Forestry

IN

WESTERN AUSTRALIA

CHAPTER II

FOREST BOTANY

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

REPRINTED FROM BULLETIN NUMBER SIXTY-THREE
FORESTS DEPARTMENT, WESTERN AUSTRALIA

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THE LIFE STORY OF A TREE

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

THE SECTIONS OF A TREE.

The Root System.

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

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

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

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

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

The Bole.

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

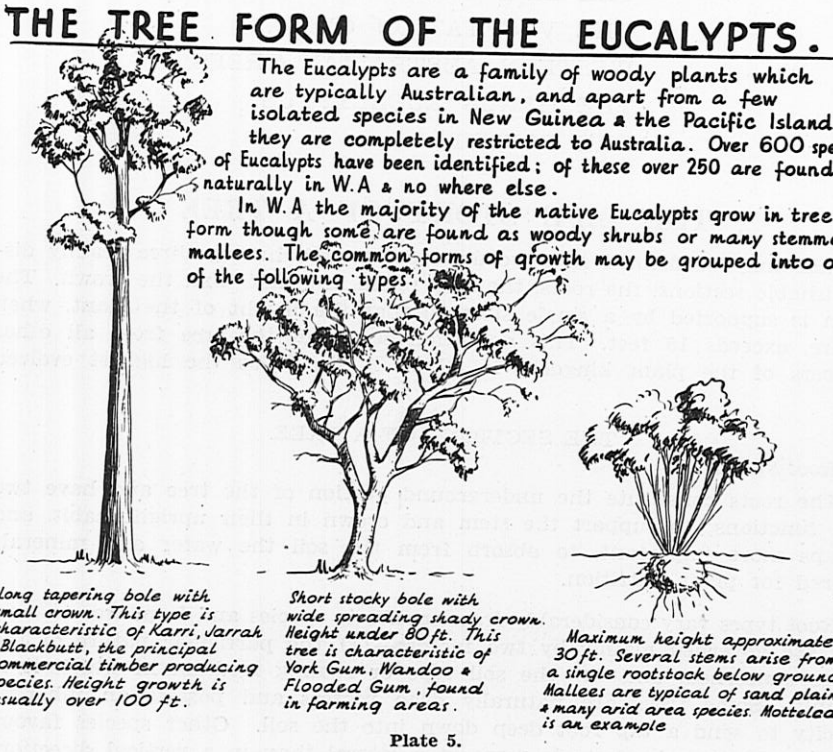

Plate 5.

Three common habits of the eucalypts.

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

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

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

The Tree Crown.

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

THE VITAL LIFE PROCESSES OF A TREE.

Tree Nutrition.

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

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

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

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

Photosynthesis.

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

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

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

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

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

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

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

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

Transpiration.

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

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

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

Respiration.

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

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

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

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

Respiration.

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

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

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

(4) Respiration uses up energy and plant food.

