Forestry

IN

WESTERN AUSTRALIA

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

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FORESTS OF THE ARID AND SEMI-ARID INLAND.

THE JARRAH FOREST

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

Description of the Forest.

Jarrah is a large tree, attaining under optimum conditions, a height of 100 feet to 130 feet, with a straight bole of up to 50 feet or 60 feet, and a diameter of 6 feet.

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

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

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

Distribution.

Jarrah was originally found scattered throughout the South-West of the State, over some 13,000,000 acres of country within the 25 to 45 inch rainfall

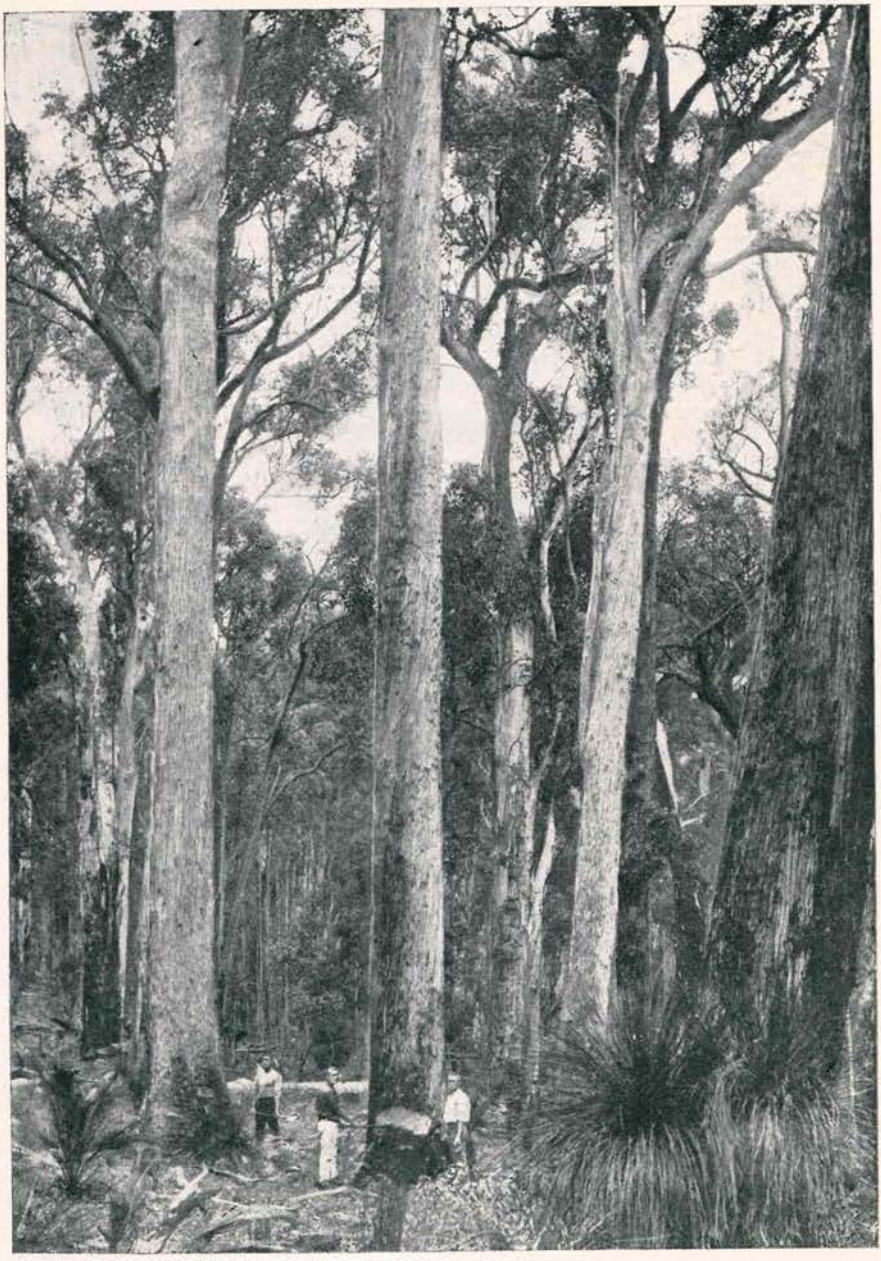

Plate 13.

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

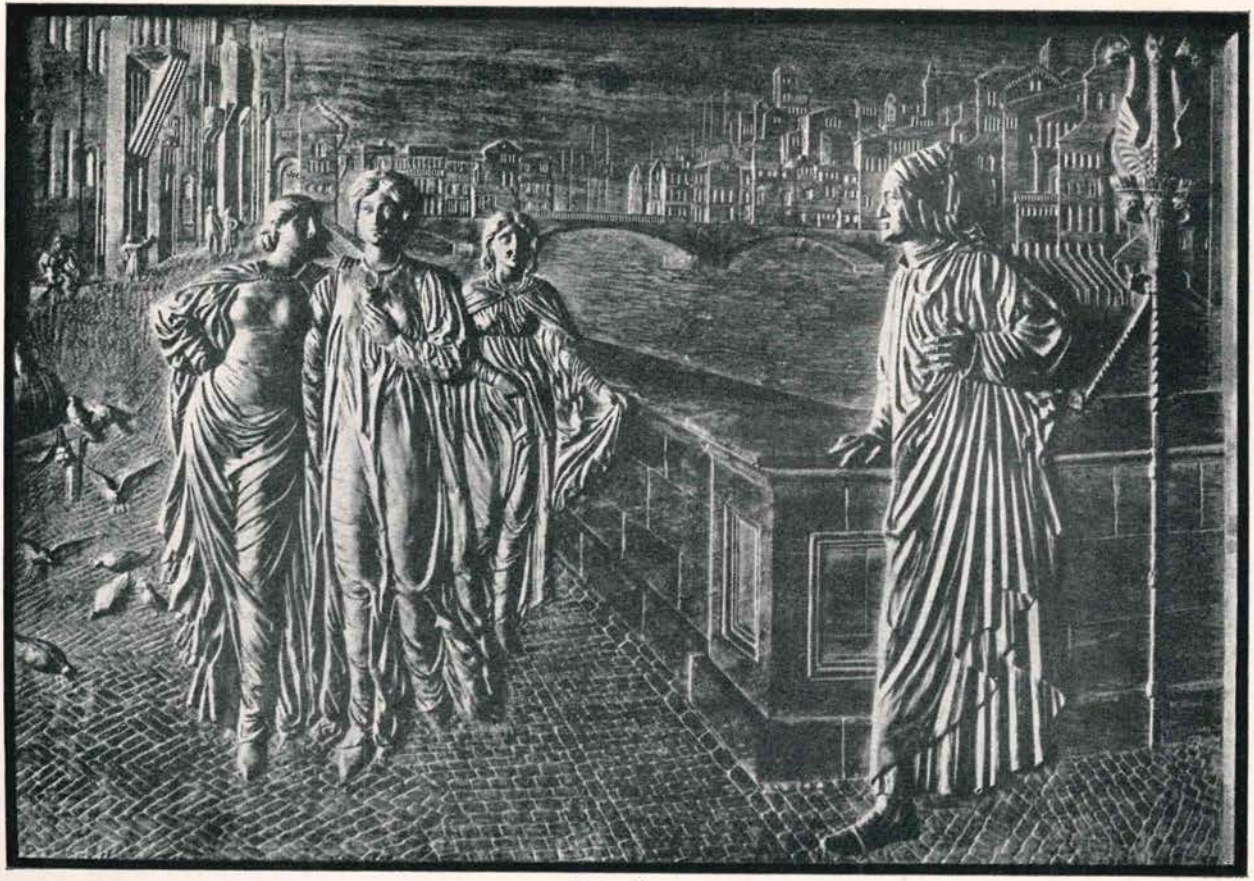

Plate 14.

