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GROWING Pinus pinaster IN THE WANNEROO PLANTATIONS

This review paper summarizes knowledge of growing Pinus pinaster and management of the resource for timber production and water recharge to underground aquifers.

A Pinaster Management Model to TEND and GROW a 65 cm dbhob sawlog, consistent with water production objectives is presented. Pedigree stands, volume mai of 8 m^3/ha for Bassendean site type, 7 m^3/ha Spearwood site type and 5 m^3/ha for Marginal site types are anticipated. These are expected to be conservative estimates.

Growing Pinus pinaster in the Wanneroo plantations is summarized in the following sections:

1. Management objectives

2. Silvicultural regimes
   - 2.1 Plantation objectives
   - 2.2 Plantation density: prescription
   - 2.3 Pruning: prescription
   - 2.4 Thinning and growing density: prescription
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   - Schedule PPP.M - Pedigree Pinus Pinaster. Marginal.

T.B. BUTCHER
S.D.F.O.

TBB:KC
Como Research
6 April 1984

Distribution:
Mr Van Noort
Mr Havel
Dr Hopkins
Northern Region
Mr Underwood

1. MANAGEMENT OBJECTIVES

Extracts from Foresters Manual:

: Pinus pinaster plantations in the Wanneroo Division north of Perth are located on the intake area of the Gnangara Mound, an important ground water resource which provides a significant portion of Perth's water supplies. This influences silvicultural practice in these plantations, since densely stocked stands prevent adequate re-charge of the ground water. The plantations are managed on a low stocking regime in which the basal area should not exceed 15 sq.m. per ha for any extended periods.

The pruning and thinning regime for P. pinaster in this area is designed to retain sufficient trees in the early years, thus preventing excessive branch development. It is then planned to maintain an open stocking which allows rapid tree growth and re-charge of the ground water. High pruning of trees retained after first thinning is required.

: Plantation silviculture in Western Australia aims at maximising sawlog production on a short rotation through heavy, early thinning and high pruning of crop trees where necessary. Production thinnings are heavy and infrequent.

Extracts from General Working Plan No. 86:

: Water production involves catchment management, water collection and distribution to the consumers. The Forests Department responsibility is limited to the management of those catchment areas which occur in the State forest in accordance with the water supply authorities.

: Intake for much of the underground water being supplied to the Metropolitan area is within State forest. The major resource in use is the Gnangara Mound.

: Objective is to manage State forest catchments which are needed for existing or future water supply in accordance with the requirements of water supply authorities to maintain and enhance water quantity or quality.

: Policy is to regulate all other uses of forested catchments when they compete with water production objectives.

Extract from Metropolitan Water Board 1981-86 Development Plan:

: With the use of increasing quantities of ground water for public supplies there is a need for increased knowledge of the natural recharge mechanism of unconfined aquifers and associated evaporative and transpirative loss processes. A study of natural recharge to the Swan coastal plain unconfined aquifers commenced in 1981. This study will improve understanding of these resources and will lead to improved management and production techniques, consistent with environmental objectives.

2. SILVICULTURE REGIMES

2.1 Plantation objective

Plantation objective is to produce large dimension straight sawlogs grown in open pine stands so as to minimize the effects on water production to aquifers. Hydrological studies have shown that there is minimal water return to aquifers above stand densities of 15 m^2/ha basal area. This has been set as an upper limit for thinning on water production areas. The average growing density over the rotation will be 11 m^2/ha.

2.2 Plantation density

The number of trees planted per hectare need only be sufficient to ensure an evenly spaced sawlog crop of vigorous straight trees. The major pinaster sawlog crop is set at 100 spha.

Intensive sampling of routine pinaster plantings has indicated only 4 percent of the seedlings planted will grow into very straight trees suitable for the final crop; this then requires the planting of 2500 spha to achieve objective, and was the situation prior to 1972, before an improved seed source of pinaster was developed.