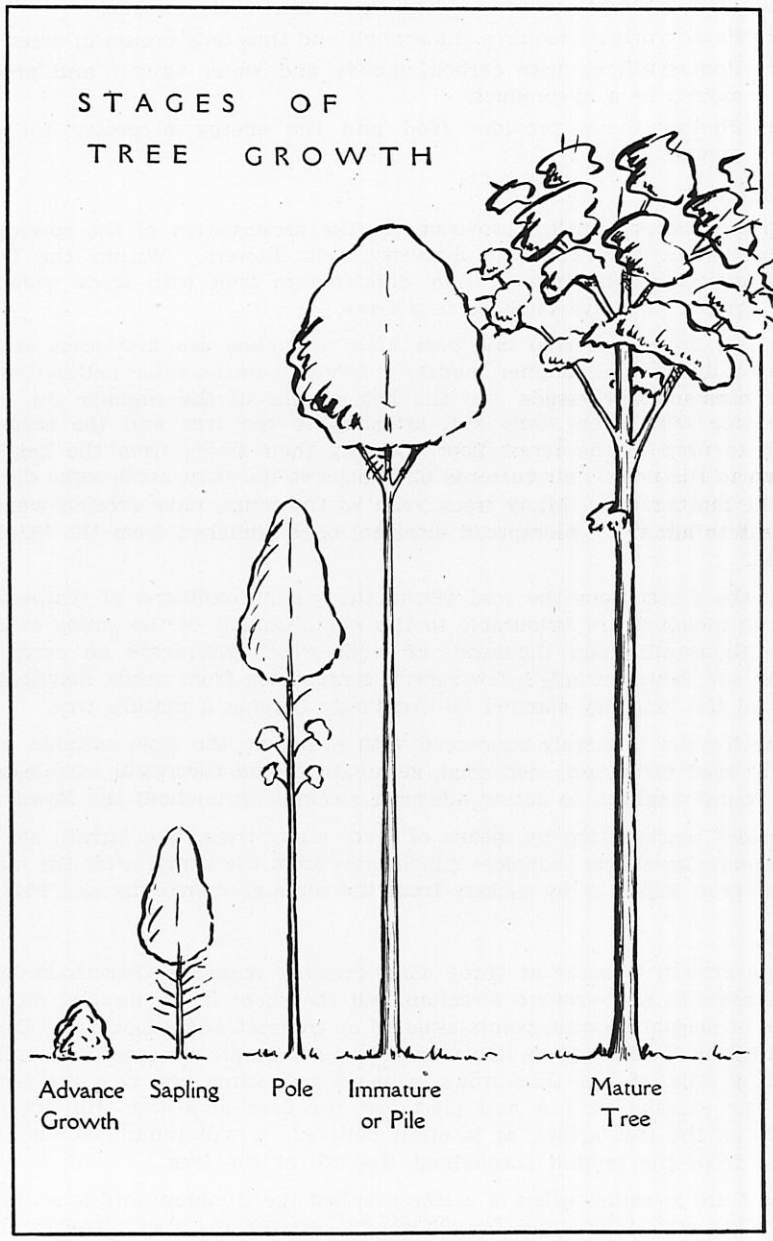

Plate 6.

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

Photosynthesis.

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

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

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

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

Reproduction.

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

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

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

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

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

Growth.

Tree growth is made at three main growing regions. Growth in length for the roots in a downward direction and the shoot in an upward direction is made at special growing points situated at the root and shoot tips. Growth is attained by the formation of new cells and not by an increase in dimensions of existing cells. A tree thus grows in height by adding new cells upwards on top of the existing tip. A nail placed at the base of a tree will not move upwards as the tree grows, as is often believed; it will remain at the same distance from the ground throughout the life of the tree.

The third growing region of a tree is called the cambium and is concerned with the growth of diameter for all woody parts of the tree. The cambium consists of a single layer of cells completely ensheathing the woody section of the tree and is located immediately below the bark. From it cells are formed in two directions; new wood cells are formed on the inside of the cambium and new bark cells on the outside.

WOOD.

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

A cross section of a tree (Plate 7) shows the following well defined features in succession from the outside to the centre:—

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

Growth Rings.

In the growing season the tree adds a layer of wood on the outside of that previously formed. If growth is interrupted annually by cold weather or dry seasons, the character of the cells at the end of each year's growth and the beginning of the next is sufficiently different to define sharply the annual layers or growth rings. (Fig. 2.) Consequently the age of such a tree may be determined by counting the number of annual growth rings at its base. In parts of the Tropics, where the growing season extends throughout the year, no well defined annual growth layers are formed and it is impossible, with any degree of accuracy, to tell the age of such trees. In eucalypts also it is generally difficult to determine the growth rings.

Sapwood and Heartwood.

Sapwood contains living cells and has an active part in the life processes of the tree. It is located next to the cambium and functions in sap conduction and storage of food. The sapwood layer may vary in thickness and commonly ranges from half to two inches. As a rule, the more vigorously growing trees of a species have wider sapwood layers.

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

Medullary Rays.

