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

REPRINTED FROM BULLETIN NUMBER SIXTY-THREE
FORESTS DEPARTMENT, 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

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.

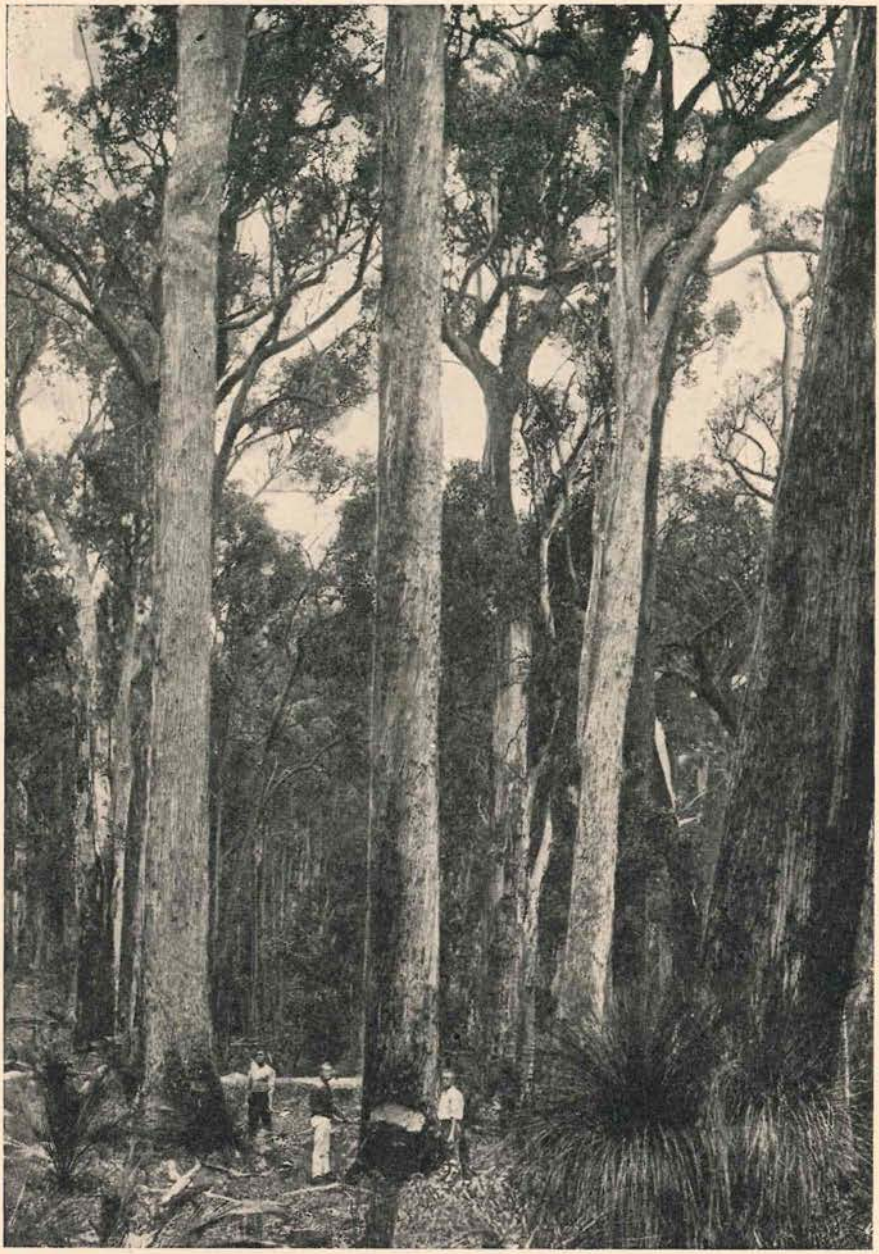

Plate 14.

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.

