SITE PREPARATION FOR THE ESTABLISHMENT OF STATE-OWNED PLANTATIONS IN WESTERN AUSTRALIA

AN OVERVIEW

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INTRODUCTION

The area of state-owned plantations as at December, 1992 was 77 904 hectares. This is comprised of:

Pinus radiata - 42 964 hectares of which 6 187 hectares is planted on private property under sharefarm agreements. These figures include approximately 4 000 hectares which is considered unproductive for various reasons.

Pinus pinaster - 28 572 hectares. A small proportion of this amount is other coniferous species.

Euc. globulus - 10 232 hectares. Of this amount 10 116 hectares is planted on private property under timberbelt or broadscale sharefarm agreements.

The annual planting program is as follows:

Pinus radiata - 2 500 hectares, of which 1 000 hectares is second rotation and 1 500 is new plantings on private property under sharefarm agreements.

Pinus pinaster - 750 hectares. Of this 450 hectares will be second rotation and 250 hectares will new plantations established under sharefarm arrangements on private property.

Euc. globulus - The program is for 1 000 hectares to be planted in 1993, increasing to 2 000 hectares each year thereafter. Plantings will be on cleared private property and will be established under sharefarm arrangements.

It is projected that, in order to meet short-term commitments, the area of land under plantations will reach 115 000 hectares.

The species breakdown is expected to be:

Pinus radiata - 45 000 hectares

Pinus pinaster - 40 000 hectares

Euc. globulus - 30 000 hectares

PHYSICAL RESOURCE SURVEYS AS THEY RELATE TO SITE PREPARATION.

P. RADIATA.

A survey of the physical resources is undertaken before planting an area with trees. This survey provides information on a broad range of physical attributes (soil, water and terrain).

The aims of the physical resource survey is to determine:

1. Topography and site hazards. For example: are slopes within the limits set for harvesting? Are there large areas of rock outcrop? Will waterlogging be a problem? Are there powerlines or other easements?

2. Potential tree performance. Unlike the site evaluation system developed for *E. globulus* (Inions 1991), the system for *P. radiata* does not equate physical attributes to growth potential. While a definitive relationship between site attributes and growth is some way off, an informed estimation can be made

based on experience. The potential hazards to be recognised include drought, wind-throw, waterlogging and root growth impediments.

3. Management requirements. The physical resource survey identifies areas that may require specific treatment in order to establish trees successfully. For example: "pans" will be identified and the recommendation will be to rip to a certain depth. Areas subject to seasonal waterlogging will be identified and will be accompanied by a recommendation to mound. Highly erodible soils are "flagged" so that plantations managers take appropriate action.

4. Extension of research results obtained elsewhere. The results of trials carried out on similar soils elsewhere are taken into account and applied to a new area. This may be in the form of specific cultivation or fertilizer recommendation.

The physical resource survey has two major stages:

- description of the nature and distribution of soils and landforms in the area,
- Interpretation of these observations to answer the questions relating to tree performance and management requirements.

P. PINASTER.

A system to determine site potential for the growth of *P. pinaster* on the Northern Swan Coastal Plain was developed by Havel (1976). The system relates growth potential of *P. pinaster* to native vegetation.

The main determinants of pine growth potential and vegetational patterns is the degree of leeching undergone by the soil and the moisture of the site. The extremes are represented by (a) strongly leached droughty sites and by (b) weakly leached moist sites. For each site /vegetation type a set of shrub indicator species was defined.

Based on the survey, recommendations were made regarding the establishment strategy. For example: a delay in planting was recommended for areas susceptible to winter flooding .

A method for assessing site potential of cleared farmland in the plantation extension area north of Perth has yet to be developed.