Another feature of wood which is particularly important in determining the "figure" of many woods are the medullary rays. These rays are observed on the cross section as discontinuous radial lines. They vary in length and thickness with different species and serve, in the living tree, as a means of moving food radially across the wood tissues and as a food storage and waste

depository area. Silky Oak, Banksia, Sheoak, and Oak, are some trees whose pronounced medullary rays produce a figure in wood highly valued for ornamental work.

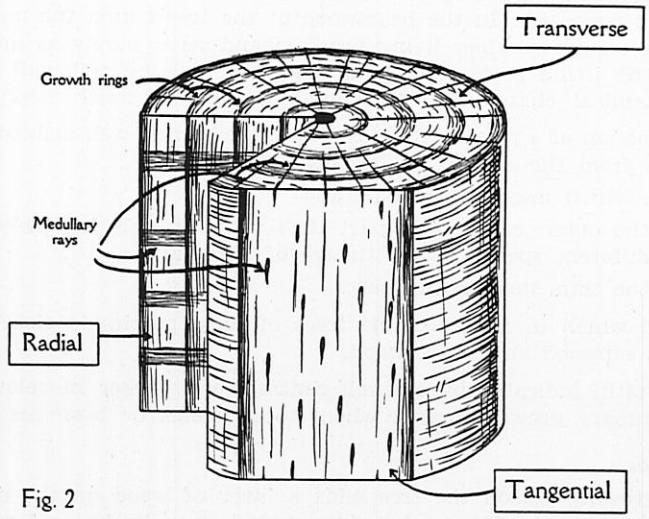

Fig. 2

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

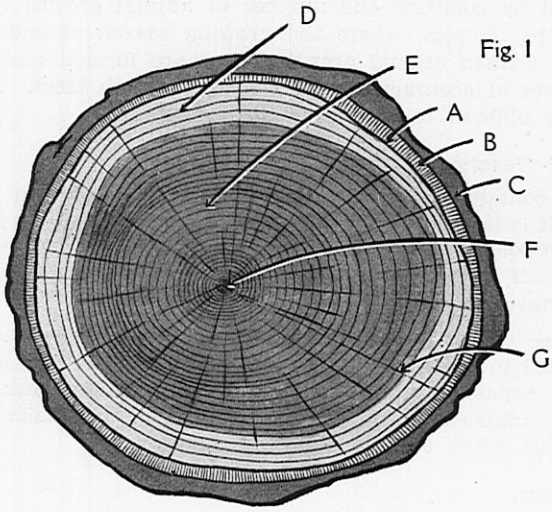

Fig. 1

Diagrammatic sketch of a transverse section of tree trunk

Plate 7.

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

THE VEGETATION OF W.A.

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

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

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

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

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

Within these Provinces, vegetative formations are separated both by local climatic and by soil factors. The accompanying vegetation map of the State on page 29 separates the following vegetative types:—

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

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

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

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

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

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

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

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

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

(5) Mulga bush.

C.—Treeless Regions.

(6) Saltbush plain. The Nullarbor Plain.