The Pinus pinaster tree improvement programme is one of the Western Australian Forests Department's major successes. Gains from the first stage of the programme have been very large; the pedigree pinaster tree is straight, smaller branched and more vigorous than its routine counterpart and stands are notable by their uniformity. Sampling of 30,000 pedigree pinaster trees indicated 15 percent to be very straight and suitable as final crop trees. If 100 crop trees are required, planting of 667 seedlings will achieve this.

Knot size in pinaster sawlogs is the main quality defect. Sawlogs will be grown in open park-like stands to maximize individual tree increment and water production such that pruning of the sawlog is paramount. Objective is to remove limbs before a critical branch diameter of 35 mm is attained.

Stocking or stand density is the principal means of controlling branch growth and it can be manipulated as a silvicultural tool. Tree diameter growth is dependent on stand density, and there is a direct relationship (5:1) between tree diameter and branch diameter. Tree height growth is independent of stand density. Simply, stand density can be used to restrict branch diameter growth below the critical 35 mm dimension and branch pruning in lifts to a specified 5 m, 7.5 m or 10 m height on the sawlog crop trees without impairing tree health and vigour.

Both branch size and angle have been improved in the first stage of the breeding programme where a gain of about 30 percent has been achieved in the number of trees with acceptable branching character. Coupled with a 15 percent increase in height growth, earlier scheduling of pruning operations is possible and will be important in maximizing objectives.

Initial stocking of 1100 spha has been used in the majority of progeny trials on the coastal plain. Control of branch diameter has been achieved on each of the major site types. On Marginal sites, a lower density can be used to control branch diameter growth. Essentially, extra pine trees are planted as "nurse" trees to control branch development of the sawlog crop and to suppress shrub vegetation.

Between 4 Rows → Between plants

Prescription: planting density

: plant at 3 x 3.3 m spacing (1000 spha).
: cull to 800 spha at time of first pruning.

3 m between Rows for harvesting. either.

2.3 Pruning

Maximum knot size of 35 mm and 15 cm knotty core are set as quality requirements for the sawlog. When to prune is a decision dictated by the height of the tree. Pruning trials have shown that there is minimal impact on growth when green pruning to retain 40 percent of tree height as crown.

Prescription: pruning

a: tree height 5-6 m, prune 800 spha to a height of 2 m.
b: tree height 10 m, prune 250 spha to a height of 5 m.
c: tree height 13 m, prune 100 spha to a height of 7.5 m.
d: tree height 17 m, prune 50 spha to a height of 10 m.

Notes

a. Silviculturally, there is no reason to prune the nurse trees; they are pruned to facilitate access and for fire protection. Malformed and small trees are culled leaving a growing crop of 800 spha.

b. Sawlog crop is increased to 250 spha to improve the selection of the 100 crop trees at the later pruning lift. This also provides an intermediate sawlog harvest of 150 spha. On critical water intake areas, consideration could be given to pruning only 100 spha.

c. Sawlog pruned length of 7.5 m is achieved and marks the end of the TEND model. To achieve both land use objectives, all nurse trees must be thinned immediately, either commercially (yield 55 m^3/ha, average diameter 18 cm) or non-commercially, leaving the 250 spha sawlog crop.

d. As nurse trees are removed and there is no restriction on branch diameter growth, it may be necessary to annual prune 50 spha up to this upper height limit. Using the "squirrel", this should not present any operational or economic problems.

2.4 Thinning and growing density

The Pinaster GROW model grows trees through a density range of 7 to 17 m^2/ha, and has an average rotation density of 11 m^2/ha. Individual tree growth and water through put will be maximized through this regime.

Prescription: thinning

Initial			End	
Basal area	stocking	dbhob	Basal area	dbhob
1. TEND				
0	800	0	18-20m^2/ha	17-18cm
2. GROW				
7 m^2/ha	250	18-20cm	17m^2/ha	30cm
7 m^2/ha	100	30cm	16m^2/ha	45cm
8 m^2/ha	50	45cm	16.5m^2/ha	65cm

2.5 Fertilizer application

Successful establishment of Pinus pinaster on sands requires the application of phosphate fertilizer. Initial application rate of 60 g superphosphate is adequate. This is critical on Bassendean and Marginal sites.