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

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

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

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

Timber.

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

Weight per cubic foot (green)	73 lb.
At 12 per cent. moisture	54 lb.
Transverse strength	16,200 lb. per sq. in.
Tensile strength	15,500 lb. per sq. in.

Uses.

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

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

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

The timber is quite durable and when used for posts or sleepers in contact with the ground it gives a long life of valuable service. The average life of jarrah sleepers in Australia is 20-35 years depending on the locality in which they are used. Jarrah sleepers are readily accepted in many overseas countries.

Prior to the development of concrete and bitumen road surfaces, its durable nature permitted many famous thoroughfares throughout the world to

be paved with jarrah blocks. Jarrah timbering employed in the first houses constructed in the Colony is still sound today and the post-and-rail fences erected by the early settlers are often still standing.

Flowering and Seeding.

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

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

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

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

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

Regeneration.

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

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

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

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

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

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

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

Plate 15.

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

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

Fire in the Forest.

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

Plate 16.

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

Silvicultural Cutting for Regeneration.

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

Next comes the operation of treemarking. Trees which are to be felled for sawmilling are marked by a forest officer. He blazes the tree to be felled and in a nick cut at the base brands it with his treemarker's brand.

This allows for the removal of mature or less vigorous elements of the old crop; and in the openings left by these trees the regrowth will become established.

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

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

Full protection from fire must be afforded for a period of years until the openings have been satisfactorily stocked with young regrowth of sufficient height to permit the reduction of the fire hazard by prescribed light burning without incurring damage to the crowns. This period of complete fire protection may be from 8 to 10 years, by which time a total height of 20 feet should have been attained, with the height of the lower level of the live crowns being above 12 feet.

Growth Rates.

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

OTHER TREES OF THE JARRAH FOREST.

MARRI. (*Eucalyptus calophylla*).

Habit.

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

Distribution.

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

Timber.

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

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

Uses.

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

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

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

The name "calophylla" signifies beautiful leaf.

BLACKBUTT *(Eucalyptus patens).*

Habit.

Blackbutt is a tree which may attain a height of up to 150 feet, with a bole of 40 to 50 feet, and up to 6 feet in diameter. The bark is persistent, hard, fibrous, deeply fissured, and dark-grey in colour with an almost corky appearance.

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

There are at least five other tree-species of lesser importance in Western Australia, several of them on the Goldfields, known in their respective districts as blackbutt. This indicates why a tree may need something more than its common or local name to distinguish it.

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

Distribution.

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

Timber and Uses.

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

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

NATIVE PEAR *(Xylomelum occidentale).*

Habit.

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

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

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

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

RIVER BANKSIA *(Banksia verticillata).*

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

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

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

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

SHEOAK *(Casuarina fraseriana).*

This tree grows to a height of 40 to 50 feet, with a bole 10 to 15 feet, and a diameter of 2 feet 6 inches. The bark is persistent, greyish, and deeply channelled longitudinally.

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

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

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

THE KARRI FOREST

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

Description of the Forest.

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

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

Distribution.

The karri forest occurs in the extreme South-West of the State in localities receiving a rainfall in excess of 40 in. per annum. The main belt of karri forest lies South of a line drawn from Nannup in the North-West through Manjimup to the Frankland River in the South-East, and thence in a belt of decreasing width through to Denmark and Torbay. Its Western limit is a line South from Nannup, separated from the coast by a belt of coastal sand-dune country varying in width from 2-10 miles.

Plate 17.

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

Two outliers from the main belt occur, namely—

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

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

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

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

Soils of the Karri Forest.

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

Timber.

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

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

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

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

Uses.

The uses of karri are numerous. The strength and stiffness of the timber, combined with the extraordinarily long, clean lengths which may be obtained, render it unsurpassable for superstructural work. It is possible to secure karri in larger sections and longer lengths than any other known hardwood. In

beams, rafters, columns, warehouse floor joists, and other members, where strength is the essential factor, it gives every satisfaction. It may be mentioned that, in one of the mills in the karri forest the roof is carried by two trusses with a common tie beam consisting of a piece of 12 in. by 12 in. karri, 80 ft. in length. In many instances karri has replaced oregon for scaffolding planks, where its greater strength has more than offset the increase in weight. In bridge construction it is used for half caps and decking. The timber is highly prized for transmission line cross-arms, and is also used to a considerable extent for coach, wagon and motor body building.

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

Large quantities of karri have been used for many years by the Postmaster General's Department for telephone crossarms and these have given good service. With the setting up of a 1,000 pounds per square inch pressure impregnation plant at Pemberton, crossarms are now being treated with 3 per cent. pentachlorphenol in oil and are expected to give even better service. The hazard from termite and fungus attack in a crossarm is low but the oil impregnation is worthwhile in reducing the weather checking that can occur in a hot, dry climate. Treated karri crossarms are now being used throughout Western Australia and are being exported to other States.

In 1944 the plywood industry was established in Western Australia using selected karri logs. Although used initially for all classes of plywood, especially

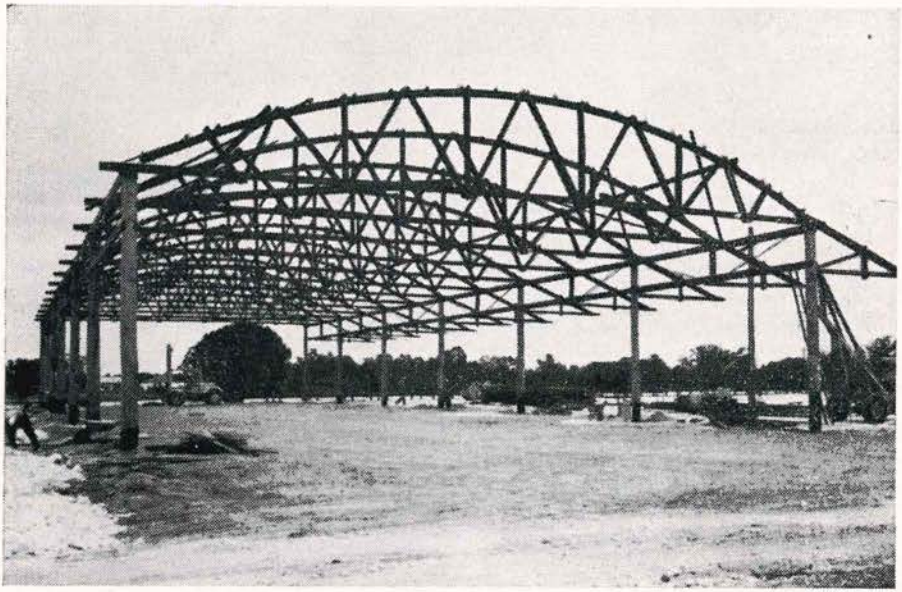

Plate 18.