E. GLOBULUS.

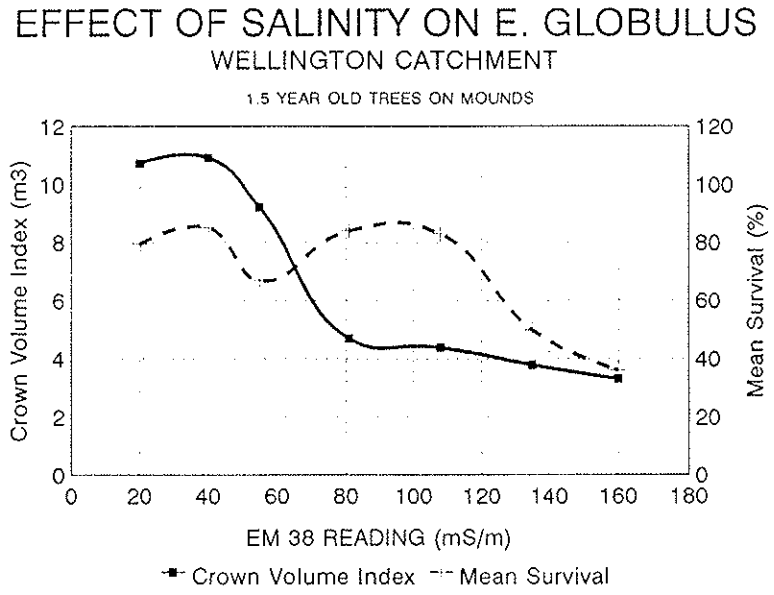
The evaluation of land for *E. globulus* plantations is currently undertaken using the *E. globulus* Growth Simulator (EGGS). This model relates growth of *E. globulus* to selected environmental attributes. Using a combination of climatic, soil physical and soil chemical data the model predicts site potential in terms of a site index (top height at age 5).

EGGS does not predict changes in productivity resulting from site manipulation. For example: EGGS provides a statement of predicted productivity for each subjectively identified land unit. The potential improvement in productivity that may occur as a result of amelioration is not predicted. Field personnel make a subjective assessment, supported by core sampling and deep augering, of each land unit to determine site preparation strategies.

Salinity has the potential to become a major factor influencing the productivity of *E. globulus* plantations in Western Australia. Identification of sites that are affected by salt is an important consideration when assessing land for conversion to *E. globulus* plantations. Visual indicators include the presence of Barley grass (*Hordeum* spp.) and Common Cotula *(Cotula australis).* A recent study by the Western Australian Department of Agriculture suggests that soil conductivities (measured by an EM 38) in excess of 50 mS/m will impact

on the growth of *E. globulus* and in excess of 100 mS/m will reduce survival (fig 1). However, as the conductivity of soil is dependant on moisture content, soil texture and soil chemistry, EM38 readings provide a guide only and calibration for different land units may be necessary. This requires further investigation, especially in relation to the depth to saline soils and water.

Figure 1.



SITE PREPARATION FOR THE ESTABLISHMENT OF *P. RADIATA.*

FIRST ROTATION.

Since 1987 all new plantings of *P. radiata* have been on cleared farmland. Prior to this, much of the planting was on land cleared of native forest. Because of the superior nutritional status of farmland, compared to virgin land, there is a greater range of soil types available for plantation establishment. Consequently, there is now much more attention paid to edaphic and geomorphic factors when establishing *P. radiata* plantations than was the case in the past. For example: detailed soil surveys are now a prerequisite to planting and site preparation plans are prepared from these and other physical surveys, similar to the system developed in Queensland (Foster and Costantini, 1991).

Site Preparation Techniques

1. Ripping. All ex pasture sites are ripped to break the "traffic pan" that is a feature of agricultural land. Studies show that tree survival and early growth (up to age 2 years) is significantly improved by ripping to a depth of 500mm (fig. 2). Trials have not demonstrated any advantage in ripping below 500mm on soils considered suitable for *P radiata* in Western Australia. There is some evidence to suggest a greater likelihood of pathological infection associated with deep ripping. Lesions were evident at the root collar of trees and it is hypothesised that this is due to soils of low mechanical strength combining with wind to cause stress wounds. Added to this, localised waterlogging in the riplines creates an environment conducive to fungal infection. *Phytophthora megastima* and *Phytophthora citricola* have been recovered from roots of dead and dying trees. There has been no growth responses to ripping on virgin soils.

   A trial comparing different ripper designs showed that there was less potential for erosion when "winged" rippers were used instead of narrow tined rippers. However there was no relationship between the cross-sectional area of shattered soil and tree volume at age 4 (Fig 3).