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

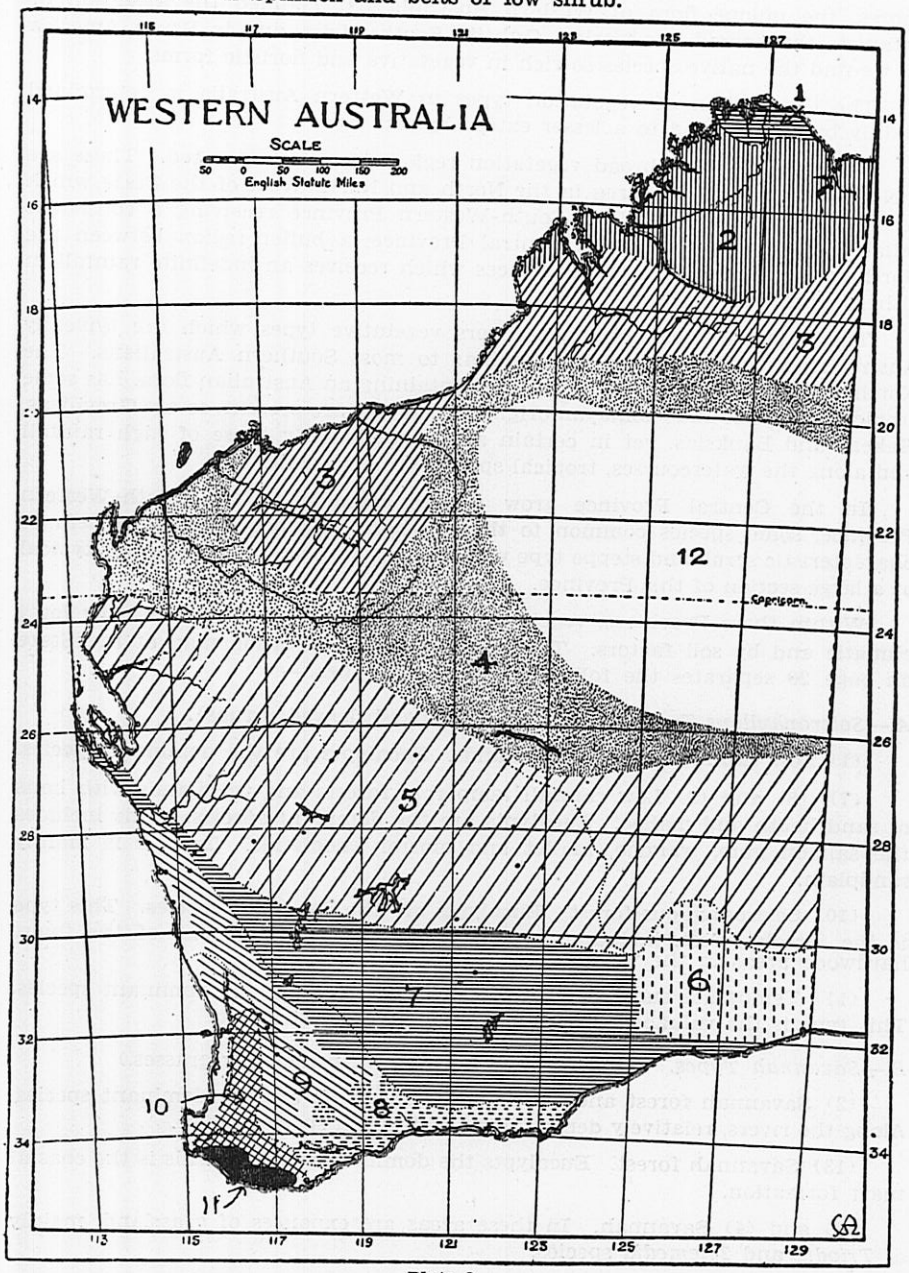

Plate 8.

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

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

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

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

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

WESTERN AUSTRALIAN TREES

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

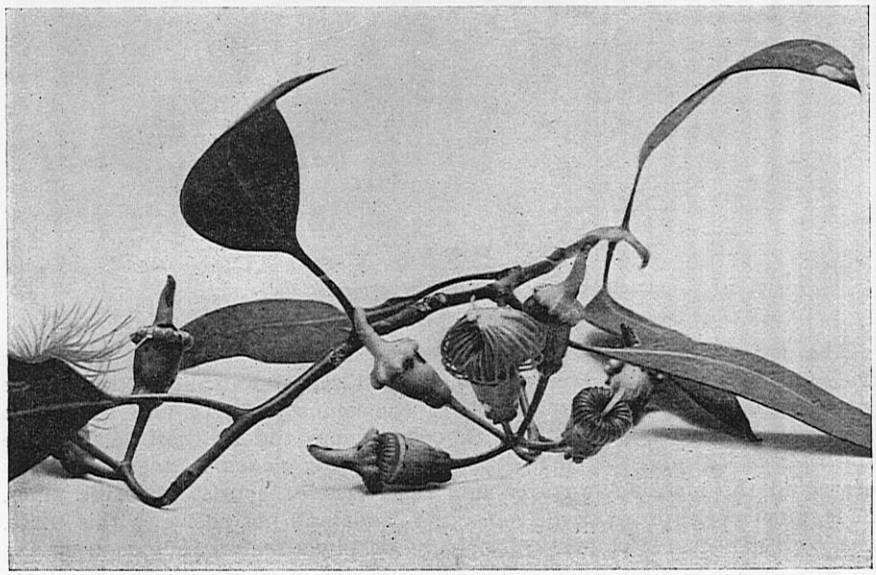

Plate 9.
Coral Gum (*Eucalpytus torquata*).