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

Plate 19.
Karri bud development, showing the flowering stage in mid-Autumn, 2¼ years after the buds are first formed.

3-ply, the main use of karri veneer today is for multi-ply waterproof sheets This type of product is in great demand for concrete form work, because of its great strength and resistance to wear. Karri plywood is also used for truck flooring, and any requirement where strength is an important factor.

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

Until partially replaced by cartons, fruit cases were produced annually to carry the apple crop to England. Karri has also been used for wine vat and cask manufacture and for wood pipes and flumes.

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

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

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

Flowering and Seeding Habits.

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

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

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

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

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

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

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

Seed Supplies.

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

Seed collection for artificial regeneration is done in association with trade cutting, following the testing of sample capsules for high quality seed of above average yield. About 1 ton of green capsules yields 11 lb. of pure seed, averaging 330,000 per pound. The seed constitutes only about one-sixth of the material extracted from the capsules, and the balance is worthless chaff.

Natural Regeneration.

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

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

Plate 20A.

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

Plate 20B.

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

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

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

Artificial Regeneration.

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

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

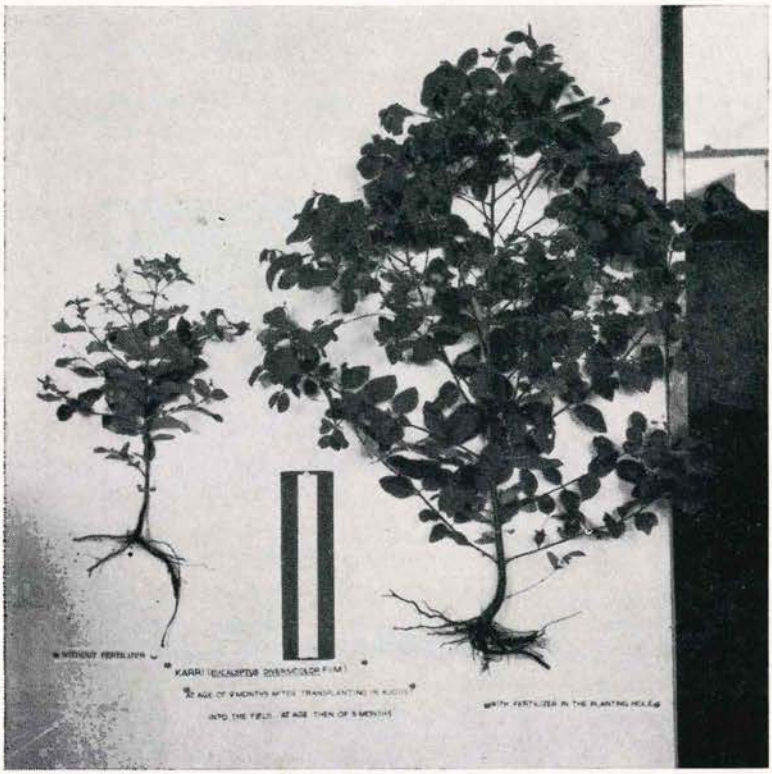

Plate 21.

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

The transplanting of suitably-sized natural regeneration (15 in.) or of open-rooted nursery plants (6-8 in.) gives more certain establishment than does seeding. A handful of equal amounts of nitrogen and phosphate fertiliser next to the planting hole has the effect of producing in transplanted seedlings growth that is more rapid and uniform than that of naturally regenerated seedlings. The shoots of karri seedlings which have been transplanted without fertiliser die back for two-thirds of their height after planting; development is retarded in the early stages and restricted subsequently by weed growth, and the leading side shoots are commonly forked and malformed. On the other hand, karri seedlings fertilised at the time of transplanting produce a vigorous leading shoot and a rush of height growth that quickly dominates the competing ground vegetation. See Plate 21 for a comparison of two equal aged transplants with and without fertiliser.

Silviculture.

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

A seedling establishment of 20,000 or more per acre under natural conditions of height growth and fire would be reduced to 1,000 trees at 10 years and 500 at 20 years. Roughly half of these would by this time be dominated.

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

The oldest stands resulting from Departmental regeneration work date from 1929, but valuable information has been obtained from areas of natural regeneration at Karridale, now aged 60-70 years, and also from old farm properties, one of which dates back to 1872.

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

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

Regeneration Systems Employed.

The earlier regrowth stands from 1929 to 1936 were produced under a clear felling system in which marketable timber was felled with no attempt to preserve smaller immature trees. Many of these were smashed in felling operations. Marri trees were ringbarked, and the understorey scrub felled, and the whole burnt by a fierce fire in a good seed year. A dense and uniform crop of seedling regeneration came from seed provided by non-marketable karri trees left in the stand. These latter were subsequently ringbarked to save the growing stock from competition.

In 1936 this method was replaced by a silvicultural operation known as the Selection System, a modified form of treemarking under which the overmature and mature karri trees were removed for sawlogs under the direction

Plate 22.

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

of a Forest Officer, with the aim of retaining undamaged the maximum number of immature trees. Standard treemarking was introduced into the karri forest about 1949. Under this system the Forest Officer marks the trees to be removed, and also indicates the direction in which they are to be felled in order to avoid damage to growing stock.

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

OTHER IMPORTANT SPECIES OF THE KARRI FOREST.

RED TINGLE TINGLE *(Eucalyptus jacksonii)*.

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. in.
Tensile strength	15,680 lb. per sq. in.