Figure 2. EFFECT OF RIPPING TO 400mm ON GROWTH AND SURVIVAL OF 1 YEAR OLD P. RADIATA

TREES PLANTED ON PASTURED SANDY SOILS AT ESPERANCE

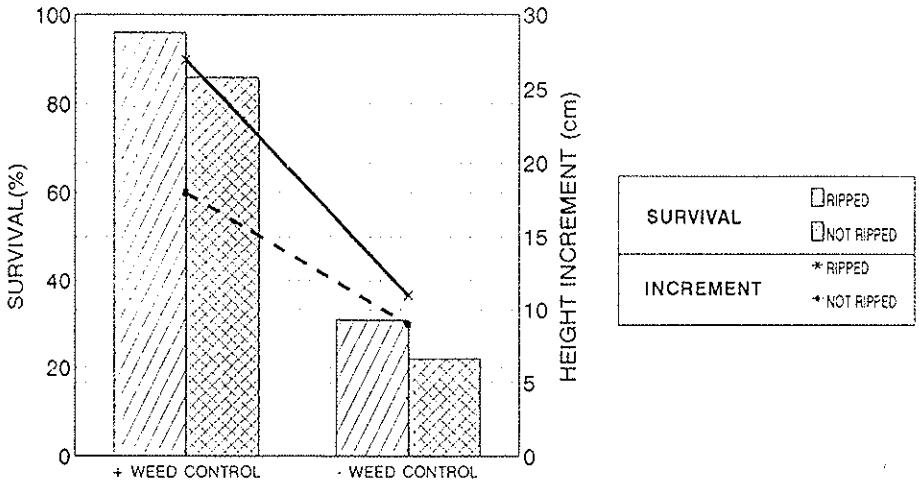
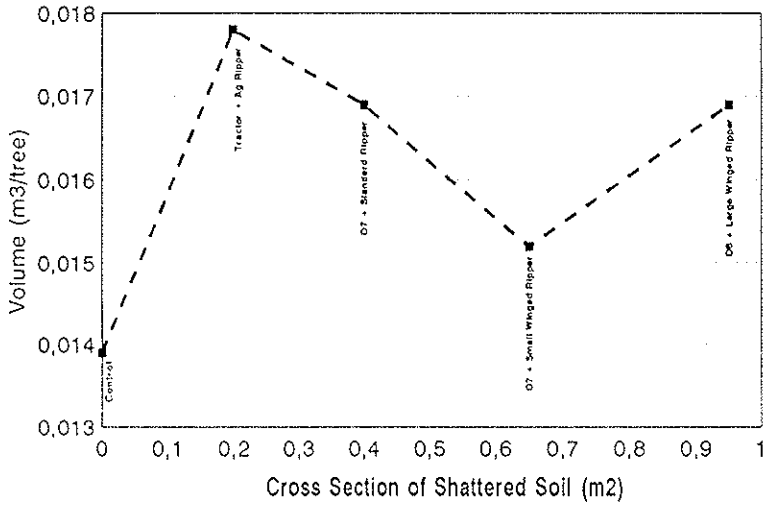


Figure 3. EFFECT OF AREA OF SOIL SHATTER ON THE GROWTH OF P. RADIATA

Growth data at age 4 years



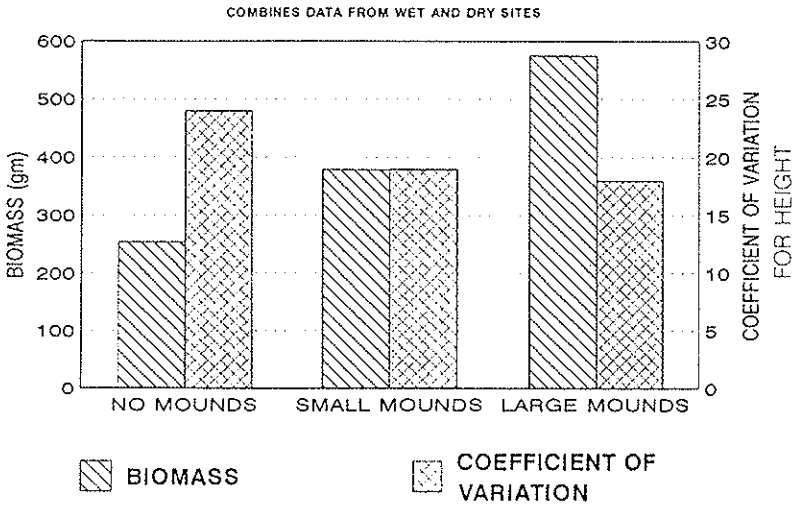
2. Mound Ploughing. Mounding has experienced wide acceptance as a technique to improve survival and growth on seasonally waterlogged sites. Experience has shown that unless mounding is integrated with a drainage strategy, potential gains may not be realised. It is now normal practice to prepare a drainage plan when mounding is prescribed.

