELDS PINE *(Callitris glauca)*

This native softwood tree may attain a height of 30 ft. with more or less spreading branches which give it a cedar-like appearance. The leaves are of a 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 ft. with a diameter of six to eight inches. Before it had been so extensively exploited, specimens reaching a height of 25 ft., with a diameter of up to 12 inches, 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 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, 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.

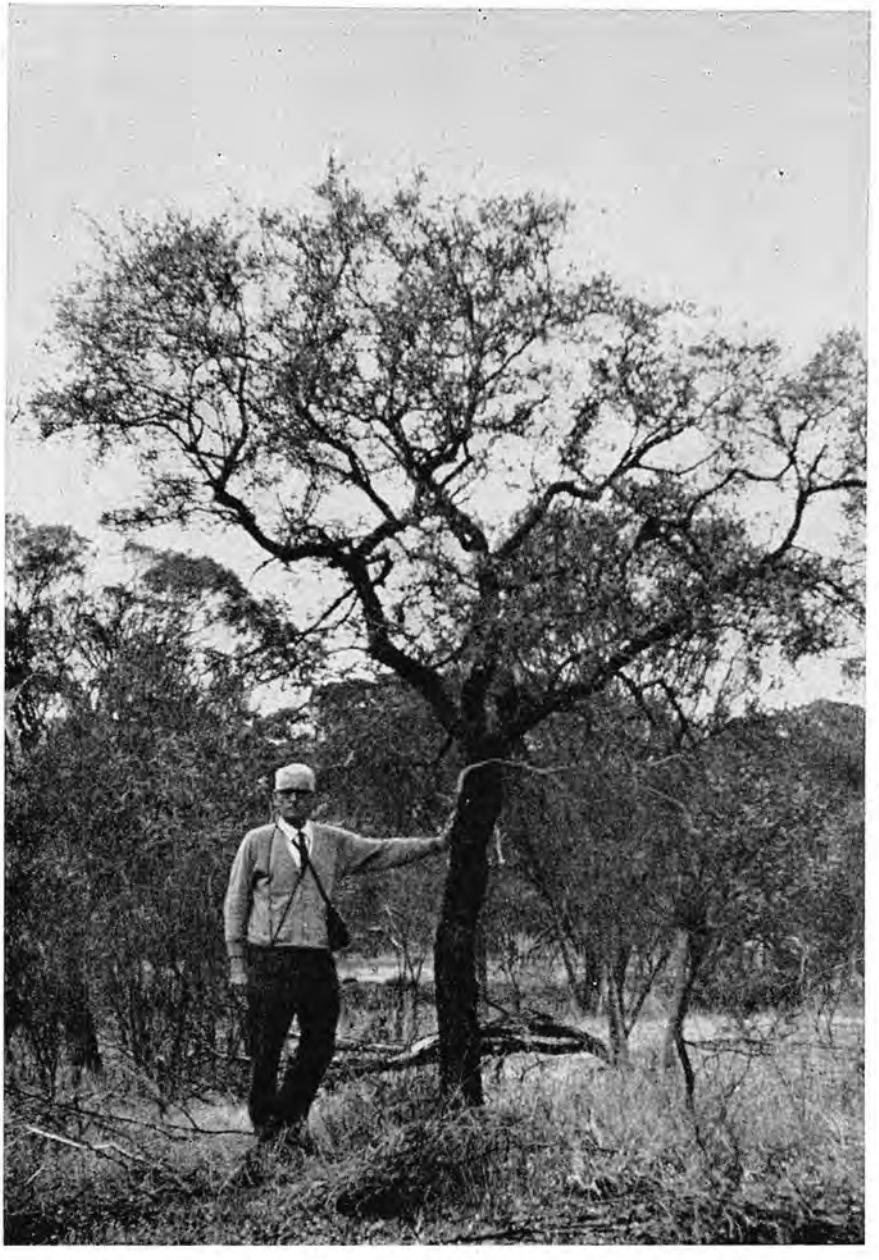


Plate 31.

Sandalwood *(Santalum spicatum).*

CHAPTER IV.

FOREST PROTECTION.

FIRE PROTECTION.
FOREST PATHOLOGY.
FOREST ENTOMOLOGY.

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.

The Damage Caused by Fire in the Forest.

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. In this latter respect different tree types have different resistances to damage by fire. As a general rule, rough-barked species such as jarrah can withstand considerable burning to the trunk without subsequent death. The smooth-barked karri has much less resistance, while brown mallet may be killed solely by the

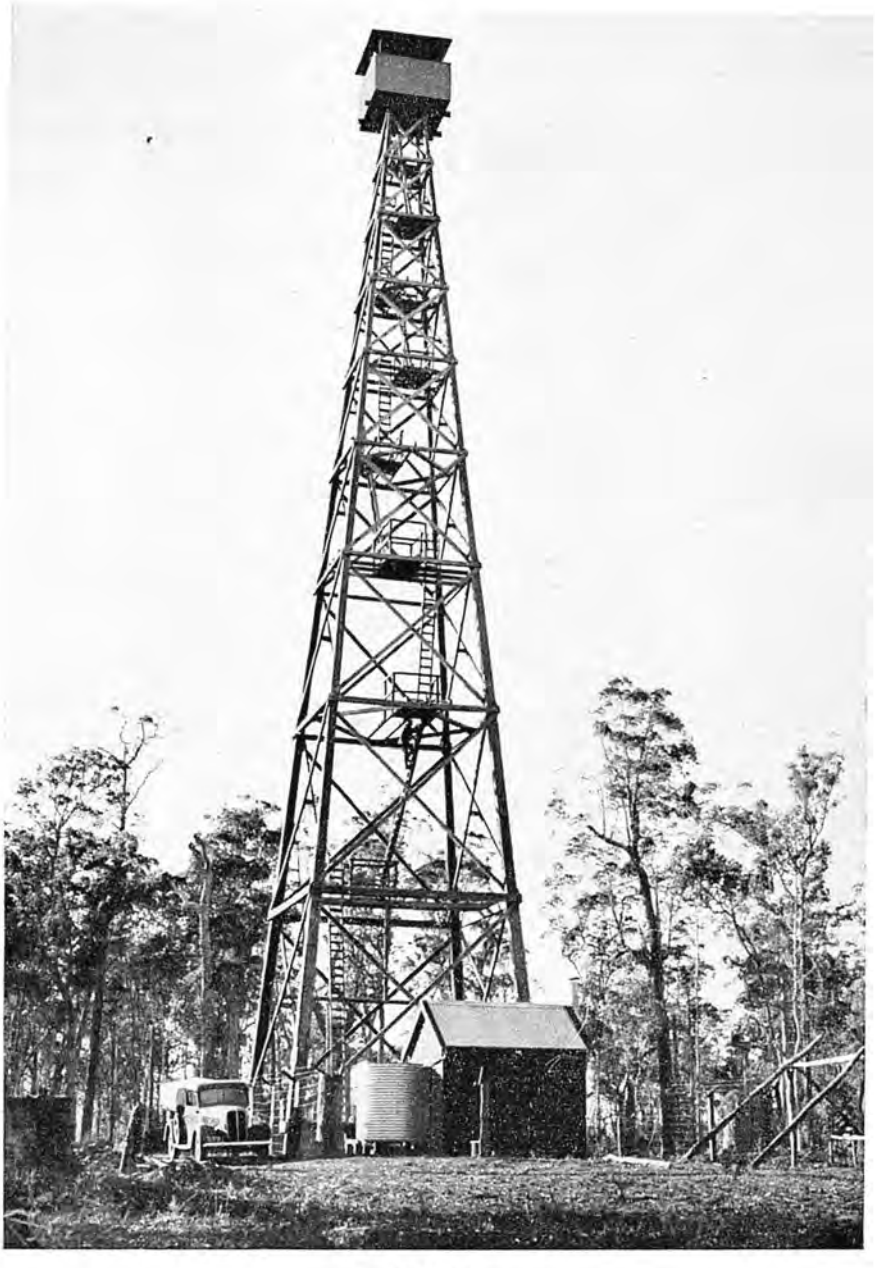


Plate 32.

A fire lookout tower 125 ft. high erected for fire detection purposes.

radiant heat of the fire without actually being contacted by the flames. Young trees of all species are, however, very susceptible and severe fires on hot days kill many trees.

Apart from killing the tree outright, direct burning 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 forest 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 the 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.

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, 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 1st October and 31st May 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) To 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 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, 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", but may be lit on the first day afterwards when the fire hazard forecast is below "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.

The second aim of fire prevention, which is to reduce rates of spread of fires, is achieved by Hazard Reduction which involves "Controlled Burning". Control burning of the forest to prevent fuel build-up implies the removal of fuel, particularly the easily lit part of the fuel such as leaves and twigs lying on the ground, by the use of mild, fairly slow-moving fire confined within definite boundaries. Such a fire does not damage the trees and can be achieved for quite extensive periods in Spring and shorter periods in Autumn, when the temperatures are reasonably low and the fuel quite moist. Where possible controlled burning is practised on about a 4-5 year rotation. This prevents the volume of fuel building up to a point at which, if a fire started on the days of Severe or Dangerous fire hazards, control would be virtually impossible. The whole northern jarrah forest is now being managed under this system of burning. In the karri forest where a heavier initial concentration of fuel and shorter safe controlled-burning periods occur it has not been possible to burn the whole area on a rotational basis with the present manpower. Instead the forest is broken into blocks surrounded by burned country so that should a fire start it can be contained within a reasonable area.

Fuel reduction by controlled burning would be carried out for any one of the following reasons:—

(1) Rotational controlled burning.

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

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

(4) Burning for silvicultural reasons such as top disposal, to clean up debris of tree tops after falling 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 on an area.

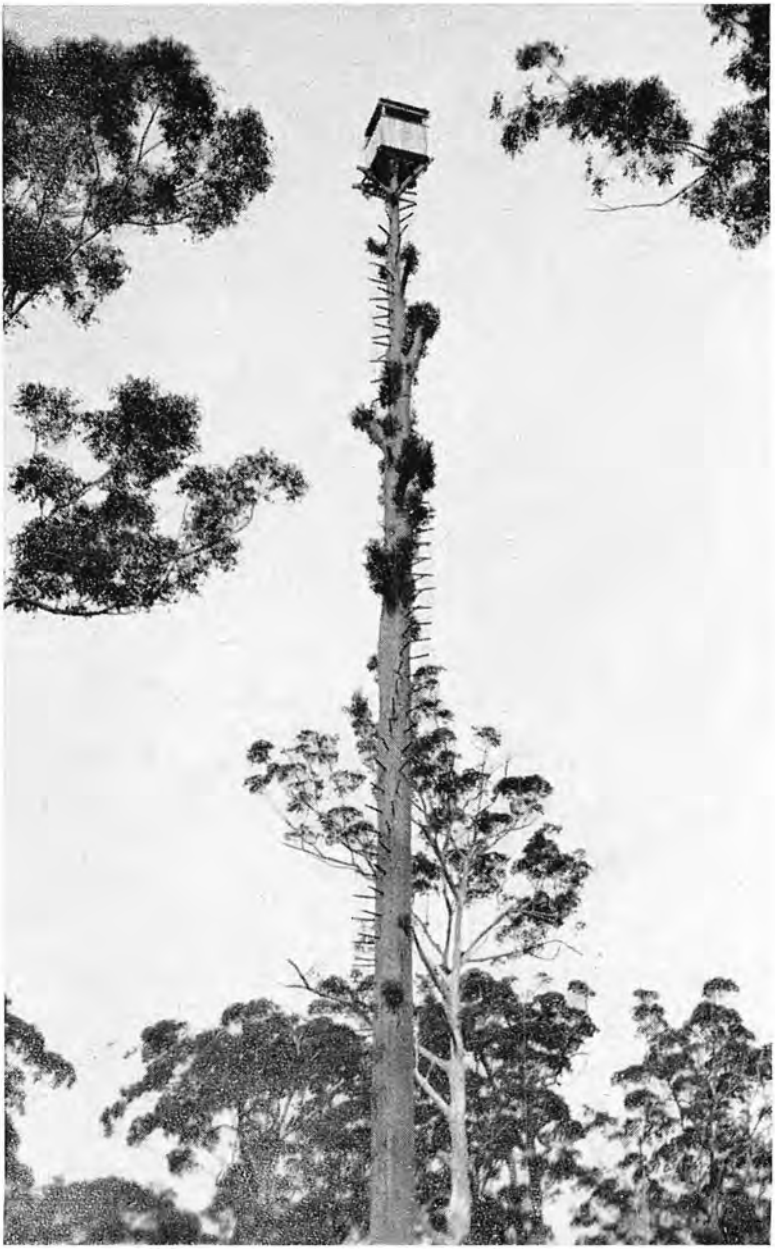


Plate 33.

Gloucester Tree, a karri tree lookout at Pemberton. The cabin is 200 ft. from the ground.

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.

The judicious use of controlled burning over the years will enable the forest canopy to reform and suppress scrub growth, both of which results are conducive to maximum growth and best quality of timber.

Fire Weather Forecasting.

Successful controlled burning involves the correlation of weather conditions, fuel quantity and condition, and forest type. Forest officers must be able to interpret the effect of weather on the rate and intensity of burning if they are to make full use of all days suitable for controlled burning operations.

Plate 34.

The radio operating room at a Divisional headquarters, showing from left to right: the V.H.F. 2-way radio, the main H.F. transmitter/receiver, and the standby H.F. set.

As early as 1934 a Fire Weather Station was established at Dwellingup. Investigations at Dwellingup correlated the combined effect of weather elements with the moisture content of half inch diameter *Pinus radiata* rods. These rods have an oven-dry weight of 50 grams each, and were considered to be fairly representative of forest fuel inflammability or fire hazard. The moisture content of the radiata rods was separated on an empirical scale 0-10 which was divided into seven classes—nil, low, moderate, average, high, severe, dangerous. The relationship of these scales and the moisture content of the wood cylinders is given in the table hereunder:

Fire Hazard.	Empirical Scale.	Moisture Content of ½ in. pine cylinders.
Nil.	Less than 1	19.4-17.0%
Low	1-4	16.9-11.0%

Moderate	4.1-6	10.9- 7.9%
Average	6.1-7	7.8- 6.5%
High	7.1-8	6.4- 5.3%
Severe	8.1-9	5.2- 4.1%
Dangerous	9.1-10	4.0- 3.2%

Other weather stations have been established at Pemberton, Dryandra, Ludlow and Margaret River.

Close co-operation is maintained with the Meteorological Bureau to whom weather telegrams are despatched at 9 a.m. and 3 p.m. each day during the fire season from Dwellingup, Pemberton and Dryandra. The 3 p.m. telegram also includes the maximum fire hazard recorded for the day.

Using the current fire hazard as a basis and applying their knowledge of possible future weather conditions the Bureau passes a forecast by telephone to Dwellingup at 4 p.m. each day. This is in the form of a brief weather forecast and the estimated fire hazard for the following day for both jarrah and karri forest areas. These forecasts are transmitted over the Department's radio system from Dwellingup at 4.15 p.m. on the same day.

At 7.30 a.m. each morning weather reports are received by Dwellingup and these together with local readings are used to check the forecast made on the previous afternoon. The latest forecast of weather and fire hazard is then transmitted from Dwellingup at 7.45 a.m. with a view to having this information available before the gangs leave headquarters for work.

Should the day be suitable for controlled burning, areas will be chosen on which fires will burn without scorching the tree crowns. This choice will take into account the fire hazard, fuel quantity, height of crop tree crowns and expected wind strength. The crews will be sent to these areas to light fires on a pattern through them.

If the fire hazard is too high for controlled burning the crews will be diverted to other work at strategic points in the Division for most rapid attack on fires should they break out.

The number of men held in preparedness will depend on the degree of hazard which is forecast. The positioning of men will depend on local knowledge of heavy fuel, danger spots and high risk areas.

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. In this second aim rapid fire detection and subsequent suppression measures are also 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. Spotting methods vary in different countries, but the major system employed in Western Australia depends on the use of skilled observers working from specially constructed lookout towers established throughout the forest. They vary from low towers on high ground to cabins built in the tops of tall karri trees. The tallest tower is Gloucester Tree, 200 feet in height. This lookout, situated three miles from Pemberton, 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 after dark 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.

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.

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.

Telephones provide the main line of communication for administrative purposes. Contact between widely separated Divisions and between Divisions and Perth Office is by P.M.G. telephone but within each Division and linking most adjacent Divisions there are single-line earth-return telephones erected and maintained by the Forests Department. These lines radiate from each Divisional Headquarters to fire towers and smaller forest settlements providing a basic network for fixed station communication. Over 2,500 miles of telephone line have been built by the Department.

In addition to the telephone network two radio systems provide added flexibility to the Forest Department's communications. The first of these systems using High Frequency radio signals provides contact between all Divisions and is used throughout the fire season to receive fire weather data, to circulate daily fire weather forecasts and to provide an alternative to telephone communication when information being passed would tie up a telephone channel for a prolonged period. To a lesser extent High Frequency radio is used to maintain communication from the Divisional Headquarters to its fire trucks during the fire season. This role is now being taken over by the second radio system using very high frequency radio signals. This is a very flexible form of communication with a simple operating procedure. Although V.H.F. has fairly limited range it provides excellent communication from vehicle to vehicle or vehicle to Headquarters within each Division and mobile transceivers are fitted to most fire trucks and officers' vehicles whilst fixed stations are set up at Divisional Headquarters.

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 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 tank of water, fire rakes, crosscut saws, axes, waterbags and emergency rations. This outfit carried a gang of four men.

Plate 35.

A modern light duty outfit, capable of speedily transporting men and equipment to the scene of a fire.

The present day light duty outfits are 2-3 ton trucks carrying 200 gallons of water which can be delivered from a power pump. This pump is also capable of replenishing the truck from static water supplies developed through the forest. These trucks carry the additional equipment of the earlier models and are often equipped with a chain saw when being worked at a fire. The chain saw has become an important unit at the fire edge, to fell trees burning too high up to be reached by pumpers.

With the advent of improved roads and the transformation of practically all firelines into trafficable roads, the light duty outfit was augmented by the heavy duty unit capable of supplying up to 200 gallons of water per minute. These larger outfits consist of a 4-5 ton truck, frequently with four-wheel drive, carrying a specially constructed slip-on unit of a 600 gallon tank and power pumper. Pumping is either from their own tanks or from shallow wells specially constructed throughout the forest for this purpose. If there is no such water supply adjacent to the fire, the trucks can retire to the nearest water point to refill the tank with their own pump.

Plate 36.

A heavy duty pumper unit at a fire-front. The pump is capable of delivering up to 200 gallons of water per minute.

Apart from the hand tools such as rakes, shovels, and axes which are standard equipment for all fire gangs, light bulldozers are extremely valuable for constructing fire lines around a fire. When required at the scene of a fire, they are transported rapidly on the back of 5 ton trucks. In the extremely dense undergrowth of the karri forest large bulldozers are frequently called in. 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. Early attack while the fire is small is the essence of fire suppression.

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 the perimeter of the fire.

Fire suppression entails three operations—knock down of the running fire, mopping up and final patrol.

On receipt of a message locating a fire in their area, the fire gang proceeds immediately to the outbreak. It is the duty of the gang to extinguish the fire

before it reaches large proportions, or if this is not possible, to hold it in check until further help arrives.

Depending on the fire information radioed back to the control centre by the Overseer after an initial reconnaissance, extra gangs and equipment are dispatched to help in suppression, or nearby gangs are alerted for possible emergency.

The fire is usually attacked with packsprays and rakes although if a truck can get close enough the light power pump replaces the packsprays. Wherever possible the truck is taken near to the fire and hose lines are run out to bring the water to the face of the fire. Frequently the rugged terrain or numerous logs on the forest floor prevent such an approach.

For years the light bulldozer has been used to clear a track around the fire and to make a rough track of access for the tankers. Recently V-shaped "snow plough" blades have been made for these bulldozers and their rate of fire line construction has been greatly improved.

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

A cleared break is constructed around the whole burnt area by hand tools and/or bulldozer, to prevent further spread. Every tree or spark that is alight close to the edge of the fire and 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.

Plate 37.

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

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 dispatching, most fires in State Forests are brought under control when small. In these days only a few reach serious proportions in the area afforded intensive fire protection.

The Forest Area.

Of the 4½ million acres of State Forest in Western Australia, more than 4 million acres are at present afforded intensive fire protection, and with the establishment of permanent staff and the steady expansion of access roads in the South, the remainder of the forest area will come within the comprehensive scheme of protection within the next few years.

Roading and subdivision are practically completed in the Northern portions of the forest, with the exception of some of the Eastern areas. The work of opening up the karri forest in the far South is proceeding at an increased tempo as exploitation of these stands gets under way and Departmental settlements are established. As soon as possible direct protection will be afforded the entire State Forest area.

FOREST PATHOLOGY.

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 AND PLANTING STOCK.

(a) *Damping-off Fungi.*

Two species of fungi, *Pythium* and *Phytophora,* cause considerable losses in nursery stock over the years.

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 disease 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.

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 disease, and an early application of a soil drench known as Cheshunt mixture is often effective once the seedlings have emerged.

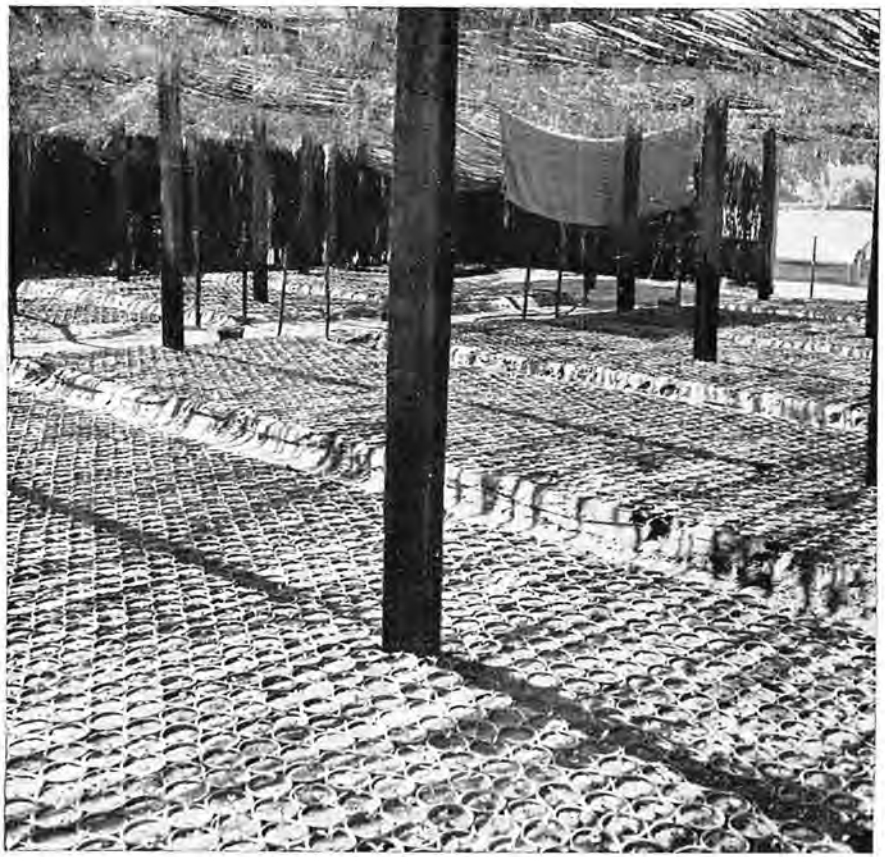


Plate 38.

Potted eucalypt seedlings in the shade house at the Dryandra nursery. Unless carefully controlled, "damping off" fungi can cause extensive deaths in a large concentration of young plants such as this.

(b) *Root-rotting.*

Every now and again, plants which have been lifted from the nursery beds are struck by a disease causing rotting of the roots. This disease has probably been responsible for many of the deaths in the field previously ascribed to unknown causes.

FUNGAL DAMAGE TO TIMBER.