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

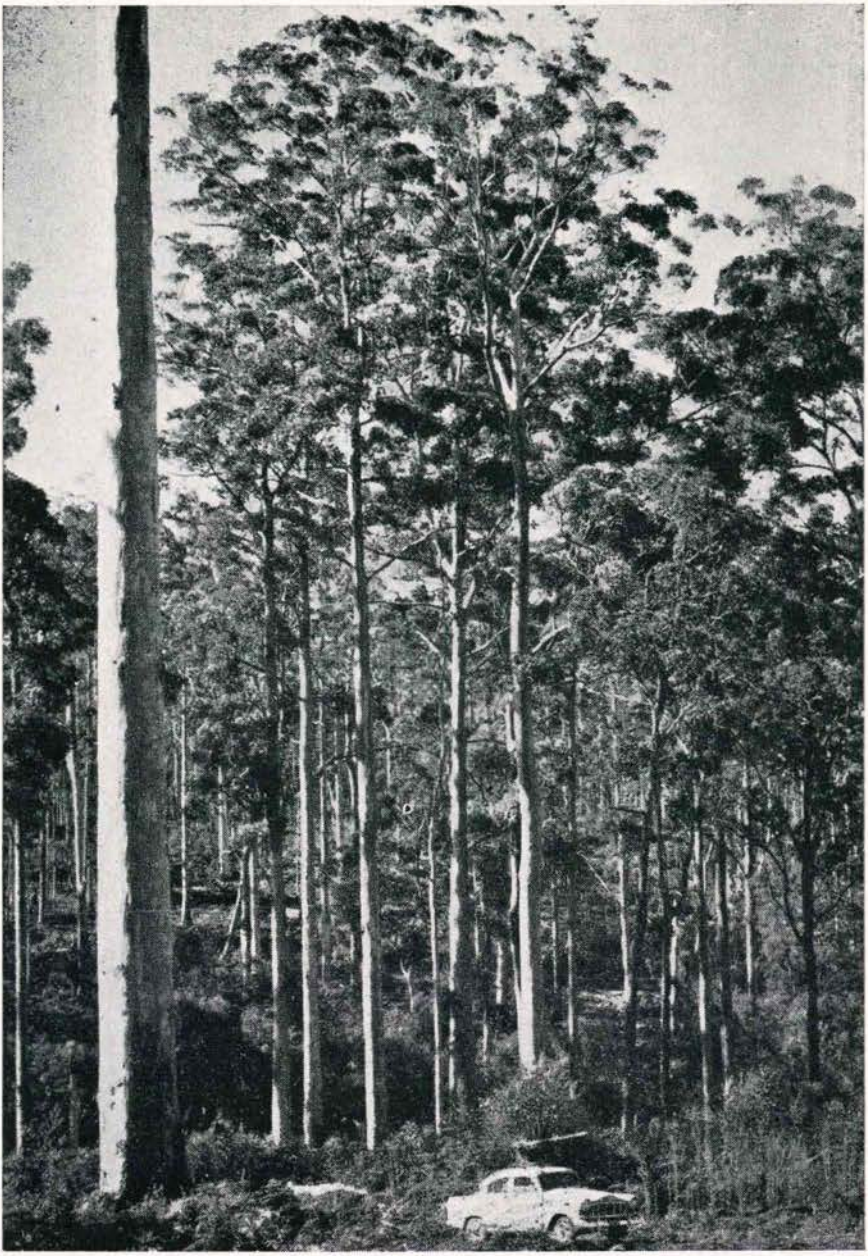

Plate 23.

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

YELLOW TINGLE TINGLE *(Eucalyptus guilfoylei)*.

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

Timber.

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

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

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

RED FLOWERING GUM *(Eucalyptus ficifolia)*.

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

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

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

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

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

WARREN RIVER CEDAR *(Agonis juniperina)*.

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

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

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

THE TUART FOREST

Description of the Forest.

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

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

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

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

Distribution.

Tuart is confined to the limestone formation, and on this formation it stretches in scattered lines from Lake Pinjar southward along the coast as far as Sabina River, some three miles east of Busselton. Curiously enough, it is not found elsewhere in the State, although limestone occurs all round the coast line.

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

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

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

Soils.

Tuart is only found on limestone in this coastal tract.

Timber and Uses.

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

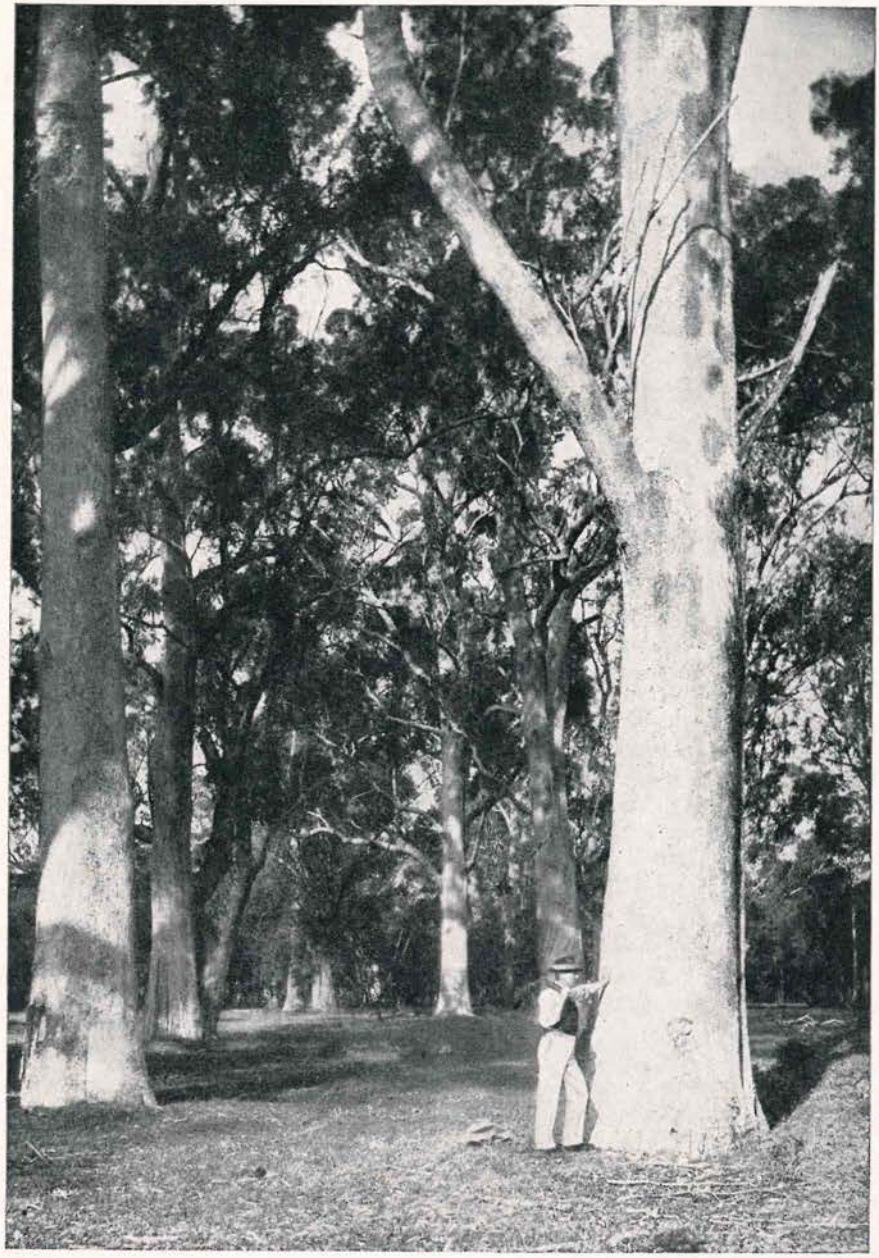

Plate 24.

