BULLETIN Nº 63

Forestry in WESTERN AUSTRALIA

FORESTS DEPT.
— W. A. —

FORESTRY

IN

WESTERN AUSTRALIA

•

PREPARED UNDER THE DIRECTION OF

A. C. HARRIS

CONSERVATOR OF FORESTS

ISSUED UNDER THE AUTHORITY OF

THE HON. H. E. GRAHAM, M.L.A.

MINISTER FOR FORESTS

o

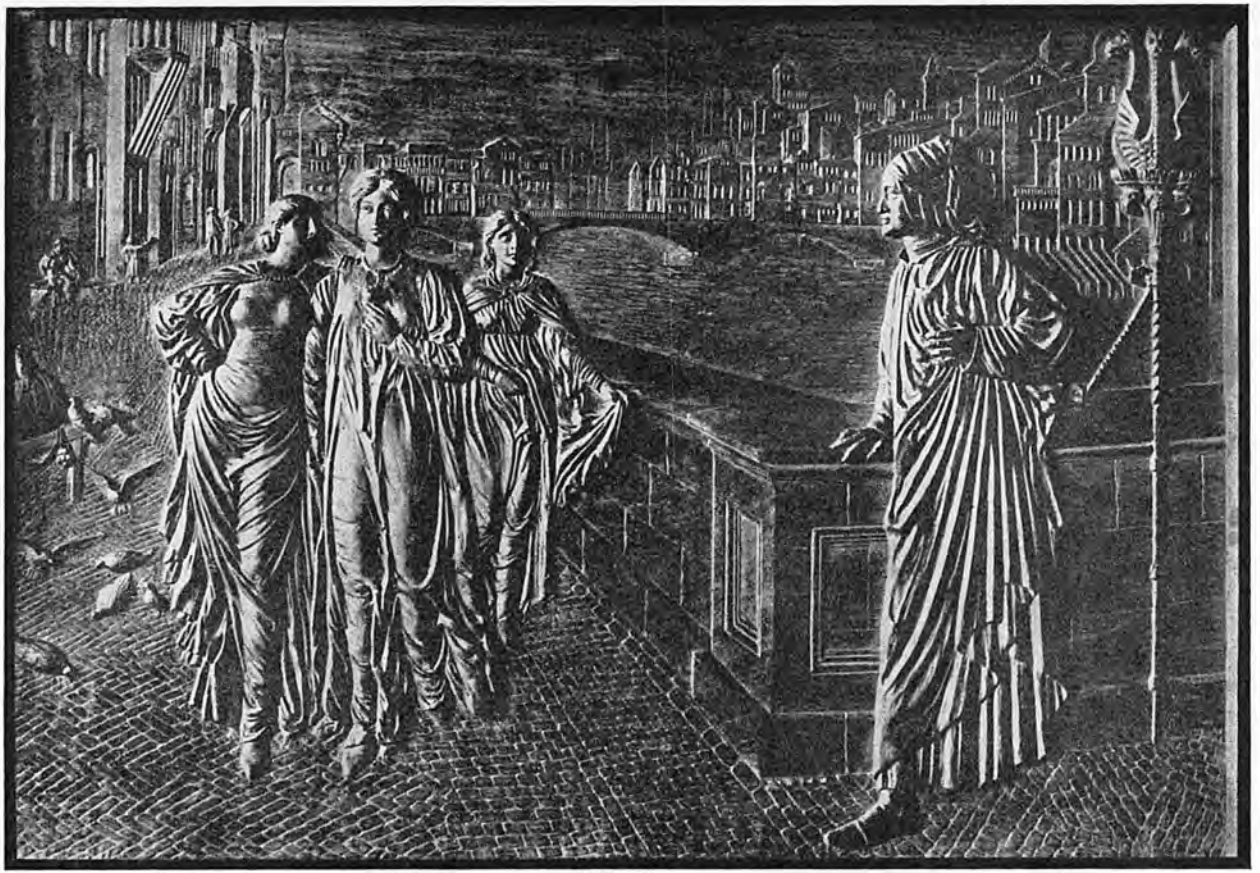


Plate 1.

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

Preface . . .

IT has become obvious from the numerous inquiries, both technical and general, received by this Department during recent years, that the people of Western Australia are becoming increasingly conscious of the value of their forest heritage and the necessity for its conservation, efficient management and wise use. This is even more important in the light of our increasing population and future timber requirements.

"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 readily understood by the interested layman.

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

As it is intended to revise this publication from time to time, any suggestions from readers for its improvement will be greatly appreciated.

A. C. Harris

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 utilisation 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.

Utilisation of produce was the first aspect of forests with which men were concerned, hence, *Forest Utilisation* 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 to calculate the annual or periodic growth and to plan for its orderly utilisation.

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 Utilisation, 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.

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 flimsy cigarette paper to the newspaper and 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.

The per capita consumption of sawn timber may be taken as a broad criterion of the standard of living of a country and a cross section of the world's requirements is given in Table 1.

TABLE 1.

Per Capita Consumption—in Super Feet of Sawn Timber (1949-1954).

Canada	284	U.K.	68
New Zealand	280	Israel	44
U.S.A.	250	Argentine	42
Norway	212	Brazil	25
Australia	174	South Korea	10
Sweden	152	Sudan	2
French Guiana	140	Ethiopia	0.8
British Guiana	114	Pakistan	0.2
U.S.S.R.	131		

World Figure 72
Western Australia 232

Plate 2.

A bush locomotive hauling a rake of logs in the karri forest.

The world's top exporting nation is Canada with also the highest per capita consumption, followed by New Zealand, U.S.A. and with Western Australia a good fourth. The less developed countries towards the end of the table show a much reduced demand. This demand, however, must increase as the standards of living and industrialisation of these nations improves.

Sweden is of interest as one of the most stable countries of the world with an economy based largely on her timber wealth. The United Kingdom has a consumption below the world average and is possibly evidence of an industrially stable community in which little expansion is taking place. It is also a nation which has always had to rely on imports for a major portion of its requirements.

For comparison the Commonwealth and State consumption is outlined in Table 2 which again shows the high demand we are placing on the forests of Western Australia compared with the more conservative requirements of New South Wales—the most populous State and the greatest importer of timber.

TABLE 2.

Australian States—Per Capita Consumption Sawn Timber in Super Feet.

Western Australia	232
Queensland	210
Tasmania	185
Victoria	185
South Australia	177
New South Wales	149
Commonwealth	177

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 regionof 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.

(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 nineteenth 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.

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 nearly 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. ~~Twenty~~ 25 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. (1963

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 of years—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 recommendation 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. Three hundred mills are operating at the present time and the industry employs more than 7,500 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 in the next 25 years. 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.

Plate 3.

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

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. Architects and builders must take more care that the correct quality is issued 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 4.

The Donnelly River Sawmill—(Wheatley)—one of over 250 mills which operate in this 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.

Some possibility of relief for the future is 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 20,000 acres of plantations and every effort is being made to attain an immediate goal of 2,000 acres planted each year. Sawn timber from small early plantings is already being produced, and over 250,000 cubic feet was cut last year.

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

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

THE LIFE STORY 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 are naturally deep rooters and 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 deep rooting, while shallow or waterlogged soils lead to shallow rooting.

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, increase in diameter 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 and 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.

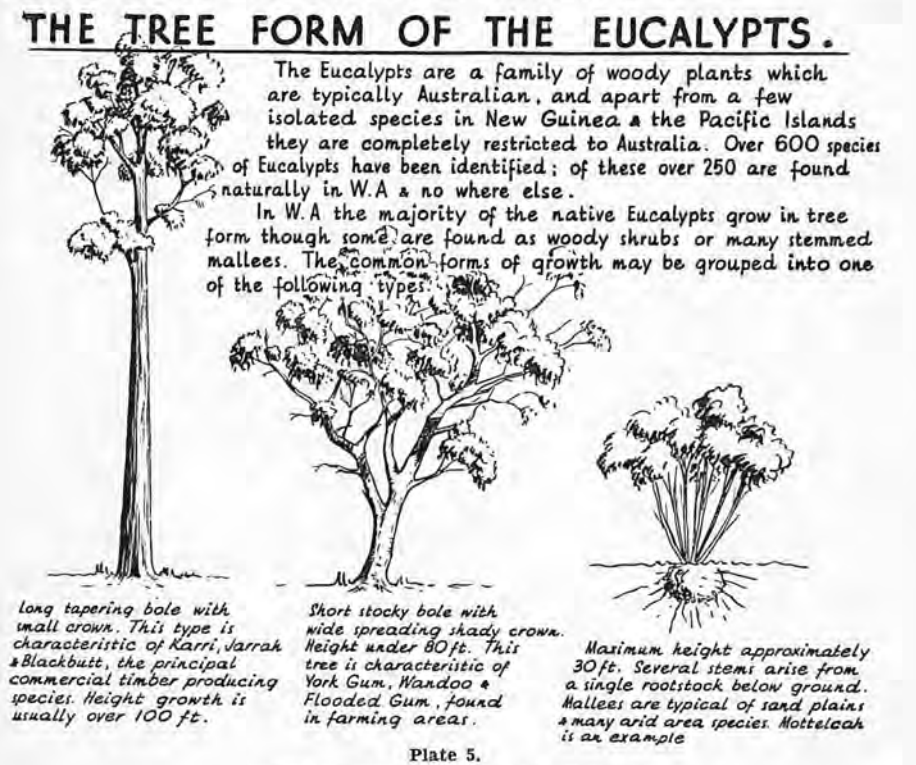


Plate 5.

Three common habits of the eucalypts.

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 usualy 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.

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.

THE VITAL LIFE PROCESSES OF A TREE.

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.

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 and 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.

The production of organic foods from simple naturally occurring elements takes place in the presence of sunlight and is called photosynthesis. This process is restricted to the green plant cells.

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—

Carbon dioxide from the air + water + chlorophyll + sunlight =
Sugars + oxygen + chlorophyll.

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 crown is transpiration, or the expulsion of excess water from the tree into the atmosphere.

Less than 1% 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 identical with animal respiration also; oxygen is utilized and carbon dioxide is expelled. The energy required for the 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 plant 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.

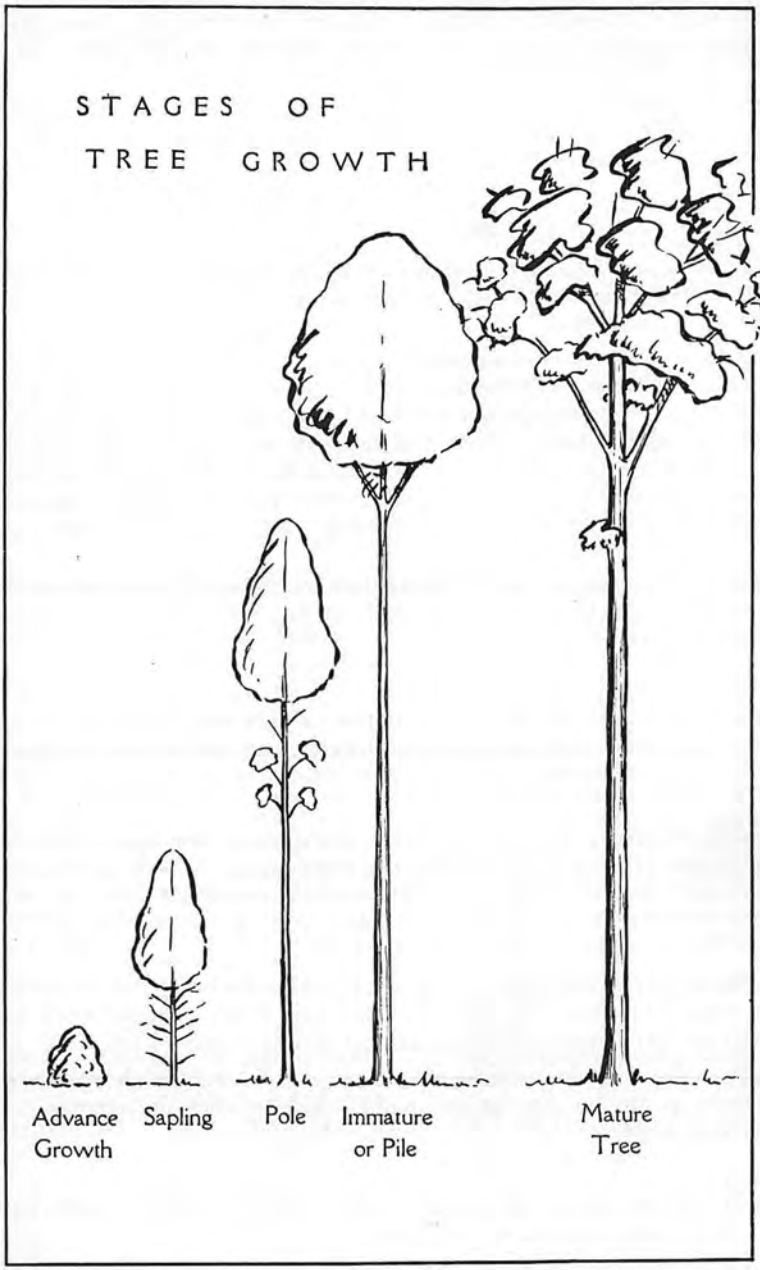


Plate 6.

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.

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 give birth to 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.

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 made at three main growing regions. Growth in length for the roots in a downward direction and the shoot in an upward direction is made at special growing points situated at the root and shoot tips. Growth is attained by the formation of new cells and not by an increase in dimensions of existing cells. A tree thus 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 third growing region of a tree is called the cambium and is concerned with the growth of diameter for 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 below the bark. From it cells are formed in two directions; new wood cells are formed on the inside of the cambium and new bark cells on the outside.

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 7) 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 heart wood.

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. (Fig. 2.) 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 has an active part in the life processes of the tree. It is located next to the cambium and functions in sap conduction and 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.

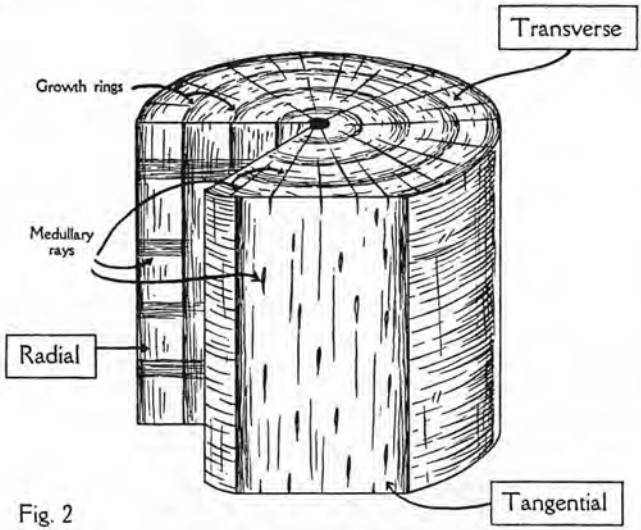


Fig. 2

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

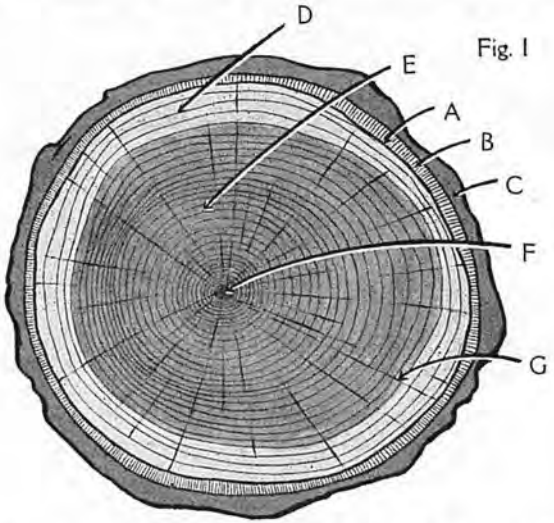


Fig. 1

Diagrammatic sketch of a transverse section of tree trunk

Plate 7.

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

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 on page 29 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.

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

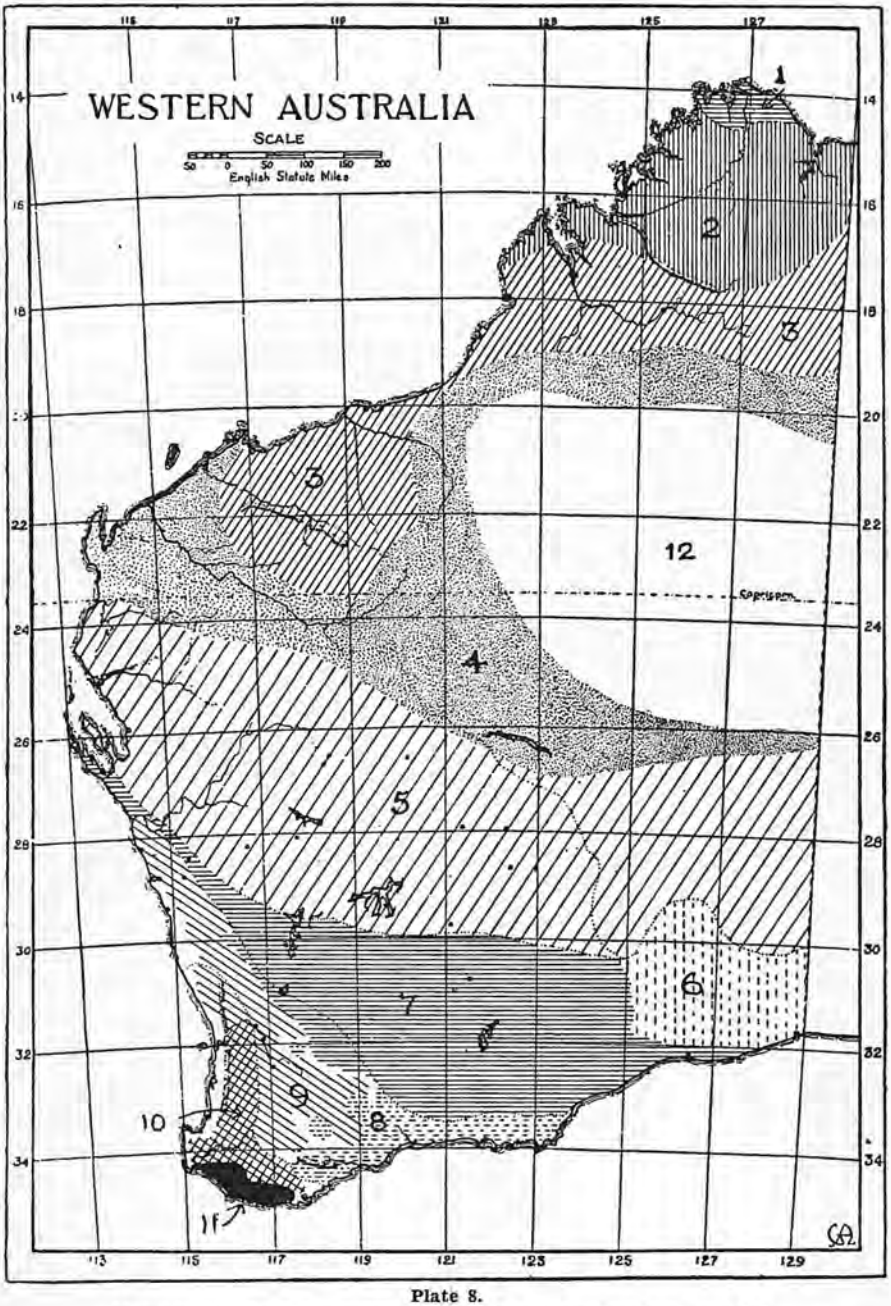


Plate 8.

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

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 industry 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 spcies jarrah (*Euc. marginata*), karri (*Euc. diversicolor*), tuart (*Euc. gomphocephala*), wandoo (*Euc. redunca var. elata*), 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.

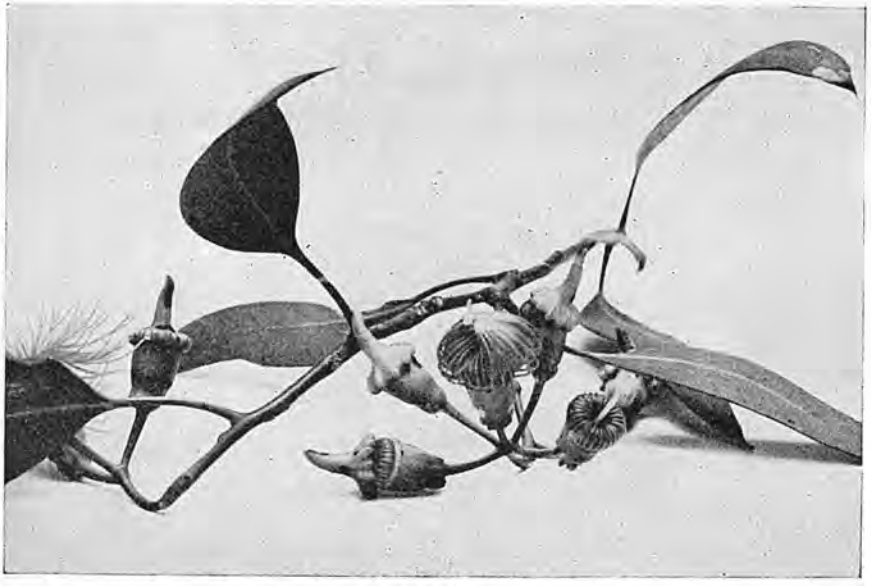


Plate 9.
Coral Gum (*Eucalpytus torquata*).

In recent year, the minor Western Australian trees have received considerable attention. Such species as salmon gum *(Euc. salmonophloia)*, the mallets *(Euc. astringens, Euc. gardneri, etc.)*, morrel *(Euc. oleosa var, longicornis)*, gimlet *(Euc. salubris)*, coral gum *(Euc. torquata)* and others, typical of semi-arid to arid regions of the State are rather 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 crimson flowered 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.

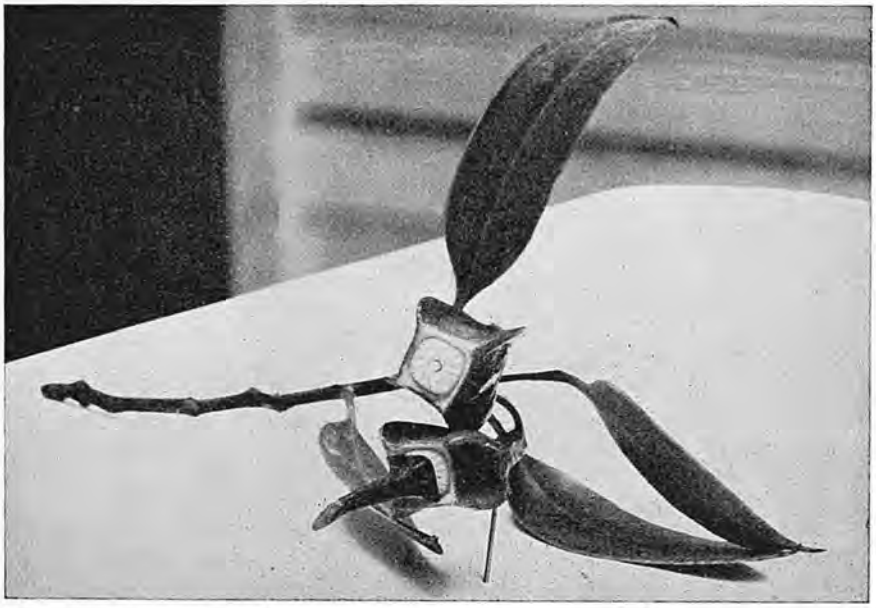


Plate 10.

Fuchsia Mallee *(Eucalyptus forrestiana)*.

The great majority of important trees of the State belong to the genus Eucalyptus, being of the evergreen, hardwood type. 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.