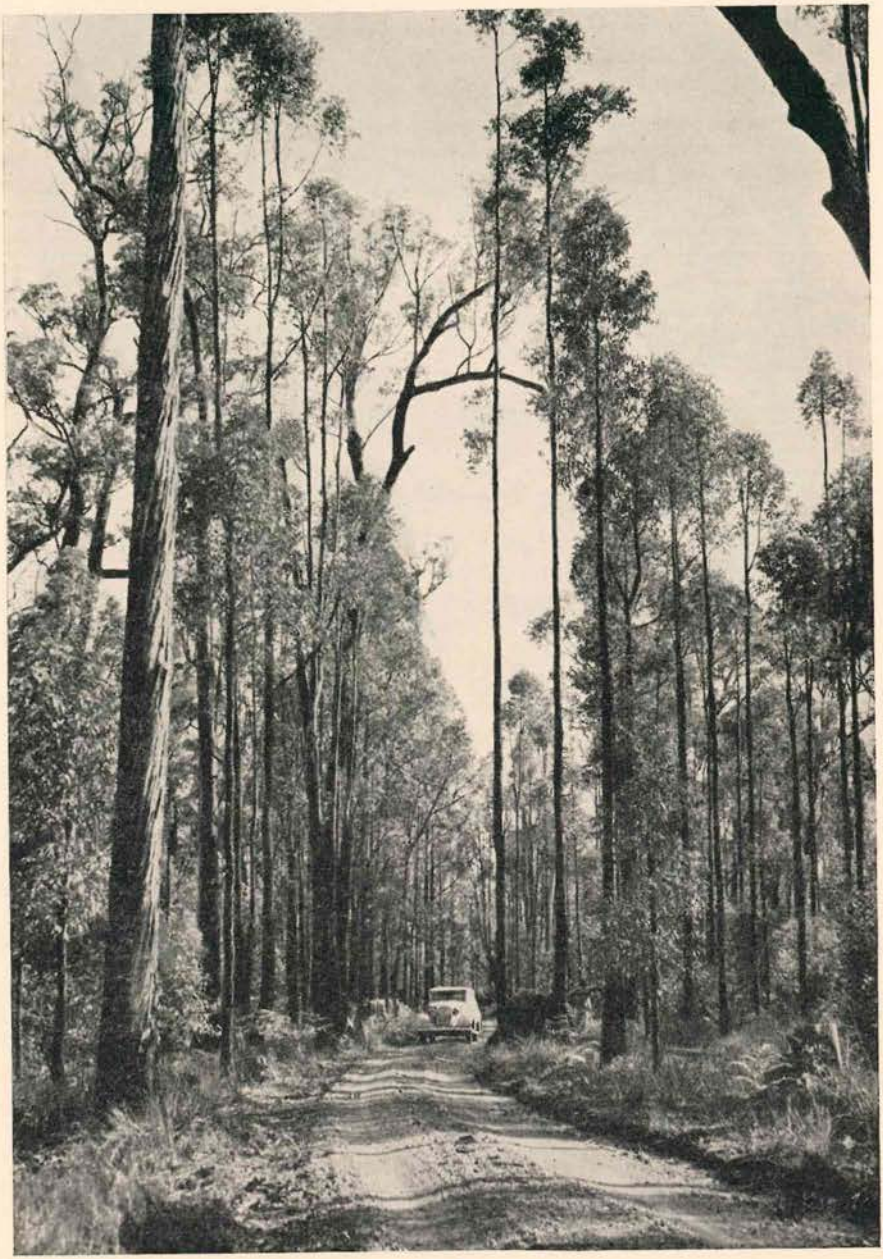

Plate 16.
A jarrah regrowth stand of age 25 years resulting from silvicultural treatment following heavy logging operations.

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.