On Marginal site types, because of the low amounts of iron and organic matter in the profile to hold phosphates, it is essential to apply fertilizer at frequent intervals. Several research trials have shown that phosphates must be re applied by the second or third year. Pine roots cover the site by the age of 3 years. Broadcast spreading of superphosphate in Spring to the 3-year-old pine is recommended. Fertilizers should then be re applied at 4 year intervals through to the end of the TEND model.

On Bassendean types, pines are first re-fertilized at the age of 8 years, after the low pruning and culling operation. This is adequate to take the tree through to the GROW model.

It is not necessary to re-fertilize Spearwood types during the TEND model. However as the distinction between Spearwood and Marginal types is continuous, it is necessary to have a flexible approach to the application of fertilizer. For example, if a designated Spearwood type fails to perform as expected when the first pruning treatment is scheduled, then the fertilizer treatment at age 8 years should be given to that stand.

Fertilizer type to apply? Phosphorus has been shown as the principal limiting nutrient on these sandy soils. Response to added nitrogen fertilizers has been variable. Large responses to added N in diameter growth have been achieved on grey sands although effects on height growth have been minimal. TEND model treatments are applied to maximize height growth, while controlling diameter growth to restrict branch development. For this reason, the use of nitrogenous fertilizers in the TEND model is not proposed.

Fertilizer timing? In research WP 2/81 early winter (April-July) application of fertilizer to young and intermediate age pines on grey sands resulted in increment loss, smaller needles and lower foliar P concentrations in the second year, relative to an optimum September application. Timing was not critical on yellow sands although increment was lower for the April spreading; August-September was optimum.

The GROW model is concerned with diameter growth of the sawlog crop. Trials have shown positive annual responses for up to 5 years after fertilizer treatment and added response to extra P and NP mixtures. Economic analysis is required of higher P, NP mixtures and more frequent application before these treatments can be recommended.

It is proposed to establish an N fixing lupin crop under the 50 spha sawlog crop and to maintain lupins by regular triennial application of superphosphate over the final years of the rotation. Large diameter responses are certain and the modification of the soil environment through continuous N input should be beneficial to the establishment of the following rotation. Study is required to formulate prescriptions, and to quantify effect of lupins on water production and quality, as well as timber production.

Prescription: application of superphosphate

Age	Bassendean type	Spearwood type	Marginal type
0 years	60g	60g	60g
3	-	-	250kg/ha
7	-	-	300kg/ha
8	500kg/ha	-	-
11	-	-	300kg/ha
16	(T14) 500kg/ha	(T14) 500kg/ha	300kg/ha
20	-	-	(T18) 300kg/ha
23	(T20-21) 500kg/ha	-	-
24	-	(T20-22) 500kg/ha	-
25	-	-	400kg/ha
31	(T28-30) L,400kg/ha	-	(T27-29) 400kg/ha
32	-	(T29-32) L,400kg/ha	-
34	200kg/ha	-	-
35	-	200kg/ha	-
37	200kg/ha	-	400kg/ha
38	-	200kg/ha	-
40	CF		-
41		CF	-
43			(T39-42) L,400kg/ha
46			200kg/ha
49			200kg/ha
52			200kg/ha
			CF
Total superphosphate =	2300kg	1800kg	3650kg

Notes : (T14) etc., approximate timing of thinning. There is a two year delay after first thinning and pruning to 7.5 m, to the application of fertilizer, to allow for recovery of the crop tree. Pruning to 10 m proceeds from age 16 years.

: Fertilizer applications on optimum sites are spaced at approximate intervals of 8 years in GROW and are applied in either the first year or second year after thinning.

: On Marginal types, 300kg superphosphate/ha is applied at intervals of 4 years in TEND, increasing to 400kg/ha at intervals of 6 years in GROW.

: Prescription allows for the establishment and maintenance of a lupin crop under the sawlog crop of 50 spha, for the final 10 to 15 years of the rotation.