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

	Common Name and Scientific Name.
Jarrah	*Eucalyptus marginata*
Karri	„ *diversicolor*
Tuart	„ *gomphocephala*
Wandoo	„ *redunca var. elata*
Marri	„ *calophylla*
Blackbutt	„ *patens*
Yate	„ *cornuta*
Red Tingle	„ *jacksoni*
Yellow Tingle	„ *guilfoylei*
Crimson Flowered Gum	„ *ficifolia*
W.A. Peppermint	*Agonis flexuosa*
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*
Red Morrel	„ *oleosa var. longicornis*
Dundas Mahogany	„ *brockwayi*
Goldfields Blackbutt	„ *lesouefii*
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 cygnorum*
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. Appendix I provides a more complete list of the Eucalypts of Western Australia.

CHARACTERISTICS OF THE GENUS EUCALYPTUS

The Eucalyptus derives its name from two Greek words which may be translated as "well covered"—a name applied to the little cap which protects the unopened flower, and one which aptly describes what is perhaps the leading feature of the genus. The most noticeable feature about a Eucalyptus flower is the absence of both sepals and petals, and the presence of the bud cap or operculum which protects the stamens in the end stage. 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* are closely allied to the genus *Angophora,* which is found only in the Eastern States, and 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.

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.

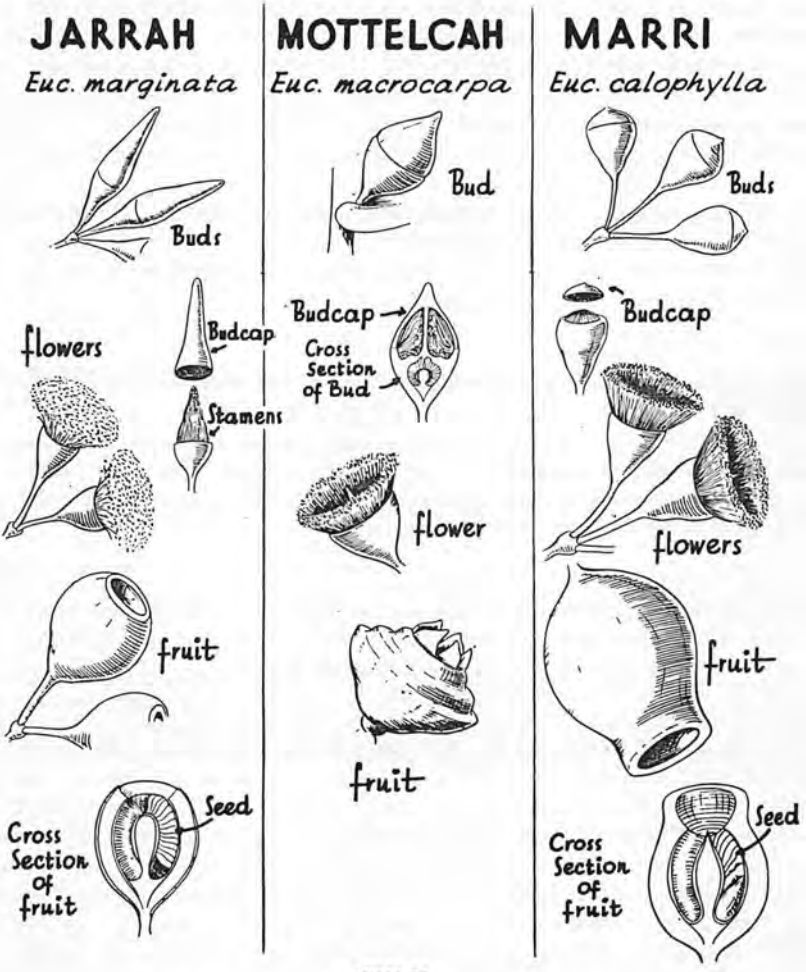


Plate 11.

The flowering forms of three common W.A. 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 forest 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 and karri and tuart areas, but also the semi-arid and arid area woodlands in which wandoo, salmon gum, morrel, gimlet and mallet are prominent. It can be seen, therefore, that within the scope of the word "Forest" 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 utilisation 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 different requirements of the main tree species occurring within them. 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 made up from several component parts. Under forest conditions these components, vegetation, soil, animals, insects and birds, do not exist as separate entities. They exist in an environment in which each

is dependent on the others for its existence. 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.

Plate 12.

Mature jarrah forest near Dwellingup.

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

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

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 stories. 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, sheoak and banksia. The lowest limit, or strata, 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 plan 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 utilised by the forest. Natural forest soils, in contrast to soils subjected to agricultural cropping, maintain their fertility under continued use.

When managing forests, if soil fertility is to be maintained and tree growth sustained over long periods, it is of prime importance that the nutrient balance is maintained.

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 utilisation.

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.

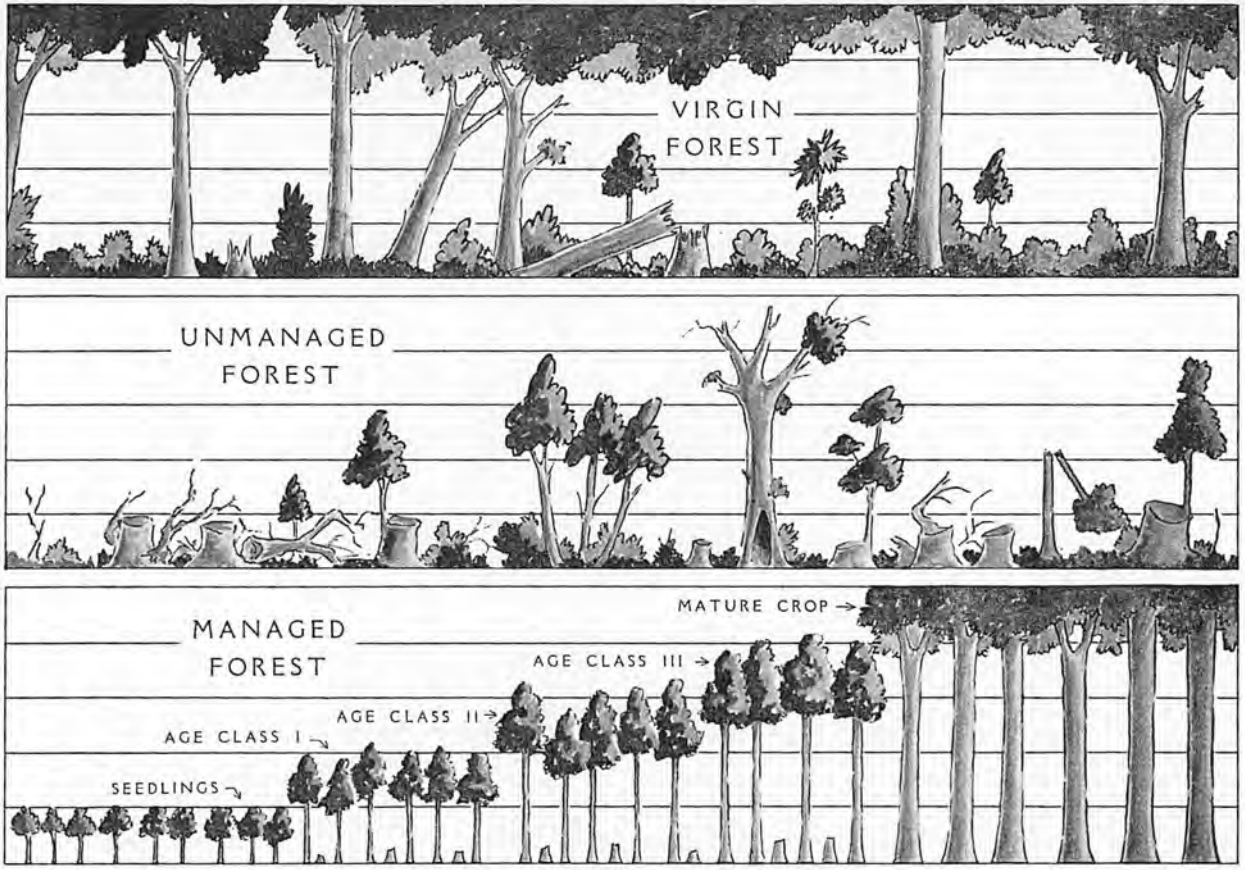


Plate 13.

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.

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 occurring in all forest formations. These, too, are part of the forest complex which must be considered by the forester in his management measures. Insects and fungi from all appearances form a minor part of the complex, but unfortunately play a large part in forest use. They represent the greatest source of damage to growing timber, apart from fire.

All insects and fungi are not harmful. Some insects are pollinators and necessary for reproduction of many of the 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 aspect of plant ecology. Each of the participants in the union give and take some substance from the other. In the case of many trees, vigorous growth is not possible without this association with a certain type of fungus.

Pines in Western Australia require a mycorrhizal association and until this was realised, and the necessary fungi introduced, all attempts at pine nursery establishment 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 stripped of its forests by man's activity. This 30% depletion of the original forest area provides a grave warning of what could be the fate of the present forests unless they are placed under wise and careful management.

The following table provides the total area of forest land in Australia:—

Total Area of Forest Land (excluding some poor forest in the Northern Territory). Thousands of acres.

	Cypress Pine.	Coniferous Plantation.	Eucalypt.	Rain Forest.	Total.
Queensland	1,621	55	13,130	2,506	17,312
N.S.W.	1,315	60	28,025	600	30,000
Victoria	—	73	17,223	—	17,296
South Australia	—	120	6,477	—	6,597
Western Australia	—	18	39,072	—	39,090
Tasmania	—	10	6,240	750	7,000
A.C.T.	—	16	227	—	243
	2,936	352	110,394	3,856	117,538
Percentage	2.5	0.3	93.9	3.3	100

In the table are included all lands carrying timber of any kind in forest formation. In relation to the total area of Australia the percentage of forested land amounts to 6%, an extremely low figure when compared with a world figure of 27%. However, if the area of the Commonwealth supporting a population of less than one person per square mile is excluded, the percentage of forested land of what may be termed the "inhabited area" reaches 38%.

The Western Australian figure includes over 19 million acres of timber in the Goldfields region, important for the supply of firewood and mining timber, and an additional 12 million acres of marginal forest capable of producing rough material only. This leaves a potential prime forest area suitable for sawmilling operations of only 8 million acres.

The following table provides an idea of the area of productive forest of sawmilling quality in the various States and includes private property and Crown land in addition to land held by forest authorities.

Area of Productive Forest of Sawmilling Quality.

State.	Millions of Acres.
Queensland	7
N.S.W. (including A.C.T.)	12
Victoria	12
South Australia	0.3
Western Australia	8
Tasmania	5
Total	44.3

This area represents 2% of the total land area of Australia, and 14% of the inhabited area.

The highest quality forests have already been dedicated to timber production and it is considered that in this State the present five million acres of State Forested Timber Reserves represent the bulk of the quality forest area available for dedication.

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 *(Euc. marginata)* is the principal timber tree of the State. Owing to its resemblance to a Honduras timber, in the early days it was called mahogany, but about 1860, as it was realised that the timber had so many fine qualities peculiar to itself, it was considered that the tree deserved a vernacular name of its own, and thenceforth it became known by its aboriginal name—Jarrah.

Description of the Forest.

Jarrah is a large tree, attaining 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, and flat, with small fissures running vertically and horizontally. This bark renders jarrah distinct from all South-Western trees, except from the Albany blackbutt *(Euc. staeri)*, and the red tingle *(Euc. Jacksoni)*, which trees also have fairly stringy barks, although not as tough as that of jarrah.

The jarrah formation is a high forest with a small admixture of marri *(Euc. calophylla)* with blackbutt *(Euc. patens)*; flooded gum *(Euc. rudis)* and bullich *(Euc. megacarpa)* occurring 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 Reidlii)* occur with grass trees *(Kingia Australia)* on the poorer sandy types. The ground is covered with a wealth of shrubs and woody plants.

Though lacking the aesthetic qualities of other forests, the saving grace of the jarrah formation is its remarkable purity, and the value and utility of the timber it produces. The prime belt is by far the least mixed eucalypt forest covering so wide an area in Australia, and is considered to be one of the finest hardwood stands in the world.

Plate 14.

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

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 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 Collie 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.

The tree gives way to wandoo *(Eucalyptus redunca var. elata)* on the eastern side of this belt on the heavier soils, and to karri (Eucalyptus diversicolor) and marri in the almost temperate rain forest climate to the south. It is the main tree on the coastal sand plain south of Perth, but is replaced by tuart *(Eucalyptus gomphocephala)* on the limestone outcrops near the coast.

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 realized that there are few uses to which jarrah cannot be put, 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 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 solution for all timber problems. 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.

A further use for jarrah is found in shipbuilding.

The durability of the timber is remarkable. 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 of use. It is not surprising that jarrah sleepers and crossing timbers have a world-wide reputation.

Prior to the development of concrete and asphalt 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, flower in the following November and December. From this flowering, the fruits mature to shed their fertile seed in the following summer, two years after first formation of the bud.

Seed years, however, are not regular and heavy seeding occurs once only 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.

The jarrah forest shows a marked reaction, in the form of an intense degradation of the crown which may lose practically all of its leaves, whenever there is a periodic heavy seeding. The annual light seeding of the healthy regrowth does not result in this crown deterioration.

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 1,500 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.

Owing to insect attack and the prolonged dry summer, the mortality rate is exceptionally high, probably exceeding 90 per cent., while further deaths occur in the second summer.

On the surviving seedlings a small ligno tuber (a hard woody tuber) develops in the first year and the seedling does not immediately develop the upright single stem of the typical young sapling. Instead, the ligno-tuber enlarges as the years go by and the young jarrah develops to some two feet in height as a hemispherical multi-stemmed bushy form, or "advance growth" as it is called locally. Under forest conditions, this lingo tuber develops to about four inches diameter before a single leader shoot can get away from the bushy growth to form a sapling. This initial development stage may take anything from 10 to 20 years.

Once the 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 reasonable shade.

Jarrah has a remarkable resistance and power of recovery, so much so that endeavours to kill it are frequently abortive.

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 to 600 years. Because of their great age, a long period of decline of perhaps 50 years 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 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 been a factor of the jarrah forest environment as far back as history can trace. It is also considered that in certain instances, 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.

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 fire hazard.

Next comes the operation of treemarking. Nearly every tree which is felled for saw-milling is 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 the least desirable elements of the old crop; and in the openings left by these trees the regrowth will become established.

The young 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 cleaned 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.

Plate 15.

Falling a large jarrah tree with a power drag saw.

Full protection from fire must be afforded for a period of years until the blanks 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 levels of live crown above 12 feet.

Growth Rates.

The growth of jarrah is extremely slow when compared with some of the introduced pines. On the best qualities 0.75 inches in girth per year can be achieved and about 18 inches in height. The lower site qualities are even slower and an 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 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.

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 little value for farming. It is also found mixed with karri over the karri forest area.

Timber.

The timber is light brown in colour, easily worked and were it not for the presence of gum veins, it would be amongst the most valuable timbers in the State. Sound marri timber may be used for all purposes where strength and elasticity are required. This timber has not been extensively used so far, but 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 process consisting of boiling the green timber in open vats containing molasses and arsenious oxide

Weight per cubic foot (green)	76 lb
At 12 per cent. moisture	54 lb.
Transverse strength	16,600 lb. per sq. in.
Tensile strength	20,200 lb. per sq. in.

Plate 16.
A jarrah regrowth stand of age 25 years resulting from silvicultural treatment following heavy logging operations.

Uses.

Marri is used for weatherboards and building scantling, case manufacture, knees of small craft, general mill work and waggon stock.

It is reputed to make a good axe and tool handle and there is a future for it for all small turnery work.

Though not popular at present, marri is a timber which will play an important part in the future timber economy of this State as is indicated by its widespread use in the construction of Forests Department houses and its present wide trials in sleeper tests.

While the presence of gum reduces the value of the timber, the gum itself has a potential value for tanning purposes. It has been found that the tannin content of the kino can be as high as 68 per cent. The cost of collection of the kino is one of the main problems at present. Marri has an advantage over all other tannin-bearing trees in that the product rich in tannin can be obtained without destroying the tree.

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 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 cork appearance. Considerable difficulty is experienced by most people in distinguishing this tree in the forest from jarrah. The leaves, however, are smaller than those of jarrah, and of a bluish-green. 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 over the prime jarrah forest region and occurring with jarrah, in portions 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 is a pale yellow coloured wood. 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 as a sleeper in the same class as jarrah sleepers.

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.

The common name "blackbutt" arises from the fact that the thick, deeply furrowed cork bark is frequently blackened by fire at the butt.

NATIVE PEAR (*Xylomelum occidentale*).

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 sea coast.

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 species suffers very badly from fire, and it is therefore very difficult to obtain in sizes greater than 12 inches in diameter.

RIVER BANSKIA (*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 two feet six inches. The bark is persistent, grey, and completely fissured longitudinally; when cut it shows red. The tree occurs along the side of 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 oak-like 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 opening which let out the seeds, are a light brown inside and open widely.

The wood is sound with broad medullary rays, which show up and make the timber particularly beautiful when cut on the quarter. It takes a good polish and stands up well, 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 erected houses 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 has a good demand as a timber for keg and cask construction due to its relatively small movement in shrinkage.

THE KARRI FOREST

KARRI is the aboriginal name for that noble tree, botanically known as *Eucalyptus diversicolor*. This latter or specific name refers to the difference in colour of the two sides of the leaves, the under surface being a paler green.

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, 120-160 feet free from side limbs 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 master piece 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 38ft. 6in. 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 the 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 40in. per annum. The main belt of karri forest lies South of the North-West-South-East line through Manjimup, extending from Nannup in the North-West to the Frankland River, 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.

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, a forest of perhaps one million acres exists over approximately 50 per cent. of the area, sometimes as pure karri stands, and sometimes in mixture with marri, or, more rarely, in mixture with

jarrah or the tingles *(Euc. jacksoni* and *Euc. guilfoylei)*. The remaining 50 per cent. of the area is occupied by jarrah-marri forest or wide poorly drained flats carrying no tree growth of commercial value.

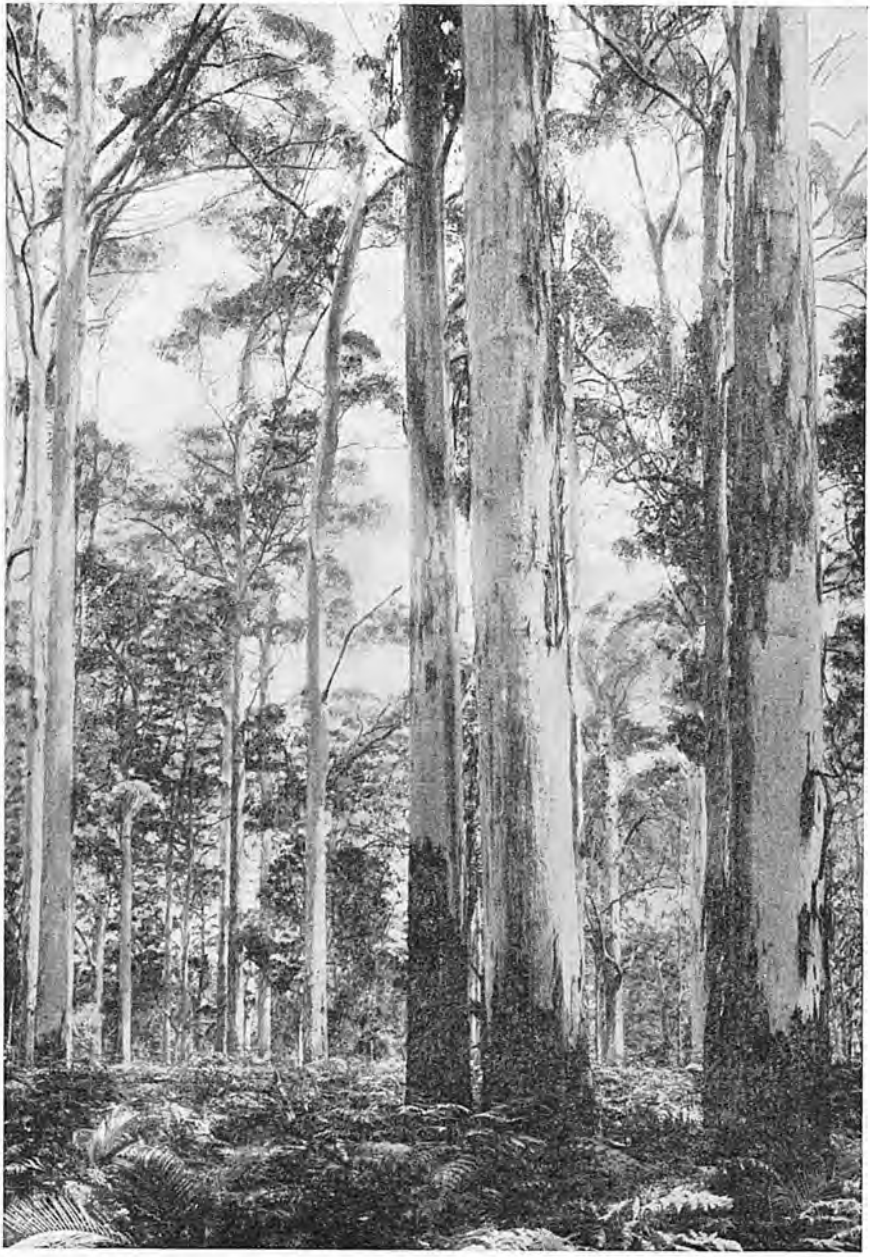


Plate 17.

Karri forest. Long clean boles with the typical "gum" bark.

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 is reddish-brown, closely resembling jarrah in appearance, although generally lighter in colour. Karri can be distinguished from jarrah by burning a splinter of the woods, the former giving a white ash, whereas jarrah burns slowly to a black charcoal.

Karri is moderately heavy in weight, hard, with a long grain and stronger and tougher than jarrah. It is not, however, durable in the ground and does not resist white ant attack. The average life of untreated karri sleepers is 6.3 years in Western Australia. On the Nullarbor Plain however, where rot and termite hazards are small, karri sleepers are used quite satisfactorily in the Commonwealth railway line. The average life under these conditions is from 20-30 years.

Weight per cubic foot (green)	73 lb.
At 12 per cent. moisture	58 lb.
Transverse strength	19,200 lb. per sq. in.
Tensile strength	18,750 lb. per sq. in.

Uses.

Karri timber really came into its own in Western Australia during and after World War II. Although a superb structural timber of great strength and available in large dimensions, it did not rank high in favour in W.A. because of its lack of durability without preservative treatment. The State had been thoroughly spoilt by abundant supplies of such durable woods as jarrah and wandoo (Euc. redunca var. elata). Karri was described by C. E. Lane-Poole as "the Queen of Structural Timbers" and was readily sought by overseas buyers for such purposes as mine guides, railway waggon scantling, telegraph cross-arms, wharf and bridge timbers, etc.

With diminuation in supplies of jarrah, karri is finding much wider use within the State for general structural purposes. Some three-quarter million fruit cases are produced annually to carry the apple crop to England. In 1944 the plywood industry was established in this State using selected karri logs and karri remains the main source of peeler logs within Western Australia.

A considerable quantity of sawn karri is still exported to the Commonwealth for sleepers and railway purposes and to Adelaide and Melbourne markets for building, motor body construction, etc.

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

While karri produces a certain amount of cream coloured blossom annually, heavy flowering occurs only once in four or five years. Occasionally heavy blossom may occur in two consecutive years.

Buds commence to form from April to July, continuing to appear for some months. Within six months they may be half an inch or more in length, with a firm, full appearance as if ready to burst, but flowering may be delayed a further 6 to 12 months or more.

Actual flowering spreads over many months, being heaviest in the summer months from January to April. When flowering, the karri forests are great honey yielders.