Decay or rot in wood is caused by fungi. The fungus *hyphae* (or thread rootlets) 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 wood before rot can begin. On the other hand completely saturated wood cannot decay because air is essential to fungal growth and activity. Decay of the standing 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 liable to occur if the wood is properly seasoned and maintained at a low moisture content.

FUNGAL ATTACK TO THE GROWING TREE.

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).

Cubical rot is the commonest rot found in Western Australia. It bears a resemblance to the so-called "dry rot" of the old world. Contrary to the experience with the "dry rots" in 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 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.

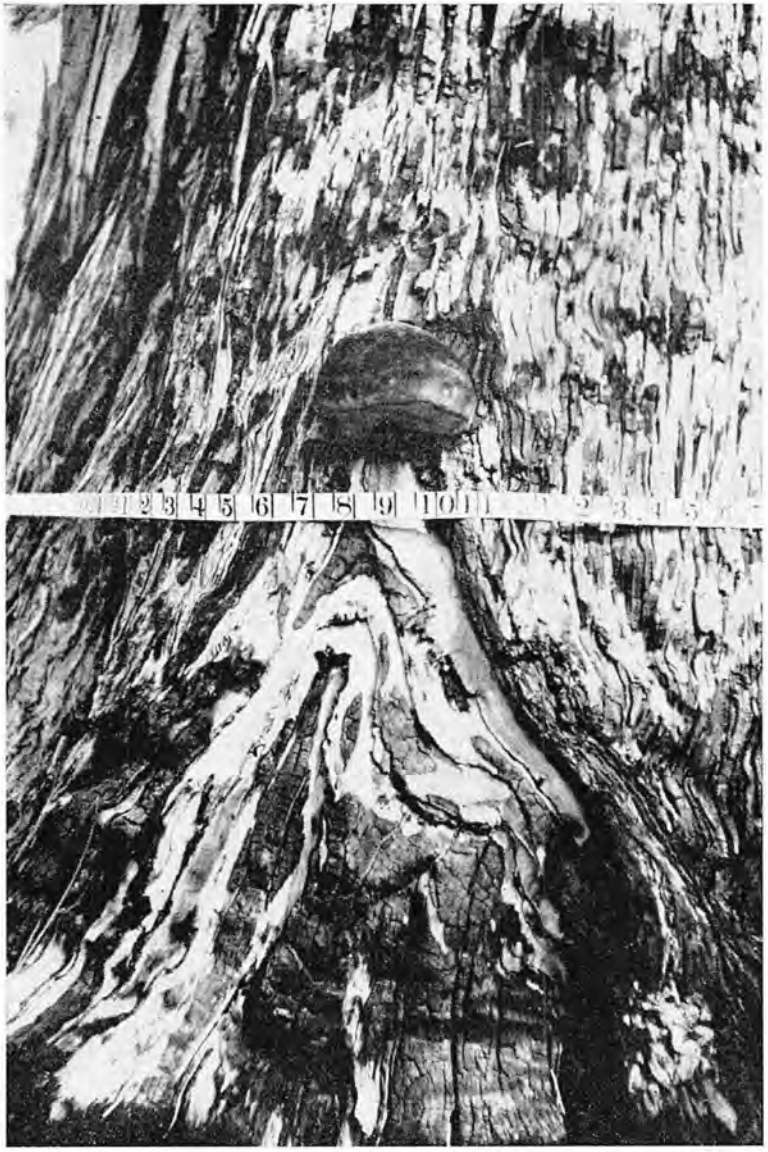


Plate 39.

Past fire damage has caused this dry side on the butt of a living tree, which then becomes subject to fungal attack. The bracket fungus shown in the photo is only the fruiting body of an extensive internal infestation.

(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.

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, 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 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 a chemical process, 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 across and five to six inches 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 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 across and half as thick. Successive sporophores formed each year are persistent and 3 or 4 may be found superimposed upon each other; a manner common also to the genus *Fomes*.

Polyporus gilvus is not as common as column or pocket rot.

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 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 across and ½ to 1 inch 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 across and ¼ inch 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. From this mycelium mass, and usually following a bush fire, mushroom type sporophores up to six inches 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 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 with stems 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 across. Usually this fruiting body is less than six inches wide and about ¼ inch 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 across and 1/16th to a ¼ of an inch 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 shows as a blue stain and reduces the value of the sawn product although it only effects the timber 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 across, 5 to 6 inches 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.

Plate 40.

Sawn timber stacked for air drying. Unless properly ventilated, timber stacks may suffer considerable damage from fungi.

OTHER IMPORTANT FOREST FUNGI.

Phytophthora cinnamomi.

This fungus has been recognised as causing the death of a range of coniferous species particularly *Pinus radiata* planted in shelterbelts in New Zealand. It rots the roots of the trees during periods when the soil is either waterlogged or nearly so and reduces the ability of these trees to withstand later summer drought.

Evidence available suggests that extensive deaths in shelterbelts of *Pinus radiata* along the coastal plain South of Perth may be attributed to this or a closely related fungus.

Armillarea 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 lucerne, 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 Flowering Gum Canker).

Sporotrichum destructor is a parasitic fungus which attacks the living cells of marri and red flowering gum. It is fairly common on marri and kills the limbs attacked but very seldom is severe enough to kill the tree. In King's Park and many other areas, red flowering 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 wide and two inches 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 medullary 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, 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 decay does not come within the section of timber most likely to fail because of its presence;
(c) 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.

FOREST ENTOMOLOGY

Forest Entomology is that branch of the biological sciences concerned with insects in their relation to forests and forest products.

Insects which have come to the notice of the Forests Department are as follows:—

1.—LEAF EATING INSECTS.

Damage by these does not seriously affect the tree's welfare but in severe infestations, defoliation interferes with food production and transpiration, checking growth. A reduction in vitality of a tree by leaf eating insects may render trees susceptible to attack by other insects such as borers or bark beetles. Examples of this type are the jarrah leaf miner *(Tinea sp.)*, the weevils and beetles.

Jarrah Leaf Miner (Tinea sp.).

This insect is a member of the *Lepidoptera* family. It causes considerable damage to the foliage of jarrah, swamp gum *(Euc. rudis)* and, to a lesser extent, tuart when growing amongst jarrah. The ravages of this moth are so far confined to the coastal jarrah growing on the plain country and, as yet, has not caused any serious damage in the prime forest region. Casual outbreaks of this insect have been recorded as far back as 1914.

Crowns attacked by the leaf miner have the appearance of being scorched by fire. Closer observation reveals the attacked leaves to be full of small oval holes and to be denuded of their green contents. These leaves are mined internally by the activity of tiny larvae which may be found in the tunnels.

Damage caused by leaf mining is temporary as far as foliage is concerned and occurs during the non-growing period for eucalypts, namely, May and June. The worst check to growth seems to be to young seedlings and coppice shoots, the moths attacking those leaves nearest the ground.

The habits of the larvae of burying themselves in the soil, just below the surface, renders them liable to destruction in large numbers by the use of controlled burning operations. So far, from the economic viewpoint, leaf miner

attack is not significant as it is not common in the most productive forest areas. Control by the use of contact insecticides does not seem practicable due to the large area of attack and difficulty of penetrating the leaves to effect the tunnelled larvae.

2.—SAP SUCKING INSECTS.

The effect of this group is never so serious in our forests as that of the leaf eaters. Injury results from sap sucking which deprives plants of food and water, and spreads plant disease.

Examples of this group are the *Aphidae* (Aphids), *Psyllidae* and *Coecidae*.

3.—INSECTS ATTACKING THE TERMINAL GROWTH REGIONS.

Growing tips which are rich in protein are highly favoured by a wide variety of insect species. Two broad groups may be distinguished:

(a) Attacking twigs, tips or shoots, i.e., Tuart Bud Weevil *(Haplonyx sp.)*.

(b) Attacking small roots—only troublesome to young trees and seedlings, i.e., Cockchafer grubs and *Elateridae* (Click Beetles).

Haplonyx tibialis (Tuart Bud Weevil).

This insect, as the name implies, attacks the flower buds of the tuart *(Eucalyptus gomphocephala)*. Its activity causes the immature flower buds to fall annually, usually during the months of November to April. During this period large numbers of terminal twigs with buds attached cover the ground around the base of the trees. Reports recording this annual falling of buds go back as far as 50 years.

The damage to the tree results from the insect cutting off twigs containing the flower buds, after an egg has been laid in the unopened bud. Having thus laid in several buds the insect deliberately returns along the twig and cuts off or rings it, causing it to fall directly or loosening it sufficiently to be dislodged by the wind. In the development of this weevil larvae it appears to be necessary that the buds should fall to the ground. When in contact with the soil they soften, and thus make the bud tissue easily available to the grub inside.

The activity of this weevil is not entirely confined to the buds of the tuart. It has also been found in a lesser degree attacking the flower buds of red flowering gum *(Euc. ficifolia)* in the Denmark District.

Control of the weevil is out of the question from present knowledge, due to the protected life of the Weevil within the flower bud, and it is necessary to rely on nature asserting herself and producing every few years an abnormal crop of flower buds in excess of the weevils' requirements. Seed is collected during such seasons.

4.—INSECTS ATTACKING THE CAMBIAL REGIONS OF THE TRUNK AND BRANCHES.

(a) *Cambium Borers.*

The Marri Borer *(Tryphocharia hamata)*. This beetle belongs to the large family *Cerambycidae*, the members of which are generally known as longicorns or long-horned beetles.

Tryphocharia hamata is found through the Southwest from Perth to Albany and the adult beetles may be found flying at dusk during January and

February. It attacks various eucalypts, but seems to have a preference for marri. Other trees attacked are tuart, blackbutt, wandoo, red flowering gum *(Euc. ficifolia)* and red tingle. Trees in all stages of growth are attacked, but for preference, young trees about a foot in diameter.

Damage incurred by the tree is due to the extensive borings of the developing larvae inside the trunk. During the period of almost two years in which the larvae occupies the trunk it may have bored upwards in the tree for a distance of 8 to 12 feet. It is not believed that the workings of the marri borer have any connection with the incidence of kino veins in marri.

No effective method of control has been considered, as marri has at present little economic value.

(b) *Bark Beetles—Scolytidae (Hylastes, Ips).*

Ips grandicolis. The insect is commonly found in the bark of recently dead pines throughout the State. This species is not a cause of disease or death but is a secondary attacker.

5.—CAMBIUM AND WOOD INSECTS.

Mostly attack dying trees and freshly cut logs, i.e., Longhorn Beetles *(Cerambycidae)*, Marri Borer and Pinhole Borer *(Atractocerus kreuslerae).*

Pinhole Borer *(Atractocerus kreuslerae).*

Probably no insect does greater damage to the commercial timber growing in Western Australian forests than the pinhole borer.

This insect deposits its eggs on the bare injured timber of the tree, generally on the seat of an old blaze mark, or where limbs have been torn off. Almost any eucalypt in the bush with a portion of the trunk injured is liable to attack, but the species of trees are favoured in the following order:—blackbutt, tuart, jarrah, wandoo, flooded gum, marri.

The larvae emerge from the eggs and bore for a considerable distance into the tree, mostly in a horizontal direction, but frequently in all directions. As the larvae progress inwards they continually push out a long threadlike core which usually projects about an inch from the burrow, eventually breaking off and accumulating in a small heap at the base of the tree or injured portion. The actual time passed by the larvae in the tree is not definitely known, but they spend at least two years in the larval state.

This pest, being so widespread and having so many hosts, could not be economically controlled by artificial means. Some degree of control is exercised by forest management practice which aims to reduce damage to the standing tree to a minimum, hence reducing the incidence of entry into the tree. Grading rules make allowance for pinholes in timber. Fresh attacks of the borer show as tiny holes no thicker than a pin and do not impair the strength properties of timber but reduce its value where appearance is important. In wood which has been attacked for some years the tunnels are at least 1/16th inch in diameter, very numerous and frequently with rotten walls making the timber useless. The zone of attack is usually in the upper bole and may extend from only 1-2 feet to the length of the bole.

6.—WOOD DESTROYERS.

These insects attack standing green timber, unhealthy and recently felled trees and timber products.

(a) Insects of moist wood, i.e., Termites, Sirex, Scolytids.
(b) Insects of dry wood, i.e., Termites, Lyctus, Anobium.

Termites.

Termites or white ants, as they are often erroneously called, may be divided into two major groups, viz, wood-dwelling and earth-dwelling termites. The wood dwellers enter wood directly from the air, and often the colony is wholly confined to the particular piece of timber in which it is working.

Earth-dwelling termites destroy wood by attacking it from the ground or from another piece of timber in contact. The main colony is situated underground and they often build tubes or covered runways from the ground over wood, plaster, brickwork, etc., to wood at higher levels. It is to this earth-dwelling group of termites that the principal species in Australia belong. All timbers are not equally attractive to termites and where possible termite resistant timbers such as jarrah, native pine *(Callitris sp)* and jam *(Acacia acuminata)* should be used for building or fencing. Other important prevention and control measures include—

(i) treating all timber in contact with the ground with coal tar creosote;
(ii) careful clearing of old roots, wood debris, etc., from land before building or planting trees;
(iii) the isolation of piers and building piles from timber above by means of metal caps;
(iv) introducing poisons into colonies when tunnelways can be located and tapped.

The Lyctus Borer.

Unlike the pinhole borers which can attack only green timber, the Lyctus borer is found infesting air-dried or kiln-seasoned timber which in practice is never too dry to be attacked. Lyctus attack is restricted to hardwood timbers and is characterised by the production of copious quantities of fine flour-like dust.

Except in special cases, the damage due to the Lyctus borer is usually of limited extent and generally should not be regarded as cause for great alarm.

Essential Facts Concerning Attack.

(1) The Lyctus borer confines its attack to the sapwood of certain hardwood timbers. Softwood timbers are never attacked by Lyctus.

(2) The Lyctus borer does not attack the living tree or the green log, but practically as soon as timber is cut and surface drying has occurred, the sapwood becomes susceptible to Lyctus attack.

(3) In some hardwoods the sapwood is very susceptible to Lyctus attack, while in other very similar timbers it may be completely immune from attack. For State hardwoods, the position is as follows:—

Jarrah—Rarely susceptible to attack.
Karri—Immune to attack.
Blackbutt (Yarri)—Highly susceptible to attack.
Marri—Moderately susceptible to attack.
Tuart—Moderately susceptible to attack.
Wandoo—Immune to attack.

Lyctus attack is easily identified by the abundant flour-like dust which is packed in the tunnels in the wood and which often forms small heaps beneath the flight holes made by the escaping beetles.

Control and Remedial Measures.

As mentioned previously, the maximum Lyctus attack which can occur in sawn eucalypt hardwood is limited to strips or edgings of sapwood; destruction of which does not significantly endanger the strength of a structure. It is thus seldom necessary to treat such timber unless a decorative effect is involved or the falling dust is a nuisance.

Sometimes the damage to the appearance is sufficient to make replacement of the piece of timber desirable, but in most cases simple remedial measures are sufficient.

Treatment with insecticidal solutions should be made with the object of obtaining good penetration of the preservative into the flight holes. This can be achieved by dipping, by liberal brush application, by flood spraying, or by injecting holes with a pressure syringe.

Pressure syringing is most applicable to decorative woodwork where treatment must be made with minimum risk of affecting the finish. As holes are interconnected between the surface it is usually unnecessary to treat every hole. Sodium pentachlorphenate is an effective insecticide for treatment.

7.—FAUNA OF THE FOREST FLOOR.

A rich fauna is responsible for much of the process of decomposition in the forest soil. The most important constituents are the *Collembala* (springtails) and *Acarina*.

Insect Control.

The measures which may be taken to control insect pests are:—

(a) Indirect means:

(i) Biological control—introduction of predators or insect destroyers to remove the harmful insect.

(ii) Control by modification of cultural operations, i.e., silviculture.

(iii) Control by statutory regulations, e.g. quarantine.

(b) Direct means:

(i) By traps or repellants.

(ii) By chemical insecticides.

In Western Australia, the Forests Department relies on quarantine to keep out new insects and sound silvicultural practice to maintain natural control of indigenous insects. Timber infested with insects is treated directly by heat sterilization or the use of chemical insecticides.

A wood wasp, *Sirex noctilio,* has caused severe damage to *Pinus radiata* plantations in New Zealand. It is hoped to prevent large scale introduction of this wasp by rigid quarantine measures even though it is possible that the insect may not be a great menace in plantations in this State. It is wisest not to put such a supposition to the test if it can be avoided.

Quarantine is the most effective control measure possible in Western Australia at present.

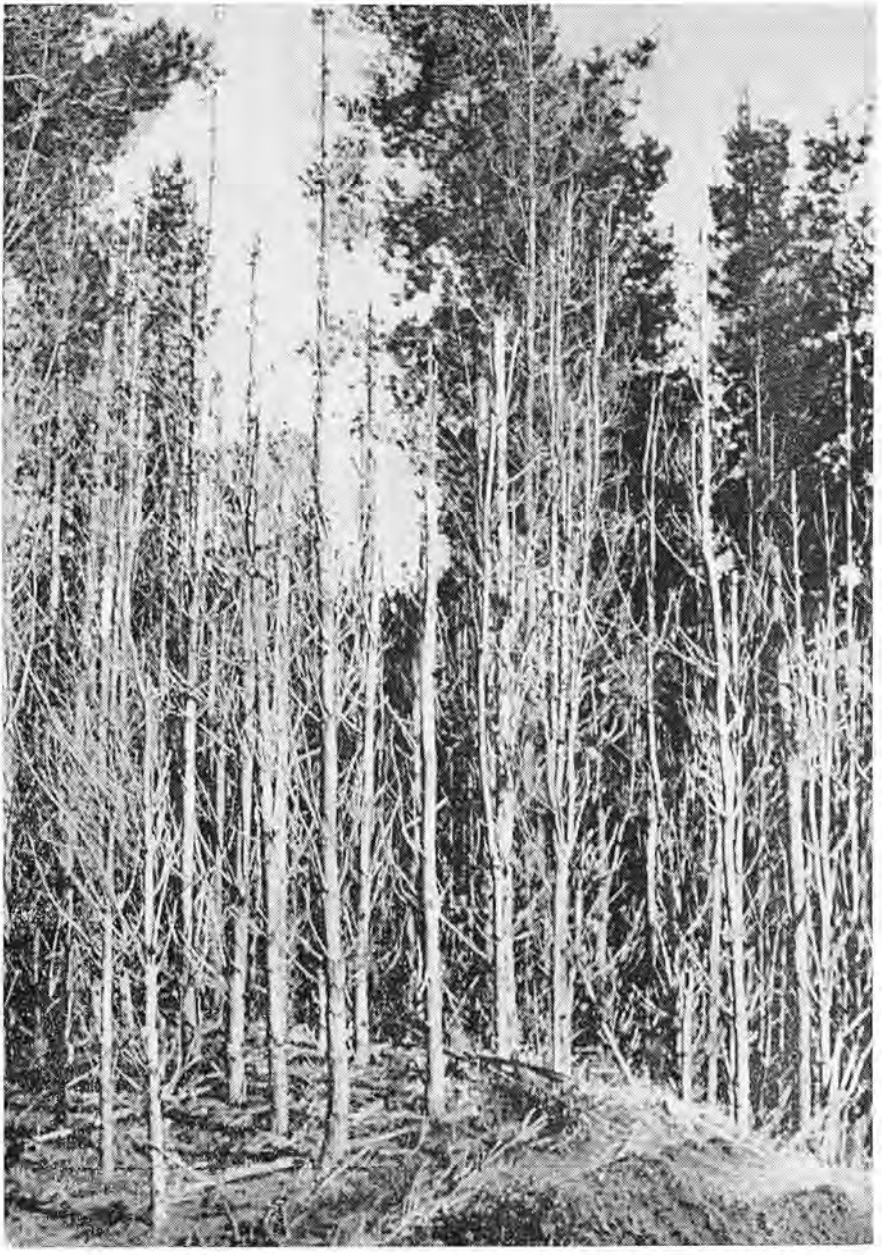


Plate 41.

These *Pinus radiata* trees in New Zealand have been killed by severe Sirex Wasp attack.

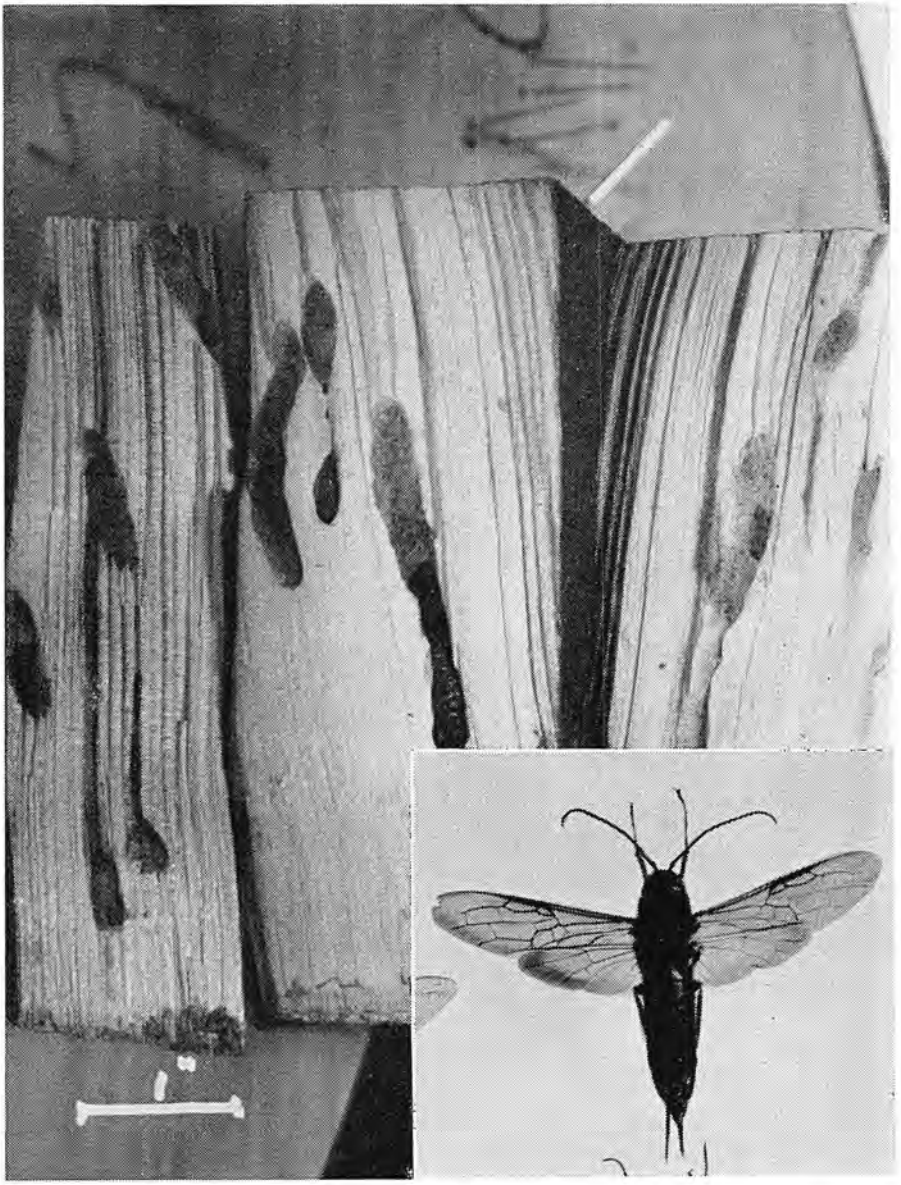


Plate 42.

Damage done to the wood by the tunnelling of Sirex larvae. Inset: an adult female Sirex 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.

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 not now of high importance in the economic field of providing large quantities 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.

With a population of 800,000 at the end of 1964, the State was using the log equivalent of about 45 cubic feet per capita of sawnwood. In addition, the log equivalent of eight cubic feet of imported wood products, mostly paper, was used. Quality paper can be made from Western Australian Eucalypts if long-fibre softwood pulp can be added to provide strength.