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

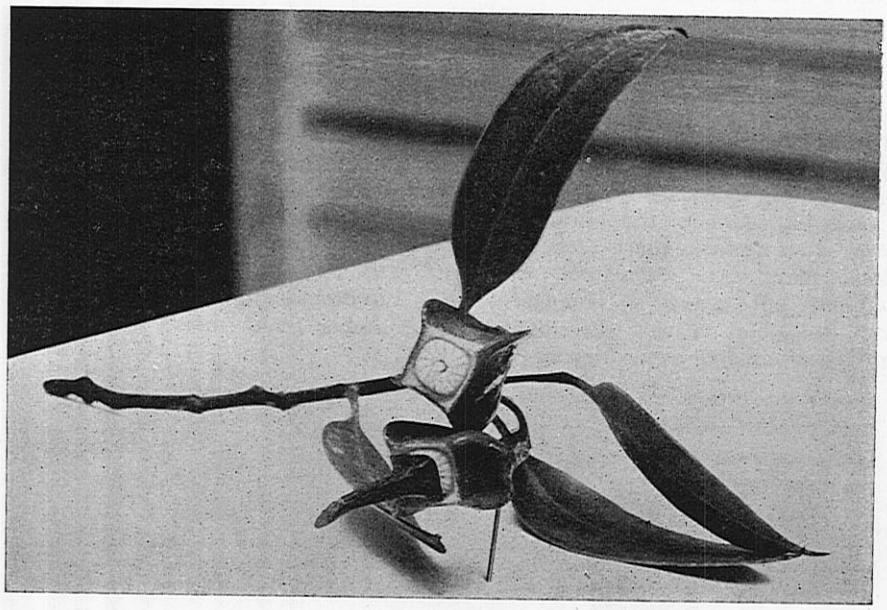

Plate 10.

Fuchsia Mallee *(Eucalyptus forrestiana)*.

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

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

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

Common Name	*and Scientific Name.*
Jarrah	*Eucalyptus marginata*
Karri	*„ diversicolor*
Tuart	*„ gomphocephala*
Wandoo	*„ redunca var. elata*
Marri	*„ calophylla*
Blackbutt	*„ patens*
Yate	*„ cornuta*
Red Tingle	*„ jacksoni*
Yellow Tingle	*„ guilfoylei*
Crimson Flowered Gum	*„ ficifolia*
W.A. Peppermint	*Agonis flexuosa*
Cedar	*„ juniperina*
Native Pear	*Xylomelum occidentale*
River Banksia	*Banksia verticillata*
Sheoak	*Casuarina fraseriana*
The Mallets	*Eucalyptus astringens, Euc. falcata, etc.*
York Gum	*Eucalyptus loxophleba*
Swamp or Flat-topped Yate	*„ occidentalis*
Salmon Gum	*„ salmonophloia*
The Gimlets	*„ salubris*
Red Morrel	*„ oleosa var. longicornis*
Dundas Mahogany	*„ brockwayi*
Goldfields Blackbutt	*„ lesouefii*
Grey Gum	*„ griffithsii*
Redwood	*„ oleosa var. glauca*
Merrit	*„ flocktoniae*
Yellow Flowered Gum	*„ stricklandi*
Coral Flowered Gum	*„ torquata*
Kurrajong	*Sterculia gregorii*
Goldfields Pine	*Callitris glauca*
Raspberry Jam	*Acacia acuminata*
Sandalwood	*Santalum cygnorum*
Flooded Gum	*Eucalyptus rudis*
Bullich	*„ megacarpa*
Bull Banksia	*Banksia grandis*
Menzies Banksia	*„ menziesii*
Karri Oak	*Casuarina decussata*
Rottnest Island Pine	*Callitris robusta*

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

CHARACTERISTICS OF THE GENUS EUCALYPTUS

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

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

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

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

THE EUCALYPT FRUIT.

