

BULLETIN 58

PAMPHLET No. 5

1964



**FORESTERS'
MANUAL**

**AFFORESTATION
WITH PINES**
(South West)

**FORESTS DEPARTMENT
PERTH
WESTERN AUSTRALIA**

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BULLETIN 58

PAMPHLET No. 5

FORESTERS' MANUAL

**AFFORESTATION
WITH PINES**

(South West of W.A.)

Prepared under the direction of
A. C. HARRIS, Conservator of Forests

PERTH: 1964

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This pamphlet is divided into sections but paragraphs are numbered consecutively throughout. Thus for reference purposes it is sufficient to quote the pamphlet and paragraph numbers.

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FOREWORD.

The attention of officers receiving this pamphlet is drawn to the introduction in Pamphlet No. 1 which is applicable to the Manual as a whole.

It is to be noted that each section as issued will override the instructions contained in circulars on subjects covered by the section and such circulars will automatically be cancelled.

This Pamphlet No. 5 covers Afforestation with Pines (South-West). It was first issued in 1927, revised in 1952 and is now superseded by this pamphlet. Copies of the 1952 pamphlet should be destroyed or clearly marked: "Superseded by 1964 revision".

A. C. HARRIS,

Conservator of Forests.

1964.

SECTION 1.

INTRODUCTION.

1. 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. 1896.

2. Up to 1922 only minor areas had been planted and had mostly failed, but in 1922 at Ludlow and Mundaring, a start was made towards a regular annual programme, which although some gaps occurred, particularly in the war years, resulted in a net area of 39,000 acres by 1964 and an accepted working plan target area of 3,500 acres a year, with a distant goal of up to 200,000 acres total exotic coniferous plantations. At 1964, there is every indication that existing plantations have a ready market for all pine available. 1922 planting.

3. 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. Soils available.

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

5. 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.

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

7. 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. Histogram on page 9 shows the rapid growth of plantations since 1953.

8. 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 area of good soils, and *Pinus pinaster* on the bulk of the coastal sands. *P. halepensis* var. *brutia* and *P. caribaea* on small specialised sites within the general plantation areas are sometimes used and various species are planted in a small way for arboreta and study purposes. Species used.

Policy on softwood plantations.

9. Policy in more detail is summed up in two pamphlets presented to the 1957 British Commonwealth Forestry Conference "Report on Exotic Conifers in W.A.," and "The Desirable Balance between Hardwood and Softwood Production in Western Australia," which are obtainable from the library.

Study still necessary.

10. Officers in charge of plantations in W.A. must appreciate that there is a large and growing literature on the subject of the genus *Pinus* in Australia and that, although conditions are often vastly different in various portions of Australia, continued study of the subject and of special allied subjects is essential.

Basic information.

11. All officers holding responsible positions in connection with plantation development are expected to read certain background information contained in:—

"Nutrition of the Pine"—Bulletin No. 30, Forestry and Timber Bureau, 1950.

"Pine Establishment"—Forests Department, Bulletin Nos. 53 and 53a.

It is most important that, with the passing of the first generation of plantation officers, the lessons of 40 years trial and error and replicated experiments should not be lost.

Basic soil survey information.

12. Soil Survey Officers particularly should seek to follow the early development of knowledge of forest soils in Western Australia and should read bound volumes available from the library headed:—

Western Australian Forests Department. Soil Surveys of Indigenous Forests, 1935-39.

Western Australian Forests Department. Soil Surveys of Pine Plantations to 31st December, 1937.

J. O'Donnell—The Soils of the Mundaring Weir Plantations—1935-1940.

Gap in soil studies.

Although these writings are all pre-war, it is pointed out that from 1939 to approximately 1951, no plantation establishment soil survey work of significance took place.

Future plantations.

13. Plant nutrition, seed provenance and tree breeding are likely to have an important effect on future plantation management and these subjects are being followed up in Western Australia, as in other States, by specialised Research Officers.

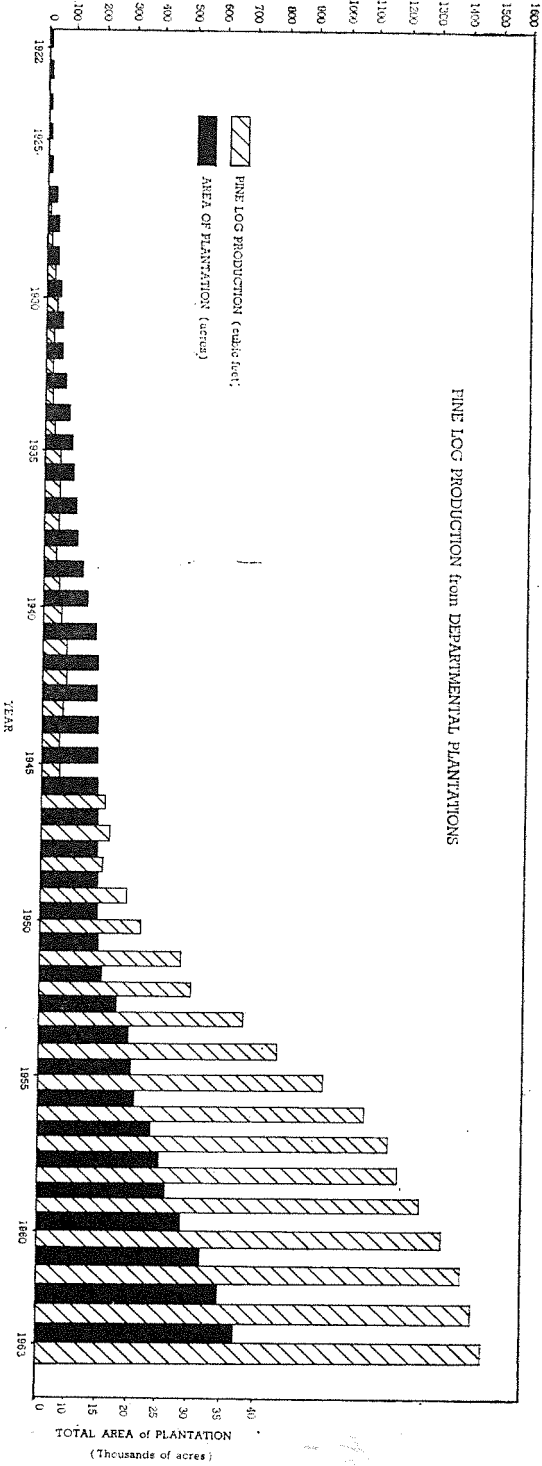
Conditions vary in W.A.

14. A warning needs to be sounded to officers managing plantations to the effect that physical and economic conditions are so widely different in the various parts of the world, where *P. radiata* and *P. pinaster* are grown, that data or even data from outside the south-west of W.A. must not be accepted without careful examination. It is essential to follow in detail the instructions contained in this Manual, which are based upon 40 years study and practice under our special conditions.

General instructions.

15. Departure from the instructions set out in this Manual in general practice, should be made only on the written authority of a Superintendent but a continued experimentation on a small scale in all plantations should be carried on by direct arrangements as to detail with the Plantation Superintendent.

LOG PRODUCTION from DEPARTMENTAL PINE PLANTATIONS
(Thousands of cubic feet)



HISTOGRAMS SHOWING DEVELOPMENT of PLANTATION AREAS AND OUTPUT of LOGS in TRUE VOLUME CU. FT. SINCE 1922.

SECTION 2.

POLICY.

AFFORESTATION POLICY.

Existing State plantations.

16. Although only approximately 39,000 acres of pine have been established over the past 40 years, the plantations concerned have covered a wide range of the soils and climates of the South-West from Moore River to Esperance and have resulted in the development of techniques in soil survey, selection of species, establishment and nutrition, and in pruning, thinning and marketing problems.

Future planting.

17. Pine working plans (1950, 1960) envisage a target of at least 200,000 acres of pine plantation for the State and an annual programme of 3,000 and perhaps up to 5,000 acres. The object of this plan is to provide softwood for the expected increased population of the future or for use as timber, as particle board and as long fibred pulp, of which a percentage is needed in many classes of paper as a mixture with the short fibred pulp of eucalypts.

The need for softwood.

18. The increased use of plantation grown softwood is also necessary as population increases to provide for an anticipated deficiency of supply from our hardwood forests; moreover the export trade in these high priced hardwoods cannot continue indefinitely unless a percentage of softwood is used locally. The peeler or veneer industry needs a replacement for imported softwood logs, and markets are arising for wood wool and treated posts and poles.

Plantation working plan.

19. All officers concerned with pine plantations must be familiar with the policy as set out in more detail in the current plantation working plan for the State as a whole.

LAND AVAILABLE.

Need for land purchase for *P. pinaster*.

20. Although large areas of coastal plains are available for planting of *P. pinaster*, a small percentage only of this land can be expected to grow site quality I, and most of it is badly placed to meet the demands of the metropolitan area due to transport costs.

There is, therefore, a need for the acquisition of more land of high site quality potential within a radius of 30 miles of major industrial centres.

Land for *P. radiata*.

21. Areas within State Forest and Crown lands suitable for *P. radiata* site quality IV and above are very limited and it is necessary to acquire large areas of suitable soil by purchase from private owners. The more rapid growth of *P. radiata* assists the economic view that such areas may be up to 50 miles from the main markets of Perth, Bunbury and Pemberton for future pulp.

Transport problems.

22. The financial return from pine plantations is heavily affected by haulage costs and for low price raw material such as case wood and pulp wood, i.e., the smaller sizes and unpruned tops of larger trees, the location of a plantation can mean the difference between profit and loss to the grower.

LAND ACQUISITION.

Land acquisition procedure.

23. The Forests Department has no authority to resume for pine planting and land is therefore purchased by private treaty where suitable offers are made, or where properties are advertised for sale.

Valuations.

24. The value of properties to the Department depends upon:

- (a) suitable soils and topography;
- (b) location in relation to markets;

- (c) clearing on suitable soils. (Clearing on unsuitable soils cannot be regarded as an asset to the Department.)

Valuations must be based on the value to the Department and not the cost value of the improvements. For example, orchards, fencing and buildings may in many cases have no value to a plantation scheme.

25. In the case of areas of private property thought to be suitable for *P. radiata* which are for sale, the Divisional Forest Officer should:—

Procedure for purchase.

- (a) Obtain a written offer from the owner indicating the price and giving permission for the Forests Department to carry out assessments and soil survey on the property.

Written offer to be obtained.

- (b) Carry out a reconnaissance of the area and submit a sketch plan with notes as to timber, clearing and other improvement values, and whether improvements are of value to a plantation.

Reconnaissance by district staff.

- (c) A decision will then be made by head office as to whether a detailed soil survey is warranted.

Soil survey.

- (d) If it is decided to proceed further with the proposal, head office will arrange for a soil survey to be carried out. (See also Section 3.)

SECTION 3.

SOIL SURVEY PROCEDURE.

26. Soil surveys of coastal sand areas will be carried out only as directed by the Conservator.

27. All *P. radiata* plantation proposals in "Hills" country must be the subject of careful soils surveys before working plans proposals for them can be adopted.

Areas of red and brown soils associated with basic or metamorphosed rocks are the chief soils to be considered for *P. radiata* during the next decade.

Officers who have areas in mind for *P. radiata*, but are not sure of the soil types required should advise Head Office, when arrangements will be made for a soils officer to demonstrate them.

The first reconnaissance of possible areas must be carried out by Divisional Forest Officers. They will submit to Head Office an 80 scale tracing showing the proposed areas.

First reconnaissance by divisional officers.

In preparation for a more detailed reconnaissance of proposed areas by a specialist officer D.F.O's. must ensure that:—

Check by specialist officers.

- (a) Deep profile holes (6 ft. x 2 ft. x 6 ft. deep) are dug in positions as indicated by the specialist officer.

- (b) Access tracks to these profile holes are opened up.

28. If and when an area is decided on as a probable future plantation, detailed soil survey by a specialist officer will be arranged by Head Office.