For a population expected to reach two million by the year 2000 A.D., production from State Forests will not be sufficient, and export trade will cease long before this.

Plantation Research in Western Australia.

When sawmilling was introduced into Western Australia the hardwood forests existed as prime mature stands. Pine plantation establishment which followed later was, however, dependent upon introduced species of which very little was known concerning their suitability for this State. Without this knowledge, the well-known European methods of establishment were unsuccessful. The first problem then was a matter of experiments to find species which were suited to Western Australian climatic conditions.

The establishment of pine plantations on a large scale is a costly undertaking, and before any ambitious plans could be formulated, this experimental work had to be carried out.

Experience showed that a pine from California, U.S.A., *Pinus radiata*, was the species most suitable for the Western Australian climate, but unfortunately the soils in which satisfactory growth could occur were limited in area, and intensive soil survey work has been carried out to determine what areas of suitable land are available. A second choice in species followed in which the slower growing Portuguese Maritime pine or *Pinus pinaster* was selected for the comparatively poor soils of the coastal areas of Western Australia.

Plate 43.

A plantation of *Pinus pinaster* at Gnangara, 12 miles north of Perth, established on poor coastal sandplain of little economic value for other purposes.

However, before large scale planting could take place, further experimental work was necessary, for the growth of *Pinus pinaster* especially was unsatisfactory. Early attempts to raise young pines in the nurseries proved failures, and much work and study were given to this problem for it was a preliminary obstacle which had to be solved before plantation establishment could take place.

The results of these studies indicated that a special fungal association with the young seedlings in the nursery was essential before satisfactory growth could be expected. Further work indicated the necessity of the use of zinc and superphosphate manurial application in certain areas.

With the initial investigations completed, there was still no guarantee that large scale plantations could be established, for it was only by observing the growth of the experimental trees through to the stage where timber was produced that certainty of success could be given.

The results of this final study indicated that certain strains of *Pinus pinaster* were more suitable than others.

Plate 44.

Mature *Pinus radiata* plantation at Greystones, near Mundaring Weir.

These strains were brought about by the geographic origin of the pines, which were either from the Atlantic coast of France and Portugal, or from the Eastern Mediterranean area. In all, there have been six recognisable strains from these areas. It was found that the Portuguese strain—Leiria—possessed desirable timber and a much better rate of growth, and was accepted as the basis of future *Pinus pinaster* planting.

The Present Position in Western Australia.

The first attempts at pine planting were in the early part of the century in the Ludlow and Hamel areas. Here some failures occurred due principally to incorrect strains being used and the lack of knowledge of any satisfactory establishment technique.

From the commencement of plantations at this time, the total area is now (September 1964) about 42,000 acres. Of this area, approximately 25,000 acres are *Pinus pinaster*, 16,500 acres *Pinus radiata* and the remainder, other species. The plantations range in size from several thousand acres down to small experimental areas of little more than a few acres. The distribution of the plantations is wide and is shown in Appendix VIII.

The older plantations are yielding limited supplies of logs for various uses, including plywood, flooring, lining mouldings, and cases. An annual production for the year 1964-65 of 2.3 million cubic feet of mill logs from thinnings has been reached and this will increase as time goes on. In addition there is a growing market for smaller logs for production of particle board.

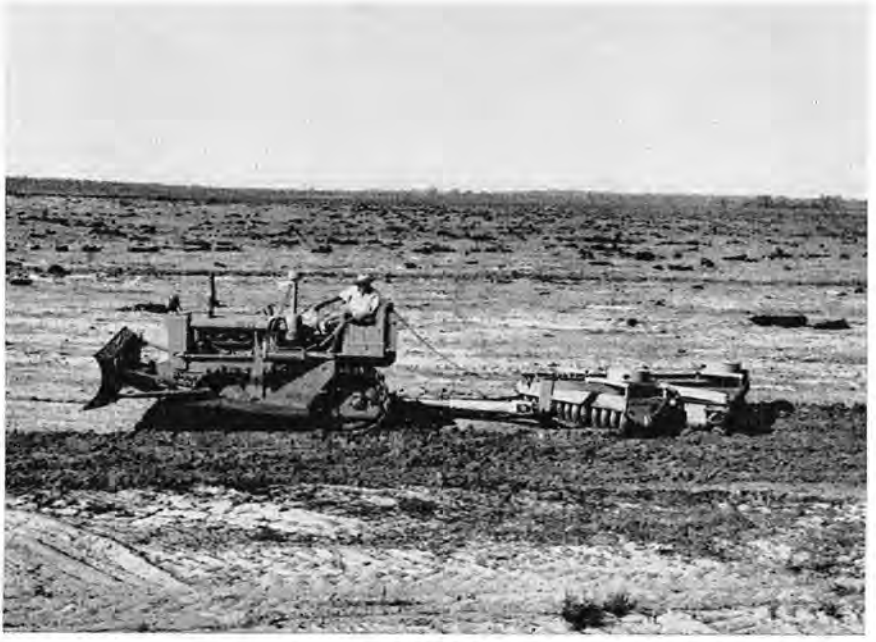


Plate 45.

A crawler Tractor and disc plough preparing land for planting on the coastal plain north of Perth.

Establishment Methods in Western Australia.

Many years of experimenting have produced a relatively standardized plantation establishment technique. However, the variability of the seasons and soils, and development and improvement of machines demand a continuous appraisal and modification of technique in order to obtain maximum results with minimum costs.

Seed Selection.

Because of the past lack of knowledge concerning suitable strains of *Pinus pinaster*, many of the existing plantations are now stocked with undesirable trees, the seed of which had been gathered and sown indiscriminately.

The wide mixture of strains represented, and the regular attacks of Black Cockatoo flocks, result in a small supply of poor quality seed in local plantations, and up to June 1964 most Lieria strain *P. pinaster* seed has been imported from reputable seed agents in Portugal. *P. radiata* seed is obtained mainly from South Australia.

A long term project commenced in 1960 to select above-average or "PLUS" trees within Lieria stands in W.A. and test their genetic properties by vegetative propagation, using a "tip-grafting" technique. This work has been carried out at Wanneroo Research Station, and in 1963 an officer was sent to Portugal to collect both seed and additional grafting material from Lieria stands. As soon as genetically superior trees are proved, they are established in seed orchards where they will produce seed of a much higher quality than can presently be obtained.

Similar breeding work with *Pinus radiata* is being done in several parts of Australia in an endeavour to produce a better form of this species.

The Nursery.

Development of the nursery is most important, for the seedlings which are ultimately used in the plantation are all raised here and at an age of about 10 months are planted out.

In the construction of new nurseries, the necessary mycorrhizal fungus must be introduced, for it is only through this association that satisfactory growth of the seedlings can occur. The method of introduction of the fungus has been to spread soil from the older established nurseries into the soil of the new nursery.

The percentage of seeds which will germinate is found from germination tests. The germination percent will then dictate the quantity of seed needed to supply the requisite number of seedlings from each nursery.

A dusting with red-lead protects seeds from attacks by vermin, and it is then sown by machine in nursery rows.

After allowing for the germination per cent., sufficient seed is sown to produce 12 usable plants per foot of nursery row. With rows 14 inches apart, an acre of nursery will produce approximately 400,000 seedlings. In the plantations the tree spacing is 8 ft. by 8 ft. for *Pinus radiata* and 8 ft. by 6 ft. for *Pinus pinaster*, but these espacements are subject to modification to suit a particular environment. The 8 ft. by 8 ft. spacing requires 680, and the 8 ft. by 6 ft. 890 plants per acre, and this number multiplied by the nett area to be planted will determine the number of seedlings which must be raised.

Once established, care must be taken of the young seedlings, for whereas the mycorrhizal fungus is beneficial and necessary for the young pines, there

Plate 46.

Gnangara nursery—pine seedlings being lifted preparatory to planting out. The tractor is about to begin its run; the arrow-shaped blade is driven into the ground and cuts underneath the plants and between the rows. The loosened plants are then wrapped in damp sacking and transported to the new plantation.

are other fungi which, if permitted to develop, can cause considerable losses in the nursery. These several fungi cause the damping-off disease which occurs when conditions become damp, due to overcrowding of the seedlings and lack of soil aeration. Damping-off must be carefully watched for and treated by the application of fungicide at its first appearance. Careful tending of the nursery must also be maintained and all weeds removed by means of either a blow torch, hand weeding, or the new method of spraying with mineral oil weedicides.

It has also been found advisable to work nursery soil on a three-year rotation system with pines, and green crops which are ploughed in. This rotation maintains soil fertility and aids control of the harmful fungi and insects.

Nurseries are given artificial watering only if made necessary by weather conditions.

The Selection and Preparation of the Plantation Site.

Before any plantation area is definitely decided upon, a soil survey of the proposed area is carried out. Only areas with suitable soils are selected for planting. For *Pinus radiata* it has been found that the required standard is high and only good red loams and sandy loams are used. *Pinus pinaster* is more tolerant of soil types, and it has been found that the better soils of the coastal sand plain near Perth produce *Pinus pinaster* stands of a quality equal to any in the State. Soil samples are collected during the survey and analysed at the Forests Department Soils Laboratory, Como. These tests must show the soils to be of a specified standard before they are selected for planting.

While the raising of the young pine in the nursery takes place, so does the preparation of the planting site. Here, bulldozers in heavily timbered country and tractors linked by heavy cables in lighter country remove the original vegetation in preparation for the pine. The general method employed is to clear the area some years in advance of planting to enable the timber to dry out for burning. Prior to planting, the area is burned and ploughed.

The plantation area is then subdivided into compartments which, in the coastal areas, are generally rectangular in shape and approximately 25-50 acres

Plate 47.

Paired pine planting machines operating on the coastal plain north of Perth. It is this bare country, so unattractive for agricultural purposes, that produces pine plantations of the quality shown in Plate 43.

in area. In hilly country the shape of the compartments varies, for the boundaries are carefully selected to provide a trafficable firebreak. Here the areas of the compartments are less and in the order of 20-40 acres.

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 spaced at distances of 8 ft. by 8 ft. or 680 trees per acre for *P. radiata*, and 8 ft. by 6 ft. or 890 per acre for *P. pinaster*. The reasons 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. A final 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.

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 or by the use of a pruning saw. The tree can then increase in volume without having to enclose the dead side branch which results in knotty timber. A second important reason for pruning is to reduce the fire hazard caused by the dead limbs. Once removed from the trees and left on the ground, they rot away within a few years.

Thinning.

As the growth of the plantation takes place, the trees increase in size until a point is reached at which the growth of some becomes stagnant while that of others goes ahead. At this stage it may be said that the trees are utilizing the land to the utmost, and the stagnation or "suppression" is due to the competition for moisture, food and light—in other words the struggle for survival between the trees on the area. As little satisfactory growth can be expected from the suppressed trees, the operation of thinning takes place whereby all of the poorer trees are removed, together with some of the other competing trees in order to give the remainder room in which to grow until a further thinning is required.

As the remaining trees become older and larger, the same process occurs, and further thinning must take place. Thinning continues until a final crop of about 80-100 trees per acre remain. These too are felled when they reach maturity and a new crop of young pines is established.

Plate 48.

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.

The age at which final felling of the plantation takes place varies according to species, but the general age for *Pinus radiata* is from 30-40 years, while that of *Pinus pinaster* is from 50-60 years.

Fire Protection of Plantations.

The establishment of plantations represents a large capital outlay, and as they are very susceptible to fire, it is essential that they be adequately protected. Accordingly, an intensive system of firebreaks is constructed and maintained by ploughing or grading each year.

The Management of Plantations.

Just as a Working Plan is written for the management of the natural forests, so a separate plan is prepared for pine plantations. Here a programme of annual planting for the period of the plan (usually five years) is laid down, together with the yields of timber that may be taken from already existing plantations. The plan has as its basis the results of the years of experimental work and experience, and allows for the many factors affecting plantation management.

The Working Plan is the authority approved by Parliament, and subject to the limitations placed on it from time to time by scarcity of finance, is carefully adhered to throughout the period of its existence.

An Example of the Results of Management in Western Australia.

Should you have the opportunity of visiting the Greystones plantation at Mundaring Weir, you would see what is possibly the best compartment of *Pinus radiata* growing in Australia (see plate 44). It was planted in 1922. The trees have attained 150 feet in height and up to 250 cubic feet in volume. In gross volume it has produced up to 9,200 cubic feet of logs in thinning over 42 years to June, 1964, and a further 9,800 cubic feet per acre contained in the 65 trees per acre remaining.

19,000 cubic feet in 42 years or 452 cubic feet each year represents nearly one ton of timber every month for 42 years. In terms of sawn timber this would have a value of over £10,000 for every acre of the compartment described.

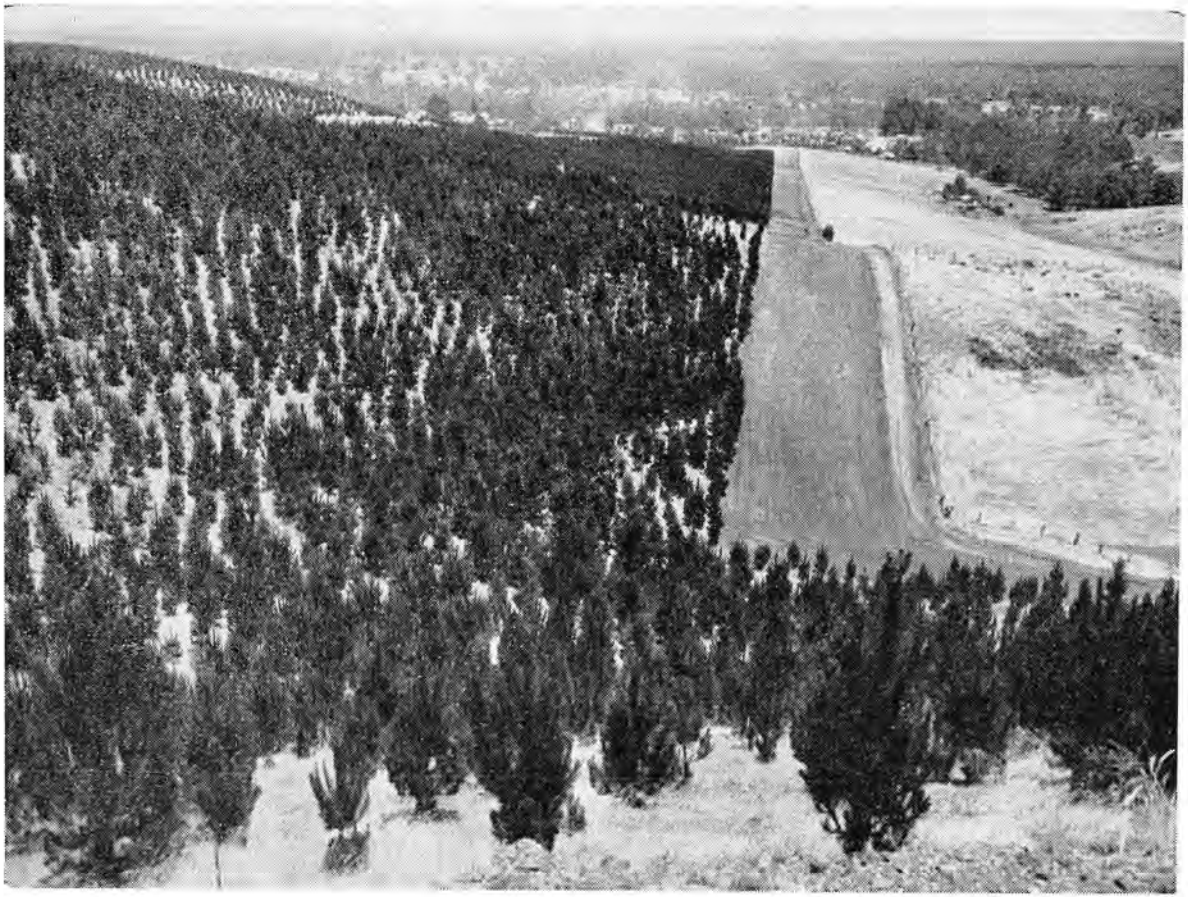


Plate 49.

Two year old *Pinus radiata* growing on the upper slopes of the Blackwood Valley near Nannup.

Plate 50.

Jib crane loading *P. radiata* peeler logs for transport to the metropolitan plywood factories.

CHAPTER VI

FOREST MANAGEMENT IN WESTERN AUSTRALIA

Introduction.

Forest management is the business activity necessary to carry out the policy of the owner of the forest, and as this policy may vary within wide limits, there is no hard and fast system of management.

Management and policy go hand in hand, for only poor management could result from a poor policy.

In State owned forests such as exist in Western Australia, for which the policy, having as its aim the continuity of production from a fixed area of forest, is clearly defined in an Act of Parliament, management has clear-cut objectives.

All foresters look upon 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 growth can be cut for public use, replaced, and ultimately increased by good management.

The business of management uses many arts and sciences towards its goal; these will be apparent to the reader through the steps which are being taken to bring the forest into a productive capacity. A natural forest, such as is found in Western Australian jarrah and karri areas, is non-productive and may be likened to a capital asset which is static and earning no interest.

While the greater part of forest management deals directly with the production of timber, there are other less important, but nevertheless essential aspects of management. These include management for the purposes of recreation and parks, scenic value, preservation of wildlife, for soil erosion control, flood and river regulation, and water yields on forested catchments.

The Building up of Management in Western Australia.

The forests of Western Australia are limited to a few commercial hardwood species. The timbers of these, however, are in valuable mature stands, and consist principally of jarrah and karri in mixture with marri. Less important, but still valuable timbers, are wandoo, tuart and tingle tingle which are located in limited areas of the State.

In the early stages the forest consisted of large, unmapped and trackless areas, and was subjected to the ravages of wildfire and uncontrolled exploitation. The first essentials were roading for fire protection and survey purposes, and control of cutting to ensure orderly harvesting of the forest crop and perpetuation of the forest as a productive unit for future generations.

Mapping and stocktaking of the forest are the next stages in forest management. Using these essential tools, the manager can prepare plans for the maintenance of existing sawmills, the introduction of new sawmills and the many other operations necessary to meet the ever-changing demands for timber.

These plans are finally combined into written documents known as "Working Plans" which under the Forests Act have the effect of a law governing the operations on a forest area.

Plate 51.

Portion of an interpreted aearial photograph. The photo is marked to show the different forest types, clearings, roads, etc., which are later transferred onto a map. In this example, J signifies jarrah and K stands for karri; A, B, etc. indicate the height class of the forest, and 1, 2, etc. refer to density of stocking.

Use of Aerial Photographs.

The collection of information or "assessment" plays a very important part in forestry, and in Western Australia during the first decade of forestry (1920-1930) most of this work had to be done on foot; about four and a half million acres were assessed by parties running sample lines at a distance of half a mile apart, as there were very few aids to the work in this period. It has been estimated that over 100,000 man miles were walked in this initial stocktaking which formed the basis of the first working plans.

Since 1930 this work has become more highly developed and improved through various stages, to the system in use today. This system consists in the first instance of studying the forest from the air by means of photographs. From these photographs skilled interpreters are able to separate the various forest types according to timber species, the density of the stand, and the various height classes. Further, the interpreter is able to indicate areas which have been seriously damaged by past fires, and to show the location and extent of areas which have been regenerated. This analysis of photographs is called Air Photo Interpretation or A.P.I.

This application of modern methods is much cheaper, more accurate and much quicker than the early strip line methods. This is most important when information for large areas is required in a short time.

Air Photos play an increasingly important role in forest management, because they are used for the selection and design of suitable roading systems and engineering works, as well as being used to map the forest area. Features such as rivers, creeks, steep slopes, etc. are readily mapped from air photos, along with details of timber types and land development. All of this information can be easily plotted with the aid of modern mapping equipment.

Stocktaking.

The method of sampling the forest, or assessment as it is more commonly termed, is carried out by crews of men trained for this type of work. Using his air photo type-map the assessor moves into the field to secure information about the various recognised forest types.

Although the form of assessment has not varied materially from the system of the early days, the quantity of work involved has been greatly reduced, for with the forest already classified from aerial photographs, the assessor only needs to obtain sufficient information to evaluate and test the uniformity of each forest type.

The method of assessment used is quite simple and consists of running a line along a compass bearing and carefully measuring every tree for half a chain on each side of this line. The details of the trees are entered in a field book and for each ten chains along the line information for one acre is available. As the assessment proceeds, further sample plot information is obtained.

The Working Plans Branch.

The assessment parties are controlled by the Working Plans Branch, which is responsible for the preparation of Working Plans for both hardwood and plantation forest areas.

Using the assessment information obtained from the field parties, growth rate information from permanent increment plots and records of all earlier forest operations, the W.P. branch is constantly preparing new information and revising old volume estimates so as to balance estimated growth against

present exploitation and prepare better plans for sustaining the yield from the forest.

This highly technical work needs information from a wealth of sources and knowledge of the most modern methods to allow the manager fully to practise the science and art of forestry.

The Working Plan.

The Working Plan, or prescribed manner of management, is built up of a series of diverse operations, but all of which are of importance in contributing to the final plan.

With four million acres of State Forest in Western Australia there is a considerable variation of forest types, and together with climatic and topographic differences it is obvious that some division into workable units is necessary. This is done by the formation of individual working plan areas, each varying to suit local conditions and ranging from about 30,000 acres to 100,000 acres. In Western Australia there are approximately 100 Working Plan areas.

With the knowledge of the volume of timber available in the various areas, proposals are put forward for the erection of sawmills to utilise the timber in perpetuity. It is the purpose of the Working Plan to define an annual cut equal to the increment which the forest is capable of yielding for ever. This aims at the provision of a stabilised permanent forest community.

The concept of this permanent forest community is most important, for with it must be considered the regular employment of mill workers and the continuity of supplies of timber to the public. As well as these points, the establishment of the mill and the associated housing and public works must be considered for they are most expensive, and unless a guarantee of permanency can be given, their construction could lead to over-capitalisation and excessive costs leading to economic failure of the project.

The general method of approach to the introduction of management into new Working Plan areas consists firstly of dividing it by roads into units of about 5,000 or 6,000 acres, thus introducing the first step towards protection by controlled burning and the prevention of disastrous fires. Following this step the forest village is built to house a permanent working gang, and this would normally go hand in hand with the introduction of sawmilling to the area.

In a country where forestry practice is relatively new, Working Plans must, of necessity, retain a certain flexibility, and must be made for only short periods of 5-10 years, for with every year that passes, more accurate information on which to improve the plan becomes available.

The Economic Aspects of Management.

Although the general principles of forest management are laid down in the Working Plan, the implementing of any such proposals is governed by the finances available from year to year. A Working Plan must be sufficiently flexible to allow for an annual preparation of a programme of work based on the amount of money which may be available. The economic consideration is the governing factor limiting such activities as forest protection, silviculture, roading and housing.

Present Management in Western Australia.

Since the passing of the Forests Act in 1918, progress in management in Western Australia has been most satisfactory, and although to the present time

Plate 52.

A 68 year old karri regrowth stand at Lefroy Brook.

intensive utilisation has been confined to the northern areas of the forest, management of two million acres of State Forest and Timber Reserves South-east of Manjimup and Pemberton is in hand. Until recently these areas had remained in their natural state.

To provide local administration, the forest area of Western Australia has been divided into fifteen areas or divisions, which in turn are divided into smaller units or districts. It is through these divisions and districts that the many aspects of management are carried out.

The divisional headquarters are located in the more important towns and are situated between Wanneroo in the north and Shannon in the south. The district headquarters are located in forest settlements some distance from the divisional headquarters, and usually are in the centre of the forest.

Control of Sawmilling Operations.

The first consideration of all forest divisions is the provision of timber. This is brought about by the issuing of permits or licenses. The more important is the permit system where, following the recommendations laid down in the Working Plan, a sawmill is granted an annual permit to cut a specified quantity of timber. It is then the duty of the forester to provide this timber from the forest in such a way as to ensure that a future crop will be available and that no uncontrolled cutting of the forest is made.