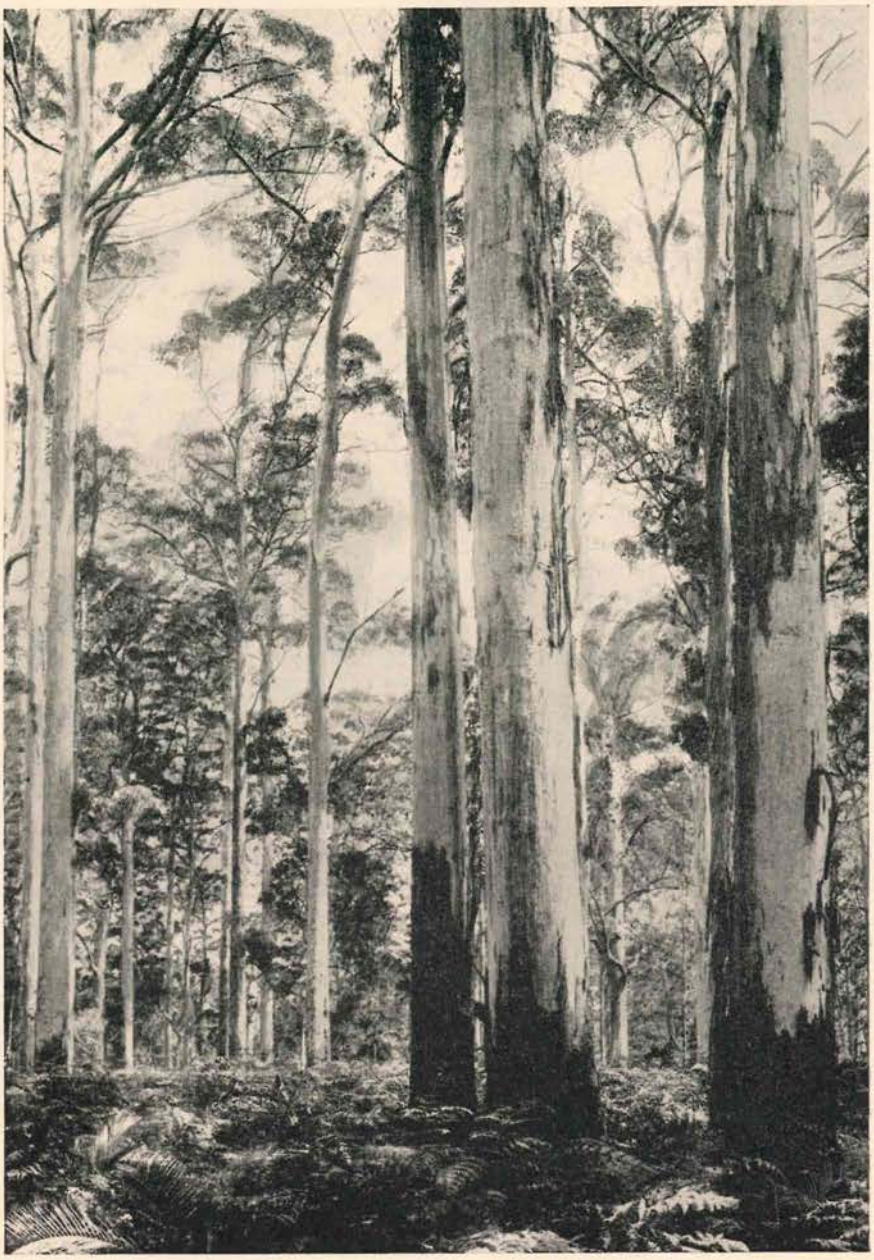

Plate 17.

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.

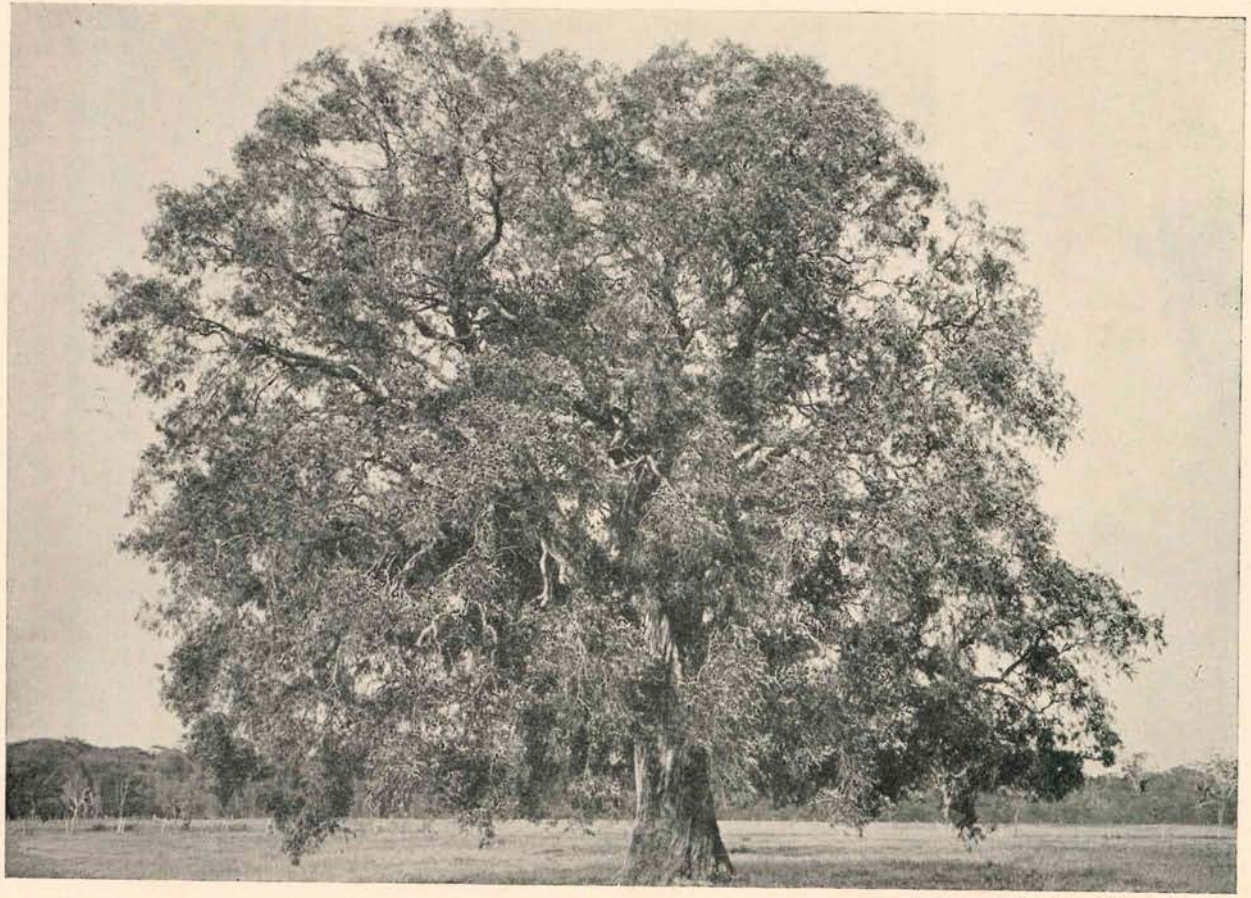

Plate 19.
W.A. Peppermint *(Agonis flexuosa).*

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.