Growth responses have been recorded across a range of sites, including deep aolian sands. A study is underway to identify the sites where a response can be expected. This study will compare mounding with other methods of cultivation.

Three Savannah mound ploughs have been acquired recently. A HD636 was purchased specifically for second rotation establishment. However, following studies that compared the growth of *P. radiata* on different sized mounds (fig. 4) this machine is being widely used for first rotation preparation, particularly on very wet sites that are difficult to drain. The main disadvantage of this machine is poor manoeuvrability and therefore it has limited application for timber belts. Also, the size of the mounds is unpopular with farmers as it interferes with

normal farming activities. In response to the evidence supporting larger mounds and the need to rip on all pastured land, two Savannah TPR4 mound ploughs were acquired. These incorporate ripper attachments and a saving of between $35 and $80 per hectare is realised by ripping and mounding in a one-pass operation.

Figure 4. GROWTH OF P. RADIATA ON DIFFERENT SIZE MOUNDS
DATA AT AGE 1.2 YEARS



Small two-disc mound ploughs are still widely used. Most of these have been adapted to provide a ripping capability. These machines are used where surface drainage is not an issue.

It is probable that the growth responses attributed to mounding on dry sites are attributed to cultivation and to the concentration of nutrients (Attiwill, *et. al.*, 1985). A study is underway that aims to identify the factors that contribute to the responses by trees that mounds provide on these soils.

Experience has shown that early installation of mounds is important to affect efficient weed control by herbicides. It appears that mounds require a period for consolidation otherwise herbicides erode from the top of the mound.

The standard "hour glass" design compacting rollers that were common on most mounders have been replaced by rollers with a shallow "M" profile. This provides a flatter top profile to the mound which is easier for hand planters to walk on. In addition, the surface is less conducive to erosion of herbicides and allows good moisture infiltration into the mounds. The latter feature is particularly important for flushing salt out of mounds where trees are being established in saline areas (Ritson and Pettit, 1992).

3. Furrowlining. This is a practice confined to the deep sands of the coastal plain. While the majority of the soils in this area fall into the "Basendean" association which are unsuitable for *P. radiata*, there is a sizeable area of "Spearwood" sands where the growth of *P. radiata* is satisfactory. *P. radiata* plantations on these soils are confined to areas south of Perth because of problems associated with sun scald in northern areas. A non wetting surface is a feature of some soils of the coastal plain (Roberts and Carbon, 1971) . Furrowlining breaks the surface allowing wetting of lower soil profiles. Other benefits include: reduced wind desiccation and weed control (see section on *P. pinaster* for further comment on this subject). Second rotation establishment forms the majority of plantings in this area. However, small parcels of farmland come available at times.

Furrows are formed using a modified blade plough. A "V" shaped furrow approximately 300mm deep and 80mm wide at the soil surface is formed. Planting machines have not been developed to operate along this type of furrow.

4. Ploughing. Since *P. radiata* plantations have been established on cleared farmland, ploughing has not been widely used as a means of preparing soils for planting. Ploughing was used as a method for controlling regrowth after native forest was cleared. Nowadays ripping and mounding have replaced ploughing as the primary method of cultivation.

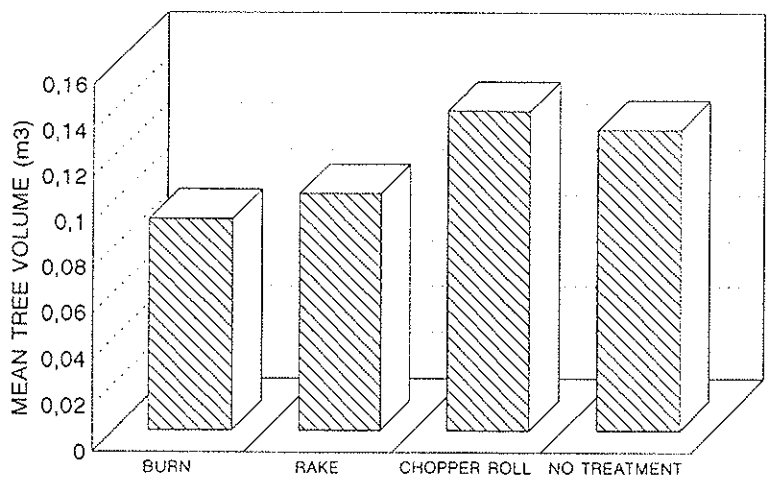
There is evidence to suggest that ploughing prior to mounding is beneficial in terms of achieving effective weed control on mounds. The profile of mounds formed after ploughing is more regular and smooth than mounds formed on non-ploughed ground.

