C.E. LANE POOLE MEMORIAL TRUST

LANE POOLE AWARD STUDY TOUR, 1983

A REPORT TO THE TRUSTEES

by

R.R.A. FREMLIN

C.E. Lane Poole Memorial Trust

The Lane Poole Memorial Trust was established to commemorate the work of Charles Edward Lane Poole, and, in particular, the connection between the former Conservator of Forests and the late Thomas Cullity.

Lane Poole was appointed Inspector-General of the Woods and Forests Department in Western Australia in 1916, and was responsible for establishing the legal framework on which the State's forestry operations have since been carried out.

That legal framework was the 1918 Forests Act. Before the Act was introduced there was no legislation to control the amount of timber cut, the place and manner of cutting, or to regenerate the forest after cutting.

When Thomas Cullity graduated from the University of Western Australia in 1918, Lane Poole offered him the newly created position of Utilisation Officer in the Forests Department, which he held for one year before leaving to start up Millars' new commercial kilns at Yarloop.

Thomas Cullity maintained an interest in forestry and timber for the rest of his life and founded Cullity Timbers in 1928 and Westralian Plywoods in 1943. From these companies WESFI was formed.

The Trust was initiated by WESFI Chairman Dennis Cullity in 1983, and was developed by a board of Trustees representing the former Forests Department and WESFI.

The current Chairman of the Board is the Executive Director of the Department of Conservation and Land Management, Dr Syd Shea.

The WESFI connection resulted from a belief held by Lane Poole that forestry needed an interdisciplinary approach to cater for the needs of society.

WINNERS OF THE C.E. LANE POOLE AWARD

1983	Paul Marsh, Ray Fremlin
1984	Graeme Hutchinson
1986	Gerard van Didden, Tony Brandis
1987	Peter Keppel
1989	Greg Voigt
1990	André Rynasewycz
1991	Greg Mair
1992	Mervyn Smith, Derek Winters
1993	Alan Hordacre
1994	Michael Cully

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INTRODUCTION

The objective of the study tour was to acquire information on techniques used for sites similar to those found in Western Australia by visiting softwood plantation silvicultural and establishment operations, including nurseries, in south-east South Australia and south-east Queensland.

Itinerary

Mt Gambier 26-30 April 1983
Brisbane 1-3 May 1983
Gympie 4-12 May 1983
Brisbane 13 May 1983

ACKNOWLEDGMENTS

The Lane Poole Memorial Trust made this tour possible. For this I am indebted to the Forests Department of Western Australia and the Trustees of the award.

I wish to thank the Woods and Forests Department of South Australia and the Queensland Department of Forestry for arranging my itinerary. I am particularly indebted to Mr Don McGuire and Mr John Pratt of the Woods and Forests Department and Mr Murray Johnson, Mr John Kitt, Mr Marko Podberscek, Mr Cliff Raddatz and Mr Peter Gordon of the Department of Forestry, Queensland.

R.R.A. FREMLIN

SOUTH-EAST REGION
SOUTH AUSTRALIA

Myora Forest Reserve - Establishment of legumes under *P. radiata* (Regional Forester, J. Pratt)

A trial was inspected where clover (a mixture of trikkala and woogenellup) and vetch were established in 1981 under 41-year-old *P. radiata* standing at approximately 250 stems per hectare. No increase in the rate of tree growth was recorded nor did soil analysis show an increase in nitrogen when the area with legumes was compared to the control.

Mt Gambier Forest Reserve (McKorquindale's) - Site preparation for second rotation *P. radiata* (Regional Forester, J. Pratt)

This trial was to compare various site preparation treatments for establishment of a second crop of *P. radiata*. For me, the Marden chopper roller, which is used by the Woods and Forests Department to crush debris after clearfelling for the second rotation of pines, was of particular interest.

The Marden chopper roller is manufactured in the USA. Model B-8GK (figure 1) was purchased by the Woods and Forests Department in 1979 at a cost of $35 000. The machine has two 2.44 metre wide x 1.45 metre diameter drums aligned in tandem.

The crusher roller appears to be efficient, fast and economical. Where large, unmerchantable logs are left on site after clearfelling, the efficiency of the chopper roller decreases. Experience shows the chopper roller does not suppress pine regeneration adequately.

It is speculated that one of the major factors in the decline of growth associated with second rotation *P. radiata* in South Australia, is the depletion of nitrogen and the destruction of organic matter caused by burning first rotation debris (Woods, 1980).