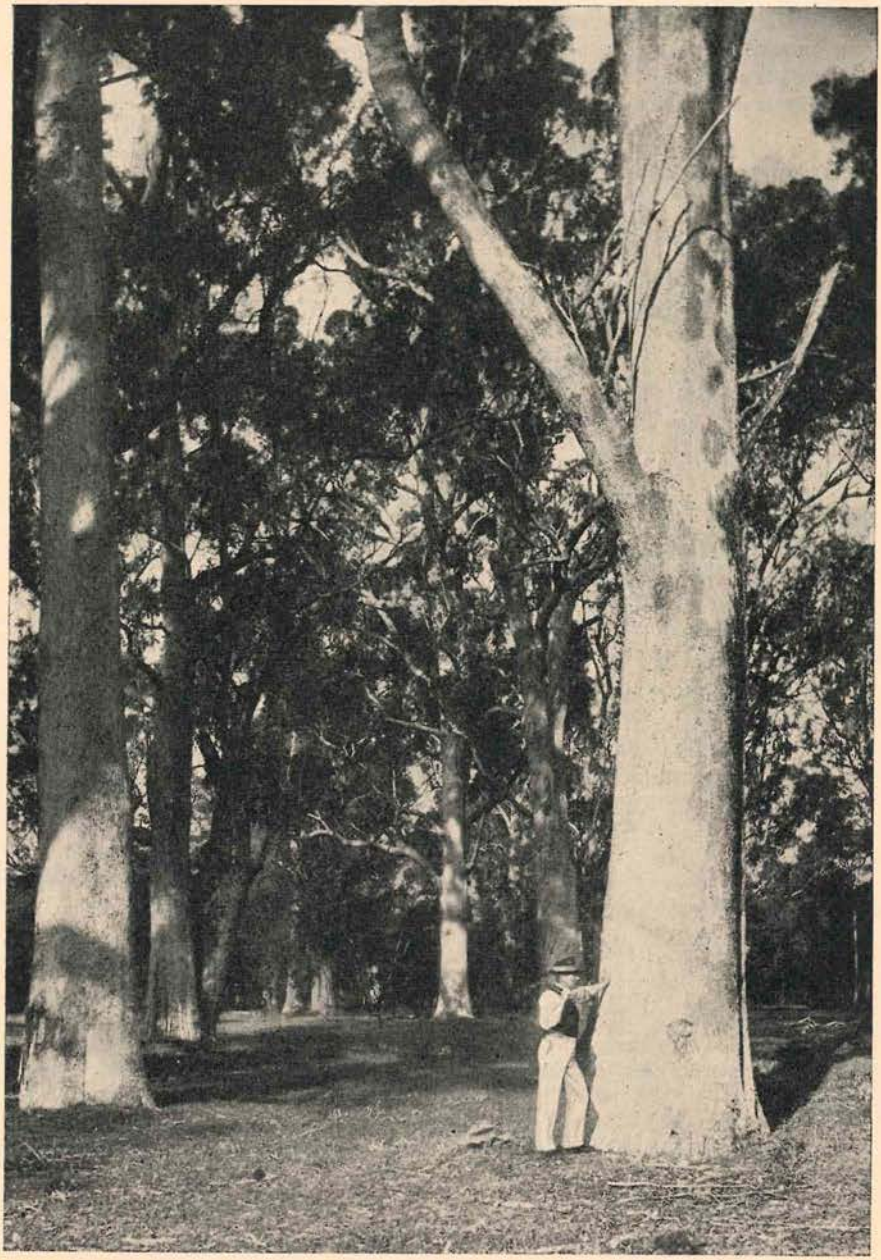

Plate 20.

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 3 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.

