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REPORT
ON
EXOTIC CONIFERS
IN
WESTERN AUSTRALIA

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EXOTIC CONIFERS
IN
WESTERN AUSTRALIA

BEING A PAPER OF
NOTES AND DIRECT INFORMATION
AS REQUESTED UNDER HEADINGS
BY THE
STANDING COMMITTEE ON BRITISH
COMMONWEALTH FORESTRY

INDEX TO REPORT

There are 3 important aspects of pine timber production

1. Use of local pine avoids high priced imports.

2. Pine used for inferior purposes locally releases highly valuable jarrah for export.

3. Waste from our hardwoods can be used to form the basis of a paper industry with pine in the southern region.

EXOTIC CONIFERS
IN
WESTERN AUSTRALIA

In 1896, the first moves were made to test pine planting in the State of Western Australia. It was even then realised that local plantations of fast growing pines were the solution to the natural deficiency of softwoods and that there would be a necessity to supplement the timber output from the indigenous hardwood forests in order to meet the demands of future populations.

From the outset it has been a difficult problem for pine establishment within the State is not the relatively easy process observed in one or two of the Eastern States. The soils available for planting are, in most cases, too low in plant food to support pines under normal establishment conditions.

The first fact to be realised was that the desirable and popular Pinus radiata, so successful in Eastern Australia, could only be grown on the limited areas of our better soils; the bulk of the poor sandy coastal country being suited only to P. pinaster.

Planting Pinus pinaster was not the solution to the whole problem, however. Four or five strains of this pine were recognised, and only one, the Portuguese or Leiria strain, proved satisfactory. A new plantation technique had to be adopted on most soils to achieve success. This practice included the application of fertilisers, mainly superphosphate, to the poor sands before acceptable growth could be achieved.

The early decades of determined effort towards establishing the desired plantations resulted mostly in disappointment, frustration and the uncovering of new problems.

Now, however, it is considered that the past failures and research have enabled a suitable appreciation of the situation and that a policy aiming initially at 200,000 acres of pine plantations is sound.

A total of some 30 species of the genus Pinus has been experimentally planted in Western Australia, and this work supports the present practice of planting Pinus radiata on the limited good soils, Pinus pinaster on the bulk of the planting area and P. halepensis var. brutia and P. caribaea on small specialised sites within the general plantation areas.

SECTION I (a)

Softwood Policy in Western Australia

Western Australia aims to establish and maintain at least 200,000 acres of softwood plantation within its boundaries and within ready access to the main marketing centres. The major points which led to the formation of this policy are discussed in papers submitted by Harris and Nunn and are briefly:—

(1) The need to provide extra wood to meet the demands of a future increased population.

(2) The necessity to establish a better balance in relation to the proportions of softwood and hardwood utilised within the State.

(3) The need to prevent future dependence on wood imports to satisfy State demands.

A population of at present 680,000 persons is estimated to increase to 1,000,000 within the next few decades.

Western Australia uses 98 per cent. hardwood to 2 per cent. softwood in everyday use. Under this present arrangement high quality hardwoods are being used where softwoods would suffice.

Local supplies of softwoods will permit a much sounder timber balance in the above respect.

Apart from being a drain on the economy of the community, softwood imports may not be fully available in the future. It is possible that present exporting countries may have to drastically cut down on the quantities available to Western Australia within the next few decades.

SECTION I (b)

Climate

The position of Western Australia with reference to its range in latitude (almost equally tropical and extra-tropical), its low elevation and uniform topography, together with the fact that it lies on the Western side of the Continent, and is therefore subjected to the desiccating effect of the South-Easterly trade winds, are facts of fundamental importance from the climatic standpoint. These facts account for the different climatic systems, and for the great arid middle region which represents the Western prolongation of the desert of Central Australia.

Three climatic zones may be recognised, a Northern area of summer rainfall of a monsoonal character, with a cool dry season; a South-Western area of winter rainfall with a period of summer drought, and a vast central area of low and unreliable rainfall of no marked periodicity, depending entirely upon extensions of the climatic systems which dominate the Northern and Southern areas.

It is only within the South-Western region of winter rainfall that commercial pine growth is at present considered.

The South-Western Climatic Region of Western Australia.

The South-Western portion of Western Australia enjoys a Mediterranean climate with cool wet winters and hot dry summers.

During the summer months the Southern half of Western Australia lies under the influence of high pressure systems and summer drought. Little or no rain falls over the majority of the area except that brought by occasional thunderstorms which are directly or indirectly influenced by the low pressure systems to the North. The extreme South-West and Southern littoral region, however, receives from five to ten inches of rain due to Northward surgings of the systems carried along by the "roaring forties" at all seasons in the Southern Ocean.

In winter, with the Northward movement of the atmospheric systems, a cycle of winter precipitation is brought about over the South-Western region. This winter rainfall cycle usually commences in May, either early or late in the month. Sometimes it commences in April, and is then more or less connected with the late cyclonic systems of the North-West. The season retires as it begins, the rainfall systems gradually weakening, until in October the precipitation affects the lower South-West only, and there is a return to drought in November.