3. PINASTER MANAGEMENT MODEL

The rotation is divided into two parts for the Pinaster Management Model, TEND and GROW. The TEND model is concerned with the establishment and the cultural treatment of the sawlog crop. Maximization of height growth to reduce the period of TEND and site occupancy to control shrub vegetation is important.

The prime concern of the GROW model is diameter growth of the sawlog tree. This is site and stand density dependent. The thinning regime will maintain an average density of 11 m^2/ha and the fertilizer regime prescribed will optimize tree diameter growth.

Objective of the model is to grow a 65 cm dbhob sawlog crop tree, pruned to a height of 10 m. Prescriptions are aimed at reducing rotation length, increasing the volume mai and the economics of timber production.

3.1 Operations of the Pinaster Management Model

I. TEND

* survival: complete cultivation of site for scrub and weed control; furrowlining for wetting of hydrophobic sands.

* establishment: plant 1000 pedigree spha at 3 x 3.3 m spacing; 60 g superphosphate/seedling at planting; first and third year cultivation of site for scrub and weed control; early re-application of superphosphate on marginal site types.

* fertilizer: superphosphate application to maximize height growth to allow early manipulation of pruning.

* cultural:
  height 5-6 m, prune 800 spha to 2 m height, cull malformed and small trees.
  height 10 m, prune 250 spha to 5 m height.
  height 13 m, prune 100 spha to 7.5 m height and thin to 250 spha.
  height 17 m, prune 50 spha to 10 m height, in more than one lift.

* inventory: site vegetation mapping prior to clearing; assessment of pine height at age 5-7 for timing of first pruning and a check on site typing; I & P plot establishment and top height mapping for confirmation of site indexing.

II. GROW

* fertilizer: superphosphate application (and lupins?) for maximum diameter growth of sawlogs.

* thinning: thinning to maximize diameter growth of sawlog trees and water through put to aquifer. Grow trees through a density range of 7-17 m^2/ha, average density for GROW is 11 m^2/ha. A higher basal area at the end of TEND is necessary to control branch size for the development of the sawlog crop tree.

  T1. 800 spha, 18-20 m^2/ha → 250 spha, 7 m^2/ha.
  T2. 250 spha, 17 m^2/ha → 100 spha, 7 m^2/ha.
  T3. 100 spha, 16 m^2/ha → 50 spha, 8 m^2/ha.
  CF. 50 spha, 16.5 m^2/ha → CF.

* inventory: periodic assessment of permanent sample plots, GROW trees and schedule harvesting.

4. FRAMEWORK PLAN

Growth rates of Pinus pinaster are directly related to site quality and to genetics of the planting stock. This gives a convenient framework for prescriptions and management of the plantations.

4.1 Site quality

Havel (1968) assessed the plantation potential of the coastal plain sands on an ecological basis. Continuous variation in soils and vegetation was evident and Havel divided the continuum into 11 types, 7 of which had varying potential for pine growth. Optimum sites were defined in each of the two main sand dune systems. Less favourable sites would also need to be planted to give larger plantation units with more regular boundaries.

Havel's vegetation classes have been grouped to define three major management types:

Bassendean type: Havel I and J, optimum for pine growth; soils are mainly humus podsols of 1-4 m leached grey sand overlying an organic or iron hard-pan; cation exchange capacity is directly related to the organic matter content.

Spearwood type: Havel C, D and E, fertile sands but also prone to drought death (particularly C); soils are podsolized sands yellow to brownish-yellow in colour, weakly acid or neutral with iron concentration ranging from 0.2 to 0.5%. Series occurs to the west of the Bassendean type.

Marginal type: Havel H and F, marginal for growth; type F is in the transition zone of the major systems, it is characterized by deep pale yellow sands with a strongly leached surface. Type H is found in the Bassendean system; it is a deep pale grey sand strongly leached throughout, dry at the surface and moist at depth. These dune sands have extremely low iron and organic matter contents.