Tuart *(Eucalyptus gomphocephala)* forest near Busselton.

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

Weight per cubic foot (green)	78 lb.
At 12 per cent. moisture	64 lb.
Transverse strength	17,900 lb. per sq. in.
Tensile strength	16,500 lb. per sq. in.

Flowering and Seeding.

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

Regeneration.

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

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

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

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

YATE *(Eucalyptus cornuta).*

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

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

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

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

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

THE WANDOO FOREST

Description of the Forest.

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

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 beteen the 15 and 30 inch rainfall limits. It extends from as far north as Moora, reaching its maximum development in the vicinity of Toodyay from whence it deviates to form two areas, one on either side of the Darling Range.

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

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

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

Soils of the Wandoo Forest.

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

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

Plate 25.

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

Timber.

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

Weight per cubic foot (green)	80 lb.
At 12 per cent. moisture	68 lb.
Transverse strength	16,100 lb. per sq. in.
Tensile strength	16,500 lb. per sq. in.

Uses.

Wandoo is best suited for purposes where strength and durability are of importance. It is used in considerable quantities for sleepers (being recognised as one of Australia's best sleeper timbers) and is in great demand for poles. It is a first class structural timber and used in the construction of bridges and wharves for beams, girders, joists and storey posts. For railway purposes it is used for truck under-frames and has proved eminently satisfactory for top planks in truck sidings where it is subject to heavy service conditions. In earlier days it was highly prized by the wheel-wright trade for naves, shafts, cogs, spokes and felloes, and from it various implements are made.

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

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

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

Natural Regeneration.

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

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

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

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

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

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

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

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

Timber Production.

Volumes of utilisable timber produced per acre in the wandoo forest are very variable. They may vary from 50 cubic feet per acre to 1,000 cubic feet per acre. Good wandoo forest is considered to carry at least 400 cubic feet of merchantable timber per acre.

OTHER TREES OF THE WANDOO FOREST.

YORK GUM *(Eucalyptus loxophleba)*.

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

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

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

Weight per cubic foot (green)	77 lb.
At 12 per cent. moisture	67 lb.
Transverse strength	14,500 lb. per sq. in.
Tensile strength	13,000 lb. per sq. in.

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

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

Swamp yate is a tree which may attain a height of about 70 feet with a trunk up to 20 inches in diameter and a rough, grey, flaky-fibrous bark covering the whole of the trunk and the lower parts of the main branches. The branches have a smooth yellowish-grey bark and usually spread giving the crown of the tree a typically broad and flat appearance, hence the name of "flat-topped" yate.

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

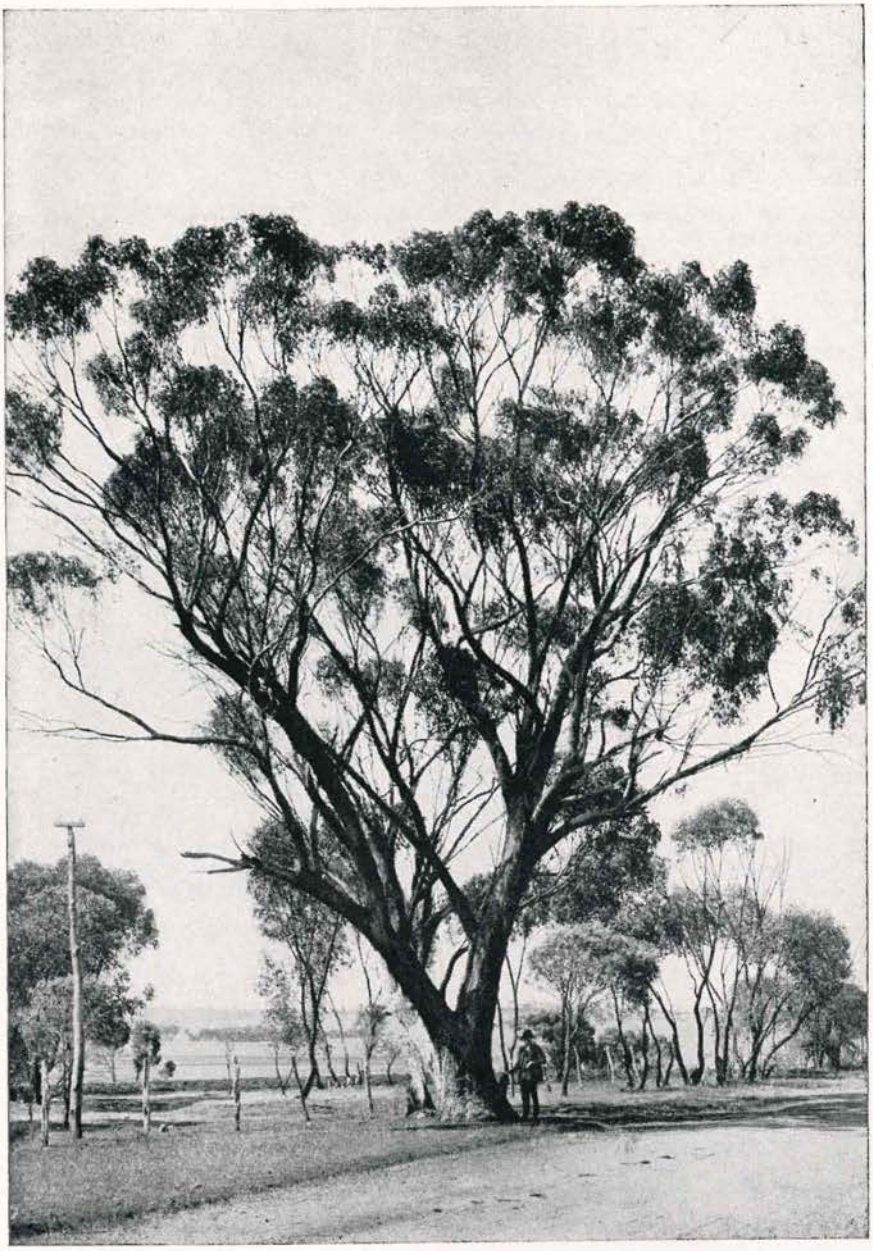

Plate 26.

York Gum *(Eucalyptus loxophleba).*

Plate 27.

Raspberry Jam *(Acacia acuminata).*

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

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

RASPBERRY JAM *(Acacia acuminata)*.

Jam occurs as a small tree 15 to 25 feet in height with a short bole 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 crushed raspberries, which is characteristic of the wood.