References: 1.—The Vegetation of Western Australia with special Reference to Climate and Soils—Charles Austin Gardner, 1942.

2.—Climatic Averages—Australian Temperature, Relative Humidity Rainfall.—Commonwealth of Australia Bureau of Meteorology, Melbourne, 1956.

SECTION I (c)

Geology and Soils

In Western Australia the planting and the experimental work have been done largely on the coastal plain, but important plantations occur also on the laterite capped Darling Range which, though appearing from the coast as a range, is the eroded edge of the plateau of the interior.

Darling Range.

In the Darling Range the underlying rock is pre-Cambrian granite with both massive and gneissic characteristics. Numerous narrow dykes of dolerite are in this mass and associated with intrusive material are zones of shearing. The whole has been covered by laterite up to six to eight feet thick in places formed in a previous climatic era. Laterite occurs both as heavy outcrops and as a hardpan overlain by varying depths of ironstone gravel. The laterite soils are extremely poor in plant nutrients and are not on present knowledge suitable for pine growth.

Where the laterite has been eroded away on the valley slopes of the larger rivers and streams, primary soils are being developed on the underlying country rock. The soils formed on these igneous rocks depend on the geology.

The intrusive basic igneous rocks give rise to red brown sandy loams which are suitable for P. radiata.

The acid granite rocks form a poor soil—light coloured sands and sandy loams—which are not suitable for pine growth.

Alluvials are generally very immature, although in some cases a tendency towards profile development is apparent. These soils are very variable and only some of them are suitable for pine growth.

Coastal Plain.

The coastal plain is geologically of the Cainozoic Series, with tertiary sands on the seaward edge. These coastal sands are deep and coarse, but do not reveal any definite profile, colour being grey or yellow, sometimes brown. Thin layers of deep yellow cemented sand pebbles are often found at depth. Except in the latter case the sands consist of an A. horizon only and subdivisions of this have been recognised mainly on colour change.

The three main types are:—

(a) Sand ridges or dunes consisting of medium to coarse grey or yellow and sometimes brown sand: The more Northerly areas are characterised by a very high coarse sand fraction reaching as high as 96% in the surface soils.

(b) Flats between dunes frequently consist of grey to dark grey coarse sands overlying an indurated coffee-brown horizon generally termed as "coffee rock": These beds are sometimes 15 inches thick and are at shallow depths of from four to seven feet. In some areas iron-stained sandstone cemented by coffee-coloured material replaces the more typical coffee rock.

(c) Limestone hills and sands over-lying limestone at shallow depth: The "limestone" is usually wind transported sea sand cemented by carbonate of lime. Sometimes comparatively high hills have been formed by these lime bearing sands and the stone occurs as floaters in brown surface sands or it may be covered to a depth of several feet by yellow-grey sands.

The soil survey of the plantations of the State has made considerable progress with the object of studying the relationship of pine growth to soil type and analyses data.

From a careful study of a large number of analyses giving for different horizons the phosphorus, nitrogen, calcium and potassium present, the value of the phosphate (P_2O_5) figure as an indicator has emerged.

As a general guide in considering afforestation proposals and problems, the following standards have been tentatively adopted:—

For P. radiata a P_2O_5 content of at least 250 parts per million is required in the surface and sub-surface soils.

For P. pinaster a P_2O_5 content of not less than 150 parts per million is required in the surface and sub-surface soils.

In this connection it is desirable to emphasise the following points:—

(a) The P_2O_5 content is suggested as an indicator figure only, and it is not intended to imply that the amount of phosphorus present in the soil is in itself the factor limiting the development of the pine stand.

(b) The P_2O_5 content ceases to be a useful indicator in the case of areas which have been cultivated previously for agricultural purposes. In other words, the fertility of any site can be increased by methods such as intense cultivation without any corresponding increase in the P_2O_5 figure obtained by analyses.

(c) On the coastal sands from the results of analyses of samples taken at greater depths, it is possible that where the phosphate content of the surface sand does not reach the above standard, satisfactory crops of P. pinaster may be grown if the P_2O_5 content over a considerable depth is of the order of 50 parts per million. This must be regarded as a tentative standard subject to verification in the light of further data. These coastal sands are largely dune sands of recent origin, and have been sampled to depths usually not greater than 20 feet.

SECTION I (d)

Exotic Establishment under Western Australian Conditions

Before any Working Plan for a plantation proposal is received, the area must satisfy a careful soil survey. Soil factors, particularly available phosphorus, are the most critical determinants for successful establishment in Western Australia and, in most cases, are the limiting factors involved. This initial soil survey not only determines the exotic species which are to be planted, but also permits a decision as to the necessity of subsequent fertilizer application.

Wherever possible, trial plots, usually of one acre extent are established on the likely new planting areas.

Survey and Sub-division of the Area.

Subject to a favourable soil survey, the Working Plan for the area is finalised and adopted and preliminary sub-division of the area is carried out.