The Gnangara plantations are primarily on the Bassendean dune system and Yanchep plantations on the Spearwood system. A considerable part of the Pinjar plantations are on transitional sites or Marginal type. It should be noted that there have been considerable areas in the eastern Pinjar group that have been incorrectly classified as Spearwood types when in fact they are Marginal.

The correct delineation of site type is critical to the Pinaster Model as prescriptions, particularly the timing of fertilizer treatments, are site dependent. Native vegetation surveys are carried out on all proposed plantation areas to delineate planting area and the site types. This survey dictates future prescriptions to the plantation. There is a check on site typing when stands are height mapped at age of 5-7 years for the timing of the first pruning operation. Accurate site maps can be obtained from I & P section after they establish plots at about age 10 years. Top height information from I and P plots can be used to stratify the plantation area into the three broad management types.

4.2 Genetics of planting stock

Prior to 1972, seed used for planting was collected from the natural Pinus pinaster forests in Portugal. After 1972, an improved (pedigree, orchard) seed source has been used for all P. pinaster plantings. The tree breeding programme is responsible for a major reduction of the rotation length. Increased height growth (15%) of pedigree stock reduces the TEND period by 3 years and increased diameter growth (20%) reduces the GROW period by 7 to 11 years.

The genetic quality of the pedigree planting stock used in plantations is continually improving. This improvement can be illustrated by seed collected from (a) Joondalup orchard, (b) Joondalup orchard culled of poor genotypes, (c) Mullaloo orchard containing best local and Portugal selections, (d) Mullaloo orchard culled of poorer performing genotypes. A further large improvement is anticipated from a second generation seed orchard; however seed can not be available before 1996.

4.3 Framework

Rotation lengths to grow a 65 cm dbhob sawlog are tabulated for an idealized Pinaster Management Model to illustrate differences within the framework.

Framework Plan	Bassendean	Spearwood	Marginal
Pedigree	42 years	45	60
Routine	53	57	74

The division into either pedigree or routine plantations is complicated by a range of silvicultural prescriptions applied in the past. These can be summarized as:

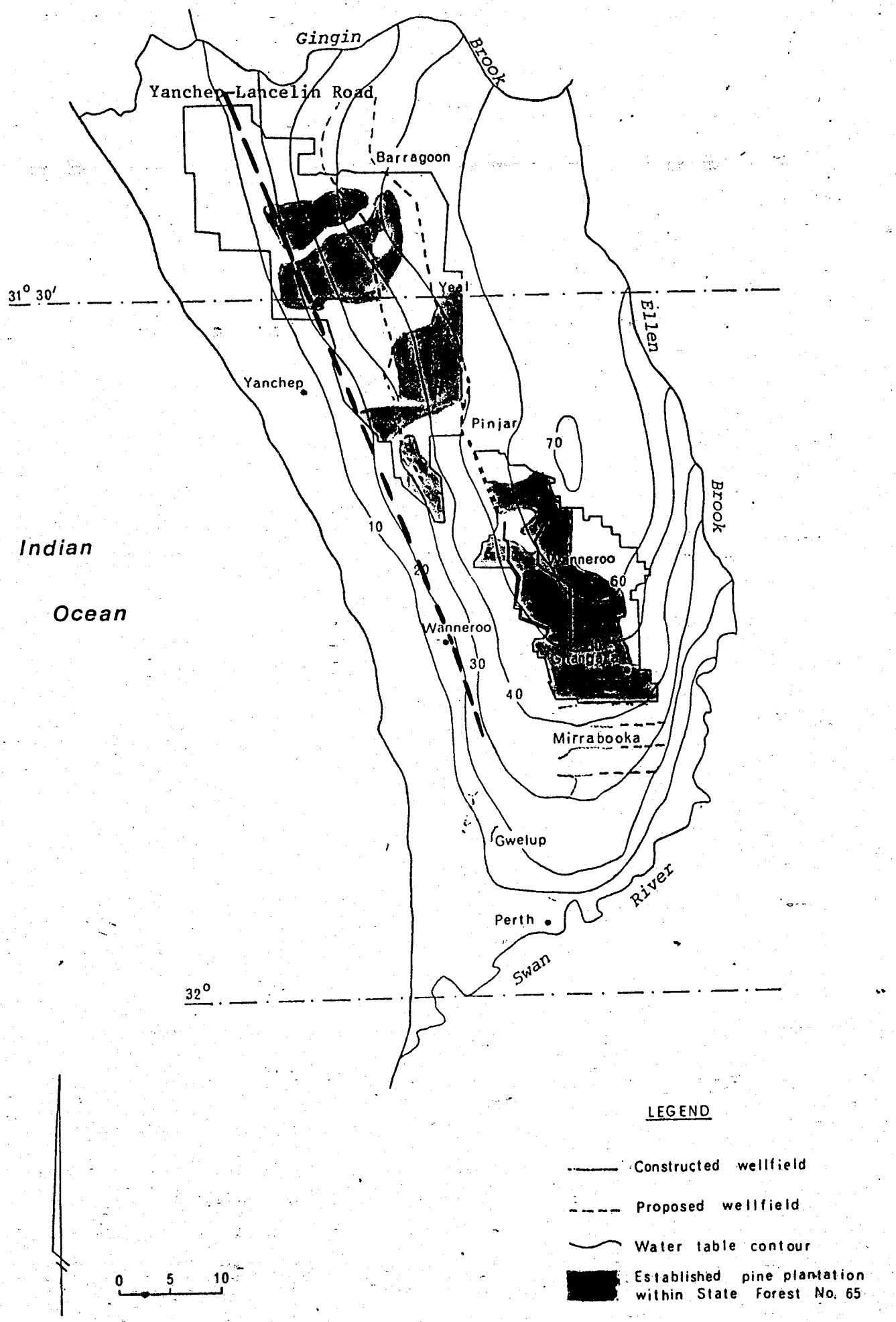
: routine plantations /other provenances (pre-1945)
: routine plantations/Leiria provenance/pre-Silvic 70
: routine plantation /Leiria provenance/post-Silvic 70
: pedigree plantation/prescription 81
: pedigree plantation/prescription 84