Karri honey is a high grade product widely recognised as the best honey produced in this State. It is a light coloured clear honey with a delicate flavour and excellent consistency. The karri forest usually contributes about 25% of all the table honey produced in Western Australia.

Viable seed production usually occurs up to 12 months after flowering. Karri is a prolific seeder, forming small seeds averaging approximately 16,000 per ounce when clean, or 3,600 per ounce when mixed with the chaff, as under natural conditions.

Seed Fall and Regeneration.

The seed vessels do not open during the first summer unless induced by external factors, such as the death of the tree (with subsequent drying), or hot bush fires. Many seed vessels shed seed during the second summer, and the remainder open during the third summer.

Seed fall and subsequent germination are abundant. On the bare mineral soil exposed by controlled burning of litter and ground vegetation, germination occurs in 3 to 4 weeks, carpeting the ground with seedlings. In virgin forest the majority of this young regeneration dies during its first summer, except in large natural openings. Opening of the forest canopy by trade cutting or ringbarking furthers vigorous establishment of this germinated regeneration material. Seedling height growth of 4 to 6 feet per year is usual, effectively suppressing other vegetation in dense thickets.

Vigorous sapling stands often attain heights of 80 to 90 feet in 20 years.

Growth from seed is rapid, the young crop rapidly taking possession of the site, particularly on heavily burnt areas where native scrub has been destroyed eliminating competition to the initial seedling growth.

Within 20 years the karri saplings have completely mastered the site, suppressing all undergrowth and weaker members of the stand.

Thinning.

Karri thins itself moderately well naturally. The dominant trees race ahead in height growth, developing larger crowns and overcoming their neighbours in the struggle for light, space, and soil nutrients. Fire probably aids this thinning process as suppressed saplings are very thin-barked and readily killed by fire.

Vigorous dominants develop a thick fire-resistant bark near the butt and can survive from all but the hottest fires. Successive severe fires, however, will kill these trees back to ground level.

Judicious use of controlled fire in sapling stands does not appear to have any adverse effect on tree growth.

A seedling establishment of 20,000 or more per acre under natural conditions of height growth and fire is reduced to 1,000 trees at 10 years, and 500 at 20 years. Except on an experimental scale no artificial thinning treatments have been carried out in the karri forest. This practice would prove quite uneconomic unless, or until, there is a market for the thinnings. Should a pulp industry develop, a large amount of raw material would 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, or 50-60 years of age, at Karridale and from old farm properties, one of which dates back to 1872.

Measurement of sample plots laid down in regrowth indicates that karri will produce from 75 to 150 cubic feet of wood per acre per annum on favourable sites.

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 attempts to preserve smaller immature trees. Many of these were smashed in felling operations. Marri trees were ringbarked, the understorey scrub felled, and the whole burnt by a fierce fire in a good seed year. The remaining non-marketable karri seed trees shed seed from vessels opened by the heat of the fire onto the burnt, bare, mineral soil. A dense and uniform crop of young karri resulted. This crop was safeguarded from competition by the standing seed trees by ringbarking and killing these latter.

In 1936 this method was replaced by a silvicultural system known as the Selection System. Under this system, mature trees for felling are selected and marked by a Forest Officer, with an effort to retain undamaged the maximum number of immature trees for subsequent growth.

Following felling, the tops left lying on the ground are cleared away from the remaining trees and burnt during a good seed year. Resulting regeneration is good, but persists only in the openings created by fellings and where far enough away from the competition of remaining groups of immature trees. Such regeneration is far less spectacular than that obtained under the former clear felling system, but is nevertheless effective and leads to the development of an uneven aged forest, as distinct from the former resultant even aged stands.

The Selection System is the accepted method of treatment and is most desirable. As well as providing for all sizes of trees to be present in the forest, it does not waste the young growth which has not yet attained merchantable size. These retained trees continue to grow vigorously and will furnish a second cut some 30 to 40 years after the initial cutting operation.

Plate 18.
Crosscutting a large karri log with a power chain saw.

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.

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.

Plate 19.
W.A. Peppermint *(Agonis flexuosa).*

Timber.

The timber is yellow in colour, exceedingly hard and dense and very durable, being used for railway sleepers having 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. inch.

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.

CRIMSON FLOWERED GUM *(Eucalyptus ficifolia).*

Eucalyptus ficifolia is a tree indigenous to Western Australia only and 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 in its native State and in the Eastern States is very much used for ornamental planting. It is one of the most showy of the eucalypts, as the flowers are of gorgeous colour and stand out very prominently above the dark green foliage. A canker disease has severely attacked specimens planted in Perth and was responsible for the death of most 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 25 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.

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 the 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 State which has a ground covering partially of grass, a factor typical of savannah formations generally.

Peppermint *(Agonis flexuosa)* attaining heights 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.

Although on the whole the tuart forms pure stands, it is nevertheless associated, particularly near its boundaries, with other eucalypts. 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, generally in pure stands of large timber. 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 the 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 exists 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.

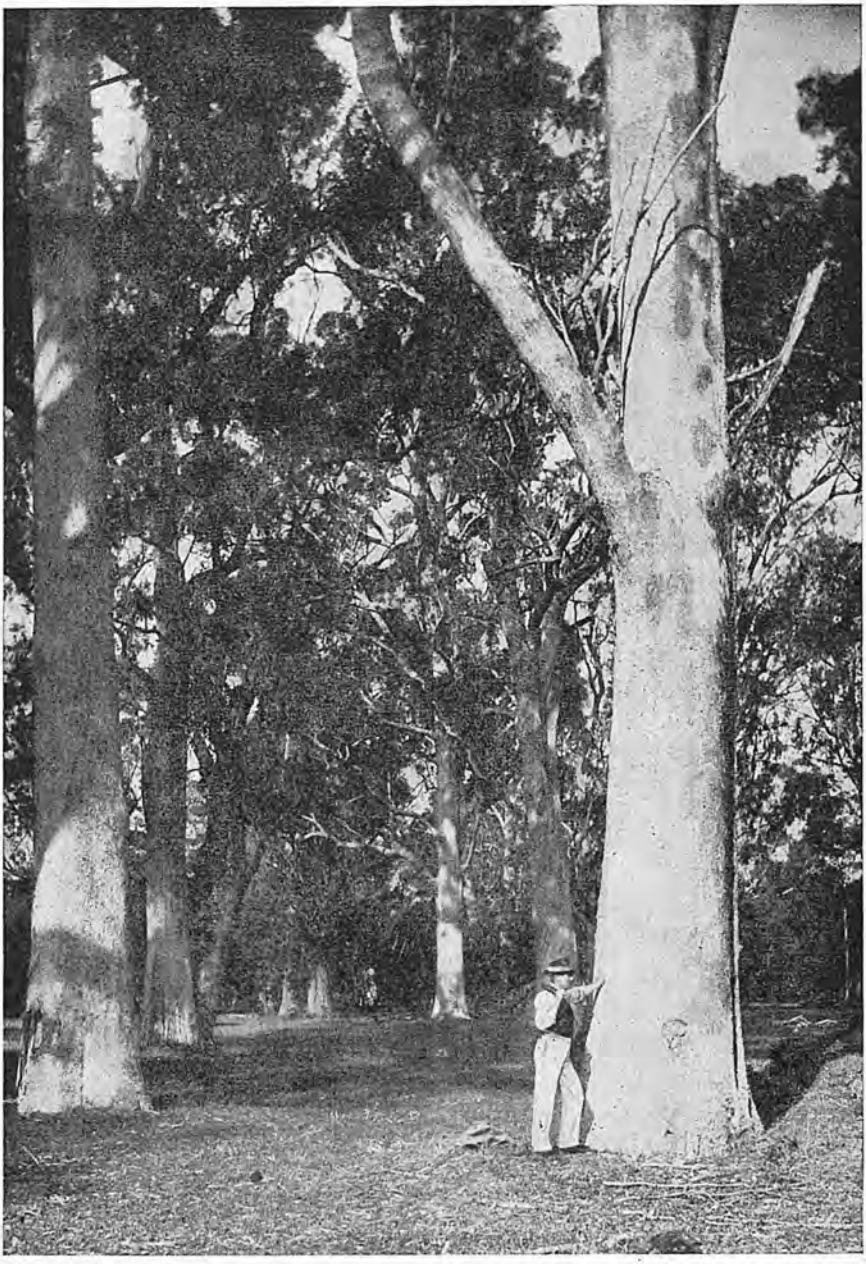


Plate 20.

Tuart (*Eucalyptus gomphocephala*) forest near Busselton.

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 pins which supported telegraph insulators. The timber is reasonably termite resistant and even stronger than that of the wandoo.

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 the story is more complicated than this.

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, and in one test for tensile strength and breaking load was 17½ tons per square inch, 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 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 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.

Plate 21.

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

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.

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 in the construction of bridges and wharves finds use 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 material.

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 exils 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 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 SPECIES OF 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.

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.

Plate 22.

York Gum *(Eucalyptus loxophleba).*

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.

readily distinguishable from other Eucalyptus associated with them. These four species occur in a fairly distinct zone. They all have an economic value for tannin production, the brown being the most important of the group and swamp mallet, which is of limited extent, being the least important.

Description of the Forest.

The mallets are smooth-barked trees, the brown, blue (refers to leaf colour) and swamp mallets having a bronze coloured bark, while the white mallet has a light grey to pale bronze bark. The bark which usually has a bluish-grey appearance is about $\frac{1}{4}$ to $\frac{3}{8}$ inch thick in young trees but up to $\frac{5}{8}$ inch thick on old trees. It decorticates and flakes during the summer, the new bark being bronze coloured, gradually growing darker as the season progresses.

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 six 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 exists today in dense groups of regrowth, naturally and under plantation conditions, producing beautiful and heavy crowns when given sufficient spacing, and making a most ornamental tree.

Plate 23.

Raspberry Jam *(Acacia acuminata).*

Distribution.

The four species occur between York and Mt. Barker in the S.E. District of the State.

To the east of the 25 inch isohyet, the jarrah forest gives place to savannah forest of wandoo *(Euc. redunca var. elata)* and further east the wandoo savannah gradually merges into the low rainfall temperate forests and woodland of salmon gum and morrell, 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 clustered on the breakaways.

Brown, blue and white mallet obtained 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.

Utilisation.

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 the mallets, however, arises from the tannin which is extracted commercially from the barks and used by the leather industry. In this respect, *Eucalyptus astringens* is the most important, and the bark of this species contains 40 to 57 per cent. tannin. The bark has in the past been the subject of an extensive export trade, but due to over-

exploitation, the supply at present is just sufficient to meet local demands. Mallet bark is obtained by stripping the bark from the tree, which is killed by this operation. Though the tree regenerates well, the stripping of young mallet saplings before they reached the seed bearing stage and the damage to the young regrowth from fire has led to a great reduction in distribution and availability of the species.

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 fire but sparse, even after trade cutting, if the area is unburnt.

The artificial regeneration of brown mallet has been carried out for over 27 years, and 18,000 acres of plantations have been established. The procedure is to remove all marketable timber on an area, clear fell the remainder and, after it has dried, burn in late summer. Sowing is carried out as soon as possible after burning to take advantage of the early winter rains. Small spots about 12in. in diameter at about 6ft. intervals are lightly cultivated with small hand hoes and a pinch of seed dropped on each (about ½lb. of seed per acre is used), lightly covered and then compacted by light pressure from the planter's foot.

Best results are obtained when the intensity of the heat from the fire is 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 has been 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 have appeared in minor proportions in the plantations showing that they can be established in the same manner as the brown mallet.

Several years ago a limited area of white mallet was sown on a laterite gravel site considered too poor for brown mallet and some of them have grown 12 feet in height and two inches in diameter at breast height whereas the best developed brown mallet on the same site did not exceed two feet. The development of white mallet to date has been sufficiently satisfactory to warrant its more extensive use in future on the poorer sites. On better sites, however, it does not give as high a yield of bark as the brown mallet.

With the exception of *Euc. spathulata,* all species have for several years been regularly raised under nursery conditions in various forms of containers —principally earthenware flower pots and also in tubes and in metal trays 4½in. 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. These species are becoming increasingly popular for street planting in Australian inland towns.

However, trees established by direct sowing in the plantations are much slower in their development, and sites are considered of first quality when the annual height increment is 18in or more. The rate of growth of the edge trees of the compartments is considerably greater and their girth is often as much as double that of the trees within the compartments away from the cultivated fire breaks. Recent sowing trials have been made in which the debris has been bulldozed into strips following the contours and then is burnt. The aim in this method is to concentrate the ash beds and so provide a more uniform crop and by subsequent cultivation of the intervening strips, reproduce the "edge effect" through the compartment.

Yield of Tan Bark.

Anticipated yields from the mallet plantation are at present 120 tons per annum progressively increasing to 700 tons per annum in 1978 when the oldest trees reach the age of 50 years. To ensure continued production of 700 tons per annum of mallet bark, a programme of sowing equivalent to 150 acres of first quality mallet is being maintained.

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° latitude and on the east by the 125° east longitude. The south-western boundary approximates to the 20 inch isohyet.

This region falls naturally into two distinct forest zones, the boundary between which approximates to the 10 inch isohyet. The southern zone is characterised by Eucalypt forest and the northern by Acacia (Mulga) forest.

The Eucalypt Zone.

This is spread over an area of approximately 135,000 square miles, but at least 60 per cent. of this is treeless scrub plain or has been cleared in the process of settlement in the wheat belt. Successful wheat growing appears to be possible only where the winter rainfall does not fall below eight inches. While this zone forms one broad climatic type, there are a number of sub-types recognised—

(1) *Salmon Gum (Euc. salmonophloia), Gimlet (Euc. salubris), and Red Morrell (Euc. oleosa var. longicornis) Forests.*—This forest under favourable conditions, attains a height of 85 feet and provides the greater part of the mining timber and a large proportion of the firewood used in the mining industry. Up to twelve tons of firewood per acre have been obtained from forest of this type. Minor species which occur in this association are merritt *(Euc. flocktoniae)*, Dundas blackbutt *(Euc. dundasi)*, black morrell *(Euc. melanoxylon)*, and redwood *(Euc. oleosa var. glauca)*. The understorey consists of hardy perennial shrubs and annual herbage.

Plate 24.

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

(2) *Goldfields Blackbutt (Euc. le souefii)—Morrell Forest.*—Where the morrell predominates, this forest attains a height of 80 feet, but farther east, where the morrell becomes less vigorous and the blackbutt forms the principal species, the height seldom exceeds 60 feet. This type of forest is also the source of large quantities of both mining timber and firewood.

This forest occurs in the vicinity of lakes on soils characterised by a fluffy texture and with a high calcium carbonate and gypsum content in the subsoil. The understorey consists mainly of salt bush *(Atriplex)*, blue bush *(Halgania)* and *Eremophilas*.

(3) *Mallee Forest.*—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 forest 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.

(4) *Sand Plain (Scrub Plain).*—This formation carries no timber of economic value and is a sub-type on which the eucalypts do not predominate. The chief genera represented are *Acacia* and *Grevillea*.

(5) 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. There Acacias have vertical phyllodes of a whitish hue and the general appearance of the mulga is drab and dull. The most outstanding species are:—

Narrow leafed mulga	*Acacia aneura*
Broad leafed mulga	*Acacia craspidocarpa*
Gidgie	*Acacia linophylla*
Myall	*Acacia sowdenii*
Irish mulga	*Acacia resinomarginea.*

The height attained by mulga is usually in the region of 15 or 20 feet, but occasional specimens up to 30 feet are found in the more favoured localities.

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 history of the goldfields forest during the last fifty years 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.

Nominally, cutting is practically on a clear felling basis, as the only trees which are excluded from the operations of licensees are those of under five inches diameter at six inches from the ground. Actually, scattered over-mature trees which are unfit for mill logs and too tough to split for firewood are left and these assist, to a limited extent, in providing seed for the second crop. Most of the seed, however, comes from the trees which have been felled and many of the seedlings become 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 years 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 such 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 1/5th of an inch in girth per annum) restocking is a very slow process. The majority of the Acacias in the association possess marked value of 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 and the pastoralist.

THE PRINCIPAL GOLDFIELDS TREES.

SALMON GUM *(Eucalyptus salmonophloia)*.

Salmon Gum ranged from 80 to 100 feet in height, with a bole of 40 to 50 feet, and about 2½ to 3 feet in diameter. Branches are spreading-erect and the burnished or lacquered dark green foliage is a feature possessed by but few other trees. The bark is smooth throughout and rather thick, friable, and yellowish-pink. 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 fresh, reddish brown when dry, exceedingly dense and strong. It has been used extensively for mining and farming purposes.

At 12 per cent. moisture	70 lb.
Weight per cubic foot (green)	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 in red loamy or light clay soils, sometimes mixed with gimlet and other species.

Plate 25.

Gimlet *(Eucalyptus salubris)*.

THE GIMLETS.

COMMON GIMLET *(Eucalyptus salubris)*.

SILVER-TOPPED GIMLET *(Eucalyptus campaspe)*.

The gimlets are small trees of a maximum height of 40 feet. 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 enjoys a wide range, always occurring on low lying areas, frequently in association with the salmon gum. The silver-topped gimlet is confined to the Eastern Goldfields in the Coolgardie and Bullabulling districts. It receives its name from the pale bluish green leaves and white powdered branches and twigs.

The timbers are very hard, and are extensively used for building and mining purposes in the districts in which they grow. Both trees are eminently suitable for planting in parks, in gardens, and as street trees.

RED MORRELL *(Eucalyptus oleosa var. longicornis)*.

BLACK MORRELL *(Eucalyptus melanoxylon)*.

These two species attain a height of 60 feet to 90 feet with a bole of 30 feet to 40 feet and a diameter up to four feet. Red and black morrell are very similar to each other in general appearance, but the former has a reddish-coloured timber and the latter a brownish-black coloured timber.

The bark of both species is rough, grey in colour, and persistent for almost the whole length of the main trunk. The morrells occur in a rainfall belt of about 10 to 12 inches through a tract of country stretching from Three Springs on the north, Katanning on the south, and the Goldfields on the east.

The following are the physical characteristics of red morrell:—

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

THE DUNDAS MAHOGANY *(Eucalyptus brockwayi)*.

This tree is indigenous to the Norseman district where it grows to a height of 80 feet, with a broad crown of deep lustrous foliage and a smooth barked trunk up to three 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 Dundas mahogany occurs freely in the Norseman district associated with the greenstone formations of the area. Its associates are salmon gum, morrell, merrit, and Dundas blackbutt.

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

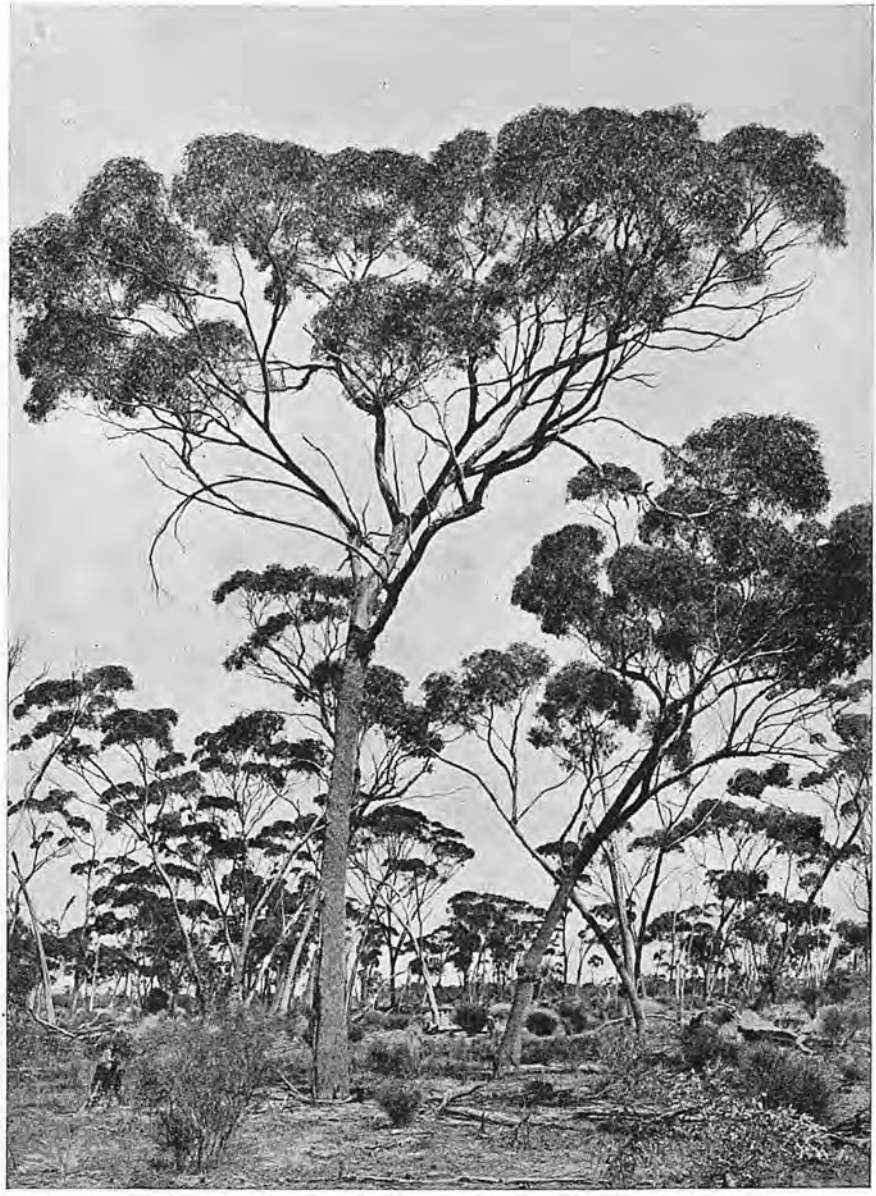


Plate 26.

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

GOLDFIELDS BLACKBUTT *(Euclayptus le souefii)*.

Eucalyptus le souefii forms a tree of 30 feet to 50 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, but is useless for anything except firewood as most trees of any size are attacked by white ants. This species occurs north of Coolgardie and is very common in the vicinity of Widgiemooltha.

There are numerous different species on the Goldfields very similar to Eucalyptus le souefii, with the characteristic dark, rough bark at the base of the tree. All of these species go by the name of "blackbutt."

GREY GUM *(Eucalyptus griffithsii)*.

Eucalyptus griffithsii forms a tree seldom exceeding 25 feet in height and having a dark grey flaky bark over most of the trunk. In general appearance it is intermediate between Goldfields blackbutt and morrel.

REDWOOD *(Eucalyptus oleosa var. glauca)*.

Redwood resembles the wandoo of the Darling Range, but is smaller, more slender, and with a much whiter bark. When in tree form it may be 30-50 feet in height with a bole of 15-25 feet and a diameter of one foot. It exists also as a mallee form.

The fruits generally have a distinct neck. The flower buds have a long narrow point, and are nearly half an inch in length. Leaves are narrow, under three inches long and a bright green.

In the Kalgoorlie-Norseman area redwood forms a well shaped tree extending in range westwards halfway to Perth and southwards almost to the sea. In the eastern wheatbelt and towards the south coast it occurs in mallee form on acid sandstone soils.

GOLDFIELDS YELLOW FLOWERED GUM *(Eucalyptus stricklandi)*.

Eucalyptus stricklandi forms a tree of 20 to 30 feet height with a light brown bark covered with grey flakes which peel off. The branches are very widely spreading or even drooping. The young branches are covered with a white powder, and the leaves are large, thick, and of a blue-green colour, usually above six inches long. The flowers are very handsome, being of a bright yellow, and one and a half inches across.

Eucalyptus stricklandi occurs to the south of Coolgardie and near Norseman, growing mainly on gravelly hills.

THE CORAL FLOWERED GUM *(Eucalyptus torquata)*.