The general layout is influenced by topography from the viewpoint of area of compartments, access tracks and direction of firebreaks. Compartment areas vary between 25-50 acres and are ideally of a rectangular section. The smaller areas are more common on relatively hilly terrain, the larger uniform compartments being common only on the flats of the coastal plain.

Firebreaks.

The firebreak system is designed to meet the anticipated hazards and access for the particular area rather than to follow a diagrammatic scheme.

As a general rule, the following are considered:—

(a) *Coastal Plains.*

(i) 1 chain to 2 chain cultivated outer breaks except where it is considered that an even wider area is necessary.

(ii) Every 600 acres surrounded by a 2 chain break.

(iii) Every 100 acres by a 1 chain break within which breaks of 21 feet width around units of approximately 25 acres are maintained only until first pruning is done.

(iv) Where high dunes occur breaks are sited on the ridges rather than to conform to a square design.

(b) *In Hilly Country.*

(i) External firebreaks are considered unreliable unless the surrounding bush can be kept burnt and, depending on conditions, may vary from a 20 foot road to 2 chains or more kept cultivated. Examples are:—

(a) A 20 foot road is considered sufficient where steep slopes adjoin the plantation and where controlled burning of the adjoining eucalypt forest can be practised. Pines are not planted within 20 feet of the edge of this road.

(b) A 2 chain ploughed break is necessary where danger exists from undeveloped bush under private ownership, but is of less value at the foot of a steep hill, as sparks can blow over before the ground fire gets near the break.

(c) A 1 chain ploughed break may be ample where adjoining cleared pasture land or orchards are being farmed.

(d) All plantations where possible have an inner and outer fire control strip of 10 or more chains which can be kept control burnt alternatively. On these strips no dead trees are left standing.

(e) On most plantations within State Forest the initial clearing of the external break is 1 chain in width. As suckers grow up on this strip they are not bashed but burnt under in spring before the pine plantation will burn.

(ii) Internal breaks aim at compartments from 20 to 40 acres surrounded by 33 feet breaks which also form extraction routes.

(iii) Through roads are 1 chain wide.

(iv) No internal 2 chain breaks are normally considered necessary.

Plan preparation and preliminary sub-division is completed at least five years in advance of clearing operations for each plantation.

Clearing the Area.

Prior to clearing operations, the area is protected for a minimum period of three years to facilitate an effective final burn. The whole clearing operations aim at attaining a clean, thorough final burn.

All merchantable logs and economical firewood are removed from the area, the scrub knocked flat and allowed to dry out. Following a lapse of at least 12 months to permit drying, the area is burnt in the winter or early spring as a safeguard to the plantation.

Cultivation of the Planting Area.

On most types of country available for planting, the ground cover consists of a dense growth of woody shrubs which have ramifying and persistent root systems. Experience has shown that the destruction of this indigenous scrub is beneficial to the pines on almost all soil types.

A thorough ploughing is carried out prior to planting. Ploughing aims at a depth of penetration of 9 inches to 10 inches.

Planting Operations.

Experience and time of planting studies have confined planting operations to definite months of the year. These are as follows:—

(1) June 1st to July 31st, South of an East-West line through Bunbury.

(2) June 15th to July 31st, North of an East-West line through Bunbury.

Planting lines are set out at right angles to a selected baseline which is, normally, a compartmental boundary. Planting is by machine, wherever feasible, and by hand in difficult situations for machine operation.

Machine planting has proved entirely successful on the coastal plain, particularly at Gnangara Plantation, where the flat terrain and sandy soil are particularly suited to this method.

Machines have not yet been extended to the Darling Ranges and the Southern Coastal Plain areas. The former is normally rocky and hilly and together with Southern plain areas, has not provided a sufficient acreage each year to warrant machine trials.

Initially, machines were not entirely satisfactory, but several corrections in design accomplished at Gnangara, have resulted in a suitable machine and technique for this particular area at least.

Alignment of hand planting is achieved by the planting crew working in echelon formation with an experienced No. 1 crew member providing the standard spacing and direction. Spacing sticks are set in along the baseline and alignment sticks placed along planting rows to aid the crew, when this is considered necessary.

Spacing used is generally 8ft. x 8ft. or 9ft. x 9ft. for Pinus radiata and 7ft. x 7ft. for Pinus pinaster.

Wherever topography and clearing methods permit, provision is made to miss one row in every two chains of width across the compartment. Such blanks serve as access lines for fire fighting vehicles prior to the time the plantation receives its first thinning. They also may be used later as log extraction routes.

Planting.

Planting operations in Western Australia are carried on in two main types of country:—

(a) *Coastal Plain.*

Except on the Tuart sands at Ludlow, where a more succulent vegetation occurs, the ground is ploughed to eliminate, or at least, reduce to a minimum, the xerophytic woody scrub.

(i) On ploughed land planting is conveniently done in a furrow ploughed along the planting line, preferably at right angles to the original ploughing. This operation is known as "furrow lining."

