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FORESTERS' MANUAL

REFORESTATION and SILVICULTURAL OPERATIONS

JARRAH AND KARRI

FORESTS DEPARTMENT
PERTH
WESTERN AUSTRALIA

CONTENTS

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REFORESTATION AND SILVICULTURAL OPERATIONS

JARRAH AND KARRI

PRELIMINARY

1. Management of indigenous hardwood forest aims at producing the highest possible yield of useable wood, consistent with the maintenance of a protective forest cover for water catchments and a general forest environment.

Aims and policy

The marking axe and the spray gun used in treemarking, for trade cutting and stand improvement works, are the tools for the manipulation of the forest crop towards these aims. Stands must be regenerated adequately after the trade cut and maintained thereafter in a vigorous and healthy condition to ensure maximum increment.

The general working plan

2. Yield control is prescribed in an overall general Working Plan for State Forests which is revised from time to time according to data gained from periodic assessments. The unit of control is the administrative Forest Division, comprising a group of Forest Blocks. A prescription for each Division specifies permissible log intake for each established sawmill and provides for adjustments to both permissible intake and permit boundaries where these become necessary.

3. The first General Working Plan was based on assessments carried out between 1920 and 1928. More effective and accurate separation of forest types is nowadays achieved by stereoscopic interpretation of aerial photographs. Estimates of increment, losses, and net permissible yield are made from a series of permanent sample plots located throughout the forest land maintained by the Working Plans Section.

Dieback control

4. The operational side of the management of all forests where jarrah is the major species is now oriented markedly towards the control of dieback, caused by the root-rotting pathogen *Phytophthora cinnamomi*. Preventing the spread of this disease involves close attention to the organisation of all forest operations, particularly those involving heavy and tracked vehicles. The movement of soil by these agencies between diseased and healthy forest must be completely avoided in areas zoned as lightly or non-affected. Details of zoning for hygiene purposes are given in a later section. The importance of forest hygiene measures with respect to dieback cannot be over-stressed; these are the sole means at our disposal of retaining healthy jarrah forest.

Intensive Management Units

5. Where high quality jarrah forest occurs in blocks of some thousands of acres and is relatively free or only lightly infected with dieback, it is demarcated and declared an Intensive Management Unit. This procedure is a move towards affording the best treatment to the most productive jarrah forest. Particular attention must be paid in these units to the exclusion of new dieback infections and to the removal of existing ones. The aim in Intensve Management Units is to bring the forest to its highest possible peak of productivity, hence it is within these units that intensive silvicultural operations will be concentrated.

The designation of intensive management units also serves to demonstrate the boundaries of "Zone A" (—zone where any reported wildfire is immediately attacked—) for fire control purposes. Areas outside "Zone A" will receive a lower priority for fire protection and other management operations. But it is important to remember that although Zone B is of lesser significance for further production, much of it is vital for catchment protection, flora and fauna conservation and recreation and will be less intensively managed for these purposes.

TRADE CUTTING AND PERMIT CONTROL

6. The main features of control of trade operations under the Forests Act and Forest Regulations are covered in Pamphlet No. 2 of this Manual.

Control of bush operations

7. The treemarker is the Conservator's representative in the field. He is responsible for ensuring effective control of trade operations in respect of orderly working, satisfactory utilization, and the protection of the growing stock. He must bring to the notice of the bush boss or Company representative any failure by the Company (as the permit holder) to observe the Department's requirements. In the event of disagreement between the treemarker and the bush boss, the dispute shall be referred to the Divisional Forest Officer (D.F.O.) and the mill management.

Permit boundaries

8. Regulaton 37 of the Forests Act covers the responsibility for demarcation of permit boundaries.

Cutting sections

9. Logging operations are confined in any one year to approved cutting sections. These areas are selected by advance planning leading to the preparation of 5-year logging plans by the D.F.O. in consultation with the mill management. Such advance planning must take into account the requirements of dieback hygiene and will allow effective road planning, and the integration of the trade cut with other operations.

Cutting coupes

10. The orderly working of each cutting section is secured by allocating cutting coupes to fallers. These must be systematically worked to an acceptable standard before a further coupe can be allotted. The treemarker must inspect coupes frequently to ensure that cutting is proceeding as specified.

Log quality

11. It is the responsibility of the sawmiller, through the bush boss, to see that useless or sub-standard logs do not reach the mill landing. Also that logs are prepared, when necessary, by long-butting or docking out defect. The treemarker is responsible for ensuring that log preparation at no time involves avoidable waste in long-butts, queen cuts, stumps, or crowns.

JARRAH FOREST OPERATIONS

ASSESSMENT

Temporary Assessment Lines

Quarterly assessments

12. All treemarkers are required to assess a portion of the area cut over, **except in areas clear felled for dieback or in karri operations,** at the close of each quarter. They are to send the results to the D.F.O. who summarises them and forwards them to head office on Form F.D. 423 with a copy to the Working Plans Office. The Forester-in-Charge should accompany the treemarker as frequently as possible.

The objects of these assessments are—

Objects of assessments

(a) To inform the D.F.O. and the treemarker himself of the volume he is removing and the volume he is retaining per acre.

(b) To inform head office and the working plans offices for management and working plans calculations.

(c) To assist the D.F.O. in preparing five-year logging programmes.

Selection of lines

13. Assessment lines must be selected so as to be truly representative of the area cut over during the quarter and the D.F.O. must satisfy himself that this is, in fact, the case. Eight acres of assessment line will normally be run in each quarterly coupe and the directon of the line should be chosen so as to cross the prevailing topography.

Running the line

14. Commencing from a known point, such as a reference tree or a track junction, the treemarker runs a compass line, preferably across the ridges through the country cut over during the quarter. Distances are measured either by chaining or by pacing. The treemarker records the volumes removed and retained for all trees over 60 inch g.b.h. including marri, within a distance of half a chain on each side of the line. In open country, where few trees are encountered, a distance of one chain on each side of the line may be used, giving an area of two acres for each 10 chains of line run; where this is done, the field book must be noted accordingly so as to avoid confusion in later calculations.

15. The treemarker is not required to measure all girths unless specifically requested to do so by the D.F.O. However, sufficient measurements should be taken to provide an effective check on estimation.

Booking procedure

16. The volumes of each tree encountered, or of each log removed, are recorded in Field Book type I/1954 and the classification of every tree as shown in paragraph 44 is also noted against each entry. The easiest way to do this is to subdivide the vertical columns to accommodate the appropriate tree classifications under their respective girth class headings. When supplies of field book I/1954 are exhausted, form F.D. 423 itself will be used for recording the assessment.

17. All columns of the field book must be filled in and if the same comments apply to successive entries, the column should be marked "Ditto" and not left blank.

18. Loadages are totalled for each 10 chains and for the whole of the assessment line and the average loadage, to the nearest 1/10th of a load, may be worked out at the foot of the field book page.

19. A summary of the assessment is then sent to the D.F.O. along with a map reference indicating the start point and the direction of the line. The original field book is retained at the District Office and it is no longer necessary to prepare a copy of it for the Working Plans Office.

Prescription required

20. Before completing his assessment, the treemarker should give a description of the forest remaining on the line and should write a prescription setting out his own ideas as to the future treatment of the forest. This is particularly important in areas where advance growth is inadequate or where only small sapling regrowth is present, as special burning measures may be required to ensure satisfactory regeneration under these circumstances.

Tree classification for jarrah

21. The following tree classification will be used:—

Standing Trees

A. Over 90 in. G.B.H.

(i) Trees retained as growing stock (or will be retained where bush not previously treemarked).

(ii) Trees held for special reasons. In treemarked bush this includes trees held—

(a) To prevent damage to immature growth.

(b) To allow a top log to reach millable size.

(c) For seed supplies where advance growth is lacking.

(iii) Marketable logs which should be taken to a mill in the district. This includes trees "marked not taken" (M.N.T.) because of quality or because they would fall over a road.

(iv) Trees not at present exploitable. These may include some of the M.N.T.'s.

B. Trees between 72 in. and 90 in. G.B.H.

(i) Growing stock for the future.

(ii) Trees that could be removed—too defective for future growing stock.

(iii) Trees not at present exploitable because of defects.

C. Trees between 60 in. and 72 in. G.B.H.

(i) Dealt with in same manner as B.

(ii) Dealt with in same manner as B.

(iii) Dealt with in same manner at B.

D. Under 60 in. G.B.H. Piles and Poles (tree classes)

When above 60 in. G.B.H. engineers' piles and poles will be classified according to their girth class, but the letter "E" will be added in the class columns, *e.g.*, BI (E).

Engineers' Piles and Poles

Poles (all species)—

Minimum length 20 ft.
Minimum crown diameter 6 in.
Maximum crown diameter 9 in.

Piles (all species)—

Minimum length 20 ft.
Minimum crown diameter 10 in.
Maximum crown diameter 16 in.

Record position, crown diameter and length of engineers' pile and poles. For others down to 24 in. G.B.H., record number only, but not on a separate line—see specimen page of field book.

Removed Trees

Over 90 in. over bark—R1.

Under 90 in. over bark—R2.

Poles and piles to be recorded

22. Owing to the scarcity of heavy poles and piles of all kinds, and because of the difficulty in locating them, the treemarker should make a special note of all trees which comply with pole and pile specifications on his assessment line. The length and top diameter of all poles and piles over 35 feet long should be recorded along with their position in relation to the start of the line.

Details of co-dominants not needed

23. Now that A.P.I. work is well in hand it is no longer necessary for the treemarker to provide detailed measurements of co-dominant trees, but he must ensure that the co-dominant height of the forest recorded in his field book is correct.

FOREST HYGIENE AND JARRAH DIEBACK

Introduction

Die-back caused by *Phytophthora cinnamomi*

24. The disease commonly known as jarrah die-back is caused by the root-rotting fungus *Phytophthora cinnamomi*. The fungus is not indigenous to Western Australia, which means that only those areas of forest to which it has been transported are at present affected.

Root damage

It attacks and destroys the fine feeding roots of both jarrah and a wide range of understorey and ground vegetation species, depriving them of access to moisture and nutrients.

Conditions for fungus development

25. The development of the fungus occurs mainly in the top 18 inches of soil and is favoured by warm and moist conditions, and especially by periods of temporary waterlogging.

Methods of dispersal

26. Dispersal is mainly by transportation of mud or soil containing already infected root material and fungal fragments. The main agents for dispersal are vehicles carrying mud, and surface run-off. The fungus also moves as water-borne zoospores which are themselves capable of locomotion over very small distances. Hence the general tendency towards rapid spread down-hill. The rate of uphill spread is slow, amounting to a few feet a year.

Resistant spores are also produced but their precise function as dispersal agents is not known.

Means of spread

27. The spread of the fungus in the forest occurs through

(a) the natural extension of already affected areas; and

(b) the establishment and subsequent development of new centres of infection.

Controlling spread

28. Physical control is likely to be extremely expensive, but any measures which make conditions on already infected areas less favourable for the development of the fungus, or which curtail the posibility of establishing new centres of infection will slow down the overall rate of spread through the forest. This is currently estimated to be at about 4 per cent. of affected areas per year.

These measures come under the general heading of Forest Hygiene. They are outlined below and they will be applied to both Departmental and trade operations.

Zoning of Dieback Types

29. The forest is divided into a number of zones, based on the degree of infection, in order to provide a basis for movement control and logging priorities. These zones are:—

Instructions for zoning

Zone A. Areas containing less than one per cent. dieback affected forest. Only to be logged under strict hygiene.

Zone B.1. Areas containing between one and 10 per cent. dieback affected forest. Logging will be restricted to affected portions only for the time being.

Zone B.2. Areas containing more than 10 per cent. dieback affected forest. Logging will be concentrated in affected portions; unaffected portions may be logged under hygienic conditions before proceeding elsewhere.