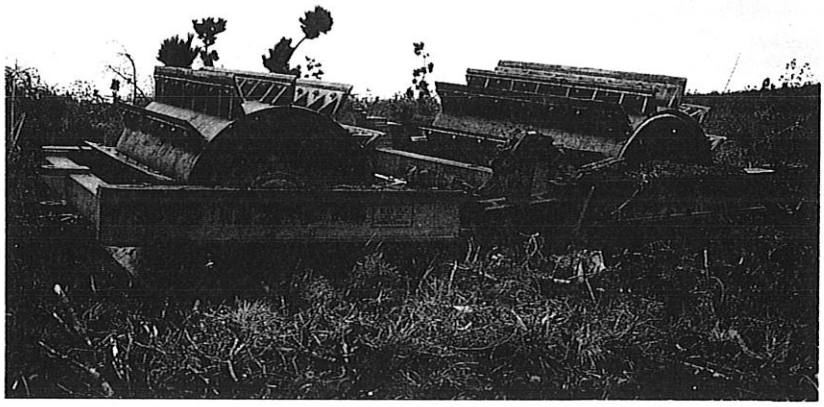

Figure 1: The Marden chopper roller.

Wandilo Siding (Walshe's) - Wide spaced woodlot (Regional Forester, J. Pratt)

This is a wide-spaced woodlot established on improved pasture. The greater part of the trial was planted in 1980 and trees are arranged as follows:

- Five metres between rows by three metres between trees (670 stems per hectare)
- Five metres between rows by two metres between trees (1 000 stems per hectare)
- Eight metres between rows by one and a half metres between trees (830 stems per hectare)
- Eight metres between rows by two metres between trees (625 stems per hectare)

In 1982 an additional area was planted in a strip arrangement of three rows two and a half metres apart and trees two metres apart (650 stems per hectare), separated by 18 metres of pasture. Sheep grazing began in the first area when trees were two and a half years old.

Tantanoola Forest Reserve - Re-fertilisation of *P. radiata* and maximum growth sequence (Senior Forester, R.V. Woods)

The period with Mr Woods was spent discussing fertilisation of mid-rotation stands of *P. radiata,* weed control at establishment and early rotation nutrition. Spectacular responses to fertiliser in mid-rotation stands were demonstrated. A 6.6:1 ratio of nitrogen to phosphorus plus zinc, copper and molybdenum was applied. The rate of application is equivalent to 300 kilograms per hectare of elemental nitrogen. Mr Woods estimates a 40 square metre per hectare (40 $m^3.ha^{-1}$) increase in volume can be expected from one application and he calculates the value to be double the cost of fertiliser. In earlier re-fertilisation trials the application of nitrogen and phosphorus showed soil had a zinc and copper deficiency. This was corrected by including these elements in the mix.

Penola Forest Reserve - Legume trial on a second rotation site (Forester, D. McGuire)

In this trial cultivars of subterranean clover and narrow-leafed lupin *(Lupinus angustifolius)* were established amongst young second rotation *P. radiata.* The cultivars of clover selected were all early or mid season varieties and included nungarin and woogenellup. The lupin cultivars were New Zealand blue and marri.

Penola Forest Reserve - Second rotation trial (Forester, D. McGuire)

The long-term plan in south-east South Australia is to eliminate windrowing in site preparation and to crush all slash *in situ.* The practice of windrowing first rotation residues causes moderate to severe nutrient losses (whether the windrows are burned or not) because all the fresh branches and needles along with most of the litter are removed from the site. This trial was designed to compare the current practice of windrowing with crushing of residue.

Penola Forest Reserve - Hydro-Ax demonstration (Forester, D. McGuire)

The Hydro-Ax was clearing four-year-old fire-damaged *P. radiata* (figure 2). No further site preparation was anticipated before replanting. Normally the Hydro-Ax is used to slash pine regeneration in plantations prior to clearfelling.

The 1983 purchase price of the Hydro-Ax in Australia is approximately $120 000, and the machine is hired by the Woods and Forests Department for $75 per hour. I see the machine having limited application in Western Australian forests other than as a contract machine for the treatment of debris in an agroforestry system.

Figure 2: The Hydro-Ax

Mount Gambier Forest Reserve - Factors affecting the productivity of successive crops of *P. radiata* (Foresters, D. McGuire and B. Mitchell (CSIRO))

This is a joint investigation by the Woods and Forests Department, the CSIRO Divisions of Forest Research, Soils and Mathematics and Statistics. The trial has seven treatments:

1. Sterilisation,
2. Efficient mycorrhiza inoculation,
3. Lime,
4. Surface cultivation,
5. Triazine,
6. Phosphate (P_0, P_1, P_2),
7. Nitrogen (N_0, N_1, N_2).