(ii) The planting method is notch planting, the tree being inserted in a notch made by a standard planting tool driven into the ground and moved backwards and forwards slightly to form a notch about 4in. by 2in. and 12in. to 14in. deep. The seedling is inserted in this notch by the digger, who shakes it sufficiently to ensure a correct vertical disposition of the roots. The notch is closed by a heavy stamp of the heel and the soil levelled off with the sole of the boot.

(iii) The most satisfactory arrangement of the gang appears to be a three-man unit—one of whom is a plant carrier who hands trees to the two planters. A fair day's work planting in this manner is 3,000 trees per three-man gang. A really good gang will plant 3,600 trees per eight-hour day.

(b) Darling Range.

A planting spear or inverted iron cone of about four inches basal diameter and 18 inches in length has been devised for planting in gravel or depressions which are liable to become water-logged in prolonged spells of heavy rain. This tool, which makes a small but deep hole, is used with the same organisation of personnel as for notching with the planting spade on sands. Where ploughing has not been done, a mattock or a spade may be used to open a hole on heavy or stony soils. On very heavy soils, where the breaking of a clod is involved, a small hoe may be necessary for use by the planter in filling the hole with earth; but on light soils anything which will save the finger-tips, such as a woodchip, is sufficient.

The following General Planting Instructions are issued to all officers connected with planting:—

(1) Trees should not be planted against Blackboys or Zamia Palms, or too close to stumps which will coppice freely and cover the pines, but the lines should be maintained in at least one direction if possible to aid future extraction.

(2) Dry soil must be avoided by making another hole reasonably close to the rejected spot.

(3) The plants are set in the ground 1½in. deeper than they stood in the nursery. This means the covering of at least ½in. of the needles. This depth has been selected because it will allow a variation by careless planters of 1in. either way without serious harm.

(4) The notches or holes must be deep enough to permit the roots to be disposed more or less vertically without bending.

One-year seedlings will not be root pruned subsequent to lifting. Some long side roots of two-year stock may have to be pruned back to 12in.

(5) Care must be taken to avoid undue drying of the plants, particularly in high wind or on clear sunny days. The total of the exposures to which the roots are subjected in the various operations from lifting to planting under careful supervision has been estimated to amount to two minutes.

Application of Artificial Fertiliser and Minor Elements.

Where it has been found essential to apply artificial fertilisers to a plantation to maintain normal growth, the type, quantity and method of application is determined from experience obtained from trial plots previously established on the specific soil type. Continuing research is being made into the methods of application and modification of the various implements used.

Zinc and phosphorus are the two main elements at present in use. Zinc is generally applied in the form of 2½ per cent. solution of $ZnSO_4$, an ordinary Ladywood knapsack spray such as is used for fire fighting being used to apply the solution. Time of application is often determined by first signs of deficiency symptoms but on known deficient areas, is standard practice from 3 to 5 years from planting date.

Phosphorus is applied in the form of superphosphate or ground phosphate rock. Small areas are generally dressed by hand and large areas with a drill. An H. V. McKay horsedrawn vineyard drill with two runs has been used extensively in the past to apply superphosphate. The two runs are modified to feed into a single outlet and the phosphate trickled along the row of trees at the prescribed rate. Application is normally at the rate of 2 oz. per tree initially.

Pine Nursery Practice in Western Australia.

Nursery practice in Western Australia is generally standard as compared with that of other countries. There are however, several modifications which were necessary to suit local conditions. Nursery procedure aims at producing one year plants of Pinus pinaster of 12in. height with a lower whorl of branches developed, while with Pinus radiata, the height should average 12-15 inches, and although no side branches are present, the plants must be sturdy.

Mycorrhiza.

Satisfactory nursery conditions can only be obtained by initially innoculating the nursery soil with mycorrhizal material from mature pine stands or old established nurseries. Past practice of innoculation has been to spread soil from the old nursery or a mature pine stand over the new site.

Time of Sowing and Spacing.

Spring sowing is practiced to provide one year plants for planting out. In cases where such has not proved entirely suitable, autumn sowing, about mid-May, has permitted sturdier plants to be available at lifting time. The aim is to produce fully developed planting stock by the following winter.

Depending on the results of germination tests on the seed, the Planet Junior seed drill is set to provide a maximum of 24 viable seeds per foot of nursery line. The depth of the drill is set to twice the diameter of the seed measured across its smallest dimension, that is a depth of ⅜in. for Pinus pinaster and ¼in. for Pinus radiata.

The distance between nursery lines is 14 inches and the aim within lines is to obtain 18 suitable plants per foot.

Seed Pretreatment.

A special winnower is used to clean seed as it has been found that winnowers previously used resulted in a decrease in viability.

Prior to drilling in, seed is coated with red lead as a necessary precaution against birds and rodents.

Soil Fertility.

The soils of departmental nurseries for the most part are podsols with leached surface horizons of a light sandy nature, and subsoils of varying retentiveness. These are extremely low in the recognised plant nutrients and the necessity for the building up and maintenance of soil fertility was early shown.