Zone sizes and boundaries

30. Zones will consist of whole forest blocks, or contiguous portions thereof. The minimum area for a single portion of a zone could be of the order of 5,000 acres, but sections of more than 500 acres of unaffected country within an affected zone will be specifically reserved for cutting under a separate prescription.

Records of zoning to be maintained

31. D.F.O.'s will maintain a set of plans showing the zone boundaries throughout their Division. These plans will be updated as new information becomes available from any sources such as ground inspection or air-photo maps supplied by Working Plans.

Selection of Intensive Management Units

32. D.F.O.'s will also search for and delineate on the plan any areas of over 1,000 acres of relatively dieback free forest which is predominantly prime jarrah (90 ft. or more mature co-dominant height). These areas will be set aside as Intensive Management Units to be worked under the strictest hygiene and intensive silvicultural treatment.

Logging Priorities

Sequence of cutting in zones

33. Bearing in mind that each of the affected zones will contain substantial tracts of unaffected country, the general sequence of logging will be—

1. Affected areas Zone B.2.
2. Affected areas Zone B.1.
2. Unaffected areas in Zone B.2 and Zone B.1 (in that order), using strict hygiene and carefully selected access routes; wherever possible cutting will be in concentric belts surrounding already affected areas.
4. Zone A—only to be logged when no other country is available, and then preferably by permits completely contained in this zone; logging will be under strict hygiene and along carefully selected access routes.

For the present, unaffected areas of 200 acres or more, in Zones B.1 and B.2, will be reserved from cutting.

Perimeter belt

34. When these areas are eventually logged, a perimeter belt two chains wide within the unaffected country will be reserved from cutting, so as to reduce the possibilities of contamination by lateral movement across the boundary between the affected and the unaffected types.

Summer stockpiling

35. Summer stockpiling by small mills is to be encouraged wherever possible so as to reduce the general level of activity during winter. This is the worst time for spreading infection by mud carried on equipment and by surface run-off.

36. These prescriptions will apply to the general run of trade operations. Specific instances, such as mining timber operations at Collie, require special prescriptions to be approved by the Inspector. At this stage, the individual permit or licence area should be regarded as the basic unit of planning. A specific recommendation should be forwarded to the Superintendent where it is evident from the five-year logging plans that mill capacity in a particular locality is insufficient to cope with dieback arrears and extensions within that period. This also applies to unallocated areas.

Integration of Operations

All trade operations to be integrated

37. To be fully effective, hygiene measures must be applied to all operations in the forest. Pole and pile, salvage, firewood and other minor operations will follow the sequence of priorities set out in Para. 4, and will be concentrated upon areas scheduled for trade cutting. These operations, using the same access, may precede or follow major logging, but must be programmed to avoid simultaneous use of the same haulage routes.

Separate minor operations

38. Where it is necessary to mount separate minor operations, strict hygiene must be observed. Cutting must be completed in all affected areas of Zones B.2 and B.1 before proceeding to unaffected country; lateral movement across the boundary between patches of affected country must not be permitted; and cutting in elevated positions, especially across ridge tops, must not be permitted without specific approval from the D.F.O.

Designation of Access Routes

39. The D.F.O. will designate specific access routes to each coupe, including those for independent pole operations, so that unaffected areas will only be logged along clean access routes and the chances of new infections as a result of hauling from affected coupes will be minimised.

The chances of picking up infection from the surface of well-drained, gravel-sheeted logging roads running through infected country are considered to be relatively slight. The main problem arises when inoculum is picked up from infected boggy gullies and transported onto unaffected ridges further along the same road. This can be avoided by restricting the use of such roads in winter and by proper attention to creek crossings, which will be required even for summer operations.

Unaffected areas to be logged via clean access routes

40. Access must receive special consideration when preparing five-year logging plans, and the routes selected to serve each coupe must be clearly indicated on Forms 49B. The reasons for selecting particular routes should be discussed in advance with mill management, as also should the general order of logging priorities. Inspectors will be required to check the selection of access so that existing tracks are used to best advantage with minimum inconvenience to the industry. (Para. 9 also refers.)

New Road Construction

41. Construction of new roads by both the industry and the Department will be kept to the essential minimum.

New alignments

42. New alignments and realignments of existing roads should be pegged and approved for hygiene by a competent officer before construction starts, especially where the boundaries of dieback are uncertain.

Drainage

Lower, but well drained, slopes following the main gully systems are the preferred locations for new roads; good surface drainage with proper turn-offs linking up with natural drainage channels are to be provided.

Gravel and borrow pits

43. Sites for borrow bits must be approved by a competent officer before the start of any excavation; infected gravel must not be used on roads traversing unaffected country; and gravel for roads traversing affected areas should be obtained preferably from isolated patches of unaffected country, from which the spread of further infection will only be very limited.

44. Inspectors will examine and approve divisional roading programmes before estimates each year, and in this connection basic units of 1,000 acres in jarrah and 400 acres in karri will be adopted to minimise new road construction when subdividing cut-over maiden forest.

Silvicultural Systems

45. The concept of heavy cutting to reduce the total area rendered liable to infection each year has many additional advantages in connection with operational control and protection of regrowth.

Subject to proper local prescription by the D.F.O., the future systems will be—

1. Green Line Cutting (Affected Types Zones B.1 and B.2).

Cutting prescription in affected areas

The "Green Line", indicating the outer edge of dieback activity, will be marked on the ground by paint marks on the edge trees which will be retained, or by toe marking a perimeter strip. Where the Green Line is difficult to detect, an arbitrary boundary may be marked in the same way up to two chains beyond the edge of obviously seriously affected country.

Clean cutting will then proceed inwards from the Green Line, and all logs will be hauled out through the affected area.

Narrow affected gullies and isolated affected patches of less than 10 acres will be ignored at this stage.

Rounding off coupes for green line cutting, by the inclusion of substantial areas of unaffected country (20 acres or more) must be approved by the Inspector in each instance.

2. Uniform System (Unaffected Types in all Zones).

Cutting prescription in unaffected areas

These areas will be treemarked under a uniform system retaining only genuine crop trees below 90 in. g.b.h. in A+, A, and B+ height class forest. In poorer forest types the limit is 72 in. g.b.h. These trees will be retained to provide a potential for jarrah regeneration.

The Inspector must approve all cutting in unaffected areas and priority will be given to concentric cutting with haulage preferably along the contour around affected areas which have already been cut over.

Cutting in unaffected areas should stop two chains short of the edge of active dieback, and all logs must be hauled back through the unaffected area.

Vehicle Cleaning

46. Proper planning and designation of access may largely eliminate the need for daily washing down of vehicles. But it is essential that all vehicles and heavy equipment should be free of any soil or mud before entering clean country. This applies particularly to material carried on crawler tracks, on the suspensions of and between the dual tyres of vehicles, and on the trays of trucks and low-loaders.

Contractors' vehicles

47. Contractors to the Department and to the industry, or their operators, will be required to see that their machinery is in a clean condition, and a hygiene clearance should be given by a competent officer before the equipment starts work in unaffected areas.

48. The transfer of contractor equipment from one Division to another will present serious problems, for which a system of vehicle identification is being considered as a possible solution.

It is hoped that an adequate standard of hygiene will be obtained and maintained through the co-operation and sense of responsibilty of the industry, rather than through legislation. Every opportunity should be taken to demonstrate the need for hygiene, but serious and consistent offenders should be reported through the normal channels.

Departmental Activities

49. Strict standards of vehicle hygiene and movement control must be maintained in all Departmental operations, so as to set an example to all other forest users and to reinforce the importance of the hygiene programme in the eyes of the industry and of general contractors.

50. The following guide lines will be adopted under the general surveillance of the Inspector:—

Works programmes and access routes

(1) Divisional works programmes will be planned to avoid cross-travel between the die-back zones, and to reduce the need to work in die-back areas in winter.

Vehicle cleaning

(2) Vehicles and equipment, obliged to work in die-back areas, should use designated access routes, and should be thoroughly cleaned down before being transferred to clean areas. A thorough hosing down with a high-pressure hose is considered an adequate cleaning. But a proper outlet must be provided for the effluent to avoid contamination of adjacent forest.

Access routes marked on zone maps

(3) Designated access routes serving both clean and affected areas within the die-back zones should be clearly indicated on the Zone Map (Para. 32). This map should be prominently displayed and the D.F.O. should explain clearly to all staff and employees the reasons why designated access must be used.

Road grading

(4) Road grading should be confined to major access routes, and to those tracks considered essential for the annual prescribed burning programme. Continuous grading through boggy creek crossings should not be permitted; these crossings on the minimum number of essential access tracks should be filled to provide dry traffic conditions.

Other road maintenance

(5) Other road maintenance should also be restricted to those routes which are considered essential for basic access. Particular attention should be paid to the provision of proper turn-offs linking to natural drainage lines for surface run-off from major roads and tracks.

Lesser tracks will be kept free from logs, but will only be graded when in danger of becoming obliterated or when needed for prescribed burning.

Road closure

(6) Relocation of existing roads should only be considered under exceptional circumstances and each project should receive specific approval from the Superintendent.

Road closure

(7) Roads constructed from the Reforestation Fund may be closed on the direction of the Conservator and subject to the display of appropriate notices. This should apply to ridge-top roads built for aerial burning in the southern forests subject to a specific recommendation in each case.

Burning and green line cutting

(8) It is desirable to avoid prescribed burning in dieback areas scheduled for Green Line cutting wherever possible because this operation obliterates many of the indications of the extent of dieback.

(9) The timber industry has co-operated extremely well with respect to die-back hygiene. However, it is vital that all other bodies or concerns using or operating in State Forest adopt similar standards

of hygiene. This includes the P.M.G., S.E.C., M.R.D., Local Authorities, W.A.G.R., Mining Companies, etc. Inspectors and D.F.O.'s are responsible for seeing that hygiene is properly implemented by all forest users. They must give prior advice of any projects or activities proposed in areas under control and take every opportunity to instruct supervisors and operatives in hygiene requirements before and during the operation. They must also supervise and see that their staff are competent to supervise the hygiene aspects of such projects while in progress.

INTENSIVE MANAGEMENT UNITS

Objects

51. The policy of establishing Intensive Management Units in the jarrah forest is aimed primarily at locating and demarcating high quality, relatively dieback-free forest areas for intensive management designed to maximise both volume and value production. Such areas will be afforded the maximum silvicultural attention, and will be kept free of dieback. The aims within I.M.U.'s are:—

(a) The elimination of existing dieback infections and the complete exclusion of the disease from the area thereafter.

(b) As disease-free forest units comprising highly productive jarrah stands, they will be afforded a maximum of silvicultural treatment and protection within sound economic limits.

(c) They will be maintained as productive jarrah forest, with the exception of dieback infected areas, flats and swamps which will be converted to exotic hardwood plantations.

Selection of areas

52. The criteria for selecting areas are as follows:—

(a) There must be less than one per cent. of the area affected by dieback.

(b) A minimum area of 1,000 acres is required.

(c) The jarrah forest in the area should be mostly height class A, Inclusion of height class B+ is also acceptable and even small portions of height class B forest may also be included where required to consolidate boundaries.

Demarcation

53. The areas are demarcated on the ground by signposts erected at all points where roads and tracks enter the area. Clear demarcation on the ground is very essential for the success of the strict hygiene measures prescribed for these areas.

Working Plans

Working plan for each I.M.U.

54. An operational working plan will be prepared and maintained for each I.M.U. A plan has been prepared for Unit No. 1 in Dwellingup Division and this will be used as a guide in preparing plans for other units.

The working plan prescribes all operations, both silvicultural and protective, to be made in the unit and the control of operations and costs is achieved by the preparation of five-year and annual plans of operations. The annual plans of operation are being used as the basis for estimates. The working plan should be revised every 10 years.