Regardless of classes, the plantation objective is the same i.e. production of large dimension sawlogs, minimizing rotation length. To achieve this objective all stands should be brought in line with the GROW model. Priorities for conversion will depend on water production objectives.

5. PRIORITIES OF LAND USE

Major land use objectives are production of pine sawlogs and water to underground aquifers. Other land uses include flora conservation areas, honey license areas, recreation in native woodland and pine plantation and limited mining.

FIGURE 1: Gnangara Mound showing groundwater table configuration, location of Metropolitan Water Board wellfields and boundary of State Forest No. 65.



The plantation resource and water resource are shown in figure 1. At present only the Wanneroo and Mirrabooka wellfields are operational, drawing on water beneath the Gnangara group of plantations. The Pinjar, Yeal and Barragoon wellfields, under the Pinjar and Yanchep plantation groups may be constructed and be operational in the mid 1990s. Plantations in the Yanchep group on the western side of the Yanchep-Lancelin road lie outside the water production area.

6. PRIORITIES OF MANAGEMENT

The Gnangara plantation contains the oldest and largest pine trees, and is on an operational wellfield. In this plantation, there should be no stand carrying more than 20 m^2/ha basal area, as the principal land use objectives are compromised. The plantation has a high public profile along the Gnangara road southern boundary and it should demonstrate how the Department manages pine plantations. This timing is now critical. I believe that the Groundwater recharge study report at the end of this year will come out strongly on the negative effects of pines on water recharge. The Forests Department must act before this and reduce stands to the stockings and basal areas prescribed in GROW. This will require harvesting of sawlogs.

The older Gnangara stands require sawlog thinning in accord with GROW. The retained sawlog crop trees have been pruned to a height of 4-5 m but branches above this are small because of the initial high stocking and late thinning. The "other provenance" stands planted before 1945, should be programmed for clear falling and replaced with pedigree leiria stock. This will first require a solution of the second rotation establishment problem. Some small areas of Landes close to the Gnangara settlement and on Marginal site type could be retained at 50 spha for recreational use.