It is now considered, after extensive trials of fertilisers of all descriptions, that the main problem in maintaining a reasonable fertility level in these nurseries hinges around the preservation of sufficient organic material in the soil. By increasing the size of nurseries and working them on a rotation of two or three years with nitrogenous green crops, it is hoped to achieve this. Some success has already been achieved in this direction and the problem is still being studied.

Weeding.

The expense of former hand weeding of some nurseries has been considerably reduced by the use of mineral oil spray for weed elimination. Dosages vary with the species at the rate of 70 gallons per acre of PR46 for Pinus pinaster and 45 gallons per acre for Pinus radiata and other species. Several sprayings are necessary.

SECTION II (a)

Pinus pinaster

1.—*Scientific Name.*

Pinus pinaster, Soland.

2.—*Trade and Local Names.*

Maritime pine, Cluster pine.

3.—*Country of Origin.*

Trees from five strains of Pinus pinaster are established in Western Australia. Of these, Portuguese or Leiria strain is by far the most suited for the particular conditions pertaining. Other strains have a much slower rate of growth, and show less adaptability to poorer soil types. Seed is received from Messrs. Ferriera Patricio, Leiria, Portugal, and from the Portuguese Forest Service.

4.—*Historical.*

Pinus pinaster was first tried in Western Australia on poor coastal sands south of Bunbury, in 1896. This trial, due to poor site and faulty establishment technique, was a failure.

In 1903, seven acres of permanent plantation was established at the State Nursery, Hamel, and in 1908, a further plantation was established at Ludlow, near Busselton. On both these areas, Pinus pinaster proved the most suitable of a half dozen different species tried. By 1915, this latter plantation consisted of 1,000 acres planted, mainly of Pinus radiata. It was decided in future only to plant pinaster on the area as the Pinus radiata growth was unsatisfactory.

In 1917-1918 came the first proposal to plant Pinus pinaster on the coastal sands north of Perth. Further plantings of Pinus pinaster had continued at Ludlow, much of this direct sown, particularly on failed Pinus radiata areas. By 1922, 300 further acres of Pinus pinaster had been established at Ludlow.

In 1922, Pinus pinaster trial plots direct sown at Gnangara (12 miles north of Perth) proved a failure. Planting had been extended to Mundaring district and Collie. In 1925, the extent of this pine at Ludlow was 570 acres.

In 1926, Pinus pinaster was planted at Applecross and Gnangara, adjacent to Perth on sands; at Mundaring Weir on laterite and at Myalup near Harvey and Ludlow on coastal sands.

Further extension of planting was as follows, the bulk of the effective area given being of Pinus pinaster.

1925-1935—1,502 acres extended to 9,204 acres.

1935-1945—9,204 acres extended to 13,609 acres.

1945-1955—13,609 acres extended to 19,000 acres.

From 1940 on it was decided that most seed previously purchased had resulted in undesirable strains and it was made policy that in future all Pinus pinaster sown should be of Leira strain purchased direct from a reputable seed firm in Portugal.

5.—*Present Extent of Planting.*

At present the Forests Department plants approximately 1,500 to 2,000 acres per year, the bulk being of Maritime pine. Future extension is to occur at the rate of 2,000 acres per annum towards a maximum total of 200,000 acres, largely of Pinus pinaster established on coastal sands. The low nutrient status of the soils available for planting has forced the general use of Pinus pinaster instead of the faster growing Pinus radiata.

(a) Present approximate total effective Pinus pinaster plantation of all strains is 15,996 acres.

(b) Approximate age distribution within the planting area.

Age	>30 years.	25–30 years.	20–25 years.	15–20 years.	10–15 years.	5–10 years.	0–5 years.
Acres	745	1,944	3,768	1,593	751	996	6,075

6.—*Climatic Zones in which Planted.*

Planting is restricted to the south-western climatic province described in Section 1(b). The bulk of the planting area available is coastal, occurring within 25 miles of the sea and with an average approximate reliable rainfall of 30 inches occurring during the winter months.

Frosts are at a minimum and offer no problems.

7.—*Descriptions of Soils and Sites Preferred.*

These are provided in Section 1(c). Under virgin conditions the sandy soil types of the coastal plain carry poor jarrah and marri forest and sand heath types in the north, and tuart forest in the southern and central areas.

The coastal sands, particularly type (b) consisting mainly of flats are considered most suitable to the species of all the types available for planting. Fertiliser technique permits most sandy types to grow fair to average Leiria stands.

On present knowledge, laterite planting areas are considered unsuitable for Pinus pinaster.

Present soils available for planting are littoral sands of the coastal plain with a maximum elevation of site of 200 feet above sea level.

8.—*Establishment Technique.*

Refer to Section 1(d). Direct sowing was tried but has been abandoned.

9.—*Early Crop Development.*

Height growth obtained for Leiria strain from a number of plots on the optimum sites shows more or less the following trends.