Sequence of Operations

55. To achieve the aims of bringing I.M.U.'s into a state of maximum productivity will require a definite priority of operations which should be strictly adhered to. The initial operations in order of priority will be as follows:—

Control of Dieback

Clearing dieback-infected areas

56. (a) All areas infected with *Phytophthora cinnamomi* will be completely cleared of natural vegetation and planted wth a hardwood or pine species which have been proven to be resistant to the fungus. Such clearing and replanting will extend for at least 2 chains into healthy forest bordering the infected area.

Road maintenance

(b) All major tracks and roads through the I.M.U. will be formed and maintained in a condition where no ponding can take place on the carriageway. Where these tracks traverse swamps and flats, enough gravel fill will be added to build up the carriageway to a point where it remains freely drained during the wettest conditions. Drainage from major roads and tracks will be channelled *via* cut drains to the nearest creek bed or natural drainage channel. Use of minor tracks in winter time is to be avoided.

Access restrictions

(c) Access of heavy vehicles and plant to and through an I.M.U. will be restricted to machinery which does not carry mud and soil which is likely to be infected with the fungus.

Silviculture

Location and treatment of understocked areas

57. The most important silvicultural aspect of operations in I.M.U.'s is the location and treatment of understocked stands. This operation should, where possible, precede any other silvicultural operation. Technical details for guidance in the location and treatment of such stands is to be found in the Working Plan for I.M.U. No. 1 (Dwellingup Division).

CURRENT CUTTING PRACTICE

General

Silvicultural system

58. The system of silviculture, including both cutting and regeneration, in use in the jarrah forest is the Australian group selection system.

In the past the cutting cycle was 30 years, resulting in a relatively light cut. Grossly overmature trees were removed resulting in the creation of relatively small gaps for regeneration. Some thinning also took place among overdense veterans.

Heavy cutting dictated by die-back

59. The present trend is towards a longer cycle and a far heavier cut, creating much larger gaps for the development of regeneration. The incidence of dieback has dictated this heavier cut; the concentration of logging operations on smaller areas reduces the possibilty of spreading the disease.

Many forest areas are now in their second cutting cycle, and the attention paid previously to the salvage of overmature and deteriorating stems is no longer of prime importance, except in dieback affected areas and virgin forest. However, salvage cuts are necessary from time to time, particularly following serious wildfires.

Constraints on cutting

60. Two constraints are placed on the quantity of timber to be taken from a coupe. The first comprises management considerations and the prescribed yield to be harvested from the area. The second concerns regeneration. The treemarker must ensure that any gaps created by trade-cutting are adequately stocked with advance growth. Where regeneration is lacking, no gap may be created.

Regeneration stocking

61. A minimum adequate stocking is 200 stems per acre, or a spacing of approximately 15 feet. Both jarrah and marri regeneration are acceptable.

Trees to be removed in the trade-cut and in pile-getting

62. As a general guide, the bulk of the trade-cut will comprise mature and overmature trees. These are identified by evidence of moderate to extensive dying backing of the outer branches in the crown. Piles and vigorous, immature veterans will only be removed as a thinning in patches that are too heavily stocked. An exception occurs when a pile-getting operation seeks bridging timbers and large transmission poles. The clear felling of groups of immature trees over 40 feet in length may be prescribed in such an operation, but the constraint of inadequate regeneration will still apply.

Cutting Prescriptions

63. A cutting prescription for each cutting section will be prepared by the D.F.O. and must be approved by the Superintendent.

64. *Cutting in virgin forest:* Gaps may be created by clear-felling where regeneration is adequate. Elsewhere the treemarker will mark individual stems for removal, either as a thinning or because the tree is unthrifty and is likely to deteriorate before the next cut. The intensity of the cut will be dependent on management prescription.

65. *The second cut—high quality forest:* Type A.—High quality forest is defined here as being B+ or better height class. All overstorey trees of more than 72 inches g.b.h. will be removed. The only constraint prescribed here is that where such removal creates gaps, the gaps must carry an adequate stocking of regeneration.

Type B.—In some cases commitments to permit holders can involve cutting over a section which is under-stocked with trees of all sizes including regeneration. In this case a minimum of eight seed trees per acre shall be left. Seed trees should have healthy, vigorous crowns and be of at least pile size. To encourage seedling establishment as much ground disturbance as possible should be made. This can be achieved by prescribing the use of a separate snigging route for each log. The regeneration period, from seed to dynamic sapling, is likely to be of the order of 10 to 12 years under these conditions.

66. *The second cut—low quality forest:* Low quality forest is defined here as being B height class or lower. Such forests are mainly located on the eastern side of the jarrah forest belt and frequently include mixtures with wandoo. Coppice is an important source of regeneration in this region, hence the constraints made by existing regeneration are relaxed. The removal of all merchantable timber of 72 inches g.b.h. will be prescribed.

The sequence of operations

67. The following sequence of operations is recommended for cutting over a section:—

(a) A prescribed burn prior to treemarking.
(b) Preparation of the cutting prescription.
(c) Treemarking.
(d) Trade cutting by the permit holder (including cull felling where this is prescribed).
(e) Salvage cutting by a salvage operator, where required.
(f) Assessment.
(g) Top disposal.
(h) Selection of final access roads for maintenance and records.
(i) Fire protection for regeneration.
(j) Completion of records.

Treemarking

Standards

68. It must be stressed that treemarking plays a vital part in determining the future condition and productivity of the forest. D.F.O.'s will ensure that careful instruction and close supervision is given to all treemarkers. Consistent attention to the maintenance of standards is imperative and all questions in this regard will be referred to the Inspector or Superintendent.

Method of treemarking

69. Trees will be marked by branding in an axe cut at the foot of the tree in such a position that the tree must be felled directly over the brand, *i.e.*, over a radial line extended from the centre of the tree through the centre of the toe-mark. The brand used is an insert in the back of the axe head and is marked F.D. over a number, the number identifying the authorised officer using the brand. All branding axes are issued from head office, where the number is registered against the name of the officer holding the axe. Branding axes may not be loaned or transferred or used for purposes other than treemarking. They must be kept in a safe place at all times when not in use.

Allocation and care of branding axes

Top Disposal

Top disposal cleaning

70. On completion of the trade operation, the Department carries out a top disposal cleaning programme to ensure that the burning of logging debris will do little or no harm to growing stock. Inflammable material is moved to a distance of at least three feet from the base of retained trees and elevated branches are lopped flat. Although mainly axe work is required, chain saws can be used to advantage on large limbs. It is the overseer's responsibility to see that no areas or trees are missed, that the standard set is maintained, and that unnecessary work is avoided. The overseer will indicate where the chainsaw is to be used. In low quality forest the top disposal operation may be excluded at the discretion of the Inspector.

Top disposal burn

71. The burning of tops is carried out during mild weather or at night to reduce the possibility of damage to the retained trees. However, in order to dispose of as much limb wood as possible it should be left until it has dried out thoroughly.

The length of time between trade cutting and top disposal will be determined by the drying period, and the integration of other silvicultural operations. In this respect see the later sections of this pamphlet on stand improvement.

Regeneration

Advance growth

72. *General:* The existence of a pool of advance growth on the ground has been relied upon as a source of regeneration during the whole history of jarrah forest management. The term "advance growth" refers to bushy jarrah plants up to three feet in height with numerous shoots, none of which show any apical dominance. A characteristic of the plant at this stage is a large, subterranean, woody lignotuber and a massive tap-root. The quantity of advance growth on the ground was regarded as generally adequate as a source of regeneration under the relatively light trade-cut achieved under treemarking as practised in high quality forest until recently. Hence, little attention was paid to assessing the regeneration pool prior to areas being cut over.

Under the present practice of heavier trade cuts, it is imperative that attention be paid to the adequacy of the advance-growth pool when treemarking. Failure to do this will result in the creation of gaps in the forest and an overall condition of understocking. The constraints placed on cutting by a lack of advance growth are described in the section headed "Current Cutting Practice". Where heavy trade-cuts are anticipated as a regular future operation, an assessment of the regeneration potential of the area must be made at least 25 years prior to the cut. If regeneration proves to be inadequate, steps should be taken to encourage the establishment of seedlings on the forest floor. Suggested methods of achieving this appear in a later paragraph.

Flowering habit

73. *Seeding Characteristics:* Although a few trees may be flowering in the forest every year, the majority exhibit a social flowering habit every five to seven years. Flower buds begin to develop in January. Flowers open the following November to February and capsules contain ripe seed about a year later. Natural seedfall takes place in the hot, dry summer months, but prescribed burning in spring is likely to result in the rapid shedding of a high proportion of the seed.

Seed shed

The seed is relatively large (60,000 per lb.) and dispersal is confined to a distance equal to the height of the mother tree. After falling, the seed remains dormant until the onset of the winter rains and lower temperatures in mid to late May, when rapid germination takes place. **Autumn prescribed burning completely destroys any seed lying on the ground.**

Seeding results in the loss of a complete season's shoot growth; the crowns of heavily seeding trees become very sparse and a massive loss in wood increment is associated with the seeding cycle.

Maximum seed production in "pile" sized trees

Veteran jarrah, particularly those with receding crowns, are very poor seed producers and are of little value in this respect. The period of maximum seed production occurs in the pile stage when seed production is ten times greater than in an ageing veteran stand. The maximum recorded fall is 340,000 viable seeds/acre from a pile stand in a seed year.

74. *Seedling Development:* The rate of development of the seedling is closely tied up with the density of the overstorey. Measured seedlings in a very dense pole stand have an average height of three inches at five years and consist of a single stem. Seedlings of the same age which have developed on disturbed soil on a landing may be over one foot high with more than a dozen stems. A similar range occurs for survival figures, losses exceeding 90 per cent. can occur over the first five years in dense stands while they may be negligible in disturbed soil in openings. The exact relationship in quantitative terms between seedling development rate and the density of the overstorey has yet to be determined.

Lignotuber

The further development of the plant consists of an enlarging lignotuber and an increase in the number and length of the stems. Best development appears to take place when regular controlled burning destroys the stems every three to five years after which new shoots emerge from the lignotuber. A lack of burning results in woody, moribund shoots and the consequent poor development of the plant.

75. *Sapling (dynamic shoot) Release:* The bushy advance growth plants, provided they have reached a certain size, respond to the trade-cut and top disposal burn by producing one or two shoots which are far more vigorous than the others. These shoots develop into saplings and are commonly called "dynamic shoots". The exact nature of the stimulus required for the formation of dynamic shoots is imperfectly understood. However, it is achieved by trade cutting operations which must reduce competition in the stand considerably, a factor which undoubtedly contributes to this stimulus.

The minimum sized advance-growth which is capable of producing a dynamic shoot is one with a lignotuber approximating the size of a clenched fist. An advance-growth plant at this stage will have at least six shoots, and the sum of the lengths of all the shoots will exceed 15 feet.

The period required for the seedling to develop this size will vary with the density of the stand. On high quality sites in stands of average density, a minimum period of 15 years has been suggested, extending to 50 years on low quality sites. At the other extreme, jarrah seedlings planted on cleared, ploughed ground will generally produce a dynamic shoot in one to five years, and the bushy, advance-growth stage is frequently by-passed.

The lignotuber and fire

76. *Prescribed Burning and Regeneration:* The young jarrah seedling is easily killed by even mild fires during the first four to five years after germination. The lignotuber forms in the axils of the cotyledons of the young seedling. Its subsequent development takes place downwards along the stem and it eventually becomes a largely subterranean organ. The four to five year period of susceptibility to fire represents the period required for the lignotuber to reach this position. Thereafter it can only be killed by prolonged, intense heat and normal prescribed burns will not affect its survival.

Dynamic shoot susceptible to fire

77. A further period of susceptibility to fire occurs when the dynamic shoot is produced from bushy advance-growth. This shoot remains susceptible to fire until thick bark develops on the lower portion of the stem; a period of between five and 10 years. If a dynamic shoot is killed by fire, the plant will revert to its original bushy form and a second dynamic shoot will subsequently develop.