Coral gum grows to a small stout tree of 20 to 30 feet with widely spreading branches bearing blue-green pendulous leaves. The bark is persistent, dark grey or almost black, longitudinally fissured and friable. The pink blossoms are produced in pendulous clusters in considerable abundance, and remain attractive from the time the yellow and red buds are formed until the flowering

season is completed. It is one of the most beautiful of our trees, and ranks with the red flowered gum of the south-west for scenic effect. It flowers in December, and for that reason is also known as the Christmas tree. Buds and fruits are very distinctive, the buds with a broad ribbed base and a narrow beak of half an inch in length. Fruits are egg-shaped, with a frill-like base.

The distribution of this species is limited in the Goldfields area, always occurring on rising ground in gravelly soil around Coolgardie and scattered to at least as far south as Widgiemooltha.

KURRAJONG *(Sterculia gregorii)*.

Kurrajong grows to 25 feet 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, broadly bell-shaped. The species occurs freely throughout the Goldfields, particularly in the "mulga" area. Initial growth rate is very slow.

THE GOLDFIELDS PINE *(Callitris glauca)*.

This native softwood tree may attain a height of 30 feet 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 in open country. It is valuable as a fencing timber, since it is resistant to white ant attack.

SANDALWOOD *(Santalum cygnorum)*.

At the present time this species may be found growing as a small tree to a height of 12 to 16 feet, with a diameter of six to eight inches. Before it had been so extensively exploited, specimens reaching a height of 25 feet, 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 the Darling Range. 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 to the railway lines running to goldmining centres of the interior as a sideline by prospectors.

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 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 medicinal purposes.

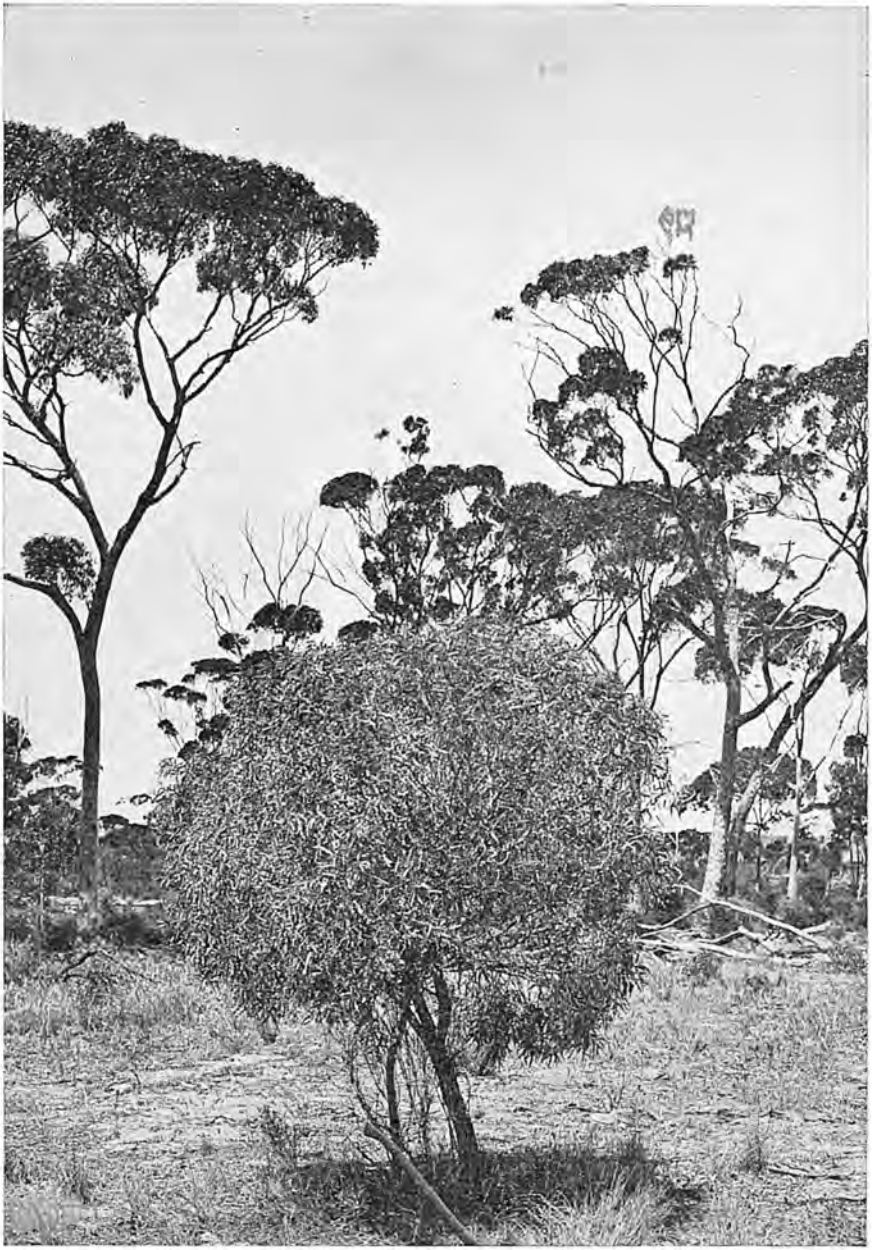


Plate 27.

Sandalwood *(Santalum cygnorum).*

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 be but 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 overmature, stabilised virgin stands in which the ground flora was completely suppressed and controlled by the dominant tree growth. The general appearance was park-like with a relatively open and clear forest floor beneath a closed shady canopy of trees.

Such forests 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 aggravated by almost a century of uncontrolled exploitation when the Forests Department first took steps to organise against uncontrolled fires.

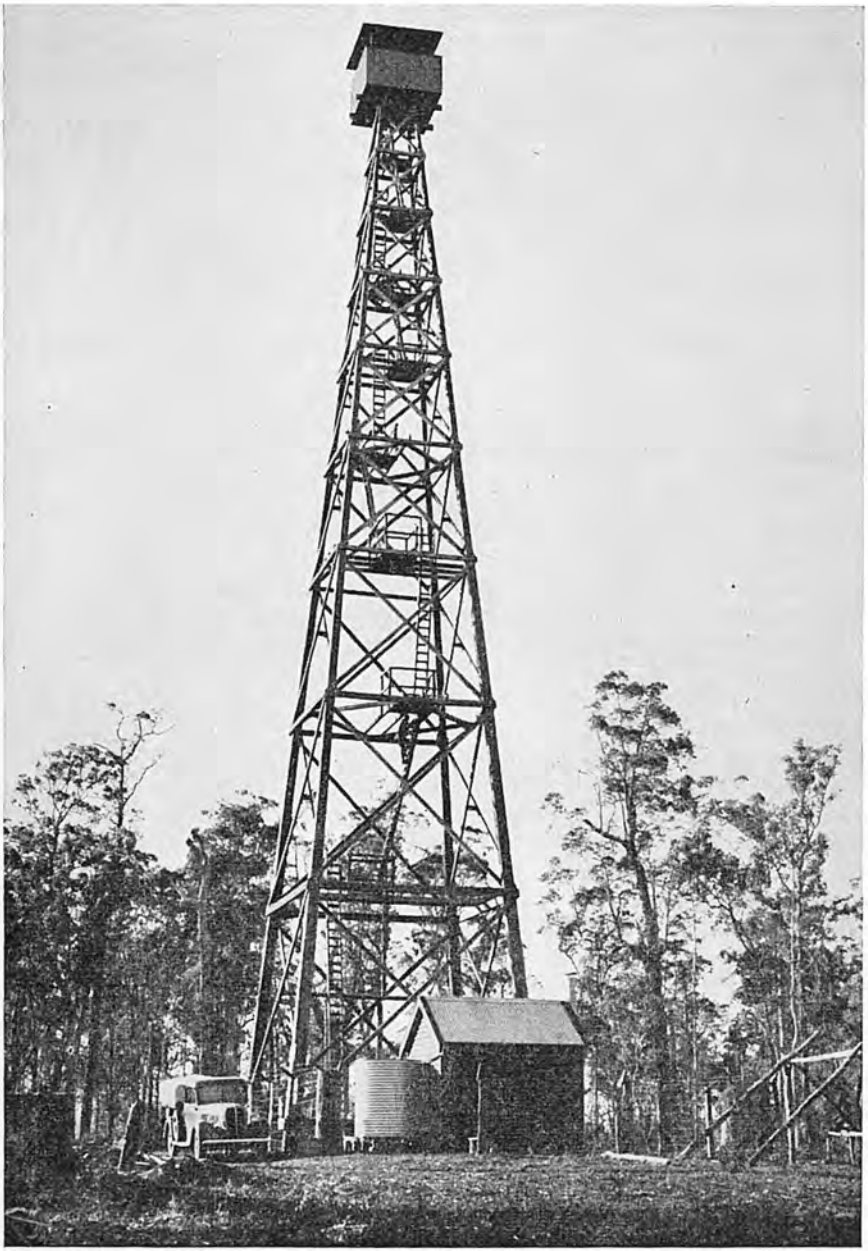


Plate 28.

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

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 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 dead areas of wood, not only affect the quality of the saw-log but allow the entrance of harmful fungi and insects. Repeated heavy fires retard the growth rate and deform the shape of the bole.

Frequent removal of the forest canopy and the ground area also favours excessive run-off, 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 often disastrous. They constitute the major contribution to timber waste 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. Fires must be prevented from starting or in those cases where they do occur, provision must be made in advance to decrease their rate of spread while the suppression force comes into action.

Ninety-six per cent. of all the fires which occur in Western Australian forests are man made. Most are caused through thoughtlessness or carelessness and are thus largely preventable. The main causes of fires dealt with by the Forests Department are found to be escapes from clearing fires on private property, railway engines (both W.A.G.R. and bush locomotives), hunters, fishermen, travellers and bush workers.

Publicity by means of road signs, newspaper articles, radio talks, pamphlets and pictures is widely used to bring home to the public the danger from uncontrolled fires.

The Bush Fires Act provides legal control of this problem and provides many safeguards.

It restricts all burning between the 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.

Plate 29.

Gloucester Tree, a karri tree lookout at Pemberton. Height to top of cabin is 200 ft.

The Act lays down conditions under which burning may be undertaken. The following are the main conditions:—

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 fire break, 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.

"Controlled" or "prescribed burning" is the second main line of defence against fire. The term "controlled burning" implies regulated periodic burning with a well established purpose in view and under conditions not injurious to the desirable forest trees. In practice such burning is carried out on cool days in autumn, spring or winter when a mild fire will move slowly over the forest floor, consuming accumulated debris with the minimum of damage to the tree trunks and crowns.

There are six types of controlled burning for fuel reduction that are standard practice.

(1) Cleaning up firebreaks around areas of high risk, that is, areas where fires frequently start or occur more or less regularly, e.g., external boundaries, railway lines, main roads and certain areas of private property.

(2) Burning out buffer areas or dangerous flanks and pockets of dangerous hazard. The burning of these two types is carried out as frequently as possible, but not less frequently than every third year.

(3) Protection of mills, schools, townsites, and isolated settlements in the forest.

(4) Prescribed burning according to the prescribed burning plan.

(5) Advanced burning before the sawmill operates over an area.

(6) Top disposal to clean up the debris of tree tops left after falling operations.

Usually it is impossible to get a clean burn in the forest more frequently than once in three years and burning plans are drawn up accordingly.

The judicious use of controlled burning over the years will enable the forest canopy to reform, suppress the scrub growth and eventually bring back the desirable park-like forests of pre-settlement days. A closed canopy and minimum ground scrub growth not only favours protection measures but also is conducive to maximum growth and quality of timber.

Fire Weather Forecasting.

A sound knowledge of the weather and the state of the fuel is essential in any prescribed burning operations. 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 30.

A Forests Department officer contacting field crews by means of a radio transceiver.

In an endeavour to arrive at a better understanding of the relationship between weather and forest fires a Fire Weather Station was set up at Dwellingup in 1934. This was later followed by the establishment of stations at Pemberton and Dryandra, and in recent years fire weather reports have also been obtained from Ludlow and Margaret River.

Early investigations showed clearly that it was not possible to measure the degree of fire danger by readings of any single weather element such as temperature, relative humidity, barometric pressure, evaporation, etc.

It became obvious that the degree of inflammability of the fuel was the result of interaction of all weather elements. It was then decided to study the moisture content of the various timbers and experiments proved that the variation in moisture content of half inch cylinders of locally grown Pinus radiata showed an almost identical trend as the averaged estimate of fire hazard given by a number of experienced forest officers.

Fifty gram units (oven dry weight) of these cylinders are now in use as the standard measure of fire hazard in this State.

In order to express the fire hazard, two scales were adopted. An empirical scale from 0-10 for use in fire weather research and a general scale of Nil, Low, Moderate, Average, High, Severe and Dangerous for general and public use.

The relationship of these scales and the moisture content of the present wood cylinders is given in the table hereunder:—

	Empirical Scale.	Moisture Content of of ½in. 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%

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 for that day.

Using the current fire hazard as a basis and applying their knowledge of possible future weather conditions, the Bureau pass 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 the 4.15 p.m. call.

At 7.30 a.m. next morning weather reports are received by Dwellingup and these together with Dwellingup 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.

Detection.

Fire weather forecasting and the prevention measures outlined above are systems which aim firstly at preventing fires starting, and secondly, to restrict those fires which do occur to a limited area. In this second aim rapid fire detection and subsequent suppression measures are also necessary to quickly locate and stop the fire, restricting damage to a minimum.

Fire detection entails the actual sighting and locating of the fire. Spotting methods vary in different countries but the system employed in Western Australia depends on the use of skilled observers working from specially constructed lookout towers. Already thirty lookout stations have been established throughout the forest, providing complete coverage for more than 2,000,000 acres of forest. Varying in form from low towers on high ground points to cabins built in the tops of tall karri trees, the tallest lookout 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 the 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.

Communications.

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

Over 1,500 miles of telephone line are maintained throughout the forest area for administrative purposes, but to speed up communications and attack on the fire, radio is employed. Radio transceivers are now standard equipment on nearly all fire trucks and many officers' vehicles, as well as at all divisional

headquarters. During the fire season each headquarters maintains a regular schedule of communication with its own fire trucks, the frequency of call-up depending on the prevailing weather conditions and fire risk.

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 roads have been installed throughout the forest allowing 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.

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 4 wheel drive, carrying a specially constructed slip-on unit of a 600 gallon tank and power pumper. The latter range in size from small high speed rotary pumps delivering 15-30 gallons per minute to larger types capable of delivering better than 200 gallons of water per minute. 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 31.

Testing fire equipment in preparation for the fire season.

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 the fire, they are transported rapidly on the back of 5 ton trucks.

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 gang after an initial reconnaissance, extra gangs and equipment are forwarded to help in suppression, or, nearby gangs are alerted for possible emergency.

Plate 32.

"Knocking down" a small fire with packsprays and rakes.

The fire is usually attacked with packsprays and rakes although if a truck can get close enough, the low down or light power pump replaces the pack sprays. 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. All too 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. A recent modification of this system is the "Aqua-track," a light Crawler tractor fitted with a pump and water tanks capable of holding up to 400 gallons. This unit can approach right to the edge of the burn in almost any type of country and is capable of knocking down fierce fires as fast as man can walk. In the few cases in which it has been used, the Aqua-track has proved highly successful.

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 spar that is alight close to the edge of the burn and which could throw sparks into the unburnt country is either put out or felled. Every log and stump burning close to the raked break is extinguished with water, completely covered with earth or cut off and rolled in onto the burnt country.

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

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

Usually with efficient detection, reporting and despatching, most fires in State Forests are brought under control when small. In these days only a few reach serious proportions in the area afforded intensive fire protection.

The Forest Area.

Of the 4,000,000 acres of State Forest in Western Australia, more than 2,000,000 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 marginal 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.

Plate 33.

"Mopping up" around a fire perimeter.

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 aims in two ways. Firstly, there are fungi which attack seeds, seedlings or the growing tree to 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 overmature tree.
(3) Fungi which attack forest products or wood once it has been sawn and seasoned.

The fungi which fall into each group are not always specific, 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 can cause death to the germinating seedling before it emerges from the soil, a disease condition known as pre-emergence damping off. Also, 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 action of these fungi is favoured by moist crowded conditions in the nursery and an unfavourable soil acidity.

Control measures aim to improve soil conditions, and in this respect the use of a pine sawdust mulch has resulted in success. When damping-off is prevalent seed dusting with fungacidal 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 34.

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, a disease occurs in plants which have been lifted from the nursery beds causing a rotting of the roots. This disease has probably been responsible for many of the deaths in the field previously ascribed to unknown causes. Since 1950, experiments have been carried out with fungacidal dip application to lifted plants. The adequacy of these control measures is unknown as the disease has not re appeared since their initiation.

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% moisture in wood before rot can begin. On the other hand completely saturated wood cannot decay because air is essential to fungus growth and activity. Decay to 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 a 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 can dry out.

Fungal attack is conveniently classed as primary or secondary.

Primary attack is that on the growing tree.

Secondary attack is fungi attack to the completely dead tree, 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 fungi which can be found fruiting freely on living trees as well as on dead logs and stumps.

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

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

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

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

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

(5) The fungi which seriously affects jarrah and most other timber which has 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 the 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 good deal 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 enters 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 yellow 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 spider 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 permit it to operate. It is fairly common in some of the Eastern States where it is said to cause jarrah to disintegrate rather rapidly.

Stemphilium (Wet Rot).

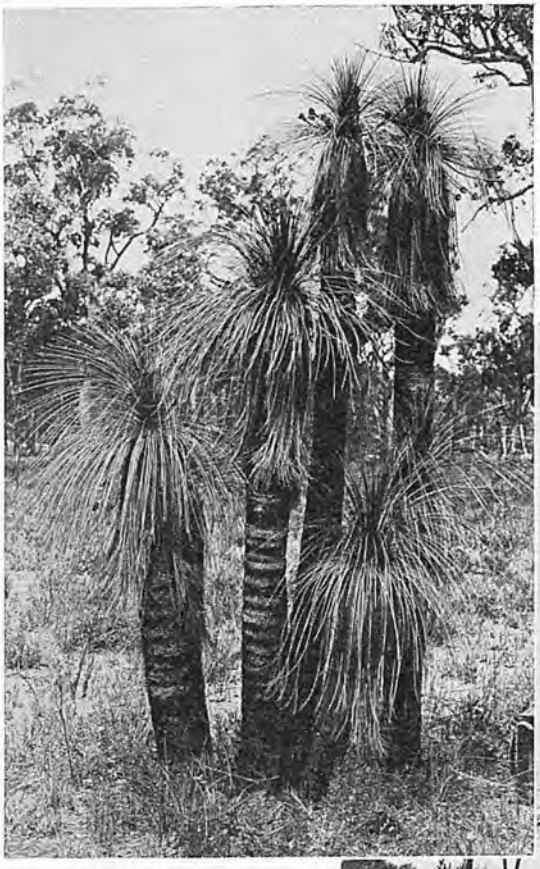
Stemphilium is the fungus which attacks jarrah and other timbers at or near ground level. It is commonly found softening the face of the wood in contact with the ground, working in slowly from the outside.

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.

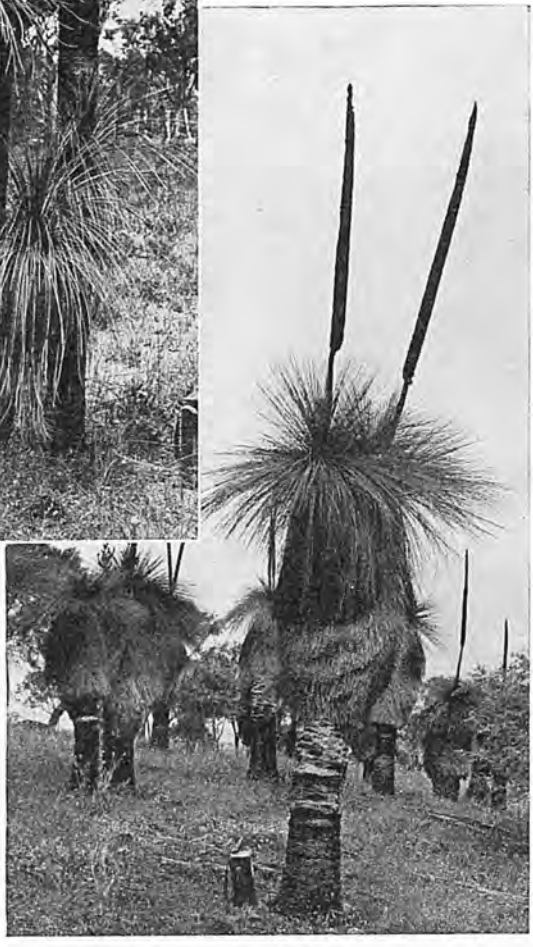
Trametes Lilacino-gilva.

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.



GRASS TREE



BLACKBOY.

Plate 35.

Grass Tree *(Kingia australis)*. Blackboy *(Xanthorrhoea reflexa)*.

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, 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 *Polystictus 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.

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 to produce 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, pigmentless specimens can be found on marri trees.

OTHER IMPORTANT FOREST FUNGI.

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, directly at least. In black-butt trees pencilling of timber is often found to be associated with some other rotting fungi.

Plate 36.
Sawn timber stacked for air drying. Unless properly ventilated, timber stacks may suffer considerable damage from 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 limited amounts of these primary rots in timber for most purposes.

It will still be necessary to ensure:—

(a) That the cavity caused by the decay and incipient decay was not large enough to impair the serviceability of the timber.

(b) That the decay did not come within the section of timber most likely to fail because of its presence.

(c) That the presence of the decay would 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 a good deal of water, 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 trees' 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 of insect are the jarrah leaf miner *(Tinea sp.)*, the weevils and beetles.

Jarrah Leaf Miner (Tinea sp.).

This lepidopterous insect causes considerable damage to the foliage of jarrah, swamp gum (Euc. rudis) and, to a lesser extent, tuart when growing amongst jarrah. Fortunately 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 habit 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 producing 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 *Coccidae*.

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 Bug Weevil *(Haplonyx sp.)*.

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

Tuart Bud Weevil (Haplonyx tibialis).

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 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.

Tryphocaria hamata is found throughout the Southwest from Perth to Albany and the adult beetles may be found flying in the evening, 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 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, at present, has little economic value.

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

Plate 37.

Log rake in the jarrah forest. The nearest log is 44 ft. long and 11 ft. 8 in. in girth.

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 developing from the egg 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 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. Timber containing pinholes is made allowance for in Grading Rules. Normally the damage only reduces the appearance of the final wood product and does not impair strength properties to any important extent.

6.—WOOD DESTROYERS.

These insects attack standing green timber, unhealthy and recently felled trees and timber products, i.e., Powder Post Beetle *(Lyctus)*, Furniture Beetle *(Anobium)*.

(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 erroneously called, may be divided into two major groups from the economic point of view, 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 runaways 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 economic species in Australia belong. All timbers are not equally atractive 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 with 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 beneath 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 on 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 repellents.

(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 thought it is possible that the insect may not be a great menace in this country's plantations. Such suppositions are not to be held if avoidable, however, as they often prove very expensive.

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

CHAPTER V

PINE PLANTATIONS IN WESTERN AUSTRALIA

Introduction.

THE continent of Australia has no natural forests of pine. A few timbers such as hoop vine, 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 approximately 80 per cent. of hardwoods are used.

The position with respect to future supplies has been under review for a considerable time, and, because of the demands of an ever-increasing population, has led to the formation of plantations of introduced pines which have the ability to reach maturity in a relatively short time. These plantations will provide the timber necessary to avoid large scale importation of the State's requirements in the future.

The Need for Pine Plantations.

The eucalypt forests of the State are slow growing, high quality hardwoods, and a population of 650,000 is using something over 50 cubic feet in the round per capita per annum of sawn timber, plus an estimated 8 cubic feet of imported wood products, mostly paper. Paper is unlikely to be made on a large scale from eucalypts unless a mixture can be made with softwood to provide desirable characteristics.