Pre-plant Weed Control. A mixture of the herbicides amitrole and atrazine (eg, Vorox AA) is the most commonly used and is applied in a strip between 1.5 metres and 2 metres wide. Where woody weeds or perennial pasture weeds occur a mixture of hexazinone and atrazine is used. When applied with amitrole, the rate of atrazine is varied according to the soil type, soil moisture and weed spectrum. The maximum rate of atrazine that is applied is 3.5 kg/ha. on wet , heavy soils or sites where Annual Rye Grass *(Lolium rigidum)* occurs. A lower rate of 2.5 kg/ha. is applied to dry or light textured soils. The rate of amitrole is 1.28 kg/ha for all sites. The rate of atrazine in the hexazinone/atrazine mixture is 2 kg/ha. while the rate of hexazinone is 1.5 kg/ha. On seasonally waterlogged sites it is usual to apply herbicides after planting to ensure residual activity last throughout spring and early summer.

SECOND ROTATION.

The second rotation strategy for *P. radiata* embraces the concept of maximum retention of logging residue. It is accepted that this practice may not be feasible on sites with slopes of 14^{o} or over. Squire (1983) summarised the knowledge relating to the conservation of logging residue in second rotation systems. In response to work elsewhere in Australia, studies were commenced to evaluate the system under Western Australian conditions. One of these was reported by Ward and Walsh (1988). This study was carried out on a red loamy soil (igneous) in the Blackwood Valley and demonstrated significant advantages in a system that retains logging residue. Much of the improvement in survival and growth could be attributed to lower weed densities in plots where logging residue was retained. Results from a more recent trial on a sandy soil confirm the benefits of retaining logging residue (fig. 5) that have been reported elsewhere in Australia.

Figure 5. EFFECT OF DIFFERENT 2R SITE PREPARATION TREATMENTS ON THE GROWTH OF P. RADIATA ON A SANDY SOIL
DATA AT AGE 4.3 YEARS



The introduction of the "residue retention" system into western Australian operations has not been without problems. It has been necessary to change logging practices, particularly in relation to the management of natural pine regeneration and the amount and size of logging waste that can be left on the site. Initially it was thought that the change of standards would add significantly to the cost of logging. However, it was found that a 5 - 10% increase in marketable material was realised which offset the extra cost.

A series of trials have been established to study the effect of different debris management strategies, cultivation and weed control techniques across different soil types.

Site Preparation Techniques.

Logging. The logging specifications call for the removal of material >15 cm in diameter and > 1.5 meters in length. Unmerchantable material that falls within these specifications must be heaped and burned on the plantation break, not within the compartment. Heaps of logging residue that occur as a result of using processors in the logging operation must be spread to provide even distribution of debris.

All standing naturally regenerated trees >75 mm DBH or 3 metres in height must be removed. Smaller material will, for the most part, be controlled by chopper rolling and cultivation.

Chopper Rolling. A drying period of >3 months after logging between the months November to March is stipulated before chopper rolling can proceed. Hardwood stumps are removed prior to chopper rolling. A one-pass operation is carried out with the chopper roller.

A single-drum Savannah chopper roller is used. The machine has a drum length of 3.65 metres and a drum diameter of 1.83 metres. Total weight, fully ballasted, is 23 tonnes.

Ploughing. Broadscale ploughing is not a common practice. This is probably because machines have not been available that will operate on second rotation sites. Recently a heavy-duty HD14 Savannah stump-jump plough was purchased. While this machine was acquired for site preparation in the *P. pinaster* plantations north of Perth, it will be evaluated in *P. radiata* plantations.

Ripping. Where *P. radiata* is grown on lateritic soils ripping to a depth of 70 cm is normal practice. However, there is no data from objective studies to support ripping to this depth. Studies are underway to determine if there is a relationship between depth of ripping, survival and growth. Ripping is not a practiced on the coastal sandplain .

Mounding. With the availability of machinery that will operate on second rotation sites, mound ploughing will become a more common practice, The benefits of cultivation have been reported by Turvey and Cameron (1986) and are supported by observations in Western Australia. Trials have been established to generate objective data that can be used to support economic and silvicultural decisions.