Stands which are being regenerated should therefore not be burnt for the four to five years following germination and seedling establishment. Nor should they be burnt in the dynamic shoot stage until the saplings have developed thick bark up to the predicted scorch height of the fire. In most instances, it is preferable to defer control burning in sapling stands for 10 to 12 years after regeneration. D.F.O.'s must pay particular attention to this in drawing up annual burning programmes. Stands to be withheld from cyclic burning for regeneration must be clearly indicated on divisional burning proposals.

78. *Establishing Seedling Regeneration:* The factors affecting the establishment of jarrah seedlings are at present being investigated. Where regeneration is desired but absent, present knowledge indicates the following two operations to aid establishment:—

(a) Trade-cut the stand to reduce the total stocking. The suggested residual level is between 80 and 100 ft.^{2}/acre basal area.

(b) Burn the stand in the spring of a seed year. This burn should be in October or November following flowering in the previous summer.

79. *Sapling Growth and Form:* There is considerable evidence that saplings growing in open conditions develop a poor form. Basal sweep and bends in the lower few feet of the stem are characteristic deformations of these plants and they invariably occur in jarrah planted at the normal spacing of around eight feet. This tendency to poor form does not occur where regeneration is very dense or where it develops in relatively small gaps in the overstorey. It seems likely that a certain degree of side shading is essential for the development of the young saplings if it is to have a straight stem.

Stand Improvement

Definition

80. *General:* The term "stand improvement" covers all silvicultural operations apart from trade cutting and regeneration.

Aim

The basic aim behind all silvicultural operations is to remove or kill the non-productive elements in a forest stand in order to reduce competition with, and increase the growth rate of, the productive and potentially productive elements.

Operations

81. Three stand improvement operations are currently practised in jarrah silviculture:—

(a) Thinning in sub-merchantable size stands.

(b) Removing or killing useless overstorey or cull trees.

(c) Killing dense understoreys of *Banksia grandis.*

Regeneration cleaning (historical)

82. *Historical:* Improvement work was carried out on a large scale in the northern jarrah forest during the depression years of the 1930's. This work was termed a regeneration cleaning and was performed in young regrowth stands. It involved the freeing of crop trees, the ringbarking of useless overstorey, mainly marri, and the falling near ground level (mullinising) of small trees which had been too severely damaged by fire to have any crop-tree potential. Vigorous coppice regeneration resulted from this latter operation on a high proportion of the 300,000 acres treated.

Coppice, sapling and pole thinning (historical)

83. Subsequent trials to test the effect of thinning coppice to one or two stems per stump showed that little advantage, if any, was to be gained. Thinning in sapling and pole sands likewise achieved little advantage, due largely to the development of competition from vigorous coppice which resulted wherever surplus trees were removed.

Hormone-type arboricides

84. The measurement of regrowth stems relatively free from competition showed that substantial increases in growth rate could accrue from thinning if the problem of coppice control could be overcome. This became possible with the appearance of hormone-type arboricides on the market. Particularly useful in this respect are the products 2,4,5-T and picloram (or tordon).

Improvement operations confined to I.M.U.'s

85. *Selection of Stands:* Stand improvement will be confined to the better jarrah forest of height classes JA+, JA, and JB+. The proximity of dieback infections to a stand will also affect its suitability for treatment; the increased growth accruing from any treatment must have culminated and be harvestable before a moving dieback infection reaches the stand. For this reason, almost all stand improvement operations will be confined to Intensive Management Units where dieback is under control.

Jarrah to be favoured. Marri acceptable

86. *Species Preference:* Jarrah will be favoured above all other species in improvement operations. However, marri will be accepted on its merits where jarrah stocking is inadequate. The same prescription applies to W.A. blackbutt.

Prescriptions

87. *Non-merchantable Thinning:* A general prescription for non-merchantable thinning is given in Appendix B, and a prescription for selecting stands for thinning is shown in Appendix A. Deviations from the thinning prescription may only be adopted with the approval of the regional Superintendent.

88. The selection of areas and the thinning prescription are based on the stand to be treated being capable of yielding an economic response to the operation. The criteria involved are as follows:—

(a) The co-dominant height of the regrowth should be at least 40 feet.

(b) Stems selected as crop trees (*i.e.*, for the residual stand) must be in need of freeing from competition from other stems. For this purpose, all woody stems in excess of two inches d.b.h. and within 20 feet of a crop tree are regarded as competitors.

(c) Sufficient crop trees must be present. The present stand selection prescription is based on a minimum of 40 crops trees per acre.

(d) Any fire damage in the stand must not be severe.

Thinning intensity

89. The intensity of thinning prescribed in Appendix B is heavy and is considered necessary due to small-sized jarrah being virtually unsaleable. The theoretical spacing of 20 feet between crop trees will allow them to continue growing at an acceptable rate with no further thinning until they reach approximately 45 inches g.b.h. It is anticipated that a thinning at this size will yield merchantable produce.

Definition of cull tree

90. *Treatment of Cull Trees:* The cull tree has no merchantable potential and occupies effective growing space, hence its death or removal will contribute to increased site productivity. In the context of this section, only stems of 40 inches g.b.h. and greater come into the cull tree category. Unwanted stems below this size are removed by different methods in non-merchantable thinning operations.

Salvage cutting

91. Wherever practical, the treatment of cull trees should be carried out as a logical sequence to trade cutting. In this respect, the market for trees rejected by permit holders ("MNT" and "sub MNT") should be fully tested. Salvage cutters with lesser commitments than the major companies are frequently able to economically remove logs yielding a lower recovery in sawn timber. These operators are being used mainly for the salvage of trees on dieback areas and of low-grade logs from plantation clearings. They can be employed with silvicultural advantage in the forest working in advance over areas listed for cull tree treatment. Any cull felling by log hauliers requires the specific approval of the Superintendent, as it is undesirable to increase the number of salvage operators or to jeopardise hygiene by wide ranging operations.

Cull marking

Felling

Poisoning

92. Cull trees are marked with a circle of silver paint. All culls within five chains of main roads and major tracks are to be felled. This is mainly a fire-protection measure.

All other culls will be poisoned by deep injections of tordon. The notching technique, used for the smaller stems poisoned in non-merchantable thinnings, is quite inadequate for cull trees. For these, holes must be bored for a depth of 3 to 4 inches into the bole to ensure that the poison is in close contact with the sapwod. The latest information on the spacing between holes and the dosage rate of tordon to use will be issued from time to time in Head Office circulars.

93. *Removal of* Banksia grandis *Understorey:* Dense understoreys of *Banksia grandis* create strong competition for the overstorey and they also form a reservoir of highly infective material for the fungus causing the dieback disease. For these reasons, their removal is silviculturally desirable.

The techniques of cheap, wide-scale *Banksia* poisoning are in an advanced experimental stage and should be available for general use shortly. They involve overbark sprays of the hormone poison 2,4,5-T in a water base, mixed with white oil. The recommended concentration of 2,4,5-T is between 3 and 4 per cent.

94. *Sequence of Operations:* It is silviculturally desirable, and in the interests of economy, that improvement operations should be integrated with both the trade cut and rotational burning whenever possible. The recommended sequence of operations is:—

(a) advance burn;
(b) trade cut;
(c) salvage cut where required;
(d) top disposal and cull tree felling;
(e) cull tree poisoning;
(f) non-merchantable thinning;
(g) burning tops.

The position of the burning tops operation in this sequence will be largely dictated by the period required for the tops to dry out sufficiently to achieve a good burn. It would be preferable to complete this operation, where possible, before cull tree poisoning and non-merchantable thinning. Access to the forest for both these operations will be far easier after the tops have been burnt.

APPENDIX "A"

SELECTION OF JARRAH STANDS FOR POLE THINNING

Introduction

The sampling method described here is intended as a guide in the selection of areas of jarrah regrowth for thinning. It requires a minimum of effort and it gives an immediate decision on the suitability of the sampled stand for thinning.

Sampling must be confined to one A.P.I. type at a time, *i.e.*, the sampling line must not traverse more than one A.P.I. type.

The critical level of regrowth stocking below which thinning is not considered to be warranted is 35 per cent. by area. To exceed this minimum level requires the presence of at least 40 regrowth stems per acre which meet crop-tree requirements as laid down in the thinning prescription, and which need freeing from competition of surrounding trees.

Method

(I) *Initial Selection of Areas for Sampling*

Areas to be investigated must have been cut-over during or prior to the 1930-1940 decade; this ensures that only crops in excess of approximately 30 years of age will be tackled. Some flexibility is required to permit the treatment of stands of 40 feet co-dominant height set in the prescription.

The initial selection of areas will be made on 20 scale A.P.I. plans and will be restricted to stands with a minimum of 60 per cent. total crown cover and "A" height class. A minimum of 30 per cent. crown cover of regrowth should also be set.

Each A.P.I. block selected for investigation will have a line drawn following its longest diagonal, subject to one end of the line being reasonably accessible and in a position to be located reasonably easily. This line is measured on the A.P.I. plan and its length *in yards* noted. If this length is less than 400 yards a second line must be drawn parallel to and approximately 10 chains from the first. This is also measured and the lengths of the two lines is totalled.

Each assessment plot is eight yards long and the assessment line (or lines) must be long enough to accommodate 50 plots.

The length of line (or lines) is divided by 50 and the resultant figure gives the distance in yards between the starting point of each assessment plot. This figure should be rounded off to the nearest whole yard.

The compass bearing of the line(s) must be read off the A.P.I. plan using a protractor.

(II) *Assessment*

The assessors, two in number, will find the end point(s) of the line(s) on the ground by pacing and using a compass where necessary (*e.g.*, where a track does not pass the end of the line) from a known point. Assessment will then begin along the first line. Plots for assessment will be eight yards (= paces) long and will extend for five yards (distance to be judged) to the right-hand side of the line. A plot is to be regarded as stocked if it contains at least one pole of 18 in. g.b.h. or more which falls within crop tree definition of the thinning prescription and which is in need of freeing from competing stems.

One assessor will pace along the line using a compass as a guide, and he will indicate to the second assessor the beginning and end point of each plot. The second assessor will determine whether or not each plot is stocked and will graph his results cumulatively on the blank graph provided.

Assessment will continue until the following conditions have been met:—

(1) At least 12 plots have been assessed. (This allows for atypical areas on the borders of A.P.I. types.)

(2) After 12 plots have been assessed, no further assessment is necessary if the plotted line of points has crossed one of the two lines on the graph *and has remained outside this line.*

(3) Where the first 12 plotted points have (a) failed to cross either of the lines on the graph or (b) have crossed a line twice (in both cases the last point plotted will be *between* the two lines), assessment will continue until either (a) the plotted points cross one of the lines on the graph or (b) 50 plots have been assessed.

Assessment will cease at this point. Enough information has now been collected to enable a decision to be made on thinning.