Detailed surveys by specialist officer.

The district concerned must arrange to open up and peg survey lines, dig profile holes and provide access where necessary. Soil survey lines will be at 10 chain intervals for areas of less than 300 acres and at 20 chain intervals for larger areas. The lines should run across the general contours of the country being surveyed. Any further breakdown of the grid will be decided by the Plantation Superintendent after the general pattern of the soil is demonstrated by the Soils Officer.

District staff to open and peg survey lines.

Soil survey reports.

29. At the completion of a detailed reconnaissance survey the specialist officer will render a Soil Survey Record (Form F.D. 435), a Soil Survey Plan and a full report including profile descriptions. The boundary of the plantable area will be defined by a blazed and painted line.

Distribution of reports and plans.

Copies of these will be distributed as follows:—

Original and one copy—Head Office.

1 copy—Research Station.

1 copy—to D.F.O. concerned.

1 copy—retained by Soils Officer.

Standard abbreviations.

Abbreviations used in soil profile descriptions are standard and are as set out below:—

ABBREVIATIONS USED IN SOIL PROFILE DESCRIPTION

Colours—Principal Colours

Red	=	R.
Yellow	=	Y.
Brown	=	B.
Grey	=	G.
Black	=	Bl.
White	=	W.
Chocolate	=	Choc.

Intensity

Light	=	l.
Dark	=	dk.
Dull	=	dl.
Bright	=	bt.
Pale	=	p.

Consistency.

Coherent	=	Co.
Friable	=	Fri.
Compact	=	Cmpct.
Hard	=	Hd.

Structure.

Angular	=	Angr.
Blocky	=	Blky.

Texture.

Sand	=	S.
Loam	=	L.
Clay	=	C.
Silt	=	Si.

Gravel Stone.

Gravel	=	g.
Rubble	=	ru.
Floaters	=	fitrs.
Massive sheets	=	m.
Outcrops	=	o/c.

Genetic Type of Stones.

Granitic	=	G.
Quartzitic	=	Q.
Basic	=	Bas.
Ironstone	=	Ist.
Latterised rubble	=	Ltsd/ru.

Intensity.

Light	=	l.
Moderate	=	mod.
Heavy	=	hy.

Form.

Fine	=	f.
Coarse	=	c.
Mixed	=	mx.
Angular	=	angr.
Rounded	=	rd.

SECTION 4.

SURVEY AND SUBDIVISION.

30. After the soil survey plan has been approved by the Plantation Superintendent, the D.F.O. concerned will prepare subdivision proposals and these proposals should be at least five years ahead of planting. Utilisation of the area must not commence until the subdivision proposals have been approved by the Plantation Superintendent.

Subdivision plans to be 5 years ahead.

31. The base plan prepared for the soil survey will normally be used as a basis for subdivision. A minimum of survey work will be required since regular aerial photographs will be used to prepare progress plans.

Base plans minimum survey.

32. In special cases, with very hilly country, it may be desirable to have a "controlled survey" line or lines put in by the forest surveyor and recommendations to this effect should be made to Head Office.

Control surveys if needed.

33. Compartment corner survey pegs will not be established. Air photos and compartment fire breaks adequately define these corners.

Use of air photos.

34. After utilisation, bulldozing and burning of the area, the final position of tracks and firebreaks may have to be "swung" to avoid stumps and other obstacles.

35. The firebreak system generally must be designed to meet the anticipated hazards and access for the particular area rather than to follow a diagrammatic scheme. Subdivisions must be supported by reasons for the plan. Some guides to design are given in succeeding paragraphs.

Firebreaks depend upon local conditions.

Principles of subdivisions:

36. Firebreaks should normally be suitable for ploughing and/or grading and be trafficable at least to four-wheel drive vehicles. They cannot always be sited as extraction routes, but should avoid as far as possible, large stumps and rocks and in easy terrain they should form part of the future extraction system. Perimeter breaks must be trafficable and in order to achieve this, small tongues of plantable country may be left unplanted.

General principles. Firebreaks general policy.

37. There is no objection to some eucalypt compartments or sub compartments being within the external firebreak. In fact, this is far preferable to clearing and planting areas which are likely to fail. Firebreaks must not include swamps and creeks, which normally give serious maintenance problems. Such features should be within the compartments to be planted.

Avoid creeks and swamps.

38. The subdivision proposal plan will be submitted as a pencil drawing on a polyester base plan as supplied from Head Office at a scale of 10 chains = 1 inch.

39. Where the suitable and available land for plantation occurs in extensive and unbroken areas, such as in the sand plains, buffer strips or indigenous forest preferably 20 chains wide will be left, for controlled burning, between every 1,000 acres of plantation.

Buffer zones.

40. In the irregular shaped and less compact hills plantations buffer strips will be the subject for individual decision by the plantation superintendent.

41. The width of the external firebreak will be decided after considering the tenure and condition of the adjoining country and the general topography.

Importance of outer fire lines.

Where the adjoining area is occupied by Euc. high forest the width of firebreak will be related to the codominant height of this forest and never less in width than the codominant height of that forest. These external breaks should be sited slightly downhill from the crest of a ridge on the plantation side.

Examples of breaks required.

42. Depending on conditions the external firebreak may vary from 40 ft. to 3 chains in width.

Some examples:—

A two chain or wider 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.

A one chain break may be ample where adjoining cleared pasture land or orchards are being farmed.

Outer fire lines.

Sounds as though it is intended to burn in plantations
43. All plantations where possible should have an inner and outer fire control strip of 10 or more chains which can be kept control burnt alternately and on which strips no dead trees, stags or paper bark trees should be left standing.

Fire proposals.

44. A fire break working plan proposal must accompany the design for subdivision.

INTERNAL BREAKS.

Road access is first.

45. In laying out a firebreak system for a plantation the natural features and road access should largely influence the design and only on level country should a chess board design be considered.

As a general guide the following may be considered:—

Coastal Plains.

Coastal plains.

46. One chain to two chain cultivated or graded and rolled outer break except where the Plantation Superintendent considers that an even wider area is necessary.

47. Every 600 acres surrounded by a two chain break.

Compartment size.

Every 100 acres surrounded by a one chain break with compartments of 25 acres surrounded by half chain breaks.

Dunes as buffers.

48. Where poor site quality high dunes occur, breaks should be sited on the ridges rather than attempt a square design, and the dunes used as wide buffers.

In Hilly Country.

Compartment size.

49. Internal breaks should aim at compartments from 20 to 40 acres surrounded by 33 ft. breaks which will in most cases, form extraction routes.

Through roads one chain wide.

50. Through roads which carry public traffic, should be one chain wide, but where needed only for Departmental purposes, may be 33 ft. only, between the lines of trees.

No internal two chain breaks are normally considered necessary.

SECTION 5.

PLANTATION NOMENCLATURE.

51. It is necessary to conform with rules for nomenclature which have been set up by a State Committee.

Names must conform.

52. Plantations should be named at the time of submitting subdivision proposals in accordance with the following policy. Plantations will be named as follows:—

Policy for names.

- (a) Divisions—Hills Plantations or Coastal Plantations.
- (b) Within both of these divisions, Groups would be used where needed—such as Mornington and Tallanalla Groups.
- (c) Within groups, subdivision would go direct to alphabetical sections.
- (d) Sections would be brought direct to compartments. Sections would not normally exceed a maximum of 1,000 acres, but could be as small as 100 acres or less, where there is geographic separation.

Groups and sections.

53. It is generally undesirable to use terms such as central, north, south, east, west, etc. So far as our naming can be kept within the policy framework, we will retain names already in existence and on plans.

54. There is no obligation to have groups where they are not needed, e.g., Mundaring does not need a series of groups and can go straight to sections.

Too many names to be avoided.

In general policy it is undesirable to have too many names, as each of these ultimately has to be accepted by nomenclature authorities.

55. Illustrating this policy, starting from the north, names are as follows:—

(a) **Wanneroo Coastal Plantations.**

Examples of names.

Gnangara Group (to include present Neaves Road area).

Pinjar Group.

Yanchep Group.

Moore River Group.

- (b) Somerville, Peel Estate and Collier Groups, as at present as these names are firmly established.

Each of these groups are subdivided into sections of about 1,000 acres each.

- (c) **Harvey Coastal Plantations.**—Would have three groups—Myalup, McLarty and Hamel; and any additional developments in this district would form sections under one of these group names.

- (d) **Harvey Hills Plantations.**—Would be covered by the Mornington Group, the Tallanalla Group, the Harvey Weir Group and the Hoffman Group, and no further names should be necessary as any developments within range of each of these centres would form another section of the group to which it was most closely allied.

SECTION 6.

CLEARING FOR PLANTING AND PLANNING OF WORK.

56. Utilisation of natural timber or clearing for planting must not be commenced until subdivision plans are approved. On receipt of approved plans, the D.F.O. must prepare a working plans programme for clearing and planting. This plan

Clearing to await approval of plans.

must be submitted to head office on Form F.D.455 after discussion with the Inspector or Superintendent. (Sample form at page 17.

Estimates.

57. Once the working plan programme is approved and returned to the Division, it will be used and referred to as a basis for financial estimates submitted from time to time.

GENERAL POLICY.

Policy governing clearing.

58. In the following paragraphs the general policy governing clearing for planting is set out:—

- (a) Every effort must be made to salvage all saleable produce from the cleared areas. The work in final clearing is greatly reduced if the larger material can be marketed.
- (b) Areas to be cleared for planting by broadcast bulldozing will be protected from fire, for three years before being bulldozed, to assist in obtaining a good burn. To aid in the protection of these areas they will be divided into sections of not more than 100 acres by a 10 ft. wide track and the adjoining forest kept burnt as an additional protection.
- (c) The planting area will be bulldozed three years in advance of planting. A one chain wide strip must be pushed clear of debris around each 100 acres during bulldozing.

This will both help to protect the area from accidental fires and assist in the burning off. The type of equipment to be used in the pushing down will depend on the material to be handled and the economics of the operation.

- (d) Where large logs have to be disposed of it is advisable to shatter them with explosive as soon as possible after the dozing, but precautions must be taken against any outbreak of fire.
- (e) In coastal sandplain country where scrub is thick and large stumps few, the use of a heavy roller several weeks in advance of the burn off greatly assists in obtaining a good burn.
- (f) In heavily timbered areas, the initial stacking should be carried out by a D7 dozer equipped with a rake blade.
- (g) The pushing in of heaps can usually be satisfactorily performed by the lighter D4 dozer.
- (h) Where it is planned to plough the area and/or a planting machine is to be used, a man will need to be employed picking up the smaller debris which could interfere with the operation of the plough or planting machine.
- (i) The precautions to be taken in each burn will be determined by the particular hazard existing.
- (j) Where the area to be burnt adjoins a plantation area or other pushing down, it is advisable to windrow the debris on the 5 chain strip immediately adjoining and to burn the windrows in advance, under mild conditions.
- (k) Where a particular hazard exists, the fire control forester should be consulted in advance and if possible he will be present at the burn.

PLANTATION CLEARING AND PLANTING
WORKING PLAN PROGRAMME

Planting Year..... Plantation.

	Spring..... Block. Section. Ac.	Summer..... Block. Section. Ac.	Autumn..... Block. Section. Ac.	Winter..... Block. Section. Ac.	Check March..... Block. Section. Ac.	Check Sept..... Block. Section. Ac.
Bulldozing, Felling, etc.						
Initial Burning						
Final Clearing						
Cultivation						
Planting						

SECTION 7.

SOIL PREPARATION OF PLANTING AREA.

COASTAL.

Initial cultivation.

59. On most types of country, available to the Department 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 essential on almost all soil types although not always for the same reasons.

60. In W.A. where the summers are hot and dry, ploughing must be a very thorough one, a depth of 9 in. to 12 in. being aimed at. The ploughs engaged on this work are subject to great strain and wear and require constant attention to keep them in good order.