Age years	Height ft.	Age years	Height ft.
3	6	10	33
4	10	11	36½
5	14½	12	40
6	19	13	43½
7	22½	14	47
8	26	15	50
9	29½	16	53

10.—*Silvicultural Practice.*

Thinning Practice.

Pinus pinaster stands are thinned as follows:—

All stands Fair Average Quality and above—

At height 40ft. thin to 300-350 per acre (plus discards).

At height 60ft. thin to 200-250 per acre.

At height 80ft. thin to 125-150 per acre.

Stands below f.a.q. will be considered for conversion or nutritional treatment.

Pruning.

Policy is to low prune all stands as labour and funds are available. In good stands, final crop trees will be high pruned as considered advisable.

11.—*Rate of Growth and Yield.*

Pinus pinaster in the early decades had been planted on unsuitable soils and without current knowledge of pine nutrition. This was further complicated by the fact that at least five strains are now recognised. These facts have resulted in increments varying from failures of as low as 20 cubic feet per acre per annum, to increments from the Leiria strain rising as high as 300 cubic feet per annum (overbark full volume).

With the present knowledge of soils and pine nutrition and the fact that only Leiria strain is likely to be planted, forward calculations tend to the acceptance of 150 cubic feet per annum as a likely increment.

Healthy stands of the poorer strains of P. pinaster, such as Landes, South African, Esterel and Corsican, occur, but in general these do not attain an increment of more than 75 cubic feet per annum, in comparison with the higher figure for Leiria strain under the same conditions.

12.—*Diseases and Pests.*

Damping off in the nursery is often a problem but appears to be at present under control with the introduction of rotation crops, and, if necessary, early use of Cheshunt mixture.

Root-rot: Planting out losses have been accredited to root-rotting due to an unidentified species of Rhizoctonia fungus. The incidence of this disease is intermittent.

Ips: Ips grandicolis has been found in P. pinaster in several plantation areas yet has not caused damage of any extent.

Black Cockatoos: The white-tailed Black Cockatoo, Calyptorrhyncus baudini has caused trouble by taking the pine cones and eating the seed. During such operations, young growing tips are damaged and the bark is often stripped from the trunk.

Magpies: It has been standard practice for 30 years to coat pine seed with red lead before sowing to prevent destruction by magpies, of the seedling emerging above the ground after germination.

Rabbits: Rabbit damage to young stock is often considerable, particularly in Southern plantation areas. Fencing and/or baiting are often necessary to ensure successful establishment.

13.—*Other Damage.*

The limited area of plantation in Western Australia suffers from numerous soil deficiency diseases. These have been described in detail in the several publications mentioned in 18.

14.—*Note on Seed Bearing.*

Locally collected seed has proved unsuitable for plantation establishment due to a great variation in the progeny. It is believed this is due to crossing of poor with good strains in the collection areas.

Cones are first produced on Leiria strain at the age of approximately four years. The staminate inflorescences begin to appear by the middle of August. By the end of September all pollen is shed and the flowers begin to fall.

15.—*Natural Regeneration.*

Natural regeneration is not encouraged and has not been considered of significance. It does occur but only to a limited extent.

16.—*Timber.*

Timber produced by plantations up to date has mainly been in the form of thinnings. It is of small section and knotty.

17.—*Potentiality of the Species in the National Economy.*

The widespread adoption of Pinus pinaster in plantations in Western Australia has been due to the necessity to use very poor soils for the establishment of plantations. Pinus pinaster has shown a greater tolerance, and adaptability to these soils than any other species tried. It has, therefore been chosen to form the main planting stock.

Even this species has been unable to form stands in some plantations without the application of fertilisers. In future, a concentration on known seed of Leiria strain and a rational use of fertilisers based on past experiences, should permit the necessary plantation aims in this State to be met.

18.—*Published Information.*

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SECTION II (b)

Pinus radiata

1.—*Scientific Name.*

Pinus radiata, D. Don.

2.—*Trade Name and Local Name.*

Radiata pine, Monterey Pine.

3.—*Country of Origin.*

Monterey, California, U.S.A. Local seed supply is obtained from the South Australian Woods and Forests Department. Whenever possible this seed is collected from elite trees by climbing.

4.—*Historical.*

Pinus radiata was first planted under plantation conditions in this State in 1896, on poor sands two miles south of Bunbury. The project was a failure due to faulty establishment technique and poor site. The first reasonable stand of Pinus radiata was established in 1903 at the State nursery, Hamel. Here too, later observations indicated that the pine was unsatisfactory for the site and the plantation was not extended.

In 1909, a plantation project involving mainly Pinus radiata plantings was commenced at Ludlow on poor coastal sands and by 1916, 600 acres of Pinus radiata has been established. Once more growth was unfavourable, in many cases being a complete failure. Planting of this pine at Ludlow was discontinued and much of the failed area planted up with drill sown Pinus pinaster.

Further trials of Pinus radiata on coastal sands continued at Gnangara (12 miles north of Perth), Applecross and Collier in the metropolitan area, and at Myalup, west of Harvey. Growth was generally unsatisfactory.