Measurements and assessments being carried out or proposed for the site are:

1. Monitoring free water table levels in cased bores,
2. Monitoring soil water contents by neutron attenuation,
3. Monitoring soil compaction using penetrometer,
4. Monitoring soil nutritional contents and microbial populations by soil and litter sampling,
5. Monitoring foliar nutrient levels,
6. Monitoring leaf water potential by pressure bomb test,
7. Monitoring root development and biomass production in specially allocated destructible sampling plots,
8. Measuring tree heights and sectional areas bi-annually and later annually.

The trial is seven years old. Definite trends are yet to emerge.

Sapfor Forest, Penola - Pine-legume system (Foresters, D. McGuire, D. Fife (CSIRO))

This is a cooperative investigation between a private timber company (Sapfor) and the CSIRO Division of Forest Research. The aim is to determine if legumes (lupins) can supply nitrogen to pines and whether this can be measured. Results show a growth response attributable to nitrogen from lupins. An increase in the levels of nitrogen in needles, soil nitrogen and carbon has also been attributed to lupins.

Research Nursery - Mount Gambier (Technical Officer, B. Grigg)

A research nursery is maintained by the Research Section. Cuttings, grafted stock and open rooted stock for the tree improvement program are raised, and herbicide and fertiliser related nursery trials are conducted here. The routine herbicide used for pine pre-emergent application is a mixture of triquat and dacthal. Aziprotryne is used after pine emergence. Glyphosate is used to control perennial weeds before germination of pines.

CSIRO Division of Forest Research - Weed control (Dr E.K.S. Nambiar)

A trial conducted by the CSIRO to determine the effect of the control of weeds on the survival and growth of *P. radiata* on a complete randomised block receiving four treatments. They are:

1. Nil (no weed control),
2. Three litres per hectare of atrazine before planting,
3. Twelve litres per hectare of atrazine before planting,
4. Complete and continuing mechanical weed control.

The trial has been repeated every year for five years. Each trial was sprayed with atrazine at two litres per hectare after ploughing.

CSIRO Division of Forest Research - Fertiliser placement in relation to pine roots (Dr E.K.S. Nambiar)

Dr Nambiar suggests that to ensure efficient uptake of nutrients on sandy soils, fertilisers should be broadcast around the plant rather than applied locally.

CSIRO Division of Forest Research - Nitrogen and phosphorus uptake in *P. radiata* (D.N. Fife)

A study of nitrogen and phosphorus levels of *P. radiata* needles from a marked position in a tree over time showed that concentrations varied markedly (Fife and Nambiar 1982). Levels began to drop rapidly in January, reaching a low point in April.

At the onset of rain, foliar levels rise rapidly levelling off during winter and rising again in late spring. It appears that foliar analysis is not a reliable technique for determining critical levels of nitrogen, phosphorus and zinc in *P. radiata* growing in a Mediterranean climate.

Mt Burr Forest Reserve - Bracken (*Pteridium esculentum*) control prior to plantation establishment (Forester, D. McGuire)

Research into the control of weeds in plantations is concentrated on improving the control of sorrel (*Rumex acetosella*), cats-ear (*Hypochoeris radicata*) and bracken. Improved growth of *P. radiata* following control of bracken has been demonstrated. A number of trials have been established to screen chemicals, evaluate methods of application and investigate mechanical means of control.

Results of these trials have been inconsistent. However, control for a period was achieved which resulted in an increase in growth of *P. radiata.* To achieve best results the following applies:

1. Apply glyphosate (3.2 kilograms per hectare) + diesel + emulsifier or glyphosate (two kilograms per hectare) + asulam (two kilograms per hectare) + diesel + emulsifier; Ulvapron (a BP product) may be a substitute for diesel + emulsifier.
2. Treat in autumn.
3. Apply to mature fronds aged between four and seven months as the age of bracken at the time of treatment appears critical.
4. Use ropewick and controlled droplet application (CDA) for best results; the ropewick applicator however is not the most practical method in most situations; hence CDA and boom spray operations are the basic options in plantations.

Note also that the following measures do not control bracken:

1. Ploughing in summer.
2. Hexazinone applied in autumn; indications are that hexazinone kills existing fronds but later stimulates regeneration.