For a future population of one million it may be said that the State Forests are sufficient, without considering paper pulp, but the export trade would cease.

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 experimenting 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.

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.

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, planting has increased to a present area of about 23,000 acres. Of this area, 17,500 acres are *Pinus pinaster* and 5,500 acres *Pinus radiata*. 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 figure, Appendix VIII.

The older plantations are yielding limited supplies of logs for various uses including plywood, flooring, lining mouldings, and cases. An annual production of 800,000 cubic feet of mill logs from thinnings has been reached and this will increase as time goes on.

Plate 38.

Pinus radiata at Mundaring Weir plantation.

Establishment Methods in Western Australia.

Through the years of experimenting, the stage has now been reached where a standardised technique of plantation establishment can be applied, and while there are still problems to be solved, the sequence of operations is straight forward and does not present the difficulties that were met with earlier.

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. It therefore is imperative that further planting of these types be avoided and until pure stands of the Leiria strain become established to provide pure seed, present supplies of seed must be imported from Portugal. Here, a certificate of purity of strain is supplied and certainty of satisfactory growth features is assured.

Pinus radiata seeds, on the other hand, are obtained from South Australia and no problems are encountered with strains of this species. The local collection of seed from trees of outstanding quality is being considered.

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 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.

Previous to any sowing of the seed, it is necessary to carry out germination tests to determine the number of seedlings which could be expected from each lot of seeds. This is a most important consideration, for it is from the results of the germination tests that the quantity of seed to be planted is determined. If, for example, the tests show only 50 per cent. germination, then to obtain sufficient young pines, two seeds must be sown to obtain each seedling.

A further precaution which must be taken before the seed is planted is to treat it with red lead as a protection against damage by vermin. Following this, the seed is sown in rows directly into the nursery beds by use of machines. A scene of a typical nursery is shown in plate 39.

The seeds are sown in this manner to provide 18 seedlings for each foot along the row. The rows themselves are spaced 14 inches apart, so that each acre of nursery can provide approximately 600,000 seedlings. In the plantations the tree spacing is 9 feet by 9 feet for *Pinus radiata*, and 7 feet by 7 feet for *Pinus pinaster*, which represents a total of 538 and 890 trees per acre respectively. Therefore, according to the annual area of plantation to be put in and allowing for a certain amount of culls, the area of nursery and number of plants necessary can be determined.

Plate 39.
Gnangara nursery—lifting one year old pine seedlings ready for planting out.

Once established, care must be taken of the young seedlings, for whereas the mycorrhizal fungus is beneficial and necessary for the young pines, there are other fungi which, if permitted to develop, can cause considerable loss 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 fungicides 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.

The Selection and Preparation of the Plantation Site.

Before any plantation area is 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 Dwellingup soil laboratory. These tests must show the soils to be of a specified standard before they are selected for planting.

As 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 in area. In hilly country the shape of the compartments vary, 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. Spacing of the young trees is at distances of 9 feet by 9 feet for *Pinus radiata*, or 7 feet by 7 feet for *Pinus pinaster*; 528 and 890 trees per acre respectively. The reasons for this seemingly close spacing are many, but principally they are used to assure that straight trees with small branches are formed. Also, this close growth enables the young trees to quickly form a cover 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 for trees which are to be kept as the final crop.

Plate 40.

Operating the "Lowther Tree Planter" on the coastal plain.

Tending the Plantation.

Planting of 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 is slashed at the end of the first year, and after this time the pines can generally take possession of the area and suppress any further natural vegetation that appears.

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 to result 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 placed on the ground, these 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 here 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—or 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 to give the remainder living room to grow on 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.

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 adequate protection of this asset from fire is essential. Accordingly, an intensive system of firebreaks is constructed and maintained by ploughing or grading each year.

Plate 41.

"Greystones" Homestead, Mundaring Weir, in 1920 prior to plantation establishment. The following photo was taken 30 years later.

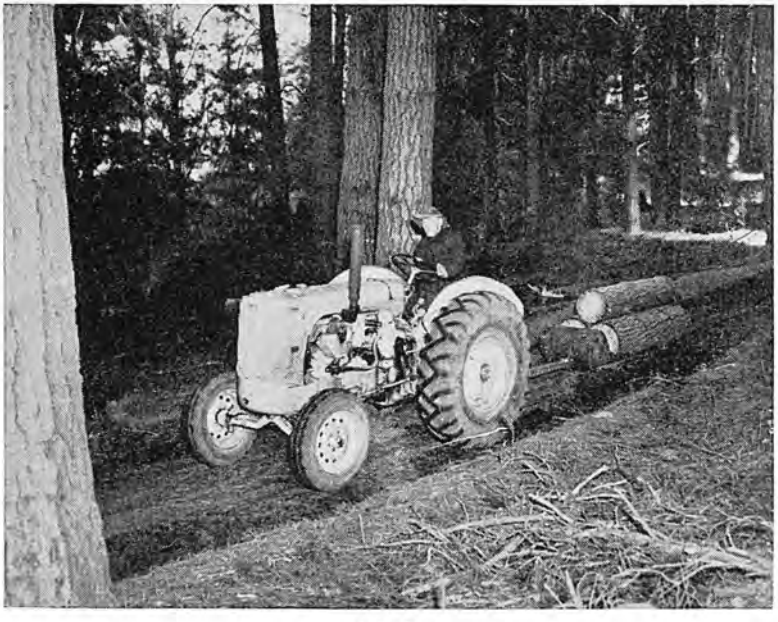


Plate 42.

Peeler logs for plywood manufacture being snigged during thinning operations. This photo was taken within a few yards of where the house stood in the previous photo.

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 aspects necessary for plantation management.

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

An Example of the Results of Management in Western Australia.

Should you have the opportunity to visit the Greystones plantation at Mundaring Weir, you would see what is possibly the best compartment of *Pinus radiata* growing in Australia (see plate 38). It was planted in 1922. It has a growth of 150 feet in height, and trees to 150 cubic feet in volume. In gross volume it has produced 9,000 cubic feet in thinnings over 33 years and also 9,000 cubic feet in the 70 trees per acre remaining in 1955.

Eighteen thousand cubic feet in 33 years or 545 cubic feet each year represents nearly one ton of timber every month for 33 years. In terms of sawn timber this would have a value of £6,000 for every one acre of the compartment described.

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, and flood and river regulation.

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 consists of a large unmapped and trackless area for which the first essentials are to have a stocktaking, maps and access, and when this information is to hand, a plan of the steps to be taken to introduce sawmilling and other forms of utilisation in such a way as to ensure that the harvesting of the crop goes hand in hand with the protection, regeneration and improvement of the forest.

This designing of the future of the forest results in a written document known as a "Working Plan," and under the Forests Act it has the effect of a law governing operations on an area.

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 when 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 various densities of the timber, and the various height classes. Further, the interpreter is able to indicate areas which have been subjected to fires and the extent of the damage caused, and is also able to show immediately the location and extent of regeneration. This analysis of photographs is called Air Photo Interpretation or A.P.I.

Not only has this application of modern methods made work much cheaper, but it is also more accurate and has reduced the time factor. This is most important when information for large areas is required in a short time.

Air photos play an increasingly important role in all forest management, for not only are they used in assessment, but play an important part in the design and selection of suitable roads and engineering works. In the matter of making topographical maps they also play a part, for from them all features such as hills and creeks and existing tracks can be mapped. Where necessary, contour plans can be made of areas where development is to take place, such as plantation areas and forest village centres. Highly specialised equipment is used today in order to obtain the utmost value from the air photographs.

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. Under the direction of the photo interpreter the assessor moves into the field with the object of securing information for the various recognised forest types.

Here, 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 it is necessary for the assessor to obtain information only for each forest type and sufficient to test the uniformity of each of these types.

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. Then, as the assessment proceeds, so further "acre information" is obtained.

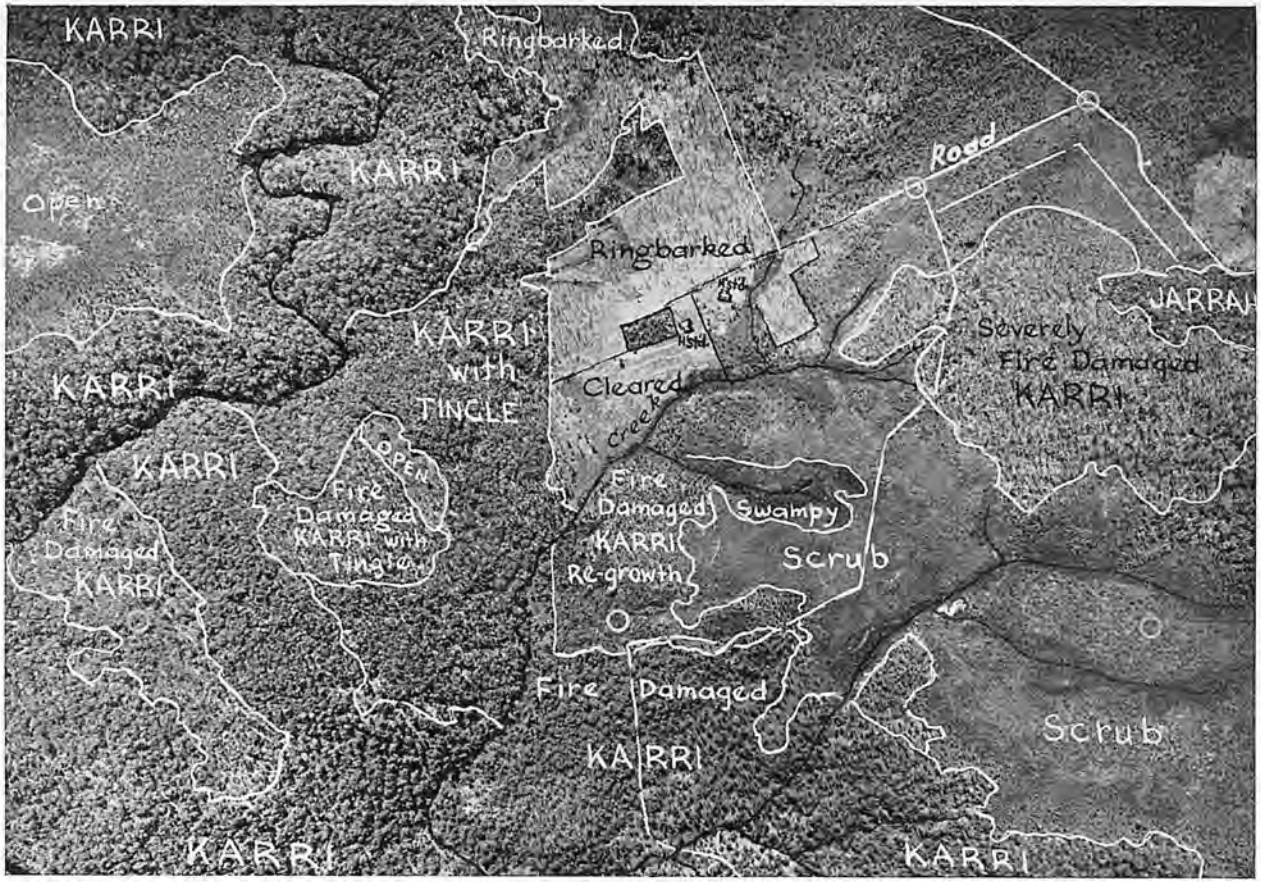


Plate 43.

The first steps in map construction from aerial photographs. The photo is marked to show the different forest types, clearings, topography, etc., as seen through the stereoscope. These markings are later transposed to a map.

Working Plans Office.

Information obtained by the assessment crew is made available to the Working Plans offices. There are two such offices in Western Australia, one situated at Dwellingup which deals with the northern areas of the State, and the other at Manjimup which uses information secured for the southern areas.

With the plans prepared from the aerial photographs the areas of each forest type are determined, and application of the assessment information enables a total forest volume to be determined. This information then provides the basis of the Working Plan.

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.

Plate 44.

A 68 year old karri regrowth stand at Lefroy Brook.

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 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 eleven 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 Mundaring in the north and Pemberton 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.

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, the 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 no destruction of young trees occurs.

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.

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.

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 13,600 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 to 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.

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 is carried out by theodolite, while forest tracks and firelines are surveyed by means of 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.

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, 380 houses have been constructed. This number is being increased annually.

As well as house construction, other buildings such as garages and workshops have been erected for 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 a central co-ordinating office has been established. This office, or management branch, has as its function the preparation of an annual programme of work, the allocation of finances to meet this programme, and finally, the recording of this work as it is carried out.

Perhaps the most important function of the management branch is the allocation of finances to enable the objects set out in the working plan to be achieved. It is the first duty of management to set out proposals of the work that is to be carried out each year in each forest division in such a manner that will enable the most use to be made of the finances available.

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 through this that a complete summary of forest management in Western Australia can be kept.

CHAPTER VII

UTILISATION AND FOREST PRODUCTS

UTILISATION 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.

Utilisation 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 principle (or 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 produce, the tree crop, are conveniently considered under the headings of bush operations—including the falling, snigging and haulage of the log material to the mill, and the final milling process which converts the log into serviceable timber once it has been removed from the forest.

BUSH OPERATIONS.

Falling.

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 left are retained to be grown to produce the crop for the next cutting. Marking is 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.

Until recent years, 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 is employed to cut a scarf into the front of the tree and to trim off side limbs. The crosscut saw is 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.

Plate 45.

Scarfing a karri tree. Platforms are used to avoid rough or damaged butts.

Plate 46.

Falling a karri tree with a chain saw.

In recent years, the motor-powered circular saw has found widespread application for all but the very big trees, such as are found in the karri forest. This saw enables the faller to do much of the work previously done with axe and crosscut saw in much shorter time.

Although the axe and crosscut are still used to a large extent for falling in the karri forest, the power dragsaw has come into general use for cutting through the log at the crown end once the log is on the ground.

In the main, the topography of the forest area of Western Australia lends itself to the use of these saws. As both are mounted on wheels and are rather heavy, they are at their best in gently undulating and open country, suffering severe disadvantages in steep country.

Another type of power saw has been tried on a limited scale. This, the chain saw, cuts by special teeth fitted on a power driven chain. Chain saws are made in a range of sizes, the smaller one-man unit being used with success in pine plantation falling. Bigger two-man chain saws have been used in both the jarrah and karri bush. Advantages over the power circular saw include greater mobility in rough country and a better adaption to falling large girth trees.

Snigging.

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 rail or motor truck.

Crawler tractors are used almost exclusively to snig logs from the stump to the loading ramps. Prior to the advent of tractors, horse and bullock teams were the main transport means; steam haulers were also used. These latter consisted of a steam driven winch fitted with a heavy wire rope. A lighter "tail rope" was used to pull the heavy rope back into the bush to the next log.

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 landing, and is extremely useful where the log timber is scattered.

Bush landings are built up ramps which allow the logs to be moved from the ramp on to the back of a haulage truck. Petrol winches in the jarrah forest and steam winches in the karri forest are used to move logs from the ramp on to the truck. Tractors are used as an aid in loading in only a few instances.

Plate 47.

Snigging with a crawler tractor and logging arch.

Haulage.

Steam locomotives still provide the means of transport from the landing to the mill for many of the bigger mills as the topography of Western Australia lends itself to this type of haulage. In the earlier days of the industry, this method was used almost entirely.

The motor truck is, however, coming into use more and more. 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.

Road haulage is used by the smaller mill working on areas containing limited supplies of timber where it would be uneconomical to put in expensive rail tracks.

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 of 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) The large general purpose mill cutting scantling, sleepers, flooring and joinery materials, etc.
(2) The smaller special mill. Within this class is the railway sleeper mill, the sheoak mill, the case mill and the pine mill which cuts thinnings from pine plantations.

General purpose mills vary in size. In the past, large mills employing 50 or more men under the one roof were common. Such 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 accrued in milling.

Present day mill design tends to select a flat site and mechanical means are employed to move the timber through the mill. A sloping site leads to difficulties with the handling and stacking out of the timber produced.

Sawdust fired boilers are also a recent innovation; the sawdust was previously burnt in a heap or carted away and dumped.

In smaller mills, diesel internal combustion engines have taken the place of steam. Where electricity is available, it has been used. Electricity has the advantage of ease of transmission within the mill compared with the belt drives of the steam or diesel-powered mill which do present a problem.

Plate 48.

A log landing in the karri forest.

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 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. Many of these mills cut timber only for railway sleepers, though some 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.

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 Case Mill operates usually on short logs or poorer quality timber, producing the small sawn boards required for the different types of boxes and cases required by the community. The greatest demand for cases in this State is for fruit packing.

Plate 49.
Loading a log onto a timber truck.

Plate 50.
Motor lorries have largely replaced steam locomotives for hauling logs from the bush landing to the mill.

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 with initial drying from the green condition to local atmospheric conditions.

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, shrinking and splitting in service would impair the value of the article.

In Western Australia, the long dry summer permits air seasoning to play the major role in our seasoning practice. To enable suitable drying under natural conditions, the boards are stacked out with each layer separated by regularly placed wooden strips. This permits even drying. Under these circumstances, the rate of drying is entirely dependent on weather conditions.

The seasoning kiln for artificial drying was first introduced to the State about 1920. Since that date, with further improvement of the method, there has been a steady increase in the number of kilns operating.

The principle of the timber kiln is to induce good drying conditions by passing hot dry air through the timber stacks by means of forced circulation. To reduce kiln drying costs, timber is still given a preliminary air drying and only the final critical drying is carried out in the kiln. In the open air this final stage is usually slow and rapid artificial drying has proved an economic success over many years.

Timber handling, both in the seasoning process and milling process generally, has been simplified by the introduction of the fork lift or straddle truck.

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 our ever increasing area of pine plantations reaches the sawmilling stage.

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. Jarrah and wandoo are ideal flooring timbers.

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 satisfaction in length, strength, straightness and a reasonably high degree of durability, karri is the ideal girder timber and a much ordered product from the forests.

Piles and Poles.

Piles and poles are also elite products of the forest which must satisfy certain specifications of length, straightness, girth and durability. Jarrah is an excellent pole and pile timber because of its durability in the ground and reasonably high resistance to marine borers. Wandoo is classed as the finest timber for this purpose, found in the State, but is not so readily available as jarrah.

Sleepers.

Western Australian hardwoods have established a wide reputation from the excellent railway sleepers that have been available for export. This export trade which was reduced of necessity during the war is being slowly revived. South Australia and the Commonwealth Railways remain the main markets for supplies in excess of State requirements.

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 will 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.

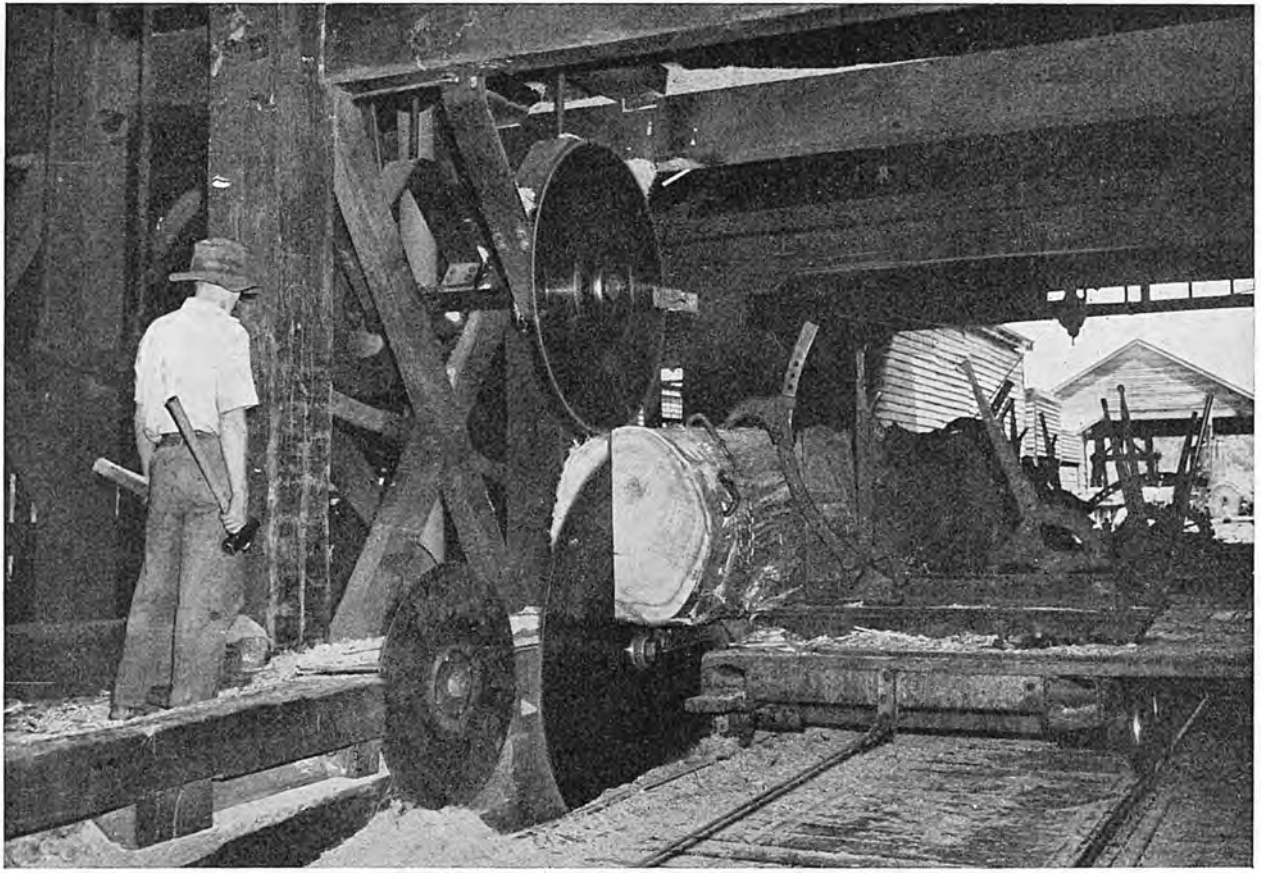


Plate 51.

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

Plywood Production.

The plywood industry is comparatively new to Western Australia. At present two plants are operating, one largely on karri logs which have proved suitable for this purpose. Other peeler logs are imported, mainly from Borneo.

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.

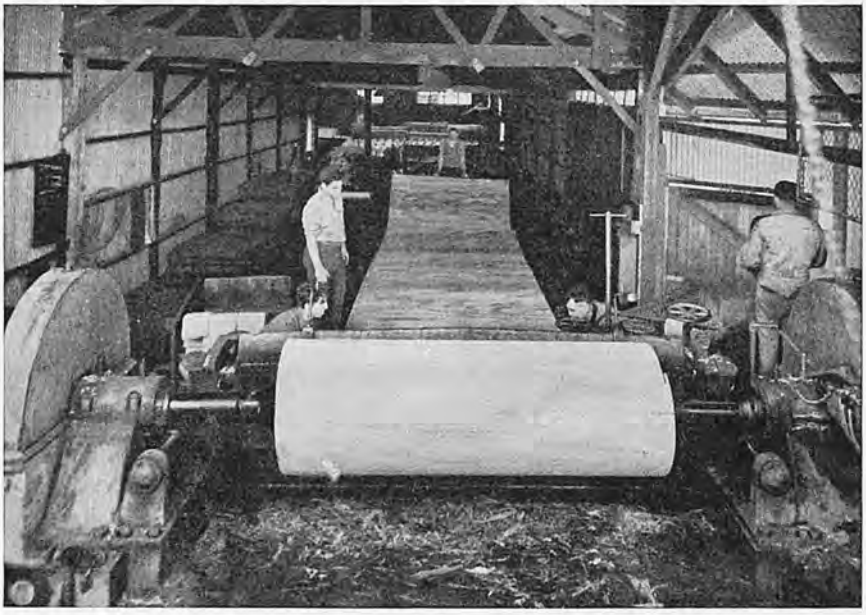


Plate 52.
Plywood peeling.