Intermediate age stands, crop trees pruned to 4-5 m, but unthinned require urgent thinning and subsequent fertilization to GROW. In areas that have been thinned, further thinning to reduce basal areas to prescribed levels is required. Stands that have been managed according to the "silviculture 70" prescription require thinning to the 250 spha crop trees. On these stands, particularly the "silviculture 70" stands, pruning height should be extended to at least 7.5 m to fit in with the new model.

Young-intermediate age stands growing on Marginal site types have received least management where by nature, they are the most difficult to grow. Depending on stand condition, they should be pruned, thinned to waste and fertilized to develop a sawlog crop than can GROW.

Pedigree stands at Gnangara have been culled to 300 spha at an early age. More frequent pruning will be necessary in TEND to restrict knot size to 35 mm and additional cultivation may be required on the poor sites to control scrub. Regular fertilization of the Marginal types should not be overlooked.

Plantations in the Pinjar group and Yanchep group have a lower immediate priority for water production and must receive a lower priority in thinning treatment to the Gnangara plantation. However pruning of crop trees prescribed in TEND has an equal high priority. Particular attention must be given to higher pruning in the Spearwood P68 stands non-commercially thinned to 250 spha and to continuous pruning in the pedigree stands culled to 300 spha.

There have been obvious errors in site classification in the Pinjar-Yanchep plantations. Marginal types have been classified as Spearwood and consequently have not received the critical re-application of superphosphate. All Spearwood types should be closely inspected and if the pines are not growing as expected, they should be listed for remedial fertilizer treatment.

SCHEDULE PPP.B - Pedigree Pinus Pinaster. Bassendean

Age		Prescription
0	:	Winter, plant at 3 x 3.3 m spacing (1000 spha), spot application of 60 g superphosphate/seedling.
1-2	:	Summer, inter-row cultivation.
4	:	Summer, inter-row cultivation.
7	:	Tree height 5-6 m, low prune 800 spha to a height of 2 m; cull malformed and small trees.
8	:	Early spring, broadcast 500 kg/ha superphosphate.
12	:	Tree height 10 m, select the best formed, vigorous and spaced 250 spha and prune to 5 m (fifth row outrow).
14-15	:	Tree height 13 m, select the best formed vigorous and spaced 100 spha and prune to 7.5 m.
	:	Thin to retain 250 crop spha, residual basal area of 7 m^2/ha (yield 550 trees, average dbhob 18 cm, volume 58 m^3/ha).
16	:	Early spring, spread 500 kg/ha superphosphate.
17-19	:	Tree height 15-17 m, select best formed, vigorous and spaced 50 spha and progressively prune to a height of 10 m.
20-21	:	Basal area 17 m^2/ha; Commercial thinning to 100 spha, residual basal area of 7 m^2/ha (yield 150 trees, average dbhob 30 cm, volume 56 m^3/ha).
23	:	Early spring, spread 500 kg/ha superphosphate.
28-30	:	Basal area 16 m^2/ha; Commercial thinning to 50 spha, residual basal area of 8 m^2/ha (yield 50 trees, average dbhob 45 cm, volume 56 m^3/ha).
31	:	Crush thinning debris, spread 400 kg/ha superphosphate and sow lupins in May.
34	:	May, spread 200 kg/ha superphosphate.
37	:	May, spread 200 kg/ha superphosphate.
38-42	:	Basal area 16.5 m^2/ha; Clear fell 50 spha, average dbhob of 65 cm, volume 147 m^3/ha - 80 m^3/ha in 10 m pruned sawlogs.