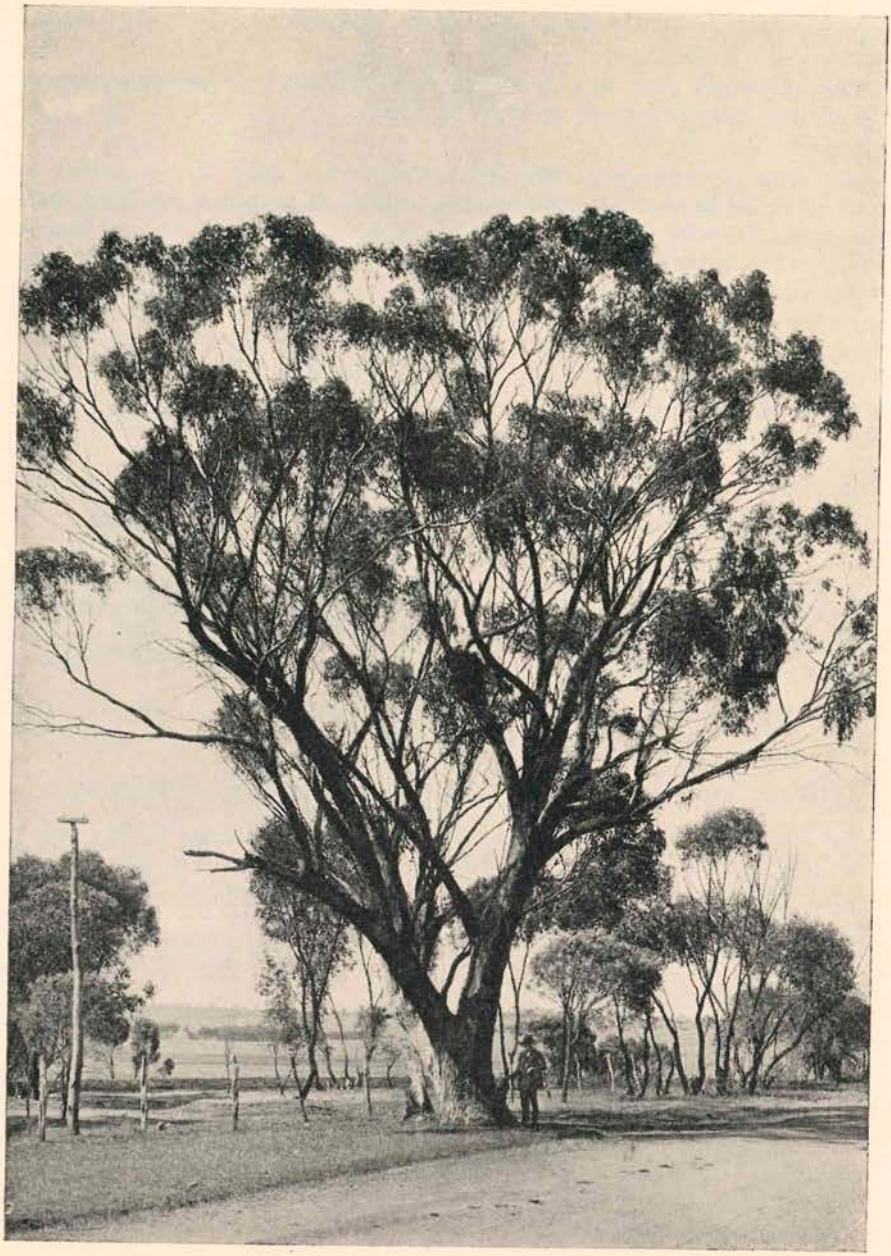

Plate 22.

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 ¼ to ⅜ inch thick in young trees but up to ⅝ 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.

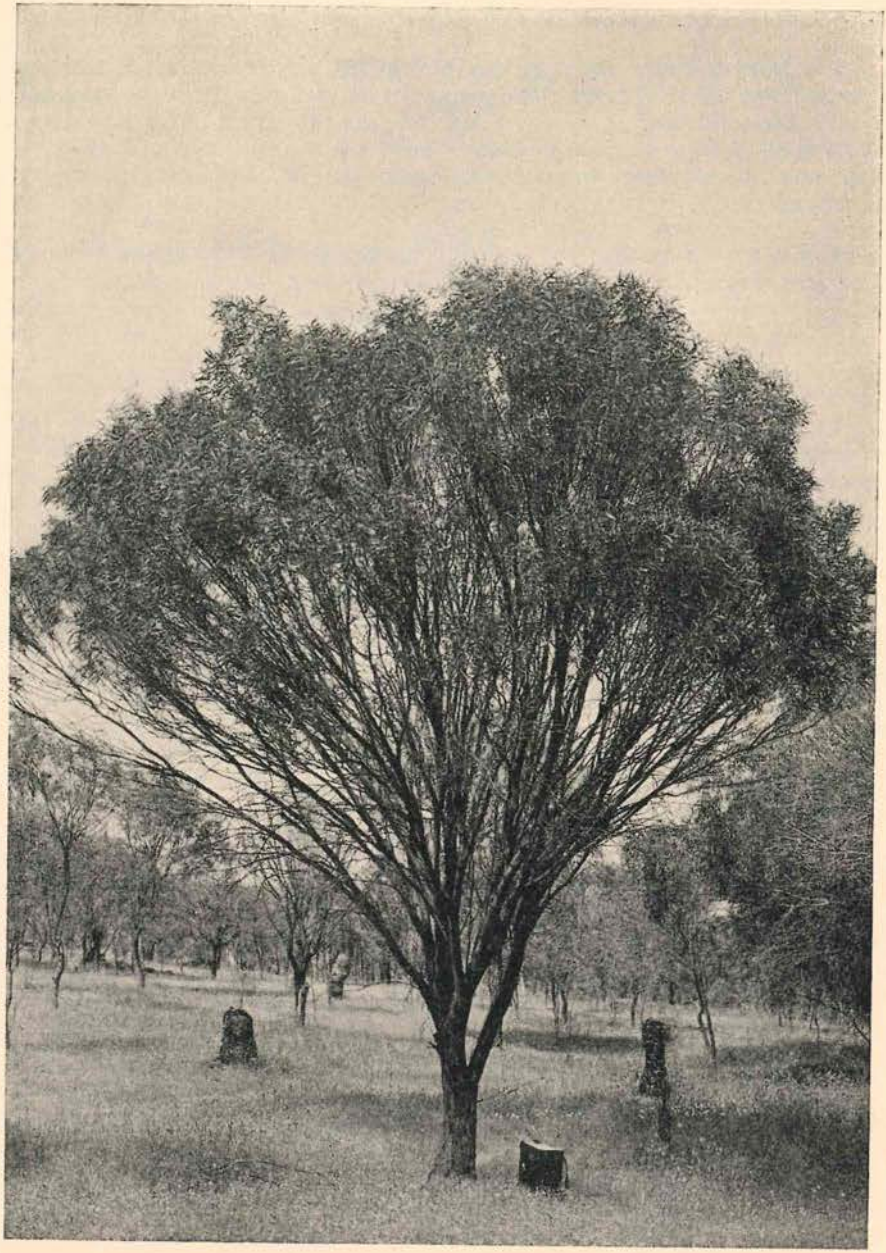

Plate 23.