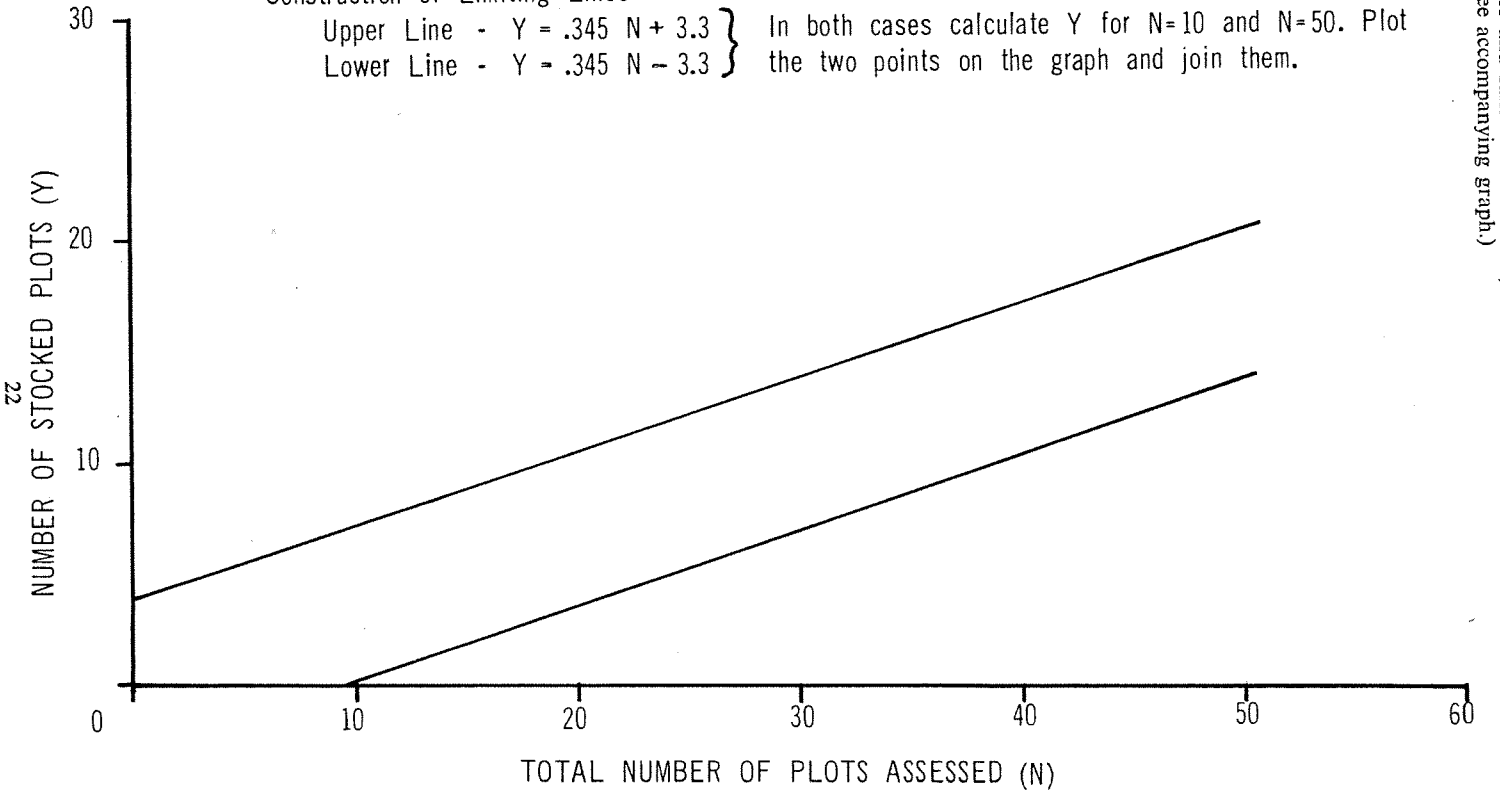
SEQUENTIAL SAMPLING FOR THE SELECTION OF POLE STANDS FOR THINNING

Construction of Limiting Lines

Upper Line - $Y = .345\ N + 3.3$

Lower Line - $Y = .345\ N - 3.3$

} In both cases calculate Y for N=10 and N=50. Plot the two points on the graph and join them.



Interpretation

When the plotted line on the graph crosses the top marked line the stand is suitable for thinning. When the plotted line continues between the two marked lines and fails to cross either, the stand is a doubtful proposition for thinning. (See accompanying graph.)

APPENDIX "B"

PRESCRIPTION FOR POLE THINNING

Marking for Thinning

The trees marked are those to be retained as follows:—

(a) Crop trees will be marked with one horizontal paint stripe.

(b) Saleable and potentially saleable trees for future removal will be marked with two horizontal paint stripes.

Definitions

(a) Crop Trees. Crop trees are between 18 inches and 40 inches g.b.h. with a reasonably straight bole of at least 20 feet length and free from visible defect. A tree with butt scarring is acceptable provided it has 20 feet of straight, defect-free bole above the scar. Exceptionally, a tree having two straight 10 ft. lengths of bole separated by a defect will be acceptable.

The crowns of crop trees will generally be at or above the general canopy level of the stand and will be in a healthy condition.

(b) Saleable and potentially saleable trees are those stems which are of a dimension or likely to reach a dimension suitable for sale as mill logs, S.E.C. and P.M.G. poles, or fencing materials.

Selection of Crop Trees

Crop trees are selected and marked on the basis of a basal area of approximately 65 ft.²/acre remaining after thinning. As a general guide, crop trees should be selected at an approximate spacing of 20 feet; this will give in the region of 110 crop trees per acre in a fully stocked stand.

A stem will not be selected as a crop tree if—

(a) it stands within 20 feet of a merchantable veteran;

(b) it will be damaged in a cull-tree falling operaton.

One of a clump of poles of coppice origin may be selected as a crop tree provided the clump consists of no more than three poles. Pole stands that are mainly of coppice origin shall be regarded as unsuitable for thinning.

Marri poles may be selected as crop trees under the following circumstances:—

(a) They have a straight defect free bole of 30 feet.

(b) Where there is a choice between jarrah and marri and the jarrah is inferior in both form and size.

(c) Where there is no jarrah.

The Freeing of Crop Trees

The non-merchantable thinning operation is basically one of freeing individual crop trees from competition. It should not be regarded as a plantation-type thinning.

All woody growth within 20 feet of a crop tree will be killed by poisoning, with the following exceptions:—

(a) Eucalypt stems less than 2 in. d.b.h.

(b) Banksia stems less than 1 in. d.b.h.

(c) *Persoonia* spp. and *Xylomelum* (Native pear) spp.

Poisoning Technique

Unwanted stems are killed by injecting Tordon 50D solution into notches cut at 5 in. intervals round the stem at any convenient height above the ground.

The notches are made with a narrow-bladed tomahawk. They must extend through the bark and well into the sapwood.

Tordon 50D (containing 5 per cent. tordon and 20 per cent. 2,4D) is diluted 1:4 with water and 2.5 cc of the diluted mixture is injected into each notch using a graduated sheep drencher. The poison must come into contact with the sapwood of the tree.

When trees of 40 in. to 50 in. g.b.h. are treated, 5 cc of the poison mixture must be injected into each notch. Trees of more than 50 in. g.b.h. should be poisoned in a cull-tree operation using a different technique.

Chainsaw operation

(a) Where a crop tree is one stem of a coppice clump, the competing stems will be felled with a chainshaw. Poison is not used.

(b) Cut and remove debris within three feet of crop trees (heavy logs excluded).

Roadside thinning

Where a thinning operation is to be done adjacent to a main road, unwanted stems will be felled for a distance of five chains on both sides of the road. The stumps of felled trees will be sprayed to saturation with a 4 per cent. solution of 2,4,5-T ester in distillate or kerosene to prevent coppicing. Areas treated in this way should not be burnt for a minimum period of six months.

KARRI FOREST OPERATIONS

CURRENT CUTTING PRACTICE

General

95. The principles of trade cutting and permit control outlined in Paras. 1 to 11 also apply to this section of the pamphlet. However, the root-rotting fungus (*Phytophthora cinnamomi*) does not kill karri and open-cut mining has not encroached into the karri forest. For these reasons, the sections on forest hygiene and intensive management units do not apply here. Nevertheless, adjoining jarrah forests must be treated as outlined in "jarrah forest operations".

Instructions and guidance given in the ensuing section pertain to stands of pure karri, free of severe fire damage, unless specifically stated otherwise. Pure karri

96. Cutting will cease where pure stands become mixed, usually with marri. Generally, the cutting boundary will be self-evident; if not, then the guidline of not more than five per cent. upperstorey stems of other species will be used to delimit the pure stand. Mixed stands

97. Cutting may be scheduled in severely fire-damaged stands, cut-over stands, and other stands which may not be virgin. The occurrence of appreciable amounts of karri regeneration may be a complicating factor. Special prescriptions for each area, compiled by the D.F.O. in consultation with the Silvicultural Officer, must be submitted to the Inspector for approval before cutting may proceed. Severely fire-damaged cut-over stands

98. All cutting shall be guided by five-year plans, prepared by the D.F.O., which will show:— 5-year plans

(a) Areas to be cut within the five-year period.
(b) Priorities of cutting.
(c) Location of extraction routes.
(d) Fire protection proposal, including surround burning and access.

General agreement between the Divisional Forest Officer and the mill management must be obtained before five-year plans are adopted.

Five-year plans must take into account dieback hygiene and will be revised annually.

99. The aim in marking virgin karri is to employ trade cutting to replace the stand with a fully stocked even-aged crop of seedling karri. Aim of treemarking

100. The silvicultural system is "Clear cutting with seed trees" (Jacobs, M. R., 1955). Seed trees are to be removed following a regeneration burn. Silvicultural system

101. The rotation envisaged for karri is 100 years. Intermediate cuttings to effect thinning and to supply pulpwood, poles and smaller sawlogs are anticipated. Rotation

Sequence of Operations

102. The following sequence of operations comprises current practice:—

(a) Fire protection on cutting section, and provision of access. Prescribed burning should be avoided five years prior to cutting.
(b) Prescription for tree marking and regeneration.
(c) Treemarking.
(d) Trade cuttng (including "cull felling") where prescribed.
(e) Scrub rolling where prescribed.
(f) Appraisal of seed supply.
(g) Regeneration burning.
(h) Removal of seed trees.
(i) Regeneration survey.
(j) Remedial planting where necessary.
(k) Record on progress plans.
(l) Fire protection as prescribed.

Protection of cutting area

103. For good karri seedling regeneration a clean regeneration burn, with widespread ashbed and complete removal of green scrub and understorey is essential. Maximum dry fuel quantity of all sizes at the time of the burn is therefore desirable. This not only ensures widespread ashbed, but extends the limit of fire danger ratings which can be used into a lower, safer range. With-

holding the cutting section from prescribed burning for five years prior to cutting ensures enough fine litter fuel to carry a fire between slash heaps, reduces the amount of fresh green scrub, and avoids the risk of damage to current seed crop development.

Karri cutting sections are now opened up with bulldozed access tracks prior to logging, and are protected by burns in the surrounding jarrah and marri forest types and in non-timbered flats.

Treemarking Prescription

104. The aim in treemarking (para. 99) is realized by:—

(a) Retaining and protecting an adequate temporary seed source in the form of the best available seed trees.

(b) Releasing for utilization the balance of the stand. Direction of fall should be controlled to protect seed trees.

(c) Removing non-utilizable cull trees.

Seed source

105. Seed trees must be of adequate size and spacing to both supply enough seed for regeneration, and to effectively disperse it over the area.

Seed tree requirements for an average healthy karri stand are:—

Density: Three seed trees per two acres, evenly spaced, will provide enough seed and disperse it for good regeneration. This corresponds to a triangular spacing of 2.5 chains.

Quality: A seed tree must be a dominant or co-dominant over 12 feet G.B.H.O.B., and must have a healthy spreading crown. Preferably it should be of good form, marketable quality, free of defects such as double leader, heavy branching, pronounced spiral grain, kinks, bumps, swellings and excessive taper. Where a choice exists, trees with hollow butts, dry sides, termites, etc., should be avoided (such trees may not survive a regeneration burn). Where no choice exists a cull type is better than no seed tree.

Atypical areas

106. It is essential for the treemarker to receive the D.F.O's guidance in respect of atypical areas, particularly where the forest is severely fire-damaged, grossly overmature, or carrying an exceptionally high proportion of marri. These areas will be withheld from cutting until treemarking and regeneration treatment is prescribed. Logging may be arranged immediately after a severe fire in karri forest, provided that seed supplies and/or planting stock are available for regeneration.

Standards of treemarking.