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Basal area = about average of native vegetation

SCHEDULE PPP.S - Pedigree Pinus Pinaster. Spearwood

Age		Prescription
0	:	Winter, plant at 3 x 3.3 m spacing (1000 spha), spot application of 60 g superphosphate/seedling.
1-2	:	Summer, inter-row cultivation.
4	:	Summer, inter-row cultivation.
7	:	Tree height 5-6 m, low prune 800 spha to a height of 2 m; cull malformed and small trees.
12	:	Tree height 10 m, select the best formed, vigorous and spaced 250 spha and prune to 5 m (fifth row outrow).
14-15	:	Tree height 13 m, select the best formed, vigorous and spaced 100 spha and prune to 7.5 m.
	:	Thin to retain 250 crop spha, residual basal area of 7 m^2/ha (yield 550 trees, average dbhob 18 cm, volume 58 m^3/ha).
16	:	Early spring, spread 500 kg/ha superphosphate.
17-19	:	Tree height 15-17 m, select the best formed, vigorous and spaced 50 spha and progressively prune to 10 m.
20-22	:	Basal area 17 m^2/ha, commercial thinning to 100 spha, residual basal area 7 m^2/ha (yield 150 trees, average dbhob 30 cm, volume 56 m^3/ha).
24	:	Early spring, spread 500 kg/ha superphosphate.
29-32	:	Basal area 16 m^2/ha, commercial thinning to 50 spha, residual basal area 8 m^2/ha (yield 50 trees, average dbhob 45 cm, volume 54 m^3/ha).
32	:	Crush thinning debris, spread 400 kg/ha superphosphate and sow lupins in May.
35	:	May, spread 200 kg/ha superphosphate.
38	:	May, spread 200 kg/ha superphosphate.
41-45	:	Basal area 16.5 m^2/ha, clear fell 50 spha, average dbhob 65 cm, volume 136 m^3/ha - 80 m^3/ha in 10 m pruned sawlogs.

SCHEDULE PPP.M - Pedigree Pinus Pinaster. Marginal

Age		Prescription
0	:	Winter, plant at 3 x 3.3 m (1000 spha); spot application of 60 g superphosphate/seedling.
1-2	:	Summer, inter-row cultivation.
3	:	Early spring, broadcast 250 kg/ha superphosphate.
4	:	Summer, inter-row cultivation.
6	:	Optional, summer inter-row cultivation.
7	:	Early spring, broadcast 300 kg/ha superphosphate.
9	:	Tree height 6 m, low prune 800 spha to a height of 2 m; cull malformed and small trees.
11	:	Early spring, broadcast 300 kg/ha superphosphate.
14-15	:	Tree height 10 m, select best formed, vigorous and spaced 250 spha and prune to 5 m (fifth row outrow).
16	:	Early spring, broadcast 300 kg/ha superphosphate.
18-19	:	Tree height 13 m, select best formed, vigorous and spaced 100 spha and prune to 7.5 m.
	:	Thin to retain 250 crop spha, residual basal area 7 m^2/ha (yield 550 trees, average dbhob 17 cm, volume 50 m^3/ha).
20	:	Early spring, broadcast 300 kg/ha superphosphate.
21-24	:	Optional, tree height 15-17 m, select best formed, vigorous and spaced 50 spha and progressively prune to 10 m.
25	:	Early spring, broadcast 400 kg/ha superphosphate.
27-29	:	Basal area 17 m^2/ha, commercial thinning to 100 spha, residual basal area 7 m^2/ha (yield 150 trees, average dbhob 30 cm, volume 54 m^3/ha).
31	:	Early spring, broadcast 400 kg/ha superphosphate.
37	:	Early spring, broadcast 400 kg/ha superphosphate.
39-42	:	Basal area 16 m^2/ha, commercial thinning to 50 spha, residual basal area 8 m^2/ha (yield 50 trees, average dbhob 45 cm, volume 52 m^3/ha).
43	:	Crush thinning debris and scrub, spread 400 kg/ha superphosphate and lupins in May.
46	:	May, spread 200 kg/ha superphosphate.
49	:	May, spread 200 kg/ha superphosphate.
51	:	May, spread 200 kg/ha superphosphate.
54-60	:	Basal area 16.5 m^2/ha, clear fell 50 spha, average dbhob 65 cm, volume 130 m^3/ha - 70 m^3 in 7.5 m pruned sawlogs or 80 m^3 in optional 10 m pruned sawlogs.