Essentials to be checked.

61. The D.F.O. should take a personal interest in the ploughing as too often poor work results from lack of attention to the essentials of—

Breast cut, undercut and parallelism.

These essentials are apt to be forgotten. Greater tow-bar horsepower does not necessarily give better ploughing.

Late ploughing desirable.

62. Where possible ploughing should be delayed until after the first rains as this late ploughing reduces grass and scrub competition and provides better soil conditions for planting.

HILLS PLANTATION.

63. Ploughing prior to planting in the heavier soils of the hills plantation is not as necessary as it is in the coastal areas.

64. Before reaching a decision on ploughing, the following points need to be considered:—

(a) Is ploughing likely to aggravate wash of the soil and perhaps cause silting of streams within a water catchment area?

(b) Has the activity of the dozers during clearing operations loosened the soil sufficiently to render ploughing unnecessary?

(c) Is ploughing necessary to suppress scrub growth?

65. The decision whether or not to plough will rest with the Inspector or Plantation Superintendent.

66. Where areas are too steep, rocky or difficult to plough and have not otherwise been loosened, the planting must be cultivated manually by mattock.

67. In this work, reliable men, singly or in pairs, should be employed, as it will often be necessary to choose the actual planting spot in pockets of soil between rocks.

SECTION 8.

PLANTING OPERATIONS.

Introductory.

68. The perfection of mechanised operations over the past decade has resulted in many advantages in time, cost and uniformity of planting; but with the growth of mechanisation extreme care needs to be exercised to ensure that the essentials governing survival of the tree are not overlooked.

Hand planting.

69. Hand planting will continue to play an important part in our operations and especially in hilly and difficult areas where even greater care is needed to ensure the best results.

70. Planting Season.

South of an east-west line through Bunbury:

1st June to 31st July.

North of an east-west line through Bunbury:

15th June to 31st July.

Planting season is limited.

Officers-in-Charge will so organise the work as to complete the planting within the above periods. They must not be departed from, without Head Office approval.

71. Layout of the Planting Site—Planting lines will be set out at right angles to some selected baseline, which will normally correspond with one of the boundaries of a compartment.

Layout of planting area.

In the exceptional cases where a boundary will not serve, a special baseline must be run, as far as possible, through the centre of the area. Such lines must, of course, be established before the planting gang moves on to the job.

72. When the terrain permits, the compartment boundaries should be marked clearly on the ground with a single furrow or graded line. This boundary is readily recognised by the planters.

Compartment boundaries to be marked before planting.

73. In order to facilitate the use of mechanical means for weed control, access, etc., the planting lines must be kept reasonably straight and parallel and evenly spaced.

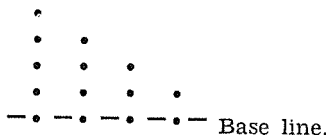
Alignment. Straightness of rows must be achieved.

74. Wherever possible plant up or down hill. This facilitates all future operations including final extraction work. With mechanised planting, it is often necessary to compromise on the direction of planting.

Direction of planting rows.

75. Alignment when hand planting will be secured by the use of the echelon formation:—

Echelon method of planting.



Planters 1 2 3 4

With a planting gang of four men working in echelon formation, the relative position of the plants when No. 1 has put in his fifth tree would be as shown in the diagram. The inner flank man (No. 1) will be guided by a set of sighting waddies.

Unless formation is maintained in echelon, the spacing and consequently the alignment will soon become too irregular. The inner flank man (No. 1) is largely responsible and should, therefore, be the most reliable and fastest man in the gang.

Importance of echelon method.

76. Sighting waddies will be used for the leader of the gang to provide for correction of alignment. They are not to be used for each row.

Sighting sticks.

77. Spacing. This is the distance between trees and between lines of trees.

Spacing.

For *Pinus radiata* spacing will be 8 ft. x 8ft. unless otherwise decided by the Plantation Superintendent. At approximately two chain intervals 12 ft. wide access ways will be left unplanted. These will be selected up and downhill avoiding stumps, logs and rock.

For *Pinus pinaster* on coastal plain plantations spacing will be 8 ft. x 6 ft. with every 15th row left unplanted for extraction routes.

Spacings for experimental areas may be varied from the above only on the approval of the Plantation Superintendent.

Number of plants per acre.

78. The number of plants required per acre for the different spacings are:—

6 ft. x 6 ft.	=	1,210
8 ft. x 4½ ft.	=	1,210
7 ft. x 7 ft.	=	890
8 ft. x 6 ft.	=	910
11 ft. x 4½ ft.	=	830
8 ft. x 8 ft.	=	<u>680</u>
9 ft. x 6 ft.	=	807
9 ft. x 9 ft.	=	538
10 ft. x 10 ft.	=	436

(Less a % when extraction rows are left).

PLANTING.

Keep the gang together.

79. It is important that the gang on normal operations must work as a compact group and not be allowed to break up irregularly into individuals or pairs. The overseer will estimate the number of plants necessary each day and only approximately that number will be lifted from the nursery or sent out to the planting site. He will spend his time organising and supervising his gang and will carry out very little actual planting himself.

Special conditions.

80. On rocky unploughed areas, do not use a gang. Give the job to one or two "old hands" to choose places where trees will grow.

Plant dumps.

81. The placing of dumps must be arranged each day by the Officer-in-Charge as the plants are brought on to the site, so that the carriers or machines can conveniently refill their plant carriers without unnecessary walking.

Planting on sandy country.

82. **Coastal Areas**—Planting whether by hand or machine, 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". After ploughing, the planting lines will be marked out with furrows. Special furrow lining implements have been designed for this purpose.

Furrow lining.

Hand planting.

83. Most of this country is best planted by machine. Where hand planting is done the method will be notch planting using a standard planting tool. The tool is driven into the ground and moved backward and forwards slightly to form a notch about 4 in. by 2 in. and 12 in. to 14 in. deep. The seedling is inserted in this notch by the digger, who will shake it sufficiently to ensure a correct vertical disposition of the roots and the notch will be closed by a heavy stamp of the heel and the soil levelled off with the sole of the boot. One heavy stamp is all that is necessary and much light tapping and patting should be avoided, but care must be taken to avoid air pockets around the roots.

84. The most satisfactory arrangement of the gang is 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 2,500 trees per three-man gang. A really good gang will plant 3,000 trees per eight-hour day. On the other hand three men with a planting machine can achieve 8,000-9,000 per day.

85. **Hills Areas.**—On sandy or sandy loam surface soils containing only a slight admixture of gravel, a planting spear is used with the same organisation of personnel as for notching with the planting spear 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 fingertips, such as a woodchip, is sufficient. On steep unploughed slopes a shelf must be matted down.

Planting on heavier soils and gravel.

86. **General Planting Instructions** (for hand and machine planting). (For packing procedure see Nursery Section).

Important points in planting instructions.

- (a) 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 management and extraction.
- (b) Dry sand, or other soil, must be avoided by making another hole reasonably close to the rejected spot.
- (c) The plants must be set in the ground $1\frac{1}{2}$ in. to 3 in. deeper than they stood in the nursery. This means the covering of at least $\frac{1}{2}$ in. of the needles.
- (d) Constant supervision is necessary to prevent planters losing their standards, resulting in settings becoming gradually shallower or deeper.
- (e) Depth must be decided from the general level of the soil. A slight heaping around the tree of loose soil which will wash down in the first heavy rains often gives a false appearance of depth.
- (f) The notches or holes must be deep enough to permit the roots to be disposed more or less vertically without bending.
- (g) Root exposure must be reduced to a minimum from the lifting to the planting.
- (h) Avoid root damage which is often caused by unnecessary handling and counting.
- (j) Keep plants wet and shaded at all stages of transport or waiting times but roots of plants must never be washed as this removes micorrhizal growth.
- (k) Avoid "heeling-in" and relifting.
- (l) Avoid exposure during the actual operation of transferring the plant from the bag or tray to the hands of the planter.
- (m) Soak all bags used for bundling for some days before use. It is not sufficient to wet the bags and pines after bagging.
- (n) If transporting for long distances do so under a truck canopy and give definite instructions for sprinkling the bags every two hours.
- (o) Avoid planting during dry spells even on dull windy days and have alternative work well organised so that men can be taken off planting at short notice.

Avoid bad spots.

Depth below nursery depth.

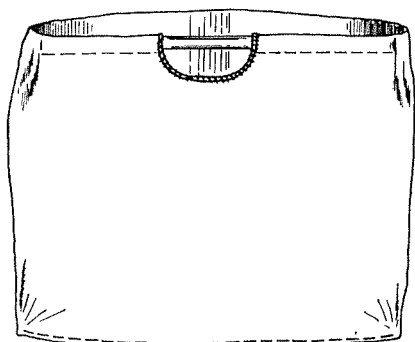
Roots vertical.

Methods of packing plants for transport are outlined in paragraph 140—Nursery Practice.

87. The standard plant carrier is made from a wheat sack. The sack is folded back on itself to exactly half its size and the top sown to the bottom. This produces a sack half the

Plant carriers.

size of a wheat sack and with a double thickness. A slot is then cut in the sack near the mouth and a short piece of stick a little shorter than the width of the bag, and about one in. in diameter is inserted. This is sewn around to make it a fixture. See sketch.



Stick inserted between the two layers of bag and sewn.

Slot through which hand grip is obtained

Sack folded over and sewn.

These carrying bags are kept wet by constantly soaking them as needed.

Planting trays.

88. The use of planting tins may be used in some centres if approved by the Plantation Superintendent.

Policing of planting.

89. It must be stressed to all officers responsible for planting, that it is not sufficient to issue written or verbal instructions to officers, overseers and planters. It is essential throughout the planting to personally and constantly police the operations from the lifting to the final planting.

90. Planting Machines Nomenclature.

Lowther types.

Type (1)—The Lowther three-point linkage planting and refilling machines.

Type (2)—The Lowther four-wheeled trailing type planting machine.

Gnangara types.

Type (3)—The Gnangara type refilling and planting machine with hydraulic power-control of coulter and share unit.

Type (4)—The Gnangara type Universal mounted dual planting machine.

Types (3) and (4) have been constructed at Gnangara by modification of the Lowther four-wheeled trailing type and both type (3) and (4) are now mounted on two wheels only.

Reference to all planting machines should use the type name to avoid confusion.

Survival counts.

91. **Pine Counts.** In October and again in March (or after the first autumn rains) a count must be made of a sample of the current season's planting.

92. Sampling rows every 20th row are to be pegged. All trees along the row are to be counted and the dead trees recorded by booking their consecutive numbers adding the row, i.e.—In a row of 120 trees, five trees, numbers 11, 17, 96, 102 and 103, may have died.

93. A pine count report is to be forwarded to Head Office giving the percentage of deaths by rows and by compartments, together with notes on causes of deaths.

94. To ensure that the same rows are counted each time they should be marked by distinctive pegs at the time of the first count.

SECTION 9.

APPLICATION OF ARTIFICIAL FERTILISER AND MINOR ELEMENTS TO PLANTATIONS.

95. It has become standard practice to apply superphosphate at the rate of two cwt. per acre to all pine trees planted on the coastal plantations. Super at plantings.
96. The use of zinc spray is generally confined to certain plantations and the question of its use at new plantations should be discussed with the Plantation Superintendent. The general policy is that in all new areas, at the age of two-three years, experiments should be put in to find whether this spray is needed. If this is not done and it is later found, say at five or six years old, that the trees need spray, the operation becomes a very costly one. Zinc experiments.
97. In hills plantations, no super will be applied except on an experimental scale as approved by the Plantation Superintendent. No super in hills plantation.
98. Research is being pursued, in conjunction with C.S.I.R.O., into the question of *Pinus radiata* growth on low fertility soil types and it is not desirable, therefore, that Divisions should institute individual research programmes except as approved in detail by the Plantation Superintendent. Research on fertilisers.
99. Subsequent manuring by broadcasting with superphosphate is necessary on certain coastal *Pinus pinaster* plantations. Any programme of this work must be approved by head office. Subsequent nutrition of pines.
100. The application of artificial fertilisers to nurseries is dealt with in more detail under "Nursery Practice" but rapid changes are taking place in the study of nursery requirements and all fertilisers applied to nurseries must be approved by the Superintendent of Research. Fertilisers in nurseries.
101. In plantations being established in new areas, properly replicated fertiliser experiments should be established after consultation with the soils research officer.