The control of this cutting is by a system known as treemarking. In this the timber that can be safely taken is marked by the forester with a distinctive brand, and only these marked trees may be removed. It is by this system that protection of the immature and vigorous trees is assured. 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 no destruction of young trees occurs.

Collection of Royalty.

All timber that is removed from the forest is subject to a fee or "royalty," and because of this, records are carefully kept. A return of logs taken from the forest is submitted by the sawmiller, and payment for these is made.

Regeneration of the Forest.

Following the cutting of an area of forest, steps must be taken to ensure that the area will, in time, provide a further crop of trees. The debris that results from logging must be removed to allow regrowth to occur, and an operation known as top disposal takes place. Here, gangs of men heap the debris from the fallen trees and when conditions are satisfactory a fire is run through the bush. In this operation care must be exercised to ensure that the remaining trees are not damaged by the fire.

A final step is taken in the cut-over bush when an assessment of the remaining trees is made. This quarterly assessment, as it is termed, is most important, for it forms the basis of plans for the future treatment and yield of the forest.

Roadmaking.

To provide access to the forest area, a road system has been developed, and in each division a network of roads and tracks has been constructed. According to their use, so has the standard of construction varied. Arterial all-weather roads provide the major system, followed by sub-arterial roads,

forest tracks and firelines. The greater the development in any area, the more intensive has been the road system.

As the utilisation of the forest has extended, so has the construction of roads, and at the present time there are over 15,500 miles of roads and tracks in the forest areas of Western Australia. To keep pace with new road construction and maintenance of existing roads, a fleet of machines is maintained.

The pattern of forest roads aims at a breakdown of large areas into small blocks or compartments. Apart from facilitating logging, the advantages obtained in forest protection are obvious, for in fire control access is a most important consideration.

Survey and Mapping.

Following road construction, the production of maps becomes essential, and to provide the information for their compilation, survey teams are continuously in the field. Here, accurate surveying of the arterial roads in carried out by theodolite, while forest tracks and firelines are surveyed by compass which is more rapid but rather less accurate.

The production of maps is carried out by a drafting office, the work being continuous, for with information coming to hand week by week, existing plans must be added to and new plans prepared. At the present time, maps have been prepared for all those forest areas in Western Australia that have been developed to any extent.

Housing.

As forest utilisation has taken place, so has the development of the divisions and districts. The construction of houses has been most important, for with the large number of employees necessary for satisfactory forest management, suitable housing is essential. Up to the present time over 450 houses have been constructed. The number is being increased annually.

As well as house construction, other buildings such as garages and workshops have been erected because the large number of machines used in road building must be properly serviced and maintained.

The Co-ordination of Management.

The forest organisation in Western Australia is spread over 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.

The money available for forest management is derived from the income of sale of timber from the forests together with Government grants for additional works such as special road construction or pine plantation establishment.

To enable records of expenditure to be kept and thereby remain within the specified limits, it is necessary that each division provide monthly reports of works' progress and expenditure.

As well as expenditure reports, records of forest treatment must be kept. Areas of bush that have been cut, assessment information, top disposal, road construction, and the many other forest activities must be recorded, for it is only through this that a complete summary of forest management in Western Australia can be kept.

CHAPTER VII.

UTILIZATION OF FOREST PRODUCTS

Utilization, which concerns the harvesting and subsequent treatment of forest produce to provide marketable material, is another important branch of forestry and 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.

The major forest product in this State is sawn timber. There are, however, many minor products such as tan barks, charcoal, sawdust, piles, poles, fence posts, boronia blossom, etc., which in themselves are vital to our economy, but whose value is considerably less than that of the major forest product—timber.

The operations concerned with the harvesting of the major forest product, the tree crop, are conveniently considered under the headings of bush operations—including the felling, snigging and haulage of the log material to the mill, and the final milling process which converts the log into marketable timber.

Plate 53.

Felling a karri tree with a chain saw. The operator has already cut out the scarf—portions of which can be seen in the right foreground—and is now finishing the final "backing down" cut.

Plate 54.

Cross-cutting a karri log with a chainsaw.

BUSH OPERATIONS.

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 such trees as are marked by an officer of the Forests Department may be felled, and those that are 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, 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 has been 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 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 cross-cut the bole into suitable log lengths.

After trials with a chain saw operated by two men, the industry now uses, almost universally, the one-man chain saw for the bush operations of felling and cross-cutting. 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 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

Plate 55.

Snigging a log to the landing with a crawler tractor and logging arch.

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. unloaded, so that a low loader is not required, as with crawler tractors, to move them from place to place.

The development of the four-wheel drive crane-truck, 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 the 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 in both the jarrah and karri forests. However, some petrol winches are still in use, and of course the rubber-tyred units previously mentioned.

Plate 56.

One method of loading logs onto a timber truck, by means of a winch mounted opposite a loading ramp.

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. Advantages 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.

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. These two conditions are not met in Western Australia.

MILLING.

Timber milling is concerned with the conversion of raw log material into sawn products suitable for marketing.

Mills, in general, fall into two classes:—

(1) General purpose mills cutting scantling, sleepers and crossings, flooring and joinery stock, etc.

(2) Special mills, usually small. These include the railway sleeper mill, the sheoak 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 40 men under the mill roof, medium-sized mills about 20 and the remainder below 20, 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 drives of the steam or diesel-powered mill. Each saw bench has its own electric motor and in the event of a breakdown at one bench, cutting can still proceed at other benches. In steam-powered mills all cutting stops until a breakdown at a bench is rectified.

Where the S.E.C. power is not available, larger mills tend to use sawdust as a fuel for the boilers, and the steam power produced is converted to electric power. This method removes the problem of disposal of waste sawdust either by burning or carting and dumping. In small mills not using electric power, diesel internal combustion engines have taken the place of steam.

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 docking (or 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 usually consists of two circular saws, mounted vertically one above the other to enable

Plate 57.

A modern method of loading logs directly in the bush, by means of a hydraulic loader.

Plate 58.

Modern motor lorries have replaced steam locomotives for hauling logs from the bush landing to the mill.

cutting of large girth logs. Logs are moved through and past the saws on a power driven carriage.

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.

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. Up to 15-20 years ago, the sleeper hewer was a familiar figure in the bush, and at one stage all sleepers were hewn. Now the work is completely exclusive to the mills, and not even one sleeper hewer's permit is on issue at the present time.

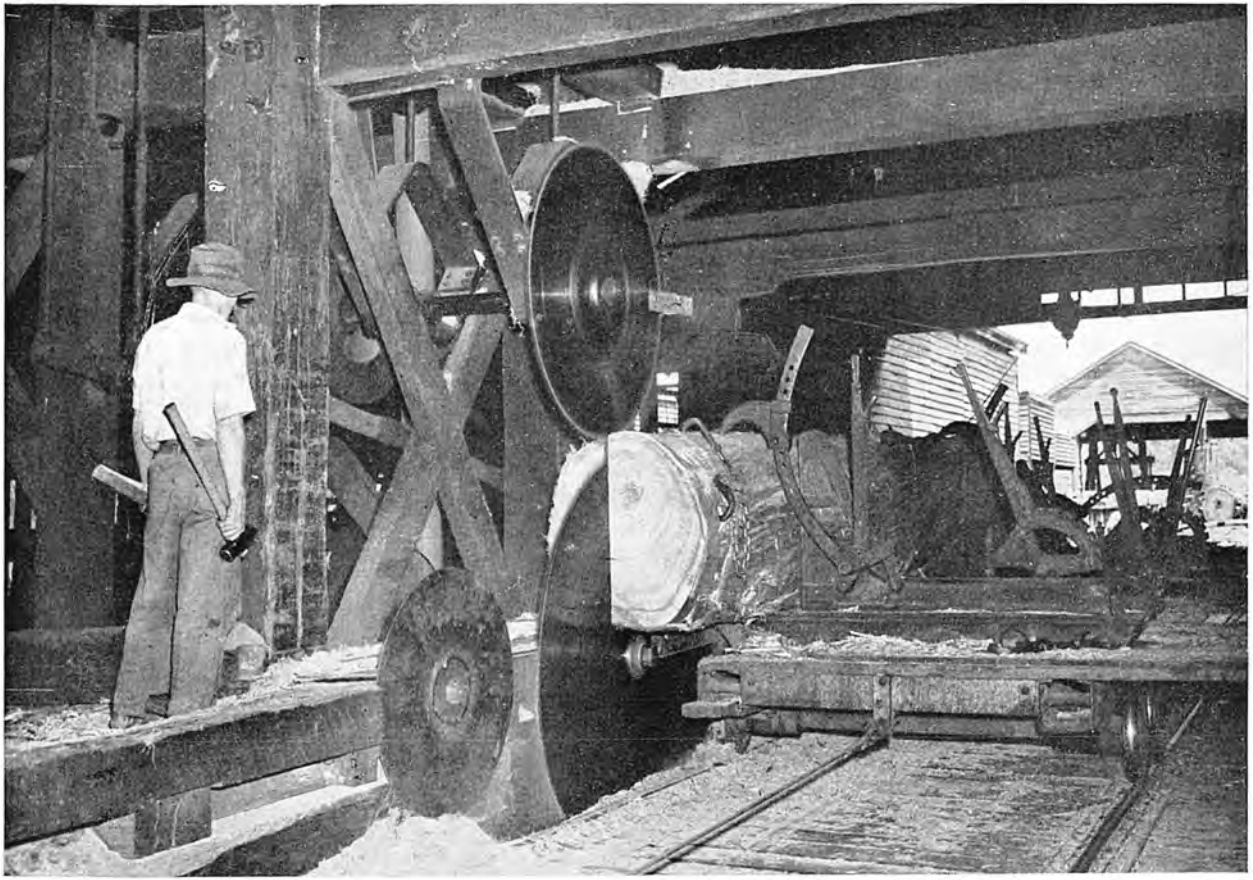


Plate 59.

Breaking down the log with twin circular saws and power driven carriage.

The Sheoak Mill cuts short length logs of sheoak into stave sizes. These staves go to the cooperage works where they are dressed and bent for final assembly into barrels. Western Australian sheoak is considered to be one of the best stave timbers obtainable.

The Hardwood Case Mill operates usually on short logs of poorer quality timber, 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 two-thirds 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 an efficient 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, the lower moisture content results in better absorption of preservatives, stronger glued joints, improved retention of oil-based paints and better insulation against the transmission of heat and electricity.

Seasoning, or controlled drying, entails the drying out of timber to requirements suited to a locality before it is put into use. Seasoning is necessary with most of our timbers due to the fact that shrinkage always accompanies the drying out process. Seasoning brings the wood to the condition at which it will remain in service, prior to shaping, finishing and installation. This is most desirable for the majority of timbers, particularly for flooring, furniture and joinery timber where deformity due to swelling, shrinkage and splitting in service would impair the value of the article.

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, fully exposed to the sun and 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.

Kiln-drying.

To reduce the time factor involved in air seasoning, it is common practice today to partly air-dry the timber, then complete the drying in specially designed kilns. This final stage may only take from four to 20 days, depending on the size of the stock, as compared with several 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 lead to surface checking and end splitting. 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 mechanical 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 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 water-born preservative in furnace oil.

There are two main types of preservatives—

(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 pentachlorphenate in furnace oil. The oily types are particularly useful in reducing "weathering".

Three treatment processes are in common 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.

Plate 60.

P.M.G. Poles being prepared for preservative treatment.

(ii) *Hot and cold bath treatment* is in fact a form of pressure treatment in which wood is heated to expel air and then allowed to cool in preservative which replaces 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 the timber under hydraulic pressure with or without the use of heat and vacuum.

For the preservation of the sapwood of round poles and the sawn timber of *Pinus radiata*, a pressure of 200 lb./sq. in. is usually applied. The heartwood of eucalypts are particularly difficult to treat as penetration of preservative is low unless very high pressures are used. The treatment plant for sawn karri applies pressure up to 1,000 lb./sq. in. and was the first commercial plant in Australia to use such high pressures. Portable plants using only 50 lb./sq. in. 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., can be effective.

Lyctus (Powder Post Borer).

Mostly attacks sapwood because of its high starch content, therefore use only the heartwood of susceptible timbers.

Marine Borers.

Common preventative measures include sheathing piles from above the high water level to below the low water level with copper, Muntz Metal (60% copper, 40% zinc) or concrete. A "plastic" type sheathing has also been used.

Weathering.

Where timber is exposed to rapid changes of temperature and moisture, application of oily compounds reduces surface breakdown.

FOREST PRODUCTS.

Our major forest product is a hardwood produced from the mature trees of jarrah, karri, wandoo, marri and 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.

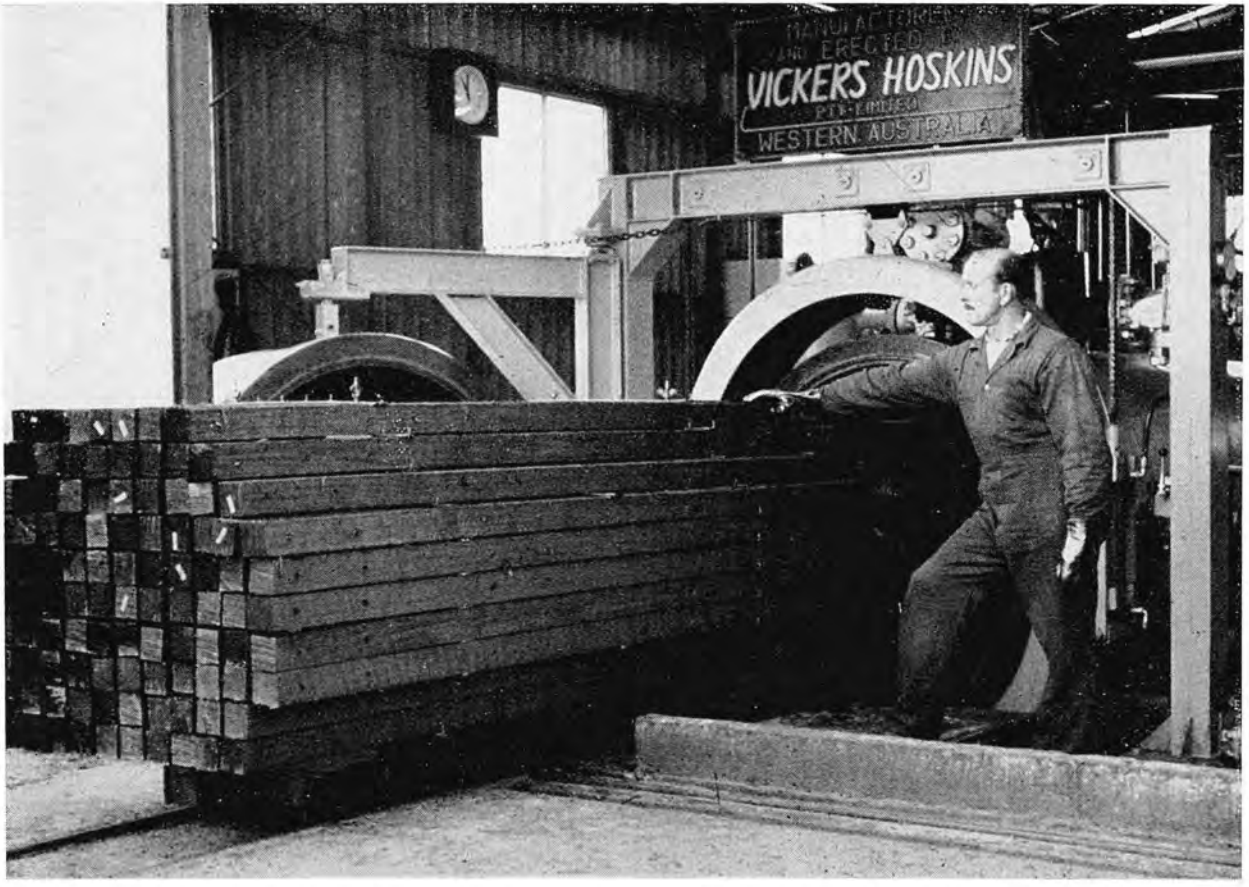


Plate 61.

Karri telephone line cross-arms leaving the tank in which they have been subjected to high-pressure preservative treatment.

Building Timbers.

This is the avenue of greatest sawn timber consumption, and dwelling construction is by far the most important consumer within the 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.

Manufactured Wood Products.

Under this heading are included cases and crates, boxes, barrels and casks, furniture, matches, motor body parts, wooden pipes, boats, 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. Karri is much in demand for auto-body construction; sheoak is an excellent cooperage timber and jarrah has wide application for furniture use. Softwood timbers, however, are much more suitable for boxes and crates, clothes pegs, paper, etc.

Constructional Timbers.

Under this heading are included round, hewn, split 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.

Piles and Posts.

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 finest timber for this purpose 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. A pressure treatment plant at Picton near Bunbury is now producing large quantities of treated marri poles for use in telephone line construction.

Sleepers.

Western Australian hardwoods have established a wide reputation from the excellent railway sleepers that have been available for export. 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 export sleeper trade. South Australia and the Commonwealth Railways absorb nearly all the remainder.

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 new field for this and other species in the near future.

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.

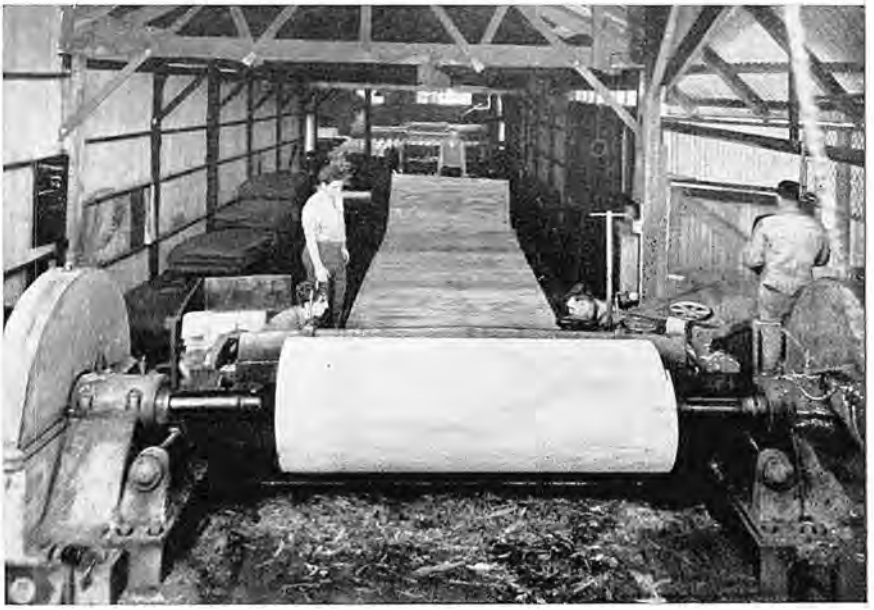


Plate 62.

Plywood veneer being peeled from a log in a metropolitan factory.

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.

Plywood is the wood composite produced by cross-banding two or more layers of veneer face to face with glue or cement. 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 value from the log.

Chipboard Production.

A new industry producing chipboard from pine thinnings has recently been started in the Metropolitan area. The removal of a large volume of

small-sized logs from the Metropolitan pine plantations will result in the more complete utilization of each tree felled.

Charcoal Iron Production.

Another development in recent years 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 an important minor 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% 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 the section in Chapter IX. As the world supply of vegetable tanning materials decreases, this phase of forestry will become more significant.

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 of late has been considered for use as a constituent of drilling mud used for oil exploration.

As far as possible, all sawmilling timber which can be utilised 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.

CHAPTER VIII.

FOREST RESEARCH AND THE TRAINING OF FORESTERS

FOREST RESEARCH.

The rapid advance in the development of forestry practice in the past two or three decades has drawn attention to the inadequacy of the information on the growth and behaviour of our trees, and has emphasised the need for deeper study of the problems associated with tree and forest growth.

Research, or at least some study and investigation, has always been an integral part of forestry practice in Western Australia. Most of the past work done in this direction has been accomplished through the initiative and enthusiasm of officers already occupied with general forest duties. In recent years, as suitably trained men and finance have become available, research and investigation have received an impetus by the allocation of research duties to definite personnel.

The Forests Department's first research laboratory was established at Dwellingup with the major aim of answering questions imposed by the complexities of forest soils and the maintenance of their fertility. This soil research worked hand in hand with investigations into the silviculture of the trees of the jarrah forest. Since its inception, the Dwellingup research centre has provided a much sounder understanding of the jarrah forest.

Recently, the increasing demand for soil and nutritional studies made it necessary to move this sphere of activity from Dwellingup to Perth. Facilities for a chemical laboratory are improved in the city, which is still suitably located to permit ready access to most hardwood and softwood centres requiring attention.

This laboratory is proving invaluable for chemical analysis of samples collected during soil surveys of proposed plantation sites. Successful pine establishment has been found to be closely associated with a knowledge of the chemical composition of the soil. The results obtained by laboratory analysis permit the adoption of suitable techniques when establishing plantations. Past plantation procedure, lacking this knowledge of the soil, has often resulted in failure due to the use of unsuitable species or a much belated application of the necessary fertiliser.

Despite the removal of the soils investigations from its duties, the Dwellingup research centre has continued to flourish. The major investigations at present are concerned with procedures for controlled burning to reduce the fire hazard, and treatments required to thin and improve stands of regrowth jarrah.

With the intensification of forest management and utilization in the Southern forests in the past decade, an officer has been stationed at Pemberton to study the growth and silvicultural requirements of the karri forest. Karri forest soils are also receiving attention and an intensive resources survey has been completed in its initial stages.

In 1959, silvicultural investigations into problems associated with softwood plantations were expanded with the initiation of a breeding progamme to provide improved seed for future establishment. This activity is centred at

Plate 63.

The Neave's Road scion arboretum, where grafts from selected trees are planted out far away from established pine plantations. With no chance of accidental fertilisation by wind-blown pollen, propagation of the plants is strictly controlled and selective breeding of the best strains can be carried out.

Wanneroo, and is mainly concentrated on improving the form of *Pinus pinaster*. The species is not receiving attention in this respect elsewhere, and since it is to play a vital role in the plantation programme for the State, is a major concern of the Department. *Pinus radiata*, however, is not neglected, and seed orchards of both species will be completed by 1966.

The Management Section, through its Working Plans Offices at Manjimup and Harvey, is actively engaged in research and study of new methods of assessment. Perhaps the most prominent feature in this field is the introduction of aerial survey and air photo interpretation to forestry in this State. Air photo interpretation has resulted in more accurate and speedier assessment at a considerably lower cost.

Numerous problems demand investigation and will receive research attention in the future. Departmental research projects, however, must be limited by the extent of finance and manpower that can be made available to them. In this regard the State is fortunate in the co-operation of the Commonwealth Forestry Research Institute and the C.S.I.R.O. Forest Products Research Division, who are equipped and were founded to handle the major items of research in forest and forest products usage in Australia. The C.S.I.R.O. Division of Soils is also actively co-operating in investigating fundamental aspects of pine nutrition on local soils. To such organisations must go the fundamental research problems necessary for the increase in basic knowledge of forestry in Australia. The State Department, with limited resources, can only permit and cater for applied research within the State.

Research in the fields of pine nutrition, fire weather forecasting, the forest soil complex, the return of litter and contained nutrients to the forest soil and the application of chemical weedicides to forest practice, have yielded fruitful results.

Examples which illustrate the nature of forest research that has been carried out over the past years are the development of suitable techniques for softwood establishment and the determination of a procedure to forecast fire weather, as a contribution to an efficient fire protection organisation.

SOFTWOOD ESTABLISHMENT.

The introduction of softwood species to supplement the timber output from natural hardwood forests and to provide a more suitable balance in the quantities of each timber used by the people of the State, was the starting point of long and intensive research.

Trial and Selection of Species.

The first problem to overcome was that of determining likely conifer species to introduce—species to provide suitable growth rates and timber quality under the conditions of climate and soil peculiar to this State. As Western Australia has no natural softwoods which could possibly fulfil these requirements, this necessitated the arboreta trial under many soil and climatic conditions to all exotic species which were thought likely to succeed. It took some years to analyse the results from these arboreta and initial plantations, since the trees had to grow to a considerable size before it could be specifically concluded that they were suitable indicators of success or failure on the site.