Mount Shank Seed Orchard (Technical Officer, B. Grigg)

Mount Shank is the only seed orchard remaining (out of three) after the fires in February. Unfortunately the trees are overmature and too tall for easy harvesting.

A new seed orchard is to be established at Mount Shank. This will incorporate irrigation facilities and it is planned to hedge or top all trees.

The need to irrigate is based on a theory that cone abortion often results if trees suffer water stress after fertilisation of flowers in early summer.

Caroline Forest Reserve - Caroline fire area (District Forester, J. Lenon)

A detailed interim review of plantation re-establishment following the Caroline forest fire has been prepared by Geddes (1981). Approximately 3 000 hectares of softwood plantation were destroyed by a single fire in February 1979. Clearing of burned pines generally involved pushing windrows and burning. After burning, final preparation involved cross-ploughing with a Rome TRN20-30 heavy duty offset plough pulled by a D7G crawler tractor. A blade on the tractor is used to disperse unburned debris in the windrows to ensure complete coverage.

CSIRO Division of Forest Research - Symptoms of manganese deficiency in *P. radiata* (J.H. Ruiter)

According to Ruiter, the first sign of manganese deficiency is the development of 'soft', yellow, new growth which becomes a darker yellow with time until finally the needles become necrotic.

Mount Gambier Forest Reserve - Fertilisation of young *P. radiata* (Forester, D. McGuire)

A series of cooperative trials with the CSIRO have been undertaken to evaluate the role of nitrogen in the establishment of *P. radiata.*

After three years there has been no response to nitrogen where chemical weed control has been practised. The stimulation of the nitrogen-fixing bacteria in the soil by triazines appears to make enough nitrogen available to the trees. Additional manufactured nitrogen does not stimulate further growth.

DISCUSSION OF SOUTH AUSTRALIAN STUDY TOUR

The adoption of the maximum growth sequence (MGS) in second rotation plantations appears not to be supported by experimental data. It is my opinion, supported by studies by Sands and Zed (1979), that the use of atrazine and hexazinone, applied in two consecutive years to control weeds, provides adequate nitrogen. The combination of excellent weed control plus the herbicides and phosphate seem to be responsible for the success of MGS on second rotation sites.

The long-term plan in the south-east of South Australia is to eliminate windrowing and burning in preparing sites for second rotation plantations. This plan is not being adopted readily because of the problems associated with the disposal of large, unmerchantable material which affects the efficiency of crusher rollers, the access for cultural tending, and the level of pine regeneration.

The stimulation of growth of *P. radiata* attributable to lupins, as shown by Fife (CSIRO), is encouraging in relation to the routine use of legumes in pine plantations in Western Australia.

It is suggested that there is no competition for soil moisture by lupins. The use of early maturing subterranean clovers by the Woods and Forests Department in trials is an extension of this hypothesis. However, Chevis (unpublished) has shown that early maturing varieties of clover did not improve the survival of *P. radiata* on the coastal sands of Western Australia. There was a strong correlation between biomass of clover and pine mortality. This is supported by observations of different cultivars of subterranean clover growing in the Donnybrook Sunkland near Busselton. When clover growth continued into summer there was significant competition with pines for moisture.

The adverse effects of weed competition on the early growth of pines in Australia is well documented. Particular interest in Southern Australia is centred on the triazine group of chemicals, especially atrazine and hexazinone. Sands and Zed (1979) showed significant growth responses of *P. radiata* to atrazine over and above the effect of weed control. In the same study they showed that nitrogen fertilisation, even after weed control, had no effect on growth. An increase in the foliar levels of phosphorus and potassium as well as nitrogen was measured following

the application of atrazine. Studies in the Donnybrook Sunkland (unpublished) have shown that *P. radiata* responds to hexazinone. Other studies (unpublished) in the same area were unable to demonstrate a response to atrazine in the absence of pasture.

SOUTH-EAST REGION
QUEENSLAND

Department of Forestry, Queensland, Division of Technical Services - Processing of data (Technician, J. Rudder)

The responsibility for processing and storing all research data is assigned to two people in the Division of Technical Services. Operatives collect data in the field and record it on standard field data forms. The forms are checked and a header sheet with instructions for processing and storing is prepared by a specialist group at each research centre. Data is then sent to Brisbane where it is transferred onto cards from the field sheets. The data is processed by various XCAL programs for plantation experiments and plantation yield plots, including those that validate, check for conformity and correct punched data.

Statistical analysis of experiments is the responsibility of another section of the Division of Technical Services.