107. It must be stressed that treemarking plays a vital part in determining the future condition and productivity of the forest. D.F.O's are to ensure that careful instruction and close supervision is given to all treemarkers, especially those in training. Consistent attention to the maintenance of standards is imperative and all questions in this regard should be referred to the Inspector or Superintendent.

Methods of treemarking with axe.

108. Trees will be marked by branding in an axe cut at the foot of the tree in such a position that the tree must be felled directly over the brand, *i.e.*, over a radial line extended from the centre of the tree through the centre of the toe-mark. The brand used is an insert in the back of an axe-head and is marked "F.D." over a number; the number signifying the authorised officer using the brand. All branding axes are issued from Head Office, where the number is registered aganst the name of the officer concerned. Branding axes may not be loaned or transferred or used for purposes other than treemarking and must be kept in a safe place at all times when not in use.

Cull removal.

109. Culls of all species shall be removed by felling or poisoning during or immediately following the logging operation. Normally, cull felling procedures will be used (para. 153) to fell cull trees within 10 chains of an important fire protection boundary; otherwise poisoning by stem injection with herbicide will suffice.

Regeneration Prescription

110. Prescriptions to obtain regeneration will be made by the D.F.O. in consultation with the Silvicultural Officer. In the karri forest detailed records are maintained of the development of buds, flowers, fruit and seed on each cutting section. From this information, predictions of seed availability can be made. Substantial variations can occur between areas only a short distance apart and additional sampling is required on specific areas to enable completely effective prescriptions. Where prescriptions require protection of regeneration by deferring prescribed burning, such areas are to be clearly defined on plans

Protection prescription

in the Divisional Office and brought to the notice of officers responsible for prescribed burn planning. This applies also to research plots specified for protection by Silvicultural and Working Plans Officers.

Scrub-rolling.

111. In the judgment of the D.F.O., sufficient green vegetation may survive logging to prejudice a good regeneration burn. This may include scrub, understorey species, or odd patches of advance karri saplings. A bulldozer may be employed to roll down this material, converting it to fuel for the regeneration burn.

Substantial patches of established regeneration may be excluded provided that the saplings are large enough to stand a protective burn before the main regeneration burn is carried out on adjacent areas.

Regeneration burn.

112. The objects of the regeneration burn are:—

(a) To bare the mineral soil and create widespread ashbed, free of all green scrub.

(b) To promote seedfall from retained seed trees upon the seedbed thus formed.

Fire damage to seed trees, other than their removal by burning down, is considered unimportant because the current seed crop is not affected by scorching. Burns therefore should be prescribed to achieve (a), without regard to seed trees.

Regeneration burns must be timed to coincide with adequate seed supply (paras. 127, 128).

Removal of seed trees.

113. Seed trees can be removed as soon as seed is shed. In a normal regeneration burn, 90 per cent. of the seed will be shed within one month of the burn. If fire intensity is less than prescribed, seedfall may be extended over a longer period. Sampling crowns by rifle shot or felling will indicate the seed-shed situation at any time.

Damage to regeneration.

114. Seed trees may have to be removed after germination has taken place. To minimize damage to seedlings:—

(a) The same network of snig tracks and landings as used previously must be used again.

(b) Slewing of logs while snigging is to be minimized. Crown cuts are to be completed by chain saw rather than rely on dozer power to effect the final break. Use of logging arches is to be encouraged.

Maximum time before removal.

115. The smaller the seedlings are when seed trees are removed, the less damage is likely to be done. Seed tree removal should not be left later than one year following germination.

Failure of regeneration.

116. Should natural regeneration fail, planting will be employed to ensure full stocking (paras. 136-140). Seed trees will not be kept to attempt reburning in subsequent seed cycles.

Regeneration appraisal.

117. Evidence suggests that regeneration surveys are unreliable before October following autumn germination, because germinants are too small to be readily seen before this time. However, to wait this long for reliable information ensures that no remedial planting can be done before the second winter from germination. Planting in the first winter rather than the second offers the considerable benefits of fresh ashbed, minimal scrub competition, and the gaining of a year's growth. Until further experience is gained, the date at which the appraisal is done is left to the discretion of the D.F.O. (For technique of regeneration appraisal see Appendix "C".)

Fire protection.

118. Fire protection planning should specify complete protection of regenerated karri until it is at least 10 years of age. (Current work will determine the minimum age or size at which a karri stand can be safely prescribed burnt.) Protection must be given during this period by regular burning of the surrounding mixed forest types.

Karri Regeneration

Natural Regeneration

119. Under ideal conditions, karri develops rapidly from seed. Although it does not produce a lignotuber it has a weak capacity to coppice after fire.

As natural regeneration depends on seedfall considerable attention is given to the planning of regeneration burns to make effective use of available seed.

Seeding forecasts.

120. Regular sampling throughout the karri forest enables the Research Branch to keep track of seeding cycles, to forecast both the quantity and time of optimum seed supply. The basis of the forecast is a graph (Figure 1) which shows the normal development of a floral cycle, and the expected loss of floral parts throughout. By consulting the graph it is possible at any stage within a cycle to forecast the number of capsules which will develop from the floral parts visible at that stage. The basic unit of measurement is the twig, which is defined as "one year's terminal leaf growth". The numbers of floral parts per twig gives the density of the crop.

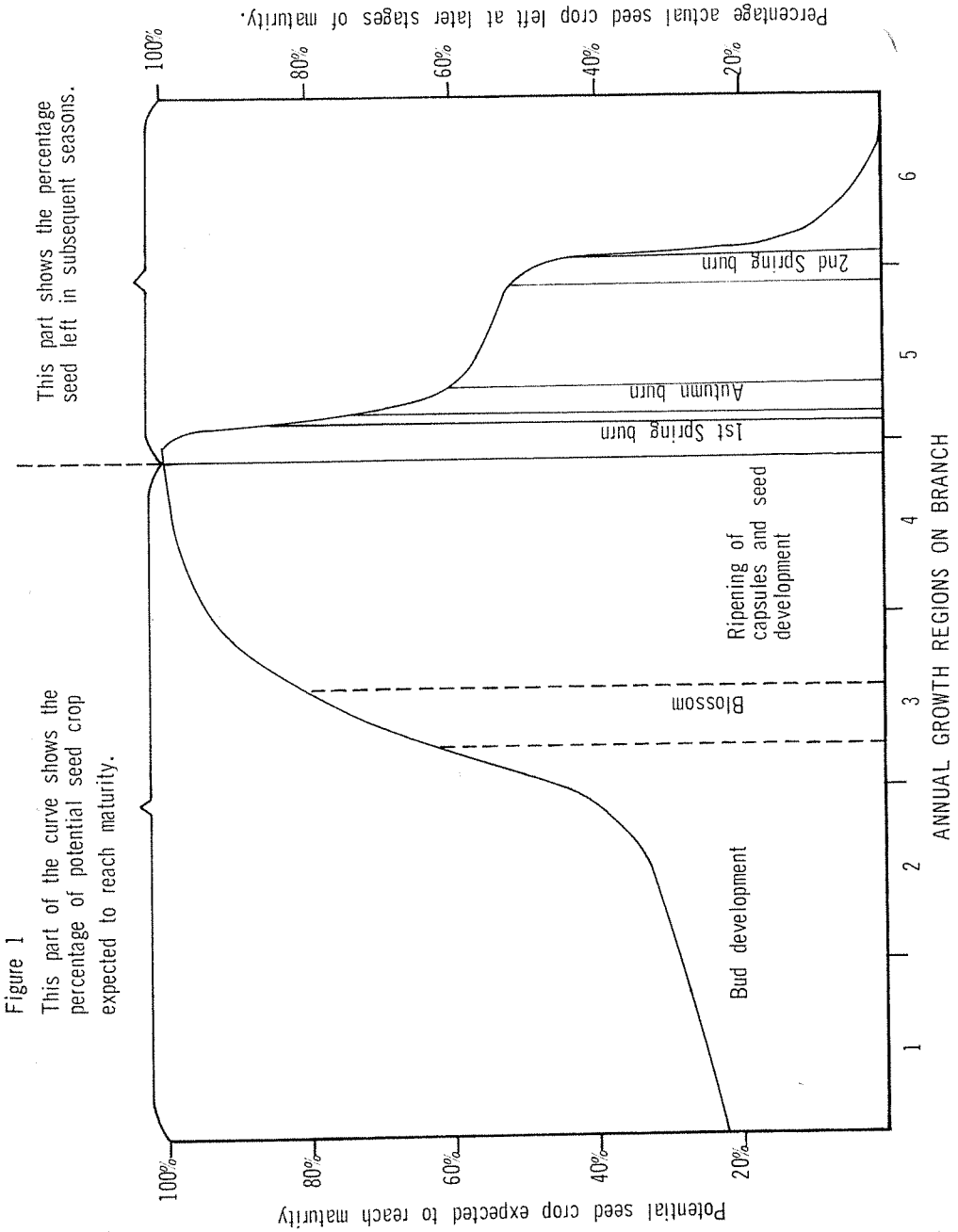


Figure 1

121. These forecasts are supplemented by observations made in the field. Treemarkers are expected to know the floral cycle by observation and by keeping in touch with Research Branch.

Floral cycle.

122. Flower bud initials can be recognised in January, but do not differentiate as buds until March, usually becoming recognisable in April as buds about one-quarter of an inch long.

Flowering commences 24 to 30 months after bud initiation (*i.e.*, bud development generally takes upwards of two years), usually commencing in February-March, becoming general in May-June and continuing throughout the winter into the following summer.

The capsule ripens and seed matures 10 to 15 months after flowering so that the elapsed time from bud initiation to first natural seed fall is approximately four years. It should be noted that whilst seed is mature at four years and its release may be triggered by a regeneration burn at that stage, natural release in quantity may be delayed while the capsule cures, extending elapsed time to five years from the first sign of buds.

The major part of the karri forest blooms in phase at intervals of four to six years. Between such general flowerings partial intermediate light to moderate flowering occurs, occasionally in successive years.

Floral cycles can become complex when two years' consecutive bud crops may merge together to allow an extended flowering period, and a consequent extended seeding period.

Seed count.

123. There are 60,000 to 80,000 seed plus chaff to the pound in a normal sample, or approximately 300,000 clean seed per pound.

Seed fall.

124. Heaviest natural seed fall occurs in midsummer. Falls as high as one million seeds per acre have been recorded during the month following the regeneration burn.

Age of seeding.

125. Seeding may commence at approximate age 15 years in open grown karri and at 25 years in dense pole stands. However, in the latter case little seed is produced at this stage.

Seed dispersal.

126. Only a small proportion of seed is carried to a distance equal to the height of the tree.

Regeneration burning.

127. As mentioned above, the regeneration burn is timed to furnish a seedbed (ashbed) for receipt of adequate seed released after the burn. As the first seed matures during spring months and ripening extends over a period, and also as mature seed may carry over the winter, there may be three opportunities for effective regeneration burning in respect of each seed crop—

(a) in early summer (December to January);

(b) in autumn;

(c) in the following spring and early summer.

Full natural seed release occurs during the second summer, hence burning in the second autumn is likely to prove abortive and should not be undertaken unless it is conclusively demonstrated that affective quantities of seed remain.

128. Owing to the natural periodicity of karri seeding, it is often necessary to withhold karri tops for periods of up to six years before adequate supplies of mature seed are available for a successful regeneration burn. For this reason, regeneration burning may be carried out during the prohibited period, under special suspension, so as to cover all areas ready for burning within the relatively short period available.

129. It is therefore essential that district officers, in consultation with the D.F.O., organise advance programmes to ensure that—

(a) The area to be burnt is surrounded by a freshly burnt buffer of adequate width to contain any escapes from the regeneration burn.

(b) All perimeter tracks and subdivision tracks within the area to be burnt are in a trafficable condition prior to commencing the regeneration burn.

Scrub competition.