These exhaustive trials established the fact that *Pinus radiata* (a native of Monterey, California), and *Pinus pinaster*, (Leiria strain from Portugal), were adaptable; the former on better class soils, the latter on the poorer coastal

plain sands available for planting. To illustrate the difficulties involved in this initial selection process it is sufficient to say that *Pinus pinaster* alone, one of at least a dozen species tried, exists in at least five distinct sub-types or strains. Only one of these (originating in Portugal) has proved entirely satisfactory under Western Australian conditions.

Nursery Troubles.

A second problem was imposed by nursery work. Early nurseries did not produce suitable pine seedlings to allow plants a fair chance of survival in the field. 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 thrifty pine growth. Only when an association exists between these mycorrhizal fungi and the young pines are nurseries satisfactory.

On locating this initial deficiency in local nursery conditions, it became standard practice to inoculate all pine seed beds with the spores of these fungi which favour the vigorous, healthy growth of pine seedlings necessary for planting out in the field.

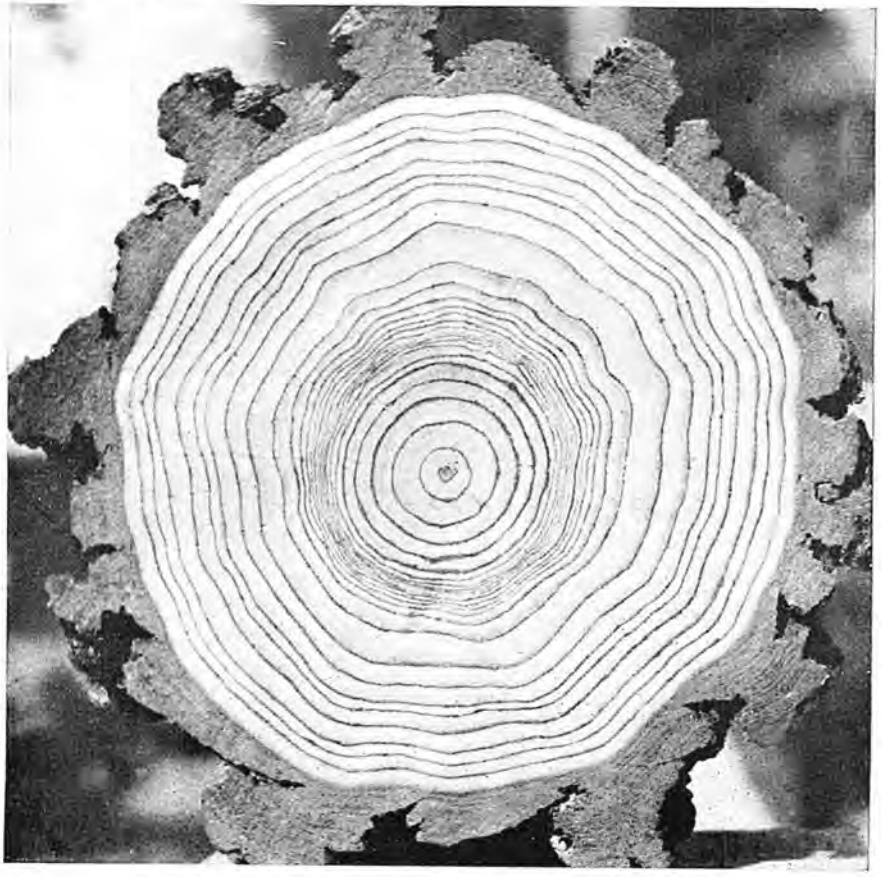


Plate 64.
The effect of superphosphate fertiliser in pine plantations. Superphosphate applied to this tree at the age of 16 years produced the increased growth indicated by the increased width of the outer rings.

Poor Nutrition in the Field.

Having found the correct species to plant and the method of obtaining suitable nursery stock for planting out, yet another problem arose. Growth was unsatisfactory under many field conditions.

Exhaustive nutrition trials indicated that local soils were deficient in certain essential nutrients. Superphosphate is necessary in practically all planting areas. Zinc is also required in other soil types. Certain limited sites require additional elements, but it was the discovery that superphosphate application, with or without zinc spraying, was a necessary part of the establishment procedure, that permitted the initial phase of softwood afforestation to be brought to a satisfactory conclusion.

Research has also established that ploughing of the planting site is necessay in most plantations. It has paved the way for the use of machines for planting, and developed suitable procedures for weeding and subsequent tending.

THE FUTURE OF FORESTRY RESEARCH.

As the demand for the benefits bestowed by the forest increases with continued development of the State, the scope of forest research must also increase in both breadth and depth. Forestry is an applied science, and its research must ultimately embrace many of the specialised sciences or disciplines such as botany, entomology, chemistry, geology, etc.

Perhaps the most pressing problem which requires detailed attention is that of increasing production from the jarrah forests. These areas, which provide the raw material for early State development, were heavily cut over and ravaged by fire before any form of control was initiated by the establishment of a Forests Department. The areas now require treatment to ensure that the regrowth stands resulting from early exploitation develop to provide the maximum benefit for the present and future generations. The implementation of silvicultural treatments to these areas represents a challenge not only to research foresters but to all those who are dependent on the forests.

With increasing areas of softwood plantations, future research will have to pay more attention to problems associated with insects and fungi. Second only to fire, these two pests are responsible for the greatest loss in timber production each year. Insects and fungi in natural forests are in harmony with the community, controlling one another so that extensive outbreaks of any particular species are rare. With exotic pines, it is not always certain that the new environment will be favourable to retaining this natural balance. Already in the Eastern States, insects and some fungi have shown that they can be a serious menace to the production from exotic pines.

A final example of research which is receiving attention and will result in great improvements in the future, is the application of electronic computers to forest management. Computer programmes can lead to greater efficiency in data processing, both for research programmes and for general management calculations. Properly used, computers will permit more intensive use of the data available, thus enabling the research forester to spend more time solving the field problems, for which there is no substitute for his training and experience.

THE TRAINING OF FORESTERS.

The steadily increasing population of the State and the consequent rise both in living standards and in the overall level of industrialization have imposed enormous demands on our limited forest resources, thus increasing the need for efficient and far-sighted management. Forestry, as a profession, has become vital to the community and the need for an increased number of highly trained forest officers has already become apparent. Forestry is a science, and it is essential that those practising it should possess the specialized knowledge and techniques necessary for its successful application.

The forest service of this State is staffed by two different types of forestry officers: a Professional Division which is made up of graduates from a University and/or a recognised Forestry School, and a General Division recruited from the Department's own employees, the sawmilling industry, or from young trainees selected at any early age and trained by officers of the Department.

The Professional Division.

The training of professional foresters involves four years of University and technical study, leading to the degree of Bachelor of Science in Forestry.

In Western Australia, the first two years of the course are spent at our own University, where the following subjects are taken:

First Year Subjects—
- Maths. or Physics.
- Geology.
- Chemistry.
- Botany.

Second Year Subjects—
- Bio-chemistry.
- Botany.
- Soil Science.
- Agriculture.

While at the University, the student is a member of the Science Faculty. His training in the prescribed subjects is conducted and supervised by the University authorities and the course is in no way different from that of other science students. During the vacation he is expected to carry out practical work in the forest under the direction of the Conservator of Forests.

These two years of the course provide the scientific background required for further intensive technical training in special forestry subjects, as well as acquainting the student with working conditions in the forest.

The final two years of the course are spent at the Department of Forestry in the Australian National University at Canberra, where the following subjects are studied:—

Third Year Subjects—
- Foundations of Silviculture.
- Dendrology.
- Forest Soils.
- Forest Mensuration.
- Forest Finance I.
- Forest Engineering I.
- Forest Utilization I.
- Forest Surveying.

Establishment of Plantations.
Forest Protection.
Elementary Meteorology.
Forest Entomology.
Statistical Method.
The Use of Aerial Photographs in Forestry.
A short course in Supervision and Administration, or other such work as may be required by the Principal.

Fourth Year Subjects—
Silviculture II.
Wood Anatomy and Identification.
Forest Pathology.
Minor Forest Products.
Forest Management.
Forest Finance II.
Forest Engineering II.
Forest Utilization II.
Forest Policy.
Forest Entomology.
Statistical Method.
A weekly survey of the weather, or other such work as may be required by the Principal.

The third and fourth years of the course at Canberra include field trips which enable forest practices in most of the States of the Commonwealth to be studied.

The final two years of the course are expensive and could be prohibitive to the private student from the more distant States. Realising this, the Commonwealth and State Departments award scholarships which financially assist selected matriculated candidates through their forestry training. In recent years, at least three scholarships have been available annually to students within Western Australia.

These scholarships pay all University enrolment fees and travelling expenses incurred during the third and fourth years in Canberra. In addition, they have in 1965 a monetary value of £1,412, which is paid as follows—

	£
First year	286
Second year	311
Third year	395
Fourth year	420

An additional allowance of £150 per annum is payable to students attending a University (4 years) and living away from home.

On the satisfactory completion of the degree course, the graduate is appointed to the position of Forest Officer under the Forests Act, or Assistant Divisional Forest Officer under the Public Service Act of this State. Both positions receive the same remuneration.

The graduated Forester in Western Australia can expect to commence his career on a minimum of £1,690 (1965 figures). Advancement through the service is by fairly regular stages to a maximum of £2,783 for a Divisional Forest Officer. Salaries exceeding this figure are paid to higher executive and specialist officers.

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 bush fires, injuries, insects and fungi; treemarking for sawmilling operations; assessment of the timber growing stock in the area; the falling, 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 utilisation, fire protection, assessment of resources, air-photo interpretation, management and growth studies, and pure scientific research. Specialists are in the minority, however, and it is essential that they too should have at least the basic training in forestry subjects as provided by the two years at the Australian National University, Canberra.

The General Division Training Scheme.

Forestry work in Western Australia offers a worthy career in the General Division for young men who are not proceeding to University and are seeking an open-air life. This field is open to young men between the ages of 17 and 19, preference being given to those with some forestry or farming background. Successful applicants must be physically fit and have studied to Junior standard or better.

The course is designed to give, over a period of two years, practical experience in Forestry to fit the trainee for future duties and responsibilities as an officer in the field staff of the Department.

Following an initial induction camp, trainees are drafted as a group to specific forest districts, where they learn the basic principles of such forest activities as: road selection, construction and maintenance; bush fire control; silviculture; sawmilling; pine plantation establishment; tree measurement; surveying; motor vehicle maintenance and many other aspects of forestry practice.

This training period lasts for two years, during which the course covers the major aspects of forestry field work in both hardwoods and plantations. An officer is appointed to take charge of each course and is responsible for the technical instruction as well as for the general conduct and guidance of each trainee.

Camp accommodation is provided at each centre visited; in certain places the trainees have to provide their own meals. In 1965, the trainees are paid at the rate of £14 per week for the first year and £15 per week for the second year.

On completing the course to the satisfaction of the Conservator, trainees are appointed as Forest Guards.

Advanced training and wider experience gained during the first three years as a Forest Guard enable the young officer to sit for a qualifying examination which permits further salary increments, and enables the young Forest Guard to apply for higher positions in the general field staff as they become available

A Forest Guard can hope to rise, by diligence, length of service, and satisfactory qualification by promotional examinations through the ranks of Forest Ranger, Assistant Forester, Forester, District Forester and Senior Forester, with a maximum salary in 1965 of £2,289 per annum.

Any trainee who is able to continue his studies to pass the matriculation examination of the University is eligible to apply for a Forestry Scholarship. This provides for the higher training necessary for appointment to the professional division of the Forests Department.

Further Information.

Interested persons requiring further information about forestry as a career are invited to enquire at the head office of the Forests Department in the R. and I. Bank Building, Barrack Street, Perth.

CHAPTER IX.

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 unsuitable, and in 1897 a site was selected near the small Hamel siding on the South Western Railway, two miles south of Waroona. The area selected was portion of the old de Hamel Estate and includes a large area of rich alluvial soil through which runs the south branch of Samson's Brook.

Plate 65.

General view of the Forests Department nursery at Hamel. Pine seedlings are shown in the foreground.

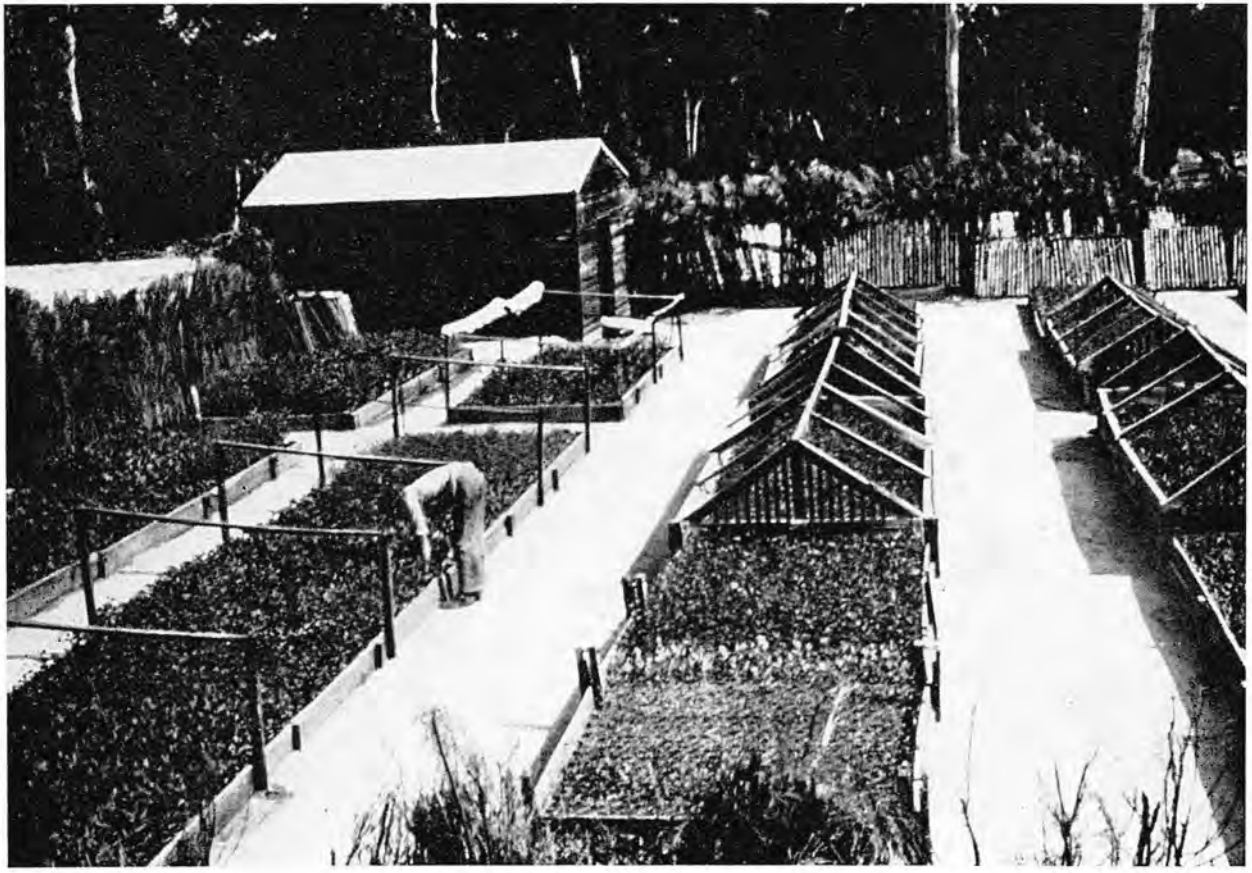


Plate 66.

View of seed beds in the Forests Department nursery at Dryandra, near Narrogin.

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 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 ft. high and 12 feet 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 land holders 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 wheat belt. To meet this demand, the Department established another nursery at Kalgoorlie in 1947. After functioning for seven years this nursery was transferred to Dryandra in 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 wheat belt and which have been raised at Dryandra 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 and 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 they exhibit a great deal of adaptability which enables many of them to thrive over relatively wide ranges of soil and climate.

TREE PLANTING

Growing trees is not a difficult enterprise provided due attention is paid to a few basic factors which are essential to success. These include intelligent selection of species, care in handling and planting, and subsequent attention to protection and tending of the young trees.

We will consider these factors in their order:

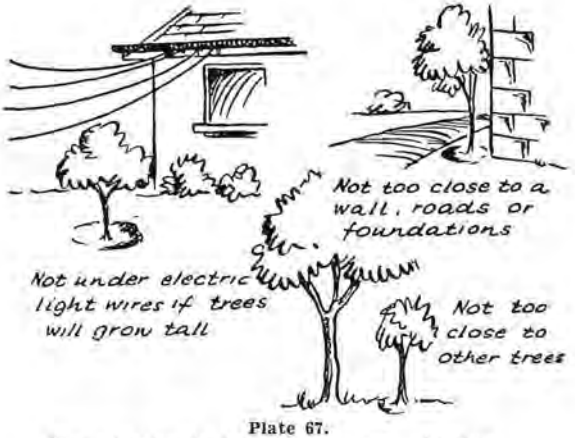


Plate 67.
Site selection is important in tree planting.

Selection of Species.

(a) *Suitability for the Required Purpose.*—In selecting trees for any particular purpose, some knowledge of their habit of growth is necessary and may save much disappointment and trouble later on. As an example, we can consider the number of tall growing trees which have been planted under electric light lines in this State and the amount of labour which is expended annually in attempting to cut them back into forms which nature never meant them to assume. It is inadvisable to plant tall growing trees too close to a house, while a row of tall trees which would make a picturesque avenue would not, unless associated with a line or two of more bushy trees, make a very effective windbreak. For clumps of shade trees in paddocks something tall is required, whereas for shade in a fowl yard something low and bushy would be preferable. The salient characters of a number of suitable trees are supplied in the accompanying table, Appendix VII.

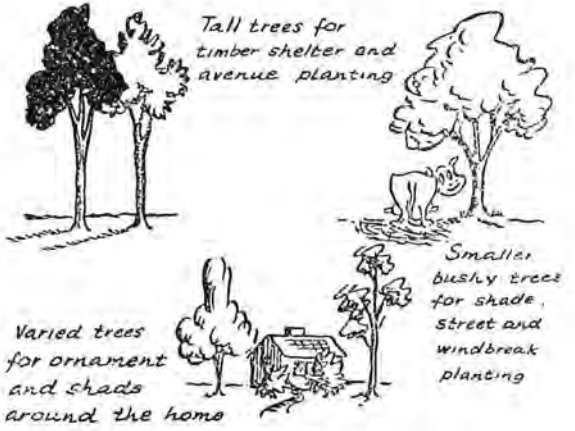


Plate 68.
Different trees for different purposes.

(b) *Suitability of a Tree for the Soil and the Locality.*—Trees selected should be either those that are indigenous to the locality or to some locality enjoying similar climatic conditions, and which are known to be suited to the soil type on which they are to be planted.

This stipulation may exclude trees for which a grower mave have a strong preference, but it is one which cannot be ignored. If trees are not suited to the locality and soil their use can only lead to disappointment and frustration.

Procurement of Planting Stock.

The Price List of Trees, available from the Forests Department, gives relevant information on the availability of trees raised at the nurseries.

However, while it is generally more convenient and reliable to obtain planting stock from a nursery some growers may desire to raise their own from seed. Briefly, this may be done in several ways.

They may be established by direct sowing in the spots where they are to remain. This requires careful cultivation of the sowing spots and subsequent removal of weed growth. However, this method is by no means dependable and is so subject to the vagaries of the weather that it is not recommended.

The most reliable method is to raise the plants in containers such as old tins or flower pots, the seed being either sown directly into the containers or first raised in seed boxes and the young plants subsequently 'pricked out' into the containers. Sowing can be done either in the Autumn or Spring, but it is essential to pay constant attention to watering (particularly in hot weather), shading, weeding and spraying against pests.

Planting of Trees Obtained from the Nursery.

Two methods are recommended:—

(a) For establishment under field conditions where cultivation by farm machinery is possible.

(b) For establishment as isolated ornamental trees, or in situations such as in street planting, where machine cultivation is not possible.

(a) *Establishment Under Field Conditions.*—A method practised and proved for establishing belts of trees in low rainfall areas (down to 13 inches) is along the following lines:

(1) Ploughing and fallowing the land for twelve months prior to planting.

(2) Cultivating again shortly before planting—preferably in late summer.

(3) Fencing to exclude stock and rabbits.

(4) Planting during early winter.

(5) Watering (about one gallon per tree) at the time of planting but no subsequent watering.

(6) Cultivation between rows shortly after planting and then at intervals during the next two years to keep the surface free of weeds—late winter is best time to cultivate.

(7) The chipping of weeds from around the trees with a hoe wherever they cannot be reached by a cultivator.

(b) *Establishment of Isolated Trees, Ornamental Trees, Street Trees Etc.*—These cannot be given the cultivation recommended above and periodic watering is advisable for one or more years after planting.

Planting should be done in early winter, preferably June but no later than August.

The positions selected for the trees need to provide ample room for their development and to ensure freedom from competition by the roots of established trees and shrubs. The zone occupied by the roots of an established tree can extend for a distance from its base roughly equal to the height of the tree itself.

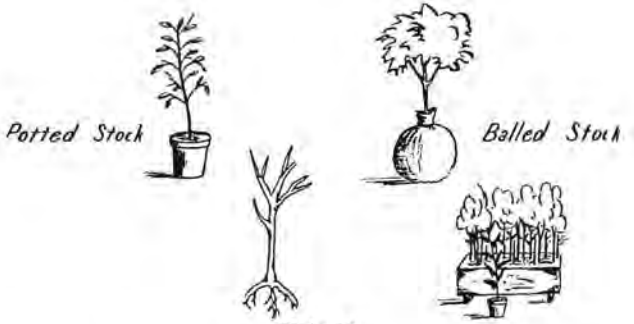


Plate 69.

Types of nursery stock.

Details of Planting Methods.

When trees are received from the nursery they should be examined immediately, and if the soil enclosing their roots is dry it should be watered thoroughly. They should be kept moist and in a shady place until they are planted out.

Trees received from Forests Department nurseries generally have their roots enclosed in cones of soil which have been removed from the pots, wrapped in paper and packed tightly in small crates. Before watering it is advisable to remove the upper portion of the paper, which is usually twisted round the stem of the plant, to ensure that the water applied is able to reach the roots.

Planting procedure should be as follows:

Shape the planting spot into a shallow saucer-shaped depression about two or three feet in diameter and a couple of inches deep to ensure that any rain falling on it will concentrate near the young tree and not flow elsewhere. Plant the tree in the centre of the saucer in a vertical position and about an inch deeper than it was in the nursery.

In the case of open rooted trees, see that the planting hole is large enough to permit the tap root to be directed straight down without bending and the lateral roots to be spread out and not bunched or twisted.

With trees raised in individual containers such as pots, tins or tubes, it will usually be found that some root coiling has taken place. If steps are not taken at planting time to deal with this fault, subsequent loss of trees by wind throw is liable to occur. If, on examining the root system, a concentration of coiled roots is found at the bottom of the enclosing ball of earth, we consider it advisable to cut them off. Where marked coiling of roots around the outside of the ball takes place the severing of such coiled roots by two shallow vertical cuts on opposite sides of the plant is suggested, but care should be taken to keep the ball otherwise intact. Extensive trials have

established that with our Eucalypts at any rate, such treatment, although apparently drastic, does not cause any set back to the trees provided all care is taken in other directions.

Some trees are raised in trays (about two dozen per tray) and at planting time should be taken out as follows:—

Remove one side of the tray, run a sharp knife between the rows both along and across the tray, thereby cutting the soil into small blocks, each containing a tree, which can then be removed singly. It is necessary to give the tray a thorough soaking a couple of hours beforehand and allow a drain.