In 1923, work of planting up farming lands resumed on the weir catchment area commenced in the Mundaring district. Pinus radiata was planted on many areas and has formed excellent stands on the limited areas of red basic soils. On the laterites which had been cleared from virgin bush, however, growth has proved exceedingly unthrifty.

Similar results have been obtained at Grimwade Plantation east of Kirup. On the better basic soils growth is exceptionally good, but is very poor on most laterite areas.

Growth, however, on all but good basic soils is extremely disappointing.

5.—*Present Extent of Planting.*

Future planting of Pinus radiata will be on plantation basis but confined to the known available areas of good basic soils. 18,000 acres are at present available for planting.

(a) Approximate total area of effective Pinus radiata plantation in Western Australia is 5,000 acres.

(b) Approximate age distribution:—

Age	> 30 years.	25–30 years.	20–25 years.	15–20 years.	10–15 years.	5–10 years.	0–5 years.
Acres ..	131	919	1,021	771	212	96	486

6.—*Climatic Zones.*

Planting is confined to the south-western climatic region which experiences a Mediterranean-type climate (c.f. section 1(b)). Distribution within this region is determined purely by edaphic factors. Rainfall variation is from 25 inches to 45 inches.

Generally, the species is quite at home within this climatic region so long as it is restricted to suitable soils.

The only imposition placed by climate is in the planting time, set at June and July. Planting out into the field in months other than these two can result in drastic establishment losses.

Altitudes of planting sites available vary from approximately 900 feet above sea level on the Darling Range and plateau areas to approximately 100 feet above sea level on the few coastal areas tried.

7.—*Soils and Sites Preferred.*

A distinct preference has been noted for the better class soils derived from basic igneous rocks. A P_2O_5 value of 250 parts per million in the surface and sub-soil is often used as a minimum criterion of suitability for this pine under natural conditions.

Such soils are rated as high quality in this State and usually carry good eucalypt forest.

8.—*Techniques of Establishment.*

Refer to section 1 (d).

9.—*Early Crop Development.*

Good pine makes approximately 4-6 feet per year in height growth after the first two years.

10.—*Silvicultural Practice.*

Thinning.

The present practice to be followed in thinning is as follows:—

All stands of Fair Average Quality and above—

At height 60 ft. thin to 300-350 per acre plus discards if any.
At height 80ft. thin to 200-250 per acre plus discards if any.
At height 100ft. thin to 150-200 per acre plus discards if any.
At height 120ft. thin to 100-150 per acre plus discards if any.
At height 140ft. thin to 80 per acre plus discards if any.
Stands of less than f.a.q. will be considered for conversion.

Pruning.

All stands of Pinus radiata are low pruned as labour and finance permit. Select final crop trees are also high pruned as funds and labour are available as there is an important market for clear logs for peeling for veneer.

11.—*Growth and Yield.*

Increment varies widely depending on the soil type. On the best soils an M.A.I. of 550 cubic feet per annum has been attained in a 33 year old stand. It is accepted that where the increment is less than 150 cubic feet per annum, this species is on a soil type which should not have been planted, and it is unlikely that such plantings will be repeated.

For forward calculations, therefore, on the assumption that only suitable soils will in future be planted, an M.A.I of 300 cubic feet per annum is generally considered possible, including thinnings, and assuming that a market will continue for all logs down to 4 inches under bark crown diameter, which is at present the case.

12.—*Diseases and Pests.*

Similar to those of Pinus pinaster in this State. (c.f. P. pinaster 12.)

13.—*Other Damage.*

Nutritional disorders are described in detail in publications listed under P. pinaster (19). These are the result of utilisation of poor soils, or proved unsatisfactory procedure.

14.—*Seed Bearing.*

Pinus radiata flowers in early August under Western Australian conditions, the male cones shedding pollen from late August into September. The female cone life is from August to August, two years later when the seed is ripe.

Due to costs and other factors local seed is not yet collected except on a small scale. Planting stock is raised exclusively from imported seed.

15.—*Natural Regeneration.*

Natural regeneration does occur to a limited extent and is the subject of early studies.

16.—*Timber.*

Thinnings and final crop trees have been marketed in this State with satisfactory reports on quality. Locally grown Pinus radiata produces a board timber of equal standard to that normally accepted for this pine elsewhere in Australia and is also highly regarded for ply wood and wood wool.

17—*Potentialities of the Species in the National Economy.*

Pinus radiata is recognised in Western Australia as the source of a rapid grown, quality, softwood timber which is much needed within the State. The only limitation imposed on this species is the restricted area of suitable soil available for planting. An energetic programme is being carried out to locate all suitable areas for planting.

18.—*Published Information.*

A complete list is provided under this heading for Pinus pinaster.

SECTION II (c)

Pinus halepensis

1.—*Scientific Name.*

Pinus halepensis var. brutia. Elwes and Henry.

2.—*Trade and Local Names.*

Aleppo Pine.