130. Burning promotes the germination of fireweeds (Karri Wattles—*Acacia pentadenia, A. urophylla, A. browniana, A. decipiens* and Netic, *Bossiaea aquifolium*). If karri seed is present and germinates on even terms with the scrub, it gains and maintains an advantage. Prior germination of fireweeds may

completely inhibit karri seedling development or condemn seedlings to an etiolated condition for years until they emerge above scrub level to become active components of the new crop. A regeneration burn which removes all scrub competition is therefore essential.

Scrub removal.

131. Dense, young, lush fireweeds present a difficult burning problem. High fire danger ratings are needed for ignition and removal by burning. Injudicious or accidental burning of the stand too soon before felling may result in such a cover being in existence at the time of the regeneration burning, It may be necessary to use machinery (para. 111) to roll down scrub, thus converting it to fuel to assist the regeneration burn.

Nature of burn.

132. It is axiomatic that the hottest burn produces the best regeneration. More fuel is consumed and ashbed, most favourable to seedling development, is more widespread and continuous. The object of the regeneration burn is to bare the mineral soil and create widespread ashbed and promote seedfall (para. 123). The only restraint on fire intensity are the requirements for control. Seed tree damage is unimportant. A large quantity of dry fuel available for burning means that lower fire dangers can be utilised to achieve the desired seed bed.

Germination.

133. Germination occurs with the first winter rains (April, May). Under ideal conditions, wheatfield regeneration occurs. Frost, fungus, drought and insects cause heavy seedling mortality.

Regeneration survey.

134. A seedling stocking of 30 per cent. by milacres, and 2,000 per acre is regarded as the minimum for acceptable establishment. (A survival count of 500 per acre at age one year is equivalent.)

Sampling procedure.

135. The procedure for sampling karri germination and survival is included in Appendix "C".

Artificial Regeneration

136. The technique for artificial establishment will be prescribed by the D.F.O. in consultation with the Silviculturist (karri). Three planting techniques are available—2¼ in x 2¼ in. peat pots, one-year-old wildings, and open-rooted nursery stock. Broadcast or spot sowing is unacceptable because of variable results and the extravagant requirements of costly seed.

Wildings.

137. If wildings are to be used, one-year-old stock 18 in. to 24 in. in height should be selected. Techniques of lifting, transportation and planting are the same as for open-rooted pine stock.

Planning for re-stocking.

138. The success or failure of a regeneration burn is not certain before October or evident before early winter (May). This leaves insufficient time to raise planting stock by the usual means (2¼ in. x 2¼ in. peat pots, open-rooted stock) for planting in the first winter. Wildings can be very useful in that they may be available in any year as a result of burning elsewhere the previous year. To use nursery raised container or open-rooted stock for remedial planting, either failures must be anticipated if planting is done in the first winter, or planting must be done in the second winter into germinated scrub.

Planting into scrub.

139. Evidence suggests that planting into germinated scrub in the second year is successful if fertilisers are used. Current research work includes use of weedicides to reduce scrub competition, and use of smaller containers which may allow the stock to be raised in a sufficiently short time to be planted in the first year.

Use of fertilizer.

140. All planting of karri must be accompanied by a surface application of fertiliser at time of planting. Until further work may indicate otherwise, 2 oz. of the general fertiliser "Nutrifert" shall be applied to each plant.

Seed Collection

141. It is essential that Divisional Officers in charge of karri divisions take every opportunity to collect karri seed whenever this can be economically carried out.

Time of collection.

142. The optimum time for collection of seed is from about 12 to 18 months after flowering and during the period November to March. Maturity of seed vessels is generally indicated by a hardening of the texture of the vessels and a dulling of their colour from green to brownish green. Cutting of capsules with a strong knife or sharp axe will enable a check to be made on the condition of the seed.

143. Before directing the collection of seed, a check should be made with the Research Station, Manjimup, where progressive records of the development of seed on each cutting section will frequently determine the area best suited for collection work. Research Station records.

Seed collecton should be done in association with trade cutting. Collectors must keep right up with the fallers as a day or two of delay can mean that seed will be already shed, or much of it will be lost during the collection operation.

144. Seed should be taken only from trees of good form and quality. Whilst vigour is a prime criterion this should not rule out a dominant tree with the first two characteristics but which through age is losing vigour. Briefly, seed trees with undesirable genetical characteristics, such as short or crooked bole, wind, etc., should be avoided, but a more tolerant view may be taken of trees which have been degraded by external factors such as fire and mechanical damage. Seed tree characteristics.

145. All branches carrying mature seed vessels are lopped and spread out on a tent fly or tarpaulin which has been treated with a fungicide to prevent rotting by mildew. (Soaking in "Shirlan" is an effective treatment.) It is desirable to lop off as much leaf material as possible. The branches are thrown loosely on the sheets to provide for free circulation of air. Collection of individual capsules by raking should only be used when artificial drying and agitation for removal of seed can be arranged. The use of heat in drying needs care and temperatures should not exceed 105° F. to 110° F. Method of collection.

146. Two or three days of bright sunlight opens the seed vessels. The branchlets are now discarded after being well shaken to remove all seed and the residue left on the sheet is sifted to remove twigs, leaves and seed vessels, leaving only seed and chaff.

147. Collected seed, unless required for local use at any early date, should be forwarded to the seed store at Como or to the Research Station at Manjimup, where there are proper facilities for storing seed. When stored locally it should be kept under cool, dry condtions and protected from insects and rodents. Seed storage.

148. Eucalypt seed retains its viability under favourable conditions for up to 10 years with a gradual decline after this. Seed viability.

Stand Improvement

Thinning and Cull Removal

149. Existing evidence shows that in even-aged karri regrowth selected crop trees benefit from thinning. Responses have been demonstrated in very young stands aged nine months, stands aged 25 years and stands aged 50 years. However, firm prescriptions for thinning in second growth karri must await the results of further research work. Thinning

Until such time as prescriptions are promulgated, thinning should be limited in extent, experimental in nature, and must have the approval of the Inspector.

150. Apart from scrub rolling, remedial planting and thinning trials, the only other stand improvement procedure currently operational is cull removal. This operation involves the replacement of useless overstorey with vigorous seedling karri regrowth. Cull removal

151. The cull tree has no millable potential, but has sufficient crown vigour to occupy effective growing space. Cull tree

Culls may be removed by felling, by stem injection using Tordon 50, or by ringbarking. Where tall, dead stags present grave fire control problems, *e.g.*, within 10 chains of a road intended for use as a fire control boundary, cull felling would normally be employed. Otherwise the alternative and possibly cheaper means can be employed.

In karri the aim is to remove culls at the time of regeneration to an even-aged new crop. Felling, if employed, would normally take place before the regeneration burn, so that the maximum slash removal would ensue and maximum ashbed area be produced. Culls may be required for seed supply, in which case they would be removed after the burn as part of the seed tree removal operation.

152. Cull felling can be done by Departmental labour, but preferably it should be done by the industry as part of normal trade operations. This process, called "cull felling", is operational in karri and is a means whereby marked, Cull felling.

useless and "doubtful" trees are felled and the latter effectively proven. Recovery of "doubtful" trees is an essential feature of the operation. All useless trees carrying 30 per cent. or more of normal full canopy (including epicormic crown) are marked for culling. Useless trees with decadent crowns do not seriously compete and are not removed.

Cull marking.

153. Current marking procedure is as follows:—

All trees marked are felled. Marking separately designates—

(a) Trees with normal millable potential. These are marked in the usual way and the Department admits no claim in respect of them.

(b) "Doubtful" trees, distinguished by a double toe mark (one above the other). Acceptable logs are paid for by the mill in the normal way. Logs not acceptable are paid for by the Department at mill rates, *i.e.*, standard piecework rate on log volume, provided that the Department accepts no commitment in respect of a tree which yields a log to the mill.

A doubtful tree which shatters in falling or which requires no proving cuts, *i.e.*, obviously useless when felled, is paid for at cull rates.

(c) Cull trees have three toe marks set one above the other. These trees are merely felled and are paid for by the Department at cull rates.

Cull rates.

154. Cull rates are based on a time study which showed that the time taken merely to fell the tree represents 40 per cent. (average) of the total time from starting one tree to starting the next. The calculated proportion of piecework rates is converted to a sliding scale per foot of stump girth and the scale of rates has been adjusted upwards to 55 per cent. of piecework earnings on cull volume to include shifting, preparation and maintenance of equipment and to compensate the faller for the slightly greater amount of dry wood, sand and charcoal which may be encountered in culls, and for the time involved in measurement.

Cull payment.

155. Payment for culls and for doubtful trees proved unacceptable is on the basis of the faller's record, subject to check and endorsement by the tree-marker. The faller records on the stump in crayon and in a record book provided the serial number and dimensions of each cull or doubtful tree proved useless.

Stem injection.

156. Where karri is to be culled by stem injection, the same technique as used for jarrah will apply.

APPENDIX "C"—REGENERATION SURVEYS

(The following instructions have been adapted from Technical Instruction No. 5 of the Tasmanian Forest Commission, August, 1968, Regeneration Surveys.)

MILACRE SURVEYS FOR REGENERATION THREE-QUARTERS TO THREE YEARS OLD

A. INTRODUCTION

Regeneration surveys are used to map out areas that have too few seedlings so that they can be restocked.

Where very small seedlings are to be assessed, only small plots can be efficiently inspected. The standard plot is the circular milacre (one thousandth of an acre in area). In practice, the "milacre stick" should be used. This consists of a steel peg which is jabbed vertically into the plot point, to which is attached a 3 ft. 8¾ in. long radius wire. The wire is free to move around the peg or up and down it.

In assessing regeneration, the wire is pulled taut and moved round in a circle about the central peg. The process is continued only until one seedling is found within the milacre. When several milacres have been assessed, it is possible to work out the percentage of milacres which are "stocked" (that carry one or more seedlings). This percentage of milacres stocked is the most commonly used measure of regeneration.

In practice, surveys should be made in January to February following the burn, enabling sowing if required to be carried out from March onwards.

B. FIELD WORK

1. STRIPS. Parallel strips should be located at *4 ch. intervals* to cover the whole area to be assessed. It is often convenient to use the road as a baseline and to run the strips at right-angles to it. The first strip should start at a randomly chosen point between 0 and 4 chains from one end of the area. Numbered pegs should be placed where strips start or cross roads to aid later location of areas needing sowing.

If the results obtained from this 4 ch. grid are insufficient, intermediate strips may later be run to form a 2 ch. grid. Intensification of the survey in this way may be required where the area is less than 30 to 40 acres and the stocking is marginal, or in patches of larger areas where the stocking is marginal. Stocking for this purpose is deemed marginal where the mapping rules tend to map out understocked areas above 10 per cent. milacre stocking.

Strip direction should be maintained by compass. Plot spacing can in most cases be measured by pacing. Pacing greatly simplifies the field work but the assessor should check his pacing from time to time. The best test is to compare the length of a strip between two points obtained by pacing with that given by an existing survey. Tests of pacing against a tape over short distances or on the even surface of a road are not comparable to that obtained on the whole strip. In very rough or steep country, paces can be estimated over short distances, but the final pace to the plot point should always be controlled by the legs and not the eyes.