Furrowlining. A machine specially designed to operate in second rotation sites on the Spearwood sands of the coastal plain has been in operation for 3 years. The machine manufactured by Savannah utilises two opposing stump-jump discs to form a furrow approximately 300 mm deep and 800 mm wide at the soil surface.

Pre- plant Weed Control. The herbicides and rates used for second rotation establishment are the same as for the first rotation. Where fire has destroyed the previous crop or been used in the clearing operation, it is usual to apply herbicides broadscale. The decision to apply herbicides before or after planting is dependant on site factors.

With the acquisition of a heavy duty plough, broadscale cultivation to control woody weeds and volunteer pine growth will replace herbicides to some extent. The economic differences will be the subject of a study to commence in 1993.

SITE PREPARATION FOR THE ESTABLISHMENT OF *P. PINASTER.*

FIRST ROTATION.

Planting ceased in 1985 with the decline of suitable land available for new *P. pinaster* plantations . With the recent signing of a contract to supply medium density fibreboard, there has been renewed interest in the development of new plantations in order to meet contractual obligations. If this proposal proceeds, planting will occur under sharefarm agreements on private property north of Perth. The strategy to prepare the sites has yet to be developed. However, it is likely to follow closely that for the establishment of P. radiata on pastured sandy soils.

SECOND ROTATION.

It is less than two years since the decision was made to replant the *P. pinaster* plantations north of Perth after clearfelling. The were two main reasons that influenced this decision were:

1. the commissioning of the MDF plant in Perth has ensured a market for small dimension material. This significantly changed the economic position of the *P. pinaster* estate,

2. plantation forestry is considered by the West Australian Water Authority (WAWA) to be the preferred land use for the area (the plantations lie over a major underground water reserve that is used to supply the Perth metropolitan area).

Like for *P. radiata* plantations, the second rotation strategy for *P. pinaster* will reflect a policy of retaining logging residue where practicable. However, it is anticipated that chopper rolling the residue of full-rotation *P. pinaster* may not be feasible because of the sparsity of material and the size of the unmerchantable portion of 50 year old trees.

The success of re-establishing *P. pinaster* plantations has been mixed. This reflects a lack of a proven strategy. In particular, a strategy to control weeds. The use of herbicides is not a favoured option because of the fear of contaminating the ground water. Cultivation alone is not likely to be successful with the introduction to the area of feral annual and perennial weeds. The questions relating to the method of weed control is the subject of debate and currently there is a proposal to monitor the infiltration, on a trial area, of selected herbicides and determine if contamination of the underground water is a real concern.

In the past three years an average of 409 hectares per year of pine forest has been destroyed by fire. The re-planting of these areas poses problems separate to that of clearfelled full-rotation stands. In addition, a significant area has been classified non productive due to poor nutritional and silvicultural management. This is due to be clearfelled and re-planted.

Until alternative systems are developed logging residue will continue to be burned.

Site Preparation Techniques.

Logging of Full Rotation Stands. Operational trials will commence in 1993 to determine if chopper rolling is feasible after clearfelling full rotation stands. The study will assess logging practice and utilisation with a view to developing an integrated system.

Logging of Non Productive Areas. The majority of the stands that are classified non productive will be clearfelled for processing into medium density fibreboard. The logging operation involves the use of processors which leave dense strips of residue that impinge upon the efficiency of chopper rolling. Operational-scale trials are underway to identify methods of distributing logging residue evenly across the site in order to maximise the efficiency of the chopper roller.

Clearing. Windrowing of logging residue is undertaken soon after clearfelling. Windrows are pushed up at 60 meter centres. These stand through one summer and are burned as soon as the season opens in March.

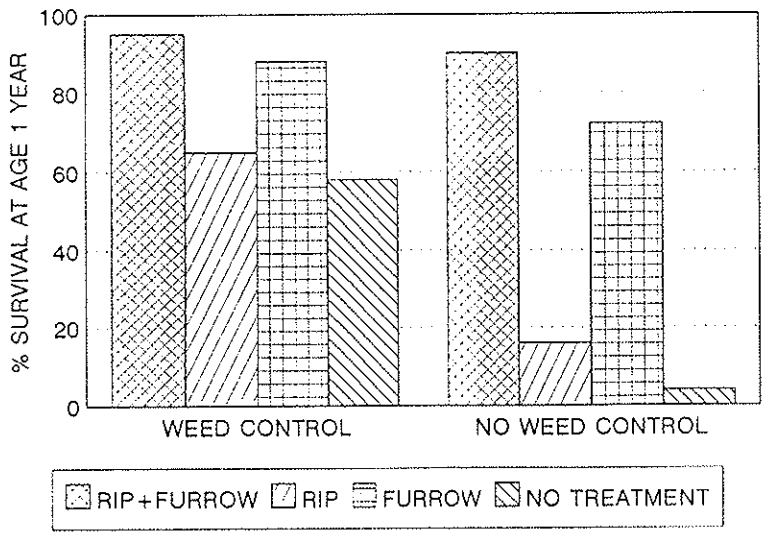
Chopper Rolling. As alluded to earlier, conservation of logging debris is not widely practiced in *P. pinaster* plantations. A major research and development effort is now centred on the *P. pinaster* plantations to develop strategies for the re-establishment of these plantations.