Eucalypt flowers differ from those of most other plants in that they have no obvious petals. When flowering, the attractiveness of the blossom is derived from the numerous, conspicuous & often lightly coloured stamens.

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

The following illustrations show the method of fruiting & flowering of three different West Australian Eucalypts.

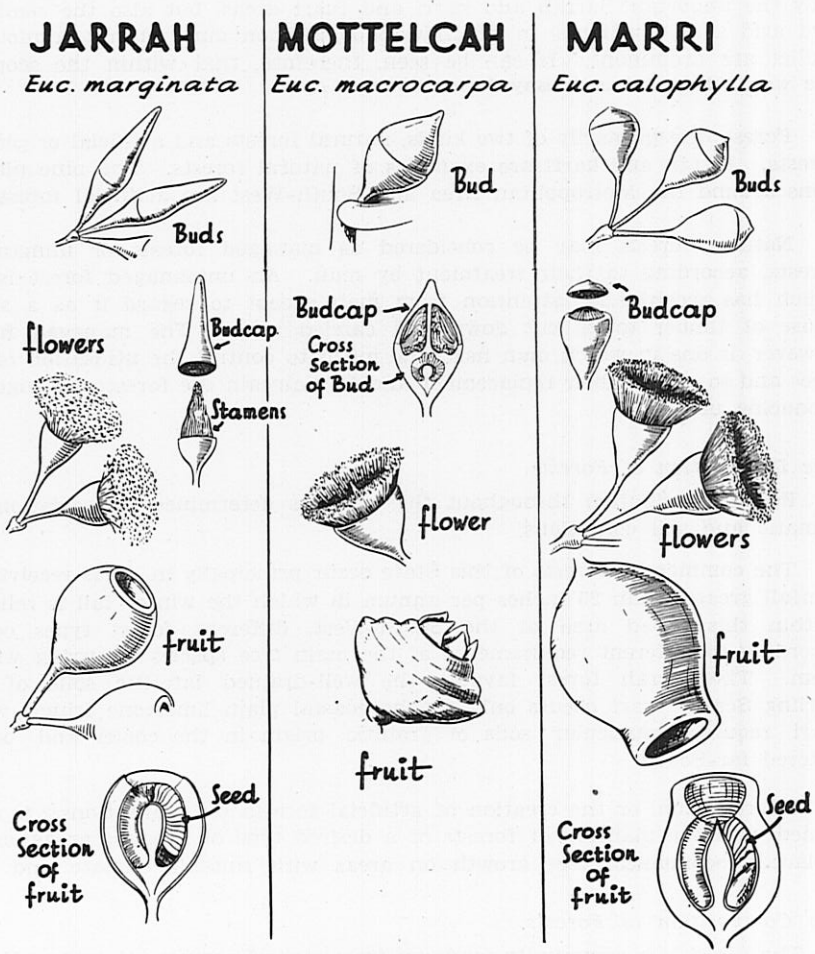

Plate 11.

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

THE FOREST

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

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

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

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

Natural forests may be considered as managed forests or unmanaged forests, according to their treatment by man. An unmanaged forest is one which has received no attention from man except to regard it as a storehouse of timber to be cut down and carried away. The managed forest, however, is one in which man has done much to control the utilisation of the trees and to ensure their replacement and to maintain the forest as a vigorous producing unit.

The Distribution of Forests.

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

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

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

The Composition of Forests.

The forest is a community made up from several component parts. Under forest conditions these components, vegetation, soil, animals, insects and birds, do not exist as separate entities. They exist in an environment in which each

is dependent on the others for its existence. Trees cannot grow satisfactorily unless certain soil and climatic factors are present, nor can they continue to reproduce and thrive unless animals, insects and birds are available to aid the process and maintain soil fertility.