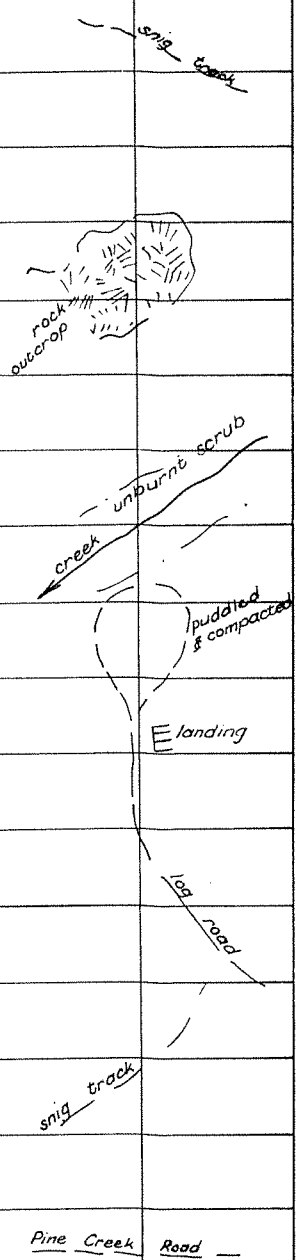
2. PLOTS. Plots should be spaced at 1 ch. intervals along the strips. It is convenient, for mapping purposes, to put the first plot in at one chain from the road. This means that, although the area within one chain of the road is sometimes undersampled, the plot number and its distance from the start of the strip correspond.

The plot point must be selected with the minimum bias. The assessor must therefore try to avoid looking where his last pace will fall. He should then implant his milacre stick either immediately in front of his toe or at some fixed distance in front of it.

At the end of the strip the assessor proceeds for 4 chains at right-angles to the strip direction to plot zero on the next strip. If this plot happens to be well inside the boundary of the area he should establish plots numbered —1, —2, —3, etc., until the boundary is reached. Then starting again at plot zero he should proceed back to the road with plots numbered 1, 2, 3, etc. Should plot zero fall outside the area he should still proceed back to the road with plots 1, 2, 3, etc., but he need not assess them until the boundary is passed. Some note should be made to explain why such plots were not assessed.

Append 1. Fig. 1 PAGE OF FIELD BOOK - REGENERATION SURVEY

1	2	3	4	5	6
17	TB	✓			
16	TB	✓			
15	A	✓			
14	TB	—	—		
13	NS	—	—		
12	TB		✓		
11	A	✓			
10	NS	—	—		
9	NS	—	—		
8	NS	—	—		
7	NS	—	—		
6	NS	—	—		
5	D	✓			
4	TB	✓			
3	TB		✓		
2	A/TB✓	✓			
1	A	✓			
0	Road			Pine Creek Road	
Strip No 3 commencing 5½ chns. N. along Pine Ck Rd:- Bearing 85° (M).			of X roads 15/6/71	Pine Ck Rd. A.P. Jones.	Telephone Rd



3. BOOKING. A sample page of a field book is given in Figure 1, one horizontal line being taken up with all the observations made at one plot point.

(a) At the start of each new area, notes should be made covering the following:—

Location, Date, Compass Number, Pacing or Chain, Name(s) of Assessor(s).

(b) *At the start of each strip*—Take-off point, Bearing.

(c) *At each Plot Point:*—

Column 1—Plot number (equals the distance in chains from the strip T.O.P.).

Column 2—Nature of Seedbed, A.B. (Ash Bed), T.B. (Top Burnt), D (disturbed), U unburnt and undisturbed), etc.

If regeneration occurs on only one of the two or three seedbeds found on the plot, the successful seedbed should be marked with a tick. It is often of value to know this when restocking an area.

Example: D/T.B. = plot has disturbed and burn seedbeds present, but seedlings only occur on the burnt seedbed.

Column 3—Presence of one or more seedlings on the milacre is here shown by a tick. In addition, seedling heights should be estimated and recorded here every third stocked milacre.

Column 4—This column is one of the most important for mapping purposes especially where the stocking is marginal. *It should be used only when the milacre is NOT stocked.* It should show the stocking within twice the (milacre) radius of the peg (7 ft. 5⅓ in.). The presence of one or more seedlings in this area is indicated by a tick in Column 4. The area within 7 ft. 5⅓ in. of the peg is four milacres. When the milacre is stocked the four milacre must also be stocked so no search of the larger plot is required. Where several milacres in succession are unstocked little time should be spent inspecting the 4 milacres. However, as soon as some field observations (such as seeing a seedling between plots) suggest that the "stocked/understocked" boundary is being approached, greater care must be taken over the 4 milacre inspections. Similarly, the first few empty milacres after a series of stocked should have their corresponding 4 milacre plots thoroughly searched.

Columns 5 and 6—These columns should show all survey information and field observations that may help to improve the accuracy of the "stocked/understocked" boundary, *e.g.,*

Approximately location of: Seed trees; boundaries between good and poor burns; between burnt, unburnt, unlogged sites; wet gullies, change of aspect; rock outcrops, etc.

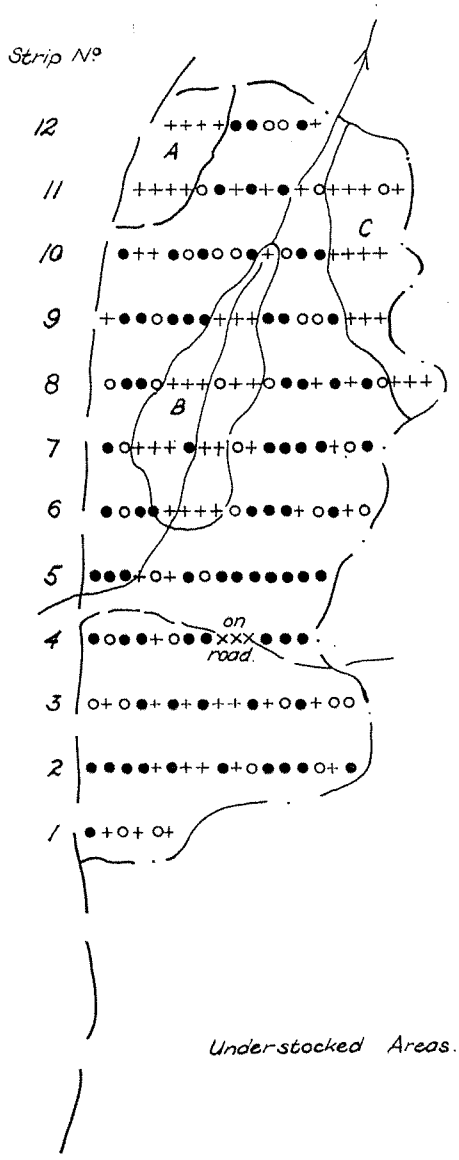
(d) *At the End of the Survey.*

Notes should be made at the end of the survey, *whilst still in the field,* of all general information likely to be of value in determining the treatment required to fully stock the area. Some attempt should be made to discover any possible correlation between the understocked patches and such natural features as aspect, rock outcrops, etc. Sketch maps of these features are likely to be of great value to those who have to re-stock the area. Notes should also be made of the most common seedling heights and the tallest and shortest seedlings.

C. OFFICE WORK

If the area is not obviously entirely empty or fully stocked, a map should be prepared showing strips and all plot points. At each plot point a sign is made to indicate whether the milacre is stocked, or the four milacre only is stocked, or neither are stocked (*e.g.,* solid circle, hollow circle, and a cross, respectively). The stocking information will be used to map out stocked and understocked areas as described below (1). The final map (Fig. 2) showing these areas and recommended sowing area (see 4) should be given to those who are going to do the sowing along with any explanatory notes on seedbed types and recommendations as to the treatment most likely to succeed (see 3).

Append 1. Fig. 2 EXAMPLE OF SURVEY LAYOUT AND MAPPING



Strip N°	Mil acre score
12	3 out of 10
11	3 " " 17
10	6 " " 17
9	8 " " 18
8	6 " " 21
7	7 " " 17
6	7 " " 17
5	11 " " 15
4	8 " " 11
3	5 " " 17
2	10 " " 17
1	1 " " 6
Total :	75 183

Understocked Areas. A. 0/8 = 0% (poor burn)

B. 1/20 = 5% (" ")

C. 0/15 = 0% (unburnt)

Total 1/43 = 2½% : Area = 43 × 0·4 = 17 acres.

Stocked area :- Total 74/140 = 53% : Area = 140 × 0·4 = 56 acres.

Wholecoup 75/183 = 41% milacre stocking

Approx. 73 acres.

1. RULES FOR MAPPING NATURAL REGENERATION. The boundary between the "stocked" and the "understocked" area is drawn using the following rules:—

(a) If the milacre is *unstocked*, it can only be in the *stocked* area if if 4 milacre is stocked or if both its neighbours on the same strip are either milacre or 4 milacre stocked.

(b) If the milacre is *stocked*, it may be in the *understocked* area if neighbours on the same strip have neither milacre nor 4 milacre stocked.

(c) Where a *stocked* milacre occurs after two unstocked plots following the end of a stocked portion of the strip, and where field notes suggest no obvious change. In stocking, all three plots may be added to the stocked portion of the strip.

Example: If 1 = milacre stocked
4 = 4 milacre stocked
0 = neither stocked

1, 1.4.0.0.1; 1.1.1.0.0.1.; are stocked
but 1, 1.4.0.0.4; 1.1.1.0.0.4; 1.1.1.0.0.0.1 are only stocked for the first three plots.

(d) It is generally inadvisable to pull out stocked or understocked sections of a strip of two plots or less in size unless other survey information shows that they are representative of the area (*e.g.*, under the only tree with seed, small patch of unburnt seedbed, etc.) Where one or two unstocked plots are adjacent to a type known to produce NO regeneration (*e.g.*, unburnt or uncut forest), they can be mapped out as understocked. Similarly, one or two stocked plots near a roadside often indicate a real stocking near the road edge even though the rest of the area may have little or no regeneration.

(e) If a stocked section of strip falls below, say, 30 per cent. stocking by milacre but there is an unusually high ratio of 4 milacre to milacre stocking, it is likely that the seedlings are distributed in an unusually even way and the strip should be accepted as stocked. If the stocking falls below 30 per cent. for any other reason, the strip should be re-examined to remove further understocked sections.

(f) Once the boundaries of the stocked and understocked areas have been established on the strip they should be interpolated between adjacent strips, taking into account any features that might be responsible for the change in stocking. The boundary enclosing a stocked section of one strip should not be extended across to a single stocked milacre or 4 milacre on an otherwise unstocked strip, unless field observations show that this is justifiable. Even crossing four chains to two stocked plots (1 to 4 milacres) should be done with caution.

This method of mapping tends to produce understocked areas with less than 10 per cent. milacre stocking, usually much less. If in a marginal area the stocking for the understocked portion exceeds 10 per cent., despite all mapping care, further strips should be put in to increase the sample. With twice the information now available and the strip interval now only two chains, the boundary between strips can be more confidently drawn.

2. RESULTS. From the map, three stocking figures can be obtained—the percentage milacre stocking for the whole, for the "stocked", and for the "understocked" areas.

Of even more value is the *area* of each section, which is proportional to the number of plots in it, e.g., number of plots multiplied by 0.4 (4 ch. × 1 ch.) or 0.2 (2 ch. × 1 ch) gives the approximate area in acres of the type.

The map shows, therefore, how much area requires treatment and where it is.

3. DESIGN OF TREATMENTS. Other field notes combined with the map should also indicate the nature of the unstocked area and so help in the planning of restocking treatments. For instance, the presence of unburnt green scrub may indicate that scrub rolling and reburning before planting may be necessary.

Restocking treatments should be recommended at the time of the survey because the assessor has the most complete knowledge of the area.

4. RELOCATING THE AREA REQUIRING TREATMENT. If several small understocked patches are mapped out without being obviously related to some natural feature there will be difficulty in finding these areas again when restocking. This can only be overcome by planting rather more than the minimum area.

The understocked areas should be either easily re-identifiable by some obvious natural feature (*e.g.*, aspect, very poor burn, etc.) or should be surrounded by a regular figure on the map including as much of the understocked area and as little of the stocked area as possible. It is better to replant a regenerated patch than to fail to sow an unregenerated one. This surround line should be clearly shown on the map along with all information required to find its take-off point.

D. ASSESSING THE EFFECTIVENESS OF THE TREATMENTS

The treated areas should be assessed later with further regeneration surveys to gauge their success and to enable further treatment to be prescribed if necessary.

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