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. glaucа)*. The understorey consists of hardy perennial shrubs and annual herbage.

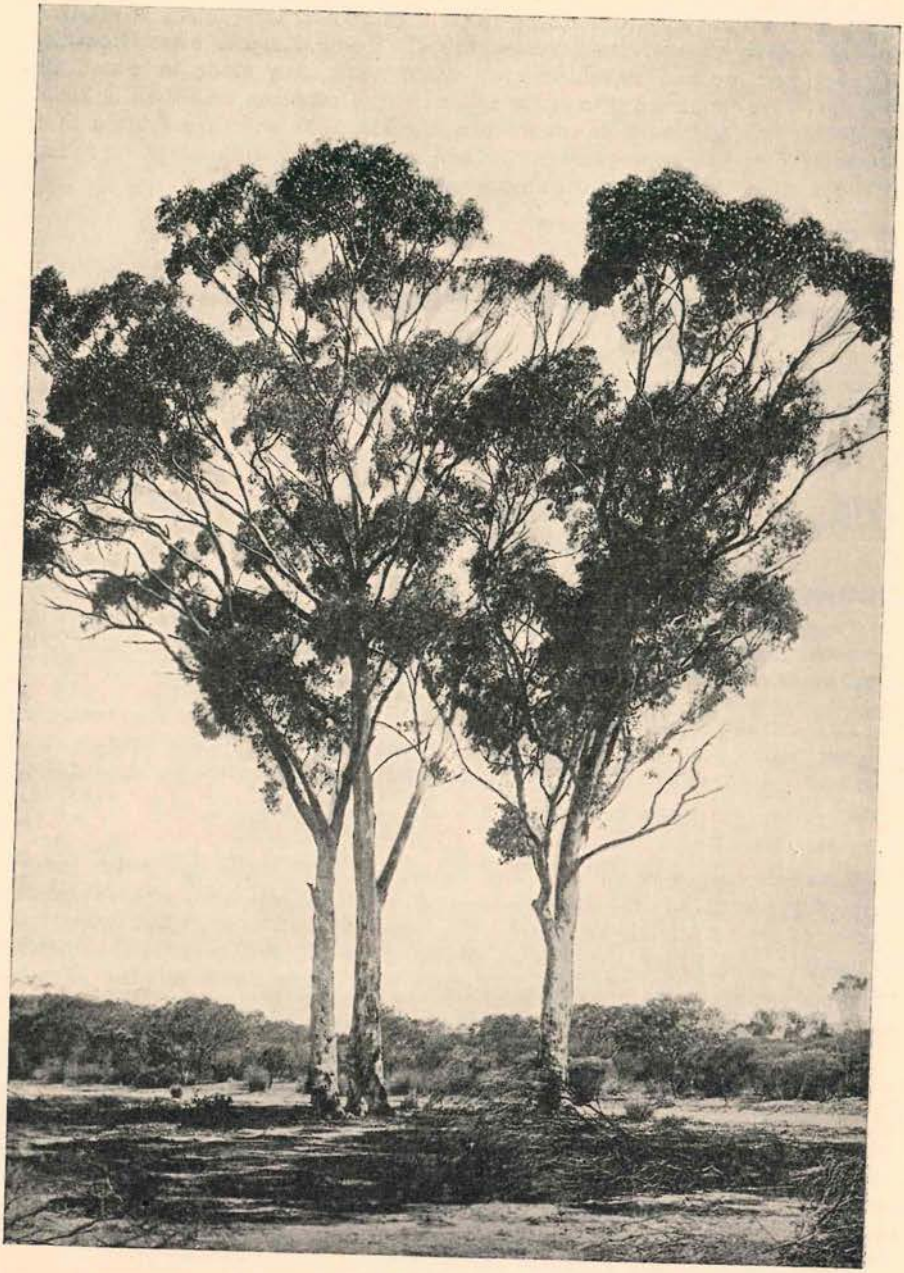

Plate 24.

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.