SECTION 10.

PINE NURSERY PRACTICE.

102. The large number of small nurseries used in the past have been replaced by major nurseries to capitalise on improved transport facilities and the economics of mechanical nursery work. Policy re central nurseries.
- Larger nurseries result in lower unit production costs and permit a more scientific study of soils, diseases and techniques.
103. One year old nursery stock is used for both *P. pinaster* and *P. radiata*, and techniques aim at producing sturdy plants not greater than 12 inches in height. Size of plants.

SEED SUPPLIES.

104. Seed received at the Departmental Seed Store at Head Office is given a separate serial number for the purpose of recording origin, age of seed, etc. Seed despatched from the seed store is clearly labelled with these details. Seed supplies and records of seeds used.
105. It is most important that these serial numbers be:—
- (a) Recorded in the local office files and register. This should be automatic as a letter is sent from Head Office Seed Store with every parcel of seed giving particulars of the seed.

(b) Recorded on pegs on that portion of the nursery area on which seed of any one serial number has been sown.

Germination percentage.

106. The seed store staff will carry out germination tests and any stratification treatments considered necessary. The germination percentage is recorded on the labels of all seed despatched.

TIME OF SOWING.

Time of sowing.

107. Sowing is normally carried out in August. Permission to sow at any other time must be obtained from Head Office.

PRE-SOWING TREATMENT.

Pre-sowing treatment.

108. Any treatment of seed prior to sowing will be a question for decision by the Research Superintendent, who will arrange for the work to be carried out by the seed store.

NURSERY LAYOUT.

Preparation of seed beds.

109. The layout of the nursery must be designed to suit mechanical operations. Long beds make for economical machine work. Paths should be marked out with the tractor wheels after levelling, and adhered to in subsequent operations.

110. The long axis of the beds should be nearly parallel to the contour but with an allowance of two inches to the chain to allow for lateral run off of heavy rainfall.

Fungus necessary for success.

111. In a new nursery it is absolutely essential that the beds be inoculated with the spores of mycorrhiza-forming fungi before any pine seed is sown. This is best done by collecting soil and litter from under a stand of pines and broadcasting it over the surface of the nursery beds. A light dressing of soil applied at the rate of about five cwt. per acre should be sufficient, after which it must be worked into the beds. It is essential to achieve an even spread over the whole area to be treated to obtain thorough inoculation in the first year.

112. All sticks, stones, roots and other similar obstructions must be removed from the nursery beds which must have a smooth, firm surface with a good even tilth.

113. Actual technique and machinery necessary to achieve these conditions will vary with each site but generally will conform to the following sequence:—

- (a) General ploughing.
- (b) Rotary hoeing or cultivating.
- (c) Hand raking.
- (d) Scraping or rolling.

FERTILISERS.

Nursery fertilisers.

114. Each nursery has its own fertiliser problems. In general a system of rotational cropping with green crops using balanced fertilisers will be employed. Advice on fertilisers and green crops required should be obtained from Research Branch and the Plantation Superintendent.

SOWING.

115. Seed of *P. radiata* number 16,500 per pound and *P. pinaster* 8,500 per pound.

116. The seed is sown with a garden seed sower of the Planet Junior type. Settings for depth and rate must be carefully checked by the Officer in Charge.

Sowing rate.

117. The sowing rate should be (12-15) viable seeds per foot of nursery line and consequently the actual number of seeds sown will depend upon the germination percentage, the object being to produce 8-10 plants per foot of nursery line.

118. The seed sower should be thrown out of gear at the end of a line, by lifting the back wheel off the ground. Seed sower.

119. The small furrower should be set according to the type of soil involved. If the front wheel is sinking to a depth of nearly one inch in soft ground, the share should be raised as high as possible. On well worked and firm soil the furrower may be lowered from one to three notches. The coverers are adjustable similarly to three different heights. Depth of sowing.

120. As a general rule the depth of sowing should be equal to twice the diameter of the seed measured across its smallest dimension, that is a depth of $\frac{3}{8}$ in. for *P. pinaster* and $\frac{1}{2}$ in. for *P. radiata*. To provide for unevenness in nursery soil, when using the Planet Junior, the depth of the drill should be increased to a maximum of $\frac{1}{2}$ in. to ensure the seed remains completely covered after the first heavy rain. However, too great a depth in sowing is a very common fault. Depth of furrow required.

121. The walking rate should be approximately two miles per hour but an even rate must be maintained throughout. Rates of sowing.

122. Where mechanical lifting is used, it is an advantage to mark out the rows for sowing with a ridged roller mounted on the tractor, to ensure a uniform row width. Rows will be 12 in. apart but this may be reduced to 6 in. to suit mechanical operations. Sowing lines.

123. The main enemies of fungal and insect type experienced in Western Australian pine nurseries are—"Damping Off" fungus, "Cut worms" and Black Beetles. Insects and fungi.

124. All nurseries should be inspected at frequent intervals, but not less than every two days and at night if cut worms are suspected. These inspections must be maintained until plants are well established and immediately an attack is suspected by any agency the D.F.O. should report by telephone or radio to the Plantation Superintendent or the Research Superintendent. Inspect and report occurrences.

125. The surroundings of all nurseries must be kept free of weeds. During nursery inspections, pay particular attention to the areas under rotational crops or grass which may form a breeding ground for insects. Hygiene.

DAMPING-OFF

126. Damping-off is caused by fungus attack. Members of more than one genus may be responsible. "*Phytophthora omnivora*" is one of the best known throughout the world. The presence of the disease which occurs during or shortly after germination may be indicated by a discoloration from dark green to black occurring on the cotyledons and stem. Should the attack be confined to the tips of the plant this may recover, but if the lower part of the stem is affected, the plant usually withers, assumes a reddish brown colour and dies without any mechanical injury being observable. Germinating plants may be attacked and die before they appear above the ground. This is known as pre-emergence damping-off and when it is known to occur the seed should be treated with one of the organic fungicidal dusts. Damping-off.

127. While handling these compounds men should wear rubber gloves, keep the nose and mouth covered with a wet cloth, and should wash their hands thoroughly before handling food, cigarettes, etc.

128. Attacks usually occur in wet, humid weather, or on poorly drained soil. The influence of rain and shade is to favour the disease. Spread occurs through the fungus growing from plant to plant, but can be greatly accelerated by the movement of men and equipment about an infected nursery. Attacks under damp conditions.

129. Seed beds on which infestation has occurred should not be used in the succeeding year if the attack has been severe.

The seed beds suspected of liability to the disease should be inspected daily in early germination.

Cheshunt mixture.

130. When any sign of "damping-off" occurs, a preparation known as Cheshunt Mixture is applied to the beds.

- (a) This is used in preference to the very much more expensive organic fungicides which are now available.

This may be obtained at short notice by telephoning Research Branch, at Head Office.

- (b) It must be stored in an airtight glass or plastic container and supplies must not be held for more than six months as it does deteriorate with time.
- (c) The mixed powder is made up in solution at the rate of one ounce to two gallons of water. Hot water is preferable to increase solubility.

- (d) Application should be at the rate of one quart of solution per square yard. Immediately after treatment, water plants to remove solution from the leaves.

The total solution plus water should be at the rate of from a half to one gallon per square yard (which is equivalent to 10-20 pts. of rain). The treatment should be repeated at weekly intervals at least twice.

- (e) Cheshunt Mixture is corrosive, and equipment used for spraying must be thoroughly washed out immediately after use.

- (f) The strength given should not affect the tops of the seedling pines provided it is applied in the cool of the afternoon. The whole of the nursery beds showing any sign of infection should be treated as it is a preventative and not a cure for the disease.

- (g) For further information officers should consult the Department of Agriculture Bulletin No. 2857.

CUT WORMS

Cut worms.

131. (a) Cut worms are larvae of the cut-worm moths of which the genus "Agrotis" has world-wide distribution. The caterpillars in the metropolitan district are dull grey to greenish naked grubs of uniform thickness, about one inch long when fully grown and having eight pairs of legs. They are first seen when somewhat less than one-quarter of an inch in length. They feed nearly always at night, concealing themselves in the ground by day.

(b) Water soluble D.D.T. has been found to give a very effective control over this pest. This may be obtained upon requisition to Head Office and instructions for use are usually printed on the tin.

BLACK BEETLES (*Heteronychus sanctae-helenae*).

132 (a) This beetle has caused considerable damage to both *P. pinaster* and *P. radiata* seedlings at Hamel and has been observed in other nurseries.

(b) Eggs are laid in the soil and the beetle breeds in uncultivated or neglected land. The beetles migrate by flying, so infestation can be from adjoining areas. Treatment is by spraying with Dieldrin as a solution of one gallon of "Dieldrin 15" to 160 gallons of water at the rate of 160 gallons per acre.

(c) Further information is available from Department of Agriculture Leaflet No. 2055.

WEEDING

133 (a) Chemical weeding is now widely practised and the procedure is being constantly reviewed but in any case should not be undertaken except as approved by the Superintendent Research. Chemical weeding.

(b) Despite results achieved with chemical weedicides it is still necessary to employ hand weeding to combat certain weeds. Hand weeding.

(c) Blow torches or fire guns have largely been superseded, but may still be of value in some cases to assist in pre-emergence control of weeds. Blow torch weeding.

CULTIVATION

134. (a) Even though weeds can be largely controlled by other means cultivating between the nursery lines should still be practised. Cultivating nursery beds.

(b) The surface soil should never be allowed to develop a hard crusty formation.

WATERING

135. Most nurseries are provided with facilities for the watering of the beds but these should be reserved for emergency use during dry periods. Excessive watering produces unsatisfactory stock. Watering.

ROOT WRENCHING

136. The practice of root wrenching has not so far been found necessary and will not be adopted except with the approval of the Supt. Research. Root wrenching.

LIFTING PLANTS

(a) Mechanical lifting is in general practice in the main nurseries by means of special implements which have been designed for this purpose. Machine lifting.

(b) The spade which must be kept sharp is inserted vertically to its full depth along the row and about two inches away from the plant, first on one side and then repeated on the other side. Hand lifting.

(c) It is then inserted about 4 inches from the plant at an angle of 22° and forced down. This serves to cut the tap root about 9-10 inches below the surface. The handle of the spade is now pressed down 12 inches or so, given several shakes after which the plants can be withdrawn from the soil.

138. The common faults in hand lifting are:—

Faults in hand lifting.

(a) Failure to keep the spades very sharp.

(b) Failure to cut the roots as directed.

(c) Failure to displace the plants sufficiently far to prevent their being under-wrenched.

(d) Undue exposure of the roots while grading and pruning.

139. After elimination of the rejects, the trees are covered loosely with earth until a sufficient number is accumulated for packing. The packing procedure is as follows:—

PACKING PROCEDURE

140. Wheat bags are used for this purpose and are cut down one side (Fig. 1). They are then soaked in a drum of Packing the pines for long distance transport.

water for about 48 hours so that they become thoroughly wetted. The best method of packing pines in the bags is as follows:—

(a) **Small Plants** (i.e. with under 12 inch top)—

- (i) The wet bag is laid flat and a layer of packing 2 inches deep, usually of rotted pine needles, grass, straw, rushes, etc., is spread evenly inside. The seedlings are laid on the packing for half the length of the bag with the ends of the roots just touching the uncut side and the tops protruding from the open side (Fig. 2). They are finally covered with a layer of packing which is placed well around the roots. The bag is then stood upright (Fig. 3a). One side of the bag is tucked firmly around the plants as shown (Fig. 3b), and the bundle is rolled tightly (Fig. 3c). A much tighter pack is obtained by kneeling on the bundle in the process.
- (ii) The loose flap is then fastened around with two wire "S" hooks (Fig. 3d).
- (iii) When packing pines for transport from a local nursery to a planting site, so much care is not necessary. The bags should be thoroughly wetted, but no packing is required and after rolling, the loose flap is adequately secured by a small wire hook.
- (iv) The bundles should be watered from the top before despatch and it is advisable where large plants are concerned to secure the tops by binding with twine.