THE MALLET AREAS

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

Eucalyptus astringens	Brown mallet,
Eucalyptus gardneri	Blue mallet,
Eucalyptus falcata	White mallet,
Eucalyptus spathulata	Swamp mallet,

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

Description of the Mallet Forest.

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

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

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

Mallet regenerates prolifically after a fire and forms dense groups of regrowth. Similar dense groups occur under plantation conditions. Unless

these are thinned, growth stagnation occurs which results in delayed production of bark of economic value. Given ample space, the mallets under favourable conditions develop into attractive ornamental trees.

The mallets are all extremely fire tender but managed to survive for untold centuries in areas subject to heavy periodic fires. When they regenerate after a fire they are commonly associated with a dense growth of poison plants. After about twelve to twenty years these plants die and disintegrate leaving a comparatively clean floor which will not readily carry a fire except under severe weather conditions. With the increase in fire frequency associated with settlement, mallet groups were generally not able to remain unburnt until the clean floor stage and many of them were destroyed.

Distribution.

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

To the east of the 25 inch isohyet, the jarrah forest gives place to savannah forest of wandoo *(Euc. wandoo)* and further east the wandoo savannah gradually merges into the low rainfall temperate forests and woodland of salmon gum and morrel, with belts of mallee and heath. In these two latter types of forest the mallet forest occurs in colonies ranging in area from 1 to 200 acres.

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

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

Swamp mallet occurs on loams in low-lying situations. It attains its best form in the Southern Wheat Belt between Katanning and Ongerup.

Utilization.

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

During recent years brown mallet has been used as a mining timber in sizes from 3 inch crown diameter upwards.

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

The economic importance of mallet has arisen from the tannin which occurs in the bark. The bark after stripping and air drying is chipped into

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

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

Silviculture.

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

Artificial regeneration of brown mallet was carried out for over 30 years (from 1927-60), and 19,000 acres of plantation were established. The procedure was to remove all marketable timber from an area, clear fell the remainder, and after it had dried, burn in late summer. Sowing was carried out as soon as possible after burning to take advantage of the early winter rains. Small spots about 12 in. in diameter at about 6 ft. intervals were lightly cultivated with small hand hoes and a pinch of seed dropped on each (about ½ lb. of seed per acre was used). The seed was then lightly covered and compacted by light pressure from the planter's foot.

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

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

Trials have shown that white mallet will succeed on laterite sites considered too poor for brown mallet. On the better sites the latter is undoubtedly the most desirable species, returning a somewhat higher yield of better quality bark.

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

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

considerably greater than that of trees less favourably situated within the compartment.

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

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

Distribution.

These forests cover a region roughly rectangular in shape, bounded on the North by the 25° parallel of latitude and on the East by the 125° meridian of longitude. The South Western boundary is the 20 in. isohyet and the Southern boundary (from a point about 70 miles east of Albany) is the South Coast.

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

THE EUCALYPT ZONE.

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

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

Whilst this zone forms one broad climatic type, a number of subzones can be recognised, viz.:—

(1) (20-15 in. Rainfall).

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

An easterly extension of this zone which forms a narrow strip of some six million acres in extent adjoins the South Coast and extends eastward to about 120 miles east of Esperance. This extension consists largely of sand plain and mallee and is at present being rapidly developed for agricultural purposes.

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

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

(3) (Below 11 in. Rainfall).

This sub-zone lies to the east of the agricultural areas and extends thence eastwards for a distance of nearly three hundred miles. Its northern limit

is about fifty miles north of Kalgoorlie and its southern limit some sixty miles south of Norseman.

A wide range of species occur including the following:

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

Salmon Gum, Morrel and Dundas Mahogany attain heights of seventy feet or more but other species vary in height from thirty to about fifty feet.

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

For approximately forty years mining operations on the Golden Mile depended solely on wood fuel for their power. During the 1930's a change was initiated with the introduction of oil fuel on two mines and this trend continued until about 1960 when wood fuel was entirely displaced by oil on all mines. It has been estimated that the total firewood consumption by the goldmining industry since its inception was of the order of twenty-five million tons.

In addition to the principal forest types described, we have associated with them the following non-forest areas which occur throughout the whole eucalypt zone.

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

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

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

THE MULGA ZONE

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

have vertical leaf-like phyllodes of a blue-grey hue and the general appearance of the mulga is drab and dull. The most outstanding species are:

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

Associated with the acacias are a number of minor genera; viz., hakea, eremophila, cassia, brachychiton, etc.

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

Silviculture.

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

Cutting has been practically on a clear felling basis, the only trees excluded from the operations of licensees being those of under five inches diameter at six inches from the ground. Actually, scattered over-mature trees unfit for mill logs and too tough to split for firewood were left and these assisted, to a limited extent, in providing seed for the second crop. Much of the seed, however, came from the trees which had been felled and many of the seedlings became established either among the leaves of the parent or in slight depressions—particularly in the wheel ruts of drays, etc.

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

Further problems arise in dealing with the mulga forest. The understorey is sparse and if too much of the cover is removed, wind erosion is liable to occur, while owing to the very slow growth rates (on trees of 3 inch diameter it is less than $\frac{1}{8}$ of an inch in girth per annum) restocking is a very slow process. The majority of the Acacias in the association possess marked value as top feed for stock, while the timber—being fungus and termite resistant—is eminently suitable for fencing and other requirements on the sheep stations. The Forests Department, therefore, is called upon here to safeguard and reconcile the conflicting claims of the miner, the firewood cutter and the pastoralist.

In order to safeguard mulga stands, firewood cutters are required to confine their cutting to the denser patches and leave at least seven living trees over 4 ft. in height per square chain on the areas cut over.

THE PRINCIPAL GOLDFIELDS TREES.