It is advisable immediately the young tree is planted to give it a gallon or even more of water to assist the settling of the soil around its roots. There are few trees that do not benefit from the addition of some fertilizer, particularly if planting is on one of the poorer soil types. A couple of ounces of superphosphate worked into the soil for a radius of about two feet round the tree is ample, but avoid nitrogenius manures at least for the first twelve months.

A small amount of two per cent dieldrin powder worked into the soil at the planting spot and dusted on the soil cone enclosing the roots will act as a deterrent to root destroying insects.

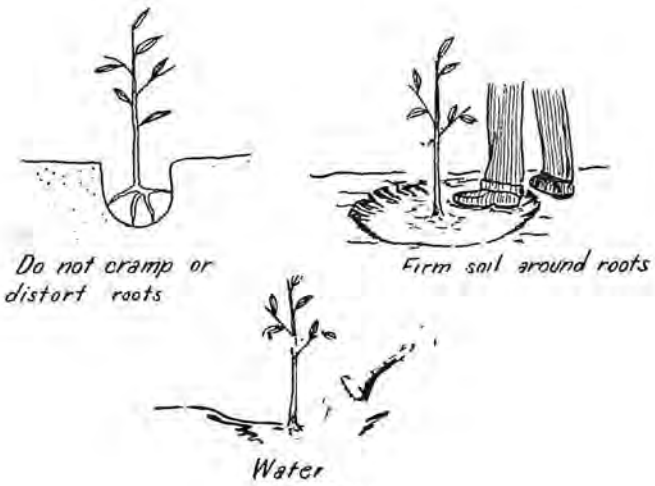


Plate 70.

Planting a tree.

In the actual planting operation with container grown stock, the planting hole should be made large enough to take the root ball and also to allow room for the hand of the planter to hold the plant in place during the operation. Fill the hole by working well-broken moist soil round the roots, gradually withdrawing the hand and pressing the soil in with the fingers, making sure to eliminate any air pockets. A final light pressure with the foot—not too close to the tree—will consolidate the refilled soil. The young tree should be planted slightly deeper (about one inch) than it was in the nursery.

When only a limited number of trees are required annually some farmers prefer to use large planting stock. The seedlings as received from the nursery, instead of being planted straight out into the field, are held until the following

winter in larger containers such as kerosene tins. This procedure is also followed by some local governing bodies who find the larger trees less liable to theft or damage by vandals and incidentally cheaper and more convenient to look after if concentrated in a holding nursery during the critical first year.

Containers should be provided with drainage holes, supported clear of the ground on blocks or bricks, and filled with good potting soil over a bottom layer of coarse drainage material. Tins should be placed about nine inches apart to allow sufficient space for the trees to develop.

In planting in these larger containers, the young trees should receive the same root treatment as for field planting. Regular watering is necessary during the whole period they are held. Planting out requires some care and should be done as follows:—

Cut the bottom out of the container and stand it in the planting hole, which should be made as deep as the container itself. Make a vertical cut from top to bottom of the container and remove it. This leaves the young tree standing in a block of soil. Fill around this block with damp well broken soil, press down firmly and water.

It is advisable to stake trees for the first couple of years—particularly in exposed situations. Without this precaution, it is found that young trees under the influence of strong winds develop a rotary motion which causes a hole to form around the base of the stem, in addiion to which they are liable to develop a permanent lean.

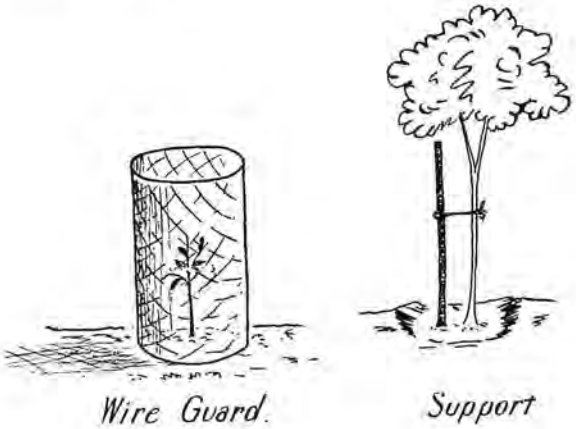


Plate 71.

Protecting the planted trees.

Protection

During their early years, trees should be protected from stock by guards or temporary fences, which should be retained until the trees are large enough to withstand damage from the type of stock which is allowed access to them.

Severe damage (or even destruction) to young trees by cockatoos has developed into a serious problem in parts of the wheatbelt. Protection during the vital initial year or two can be given by surrounding the tree with a tree guard in the form of a tube made from rabbit netting about 3 or 3½ feet long

and about 10 in. in diameter. If this is sunk a couple of inches into the ground, pinched together at the top and supported by one or preferably two wooden stakes on opposite sides of the tree, besides providing protection from cockatoos, rabbits and sheep, it will keep the young tree erect.

Planting Layout.

For shelter belts, two parallel rows of trees, one dwarf (on the windward side) and the other tall, is recommended. Shade groups should not be made too large and the following layouts are suggested, with spacing distances of thirty feet between trees:

1. Seven trees, six of them arranged to form a hexagon with one in the centre.
2. Nine trees in three parallel rows each containing three trees.

It will be noted that, with the exception of one central tree in each arrangement, every tree has root access to the surrounding land. The wide spacing permits the development of large spreading crowns.

Heavy pruning of the stems of young trees is inadvisable, and if carried to excess, can cause the trees to become spindly and unable to support their own weight. Pruning should be restricted to the removal of double leaders, and to side limbs only when it becomes obvious that these are developing abnormally and to the detriment of the central shoot.

Particular care must be taken to protect trees from fire. Many of the trees listed, particularly those for the drier areas, are very fire tender, and even the burning of grass litter or piles of leaves near them may cause disfigurement, damage or possibly death.

In view of the fact that a tree, once established, will be a feature of the environment for a long time, a little thought and attention given to the initial selection, planting and maintenance is fully warranted.

SAND DRIFT RECLAMATION

The loose, sandy nature of the soil of much of our coastal belt renders it particularly susceptible to wind erosion. Stability of this sand is entirely dependent on the protective action of native vegetation, and any serious damage to this by overgrazing, fire, trampling, etc., very quickly results in sand movement which can ultimatetly lead to the formation of large drifting sand dunes which bury everything in their path.

Numerous areas of drifting sand exist around our South and South-Western coastline. These areas vary in size from a few acres to many square miles. It is considered that these 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, are engulfing karri forest 200 ft. high. Most dunes are in very inaccessible country and are not, at the present time, causing any serious economic damage. There have been several exceptions, however, and dunes at Swanbourne, Boranup, Augusta, the mouth of the Warren River, and around the Greenough River at Geraldton, have been or are in the course of being stabilised.

Dunes at Swanbourne were encroaching on valuable suburban property, those at Boranup on roads and railways, and those at the Warren River gave indications of proving a serious obstruction to stream flow. In the Geraldton District, dunes are encroaching onto valuable land, approaching the townsite, and endangering the Greenough River.

History of Dune Fixation in W.A.

It is to our credit that in a country little over 100 years old and still with a population of much less than 1 per square mile, battle has been joined and some victories already won against "sea sand".

It is interesting, that as far back as 1892, sawmillers first challenged the wind and "sea sand".

The firm of M. C. Davis & Sons of Karridale imported "Marram Grass" from South Africa and planted it on the Boranup Dunes over a hundred and fifty miles from Perth. The sand dunes were fixed and remain stable. They confirmed the knowledge of the Old World and set the pattern for the pioneers of our State.

Little further work was recorded in the State until in 1919 and 1920, the Cottesloe and Claremont local authorities carried out successful fixation of dunes on the coastline near Perth, and from 1924 to 1927 the Forests Department planted about 100 acres of University Endowment Land at Swanbourne, financed by University Funds.

In 1936 a report was received by the Forests Department that a very large shifting sand dune some 1,000 acres in extent was threatening the flow of the Warren River near Calcup Ford. Immediate steps were taken by the Department to fix this dune with Marram Grass. The whole surface of the dune was planted and no further encroachment took place.

In 1937 and 1938, after an inspection to ascertain the extent and economic loss being caused by the advance of the huge Yeagerup dune North of the Warren River, a start was made to arrest the dunes which stretched for some 10 miles from the vicinity of the Warren River towards Mt. Silvertop. Marram Grass was established at a number of points on the dune to form nurseries from which large quantities of grass could be obtained at a later date to extend over the dune.

In 1938 and 1939 the movement of a number of dunes between Cowaramup and Augusta was arrested. These dunes were threatening valuable agricultural and grazing lands at Cowaramup, Ellensbrook, Groocardup, Wilcarnup, Gnarabup, Boodjedup and Caljardup.

Further small areas of moving sand were dealt with at Rottnest Island, Garden Island and Point Peron during World War II, with funds provided by the Department of the Army.

Unfortunately, success has not attended the efforts to establish Marram Grass on certain Rottnest sand drifts due to the exceedingly high lime content of the sand. This sand consists almost solely of fine shell particles and contains up to 98% calcium carbonate.

The same trouble has also been experienced with similar lime dunes at Greenough River and Mahomet Flat near Geraldton. A number of different plants, both local and imported, have been tried, so far without success.

Marram Grass is the outstanding medium which has been successfully used for stabilising coastal sand dunes in this State. It is easy to establish and extremely hardy within the 20 in. isohyet, and will thrive on any sand not con-

taining more than 60% to 70% of calcium carbonate in the form of shell particles.

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.

Method of Dune Fixation.

Satisfactory fixation of all dunes threatening points of economic importance has been effected by the systematic planting of Marram Grass. This grass, a native of South Africa, is admirably suited to the purpose. It thrives on white beach sand in close proximity to the sea, where mean annual rainfall is not less than 20 inches. Possessing the ability to grow rapidly through shifting sand, it may in the short period of a year, be responsible for a hummock 6 ft. to 8 ft. in height. This rapid growth is arrested once the sand movement ceases and stable or fixed dunes are characterised by tussocks of dead or dying grass. By this time, however, much of the indigenous flora has become sufficiently re-established to continue to hold the sand in position.

Drift sands dealt with in this State fall into two classes:—

(1) Those commencing immediately from high water mark and spreading inland.

(2) Areas of drifting sand separated from the coast by a belt of country on which the indigenous flora remains unharmed.

In the first case, a belt of *Spinifex hirsutus*, an indigenous plant which thrives just above the high water mark, is planted to protect the first plantings of Marram Grass. The spinifex accumulates on low dunes sheltering the grass planted immediately beyond, in rows parallel to the sea. The greater the degree of exposure, the closer is the planting spacing employed.

Dunes of the second type are comparatively easy to fix, since they are usually not so exposed. Marram Grass is planted in rows at right angles to the direction of the most damaging winds. The espacement may vary from 12 ft. between the rows and 4 ft. between the plant sets, to 60 ft. between the rows and 5 ft. between the sets, depending on various factors concerned.

Grass cuttings are the usual planting material, these being readily obtained from established clumps. Establishment from seed may only be effected in areas well protected from exposure—conditions which do not often prevail.

For maximum benefits to be derived from any planting programme, sheep and goats must be totally excluded and the grazing of horses and cattle strictly regulated over the area.

The whole of the State's coastline from Shark Bay to Eucla is unstable, and any factors such as overgrazing or fire, which destroy the vegetational cover, will start the sand moving. There is no doubt that as time goes on and pressure of population requires the utmost use of our land, the State will be increasingly concerned with the stabilisation of these areas.

In recent years some success has been reported from Mediterranean countries in the establishing of vegetation on dunes on which the sand had been temporarily stabilised by spraying the surface with a bituminous emulsion.

Following discussions in late 1964 between representatives of the Department of Agriculture, the Forests Department and one of the large oil companies, preparations are in hand for an initial trial along these lines during 1965 in this State. Species to be used are the local coastal acacias.

Plate 72.

Brown Mallet *(Euc. astringens)* plantation at Dryandra, near Narrogin.

TANNIN TREES OF WESTERN AUSTRALIA

Tannin is a valuable commodity which has the ability to convert hides to leather, making them resistant to air, moisture, temperature change and bacterial attack. They are also useful as a basic ingredient of ink, as an astringent in medicine, and in the United States, a significant portion of total tannin consumption is used as a dispersant to control the viscosity of mud in oil-well drilling.

While synthetic materials have in recent years displaced leather from many of its traditional uses, it has by no means been entirely superseded, so that tanning materials appear likely to be in demand, although on a reduced scale during the foreseeable future.

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)*.

(a) Mallet Bark.

The bark of the brown mallet, a tree which occurs in the Great Southern districts, is one of the richest natural tanning materials in the world and has been used in the manufacture of leather for over sixty years.

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 in 1903 rose to 20,700 tons in 1905. A rapid decline of production followed as stocks of mature mallet trees were destroyed by stripping, by fire, or by removal during the clearing of land for agricultural purposes. Much of the mallet bark obtained today is from privately held land where it is collected with little attention to regeneration.

The Forests Department supplies from its plantations about one hundred tons of mallet bark per year.

When it was plentiful, the bark (which contains approximately 45 per cent tannin) was held in such high esteem that attempts were made to grow brown mallet *(Eucalyptus astringens)* in other countries. Whilst there was at least partial success in South Africa, it is known that attempts failed in the former German colonies of East Africa.

While brown mallet has been the principal source of tan bark, two other species which also produce bark of high quality, viz. blue mallet *(Eucalyptus gardneri)* and white mallet *(Eucalyptus falcata)*, have provided smaller amounts.

Four other species which provide bark of fair quality, but inferior to the above, are—

Swamp (or flat-topped) yate *(Eucalyptus occidentalis)*.

Swamp mallet *(Eucalyptus spathulata)*.

Dundas mahogany *(Eucalyptus brockwayi)*.

Dundas blackbutt *(Eucalyptus dundasi)*.

The last named two occur in the Norseman district.

Artificial regeneration of mallet by direct sowing of seed was carried out for over thirty years (1927-60) in the Narrogin district. The greatest activity in this direction was during the depression years when mallet establishment was recognised as a suitable avenue for the employment of relief workers. In all, some 19,000 acres of plantation were established.

Mallet timber is tough and resilient and well suited for the manufacture of tool handles.

Experimental work with wattle planting was undertaken at Mundaring Weir by the Forests Department in the 1930's to see if such a source of tannin was economically feasible in this State, as it is in South Africa. In view of the fact that wattles require a good soil more suited to other purposes, such as pine growing, and that the timber by-product from wattles has not the value of mallet, wattles were abandoned for the more favourable eucalypt source.

(b) *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 investigations have definitely established that the tannins from it are very suitable for tanning heavy leather.

(c) *Wandoo Wood Extract.*

Both the wood and bark of the wandoo tree contains tannins in a high enough concentration to warrant commercial extraction.

A large plant which provides extract for both local use and export markets operates at Toodyay.

The trees used as a raw material for extraction are the Wandoo *(Eucalyptus wandoo)* and the Powder Bark *(Eucalyptus accedens)*.

The districts in which wandoo occurs are being rapidly developed for agriculture so that much of the timber being utilised for tannin production would otherwise be wastefully destroyed in clearing.

APPENDIX I.

W.A. EUCALYPTS—INDEX OF VERNACULAR NAMES

Albany Blackbutt	*Euc. staeri*, Maiden.
Apple Gum	*Euc. pruinosa*, Schau.
Bald Island Marlock	*Euc. lehmanni*, Preiss.
Bastard Bloodwood	*Euc. perfoliata*, R. Brown.
Bell-fruited Mallee	*Euc. preissiana*, Schau.
Blackbutt	*Euc. patens*, Bentham.
Blackbutt	*Euc. intertexta*, R. T. Baker.
Blackbutt, Albany	*Euc. staeri*, Maiden.
Blackbutt, Cleland's	*Euc. clelandi*, Maiden.
Blackbutt, Dundas	*Euc. dundasi*, Maiden.
Blackbutt, Goldfields	*Euc. clelandi*, Maiden.
Blackbutt, Goldfields	*Euc. stricklandi*, Maiden.
Blackbutt, Goldfields	*Euc. le souefii*, Maiden.
Blackbutt, Le Souef's	*Euc. le souefii*, Maiden.
Blackbutt, Coastal	*Euc. todtiana*, F. v. M.
Blackheart	*Euc. microtheca*, F. v. M.
Black Morrel	*Euc. melanoxylon*, Maiden.
Black Morrel (or Yorrel)	*Euc. gracilis*, F. v. M.
Black Yate	*Euc. gracilis*, F. v. M.
Blackwood	*Euc. foelscheana*, F. v. M.
Blackwood	*Euc. latifolia*, F. v. M.
Blackwood	*Euc. pyrophora*, Bentham.
Blue Gum	*Euc. megacarpa*, F. v. M.
Blue Mallet	*Euc. gardneri*, Maiden.
Blue-leaved Mallet	*Euc. gardneri*, Maiden.
Blue Snap and Rattle	*Euc. calycogona*, Turcz.
Book Leaf Mallee	*Euc. kruseana*, F. v. M.
Boongul	*Euc. transcontinentalis*, Maiden.
Brown Mallet	*Euc. astringens*, Maiden.
Bullich	*Euc. megacarpa*, F. v. M.
Cabbage Gum	*Euc. papuana*, F. v. M.
Cleland's Blackbutt	*Euc. clelandi*, Maiden.
Coastal Blackbutt	*Euc. todtiana*, F. v. M.
Coastal White Gum	*Euc. decipiens*, Endlich.
Coolibah	*Euc. microtheca*, F. v. M.
Coral-flowered Gum	*Euc. torquata*, Leuhmann.
Desert Blackbutt	*Euc. intertexta*, R. T. Baker.
Desert Gum	*Euc. cliftoniana*, W. V. Fitz.
Desert Gum	*Euc. gongylocarpa*, Blakely.
Desert Gum (Ghost Gum)	*Euc. papuana*, F. v. M. (an inland form).
Dundas Blackbutt	*Euc. dundasi*, Maiden.
Dundas Mahogany	*Euc. brockwayi*, Gardner.
Flat-topped Yate	*Euc. occidentalis*, Endlich.
Flooded Gum	*Euc. rudis*, Endlich.
Fuchsia Mallee	*Euc. forrestiana*, Diels.
Gimlet	*Euc. salubris*, F. v. M.
Gimlet	*Euc. annulata*, Bentham.
Gimlet, Silver-topped	*Euc. compaspe*, Spencer Moore.
Gimlet, Swamp	*Euc. spathulata*, Hooker.
Goldfields Blackbutt	(See under Blackbutt).
Goldfields Yellow-flowered Blackbutt	*Euc. stricklandi*, Maiden.
Goldfields Coral-flowered Gum	*Euc. torquata*, Leuhmann.
Grey Box	*Euc. spenceriana*, Maiden.
Grey Gum	*Euc. griffithsii*, Maiden.
Gungunnu (or Gungurru)	*Euc. caesia*, Bentham.

Illyarrie	*Euc. erythrocorys*, F. v. M.
Ironbark	*Euc. terminalis*, F. v. M.
Ironbark, Isdell River	*Euc. melanophloia*, F. v. M.
Ironbark, Silver-leaved	*Euc. melanophloia*, F. v. M.
Jarrah	*Euc. marginata*, Smith.
Karri	*Euc. diversicolor*, F. v. M.
Karri, Swamp	*Euc. megacarpa*, F. v. M.
Kimberley Red Gum	*Euc. ptychocarpa*, F. v. M.
Kimberley White Gum	*Euc. houseana*, (W. V. Fitz) Maiden.
Lemon-flowered Gum	*Euc. woodwardi*, Maiden.
Le Souef's Blackbutt	*Euc. le souefii*, Maiden.
Mallet, Blue	*Euc. gardneri* Maiden.
Mallet, Brown	*Euc. astringens*, Maiden.
Mallet, Red	*Euc. astringens*, Maiden.
Mallet, Swamp	*Euc. spathulata*, Hooker.
Mallet, White	*Euc. falcata*, Turcz, var. *ecostata*, Maiden.
Marble Gum, (Desert Gum)	*Euc. gongylocarpa*, Blakely.
Marri	*Euc. calophylla*, R. Brown.
Merrit	*Euc. flocktoniae*, Maiden.
Messmate	*Euc. tetrodonta*, F. v. M.
Micum	*Euc. pallidifolia*, F. v. M. syn. *Euc. brevifolia*, F. v. M.
Mirret, (Snap and Rattle)	*Euc. celastroides*, Turcz.
Moich	*Euc. rudis*, Endlich.
Moort	*Euc. platypus*, Hooker.
Moort, Hopetoun	*Euc. platypus*, Hooker var. *heterophylla*, Blakely.
Moort, Round-leaved	*Euc. platypus*, Hooker.
Morrel, Black	*Euc. melanoxylon*, Maiden.
Morrel, Red	*Euc. longicornis*, F. v. M.
Mottelcah	*Euc. macrocarpa*, Hooker.
Mountain Gum (Mountain Marri)	*Euc. haematoxylon*, Maiden.
Parker's Gum	*Euc. foecunda*, Schau, var. *loxophleba*, Bentham
Pear-fruited Mallee	*Euc. pyriformis*, Turcz.
Pear Gum	*Euc. stoatei*, Gardner.
Poot	*Euc. longicornis*, F. v. M.
Powder-bark	*Euc. lane-poolei*, Maiden.
Powderbark Wandoo	*Euc. accedens*, W. V. Fitz.
Prickly-bark	*Euc. todtiana*, F. v. M.
Red-flowering Gum	*Euc. ficifolia*, F. v. M.
Redgum	*Euc. calophylla*, R. Brown.
Redgum, Kimberley	*Euc. ptychocarpa*, F. v. M.
Redgum, Mountain	*Euc. hoemotoxylon*, Maiden.
Red Morrel	*Euc. longicornis*, F. v. M.
Red Tingle Tingle	*Euc. jacksoni*, Maiden.
Redwood	*Euc. oleosa* var. *obtusa*, Gardner.
Ridge Gum	*Euc. alba*, Reinwardt.
River Gum	*Euc. camaldulensis*, Dehn.
Round-leaved Moort	*Euc. platypus*, Hooker.
Salmon Gum	*Euc. salmonophloia*, F. v. M.
Salmon White Gum	*Euc. lane-poolei*, Maiden.
Salt River Gum	*Euc. sargenti*, Maiden.
Silver-leaved Ironbark	*Euc. melanophloia*, F. v. M.
Silver-topped Gimlet	*Euc. campaspe*, Spencer Moore.
Snap and Rattle	*Euc. gracilis*, F. v. M.
Snap and Rattle	*Euc. celastroides*, Turcz.
Stringybark	*Euc. tetrodonta*, F. v. M.

Swamp Gimlett	*Euc. spathulata*, Hooker.
Swamp Gum	*Euc. rudis*, Endlich.
Swamp Karri	*Euc. megacarpa*, F. v. M.
Swamp Mallet	*Euc. spathulata*, Hooker.
Swamp Yate	*Euc. occidentalis*, Endlich.
Tingle Tingle, Red	*Euc. jacksoni*, Maiden.
Tingle Tingle, Yellow	*Euc. guilfoylei*, Maiden.
Tuart	*Euc. gomphocephala*, A. De C.
Wandoo	*Euc. redunca*, Schau. var. *elata*, Bentham (Syn. *Euc. Wandoo*, Blakely).
Wandoo, Powderbark	*Euc. accedens*, W. V. Fitz.
Wandoo, Salmon-bark	*Euc. lane-poolei*, Maiden.
Weeping Gum	*Euc. sepulcralis*, F. v. M.
Whitegum (Kimberley)	*Euc. houseana*, (W. V. Fitz) Maiden.
Whitegum (Wandoo)	*Euc. wandoo* Blakely syn.: *redunca* Schau; *var. elata* Bentham.
Whitegum (Coastal)	*Euc. decipiens*, Endlich.
White Mallet	*Euc. falcata*, Turcz. var. *ecostata*, Maiden.
White Mallee	*Euc. erythronema*, Turcz.
Woollybutt	*Euc. miniata*, A. Cunningham.
Yate	*Euc. cornuta*, Labill.
Yate, Flat-topped	*Euc. occidentalis*, Endlich.
Yate, Black	*Euc. gracilis*, F. v. M.
Yate, Swamp	*Euc. occidentalis*, Endlich.
Yellow-flowered Blackbutt	*Euc. stricklandi*, Maiden.
Yellow Tingle Tingle	*Euc. guilfoylei*, Maiden.
York Gum	*Euc. loxophleba*, Bentham.
Yorrel	*Euc. gracilis*, F. v. M.