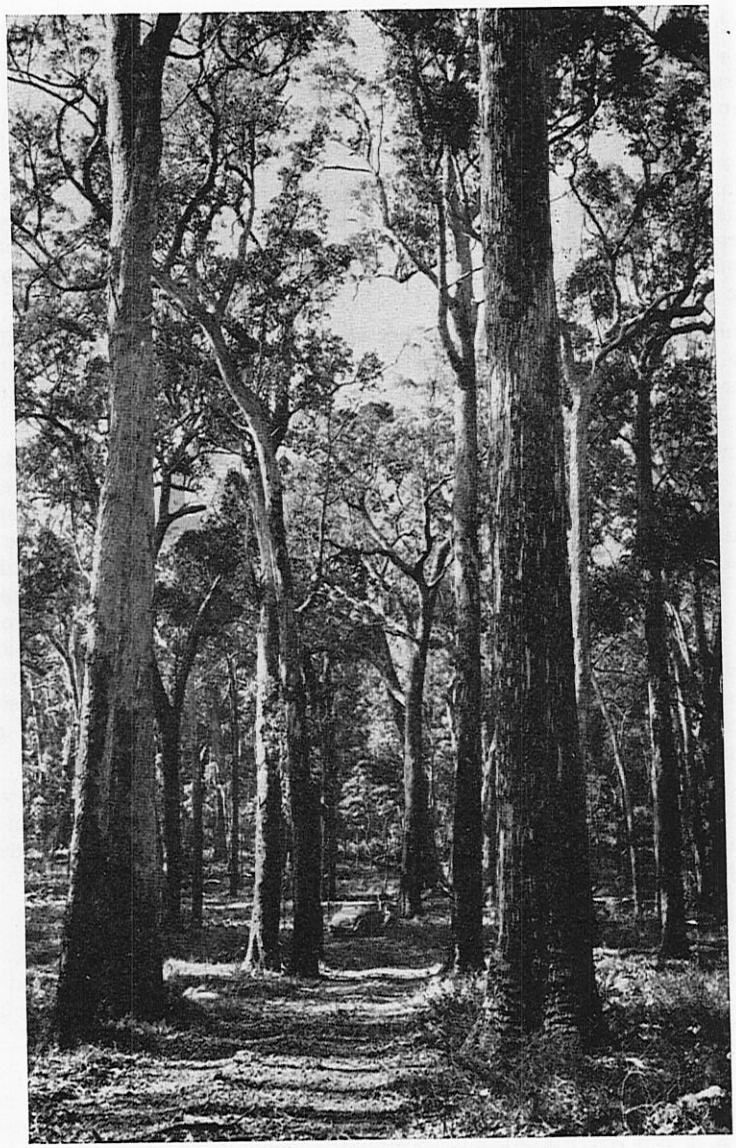

Plate 12.

Mature jarrah forest near Dwellingup.

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

The Trees of the Forest.

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

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

Competition between trees for space, light and soil nutrients gives to the forest a distinctive structure in which the crowns of different species form successive layers or stories. These canopy or crown levels are more distinctive in certain types of forest, the tropical rain forest in particular. In the jarrah forest, a reasonable example of these storied vegetation layers may often be found. Mature jarrah crowns form the upper storey which may be generally divided into three separate regions, the top level of the dominant trees, the general level of the co-dominant trees and the lower level of the dominated and younger tree crowns. Underneath this general canopy level is the understorey of suppressed trees, saplings, sheoak and banksia. The lowest limit, or strata, is classed as the ground flora and embraces the smaller shrubs, herbs and prostrate forms growing close to the ground.

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

The Forest Soil.

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

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

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

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

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

Managed and Unmanaged Forests.

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

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

The Animals and Birds of the Forest.