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 a firewood cutter, 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 emits a deep aroma. 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 honey yielding tree. The coastal stands produce fairly large quantity 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, of a pleasing flavour and fine grained when candied.

Tannin.

A further section treats in some detail, potential tannin production from local trees. As the world supply of vegetable tanning materials decreases, this phase of forestry will become more significant.

Two plants at present are operating, at Boddington and 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 exploitation.

As far as possible, all sawmilling timber which can be utilised is removed from an area before the bush operations for the extract plants 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

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 problem of 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 proportioning of research duties to definite personnel.

A research laboratory has been established at Dwellingup mainly with a view to answering the questions imposed by the complexities of forest soils and the maintenance of their fertility. This soil research is working hand in hand with silvicultural research of the jarrah forest trees and since its inception, the Dwellingup research centre has provided for a much sounder understanding of the jarrah forest complex.

This laboratory is also 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.

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

The Management Section through its Working Plans Office at Manjimup, is also 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 to the extent of finance and manpower that may be safely proportioned to them. In this regard the State is fortunate in the co-operation of the Commonwealth Forestry and Timber Bureau 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. 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.

Two illustrative examples of the nature of forest research which has occurred over the past years are given by way of illustration in the formation of a suitable method of fire weather forecasting to provide for 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 particular 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 of all exotic species which might succeed. It took some years to analyse the results from these arboreta and initial plantations, since the trees had to grow to a suitable 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 just this initial selection process it is suitable to say that *Pinus pinaster* alone, one of at least a dozen species tried, existed in at least five distinct sub-types or strains. Only one (originating in Portugal) of these 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 between these mycorrhizal fungi and the young pines exists, 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.

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 areas. Certain limited sites

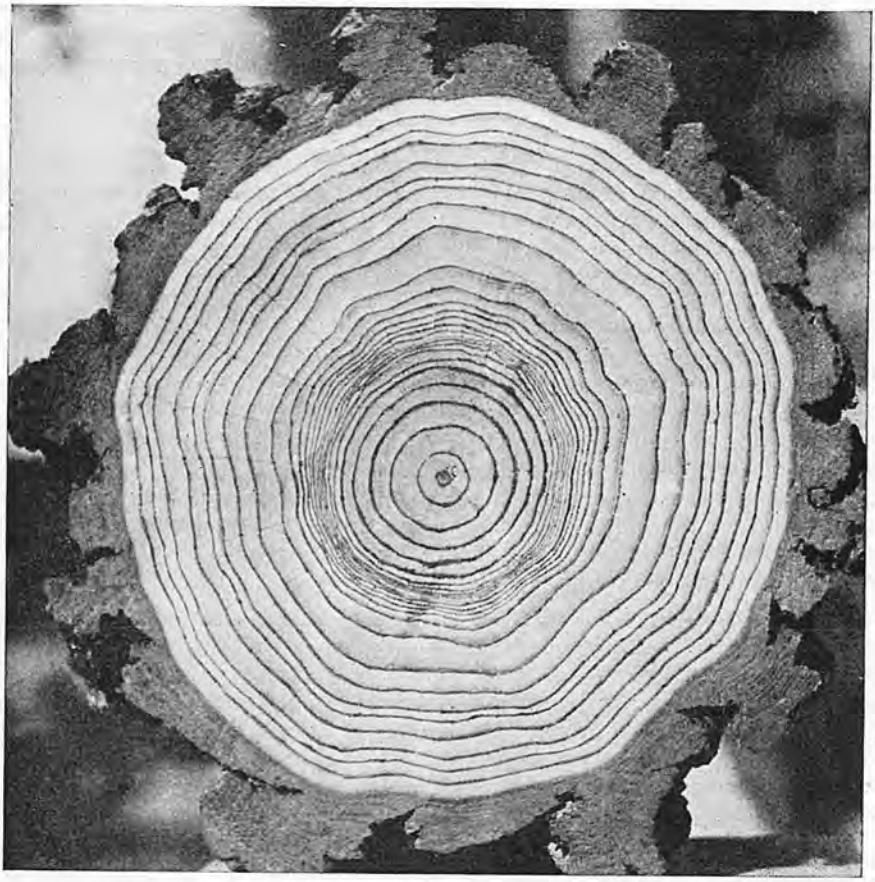


Plate 53.

The effect of superphosphate fertiliser in pine plantations. Superphosphate applied to this tree at the age of sixteen years produced the increased growth indicated by the increased ring width.

require further 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 work on softwood growing to be brought to a satisfactory conclusion.

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

FIRE WEATHER FORECASTING.

The object of early work in this direction was to provide advance information on the fire danger in the forest, thus enabling the fire protection organisation to be one jump ahead of the forest's greatest enemy—fire.

The combination of a personal estimation of fire danger by experienced foresters, the calculation of forest fuel inflammability by gain or loss in weight of moisture by half-inch cylinders of locally grown pine, correlation of weather data and the development of an efficient radio system to permit rapid and wide relay of information to workers all over the forest, was gradually evolved.

This fire weather forecasting system is rather unique and of proved efficiency in operation. Its use enables the fire protection organisation to save millions of cubic feet of timber from fire damage.

THE TRAINING OF FORESTERS.

Much has been accomplished by the Forests Department since the Forests Act in 1918 permitted the introduction of scientific management to the State's hardwood forests. It has paved the way towards that ultimate aim, to provide from local hardwood and softwood forests the timber requirements for an increased future population.

Preliminary work has shown the narrow margin which lies between the ability of the State's land resources to make Western Australia a timber independent country and the necessity to become an importing country due to insufficient local supplies.

This fact together with the rapid advance in wood use in living standards and the increase in technical knowledge in all fields of forestry, has made the training of young officers the most important aspect to the continued success of forest policy and management in Western Australia. The future of the forest lies completely in the competence and initiative of the officers concerned. This realisation has emphasised training as the key to success in all forest enterprises. Forestry is a science and it is essential therefore, that those whose duties lie in the forests should possess the special knowledge which the efficient practice of foretry demands.

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

The Professional Division.

A forestry degree course is included in the curriculum of all Australian Universities to provide the necessary training for young men wishing to become professional foresters. In all instances, the course involves two years' study in science subjects at a University, followed by a two years' course at the Australian Forestry School situated at Canberra. This course is recognised as a high standard and is accepted throughout the British Empire.

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.

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.

Interested students should consult the University handbook for further details of the course or write directly to the Forests Department, Treasury Buildings, Perth, for further information.

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 High Schools or Universities and are seeking an open-air life. This field is open to young men between the age of 16 and 20, preference given to those with some forestry or farming background. Successful applicants must be physically fit and have studied to at least the Junior standard.

A senior forest officer is appointed as a guidance officer to teach each trainee and is responsible for both his general behaviour and his training in the theory and practice of the various forest activities.

The training period lasts two years during which time the trainee is moved from centre to centre to provide the wide experience necessary as a basis for future work. Trainees have to camp and provide their own meals at the various centres. Working clothes, boots, blankets, cooking and eating utensils and personal necessities are required by all successful applicants. In 1957 the trainees are paid at the rate of £11 per week for the first year and £12 per week in the second year.

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

Advanced training and wider experience provided 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.

Present salary ranges for the various classes of forest officer to which a Forest Guard can aspire in his later years are as follows:—

Forest Guard	£786- £842	(Promotional bar)
	£873- £925	
Assistant Forester (Class 2)	£1006-£1036	
Assistant Forester (Class 3)	£1066-£1186	
Forester	£1231-£1321	
District Forester	£1366-£1456	
Senior Forester	£1501-£1591	

Any trainee who is able to continue his educational studies to pass the matriculation examination of the University of Western Australia is eligible to apply for a Forestry Scholarship. This provides for the higher training necessary for appointment to the professional divisions of the State Forest Service.

CHAPTER IX

TREE PLANTING IN WESTERN AUSTRALIA

SAND DRIFT RECLAMATION

TANNIN TREES OF WESTERN AUSTRALIA

IN many parts of the State, particularly in the arid and semi-arid areas where much of the original vegetation has been removed for agricultural purposes, the need for more suitably placed trees to meet shade, windbreak and ornamental purposes is realised. To aid people who desire to improve such conditions on farms and other properties, the Forests Department maintains nurseries, providing plants at a reasonable cost. A seed store also operates to supply seed for those who either prefer to raise indigenous trees and shrubs by this means, or who are unable to take advantage of the nursery stock. This store plays an important part in supplying local eucalypt seed for afforestation purposes overseas.

Forests Department Hardwood Nurseries.

Following the formation of the Forests Department, a nursery for the propagation of commercial timber trees for Departmental plantations was established at Guildford in 1896. However, conditions proved unsatisfactory, and in 1897 a site was selected at Hamel, a small siding on the main South-Western Railway, two miles south of Waroona. The area selected was a portion of the old de Hamel Estate and consists chiefly of rich alluvial soil through which runs the south branch of Samson's Brook.

Plate 54.
General view of the Forests Department nursery at Hamel. Pines are shown in the foreground.

Still surviving are many fine trees and shrubs planted at the time of establishment of the nursery. Among the most outstanding are Norfolk Island pines, well over 100 feet in height, camelia bushes up to 20 feet in height, and a number of plants of the New South Wales waratah. Of particular interest is a huge specimen of cork oak about 80 feet high and 11 feet in girth, from the butt of which strippings of commercial cork have been obtained. Most of the areas planted with pines at the beginning of the century have now been cut out, but one or two stands still remain, these being probably the oldest stands of commercial pines in the State.

Although the nursery was established mainly to supply commercial timber trees to Departmental plantations, a number of ornamental trees were soon being raised 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 was gradually extended to include land holders who required trees for shade and shelter for stock, for ornamental and shelter planting around farm homesteads, 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 four-and-a-half million trees covering seventy-five different varieties.

Owing to its situation in the heavy rainfall area of the South-West, conditions at Hamel have proved unfavourable for the raising of trees suitable for planting in the low rainfall of the wheatbelt. To meet this end, the Department established another nursery at Kalgoorlie in 1947. This nursery has since been removed to Dryandra, near Narrogin, where it is best able to meet the demand for this type of stock.

The aim of the Forests Department in establishing these nurseries was to have a suitable tree for every site and every job, and there seems little need to seek outside of Australia to find most of them. Little is to be gained by even departing from our own eucalypts which exhibit such an outstanding variety of form and shades of leaf colour, while many bear blossoms of very great beauty. Furthermore, they possess that rather uncommon combination —fast initial growth and long life. Eucalypts also exhibit a great deal of adaptability enabling many to thrive over relatively great variations in climate and soil.

Tree Planting.

Growing trees is not a difficult business normally, provided time and care are given to the few necessities ensuring success—initial selection of species, initial planting, and watering and tending over the first one or two years. Once past the first two difficult years, established plants are able to continue with very little attention.

In the establishment of trees on properties, there are several points to consider:—

(1) Purpose for which required.
(2) Suitable species for the locality.
(3) How planting stock may be obtained.
(4) Method of planting.
(5) Subsequent tending and protection.

1—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 that 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

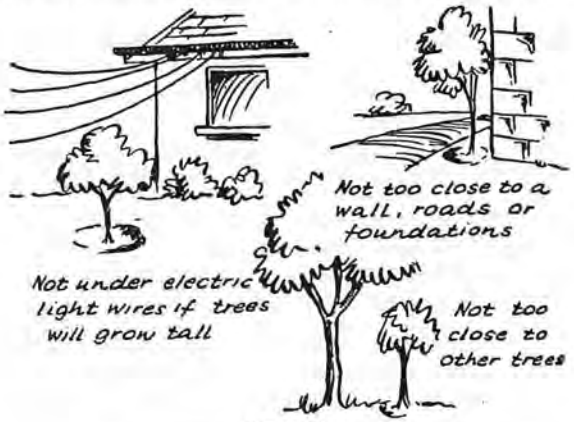


Plate 55.
Site selection is important in tree planting.

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.

2—Species.

Trees selected should be either those that are indigenous to the locality or to some locality enjoying similar climatic conditions. This stipulation may eliminate trees for which a grower may have a strong preference, but it is one that cannot be ignored. Besides climate we have to consider the suitability of the soil type for the species. Most farmers know that different species are associated with different soil types—in fact it is not uncommon to hear a soil described by the trees it originally carried, e.g., "morrel country", "gimlet flat", and so on.

3—Planting Stock.

Where a small number of trees is required, say one hundred or less, it is much less trouble to obtain them from the nursery, but where a greater number is required, consideration may be given to raising them on the farm.

4—Planting Methods.

Methods of Direct Sowing.—While trees can be established by direct sowing (spot sowing), this method requires favourable conditions both from the point of view of soil and of climate. Moreover, plenty of seed is required. If sowing is to be attempted, the best procedure is to sow directly into pots or jam tins, thinning the seedlings which germinate from a pinch of seed, and holding the plants in the container for a year until they are of suitable size to plant out.

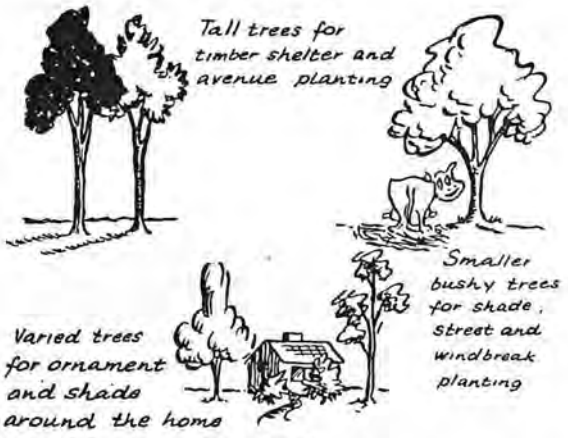


Plate 56.

Different trees for different purposes.

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 such 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 (13 inches) is along the following lines.

(1) The ploughing and fallowing of land for twelve months prior to planting.

(2) Fencing to exclude stock and rabbits.

(3) Planting during early winter.

(4) Watering (about one gallon per tree) at the time of planting but no further watering subsequently.

(5) Cultivation between rows shortly after planting and then at intervals during the next two years to keep the surface free of weeds.

(6) 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 not later than August

Positions for the trees should be selected to provide ample room for development and to eliminate competition from adjacent trees and shrubs as far as possible. An area 3 or 4 ft. in diameter should be cleared of all debris, worked to a depth of about 24 inches and hollowed into a saucer-shaped depression about five inches deep, in the centre of which the tree is to be planted. Where the ground is rocky it is sometimes advisable to break it up with explosives.

Watering at the time of planting is advisable and thereafter at intervals as required. During the first summer, watering once per week may be necessary but after this, at less frequent intervals. Waterings must be heavy enough to ensure that the moisture soaks well down.

Frequent light waterings which just moisten the top ultimately do more harm than good.

Manure, if any, should be used sparingly, and well mixed with the soil. If of animal origin, it should be well rotted before application. The native trees grow naturally in our soils without manure and an excess, added to the planting hole, may cause damage to growth. A mulch of grass, leaves or old rotted manure around the tree checks drying out.

Details of Planting Methods.

Trees received from the nursery should be inspected immediately, and if dry, the soil surrounding the roots should be watered and kept moist up to the time of planting.

Care is necessary in removing plants from pots and in subsequent handling. The covering cone or ball of earth must not be broken as eucalypts cannot tolerate damage to the roots. If a coil of roots is found at the bottom of the pot, these can be gently uncoiled and the planting hole deepened to take them.

In planting, roots should not be cramped or distorted, but permitted to dangle straight into the hole and soil filtered through the fingers in around them.

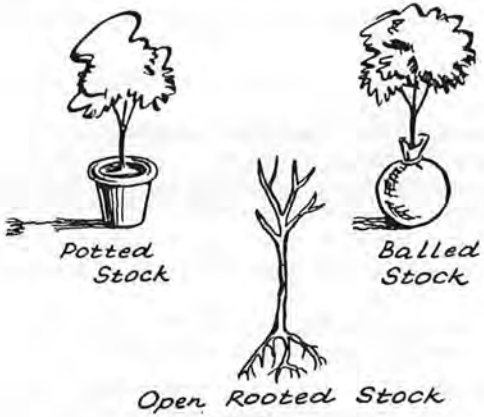


Plate 57.

Types of nursery stock.

Planting is preferable in damp soil with the surface of the root ball of earth covered to a depth of about one inch. All air pockets should be removed on filling in the planting hole by firmly pressing the soil with the hands and finally gently pressing with the side of the planter's boot. The first watering should now follow.

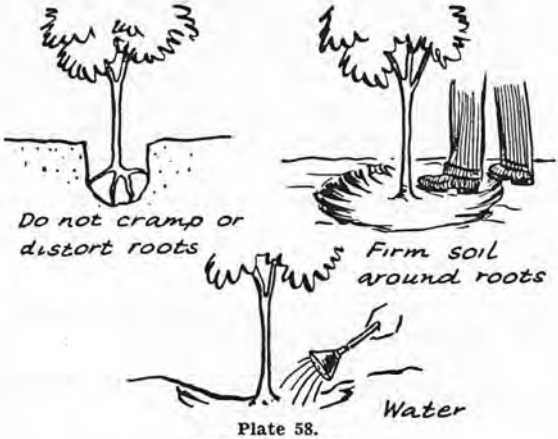


Plate 58.
Planting a tree.

5.—Spacing and Subsequent Attention.

With medium to large-sized trees, particularly those destined for shade or ornamental purposes, it is unadvisable to space closer than twenty-five feet apart. With smaller trees it is often permissible to place at closer intervals.

Adequate protection from rabbits, stock and other animals is essential. Above all, make certain the trees are protected from fire. A guard consisting of chicken wire surrounding three or four stakes is usually all that is needed for normal protection of isolated trees in their young stages. It will also permit hessian or branches to be attached if shelter from frost, wind or excessive insolation is deemed advisable. A straight stick inserted alongside the young tree and about four inches from it will serve as a support to which the plant may be loosely attached by a slack cord.

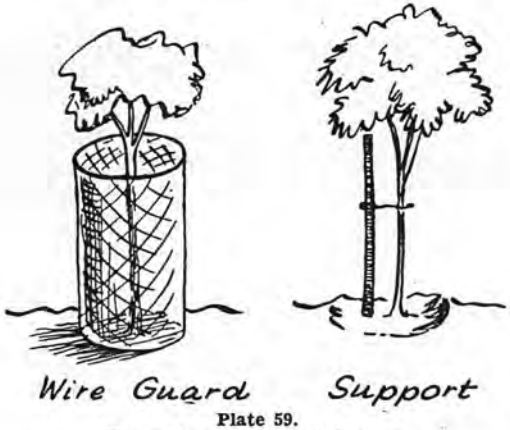


Plate 59.
Protecting the planted trees.

The planter must make sure that weeds do not grow around the young tree. Rank weed growth is one of the most frequent causes of death to young trees.

A variation of planting method is recommended when conditions permit. This entails the holding of plants for twelve months in larger containers such as kerosene tins instead of planting direct into the soil on reception from the nursery. For street planting in built-up areas, this method has much to commend it. At the end of the second year, the trees will be four or five feet high. With careful planting and subsequent attention, losses are negligible.

In holding trees for this extra year, certain precautions should be taken.

(1) See that the containers have ample drainage holes, preferably at the bottom of the sides.

(2) Containers should be stood on supports a couple of inches high to prevent roots passing into the soil below.

(3) To prevent the trees becoming too spindly, tins should be spaced about a foot apart.

(4) Refrain from pruning except to correct a misshapen form or growth.

(5) Water at least two or three times a week.

(6) At time of planting the hole must be deep enough to take the large block of earth in which the tree is established.

In view of the fact that once established, a tree will be a feature of the environment for a long period, initial selection and planting procedure should be given considerable thought to ensure that the final tree fully meets the requirements which instigated the planting.

SAND DRIFT RECLAMATION

The loose, sandy nature of the soil 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 such by overgrazing, fire, trampling, etc., very quickly results in 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 that 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 of 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 fixed.

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 target for the pioneers of our State.

Little further work was recorded in the State until in 1919 and 1920, the Cottesloe and Swanbourne local authorities carried out successful fixation of dunes in 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 Forests 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 agriculture and grazing lands at Cowaramup, Ellensbrook, Groocardup, Kilcarnup, 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 effort to establish Marram Grass at certain Rottnest sand drifts due to the exceedingly high lime content of the sand. This sand consists almost solely of fine shell particles and analyses as 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 on any sand not containing more than 60% to 70% of calcium carbonate in the form of shell particles.

Method of Dune Fixation.

Satisfactory fixation of all dunes threatening points of economic importance has been effected by the systematic planting of Marram Grass until recently. 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 sand dealt with in this State falls 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 affected 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 are likely to upset the balance of nature, 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 very concerned with the stabilisation of these areas.

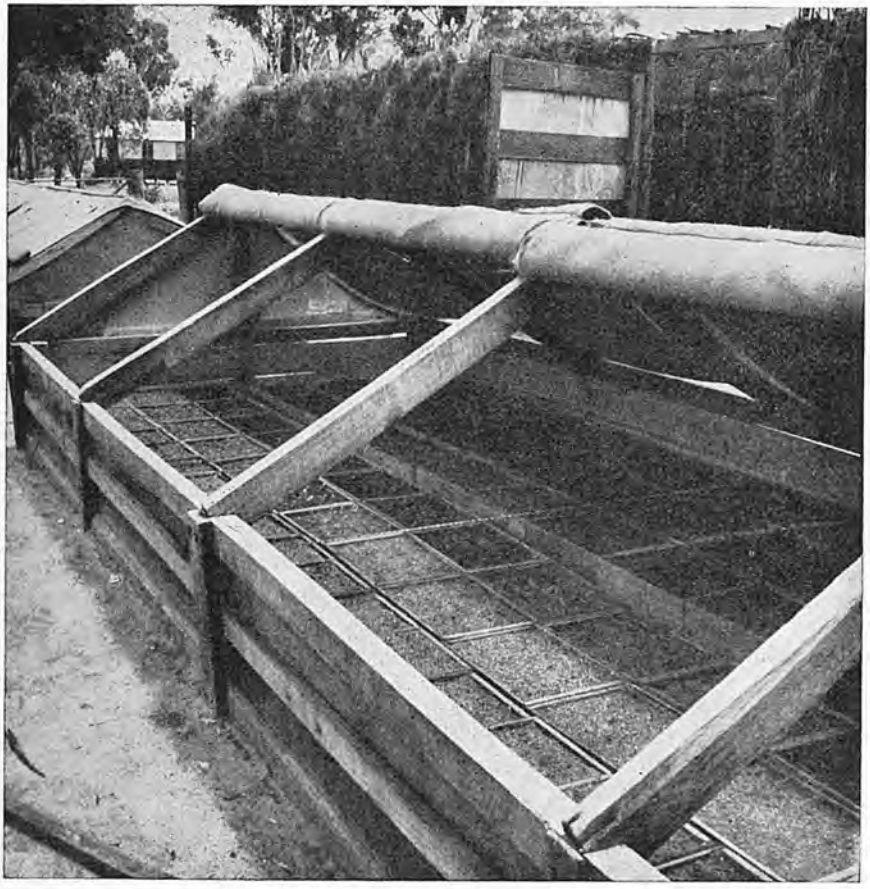


Plate 60.
Eucalypt seedlings in trays in a shade frame at Dryandra nursery.

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 basis 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.

At the present time the world is suffering from a shortage of tanning materials. This shortage promises to become more acute in the future. It is therefore necessary to consider conservation of existing resources, wherever possible.

Several of the native eucalypt trees of Western Australia, namely, the mallets, wandoo and marri are at present, or could be, commercial sources of tannin of value to the State. These resources are under the control of the Forests Department and it is desirable to place them as with other forest enterprises, on a sustained yield basis to ensure permanence of supply.