Packing for local transport.

(b) **Large Plants** (i.e. with over 12 inch tops)—

- (i) The bag is split down one side and across the bottom as shown in Fig. 1, and then laid out flat. One corner is folded in to a depth of 21 inches when using plants with 2 feet tops. The plants are then laid on the bag clear of the fold and at right angles to the diagonal formed by it so that only about one-third of their length protrudes (see Fig. 2).
- (ii) When the required number of plants have been obtained, earth or packing is placed over the roots, the end "A" is tucked over the trees and the bundle rolled tightly towards "C" (see Fig. 3). At an appropriate point in this process, the end "B" is brought up over the roots and tucked in as shown in Fig. 4, the rolling then being completed. To secure the bundle the flap "C" is sewn for long distance transport, or hooked for despatch to a nearby plantation. The reason for folding in the corner is that for a bundle of 9 in. diameter which is about the usual size, the diagonal formed will completely encircle the bundle and produce a tight pack.

Packing large plants.

Numbers in bundles

141. When smaller plants are used, a larger number can be packed in the same manner by increasing the size of the first fold to conform with the limits of the bag. Bundles usually contain about 500 small trees, 300 12 inch to 15 inch trees, or as few as 100 big two-year *Pinus radiata* plants.

142. Counting of pines in all bags is not to be done as this takes time at a stage when a minimum of exposure of the roots is vital. Sample counts to determine an average number per bag will suffice.

BUNDLING OF SMALL PLANTS

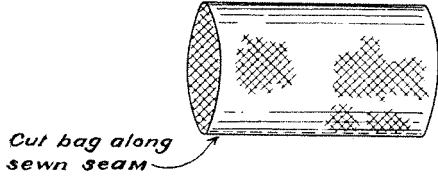


FIG 1

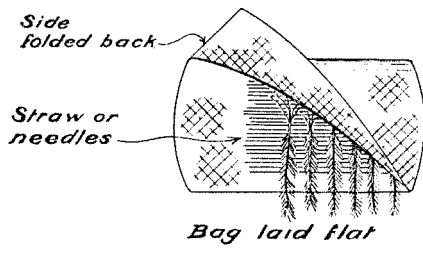


FIG 2

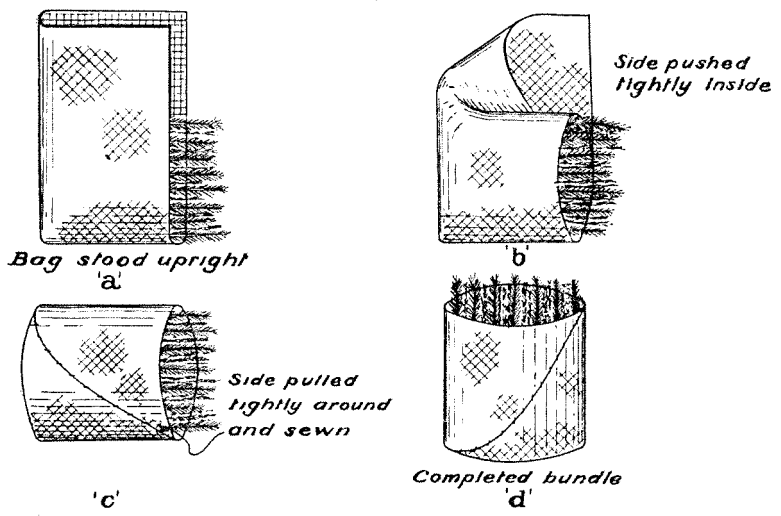


FIG 3

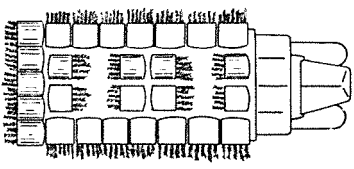


FIG 4

BUNDLING OF LARGE PLANTS

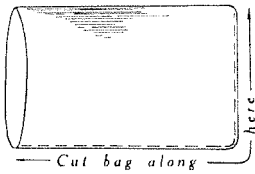
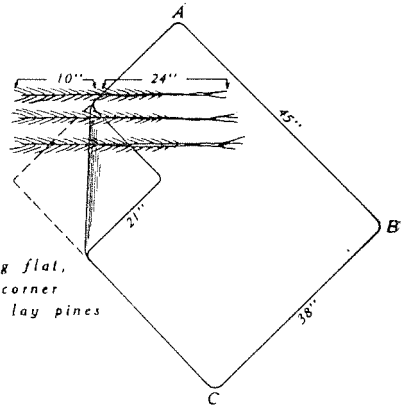
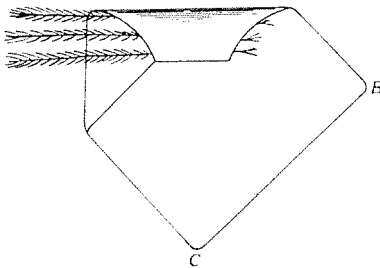


Fig. 1



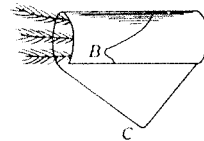
Lay bag flat,
fold corner
and lay pines

Fig. 2



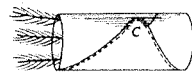
Tuck 'A' over and roll as shown

Fig. 3



Fold in end 'B' and
continue rolling

Fig. 4



Sew or hook flap 'C'

Fig. 5

SECTION 11.

TENDING PLANTATIONS.

Inspection of
young stands.

143. Young stands must be frequently inspected so that any tending required may be carried out promptly. Signs of insect attack, disease, lack of vigour, coppice regrowth and scrub competition should be noted.

SUCKERBASHING

Suckerbashing of
scrub growth.

144. Scrub growth and Eucalypt suckers must not be permitted to dominate the pines at any stage. Where there is evidence of troublesome scrub or sucker development the area must be kept under observation so that appropriate action can be planned and put into operation before the pines suffer any check in growth.

Method of
suckerbashing.

145. Experience has shown that young suckers are best discouraged from vigorous shooting by being broken about one foot above the stump. The more the shoot is broken or twisted the less is the vigour of the subsequent shoot. Pulling suckers off a stump usually encourages vigorous new shoots to grow from the original stump.

146. The practice to be followed in suckerbashing, therefore, is to use a slasher on small suckers and slash at about one foot above ground or stump level. Where suckers have reached a size necessitating the use of an axe they should be cut part through at a point about one foot above the ground and allowed to fall over rather than being cut right off.

147. In the coastal plantations recultivation with machines between the rows during the first two or three years may be necessary, when the growth of native scrub is vigorous. This must not be initiated without Head Office approval.

Recultivation.

SECTION 12.

PLANTATION PROTECTION.

148. Early detection of forest enemies, be they men, animals, insects, fungi, or soil deficiencies, is one of the axioms of forest protection. The plantations of Western Australia have been relatively free of natural enemies, but it is wise not to be lulled into a false sense of security. Vigilance is necessary.

Detection of forest enemies.

149. Officers-in-charge of plantations have, apart from man, three main factors to watch—

Report unusual occurrences.

- (a) Birds, insects, rabbits, marsupials and other animals. Should any increase in numbers or any new species be seen, the facts should be reported promptly to Head Office.
- (b) The appearance of a new fungus may sometimes represent beneficial conditions and at other times the reverse. These likewise, should be reported as soon as they are seen.
- (c) Nutritional disorders occur throughout the State in a number of different forms as dealt with in more detail in Bulletin No. 30 "Nutrition of the Pine". Possibly there may be others which have not yet been recorded and also disorders which have not been noted.

150. It is therefore not sufficient for officers to count the timing and number of deaths in the year's planting; it is equally important to study whether the leaves of the pines show any serious lack of growth or poor colour. Cases can be quoted where 100 per cent. takes have been obtained, but the pines are extremely unhealthy and badly in need of corrective treatment.

151. All officers, therefore, should keep these factors in mind at all times when travelling through their plantations and particularly in the early years when nutrition disorders first manifest themselves.

Note and report poor growth.

INSECTS AND FUNGI

152. All D.F.O.'s. should seek to build up at the Divisional Office specimen boxes of insects and fungi for the education of their staff.

Specimens to be held.

153. Sirex and Hylastes have not yet been recorded in Western Australia, but officers should be constantly on the look out for them. Illustrations of these insects are to be found in publications available.

Insects.

154. The Bark Beetle "*Ips grandicollis*" is now generally found in our plantations, but so far it is not considered to be the cause of the death of trees. During spring and summer months, the prevalence of "*Ips*" results in a greater extent of Blue Stain due to the spores entering the flight holes of the Bark Beetle.

Bulletin 2640 of the Department of Agriculture, Western Australia, gives further details.

Diplodia.

155. Diplodia Pinea although not yet proven is suspected in leading shoots of Pinus pinaster.

Autumn brown top.

156. "Autumn Brown Top" in Pinus radiata is prevalent on good sites but so far is regarded as a physiological problem.

Blue stain.

157. Sap staining fungi (or moulds) occur generally in fallen or sawn pine and reference should be made to Utilisation Branch for up to date treatments.

Symbiotic fungi.

158. A number of fungi are thought to be beneficial to pine growth by symbiotic association. Amongst these are the mycorrhiza group of fungi such as those of the Boletus and Agaricus families. Some of the saprophytes may also be beneficial indirectly in breaking down of debris and litter. The occurrence of fungi should, therefore, be noted for reference in Compartment Registers.

Record of fungi.

FIRE IN PLANTATIONS

159. Fire protection generally is dealt with in a separate section of the Manual, but attention is drawn to the following restrictions on controlled burning within pine plantations.

Policy for burning.

(a) No controlled burning under the pine canopy is to be carried out except with the written authority of the Plantation Superintendent. Full details of burning carried out under such authority must be measured and recorded.

The details will include weather, ground fuel and stand conditions, the burning methods, techniques and results achieved.

Areas which may be burnt.

(b) D.F.O's. are authorised to carry out controlled burning within plantation boundaries:—

(i) On areas where there are no pines.

(ii) On firebreaks.

(iii) On clear felled areas being prepared for re-planting.

(iv) On buffer strips.

*Provided the burnt
come within Burn Code
Ad of Forestry Manual
instructions.*

REASONS FOR RESTRICTIONS

160. The main reasons for the restrictions set out above are derived from considerable experience in the effects of burning under pines and are:—

Reasons for restrictions.

(a) **Damage to Pines**—Damage can be, and usually is, done to pines by—

(i) Scorching of the green crown.

(ii) Killing of the cambium (with resultant scars and overgrowths on merchantable boles).

(iii) Killing portion of the root system. (Fine feeding roots can be found well into the needle litter which it is hoped to remove by burning.)

(b) Controlled burning under pine canopy seldom fully achieves the main objectives such as:—

Objectives are not attained.

(i) Reducing the fuel quantities to a level where uncontrolled fires on the burnt areas are much more easily contained by normal suppression methods. (Burning also often results in increasing scrub regrowth which both canopy and prunings discourage).

(ii) Reducing the fuel quantities to the extent that uncontrolled fires will not be sufficiently fierce to damage the growing pines.

- (iii) Providing breaks or buffer strips of sufficiently reduced fuel to stop the spread of uncontrolled fires over large areas.
- (c) **Costs**—The cost of burning under pine canopy has been estimated to be extremely high and out of proportion with the benefit gained over the present control methods and the losses sustained under the present system.

SECTION 13.