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

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

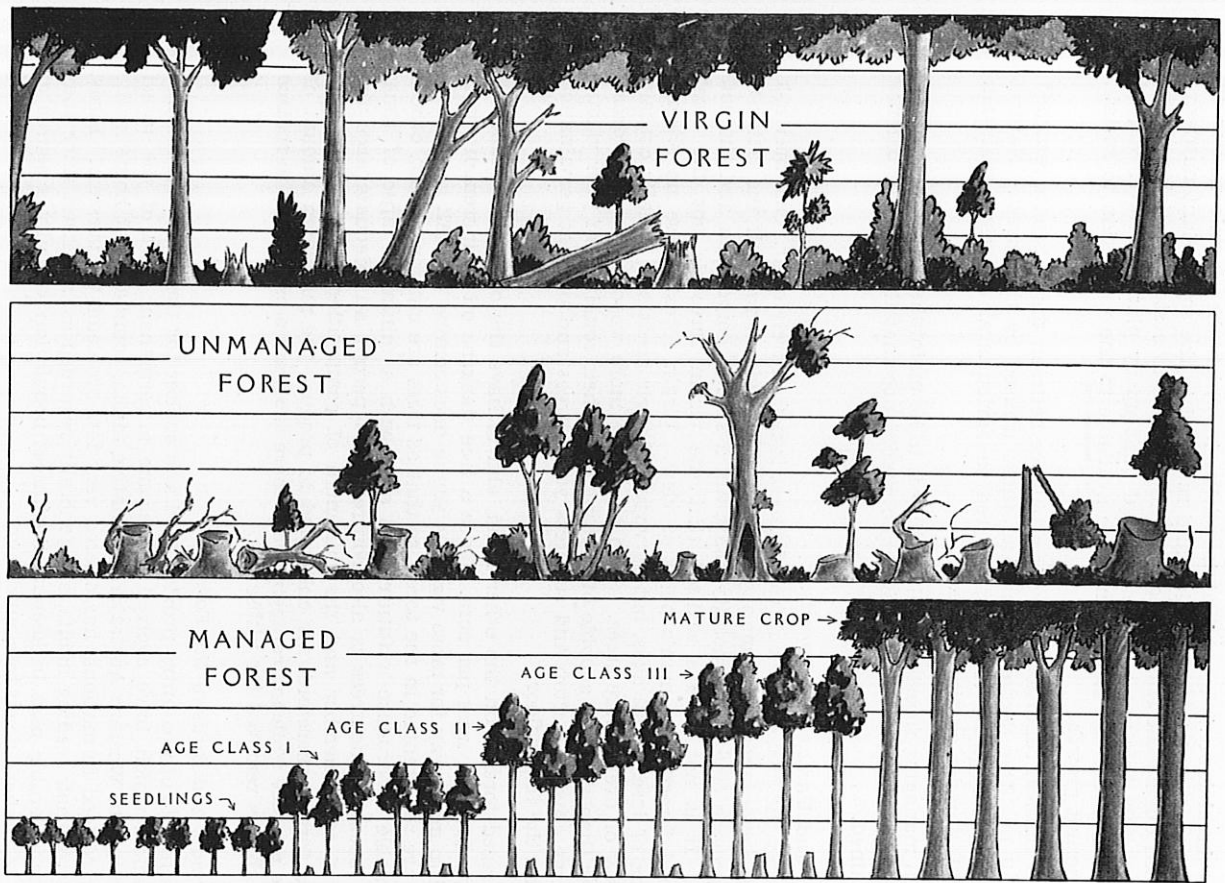

Plate 13.

Diagrammatic representation of a forest under management.

Virgin forest—mature to over-mature trees; very little regeneration present and frequent insect, fungi and fire damage.

Unmanaged forest—All good mill timber has been removed with subsequent damage to remaining stems. No provision for regeneration.

Managed forest—A regular succession of all age classes represented to provide regular timber crops in perpetuity.

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

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

Insects and Fungi.

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

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

Many fungi grow in association with tree and plant roots constituting mycorrhiza which is essential to the growth of such plants. This association of the lowly fungus with the highest forms of plant life is a remarkable aspect of plant ecology. Each of the participants in the union give and take some substance from the other. In the case of many trees, vigorous growth is not possible without this association with a certain type of fungus.

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

The Forest Area.

Of the total land area of 34,000 million acres, the world has 10,000 million acres of forested land. This is separated as follows:—

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

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

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

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

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

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

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

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

Area of Productive Forest of Sawmilling Quality.

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

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

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

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