APPENDIX II

ALPHABETICAL LIST OF WESTERN AUSTRALIAN EUCALYPTUS TREES

Euc. accedens, W. V. Fitzgerald.
Euc. alba, Reinwardt.
Euc. argillacea, W. V. Fitzgerald.
Euc. astringens, Maiden.
Euc. brachyandra, F. v. Mueller.
Euc. brevifolia, F. v. Mueller.
Euc. brockwayi, Gardner.
Euc. caesia, Bentham.
Euc. calophylla, R. Brown.
Euc. camaldulensis, Dehn.
Euc. campaspe, Spencer le M. Moore.
Euc. celastroides, Turczaninow.
Euc. clavigera, Allan Cunningham.
Euc. clelandi, Maiden.
Euc. cliftoniana, W. V. Fitzgerald.
Euc. collina, W. V. Fitzgerald.
Euc. confluens (W. V. Fitz.), Maiden.
Euc. cooperiana, F. v. Mueller.
Euc. cornuta, Labill.
Euc. corrugata, Luehmann.
Euc. decipiens, Endlicher.
Euc. dichromophloia, F. v. M.
Euc. diversicolor, F. v. Mueller.
Euc. drummondii, Bentham.
Euc. dundasi, Maiden.
Euc. erythrocorys, F. v. Mueller.
Euc. falcata, Turcz.; *var. ecostata*, Maiden.
Euc. ficifolia, F. v. Mueller.
Euc. flocktoniae, Maiden.
Euc. foecunda, Schau.; *var. loxophleba*, Bentham.
Euc. foelscheana, F. v. Mueller.
Euc. gamophylla, F. v. Mueller.
Euc. gardneri, Maiden.
Euc. gomphocephala, A. DeCandolle.
Euc. gongylocarpa, Blakely.
Euc. gracilis, F. v. Mueller.
Euc. grandifolia, R. Brown.
Euc. griffithsii, Maiden.
Euc. guilfoylei, Maiden.
Euc. haematoxylon, Maiden.
Euc. houseana (W. V. Fitz.), Maiden.
Euc. intertexta, R. T. Baker.
Euc. jacksoni, Maiden.
Euc. lane-poolei, Maiden.
Euc. latifolia, F. v. Mueller.
Euc. le souefii, Maiden.
Euc. lirata (W. V. Fitzgerald), Maiden.
Euc. longicornis, F. v. Mueller.
Euc. marginata, Smith.
Euc. megacarpa, F. v. Mueller.
Euc. melanophloia, F. v. Mueller.
Euc. melanoxylon, Maiden.
Euc. microtheca, F. v. M.
Euc. miniata, Allan Cunningham.
Euc. mooreana (W.V.F.), Maiden.
Euc. mundijongensis, Maiden.
Euc. occidentalis, Endicher.
Euc. oleosa, F. v. M.
Euc. oligantha, Schauer.
Euc. pallidifolia, F. v. M.
Euc. papuana, F. v. Mueller.
Euc. patens, Bentham.
Euc. perfoliata, R. Brown.
Euc. platypus, Hooker.
Euc. pruinosa, Schauer.
Euc. ptychocarpa, F. v. Mueller.
Euc. pyrophora, Bentham.
Euc. wandoo Blakely syn.: *reduncа* Schau; *var. elata* Bentham.
Euc. rostrata, Schlecht.
Euc. rudis, Endlicher.
Euc. salmonophloia, F. v. M.
Euc. salubris, F. v. Mueller.
Euc. sargenti, Maiden.
Euc. sepulcralis, F. v. Mueller.
Euc. setosa, Schauer.
Euc. spathulata, Hooker.
Euc. spenceriana, Maiden.
Euc. staeri, Maiden. Ms.
Euc. striaticalyx, W. V. Fitzgerald.
Euc. stricklandi, Maiden.
Euc. terminalis, F. v. M.
Euc. tetrodonta, F. v. M.
Euc. todtiana, F. v. M.
Euc. torquata, Leuhmann.
Euc. transcontinentalis, Maiden.
Euc. woodwardi, Maiden.

Trees which occasionally take on a mallee form—

Euc. astringens, Maiden.
Euc. celastroides, Turcz.
Euc. cornuta, Labill.
Euc. decipiens, Endl.
Euc. diptera, C. Andrews.
Euc. falcata, Turcz.
Euc. flocktoniae, Maiden.
Euc. gardneri, Maiden.
Euc. gracilis, F. v. M.
Euc. marginata, Smith.
Euc. megacarpa, F. v. M.
Euc. oleosa, F. v. M.
Euc. salubris, F. v. M.
Euc. spathulata, Hooker.
See also Mallees occurring as trees.

ALPHABETICAL LIST OF MALLEES AND MARLOCKS

Euc. angulosa, Schauer.
Euc. angusta, Maiden.
Euc. angustissima, F. v. M.
Euc. annulata, Benth.
Euc. buprestium, F. v. M.
Euc. calycogona, Turcz.
Euc. comitae-vallis, Maiden.
Euc. conglobata (R. Rr.), Maiden.
Euc. crucis, Maiden.
Euc. decurva, F. v. M.
Euc. diptera, Cecil Andrews.
Euc. doratoxylon, F. v. M.
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. v. M.
Euc. ewartiana, Maiden.
Euc. falcata, Turcz.
Euc. foecunda, Schauer.
Euc. forrestiana, Diels.
Euc. goniantha, Turcz.
Euc. grossa, F. v. M.
Euc. herbertiana, Maiden.
Euc. incrassata, Labill.
Euc. jutsoni, Maiden.
Euc. kalganensis, Maiden.
Euc. kruseana, F. v. M.
Euc. lehmanni, Preiss.
Euc. leptophylla, F. v. M.
Euc. leptopoda, Benth.
Euc. macrandra, F. v. M.
Euc. macrocarpa, Hooker.
Euc. micranthera, F. v. M.
Euc. occidentalis, Endl. *var. stenantha*, Diels.
Euc. odontacarpa, F. v. M.
Euc. oldfieldii, F. v. M.
Euc. oleosa, F. v. M.
Euc. orbifolia, F. v. M.
Euc. pachyloma, Benth.
Euc. platypus, Hooker; *var. nutans*, Benth.
Euc. preissiana, Schau.
Euc. pyriformis, Turcz.
Euc. pyriformis, var. minor, Maiden.
Euc. pyriformis, var. elongata, Maiden.
Euc. pyriformis, var. rameliana, Maiden.
Euc. pyriformis, var. kingsmilli, Maiden.
Euc. redunca, Schauer.
Euc. redunca, var. melanophloia, Benth.
Euc. redunca, var. oxymitra, Maiden.
Euc. sheathiana, Maiden.
Euc. tetragona, F. v. M.
Euc. tetraptera, Turcz.
Euc. uncinata, Turcz.
Euc. websteriana, Maiden.
Euc. xanthonema, Turcz.

Mallees, which sometimes have a tree form—

Euc. annulata, Bentham.
Euc. conglobata (R. Br.), Maiden.
Euc. diptera, Cecil Andrews.
Euc. doratoxylon, F. v. M. (?).
Euc. eremophila, Maiden.
Euc. eudesmioides, F. v. M. (?).
Euc. falcata, Turcz.
Euc. lehmanni, Preiss.
Euc. leptophylla, F. v. M.
Euc. oleosa, F. v. M.
Euc. platypus, Hooker.
Euc. spathulata, Hooker.
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.	Value		Cub. ft.	Value	Value	Value	Value
		£			£	£	£	£
1836 (a)	10,000	2,500	1901	7,150,600	572,354	....	....	....
1837	....	....	1902	6,256,750	500,533	....	....	....
1838	....	....	1903	7,748,450	619,705	....	859	....
1839	....	....	1904	8,072,300	654,949	....	32,876	....
1840	....	....	1905	8,709,500	689,943	....	154,087	....
			1906	(c) 8,830,700	708,993	....	140,720	....
1841	....	....	1907	(c) 6,409,550	511,923	....	98,773	....
1842	....	....	1908	(c) 9,869,509	813,591	....	79,934	....
1843	....	....	1909	(c) 10,830,450	867,419	....	59,633	....
1844	....	(b)	1910	(c) 12,074,100	972,698	....	93,733	....
1845	....	....						
1846	....	2,550	1911	(c) 12,449,500	986,341	....	83,470	....
1847	....	12,200	1912	(c) 11,297,100	903,396	....	49,004	....
1848	....	3,350	1913	(c) 13,619,850	1,089,481	....	47,377	....
1849	....	....	1914 (d)	(c) 6,279,750	502,153	....	18,197	777
1850	....	10,500	1915 (e)	(c) 9,968,500	808,392	....	6,127	381
			1916 (e)	5,432,100	441,991	....	10,208	1,102
1851	....	1,250	1917 (e)	3,890,650	310,893	....	18,959	2,060
1852	....	7,050	1918 (e)	3,436,250	274,141	....	16,886	3,995
1853	....	52,200	1919 (e)	4,135,750	332,584	11,535	18,875	3,987
1854	....	58,500	1920 (e)	5,065,300	465,731	21,935	22,121	3,704
1855	....	76,900						
1856	....	70,500	1921 (e)	9,816,250	1,137,819	24,916	23,073	10,107
1857	....	69,200	1922 (e)	8,309,750	1,041,047	22,248	13,328	6,878
1858	....	29,250	1923 (e)	7,911,310	997,454	12,377	21,161	20,075
1859	....	67,250	1924 (e)	11,126,861	1,367,517	11,505	29,606	39,877
1860	....	54,800	1925 (e)	11,844,303	1,477,997	13,298	40,136	42,057
			1926 (e)	12,001,384	1,522,958	10,072	15,056	47,819
1861	....	27,750	1927 (e)	12,580,262	1,651,149	8,727	15,818	26,544
1862	....	68,800	1928 (e)	10,384,784	1,265,383	7,783	27,662	39,131
1863	....	32,900	1929 (e)	7,635,237	960,435	6,603	35,850	63,307
1864	....	58,300	1930 (e)	6,579,743	807,425	4,687	40,628	77,510
1865	....	183,950						
1866	....	85,650	1931 (e)	4,127,856	507,382	26,615	35,333	56,170
1867	....	56,750	1932 (e)	3,062,673	361,700	85,488	42,016	59,301
1868	....	8,000	1933 (e)	2,235,540	262,617	80,332	33,352	26,331
1869	....	179,900	1934 (e)	4,060,830	487,248	76,107	20,904	20,720
1870	....	157,200	1935 (e)	5,326,117	636,466	65,494	15,284	35,363
			1936 (e)	5,508,180	697,522	50,665	12,237	27,526
1871	....	218,500	1937 (e)	5,673,903	699,684	52,338	14,491	38,185
1872	....	37,000	1938 (e)	7,545,744	932,420	47,934	13,865	35,128
1873	....	68,150	1939 (e)	5,704,250	722,310	43,518	17,842	25,550
1874	....	345,600	1940 (e)	5,049,585	634,859	62,796	19,485	47,736
1875	....	342,350						
1876	....	219,050	1941 (e)	6,091,187	790,876	74,935	13,686	59,867
1877	....	336,150	1942 (e)	5,244,634	709,474	64,454	6,896	74,904
1878	....	580,900	1943 (e)	3,516,566	605,327	32,426	1,598	70,523
1879	....	627,250	1944 (e)	3,645,354	613,994	25,324	1,294	72,704
1880	....	662,550	1945 (e)	2,851,475	570,028	27,307	2,795	103,055
			1946 (e)	3,373,025	722,061	(f) 2,618	4,872	128,050
1881	....	792,750	1947 (e)	3,458,628	865,255	(f) 13,118	12,056	151,768
1882	....	936,500	1948 (e)	3,584,405	1,099,073	(f) 6,572	9,556	116,465
1883	....	997,000	1949 (e)	3,198,212	993,152	(f) 6,639	5,112	75,395
1884	....	861,700	1950 (e)	2,857,946	974,493	(f) 13,525	8,243	78,550
1885	....	848,150						
1886	....	626,150	1951 (e)	2,342,492	(g) 918,485	(f) 25,101	16,581	125,833
1887	....	354,800	1952 (e)	2,373,553	(g) 1,032,909	(f) 47,689	19,120	119,109
1888	....	525,570	1953 (e)	3,965,188	(g) 2,074,421	(f) 120,095	34,136	70,852
1889	....	788,500	1954 (e)	3,858,956	(g) 2,248,320	(f) 59,360	80,248	55,273
1890	....	1,172,200	1955 (e)	3,477,249	(g) 1,935,019	(f) 79,893	37,338	80,822
			1956 (e)	4,568,034	(g) 2,818,716	(f) 119,459	554,760	90,928
1891	....	1,273,950	1957 (e)	4,684,017	(g) 3,256,719	(f) 78,934	588,544	58,993
1892	....	1,082,650	1958 (e)	5,572,681	(g) 3,875,705	(f) 39,762	337,655	101,814
1893	....	512,950	1959 (e)	6,461,535	(g) 4,373,218	(f) 41,612	259,046	52,843
1894	....	1,003,700	1960 (e)	6,133,240	(g) 4,160,354	(f) 20,549	366,606	63,905
1895	....	1,255,250						
1896	....	1,545,600	1961 (e)	5,533,847	(g) 3,838,387	(f) 25,305	201,957	95,475
1897	....	2,303,300	1962 (e)	5,660,937	(g) 3,993,663	(f) 194,380	281,364	81,506
1898	....	4,086,150	1963 (e)	5,484,259	(g) 3,966,697	(f) 255,190	254,726	70,402
1899	....	6,913,550	1964 (e)	5,266,329	(g) 3,686,732	(f) 272,187	322,916	88,666
1900	....	5,725,400						
			Total	449,863,161	84,433,342	2,394,215	4,860,161	2,853,891

(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.
(f) Excludes Casks (principally empty returns) previously included in this item.
(g) Includes items for which the quantity in cub. ft. is not available.

APPENDIX IV.

SUMMARY OF IMPORTS OF TIMBER, TANNING MATERIALS AND ESSENTIAL OILS, SINCE 1848.

Year	Timber, Woodware, etc.	Tanning Materials	Essential Oils	Year	Timber, Woodware, 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	6,055
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	101,686
				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
				Total	24,021,083	575,576	2,068,043

* This and subsequent years include tanning extracts, not previously recorded.
† This and subsequent years include values for furniture, bamboo, cane, etc., not previously included.

APPENDIX V.

SUMMARY OF LOG VOLUMES PRODUCED IN WESTERN AUSTRALIA SINCE 1829.

Year	*Crown Land	Private Property	Total	Year	*Crown Land	Private Property	Tota
	Cubic feet	Cubic feet	Cubic feet		Cubic feet	Cubic feet	Cubic feet
1829–1916† ..	....	....	663,267,850	1939 (c)	29,247,650	11,086,000	40,333,650
1917 (a)	19,333,100	2,144,500	21,477,600	1940 (c)	27,660,100	9,139,550	36,799,650
1918 (b)	7,665,550	504,950	8,170,500	1941 (c)	28,089,200	10,289,000	38,378,200
1919 (c)	19,987,050	3,390,450	23,377,500	1942 (c)	26,636,650	5,633,400	32,270,050
1920 (c)	28,292,200	5,762,900	34,055,100	1943 (c)	23,604,900	4,322,950	27,037,850
1921 (c)	29,308,950	7,018,450	36,327,400	1944 (c)	22,252,500	4,456,200	26,708,700
1922 (c)	36,122,400	15,640,150	51,762,550	1945 (c)	21,970,000	4,309,550	26,279,550
1923 (c)	26,807,300	9,867,050	36,674,350	1946 (c)	21,126,500	5,482,350	26,608,850
1924 (c)	42,004,450	9,342,800	51,347,250	1947 (c)	21,948,550	7,831,950	29,780,500
1925 (c)	43,832,900	18,142,250	61,975,150	1948 (c)	22,251,350	8,871,900	31,123,250
1926 (c)	48,823,750	25,037,600	73,861,350	1949 (c)	20,261,800	9,814,300	30,076,100
1927 (c)	46,887,600	31,356,100	78,243,700	1950 (c)	21,081,150	9,932,650	31,013,800
1928 (c)	42,781,250	23,334,450	66,115,700	1951 (c)	25,391,450	10,713,050	36,104,500
1929 (c)	32,289,750	11,098,950	43,388,700	1952 (c)	28,942,550	11,938,300	40,880,850
1930 (c)	31,654,150	11,653,600	43,307,750	1953 (c)	34,223,400	13,021,400	47,244,800
1931 (c)	18,822,600	12,148,500	30,971,100	1954 (c)	37,485,950	13,562,000	51,047,950
1932 (c)	11,742,850	4,115,950	15,858,800	1955 (c)	37,467,650	15,195,450	52,663,100
1933 (c)	13,165,650	2,456,650	15,622,300	1956 (c)	39,811,350	13,773,350	53,584,700
1934 (c)	21,263,100	6,330,400	27,593,500	1957 (c)	39,426,100	11,585,350	51,011,450
1935 (c)	27,458,250	11,451,750	38,910,000	1958 (c)	39,069,500	12,397,450	51,466,950
1936 (c)	31,400,600	13,436,150	44,836,750	1959 (c)	40,533,471	13,756,198	54,289,669
1937 (c)	31,703,850	15,902,200	47,606,050	1960 (c)	38,882,048	12,017,553	50,899,601
1938 (c)	31,737,450	15,928,950	47,666,400	1961 (c)	37,752,774	10,818,790	48,571,564
				1962 (c)	39,243,552	9,789,268	49,032,820
				1963 (c)	38,671,715	9,831,552	48,503,267
				1964 (c)	39,431,089	10,220,000	49,651,089
				Total	....	....	2,624,669,810

* 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.

PHYSICAL PROPERTIES OF TIMBERS—SUMMARY.

Timber		Weight, lb./cub. ft.		Per cent. Shrinkage, Green to 12 per cent. M.C.		Transverse Strength (Beams 20 sq. in. cross section 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	54	5·3	7·9	16,200	2,080,000
Karri	*Euc. diversicolor*....	72	57	5·1	10·1	19,200	2,680,000
Tuart	*Euc. gomphocephala*	78	64	4·0	7·0	17,800	2,600,000
Wandoo	*Euc. reduncа var. elata*	80	68	2·5	3·5	16,100	2,250,000
Brown Mallet	*Euc. astringens*	70	63	4·4	7·1	26,000	2,680,000
Blackbutt (Yarri)	*Euc. patens*	70	54	3·5	6·9	14,300	2,000,000
Yellow Tingle	*Euc. guilfoylei*	74	62	....	....	19,400	2,820,000
Red Tingle	*Euc. jacksoni*	60	51	5·7	9·9	14,200	2,934,000
Marri	*Euc. calophylla*	76	54	3·7	6·6	16,500	2,600,000
Sheoak	*Casuarina fraseriana*	60	46	1·2	4·5	12,000	1,356,000

* Detailed information regarding the working 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.

APPENDIX VIII.

TREES SUITABLE FOR PLANTING IN WESTERN AUSTRALIA.

(A) In the South-West (over 20 in. Annual Rainfall).
(B) In that Portion of the Esperance District which receives over 18 in. Rainfall per Annum.
(C) In the Wheatbelt (less than 29 in. Annual Rainfall).

(A) SOUTH-WEST (Over 20 in. Rainfall).

Botanical and Common Name.	Height.	Description.	Recommended Use.	Minimum Rainfall.	Soils.
Acacia baileyana (Cootamundra Wattle)	20 ft. max.	Winter flowering, yellow blossoms, silver foliage	Ornamental	20 in.	Prefers well-drained sites. Sands to medium loams.
**Acacia cyanophylla* (Western Wattle)	20 ft.	Small, quick growing, short lived tree. Rounded, shady, dark green crown	Shade and ornamental	20 in.	Sand and light loams. Suitable for sandy coastal areas.
Acacia dealbata (Black Wattle)	25 ft.	Fast growing, feathery leaves, silver sheen. Strong tendency to sucker from roots	Shade and ornamental	20 in.	Sand, gravel, light loam.
Acacia decurrens (Black Wattle)	Up to 30 ft.	Yellow blossoms, dark green feathery foliage	Ornamental	20 in.	Sand, loam and gravel.
Acacia elata (Cedar Wattle)	40 ft.	Larger and longer lived than most wattles	Ornamental	25 in.	Adaptable to most well drained soils.
Acacia melanoxylan (Tasmanian Blackwood)	60 ft. and over	Larger and longer lived than most acacias. Dense dark green bushy crown	Shade, ornament, avenue planting	35 in.	Light loams and loamy gravels.
Acacia podalyriaefolia (Queensland Silver Wattle)	20 ft.	Very early winter flowering	Ornamental	20 in.	Wide range of soils.
Acacia pycnantha (Golden Wattle) (Note: Acacias are generally short lived with an effective life of 12-25 years)	20 ft.	Hardy species, broad leaves, large golden flowers	Ornamental	18 in.	Wide range of soils.
Agonis flexuosa (W.A. Peppermint)	Up to 25 ft.	Attractive shady tree, often weeping habit	Ideal for metropolitan shade, street and ornamental planting	25 in.	Adaptable to most soils. Prefers sands and light loams.
Angophora costata Syn. Angophora lanceolata (Smooth barked apple)	60 ft. and over	Medium sized tree. Spreading shady crown. Similar to brush box in appearance	Shade, ornamental	30 in.	Adapted to range of soils, light loam, gravel, sand.
Araucaria excelsa (Norfolk Island Pine)	To 100 ft.	Tall, pyramidal tree. Suited to coastal areas. Resistant to sea winds	Ornamental and avenue planting	25 in.	Sand to medium loam.
Brachychiton acerifolium (Illawarra Flame Tree)	To 40 ft.	Massed red flowers in early summer, large glossy leaves	Ornamental	30 in.	Good loamy soils in sheltered position preferred.
Brachychiton diversifolium (Kurrajong)	To 60 ft.	Crown bushy, leaf shape variable	Street, shade and ornamental	18 in.	Sands and light loams.
Callitris robusta (Rottnest Island Cypress)	To 25 ft.	Compact, upright habit	Windbreak, shade, ornamental, suitable for coastal areas	18 in.	Limestone soils, sands and light loams.