SITE QUALITY MAPPING PINES.

DEFINITION AND GENERAL

161. The term "Site Quality" is used in Western Australia in the same sense as "Productivity Index". Site Quality is measured by the volume to 4 inches U.B. crown diameter which an area can be expected to produce at various ages with a certain species of pine, under present methods of treatment, including thinnings removed.

Broad definition
See also para.

- (a) Experience in Western Australia has shown that at 10 years for *Pinus radiata* and at 15 years for *Pinus pinaster*, the site can be assessed and thus the production of the area for the rest of the rotation reasonably estimated from the Yield Tables.

Age of mapping.

- (b) Generally speaking, after the ages of 10 and 15 years, respectively, our healthy plantations maintain their site quality with only rare cases of a recession of quality. Recession of quality is, however, frequently seen in *Pinus radiata* S.Q. 5 and 6 which frequently fails and dies in later years and in *Pinus pinaster* S.Q. 4 which tends to stagnate but seldom dies outright.

162. Site Quality mapping serves the dual purpose of correlating growth with soil types and treatment and of providing the basic data from which estimates of timber available and becoming available can be made.

Objects of mapping.

163. All plantations of sufficient age were mapped in 1957 and Site Quality mapping will be done as areas reach ages shown in paragraph 161a above.

Programme of mapping.

164. It has been found that air photos are not satisfactory for the standard mapping, but as photos are available even at 1:40,000 scale they are a useful aid in separating qualities prior to the closing of canopy. It will be seen from suitable photos, that much field work can be saved by sketching from the photos, the areas which are backward in canopy closure, poorly stocked, or failed.

Use of air photos.

165. After canopy has closed the photos cannot separate Site Quality beyond divisions—such as: "No pine", "Failed", "Doubtful", "Fair to Excellent", which is not sufficient for management estimates.

Not suitable for older stands.

166. General Policy

- (a) South Australian practice will be followed with slight amendments and their site qualities and Yield Tables used for *Pinus radiata*. See Table 5, (printed Booklet of Tables).

Yield tables used.

- (b) For *Pinus pinaster* the same methods of mensuration will be used, but Site Qualities will be as set out in Table 6, which have been developed chiefly from Western Australia's plots and South African data (Craib 1939-1947).

- Plots kept for permanent plots. (c) Plots established in the course of site quality mapping will become permanent plots for re-study in later years.
- When to do site quality mapping. (d) The general policy will be to type map all areas in future at the age 10 years for *Pinus radiata* and 15 years *Pinus pinaster* and it will be the function of Management to keep the programme up to date in the autumn of each year. Head Office will advise each year what areas are to be done. Divisional Officers should notify Head Office of any areas not mapped at the due date.
- Use of plots. (e) A major problem of Site Quality assessment is to maintain consistency if it is done by different assessors in widely separated plantations. It is important, therefore, to provide yardsticks to Site Qualities by the establishment of sample plots over the whole range of plantations by a single officer. These plots in the plantation concerned must be inspected almost daily by any officer carrying out site quality mapping.

DEFINITIONS AND EXPLANATION OF TERMS

- Definition. 167. **Site Quality.** The capacity of the site and the stand as it exists at the time of assessment to produce a volume per acre not below the mean of the S.Q. and that S.Q. below it, as given in the Yield Table for its age.
- Areas of site quality to be mapped. 168. No subdivision of sites to II/III and I/II etc. is desirable and no area of less than 1 acre should be mapped as a type unless it is above site quality II. Heights, basal areas, and general appearance are aids to determine the site.
- Poor colour and poor stocking. 169. Due to "poor colour" areas in Western Australia, the lower site qualities should, where these occur, have the letters "P.C." shown after the site quality. Sites below quality VI for *Pinus radiata* and S.Q. IV for *Pinus pinaster* will be marked failed "F". Poorly stocked areas will, on occasions, be placed in a site quality above their actual volume and in this case should be followed by the letters "P.S."
- Average dominant height. 170. **Average Dominant Height.** The mean height of the tallest 100 trees per acre at 10 years, or of the tallest 80 trees per acre at 20 to 30 years (for both *Pinus pinaster* and *radiata*) will be known as the Average Dominant Height.

THINNING OF SAMPLE PLOTS

- Thinning of plots. 171. The plots established by the S.Q. personnel are valuable permanent plots and must not be thinned without reference to the Working Plans Officer.
172. When thinning is carried out the trees to be thinned are blazed, numbered, diametered and measurements at 4 feet 3 inches recorded before felling. Marking, felling and measurement of thinnings are done under supervision of S.Q. personnel. Local treemarkers should do the treemarking if possible.

MARKING OF PLOTS

- Marking of plots in the field. 173. All plots are marked in the field by white paint crosses painted on trees just outside the plot and facing in. They are required for inspection and record purposes.
- Plots recorded in plantation register. 174. Position of these plots must be recorded in the plantation registers.

SECTION 14.

PINE PRUNING.

175. Officers responsible for pruning in pine plantations must appreciate that the expenditure of money on this work is an investment which should bear a return reflected in higher future royalties for clean timber. While the low pruning of trees to 7 ft. may be justified as a fire protection and access measure, pruning above this height must have economic justification.
176. The work of pruning, therefore, requires the close supervision of the D.F.O. and the following policy is based upon present and foreseeable economic conditions in Western Australia.
177. It is desirable to carry out pruning to limit the knotty core to 4 inches diameter. To approximate this, it is necessary to prune all trees as they reach 3½ inches d.b.h.o.b.
178. This means that more than one low-pruning operation will be needed to cover any one area. If stands are left till all trees can be pruned in a single operation, the important dominant trees, which will provide the 80 to 100 final crop trees, will have reached at least 7 inches d.b.h.o.b.
179. Stands will be considered due for the first low-pruning operation as soon as 100 trees per acre have reached 3½ inches d.b.h.o.b.
180. When first low-pruning of an area is to be undertaken, it is the practice to prune paths in advance to approximately one chain intervals. These will be paths left clear of pruning debris and will normally follow along the direction of the row. (In the case of areas, which have been contour-planted in steep country, however, it is advisable to site them up and down the slope at right angles to the rows and the main access). The advantages of this operation are as follows:—
- Measuring up of areas worked, for costing and record purposes, is facilitated.
 - The paths are of value in fire control, inspection work and assessments.
 - They are of assistance to the tree marker at a later date when marking for first thinning.
 - When pruning or first thinning is put on a piece-work basis they are essential for proper inspection of work done and fixing of coupes and prices. In a normal stand the cost of this work is not a serious addition to the over-all cost.
181. All trees of 3½ inches d.b.h.o.b., including break trees, but excluding badly malformed trees must be pruned. Others, below this diameter limit, are to be left untouched. No cleaning, by felling suspected "whips" is to be carried out in this first operation, unless canopy is already formed.
182. Low-pruning of a tree once undertaken, must be carried up to ensure that at least a 7 ft. log is available. That is, the worker must prune as high as he can reach with the axe or saw.
183. Following the first low-pruning, mentioned above, second or more low-pruning operations will be carried out to tend all trees as they reach the 3½ inches d.b.h.o.b. limit, until only the useless suppressed stems remain unpruned.

Pruning is an investment.

Supervision by D.F.O.

Limit of 4 in. knotty core.

More than one operation to cover an area.

First pruning due.

Pruning paths.

All trees 3½ inches d.b.h. to be pruned.

All trees pruned to full 7 ft.

Second and subsequent low-pruning operations.

Removal of suppressed stems.

184. "Useless" trees referred to above, will be considered to be those heavily suppressed trees and "whips" which will not make a mill log at time of first thinning (i.e. will be less than 4 inches d.u.b. at 7 ft. by the time the co-dominant height of the stand has reached 60 ft. in *Pinus radiata* and 40 ft. in *Pinus pinaster*). Under no circumstances are these trees to be pruned as this is a waste of money. As a final phase of the low-pruning operations these suppressed trees will be cut down.

Pruning low quality areas.

185. Some poorer quality and failed areas (those which will almost certainly be classified as S.Q. VI and Failed in *Pinus radiata* and S.Q. IV in *Pinus pinaster*) should be withheld from pruning temporarily. After inspection the Plantation Superintendent, or his staff, will give directions for full-scale low-pruning or the cutting of the paths for fire control and access purposes.

3½ inches d.o.b. limit for high pruning.

186. The same 3½ inches d.o.b. limit must be complied with when high-pruning is undertaken. The first high-pruning will be done with 8 ft. handle saw. This saw normally reaches to approximately 13 ft. When pruning is done by contract or piece work, it is necessary to specify the minimum height to which trees are to be pruned.

Marking for high pruning.

187. Marking for high-pruning should be carried out when the average dominant height of the stand has reached approximately 30 ft., regardless of age or species. The following rules must be observed in this marking:—

- (a) 100 trees per acre will be marked.
- (b) Marking will be permanent and be made with a round spot paint mark on each of the 100 trees selected.
- (c) Trees selected should be those which will be carried through for the full rotation of the stand—final crop trees.
- (d) Trees for high-pruning will be selected primarily for vigour (fast growing dominants) with secondary consideration given to form (perfect straightness of bole, light and horizontal branching and long internodes).
- (e) Care must be exercised to avoid high-pruning trees which will have to come out on extraction tracks.
- (f) No high pruning should be carried out in poorer quality or failed stands. (Those which will be classified S.Q. VI or Failed in *Pinus radiata* and S.Q. IV in *Pinus pinaster*).

First high-pruning operations.

188. Trees marked for high-pruning should not be allowed to exceed the 3½ inches d.o.b. limit at 13 ft. before the pruning takes place.

High pruning with 12 ft. handle.

189. A later extension to the first stage high-pruning may be carried out using a 12 ft. handle saw. Once again this must be done when the section of the stem to be pruned is 3½ inches d.o.b. (The 12 ft. handled saw normally reaches to approximately 17 ft.). This extension pruning must, of course, only be carried out on marked trees already pruned with the 8 ft. saw and only after approval from the Plantation Superintendent. This work should not be undertaken while there is still a backlog of lower pruning.

190. It is very important that all arboreta plots of other species receive similar treatment to ensure that the best results are obtained from these sample areas.

191. D.F.O's. must ensure that all pruning operations are fully and accurately recorded. This will entail immediate entries in the Compartment Register together with the marking up of Progress Plans and the recording and costing in Quarterly Reports. Records are particularly important for future estimates of the size of core to be expected in different compartments.

Records of all pruning operations.

192. Over a long period of trial a great variety of pruning tools have been tested including motor driven and compressed air chisel tools, various pruning shears and a wide variety of hand saws, billhooks and single handed choppers.

Pruning tools.

193. The Department has standardised on tools as follows:

- (a) Axe pruning is favoured for all low pruning (i.e. to 8 ft.) subject to the following:—

Axe.

Only competent axemen should be permitted to carry out axe pruning and responsibility for this rests with the Officer-in-Charge of the plantation.

In no circumstances should employees be trained to use an axe by taking part in an axe pruning operation. Competency with the axe should be learnt outside the pruning operation.

- (b) Saws for low-pruning and high-pruning have been developed using different curves, teeth number, hook and kerf and standard types are held by stores branch.

Saws.

- (c) Departure from the standard types is not encouraged and the policy is that any new proposals should be brought directly to the notice of the Plantation Superintendent who will arrange for tests by employees who have had many years' experience in pruning.

Policy on new tools.

194. "Extra high" and "Climb pruning," i.e. beyond the height reached with the 12 ft. handle is a matter for control by the Plantation Superintendent.

Climb pruning policy.

SECTION 15.

PINE THINNING.

195. The thinning regime, using number of trees per acre, has been periodically reduced in numbers over the past 2 decades, as a result of not only Western Australian experience, but in accordance with general forestry thinking in the New World, where the emphasis for softwood logs has been upon the production of rapid diameter growth to meet markets for which there were no supplies, apart from importations.

Thinning regime by numbers per acre.