Furrowlining. de Braganca (1986) recorded significant improvements in tree survival associated with furrowlining. The explanation for this is given as:

1. a concentration of moisture around the seedling roots,
2. reduced desiccation by wind,
3. removal of the non-wetting soil surface,
4. weed control.

It is difficult to identify which of these has the greatest impact on survival. de Braganca (1986) did not include weed control as a variable in her experiments, although she suggests that the weed control provided by furrowlining may have contributed to the better survival of trees. A study (Fremlin, unpublished) that compared furrowlining, ripping and a control (no treatment), with and without weed control, in a factorial arrangement showed that the majority of the response to furrow lining was attributed to weed control (Fig. 6).

Figure 6. EFFECT OF DIFFERENT SITE PREPARATION TREATMENTS ON THE SURVIVAL OF P. PINASTER ON A SANDY SOIL



There is strong evidence that furrowlining (or scalping) has a detrimental effect on tree growth (Fremlin, unpublished, Ellis, unpublished, de Braganca, 1986). de Braganca (1986) found that trees planted in furrows established after chopper rolling grew significantly less in the first year than trees not planted in furrows. Height increment was similar for both treatments thereafter.

Currently a fireline plough is used for both first and second rotations to install furrows. This leaves a "V" shaped furrow approximately 1 metre wide and 100 - 150mm deep. It is necessary to travel between the rows of stumps on second rotation sites. This locks the second rotation spacing to that of the first rotation. At least 4 different row spacings have been used in the *P. pinaster* plantations. The advantage of using the fireline plough over the Savannah disc furrowliner is that machine planting is possible using the available "Lowther" type planting machines. The recently released Savannah planting machine that is reputed to plant in second rotation sites will be evaluated in 1993.

Ploughing. For second rotation establishment, ploughing is not frequently prescribed. The likely reason for this is that a suitable plough was not available. With the purchase of a Savannah HD 14 stump-jump disc plough cultivation of second rotation sites is now feasible. This machine is designed with "lift-up" disc arms to enable it to be used for inter-row cultivation between rows of different widths.

SITE PREPARATION FOR THE ESTABLISHMENT OF *E. GLOBULUS*

The Department of Conservation and Land Management (CALM) controls a *E. globulus* estate of 10 232 hectares. The land was acquired from private landholders and for the most part consists of improved agricultural pastures. No native forest is cleared for conversion to plantation.

In 1992 an agreement was signed with the Oji/Itochu company of Japan to establish 20 000 hectares of *E. globulus* plantation over a period of 10 years. Plantings will be concentrated on privately owned farmland along the south coast of Western Australia, centred on the town of Albany. Negotiations are progressing with Hansol of Korea to plant an additional 10 000 hectares in the Collie river catchment on the west coast.

Plantings are integrated into the farm to achieve benefits in addition to timber production. These include:

1. Protection of livestock and crops,
2. lowering ground water levels to reduce salinity,
3. erosion control,
4. absorb nutrient runoff to protect streams, rivers and estuaries from problems of eutrophication,
5. reduce waterlogging by the interception of ground water.

As well as achieving on-farm benefits, landowners share in the revenue from the first and second harvests.

Broadscale plantations are uncommon under this arrangement. A single timberbelt may traverse many different site types, some or all of which may require different site preparation strategies.

Site Preparation Techniques.

Mounding. The majority of sites along the western south coast of WA are characterised by low relief and are subject to periods of waterlogging during the winter months. Consequently, most sites are mounded. To date, the wettest sites have been ripped and mounded with a Savannah TPR 4. Mounding is generally up and down the slope with due regard to drainage and the likelihood of erosion. The mounder is lifted over natural watercourses to facilitate drainage. The drier sites (higher relief) are mounded with a small two disc mound plough, some of which have ripper attachments fitted. This is mostly on the contour.