Cinnamomum camphora (Camphor Laurel)	To 40 ft.	Spreading tree, dense crown of smooth shining leaves	Street shade and ornamental	30 in.	Loam soil.
Cupressus arizonica (Arizona Cypress)	40 ft.	A hardy but slow growing tree, conical grey green crown	Windbreak, shade and ornamental	18 in.	Sands and loams.
Cupressus sempervirens (Morocco Cypress)	40 ft.	Dense crown, pyramidal form	Windbreak, shade and ornamental	30 in.	Sands and loams.
Eucalyptus botryoides (False Mahogany)	60 ft.	Broad leaves, heavy crowned. Bark rough, dark grey in colour	Shelterbelt, shade and roadside planting	20 in.	Sands and loams.
Eucalyptus calophylla var. *rosea* (Pink Flowered Marri)	To 100 ft.	Broad leaves, dense spreading crown, handsome pink blossoms	Shade and ornamental	20 in.	Well drained sand, gravel or loam.
Eucalyptus camaldulensis (Murray River Red Gum or River Gum)	90 ft.	Fast growing, bark white or grey and smooth. Crown dense and often with pendulous branches. Grows well in Metropolitan area	Ornamental, shade, wind breaks and shelter belts	8 in.	Adaptable to a wide range of soils and climatic conditions.
Eucalyptus citriodora (Lemon Scented Gum)	70 ft.	Slender, erect, graceful form	Ornamental and avenue planting	25 in.	Adaptable to most soils. Frost tender when young.
Eucalyptus cladocalyx (Sugar Gum)	70 ft.	Large spreading crown and clean, smooth bark. Fast growing	Shade, shelter belt and roadside planting	18 in.	Adaptable to most light textured soils.
Eucalyptus cladocalyx, var. *nana*. (Dwarf Sugar Gum)	To 30 ft.	Fast growing, smooth bark, good crown	Street planting, shade groups, shelter belts	12 in.	Light and medium loams and deep sands.
Eucalyptus erythrocorys (Illyarrie)	25 ft.	Slender tree, bark moderately smooth, dull white in colour. Striking scarlet capped buds and bright yellow blossoms	Ornamental	18 in.	Adaptable, better on light soils, lime tolerant.
Eucalyptus globulus (Tasmanian Blue Gum)	150 ft.	Fast growing. Large pendulous leaves	Shade and roadside planting	20 in.	Well drained sand and loams.
Eucalyptus ficifolia (Red Flowered Gum)	40 ft.	Dense, dark green rounded crown. Bark rough. Striking blossoms — various shades of red carried clear of the leaves	Ornament, shade and avenue planting	30 in.	Adaptable, occurs naturally on poor sand and gravel.
Eucalyptus gomphocephala (Tuart)	100 ft.	Fast growing with rough ash-coloured bark and a heavy crown	Shade, shelter belt and roadside planting	20 in.	Well drained sand and loams. Tolerates soils with high lime content.
Eucalyptus lehmanni (Bald Island Marlock)	To 25 ft.	Bushy tree. Flowers unusual and attractive	Windbreak, shade and ornamental	18 in.	Sand and loams.
Eucalyptus maculata (Spotted Gum)	100 ft.	Smooth mottled bark, attractive crown, fast growing	Ornamental, shade and avenue planting	25 in.	Loam and better sands.
Eucalyptus melliodora (Yellow Box)	To 100 ft.	Moderately dense crown	Ornamental, shade and shelter. Good honey producer	30 in.	Adaptable to most soils except poor sand. Prefers loam.

* Salt tolerant.

TREES SUITABLE FOR PLANTING IN THE SOUTH-WEST—continued
(Over 20 in. Annual Rainfall.)

Botanical and Common Name.	Height.	Description.	Recommended Use.	Minimum Rainfall.	Soils.
Eucalyptus occidentalis (Flat Topped Yate)	To 60 ft.	Tall tree, umbrella crown. Bark on trunk rough and dark, on limbs grey and smooth	Shade tree	16 in.	Occurs in low-lying poorly drained clay soils, with or without sandy surface. In wheat belt planting on deep sand has given good results.
Eucalyptus robusta (Swamp Mahogany)	To 40 ft.	Fairly dense crown, large glossy leaves. Bark dark grey	Ornament, shade and shelter	20 in.	Adaptable to most soils including deep sands. Suitable for swampy area.
Ficus macrophylla (Moreton Bay Fig)	40 ft.	Heavy crowned tree. Massive buttress roots	Shade tree and ornamental	20 in.	Adaptable to soils, including coastal sands.
Grevillea robusta (Silky Oak)	40 ft.	Deeply divided leaves. Bright coppery golden flowers	Ornamental	20 in.	Well drained loams.
Hakea laurina (Pin Cushion Hakea)	15 ft.	Large ornamental shrub with rounded crown. Blossoms globular—red tipped with yellow	Ornamental and low windbreak	14 in.	Sand, gravel and light loam.
Jacaranda mimosifolia (Jacaranda)	50 ft.	Popular deciduous tree with fern-like foliage and masses of violet-blue flowers	Ornamental and street planting	20 in.	Good sand or loam. Frost tender when young.
Melaleuca pubescens (Rottnest Island Tea Tree)	To 30 ft.	Dark green, dense spreading rounded crown. Rough bark	Low shelterbelt shade and ornamental suitable for coastal areas	18 in.	Limestone soils, sands and light loams.
Melia azederach (Cape Lilac or White Cedar)	To 30 ft.	Deciduous. Fern-like foliage. Clusters of mauve flowers followed by large yellow berries	Ornament, shade	25 in.	Adaptable to most soils, including deep sand.
Pinus brutia (Closely related to *P. halepensis* but of more symmetrical growth habit)	70 ft.	Small, fine needles. Erect habit of growth	Drought resistant. Shade shelter tree including seaside areas	18 in.	Good sands and light loams. Suitable for limestone areas.
Pinus canariensis (Canary Island Pine)	80 ft.	Hardy pine with broad pyramidal crown long pendulous needles	Shelterbelt, shade and ornamental	18 in.	Good sand or loam.
Pinus halepensis (Aleppo Pine)	60 ft.	Small fine needles, heavily branched, short trunk	Drought resistant. Shade shelter tree including seaside areas	18 in.	Good sands and light loams. Suitable for limestone areas.
Pinus pinaster (Maritime Pine)	60 ft.	Hardy tree with dense crown	Shelterbelt and shade tree. Commercial timber	18 in.	Sandy soils.
Pinus pinea (Stone Pine)	40 ft.	Dense wide spreading umbrella crown	Shelter and shade for farms	18 in.	Sands and loams.
Pinus radiata (Monterey Pine)	100 ft.	Dense erect crown. Rapid growth	Shelterbelt, road and ornamental planting. Commercial timber	25 in.	Good loam soils.

Platanus occidentalis (Plane Tree)	70 ft.	Deciduous, wide spreading crown	Street and ornamental planting	25 in.	Good sands and loam.
Populus nigra (Black Poplar)	100 ft.	Deciduous, erect columnar	Shelterbelt and avenue planting	25 in.	Prefers damp soils.
Quercus lusitanica (Portuguese Oak)	30 ft.	Semi-deciduous, hardy tree, compact crown	Shade tree	25 in.	Adaptable to most soils.
Salix babylonica (Weeping Willow)	30 ft.	Rapid growing tree. Attractive foliage and weeping habit	Shade and ornamental	25 in.	Requires damp conditions.
Tristanea conferta (Brush Box)	Up to 50 ft.	Neat appearance, compact, dark green foliage, small white flowers	Street and ornamental planting	20 in.	Adaptable with a preference for heavy soils.
Ulmus pumila (Chinese Elm)	60 ft.	Deciduous, compact crown	Shade and street planting	20 in.	Good sand or loam.

(B) ESPERANCE PLAINS (18 in. Rainfall Minimum).—For further details see Bulletin No. 2644.

The undermentioned species are recommended as the result of successful local plantings over a number of years. Descriptions are given above.

Eucalyptus cladocalyx (Sugar Gum).
Eucalyptus cladocalyx, var. *nana* (Dwarf Sugar Gum).
Eucalyptus gardneri (Blue Mallet).
Eucalyptus globulus (Tasmanian Blue Gum).
Eucalyptus gomphocephala (Tuart).
Eucalyptus lehmanni (Bald Island Marlock).
Eucalyptus platypus var. *heterophylla* (Hopetoun Moort).
Pinus pinaster (Maritime Pine).
Pinus pinea (Stone Pine).
Acacia pycnantha (Golden Wattle).
Callitris robusta (Rottnest Island Cypress).

(C) TREES SUITABLE FOR PLANTING IN THE WHEATBELT OF WESTERN AUSTRALIA.

(Less than 20 in. Average Annual Rainfall.)

Botanical and Common Name.	Height.	Description.	Recommended Use.	Minimum Yearly Rainfall.	Soils.
Acacia acuminata (Raspberry Jam)	To 25 ft.	Small tree, rounded umbrella crown	Shade, ornamental, fence posts	12 in.	Loams.
Acacia microbotrya (Manna Gum)	To 20 ft.	A small, fast growing tree, dense bluish green foliage	Shade, ornamental, Manna gum production	11 in.	Prefers loamy soils.
Acacia pycnantha (Golden Wattle)	20 ft.	Hardy species, broad leaves, large golden flowers	Ornamental	18 in.	Wide range.
Note: Acacias generally have a limited effective life of 12-25 years.					
Brachychiton gregorii (W.A. Kurrajong)	To 30 ft.	Dense crown, drought resistant, slow growing	Shade and ornamental	8 in.	Loams.
Callitris calcarata (Black Cypress Pine)	50 ft.	Erect symmetrical tree. Dark green conical crown	Windbreak, shade and ornamental	12 in.	Sand, laterite gravels, light loam.
**Callitris glauca* (White Cypress Pine)	30 ft.	Compact, upright habit, silvery green foliage, slow growing	Windbreak, shade and ornamental	7 in.	Sands and medium loams.
**Casuarina glauca* (Swamp Sheoak)	To 30 ft.	Dense crowned sheoak	Shade and sheltre belt—especially for low lying salty areas	12 in.	Sand, light loams.
Casuarina huegeliana (Rock Oak)	To 30 ft.	Symmetrical habit, dense globular crown	Shade, on poor shallow sands.	12 in.	Found on shallow sandy soil around granite rocks. Thrives on deeper sands.
Ceratonia siliqua (Carob Bean)	To 25 ft.	Hardy. Dense spreading crown. Slow growing	Shade and ornamental. Beans useful stock feed	16 in.	Good loam.
Cupressus arizonica (Arizona Cypress)	To 50 ft.	Hardy, but slow growing tree, conical grey-green crown	Windbreak, ornamental	15 in.	Sand and light loam.
Eucalyptus astringens (Brown Mallet)	To 70 ft.	Upright tree, bronze coloured bark, dark green leaves, umbrella crown	Shade and shelter. Tan bark production	15 in.	Sandy or gravelly to loamy soils, preferably with clay subsoil.
Eucalyptus botryoides (False Mahogany)	To 60 ft.	Broad leaves, heavy crowned. Bark rough, dark grey	Windbreak, shade, roadside planting	18 in.	Deep sandy or medium loam.
Eucalyptus brockwayi (Dundas Mahogany)	To 80 ft.	Fast growing upright. Bark pinkish grey, leaves dark green, shining	Shade and ornamental	11 in.	Medium loam.
Eucalyptus caesia (Gungunnu)	To 25 ft.	Bark dark greenish-brown to bronze. Crown rather sparse, flowers large and attractive pink	Ornament — homestead gardens and parks	12 in.	Sands and light loams. Occurs naturally around granite outcrops.
Eucalyptus camaldulensis (River Gum)	To 90 ft.	Fast growing, bark white or grey and smooth. Crown dense and often weeping habit	Ornamental, shade, windbreaks and shelter belts	8 in.	Adaptable to wide range of soils.
Eucalyptus campaspe (Silver Gimlet)	To 35 ft.	Bark smooth and bronze coloured to almost white on smaller twigs. Crown silvery blue-green	Shade, windbreak and ornament	7 in.	Good loams only.

Eucalyptus cladocalyx (Sugar Gum)	To 70 ft.	Fast growing. Bark smooth, light coloured. Wide spreading crown	Shade groups, shelter belts	15 in.	Light and medium loams and deep sands.
Eucalyptus cladocalyx, var. *nana* (Dwarf Sugar Gum)	To 30 ft.	Fast growing, smooth bark, vigorous crown	Street planting, shade groups, shelter belts	12 in.	Light and medium loams and deep sands.
Eucalyptus crucis (Southern Cross Silver Mallee)	To 20 ft.	Hardy, decorative foliage tree, "bloom" covered twigs and leaves	Ornamental, street planting	8 in.	Sands to loam.
Eucalyptus dundasi (Dundas Blackbutt)	To 50 ft.	Fast growing, bark rough and dark brown at base, limbs smooth and copper coloured. Dense crown, leaves shining dark green	Street planting and shade	10 in.	Good loams. Prefers soils with alkaline reaction.
Eucalyptus eremophila (Tall Sand Mallee)	To 20 ft.	Mallee—foliage to ground level Cream flowers, occasionally red or pink in showy clusters	Ornament, wind break, street planting—especially under overhead wires	10 in.	Sand to sandy loams.
Eucalyptus erythronema (White Mallee)	To 20 ft.	Erect handsome mallee. Bark smooth, light grey. Beautiful flowers varying from white to pink or red	Ornamental and street planting, especially under overhead wires	8 in.	Loam to loamy clay.
Eucalyptus forrestiana (Fuchsia Mallee)	To 20 ft.	Attractice mallee. Capsules at flowering time bright red, clustered and pendulous	Ornamental and garden specimen	15 in.	Loamy soils.
Eucalyptus gardneri (Blue Mallet)	35 ft.	Large dense crown, leaves blue-green. Bark smooth and grey-brown	Shade, windbreak, ornamental. Tan bark. Particularly suited to southern wheatbelt	12 in.	Sandy to loamy soils.
Eucalyptus gomphocephala (Tuart)	To 100 ft.	Fast growing, heavy crown, ash-coloured bark	Shade, shelter belt and roadside	18 in.	Sand to light loam. Tolerates soils with high lime content.
Eucalyptus kruseana (Book Leaf Mallee)	To 20 ft.	Unique appearance. Leaves small, round, sessile and bluish. Flowers yellow in spike-like arrangements	Ornamental	8 in.	Loamy sand (occurs naturally in shallow soils near granite outcrops).
Eucalyptus lehmanni (Bald Island Marlock)	To 30 ft.	Bushy globular form from near ground. Umbrella crown develops with age. Flowers greenish yellow fused together in clusters	Windbreak, shade and ornament	18 in.	Sands and loams.
Eucalyptus leucoxylon (Yellow Gum—N.S.W., Blue Gum—S.A.)	To 70 ft.	Attractive tree; white bark, pink or white flowers	Ornamental, street or avenue planting, shelter belts, honey production	14 in.	Medium to heavy loams.
Eucalyptus leucoxylon var. *macrocarpa*—pink form (S.A. Blue Gum).	To 30 ft.	Attractive tree; large pink blossoms	Ornamental, street planting, wind breaks, honey production	14 in.	Sand to medium loams.
**Eucalyptus lozophleba* (York Gum)	35 ft.	A fair shade tree with umbrella crown. Trunk rough barked and usually crooked	Shade and shelter belt	16 in.	Prefers sandy loams to medium loams. Will often survive on shallow soils when other species may fail. Fairly salt tolerant.

* Salt tolerant.

TREES SUITABLE FOR PLANTING IN THE WHEATBELT OF WESTERN AUSTRALIA—continued.

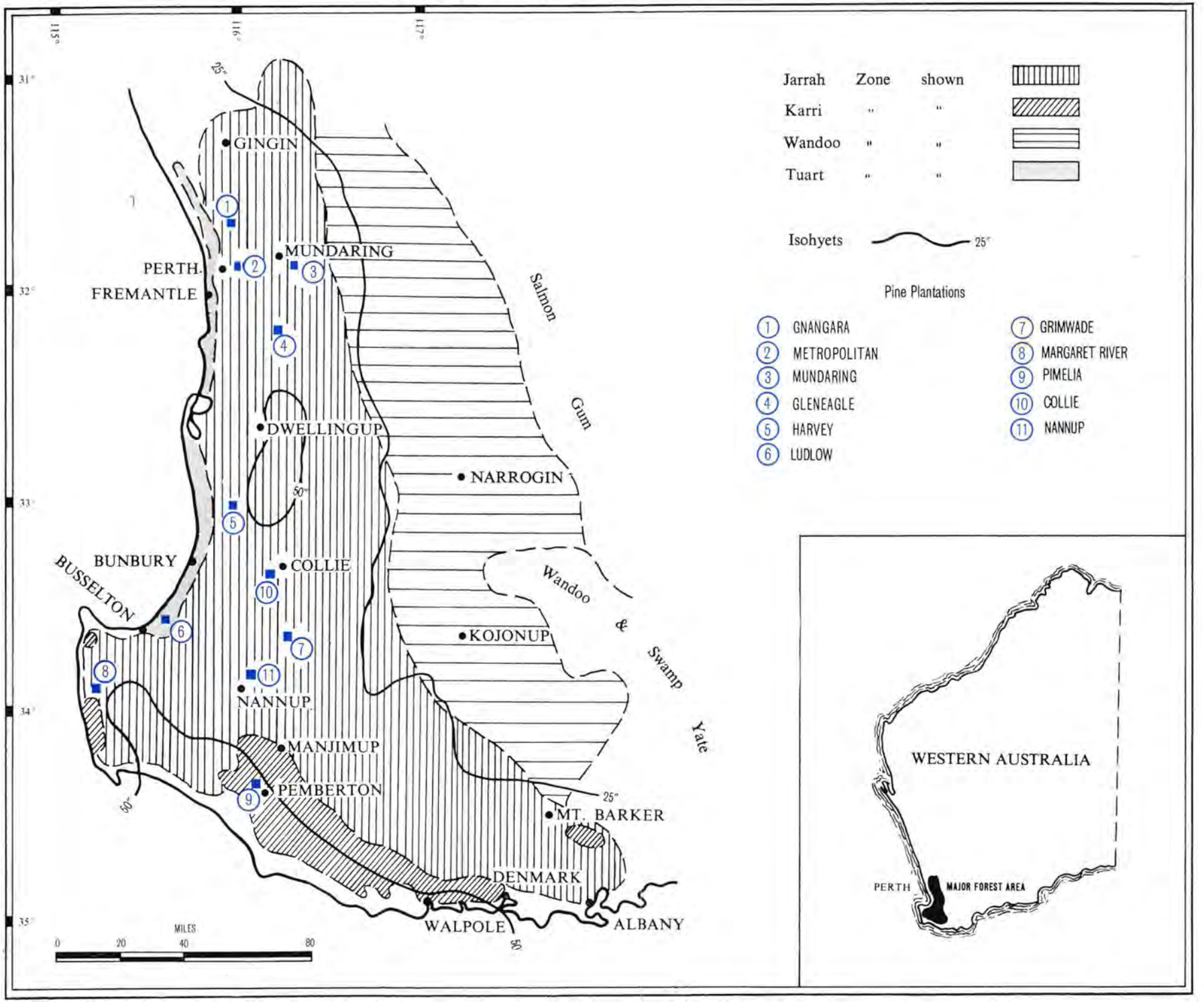
Botanical and Common Name.	Height.	Description.	Recommended Use.	Minimum Yearly Rainfall.	Soils.
Eucalyptus occidentalis (Flat Topped Yate)	To 60 ft.	Tall tree, umbrella crown. Bark on trunk rough and dark, on limbs grey and smooth	Shade tree	16 in.	Occurs in low-lying poorly-drained clay soils with or without sandy surface. In wheat belt planting, deep sand has given good results.
Eucalyptus oleosa, var. *kochii* (Watheroo Mallee)	To 25 ft.	Tall, mallee, umbrella crown, rough grey bark, very drought resistant	Low shade or low shelter belt	12 in.	Sands, sandy gravels and light loam.
Eucalyptus platypus (Moort)	To 25 ft.	Dense rounded crown. Bark moderately smooth, light grey. Greenish-yellow flower	Shade, street planting, low windbreaks and shelter belts	14 in.	Medium to heavy loams.
Eucalyptus platypus, var. *heterophylla* (Hopetoun Moort)	To 20 ft.	Bushy tree, cream blossoms	Ornament, low wind break and shelter belts. Good tree for coastal areas	15 in.	Sand to medium loam.
Eucalyptus pyriformis (Pear Fruited Mallee)	20 ft.	Rather sparse crowned mallee with very large blossoms varying on different trees from pale yellow to rich red	Ornamental	12 in.	Sand to medium loam and loamy gravel.
Eucalyptus (Wandoo)	To 90 ft.	Fairly dense spreading crown. Bark smooth and light coloured. Foliage bluish green	Shade and shelter belts	18 in.	Heavy soils preferably with clay subsoil.
Eucalytus inland form (Wandoo)	To 50 ft.	Fairly dense spreading crown. Bark smooth and light coloured. Foliage bluish green	Shade and shelter belts	9 in.	Adaptable, including poor gravelly sands.
Eucalyptus redunca, var. *melanophloia* (Black Barked Marlock)	25 ft.	Rounded shady crown. Large dark green leaves	Shade, ornament, low shelter belt or windbreak	15 in.	Occurs naturally on sandy clay flats but will adapt itself to a range of soils.
Eucalyptus salmonophloia (Salmon Gum)	To 80 ft.	Handsome tree. Early growth rather slow. Bark smooth salmon coloured. Fairly dense crown with shiny leaves	Shade, windbreak, shelter belt and avenues	7 in.	Medium to heavy loams.
Eucalyptus salubris (Gimlet)	To 40 ft.	If adequately spaced, forms good shady crown, leaves dark green. Bark smooth, bronze coloured. Trunk straight and fluted	Shade, street and avenue	7 in.	Medium to heavy loams.
**Eucalyptus sargenti* (Salt River Gum)	To 30 ft.	Vigorous early growth. Bushy globular crown. Medium density	Shade, shelter and windbreaks. Suited to salty areas	15 in.	Sand to medium loams. (Found on low lying areas near salt lakes.)
**Eucalyptus spathulata* (Swamp Mallet)	25 ft.	Small tree or mallee with smooth bronze coloured bark. Leaves very narrow. If given adequate growing space develops a bushy crown	Shade and shelter belt	12 in.	Medium to heavy loam. Fairly salt tolerant.

Eucalyptus stoatei (Scarlet Pear Gum)	20 ft.	Erect tree with compact dense dark green crown. Buds and capsules large and bright red immediately prior to and following flowering	Ornamental and street planting	12 in.	Sands and light to medium loam.
Eucalyptus stricklandi (Yellow Flowered Blackbutt)	To 35 ft.	Bark—lower trunk, black and rough, upper trunk and limbs grey and smooth. Leaves large and shining. Striking large yellow blossoms	Shade, shelter and ornament. Highly drought resistant	7 in.	Loams and loamy gravels (not suitable for poor sands).
Eucalyptus torquata (Coral Gum)	To 35 ft.	Rounded dense crown, leaves dark green but lack lustre. Handsome blossoms white to deep pink. Bark rough, flaky and dark grey	Street, ornamental and shelter belt	7 in.	Loams and better quality gravel soils.
Eucalyptus woodwardi (Lemon Flowered Gum)	To 35 ft.	Rather open crowned. Mature form bears pendulous branches. Leaves large and glaucous. Large lemon-yellow blossoms	Ornamental	7 in.	Good light or medium loam.
Eucalyptus woodwardi x Euc. torquata (hybrid)	Probably 40 ft.	Taller and more erect than *Euc. torquata* and more densely crowned than *Euc. woodwardi*. Bark dark grey and smooth. Blossoms vary from yellow to orange pink	Shade, shelter and ornamental	10 in.	Good light or medium loams.
Pinus brutia (Closely related to *Pinus halepensis*)	To 70 ft.	Erect form, small fine needles	Shade and shelter belts including seaside areas. (Drought resistant)	18 in.	Sandy soils. Suitable for limestone areas.
Pinus canariensis (Canary Island Pine)	To 80 ft.	Hardy pine, stately broad pyramidal crown, long pendulous needles	Shelterbelt and ornamental	18 in.	Good sand or light loam.
Pinus halepensis (Aleppo Pine)	To 60 ft.	Heavily branched with small fine needles	Shade and shelter belts including seaside areas. (Drought resistant.)	18 in.	Sandy soils suitable for limestone areas.
Pinus pinaster (Maritime Pine)	To 60 ft.	Hardy with dense crown	Shelterbelt and shade tree. Commercial timber	18 in.	Deep sandy soils.
Pinus pinea (Stone Pine)	40 ft.	Dense wide-spreading umbrella crown	Shelter and shade for farms	18 in.	Deep sandy soils.
Schinus molle (Pepper Tree)	To 25 ft.	Feathery leaves; bears clusters of small white flowers and pink "berries"	Ornamental. Should not be planted near gardens, sewerage systems, etc., due to its aggressive rooting habit	12 in.	Adaptable in its requirements —from sandy to medium loams.
**Tamarix articulata (Syn. T. aphylla)* (Athel Tree or Evergeen Tamarisk)	To 40 ft.	Dense, bushy tree, fine greyish-green leaves. (Easily grown from cuttings.)	Shade, windbreak, ornament	7 in.	Suitable for heavy salty soils.

* Salt tolerant.

APPENDIX VIII

Major Forest Types and Pine Plantations in W.A.



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