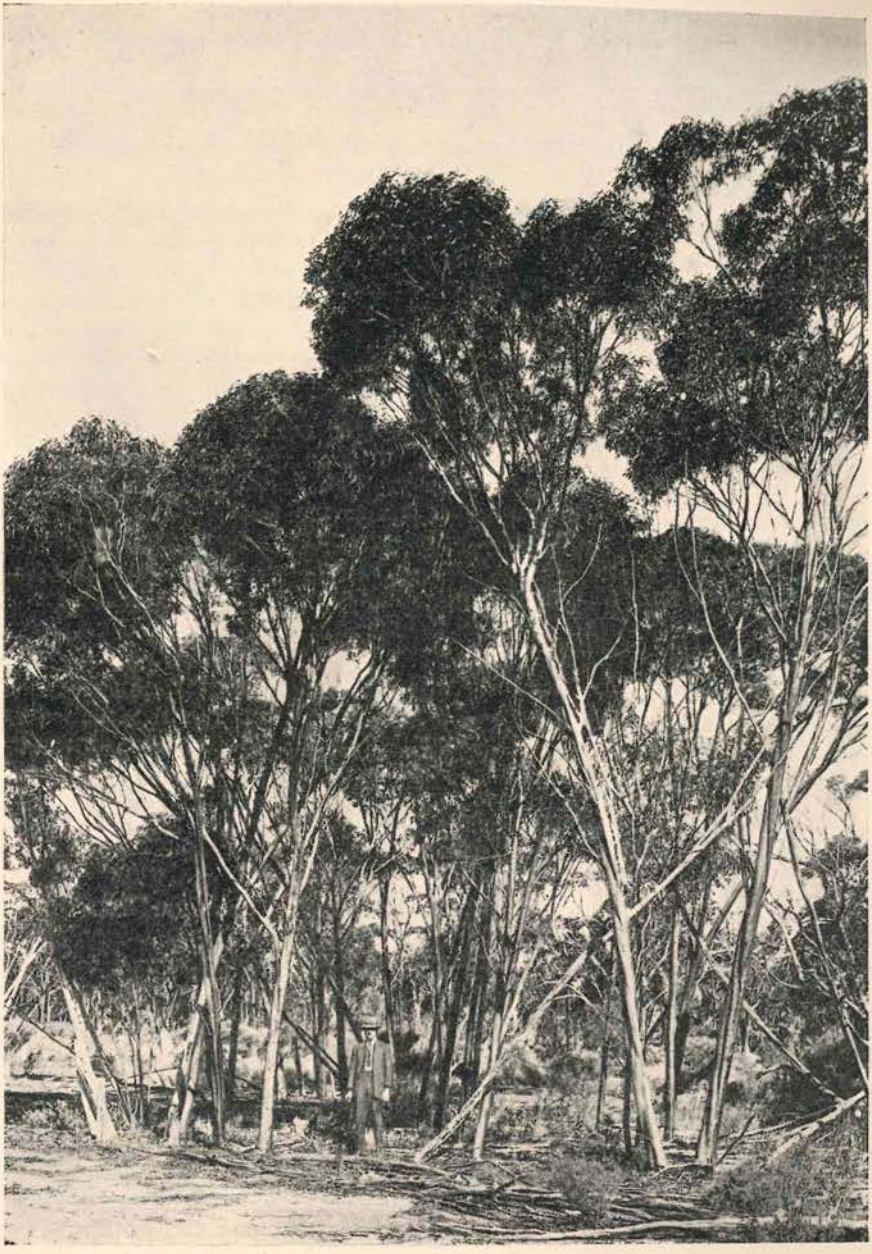

Plate 25.

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.