196. Indications are that the present thinning regime will stand for many years to come in the Western Australian economy and this regime is now set out as follows:—

Present regime.

197. *Pinus radiata*.—All stands of S.Q. 5 and above.

At height 60 feet thin to 300 per acre plus discards

At height 80 feet thin to 200 per acre plus discards

At height 100 feet thin to 150 per acre

At height 120 feet thin to 100 per acre

At height 140 feet thin to 80 per acre

In cases where the stand will not reach 140 feet, 100 trees per acre are carried to maturity. See also Table 7 in "Pine Yield Tables" booklet.

198. *Pinus pinaster*

Thinning	At Height	Stems Retained (per acre)	
		S.Q.I. and II	S.Q. III
First	ft. 30-45	300	300
Second	50-60	200	150
Third	80	100

Thinnings outside the range shown on the above table will be determined at a later date or on advice from the Plantation Superintendent.

199. Thinnings yield tables will be found in the "1963 Pine Yield Log and Volume Tables", but these must be used with caution due to the variations of spacing and site qualities in the older plantations.

Vigorous trees to be favoured.

200. In the first thinnings of both *Pinus pinaster* and *Pinus radiata* it has always been the practice to remove malformed dominants and co-dominants, but it must be remembered that in so doing, if the action is taken too far, a large proportion of the most vigorous growing stock will be removed and caution, therefore, must be exercised to see that the term "malformed" is not extended to include trees with slight defects.

Vigour means financial increment.

201. It is even more important in the second and subsequent thinnings to remember that the vigorous tree is the one which will produce rapid stumpage values and it should not be taken out in favour of a good form sub-dominant, more especially with our pine species which mature in comparatively short rotations.

Importance of high pruning.

202. The established practice of marking 100 trees per acre for high pruning allows close control of treemarking by the D.F.O. and these trees form a valuable guide throughout the rotation. Only rarely will one of these trees be removed and thinnings should be designed to favour the high pruned trees.

Marking of trees.

203. It is important that axe or paint marks be all made to face the same direction—normally down hill, or on flat country in the direction of the planting rows. This enables the treemarker to see all trees he has marked from one direction and also assists the fallers later in working out falling problems.

Felling pine trees.

204. During thinning work all trees are to be felled at ground level.

Branding trees.

205. Trees are not marked with a brand except in special circumstances where a permit holder is to do his own falling in stands of over 20 years of age.

Mark all removable trees.

206. It is important to mark all trees which may come out including whips, even if they are not of sufficient size to make a log as otherwise a further marking may be necessary if it is found that lower sizes are saleable. The marking of these also assists the treemarker and inspecting officers to visualise what his stand of crop trees will look like.

Extraction routes.

207. The method of extraction varies considerably throughout the State depending upon contour and presence of logs or stumps. The two extremes are (a) Flat sand plain country which has been thoroughly cleared and (b) Steep rocky areas which were poorly cleared originally and in which no extraction routes were left.

Para. 210.

Delete and Substitute.

Present markets for logs in Western Australia are divided into the following price classes measured under bark :-

Fence Posts 2 $\frac{1}{2}$ inch to 4inch crown diameter

Sundry other types of posts covered by a published schedule.

Pulpwood 2 $\frac{1}{2}$ inch to 4inch crown diameter.

Case Timber over 4inches but less than 7 inches crown diameter.

Case and Mill Logs 7 inches and over but less than 9 inches crown diameter.

Mill logs 9 inches and over but less than 12 inches crown diameter.

12 inches and over but less than 15 inches crown diameter.

15 inches and over but less than 18 inches crown diameter.

18 inches and over crown diameter

Peeler Logs and Slicer Logs.

9 inches and over but less than 12 inches crown diameter.

12 inches and over but less than 15 inches crown diameter.

15 inches and over but less than 18 inches crown diameter.

18 inches and over crown diameter

The specification for all the above is 6 feet to 7 feet 9 inch lengths with a premium to be charged for any logs of the above crown diameters which are supplied in longer lengths.

Para. 214.

Delete and substitute.

"As from 1.7.67 all pine statistics will be on the basis of under bark volumes. This will include measurement for log sales whether by the bin system for logs under 9" crown diameter underbark or by individual measurement for logs over 9" C.D.U.B. For conversion of Over Bark to Under Bark volumes, a bark per cent of 18% for P. radiata and 30% for P. pinaster will be applied."

Para. 215.

Delete and replace by -

"Due to the extreme variation in bark per cent there will be inaccuracies in under bark volumes. Until further notice, bark per cent figures of 18% for P. radiata and 30% for P. pinaster will apply for conversion of O.B. to U.B. volume.

Bin measure practice for logs under 9" diameter U.B. will continue, except that equivalent U.B. volumes will be recorded. For logs over 9" C.D.U.B., the practice of measuring and numbering individual logs will continue."

The treemaker in the case of (a) will normally remove a complete row of pines for a straight extraction route for motor truck pick up. In the case of (b) it is important to mark carefully all the extraction routes before doing the general marking as, unless this is done it will be found that trees it was desired to keep will have to come down later to permit extraction.

208. After the stand has been reduced to approximately 200 per acre, tree marking with paint indicates the trees to be retained.

209. Although our thinning regime has reached a reasonably final stage, problems arise where the first thinning has been delayed and where spacing of less than 8 feet by 8 feet has occurred. In such stands, it is not desirable to apply the Thinning Grade, as by so doing, in overcrowded stands "wind bend" and in some case "wind throw" follows the opening up.

Delayed thinning.

210. Present markets for logs in Western Australia are divided into the following price classes:—

Price classes depend on diameter.

Fence Posts 2½ inch to 4 inch crown.

Sundry other types of posts covered by a published schedule.

Pulpwood 2½ inch to 4 inch crown.

Case Timber 4 inch to 7 inch crown.

Case and Mill Logs 7 inch to 9 inch crown.

Mill Logs 9 inch to 12 inch crown.

Mill Logs over 12 inch crown.

Peeler Logs 9 inch to 12 inch crown.

Peeler Logs over 12 inch crown.

Slicer Logs over 12 inch crown.

Long Length Peelers 9 inch crown.

The specification for all of the above is 6 feet to 7 feet 6 inch lengths with a premium to be charged for any logs of the above crown diameters which are supplied in longer lengths.

Specifications.

211. A peeler is defined as a reasonably straight log circular in section with not more than 3 whorls of branches per 7 foot length and no knots to be over 2 inches in diameter.

Peeler logs.

212. The specifications for a slicer log is a log which is personally selected by a professional officer to give, to the best of his ability, at least 3 inches on the radius of clear pine.

Slicer logs.

213. Long peelers are specified as trees of any length over 9 inch u.b. at the crown with generally an average of 15 feet per log of pruned stem or showing only small knots, while in the balance of the log no knot should exceed 2 inches in diameter and there should not be more than 3 whorls of limbs in any 7 foot length. Straightness is not so important as the logs are cut into various lengths before being peeled.

Long peelers

214. The Department continues to sell all pine logs on total o.b. measure, whether by the bin system or by calipering of the mid-diameter o.b. of each log, and it is the practice to measure and number individual logs for all sales of logs greater than 9 in. crown diameter u.b.

Sales based on o.b. measure.

215. Due to the extreme variation found in bark percentage in both *Pinus radiata* and *Pinus pinaster*, it is likely that the o.b. sales will continue to be a feature of pine log measurement and that the bin system for all pulp and case logs will continue.

Bark percentage.

Keep vigorous trees growing.

216. Price differences between the various grades of logs mentioned above is so great that it must be considered by all D.F.O's. in their thinning treatment and it will readily be seen that, particularly with *Pinus pinaster*, the aim should be to keep vigorous trees growing vigorously in diameter, even if only relatively short length of clear log of large diameter is obtained. The value increment due to diameter, far exceeds considerations of gross wood increment, and in general the following out of the thinning regime will result in a total production of marketable timber at least equal to the total production from regimes of a less drastic nature, while at the same time placing the logs in a larger diameter and value group.

Rotation problems affect final thinning.

217. With good quality *Pinus radiata* stands of 30 years and over, it may often be found that due to gaps in age classes, it will become necessary to extend the rotation in order to even out supplies to the market (this has already occurred at several centres) and when this is seen to be the case, it is not desirable that the final reduction to 80 or 100 trees per acre should be made within 10 years of the date of final felling, since if this is done, a period of 10 years will elapse, during which no thinnings for special peelers, etc., can be done, without reducing the stand to below the minimum per acre.

218. While normal rotations are considered as *Pinus radiata* 40 years and *Pinus pinaster* 60 years, it is unlikely that these can be strictly adhered to due to the uneven distribution of age classes. See Histogram at "Introduction".

Canopy and spacing.

219. Considerable importance is attached to the closing of canopy in our plantation of *Pinus radiata* and *Pinus pinaster*. The spacings of 8 ft. x 6 ft. for *Pinus pinaster* and 8 ft. x 8 ft. for *Pinus radiata* ensures the closing of canopy at about six to seven years depending on the site. It also results in the lower limbs dying at $\frac{1}{2}$ inch to 1 inch (if not already pruned) diameter as opposed to 2 inch or upwards with wide spacings and gives sufficient trees per acre to enable the selection of good form crop trees. These spacings adopted in Western Australia are based upon these reasons and other economic considerations.

Working plans to be drawn up by D.F.O.

220. Our plantations have reached the stage of providing a permanent output of thinnings and factories and sawmills are being kept in production by this output. As each plantation reaches the age when a thinning programme is necessary, the D.F.O. concerned is required to draw up working plan proposals, giving the order of thinning by compartments, with the object of determining the sustained yield and thinning programme for the plantation. This plan should cover 10 years, inclusive of any areas listed for clear felling for conversion to other species. All plantations are covered by recent air photos and Site Quality Maps, which form the basis of Working Plan estimates.

Photos.
Site quality maps.

Working plan policy.

221. Although sustained yield is worked out for each plantation, it rests with management to adjust outputs by groups of plantations to meet the many varied demands and problems caused by alienations of pine areas, fires, etc., and D.F.O's. therefore, will appreciate that the cut allocated to any plantation for a period is not necessarily the sustained yield figure which was calculated.

More accurate working plans are now needed.

222. Increasing demands for all sizes, including pulp wood sizes down to 2½ inch crown, makes it necessary for all D.F.O's. to revise their estimates frequently as more information becomes available on actual yields. Working Plan estimates should be submitted in duplicate following the form illustrated on page 42.

Form to be used.

223. D.F.O's. should note the following points:—

- (a) The Management and Plantation Inspectors will decide whether estimates will deal with S.Q. within each compartment or group of compartments.
- (b) Where areas of any large extent are suitable only for summer hauling, this should be indicated in remarks column.
- (c) Where the D.F.O. considers that due to factors such as close spacing, poor stocking, delayed thinnings etc., the Thinnings Yield Table is not applicable, he should use his own estimate and note the reason in the remarks column.
- (d) D.F.O's. when preparing the schedule as per Working Plan Appendix 2, should not endeavour to smooth out the yield over the 10 years but will show the volume under the years in which it falls due in accordance with the regime.

For example—an area of 100 feet height and 20 years old which had never been thinned is due theoretically for three thinnings in 1958. It will probably yield about half the total of the three thinnings as given in the Yield Table and this should be shown in the "due 1958" column.

- (e) Copies of the Working Plan proposals should be typed (if possible) and original and duplicate sent to Head Office.

AGE-DIAMETER (Pine trees in Western Australia)

224. Diameter of the co-dominants at any age is, of course, dependent on factors such as Site Quality and thinning history and it is, therefore, not possible to offer a table in the true sense.

Age diameter.

225. As a guide, the following figures are given:—

Pinus radiata

B.H.O.B. diameters by Site Quality. Mean of Stand on present thinning regime.

Pinus radiata diameters.