The tannins of the State occur in one of the following forms:—

(a) In the bark of the tree.

(b) In the kino or gum of the tree.

(c) In the wood of the tree.

(a) Tan Barks of Western Australia.

The bark of brown mallet *(Euc. astringens)* is the most important tannin producer in Western Australia.

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. The greater part of mallet bark obtained today (about 1,000 tons per annum) is from privately held land where it is collected with little attention to reproduction. The supply is sufficient to meet the local demand but leaves little for export.

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. Eucalypts are of proven value in afforestation of arid (under 10 inch annual rainfall) and semi-arid (10-20 inch rainfall) regions outside Australia and the potential value of the formerly important mallet bark in assisting to overcome the serious world tannin shortage is one not likely to be forgotten.

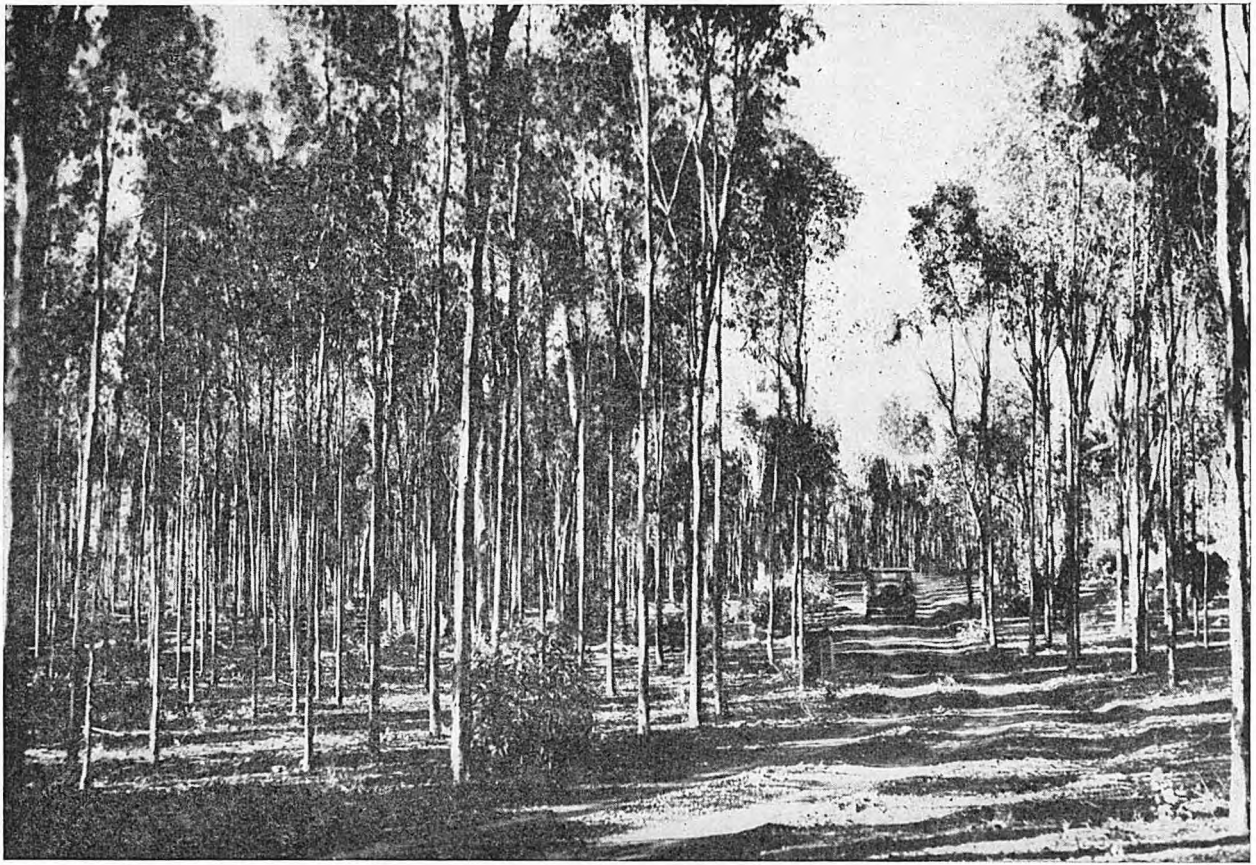


Plate 61.
Brown mallet *(Eucalyptus astringens)* plantation at Dryandra near Narrogin.

Seven tan bark species occur in the semi-arid regions of this State. In order of importance they are:—

Brown mallet *(Eucalyptus astringens)*.
Blue mallet *(Eucalyptus gardneri)*.
White mallet *(Eucalyptus falcata)*.
Swamp or flat-topped yate *(Eucalyptus occidentalis)*.
Swamp mallet *(Eucalyptus spathulata)*.
Dundas mahogany *(Eucalyptus brockwavi)*.
Dundas blackbutt *(Eucalyptus dundasi)*.

The first three species are the only ones that have been used commercially as a source of tannin and their barks have been sold collectively under the name of Mallet Bark. It is with these three, and in particular the first, that the State is concerned as regards future supplies of tannin.

Artificial regeneration of brown mallet has been carried out for over twenty-seven years in Western Asutralia, and 18,000 acres of plantations have been established at Dryandra 20 miles north-west of Narrogin. Here it is proposed to grow the trees to a size which will permit the use of the wood for sawn timber, as well as producing bark as a major crop.

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 required 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 has proceeded, for over twenty years, into the suitability of marri kino as a supply of tannin materials. As yet, this kino has not been used commercially because of difficulties of insolubility and colour, but investigations have definitely established that the tannins from it are very suitable for tanning heavy leather.

(c) Wandoo Wood Extract.

The wood of the wandoo tree contains usuable tannins in a high enough concentration to warrant commercial extraction.

Two plants are operating, one at Boddington and one at Toodyay, to supply a commercial extract for local and export markets.

The trees used as a raw material for extraction are the wandoo *(Eucalyptus redunca var. elata)* felled during clearing operations for the extension of agricultural lands. Normally much of this cleared timber would either be burnt or just left to rot on the area. The extraction process is a satisfactory method of utilising a forest resource which would otherwise be wasted in the process of development.

APPENDIX I

INDEX OF VERNACULAR NAMES

Albany Blackbutt	*E. Staeri*, Maiden.
Apple Gum	*E. pruinosa*, Schauer.
Bastard Bloodwood	*E. perfoliata*, R. Brown.
Blackbutt	*E. patens*, Bentham.
„ Albany	*E. Staeri*, Maiden, Ms.
„ Cleland's	*E. Clelandi*, Maiden.
„ Dundas	*E. Dundasi*, Maiden.
„ Goldfields	*E. Clelandi*, Maiden.
	E. Dundasi, Maiden.
	E. Le Souefii, Maiden.
	E. intertexta, R. T. Baker.
	E. transcontinentalis, Maiden
„ Le Souef's	*E. Le Souefii*, Maiden.
„ Coastal	*E. Todtiana*, F. v. M.
Blackheart	*E. microtheca*, F. v. M
Black Morrel	*E. melanoxylon*, Maiden.
„ „ (Yorrel)	*E. gracilis*, F. v. M.
Black Yate	*E. gracilis*, F. v. M.
Blackwood	*E. Foelscheana*. F. v. M.
„	*E. latifolia*, F. v. M.
„	*E. pyrophora*, Bentham.
Blue Gum	*E. megacarpa*, F. v. M.
Blue Mallet	*E. Gardneri*, Maiden.
Blue-leaved Mallet	*E. Gardneri*, Maiden.
Brown Mallet	*E. astringens*, Maiden.
Bullich	*E. megacarpa*, F. v. M.
Cabbage Gum	*E. papuana*, F. v. M.
Cleland's Blackbutt	*E. Clelandi*, Maiden.
Coastal Blackbutt	*E. Todtiana*, F. v. M.
Coastal White Gum	*E. decipiens*, Endl.
Coolibah	*E. microtheca*, F. v. M.
Coral-flowered Gum	*E. torquata*, Leuhmann.
Desert Blackbutt	*E. intertexta*, R. T. Baker.
Desert Gum	*E. Cliftoniana*, W. V. Fitzg.
„ „	*E. papuana*, F. v. M. (an inland form)
Dundas Blackbutt	*E. Dundasi*, Maiden.
Dundas Mahogany	*E. brockwayi.*
Flat-topped Yate	*E. occidentalis*, Endl.
Flooded Gum	*E. rudis*, Endl.
Gimlet	*E. salubris*, F. v. M.
„ Silver-topped	*E. campaspe*, Spencer Moore.
„ Swamp	*E. spathulata*, Hooker.
Goldfields Blackbutt—(See Blackbutt, Goldfields)	
„ Yellow-flowered Blackbutt	*E. Stricklandi*, Maiden.
„ „ Gum	*E. Stricklandi*, Maiden.
„ Red-flowered Gum	*E. torquata*, Leuhm.
Grey Box	*E. Spenceriana*, Maiden.
„ Gum	*E. Griffithsii*, Maiden.

Illyarrie	*E. erythrocorys*, F. v. M.
Ironbark	*E. terminalis*, F. v M.
„ Isdell River	*E. melanophloia*, F. v. M.
„ Silver-leaved	*E. melanophloia*, F. v. M.
Jarrah	*E. marginata*, Smith.
Karri	*E. diversicolor*, F. v. M.
„ Swamp	*E. megacarpa*, F. v. M.
Kimberley Red Gum	*E. ptychocarpa*, F. v. M.
„ White Gum	*E. Houseana*, (W.V.F.), Maiden
Le Souef's Blackbutt	*E. Le Souefii*, Maiden.
Mallet, Blue	*E. Gardneri*, Maiden.
„ Brown	*E. astringens*, Maiden.
„ Red	*E. astringens*, Maiden.
„ Swamp	*E. spathulata*, Hooker.
„ White	*E. falcata, Turcz. v. ecostata*, Maiden.
Marri	*E. calophylla*, R. Br.
Messmate	*E. tetrodonta*, F. v. M.
Micum	*E. pallidifolia*, F. v. M.
Mirret	*E. celastroides*, Turcz.
Moich	*E. rudis*, Endl.
Moort	*E. platypus*, Hooker.
„ Round-leaved	*E. platypus*, Hooker.
Morrel, Black	*E. melanoxylon*, Maiden.
„ Red	*E. longicornis*, F. v. M.
Mountain Gum	*E. haemotoxylon*, Maiden.
„ Marri	*E. haemotoxylon*, Maiden.
Parker's Gum	*E. foecunda, Sch. v. loxophleba*, Benth
Poot	*E. longicornis*, F. v. M.
Powder-bark	*E. Lane-Poolei*, Maiden.
Powder-bark Wandoo	*E. accedens*, W. V. Fitzg.
Prickly-bark	*E. Todtiana*, F. v. M.
Red-flowering Gum	*E. ficifolio*, F. v. M.
„ „ „ Goldfields	*E. torquata*, Leuhm.
„ Gum	*E. calophylla*, R. Brown.
„ „ Kimberley	*E. ptychocarpa*, F. v. M.
„ „ Mountain	*E. haematoxylon*, Maiden.
„ Morrel	*E. longicornis*, F. v. M.
„ Tingle Tingle	*E. Jacksoni*, Maiden.
Redwood	*E. transcontinentalis*, Maiden.
Ribbon tree	*E. celastroides*, Turcz.
Ridge Gum	*E. alba*, Reinwardt.
River Gum	*E. rostrata*, Schlecht.
Round-leaved Moort	*E. platypus*, Hooker.
Salmon Gum	*E. salmonophloia*, F. v. M.
„ White Gum	*E. Lane-Poolei*, Maiden.
Silver-leaved Ironbark	*E. melanophloia*, F. V. M.
„ topped Gimlet	*E. campaspe*, Sp. Moore.
Snap and Rattle	*E. gracilis*, F. v. M.
Stringybark	*E. tetrodonta*, F. v. M.

APPENDIX II

ALPHABETICAL LIST OF WESTERN AUSTRALIAN EUCALYPTUS TREES

Eucalyptus accedens, W. V. Fitzgerald.
" *alba*, Reinwardt.
" *argillacea*, W. V. Fitzgerald.
" *astringens*, Maiden.
" *brachyandra*, F. v. Mueller.
" *brockwayi*, Gardner.
" *caesia*, Bentham.
" *calophylla*, R. Brown.
" *campaspe*, Spencer le M. Moore.
" *celastroides*, Turczaninow.
" *clavigera*, Allan Cunningham.
" *Clelandi*, Maiden.
" *Cliftoniana*, W. V. Fitzgerald.
" *collina*, W. V. Fitzgerald.
" *confluens* (W.V. Fitz.), Maiden
" *Cooperiana*, F. v. Mueller.
" *cornuta*, Labill.
" *corrugata*, Luehmann.
" *decipiens*, Endlicher.
" *dichromophloia*, F. v. M.
" *diversicolor*, F. v. Mueller.
" *Drummondii*, Bentham.
" *Dundasi*, Maiden.
" *erythrocorys*, F. v. Mueller.
" *falcata*, Turcz.; *var. ecostata*, Maiden.
" *ficifolia*, F. v. Mueller.
" *Flocktoniae*, Maiden.
" *foecunda*, Schau.; *var. lozophleba*, Bentham.
" *Foelscheana*, F. v. Mueller.
" *gamophylla*, F. v. Mueller.
" *Gardneri*, Maiden.
" *gomphocephala*, A. DeCandolle.
" *gracilis*, F. v. Mueller.
" *grandifolia*, R. Brown.
" *Griffithsii*, Maiden.
" *Guilfoylei*, Maiden.
" *haematoxylon*, Maiden.
" *Houseana* (W. V. Fitzg.), Maiden.
" *intertexta*, R. T. Baker.
" *Jacksoni*, Maiden.
" *Lane-Poolei*, Maiden.

Eucalyptus latifolia, F. v. Mueller.
" *Le Souefii*, Maiden.
" *lirata* (W. V. Fitzgerald), Maiden.
" *longicornis*, F. v. Mueller.
" *marginata*, Smith.
" *megacarpa*, F. v. Mueller.
" *melanophloia*, F. v. Mueller.
" *melanoxylon*, Maiden.
" *microtheca*, F. v. M.
" *miniata*, Allan Cunningham.
" *Mooreana* (W.V.F.), Maiden.
" *Mundijongensis*, Maiden.
" *occidentalis*, Endlicher.
" *oleosa*, F. v. M.
" *oligantha*, Schauer.
" *pallidifolia*, F. v. M.
" *papuana*, F. v. Mueller.
" *patens*, Bentham.
" *perfoliata*, R. Brown.
" *platypus*, Hooker.
" *pruinosa*, Schauer.
" *ptychocarpa*, F. v. Mueller.
" *pyrophora*, Bentham.
" *redunca*, Schau.; *var. elata*, Bentham.
" *rostrata*, Schlecht.
" *rudis*, Endlicher.
" *salmonophloia*, F. v. M.
" *salubris*, F. v. Mueller.
" *Sargenti*, Maiden.
" *sepulcralis*, F. v. Mueller.
" *setosa*, Schauer.
" *spathulata*, Hooker.
" *Spenceriana*, Maiden.
" *Staeri*, Maiden, Ms.
" *striaticalyx*, W. V. Fitzgerald.
" *Stricklandi*, Maiden.
" *terminalis*, F. v. M.
" *tetrodonta*, F. v. M.
" *Todtiana*, F. v. M.
" *torquata*, Leuhmann.
" *transcontinentalis*, Maiden.
" *Woodwardi*, Maiden.

Trees which occasionally take on a mallee form–

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

ALPHABETICAL LIST OF MALLEES AND MARLOCKS

E. angulosa, Schauer.
E. angusta, Maiden.
E. angustissima, F. v. M.
E. annulata, Benth.
E. buprestium, F. v. M.
E. calycogona, Turcz.
E. Comitae-Vallis, Maiden.
E. conglobata (R. Br.), Maiden.
E. crucis, Maiden.
E. decurva, F. v. M.
E. diptera, Cecil Andrews.
E. doratoxylon, F. v. M.
E. dumosa, A. Cunn.
E. Ebbanoensis, Maiden.
E. eremophila, Maiden.
E. eremophila var. grandiflora, Maiden.
E. erythronema, Turcz.
E. erythronema, var. marginata, Benth.
E. eudesmioides, F. v. M.
E. Ewartiana, Maiden.
E. falcata, Turcz.
E. foecunda, Schauer.
E. Forrestiana, Diels.
E. goniantha, Turcz.
E. grossa, F. v. M.
E. Herbertiana, Maiden.
E. incrassata, Labill.
E. Jutsoni, Maiden.
E. Kalganensis, Maiden.
E. Kruseana, F. v. M.
E. Lehmanni, Preiss.
E. leptophylla, F. v. M.
E. leptopoda, Benth.
E. macrandra, F. v. M.
E. macrocarpa, Hooker.
E. micranthera, F. v. M.
E. occidentalis, Endl. var. stenantha, Diels.
E. odontacarpa, F. v. M.
E. Oldfieldii, F. v. M.
E. oleosa, F. v. M.
E. orbifolia, F. v. M.
E. pachyloma, Benth.
E. platypus, Hooker; *var. nutans*, Benth.
E. Preissiana, Schau.
E. pyriformis, Turcz.
E. pyriformis, var. monor, Maiden.
E. pyriformis, var. elongata, Maiden.
E. pyriformis, var. Rameliana, Maiden.
E. pyriformis, var. Kingsmilli, Maiden.
E. redunca, Schauer.
E. redunca, var. melanophloia, Benth.
E. redunca, var. oxymitra, Maiden.
E. Sheathiana, Maiden.
E. tetragona, F. v. M.
E. tetraptera, Turcz.
E. uncinata, Turcz.
E. Websteriana, Maiden.
E. xanthonema, Turcz.

Mallees, which sometimes have a tree form—

E. annulata, Bentham.
E. conglobata (R. Br.), Maiden.
E. diptera, Cecil Andrews.
E. doratoxylon, F. v. M. (?).
E. eremophila, Maiden.
E. eudesmioides, F. v. M. (?).
E. falcata, Turcz.
E. Lehmanni, Preiss.
E. leptophylla, F. v. M.
E. oleosa, F. v. M.
E. platypus, Hooker.
E. 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	7,150,000	572,354	....	....	....
1837	....	....	1902	6,256,750	500,533	....	....	....
1838	....	....	1903	7,748,450	619,705	....	859	....
1839	....	....	1904	8,072,300	654,049	....	32,876	....
1840	....	....	1905	8,709,500	689,943	....	154,087	....
			1906	(c) 8,830,700	708,993	....	140,720	....
1841	....	....	1907	(c) 6,400,550	511,023	....	98,773	....
1842	....	....	1908	(c) 9,869,509	813,591	....	79,934	....
1843	....	....	1909	(c)10,830,450	807,419	....	59,633	....
1844	(b)	163	1910	(c)12,074,100	972,698	....	93,733	....
1945	....	....						
1946	2,550	255	1911	(c)12,499,500	986,341	....	83,470	....
1847	12,200	1,120	1912	(c)11,297,100	903,396	....	49,004	....
1848	3,350	333	1913	(c)13,619,850	1,089,481	....	47,377	....
1849	....	....	1914 (d)	(c) 6,279,750	502,153	....	18,197	....
1850	10,500	1,048	1915 (c)	(c) 9,968,500	808,392	....	6,127	381
			1916 (c)	5,432,100	441,991	....	10,208	1,102
1851	1,250	268	1917 (c)	3,890,650	310,893	....	18,959	2,960
1852	7,050	806	1918 (c)	3,436,250	274,141	....	16,886	3,995
1853	52,200	5,220	1919 (c)	4,135,750	332,584	11,535	18,875	3,987
1854	58,500	7,023	1920 (c)	5,005,300	465,731	21,935	22,121	3,704
1955	76,900	12,076						
1956	70,500	9,671	1921 (c)	9,816,250	1,137,819	24,916	23,073	10,107
1857	69,200	9,449	1922 (c)	8,309,750	1,041,047	22,248	13,328	6,878
1858	29,250	2,340	1923 (c)	7,911,310	997,454	12,377	21,161	20,075
1859	67,250	6,051	1924 (c)	11,126,861	1,307,517	11,505	29,606	39,877
1860	54,800	4,932	1925 (c)	11,844,303	1,477,997	13,298	40,136	42,057
			1926 (c)	12,001,384	1,522,958	10,072	15,056	47,819
1861	27,750	2,497	1927 (c)	12,580,262	1,651,149	8,727	15,818	26,544
1862	68,800	7,151	1928 (c)	10,384,784	1,265,383	7,783	27,662	39,131
1863	32,900	2,963	1929 (c)	7,635,237	960,435	6,603	35,850	63,307
1864	58,300	5,508	1930 (c)	6,579,743	807,425	4,687	40,628	77,510
1865	183,950	15,693						
1866	85,650	6,849	1931 (c)	4,127,856	507,382	26,615	35,333	56,170
1867	56,750	4,541	1932 (c)	3,062,673	361,700	85,488	42,016	59,301
1868	8,000	638	1933 (c)	2,235,540	262,617	80,332	33,352	26,331
1869	179,900	14,273	1934 (c)	4,060,830	487,248	76,107	20,904	26,720
1870	157,200	17,551	1935 (c)	5,326,117	636,466	65,494	15,284	35,363
			1936 (c)	5,598,180	679,522	50,665	12,237	27,526
1871	218,500	15,304	1937 (c)	5,673,903	699,684	52,338	14,491	38,185
1872	37,000	2,590	1938 (c)	7,545,744	932,420	47,934	13,865	35,128
1873	68,150	4,771	1939 (c)	5,704,250	722,310	43,518	17,842	25,550
1874	345,600	24,192	1940 (c)	5,049,585	634,859	62,796	19,485	47,736
1875	342,350	23,965						
1876	219,050	23,743	1941 (c)	6,091,187	790,876	74,935	13,686	59,867
1877	336,150	26,979	1942 (c)	5,224,634	700,474	64,454	6,896	74,904
1878	580,900	63,902	1943 (c)	3,516,566	605,327	32,426	1,598	70,523
1879	627,250	69,742	1944 (c)	3,645,354	613,994	25,324	1,294	72,704
1880	662,550	66,252	1945 (c)	2,851,475	570,028	27,307	2,795	103,055
			1946 (c)	3,373,025	722,061	(f) 2,618	4,872	128,050
1881	792,750	79,277	1947 (c)	3,458,628	865,255	(f) 13,118	12,056	151,768
1882	936,500	93,650	1948 (c)	3,584,405	1,099,073	(f) 6,572	9,556	116,465
1883	997,000	79,760	1949 (c)	3,198,212	993,152	(f) 6,639	5,112	75,395
1884	861,700	68,936	1950 (c)	2,857,946	974,493	(f) 13,525	8,243	78,550
1885	848,150	67,850						
1886	626,150	50,092	1951 (c)	2,342,492	(g) 918,485	(f) 25,101	16,581	125,833
1887	354,800	28,384	1952 (c)	2,373,553	(g) 1,032,909	(f) 47,689	19,120	119,109
1888	525,750	42,060	1953 (c)	3,965,188	(g) 2,074,421	(f) 120,095	34,136	70,852
1889	788,500	63,080	1954 (c)	3,858,956	(g) 2,248,320	(f) 59,360	80,248	55,273
1890	1,172,200	82,052	1955 (c)	3,477,249	(g) 1,935,019	(f) 79,893	37,338	80,822
			1956 (c)	4,568,034	(g) 2,818,716	(f) 119,459	554,760	90,928
1891	1,273,950	89,179						
1892	1,082,650	78,419	Total	405,066,316	53,281,867	1,466,296	2,247,347	2,240,287
1893	512,950	33,888						
1894	1,063,700	74,804						
1895	1,255,250	88,146						
1896	1,545,600	116,420						
1897	2,393,300	192,451						
1898	4,086,150	326,195						
1899	6,913,550	553,198						
1900	5,725,400	458,161						

(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	95,220	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	2,012	4,038
1860	2,005	....	....	1912	167,244	3,089	4,598
1861	1,459	....	....	1913	202,640	2,651	5,392
1862	1,920	....	....	1914	78,736	629	2,823
1863	1,568	....	....	1914–15	107,763	2,082	4,988
1864	894	....	....	1915–16	76,849	3,313	4,788
1865	548	....	....	1916–17	75,681	2,848	3,848
1866	1,442	....	....	1917–18	58,305	2,020	4,358
1867	1,727	....	....	1918–19	62,824	1,181	4,168
1868	1,451	....	....	1919–20	100,083	3,748	10,043
1869	1,408	....	....	1920–21	171,654	*4,899	6,106
1870	1,518	....	....	1921–22	92,448	5,865	6,577
1871	736	....	....	1922–23	109,428	6,991	4,033
1872	1,660	....	....	1923–24	133,983	2,790	3,301
1873	1,008	....	....	1924–25	161,893	2,670	4,429
1874	1,774	....	....	1925–26	144,989	5,826	4,449
1875	2,707	....	....	1926–27	162,193	8,971	4,254
1876	3,098	....	....	1927–28	183,196	9,648	6,955
1877	2,036	....	....	1928–29	241,601	6,894	4,413
1878	2,947	....	....	1929–30	197,532	10,825	3,980
1879	2,340	....	....	1930–31	76,533	4,145	3,160
1880	3,061	....	....	1931–32	164,496	4,705	3,505
1881	3,639	....	....	1932–33	197,916	4,903	3,421
1882	3,692	....	....	1933–34	183,944	4,310	3,888
1883	6,667	....	....	1934–35	211,056	4,076	5,040
1884	2,930	....	....	1935–36	228,451	5,401	3,921
1885	11,479	....	....	1936–37	257,164	5,267	4,810
1886	17,888	....	....	1937–38	270,126	4,777	6,560
1887	8,136	....	....	1938–39	254,315	3,974	7,014
1888	4,461	....	....	1939–40	259,399	6,802	23,027
1889	7,686	....	....	1940–41	249,111	3,798	32,399
1890	14,979	....	....	1941–42	283,611	15,846	33,828
1891	18,406	....	....	1942–43	163,480	6,250	47,718
1892	26,713	....	....	1943–44	149,928	7,883	68,871
1893	14,493	....	....	1944–45	148,838	9,264	75,449
1894	17,964	....	....	1945–46	†219,466	19,573	56,295
1895	47,128	....	....	1946–47	386,465	12,395	78,091
1896	5,381	....	....	1947–48	345,508	8,019	96,769
1897	164,552	....	....	1948–49	570,755	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
				Total	14,283,262	442,136	1,436,267

* 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 W.A. SINCE 1829.