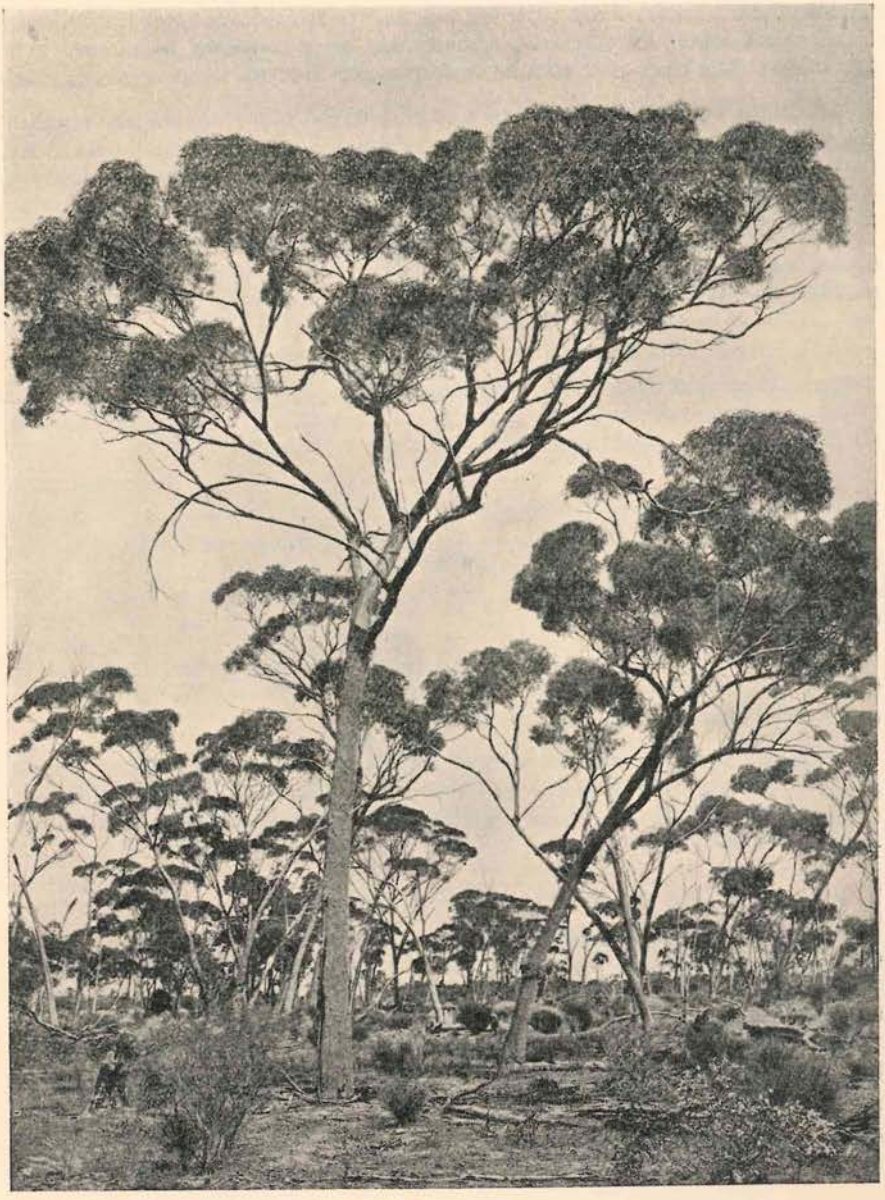

Plate 26.

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.

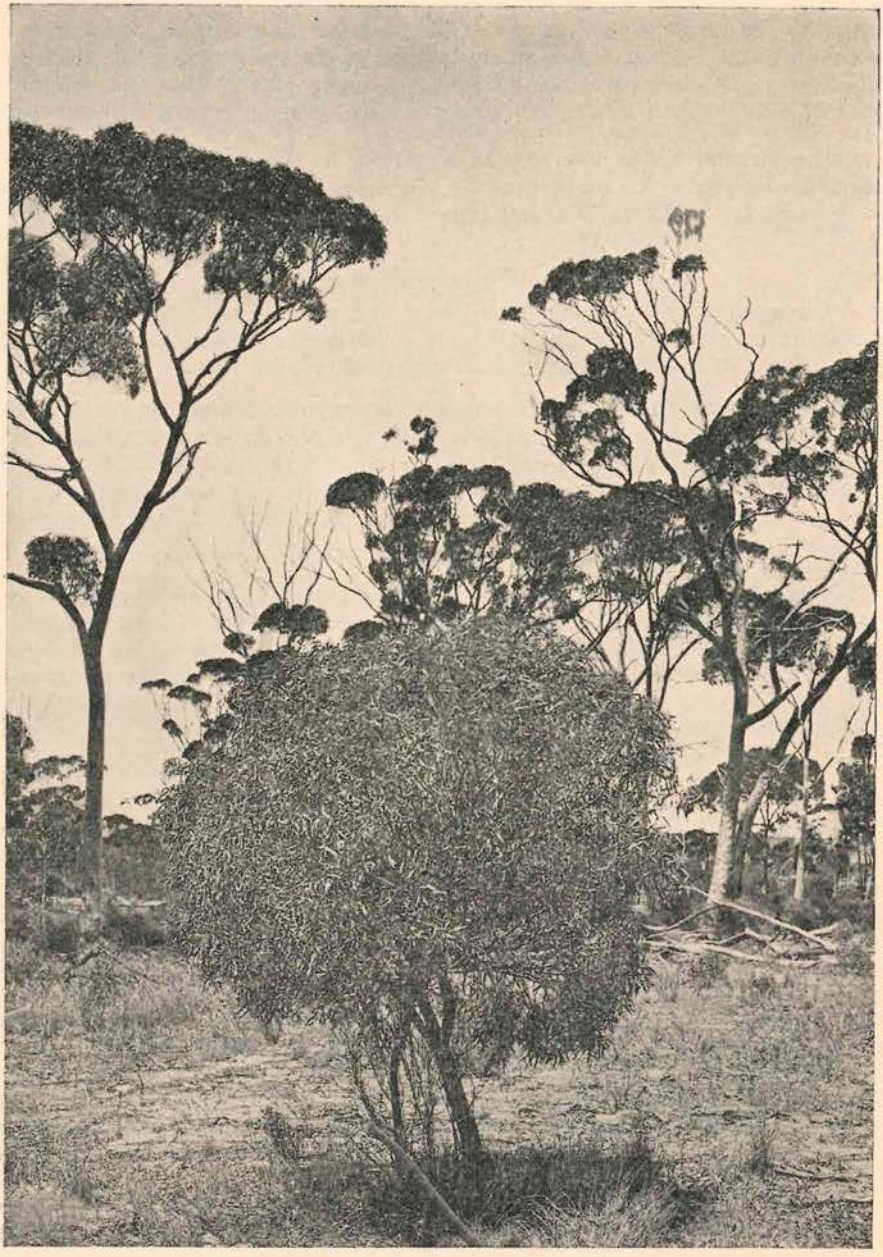

Plate 27.

Sandalwood *(Santalum cygnorum).*

5083/5/57—2m

By Authority: WILLIAM H. WYATT, Government Printer, Perth.