Age	S.Q. 1-2	S.Q. 3-4	S.Q. 5
	inches	inches	inches
15	10	9	7
20	12	10	8
25	14	11	9
30	16	12	10
35	18	14	12
40	20	16	14

The mean of the final crop at Age 40 on some sites will be higher than those given for Age 40, but will seldom exceed 24 inches for the best sites. An estimate of the sizes of logs removed in thinnings is given in Tables No. 7, 8 and 9 of Pine Volume and Yield Tables 1963.

Pinus pinaster

226. Diameters are estimated in Table 9, and it will be noted that severe third thinning in low site qualities brings up the diameters of the final crop.

Pinus pinaster diameters.

Sample page of Plantation Thinnings Working Plan follows.

SECTION 16.

RECORDS OF PLANTINGS, REPORTS AND REGISTERS.

227. With all areas planted, it is most important that full and detailed records are kept for the next generation of Foresters who will not have available the memory of the officer who first established the crop. By keeping a detailed register, all planting becomes, to some extent, of the nature of a scientific experiment.

Importance of records.

228. Seed provenance has had very careful attention throughout the history of our plantations and there should be no compartment for which we do not have the record of the origin of the seed. Serial No's. must be recorded on the plantation progress plans and compartment registers. A study of these origins and their reactions to different soil sites is likely to prove of value in connection with the continued effort to improve the strains of pine to be established in the future.

Seed provenance.

229. **Annual Reports.**—An Annual Report is required for each plantation at the close of planting. Costs are normally taken up to the close of the September quarter. This report must summarise the whole of the work for the year and endeavour to arrive at a unit cost for each stage of the operations. Where land is only partly cleared or partly established or firebreaks only partly cleared this must be made clear in the report and a unit cost per acre estimated to complete the job.

Annual report.

Planting report form F.D. 406/59 should be used.

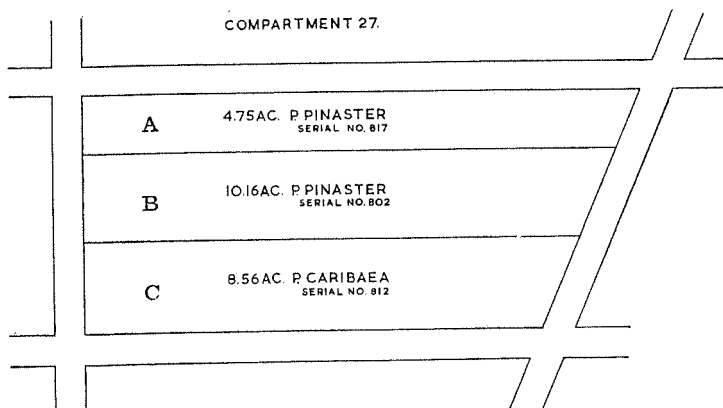
230. PLANTATION REGISTER.

- (a) A compartment register will be kept for every plantation. This will consist of two stiff covers and a number of loose leaves which may be added to as necessary. This is a standard loose leaf register as used by the Accounts Branch and may be obtained by requisitioning to Head Office.
- (b) The Officer-in-Charge will be responsible for the preparation and regular entering up of this register. The information will be entered under compartment headings.
- (c) The head of the page will carry the compartment number. Under this will be a sketch of the compartment and on this will be shown the location of species, serial numbers of stock, location of experiments, etc.
- (d) Written details of species planted, serial numbers of stock, age of planting, method of soil preparation, method of planting, application of fertiliser, etc. Any information which may later be of value concerning the compartment should be entered.
- (e) In later years other pages are inserted and information in connection with the number of trees to "take" after planting (usually expressed as a percentage), the serial number of stock which may be used for refilling, details of any work done on the compartment such as further application of fertiliser, pruning, thinning, etc. This register should form a complete history of all that has happened on each compartment in the plantation.

Importance of plantation register book.

Following is a suggested layout for a specimen page for the initial entries:—

COMPARTMENT 27



Notes 1931

- A. 90% takes no refills
- B. 70% takes refilled Serial No. 802
2 + 0 plants ex Hamel
- C. 50% takes unhealthy refilled Serial
802 P. pinaster 2 + 0.

Progress plans required at working plans offices.

231. **Progress Plans—Plantation Progress plans** at a scale of 10 chains to 1 inch are kept for all plantations.

These plans must be brought up to date every quarter and after the completion of planting for the season they should be forwarded to Working Plans Office. The legend to be used on the progress plans is shown on pages 43 and 46.

Bi-annual reports.

232. Separate bi-annual reports are necessary for each plantation which is covered by an estimate and particular attention must be given to the item numbers used in the Annual Report Form 406/59 and conform to the instructions as set out in Circular No. 6/64.

Nursery records costs.

233. **Nursery Records**—The main cost records required are covered by the Annual Report Form 406/59 which provides for the calculation of the cost per 1,000 of effective plants.

Nursery history.

234. Most nurseries will be governed by technique set out by Research or Plantation Superintendents but the onus rests upon the D.F.O. to see that full history records of all treatments and results are entered in the "Nursery Register" which must be kept at the Division concerned for ready reference by local officers and visiting inspectors.

Interim reports for management.

235. With central nurseries in operation, it is necessary for Management Branch to be advised in December, and again after the first rains, of the total number of effective plants to be expected in the coming planting season, as allocations from the central nurseries are made by the Superintendent to the different centres, and unless he has prior warning of deficits or excess stock, he is not in a position to arrange for the correct amount of land to be prepared in time for planting.

236. Again, after the close of planting, immediate reports should be sent in giving the approximate net areas actually planted, as this seldom conforms exactly with the original estimate, and the figure is needed for a number of purposes before the annual planting report is received during October.

Interim planting reports.

237. **Records of Removals by thinning; clear felling**—A set of cards shall be kept for each plantation with separate cards for each compartment and where the compartment is composed of more than the one species a separate card will be prepared for each species.

Records of removals.

238. At the close of each quarter a record must be made on the respective card giving details of the volume of timber removed during the quarter.

The details required are as follows:—

PLANTATION.....

COMPARTMENT..... DATE PLANTED..... AREA PLANTED..... SPECIES.....

Quarter	Area	Loads Removed						Progressive Total					Remarks		
		Pulp	4"-7"	7"-9"	>9"	Total	Per Acre	Pulp	4"-7"	7"-9"	>9"	Total	Type of Thinning	Type of Log	

PLAN LEGEND FOR PLANTATIONS.

Plan No. P.1.

INITIAL CLEARING—INCOMPLETE—(i.e. Dozing, no Falling).—Broken blue border, blue figures.

INITIAL CLEARING—COMPLETE—Unbroken blue border, black figures.

FINAL CLEARING COMPLETE—(i.e. Burnt and Picked-up)—Blue diagonal hatch, black figures along diagonal.

Plan No. P.2.

CULTIVATION—Blue wash, blue figures.

PLANTING—Blue wash, black figures for:

Species, Year planted, Area planted, serial No., Spacing.

Plan No. LP.

PRUNING LOW—

1st Operation—Border and figures red.

2nd Operation—Border and figures blue.

3rd Operation—Border and figures green.

Plan No. HP.

PRUNING HIGH—

8 ft. Handle—Blue wash, blue figures.

12 ft. Handle—Red diagonal hatch, red figures along diagonal.

Plan No. T.1.

THINNING—

1st Thinning—Yellow wash, black figures.

2nd Thinning—Red diagonal hatch, red figures along diagonal.

T.2.

3rd Thinning—Red wash, red figures.

4th Thinning—Blue diagonal hatch, blue figures along diagonal.

T.3.

5th Thinning—Green wash, black figures.

6th Thinning—Red diagonal hatch, red figures along diagonal.

Boundaries of Thinned areas—dotted black.

Plan No. CF.

CLEAR FALLING—

Areas Clear-felled—Brown wash, black figures.

Boundaries of areas Clear-felled—dotted black.

Note:—

- (a) Only the Quarter will be shown on Plans P.1., P.2., LP, and HP.
- (b) The SW-NE diagonal will be used for convenience in hatching.
- (c) All figures will be printed horizontally across the page, unless otherwise stated.

ROADS AND TRACKS (ALL PLANS)

FIREBREAKS.—Cleared, trafficable.

(Yellow wash)

FIREBREAKS.—Cleared, but non-trafficable.

(Yellow wash)

Special fire danger points on Plantation breaks to be shown



FIRST CLASS ROADS.—(Arterial and major logging roads).

SECOND CLASS ROADS.—(Sub-arterial and extraction roads).

THIRD CLASS ROADS.—(Extraction and other tracks).

SECTION 17.

ARBORICULTURE.

239. Trees for sale to the public are raised at the State Nurseries at Hamel—for higher rainfall areas—and Dryandra—for the drier agricultural areas and the Goldfields.

240. Deciduous and some evergreen species are raised as open rooted stock. Most evergreen species, because of handling difficulties are handled in trays, tubes or pots.

241. Method of transplanting is set down in publication Forests Department "Price List of Trees".

242. Towards the end of each distributing season (May to August) the figures for sales of the various species are examined, any particular trends in demand are considered and a schedule of plants to be raised for the following season is drawn up. As unsold trees are discarded at the end of the season and represent a dead loss, nurseries do not budget for any large surplus. Officers will understand from this why large orders for trees for Departmental requirements unless lodged twelve months in advance can seldom be met.

Surplus trees not carried.

Twelve months notice for departmental requirements.

TREE BREEDING—TREE IMPROVEMENT.

EXOTIC CONIFERS.

243. The Department has set up a Tree Breeding Station at Wanneroo with the object of improving the form of *Leiria Pinus pinaster*. "Plus" trees have been selected as a basis for this breeding work, but all officers engaged in plantation work must continue to search for outstanding trees to assist extension of this work. From time to time, Research Branch will issue detailed instructions to assist in the assessment of these trees.

244. Similar work has been initiated for *Pinus radiata* and *Pinus canariensis* and Research Branch will require assistance from all plantation officers to assist in the location of "Plus" trees for these species.

SELECTION OF PLUS TREES

245. Officers have previously been advised to report the finding of trees of exceptional properties to the research branch for consideration within the breeding programme. In general any tree with a characteristic or characteristics which are exceptional could be of value in this respect. The following brief outline provides a basis for the selection of plus trees. The main points to consider with respect to a plus tree are vigour and form.

- (a) Plus trees should be dominant or predominant stems with girth as great or greater than any tree within a half chain radius. The only time that a tree of smaller dimensions, i.e. a codominant, is to be considered is if it has exceptional properties of stem form and/or branching. Vigour.
- (b) The stem should be of circular cross section and straight. When considering straightness the merchantable bole is the most important section although it is desirable that form should be carried right through the crown to the shoot apex. Double leaders and trees with large ramicorns or side branches are not to be considered. Stem form.
- (c) The stem should ideally be smooth, but this point must be evaluated together with the age of the tree, its vigour and the branching characteristics.
- (d) A vertical tree is most desirable. It will be found, however, that a slight lean could often be the result of silvicultural treatment and under certain instances a straight tree with a lean is acceptable. Trees with butt sweep or definite bends are normally unacceptable. Lean.
Branching.
- (e) The ideal tree is one with small branches orientated at right angles to the stem. Branch diameter requires to be evaluated with respect to the stem diameter since normally branches will increase in size proportionally with increasing vigour of the tree.
- (f) A symmetrical crown is usually coincident with high values for the previous factors mentioned. Lack of symmetry is, however, often due to competition or silvicultural treatment and trees should not be ruled out if this is the case. A dense crown is desirable. The crown.
- (g) For *Pinus radiata* it is essential to have the minimum number of cones on the stem.
- (h) A plus tree should be in good health with no signs of nutritional disorders or attack by insects or fungi. Health.

246. The maximum number of points should be given for vigour and stem form. If it is kept in mind that the breeding programme aims to produce the tree of most advantage to silvicultural treatment and with the greatest recovery of quality wood in utilisation, a reasonable basis for selection is at hand. An exceptional tree in a poor stand is probably of greater value than a slightly better than average tree in a good stand. General.