3.—*Country of Origin.*

Cyprus. Seed used was delivered by the Forests Department, Nicosia, Cyprus. This seed is certified as collected from elite trees.

4.—*Historical.*

P. halepensis was planted in the first plantation established in 1896, and has had a varied success throughout 50 odd years of planting. Early seed planted was considered unsatisfactory, but since attention has been paid to source of seed, a limited success has resulted. Early seed was not the brutia variety.

A few acres of thrifty pine of this variety planted in 1931 exists at Somerville Plantation in the Perth metropolitan area and is growing well on small areas at Myalup, East of Harvey.

In both of these sites, a distinct limestone influence is recorded.

5.—*Present Extent of Planting.*

Present planting is limited to small areas in which limestone is prevalent. Work is still mainly experimental. The present approximate total area established is less than 250 acres.

6.—*Climatic zones* in which planted. Planting is in specialised areas within the defined Pinus pinister and Pinus radiata plantations.

7.—*Soils and Sites Preferred.*

From trial areas, it seems that Aleppo pine is best planted on soils with a definite surface limestone influence. Such soils and sites are unsuitable for other pines.

8.—*Techniques of Establishment.*

As outlined for P. pinaster and P. radiata in Section 1 (d).

9.—*Early Crop Development.*

Growth on areas in which residual limestone boulders occur at the surface is quite satisfactory in most cases. The good plot existing at Somerville Plantation has received attention from visiting foresters, indicating that this species should receive further experimentation under Western Australian conditions.

10, 11, 12, 13—No information considered worthy of mention in lieu of restricted and trial methods of establishment.

14—*Seed Bearing.*

Established trees have excellent cone development. Seed collection and trial has received no attention.

15, 16—No data available.

17—*Potentialities in the National Economy.*

It is considered that Pinus halepensis var. brutia will always play only a minor role in the State's plantations. Further trials on difficult limestone areas will, however, be carried out due to present promise on such areas which are considered unsuitable for Pinus pinaster and Pinus radiata growth.

18—*Published information:* None available.

SECTION II (d)

Pinus caribaea and Pinus elliotti

1—*Scientific name.*

Pinus caribaea Morelet (syn. P. hondurensis Loock). Pinus elliotti var. elliotti.

2—*Trade Name and Local Name.*

Slash pine.

3—*Country of Origin.*

Some doubt exists as to the actual species and varieties established in this State. Seed of Pinus caribaea has probably been supplied at a request for seed to the Conservator of Forests, Belize, British Honduras. Seed formerly referred to as P. caribaea, received from Queensland, is now reputed to be Pinus elliotti var. elliotti. A consignment of seed received from Otto Katzenstein Co., Atlanta, U.S.A., is also believed to be of this species and variety.

Most seed received appears to be suitable under experimental conditions.

4—*Historical.*

Planting of slash pine has been of an experimental nature on a variety of soil types, but never to an extent other than to serve as an indicator.

In 1925, approximately six acres of P. caribaea were planted at Gnangara and from this date on, very limited areas were established in practically all plantation areas.

5—*Present Extent of Planting.*

Planting is still mainly of an experimental nature on swampy sites unsuited for Pinus pinister, Pinus radiata or Pinus halepensis var. brutia.

6—*Climatic Zones in which Planted.*

As for Pinus radiata and Pinus pinaster.

Altitudinal limits for planting. No set limits. Varies over the whole plantation area of a maximum elevation of 1,000 feet above sea level.

7—*Soils and Sites Preferred.*

Present experience indicates that this species will be of value for swampy areas of high water table areas.

8—*Techniques of Establishment.*

As for Pinus radiata and Pinus pinaster.

9, 10, 11—Due to the limited nature of planting, no definite figures are available. In no instance has this species proved superior to Pinus radiata on good soils and Pinus pinaster on poorer, sandy or laterite soils.

12, 13, 14, 15, 16—No data available.

17—*Potentialities of the Species in the National Economy.*

Present indications point to slash pine proving a subsidiary species in Western Australia conifer plantations, reserved for those areas of a swampy nature.

Consideration is being given for trials of this species on lateritic soils which up to now have proved unsatisfactory with all species and technique tried.

19—*References to Published Information:* None.

SECTION II (e)

Species of Experimental Trial Only

Pinus laricio.
„ canariensis.
„ echinata.
„ clausa.
„ muricata.
„ coulteri.
„ jeffreyi.
„ murrayana.
„ densiflora.
„ luchuensis.
„ strobus.
„ rigida.
„ pinea.
„ longifolia.
„ taeda.
„ palustris.
„ patula.
„ attenuata.
„ ponderosa.
„ lambertiana.
„ contorta.
„ massoniana.
„ torreyana.
„ sylvestris.
„ banksiana.

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Qld For Service have 5 main species +
5 soil management systems to follow -

Slash.	Pinus	elliottii
	P.	caribaea
Loblolly	Pinus	taeda
Hoop Pine	Araucaria	cunninghamii
Kauri	Agathis	robusta