Compacting rollers are fitted to all mounders; the profile of which provides a flat, slightly concave surface to the mound. As described earlier in this document, this profile encourages good infiltration of moisture into the mound, reduces herbicide erosion and allows hand planters to traverse the mounds.

Mound ploughing is carried out in the period March to April to allow sufficient time for the mounds to consolidate before pre-plant herbicide spraying and planting.

Ripping. All sites are ripped to a depth of at least 400mm. Ripping is on the contour except on the occasions where it is combined with mounding on wet flat sites. Where deeper "pans" are identified, ripping depth will be prescribed accordingly.

A series of trials to study the effect of ripping on tree growth were established under the National Afforestation Program (NAP) in 1989. These are due for assessment.

Pre-plant Weed Control. On sites where Sorrel or Dock *(Rumex spp.)* occur broadscale spraying, prior to mounding is carried out using metsulfuron-methyl at 6 - 9 gm/ha (Brush-Off at 10 - 15 gm/ha.). Application is delayed until there is sufficient leaf area to ensure adequate kill. Where germination of annual weeds has occurred on sites to be mounded glyphosate is added to the spray tank. Experience has shown that if live weeds are incorporated into the mound they may re-emerge despite applications of residual and knockdown herbicide sprays. An interval of 4 weeks between applying Brush-Off and planting is required to ensure tree safety.

A pre-plant application of a mixture of simazine and glyphosate is applied in a strip to the mound after a sufficient period of consolidation. The minimum rate of simazine is 3 kg/ha. applied to deep leeched sands; increasing to 5 kg/ha on coloured well drained soils. On wet organically-rich soils simazine is applied at 8 kg/ha. The rate of glyphosate varies according to the weed species and development. A period of no less that 2 weeks plus at least 50mm of rain must fall between spraying and planting. Brush-Off (at 5 gm/ha) is mixed with simazine and glyphosate in the event that Sorrel or Dock is present on the mound. In this event, a longer lapse time is necessary between spraying and planting.

Considerable effort in the last 3 years has been devoted to the evaluation of sulfometuron-methyl (Oust) for selective control of weeds in *E. globulus* plantations. Unfortunately the conclusion did not match the expectation. On sandy, acid soils Oust mixed with simazine and glyphosate and applied at 25 gm/ha. can provide effective, safe control of sorrel, dock and legumes. However, a slight increase in the rate can effect tree growth while a slight reduction in the rate reduces efficacy.

PRIORITIES FOR PLANTATION ESTABLISHMENT RESEARCH

P. RADIATA.

Site preparation requirements for first rotation *P. radiata* plantations are, to a great extent, understood. A trial repeated on 7 site types was established in 1992. It is expected this will

provide information on the value of ripping to different depths, ploughing and mounding across a range of sites. No further research work is anticipated.

The systems for second rotation establishment on slopes of $<14^{0}$ are in place, although the benefits of deep ripping are not known. A series of trials have been established to answer this and provide economic data for different strategies. Some refinement of pre-plant weed control strategies is required. However, this is likely to be achieved through operational-scale study areas that will provide viable economic comparisons.

The emphasis of future development work will concentrate on the development of systems that embrace the knowledge acquired from established experiments.

Windrowing and burning will remain the strategy for re-establishing trees on slopes $>14^{0}$ for the foreseeable future. Gravity rolling (Everts, 1981) is an option for future consideration.

P. PINASTER.

The entire system for second rotation establishment of *P. pinaster* plantations is under review. The specific questions that need to be answered include:

- Will residue conservation in full-rotation clearfelled areas contribute positively to second rotation productivity?
- Are the benefits attributed to furrowlining on the coastal sandplain simply a reflection of the weed control it provides?
- Can cultivation provide sufficient competition control, or are herbicides necessary?
- Will herbicides used at forestry rates of application contaminate underground water?

A system needs to be developed to establish new plantations of *P. pinaster* on pastured farmland north of the existing plantation.

E. GLOBULUS.

- Deep ripping (>400mm) is carried out on a high proportion of sites to be planted with *E. globulus*. There is no data to support ripping below depths of 500mm. There is a need to establish if a relationship exists between depth of ripping, site type and growth of *E. globulus*.

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