Year.	*Crown Land.	Private Property.	Total.	Year.	*Crown Land.	Private Property.	Total.
	Loads.	Loads.	Loads.		Loads.	Loads.	Loads.
1829-1916—Estimated	....	....	13,265,357	1937 (c)	634,077	318,044	952,121
1917 (a)	386,662	42,890	429,552	1938 (c)	634,749	318,579	953,328
1918 (b)	153,311	10,099	163,410	1939 (c)	584,953	221,720	806,673
1919 (c)	399,741	67,809	467,550	1940 (c)	553,202	182,791	735,993
1920 (c)	565,844	115,258	681,102	1941 (c)	561,784	205,780	767,564
1921 (c)	580,179	140,369	726,548	1942 (c)	532,733	112,668	645,401
1922 (c)	722,448	312,803	1,035,251	1943 (c)	472,098	86,459	558,557
1923 (c)	536,146	197,341	734,087	1944 (c)	445,050	89,124	534,174
1924 (c)	840,089	186,856	1,026,945	1945 (c)	439,400	86,191	525,591
1925 (c)	876,658	362,845	1,239,503	1946 (c)	422,530	109,647	532,177
1926 (c)	976,475	500,752	1,477,227	1947 (c)	438,971	156,639	595,610
1927 (c)	937,752	627,122	1,564,874	1948 (c)	445,027	177,438	622,465
1928 (c)	855,625	466,689	1,322,314	1949 (c)	405,236	196,286	601,522
1929 (c)	645,795	221,979	867,774	1950 (c)	421,623	198,653	620,276
1930 (c)	633,083	233,072	866,155	1951 (c)	507,829	214,261	722,090
1931 (c)	376,452	242,970	619,422	1952 (c)	578,851	238,766	817,617
1932 (c)	234,857	82,319	317,176	1953 (c)	684,468	260,428	944,896
1933 (c)	263,313	49,133	312,446	1954 (c)	749,719	271,240	1,020,959
1934 (c)	425,262	126,608	551,870	1955 (c)	749,353	303,909	1,053,262
1935 (c)	549,165	229,035	778,200	1956 (c)	796,227	275,467	1,071,694
1936 (c)	628,012	268,723	896,735	Total	....	....	44,425,468

* Includes State Forests, Timber Reserves, Crown Land and Private Property (Timber Reserved).
(a) Year ended 31st December. (b) Six months ended 30th June. (c) Year ended 30th Ju

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 lb./sq. in.	*Modulus of elasticity lb./sq. in.
Jarrah	*Euc. marginata*	73	54	5·3	7·9	16,200	2,080,000
Karri	*Euc. diversicolor*	73	56	5·1	10·1	19,200	2,080,000
Tuart	*Euc. gomphocephala*	78	64	4·0	7·0	17,800	2,600,000
Wandoo	*Euc. redunca 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 VII.

SUITABLE TREES FOR PLANTIN G IN WESTERN AUSTRALIA

Botanical Name.	Common Name.	Description.	Recommended Use.	Minimum Rainfall.	Soils.
Acacia acuminata	Raspberry Jam	Attractive small tree of maximum height 20 ft. Bushy, fairly dense crown	Windbreak, shade and ornamental	15in.	Prefers loamy soils.
Acacia baileyana	Cootamundra Wattle	Winter flowering with masses of yellow flowers. Attractive silver foliage. Maximum height 20 ft.	Ornamental	20in.	Prefers well-drained sites.
Acacia decurrens	Black Wattle	Pale yellow blossom. Attractive tree or shrub up to 20 ft. in height	Ornamental	20in.	Sandy to loamy and gravelly soils.
Acacia microbotrya	Manna Wattle	Large shrub or small tree with dense bluish-green foliage. Flowers pale yellow	Shade and ornamental	15in.	Prefers loamy soils.
Acacia podalyriaefolia	Queensland Silver Wattle	Beautiful winter flowering species of 15 ft. height	Ornamental	20in.	Wide range of soils.
Acacia pycnantha	Golden Wattle	Hardy species with broad leaves and large golden flowers. Height 20ft.	Ornamental	20in.	Wide range of soils.
*Actinostrobus pyramidalis**	Native Cypress	Narrow columnar tree with dense foliage of small bright green leaves. Height 25 ft.	Windbreak and ornamental planting	20in.	Salt tolerant. Sandy Soils.
Agonis flexuosa	W.A. Peppermint	An extremely attractive and shady tree of up to 25 ft. in height	Ideal for metropolitan shade, street and ornamental planting	25in.	Adaptable to most soils.
Araucaria excelsa	Norfolk Island Pine	Tall pyramidal conifer to 100 ft. in height. Suited to coastal planting	Ornamental and avenue planting	25in.	Survives coastal winds and salt spray.
Araucaria bidwillii	Bunya Pine	Tall conifer with large umbrella-shaped crown. Up to 100 ft. in height	Ornamental	30in.	Rich soils.
Brachychiton acerifolium	Illawarra Flame Tree	Attractively shaped tree to 100 ft. in height. Red bell-shaped flowers are borne in profusion	Ornamental	35in.	Good loamy soils in sheltered position preferred.
Brachychiton diversifolium	Kurrajong	Stout tree up to 60 ft. in height. Crown bushy with variously-shaped leaves	Street, shade and ornamental planting	18in.	Loamy soils.
*Callitris glauca**	Native Pine	Height 30 ft. Shapely conifer of rapid growth. Suitable for arid areas	Windbreak, shade and ornamental	12in.	Sandy soils. Salt tolerant.
*Callitris robusta**	Rottnest Cypress	Height 20 ft. Cypress-like habit	Windbreak and shade	25in.	Sandy soils.
*Ceratonia siliqua**	Carob Bean	Hardy, drought resistant tree with a spreading crown. Height up to 25 ft.	Shade. Beans are useful stock fodder	20in.	Loamy soils.

SUITABLE TREES FOR PLANTING IN WESTERN AUSTRALIA—continued.

Botanical Name.	Common Name.	Description.	Recommended Use.	Minimum Rainfall.	Soils.
Cinnamomum camphora	Camphor Laurel	Stout tree with a compact crown of smooth shining leaves. Grows to 40 ft. in height	Street and ornamental	30in.	Loamy soils.
*Cupressus arizonica**	Arizona Cypress	A hardy and drought resisting tree with a conical crown of greyish-green foliage. Height 40 ft.	Windbreak, shade and ornamental	15in.	Light sandy and loamy soils.
*Cupressus sempervirens var. stricta**	Pencil Pine	Narrow erect conifer with a dense green crown. Height 40 ft.	Ornamental	25in.	Adaptable.
*Eucalyptus astringens**	Brown Mallet	Tree to 50 ft. height. Bark smooth, bronzy-green in colour. Crown dense and bushy	Street and ornamental planting	16in.	Sandy to loamy soib-preferably with clay suls, soil.
*Eucalyptus brockwayi**	Dundas Mahogany	Fine tree up to 70 ft. in height. Bark smooth, pinkish-grey in colour. Crown dense, umbrella-shaped, dark green and shining	Fast growing ornamental and street tree	11in.	Sandy loams and gravelly loams.
*Eucalyptus botryoides**	False Mahogany	Broad leaves, heavy-crowned tree up to 60 ft. in height. Bark rough, dark grey in colour	Windbreak, shade and roadside planting	20in.	Loamy to sandy loam soils.
*Eucalyptus camadulensis**	River Gum	Attractive densely-crowned tree with a somewhat weeping habit. Grows to 60 ft. in height	Street, shade and ornamental planting	8in.	Adaptable to soils. Fine trees for inland planting.
*Eucalyptus campaspe**	Silver Gimlet	Height 35 ft. Bark bronze-coloured, crown a silvery-green colour	Shade and street planting ...	12in.	Loamy soils.
*Eucalyptus citriodora**	Lemon-scented Gum	Slender, erect, handsome tree to 70 ft. height. Attractive foliage and bark	Ornamental and avenue planting	25in.	Adaptable to most soils. Frost tender when young.
*Eucalyptus cladocalyx** ...	Sugar Gum	Tree of height 60 ft. with a large spreading crown and clean, smooth bark	Shade and roadside planting	18in.	Adaptable to most light-textured soils.
*Eucalyptus dundasi**	Dundas Blackbutt	Dense-crowned tree up to 50 ft. in height. Limbs smooth and copper-coloured. Bark at base rough and dark grey in colour	Fast-growing street and shade tree. Ideal for inland planting	10in.	Loams. Prefers soils with alkaline reaction.
Eucalyptus eremophila	Sand Mallee	Height 18 ft. Prolific, unusual buds. Flowers greenish-yellow in colour	Ornamental	10in.	Loamy to loamy clay soils.
*Eucalyptus erythronema**	Red Flowering Mallee	Beautiful flower buds of a rosy or pale crimson hue. Bark smooth, light grey in colour ; leaves bluish-green. Height 18 ft.	Ornamental	10in.	Loamy to loamy clay soils.
Eucalyptus erythrocorys	Illyarri	Small tree with dull, whitish bark. Striking scarlet and yellow buds and flowers	Ornamental	20in.	Adaptable. Preference for light soils.

*Eucalyptus falcata**	Silver Mallet	Height 50 ft. Bark smooth and white; crown bushy and a shining green in colour	Shade, street planting	15in.	Good growth on poor soils
Eucalyptus ficifolia	Red Flowering Gum	A tree up to 20 ft. in height, distinguished by striking clusters of crimson flowers against a dark green background of leaves. Rough bark	Street and garden ornamental planting	30in.	Sandy soils.
*Eucalyptus gardneri**	Blue Mallet	Compact tree of 50 ft. height, smooth greyish bark and a bushy, bluish-green crown	Shade and street planting in wheatbelt	15in.	Sandy to loamy soils.
Eucalyptus globulus	Tasmanian Blue Gum	Fast growing heavy-crowned tree up to 60 ft. in height. Foliage attractive	Shade and roadside planting	20in.	Loamy soils.
Eucalyptus gomphocephala	Tuart	Attractive tree with rough, ash-coloured bark and a heavy crown. Height 100 ft.	Shade and roadside planting	20in.	Sandy to loamy soils. Tolerates excess lime in the soil.
*Eucalyptus lehmanni**	Bald Island Marlock	Bushy tree up to 25 ft. in height. Flowers unusual and attractive	Windbreak, shade and ornamental	18in.	Sandy and loamy soils.
*Eucalyptus occidentalis**	Flat-topped Yate	Umbrella crown with shining leaves. Bark rough on trunk, smooth on limbs. Height 70 ft.	Shade tree	15in.	Suitable for planting in poorly-drained situations.
Eucalyptus maculata	Spotted Gum	Tall tree to 100 ft. in height. Beautiful mottled bark and small attractive crown	Ornamental and avenue planting	25in.	Loamy soils.
*Eucalyptus redunca var. elata**	Wandoo	Dense crowned tree of 60 ft. height. Bark smooth and white, foliage a bluish-green hue	Shade tree for farms	15in.	Heavy soils, preferably with a clay sub-soil.
*Eucalyptus salmonophloia**	Salmon Gum	Fine tree up to 80 ft. in height with a smooth salmon-coloured bark. Fairly dense shining green umbrella crown	Shade and shelter. The largest and best of the inland trees	10in.	Sandy loams to heavy clay loams.
*Eucalyptus salubris**	Gimlet	Height 40 ft. Bark smooth, bronze-coloured, compact crown of small dark green leaves	Street, shade and ornamental planting	10in.	Medium to heavy loams.
*Eucalyptus saraentii**	Salt River Gum	Height 30 ft. Medium crown, bark rough on bole, smooth and ribbony on limbs	Shelter in salt areas	15in.	Saline soils.
*Eucalytus stricklandi**	Yellow Flowering Blackbutt	Height 35 ft. Leaves long and leathery dark green and shining. Striking yellow blossoms	Ornamental and street planting	11in.	Gravelly loams.
*Eucalyptus torquata**	Coral Gum	Small tree 35 ft. height. Attractive, unique pink blossom	Street and ornamental	10in.	Loamy soils.
*Eucalyptus woodwardi**	Lemon Flowered Gum	Height 40 ft. Rather straggly habit	Street and ornamental planting	10in.	Loamy soils preferred.
*Eucalyptus forestiana**	Fuchsia Mallee	Small tree up to 10-15 ft. high. Fruit red in colour, clustered and pendulous	Ornamental	15in.	Loamy soils.

SUITABLE TREES FOR PLANTING IN WESTERN AUSTRALIA—continued.

Botanical Name.	Common Name.	Description.	Recommended Use.	Minimum Rainfall.	Soils.
Ficus australis	Port Macquarie Fig	Heavy crowned tree up to 40 ft. in height. Massive roots	Shade tree	20in.	Adaptable to soils.
Ficus macrophylla	Moreton Bay Fig	Heavy crowned tree up to 40 ft. in height. Massive roots	Shade tree	20in.	Adaptable to soils.
Jacaranda mimosofolia	Jacaranda	Beautiful deciduous tree with elegant foliage and masses of violet-blue flowers. Grows to 50 ft. high	Ornamental and street planting	20in.	Good soils. Frost tender when young.
Pinus canariensis	Canary Island Pine	Attractive, hardy pine with broad pyramidal crown. Height 80 ft.	Windbreak, shade and ornamental	20in.	Gravelly loams.
Pinus halepensis	Allepo Pine	Height 50 ft. Fine foliage	Drought resistant. Shelter tree for seaside areas	20in.	Suitable for limestone areas.
Pinus pinaster	Maritime Pine	Hardy tree with dense crown. Height 60 ft.	Windbreak and shade tree	20in.	Sandy soils.
Pinus pinea	Stone Pine	Wide spreading dense crown. Height up to 40 ft.	Windbreak and shade for farms	20in.	Adaptable to most soils.
Pinus radiata	Monterey Pine	Tall tree with dense erect crown. Rapid growth to 100 ft. height. Attractive appearance	Windbreak, road and ornamental planting	25in.	Loamy soils.
Pittosporum undulatum	....	Attractive tree with bright green foliage and scented flowers. Grows to 80 ft. height	Windbreak, street and ornamental planting	25in.	Loamy soils.
Platanus occidentalis	Plane Tree	A large deciduous tree with attractive flaking bark and beautiful broad lobed leaves	Street and ornamental planting	25in.	Good soils.
Populus nivra	Black Poplar	Narrow erect tree with long crown of attractive deciduous foliage. Height up to 100 ft.	Windbreak and avenue planting	25in.	Prefers damp soils.
Quercus lusitanica	Portuguese Oak	Hardy evergreen tree with a compact crown. Height 30 ft.	Shade tree in coastal districts	25in.	Adaptable to most soils.
Salix babylonica	Weeping Willow	Rapid growing tree up to 30 ft. in height. Attractive foliage and weeping habit	Shade and ornamental	25in.	Favourable along water courses in South-West.
Schinus molle	Pepper Tree	An extremely useful drought-resistant tree with a dense globular crown and pendulous branches. Height 25 ft.	Shade and street tree in dry areas	10in.	Adaptable to soils and wil withstand heat and drought.

Tristanea conferta	Brush Box	Neat appearance, compact, dark green foliage, small white flowers. Grows up to 50 ft. in height	Street and ornamental planting	20in.	Adaptable with a preference for heavy soils.
Ulmus campestris	English Elm	Height 60 ft. Deciduous tree with a compact crown	Shade and street planting	30in.	Good loamy soils.

The above list of trees is, of necessity, brief in extent and description of species. It represents a selection of trees which have proved suitable for planting in Western Australia and will be of assistance to those people who are not sure as to which species to plant.

Trees for windbreak, shade, roadside, street and ornamental garden planting are included. Minimum rainfall requirements and soil conditions are supplied as a guide for street and farm planting. In the garden, these conditions are not all important as they can, to some extent, be controlled.

Country residents wishing to purchase any of the listed species should address inquiries to the Forester in Charge, Forests Department Nursery, Dryandra, via Narrogin, for those species marked with an asterisk and to the Forester in Charge, Forests Department, Nursery Hamel, for the remaining unmarked species.

These nurseries supply trees only to country areas. Residents of the Metropolitan Area between Midland Junction, Cosnells and Fremantle may purchase many of the listed trees, together with others of ornamental value from Metropolitan nurseries.

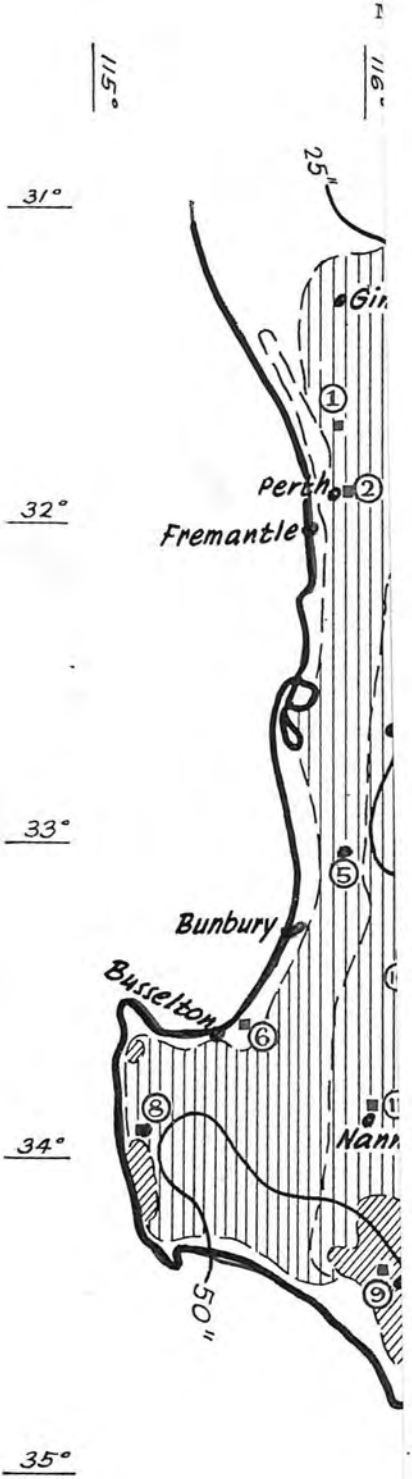

115°
116°
31°
32°
33°
34°
35°
25"
50"
Perth
Fremantle
Bunbury
Busselton
1
2
5
6
8
9

PLATE 30.—A Forests Department officer contacting field crews by means of a radio transceiver.

PLATE 31.—Testing fire equipment in preparation for the fire season.

PLATE 32.—"Knocking down" a small fire with packsprays and rakes.

PLATE 33.—"Mopping up" around a fire perimeter.

PLATE 34.—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.

PLATE 35.—Grass Tree *(Kingia australis)*. Blackboy *(Xanthorrhoea reflexa)*.

PLATE 36.—Sawn timber stacked for air drying. Unless properly ventilated, timber stacks may suffer considerable damage from fungi.

PLATE 37.—Log rake in the jarrah forest. The nearest log is 44 ft. long and 11 ft. 8 in. in girth.

PLATE 38.—Pinus radiata at Mundaring Weir plantation.

PLATE 39.—Gnangara nursery—lifting one year old pine seedlings ready for planting out.

PLATE 40.—Operating the "Lowther Tree Planter" on the coastal plain.

PLATE 41.—"Greystones" Homestead, Mundaring Weir, in 1920 prior to plantation establishment. The following photo was taken 30 years later.

PLATE 42.—Peeler logs for plywood manufacture being snigged during thinning operations. This photo was taken within a few yards of where the house stood in the previous photo.

PLATE 43.—The first steps in map construction from aerial photographs. The photo is marked to show the different forest types, clearings, topography, etc., as seen through the stereoscope. These markings are later transposed to a map.

PLATE 44.—A 68 year old karri regrowth stand at Lefroy Brook.

PLATE 45.—Scarfing a karri tree. Platforms are used to avoid rough or damaged butts.

PLATE 46.—Falling a karri tree with a chain saw.

PLATE 47.—Snigging with a crawler tractor and logging arch.

PLATE 48.—A log landing in the karri forest.

PLATE 49.—Loading a log onto a timber truck.

PLATE 50.—Motor lorries have largely replaced steam locomotives for hauling logs from the bush landing to the mill.

PLATE 51.—Breaking down the log with a twin circular saw and power driven carriage.

PLATE 52.—Plywood peeling.

PLATE 53.—The effect of superphosphate fertiliser in pine plantations. Superphosphate applied to this tree at the age of sixteen years produced the increased growth indicated by the increased ring width.

PLATE 54.—General view of the Forests Department nursery at Hamel. Pines are shown in the foreground.

PLATE 55.—Site selection is important in tree planting.

PLATE 56.—Different trees for different purposes.

PLATE 57.—Types of nursery stock.

PLANT 58.—Planting a tree.

PLATE 59.—Protecting the planted trees.

PLATE 60.—Eucalypt seedlings in trays in a shade frame at Dryandra nursery.

PLATE 61.—Brown mallet *(Eucalyptus astringens)* plantation at Dryandra near Narrogin.

SUBJECT INDEX

A.

B.

C.

G.

H.

M.

N.

O.

P.

S.

5082/5/57—2m. By Authority : WILLIAM H. WYATT, Government Printer, Perth