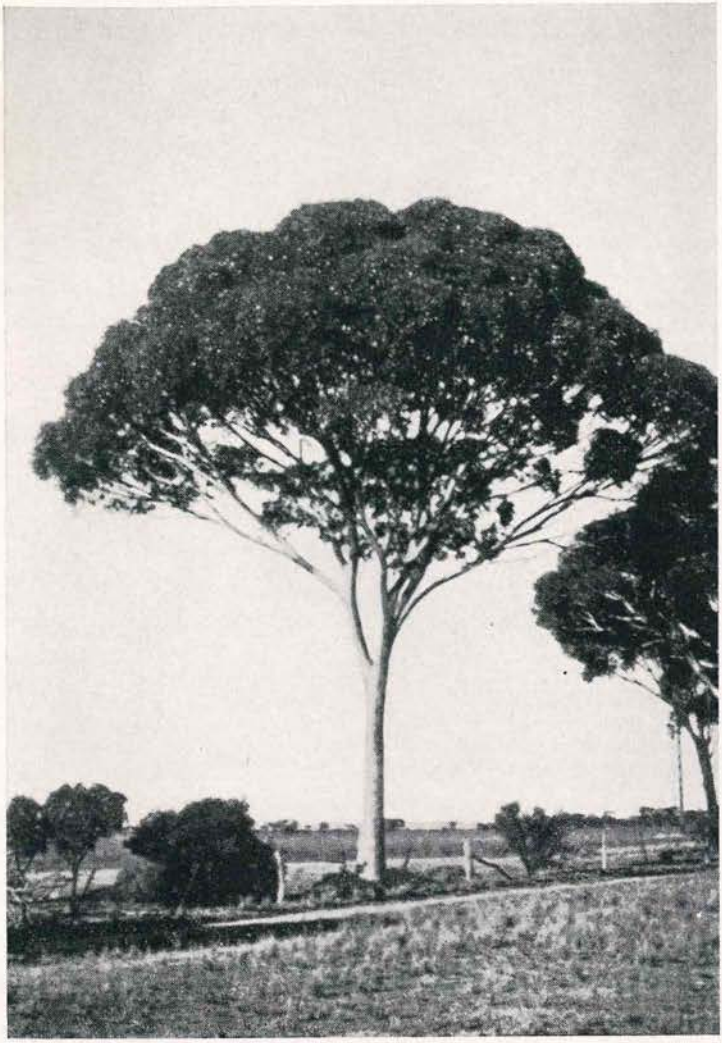

Plate 28.

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

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

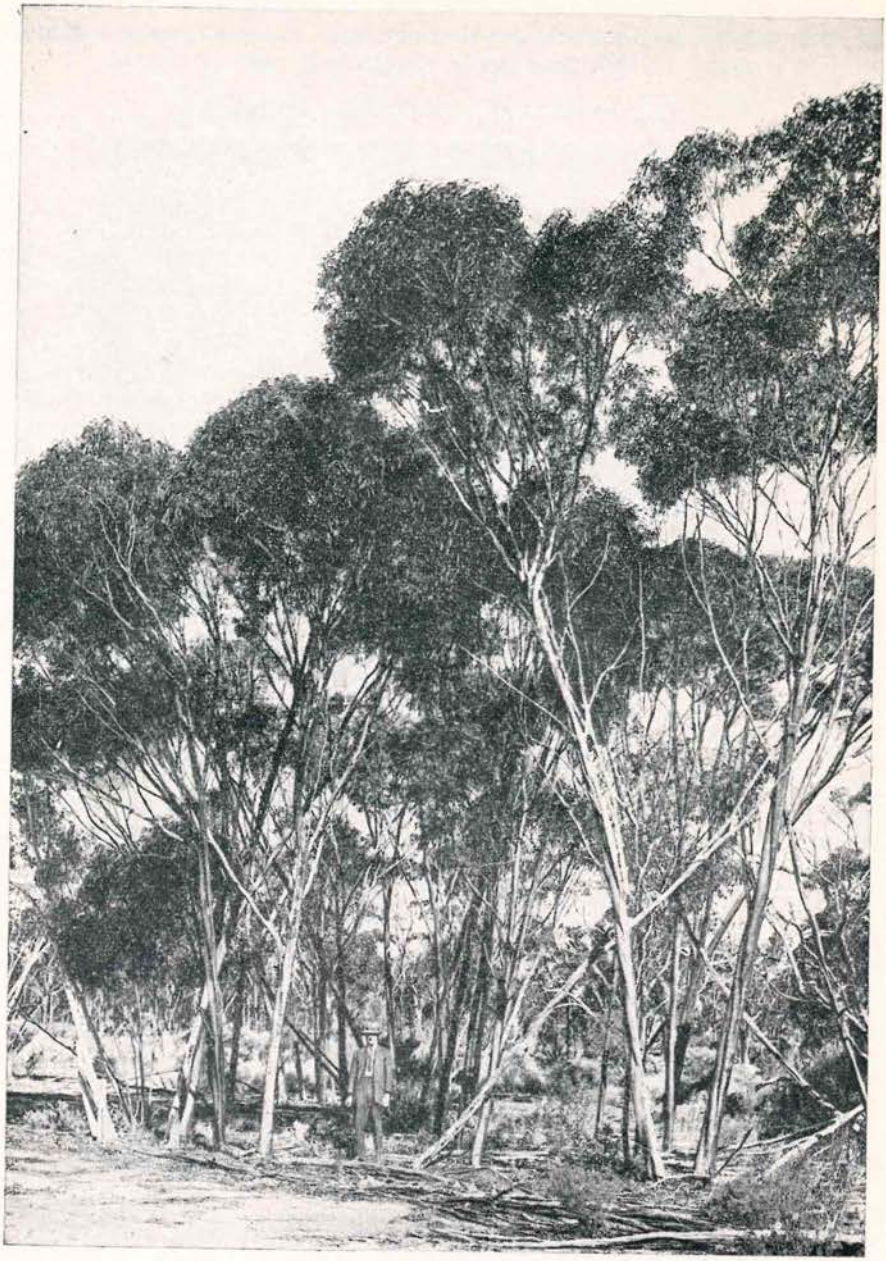

Plate 29.

Gimlet *(Euc. salubris)*.

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

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

Weight per cubic foot (green)	70 lb.
At 12 per cent. moisture	66 lb.
Transverse strength	20,100 lb. per sq. in.
Tensile strength	19,200 lb. per sq. in.

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

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

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

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

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

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

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

Red Morrel is larger and more widely distributed than Black Morrel. It attained heights of up to 90 feet in the wheatbelt and somewhat less further east. While red morrel occupies a range covering almost the whole of the wheatbelt and eastwards to the Goldfields, the black morrel occurs in a more restricted area from Westonia to Bulla Bulling. Although somewhat similar in appearance, the two can be distinguished fairly easily. With red morrel the wood is red, the under-bark pink and the bark on the upper branches

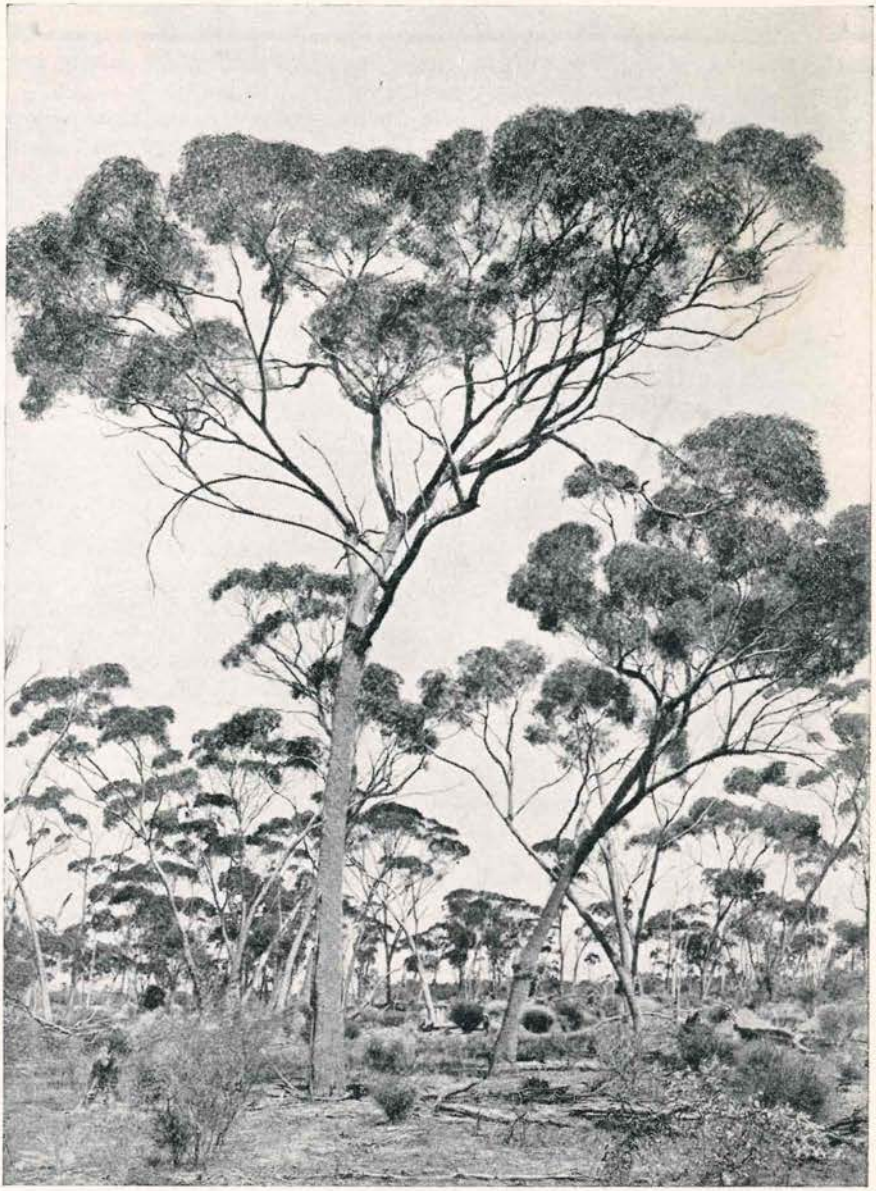

Plate 30.

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

reddish grey. With black morrel the wood is dark brown, the under-bark yellow and the bark on the branches silver-grey with darker patches.

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

The following are the physical characteristics of red morrel—

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

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

DUNDAS MAHOGANY *(Eucalyptus brockwayi)*

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

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

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

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

GOLDFIELDS BLACKBUTT *(Eucalyptus le souefii)*.

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

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

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

BOONGUL *(Eucalyptus oleosa var glauca)*.

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

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

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

CORAL FLOWERED GUM *(Eucalyptus torquata)*

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

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

Buds and fruits are quite unique in form, in that both the base of the capsule and the operculum are distinctly ribbed, while the latter terminates in a beak some half inch in length. (See plate 7.)

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

KURRAJONG *(Sterculia gregorii)*

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

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

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

THE GOLDFIELDS PINE *(Callitris glauca)*

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

SANDALWOOD *(Santalum spicatum)*

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

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

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

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

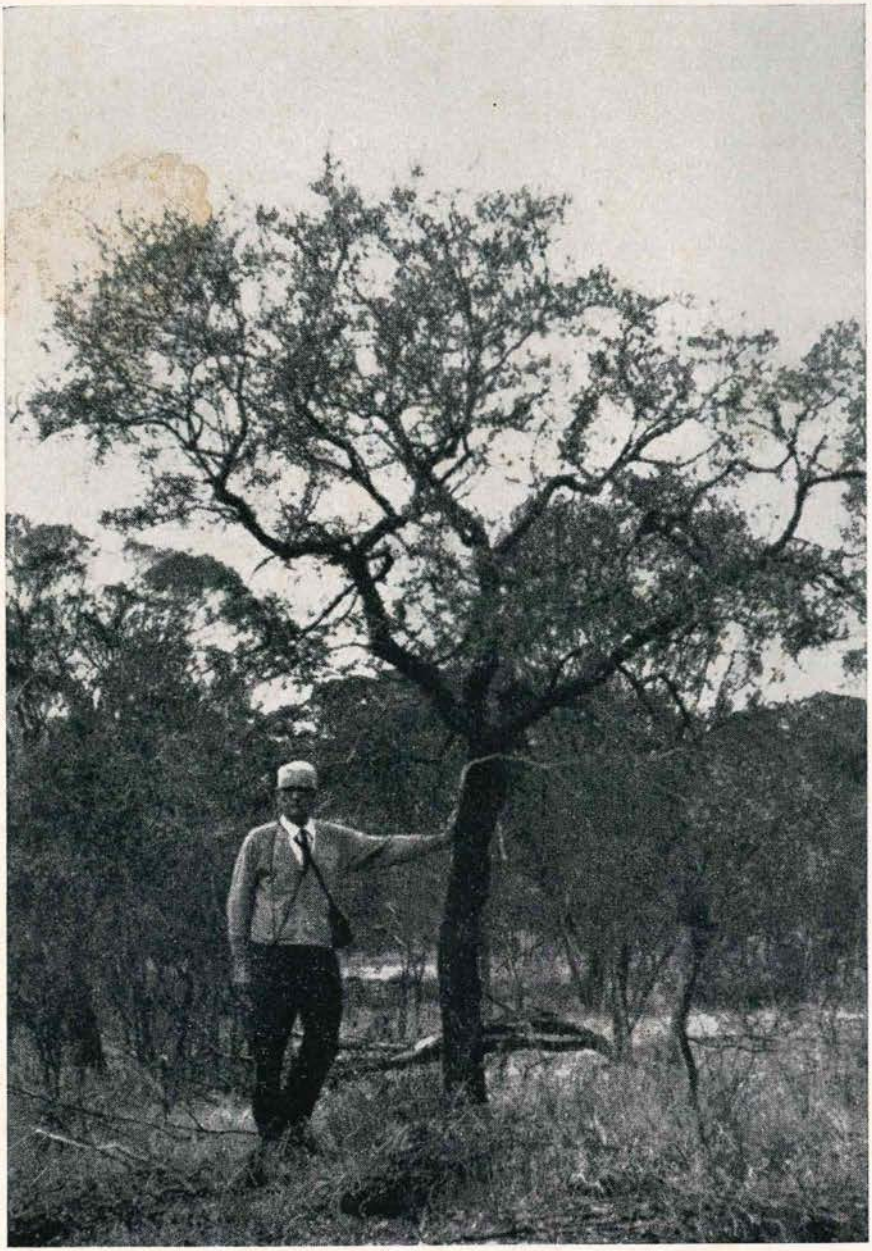

Plate 31.

Sandalwood *(Santalum spicatum)*.

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