Department of Forestry Gympie Research Centre (Senior Technician, M. Johnson)

All research activity in the south-east of Queensland is centred on Gympie. Spheres of research encompass exotic pines, hoop pine, hardwoods, hydrology, weed control, genetics and fire research. Each section is headed by a professional forester with assistance from a specialist technician. Other technicians (operatives) at the centre have responsibility for establishment, maintenance and measurement of trials in specific geographic districts. Research gangs are maintained in each of these districts. Procedural methods are detailed in a research manual.

The research complex includes extensive glasshouse facilities which currently are used entirely for studies associated with raising hoop pine (*Araucaria cunninghamii*). Various containers and potting media are being evaluated, along with studies of moisture stress and nutrition. The aim is to lower nursery costs by reducing the period trees spend in the nursery, eliminating transplanting of seedlings from germination beds to containers, and improving containerisation. The use of re-usable polystyrene containers is of particular interest.

Toolara and Tuan State Forests - the nutrition of *P. elliottii* and *P. caribaea* var. *hondurensis* on the coastal lowlands (Wallum) of south-east Queensland (Technical Assistant, J. Kitt)

Coaldrake (1961) described the geology of the coastal lowlands as Mesozoic sandstone and Quaternary sands intruded in places by tertiary trachyte. Soils vary greatly over short distances. They have been classified into eight groups, of which the following are the most important:

1. Red earth residuals - uncommon relic soil of high fertility.
2. Lateritic podzolics - a group comprising a wide range of forms, similar to Donnybrook Sunkland soil types 1, 2, 3 and 4 (except 4D) as described by McCutcheon (1978).
3. Gleys and humic gleys - soils characterised by gley textures (rusty markings) in the profile, occurring chiefly where there is a prolonged high water table; surface soil may have a high humus content and clay occurs in the 'B' horizon; these soils are similar to the type 5 soils of the Donnybrook Sunkland described by McCutcheon (1978).
4. Groundwater podzols - these occur in lower slopes and flat areas of prolonged high water table; the characteristic features of the profile are sandy 'A' horizons over dark, organic, 'coffee rock' restrictive to drainage; these soils are very similar to Donnybrook Sunkland type 4D soils (McCutcheon, 1978).
5. Alluvials - well drained flats along major watercourse similar to type 7 soils in the Donnybrook Sunkland.
6. Lithosols - shallow soils on ridge, and slope positions overlying parent rock (sandstone or trachyte); these are of limited occurrence.

The most important of the soil groups are the lateritic podzolics, as it is on these that the bulk of the exotic pines plantations are established. Since 1970 exotic plantings have been extended from the better quality, well drained sites (lateritic podzolics) to include the less fertile, poorly drained sites (gleys and groundwater podzols).

Phosphorus is recognised as the major limiting nutrient on all soil types of the coastal lowlands, and currently 50-60 kilograms per hectare of phosphorus are applied at establishment to all sites. This initial dressing of phosphate is not adequate for all stands (especially those on gleys and groundwater podzols) for the whole rotation. In order to predict which stands need re-fertilising, a program of foliar sampling has been initiated.

On groundwater podzols nitrogen is applied at planting at the rate of 25 kilograms per hectare (120 $kg.ha^{-1}$ ammonium sulphate). It is

recognised that the response to nitrogen is ephemeral, but it is considered essential if trees are to compete with the heavy regrowth of native species common on these sites.

Deficiencies of copper are widespread on groundwater podzols, and especially with *P. elliottii.* Applications of nitrogen of these sites have increased the potential for copper deficiency. The addition of five kilograms per hectare (15 $kg.ha^{-1}$ $CuSO_4.H_20$) has alleviated the problem on most sites. On soils that have high levels of organic matter long-term correction is not being achieved with these additions of copper. Trials are in progress that aim to compare various forms of copper.

Following the foliar sampling program a significant area of *P. elliottii* plantation was identified as potassium deficient. The condition is characterised by yellowing foliage. Responses in growth and levels of foliar potassium have been recorded after the addition of 50 kilograms per hectare of potassium.

All applications of phosphatic fertiliser are by air, however, uneven distribution is seen as a problem.

Kenilworth hoop pine nursery - the tolerance of *Cassia* sp. to different herbicides (Senior Technician, M. Johnson)

The current procedure for the establishment of hoop pine plantations is to clear and burn the native forest, allow a period of time for regeneration to occur, then spray with one of the phenoxy herbicides. To maintain weed free conditions is considered environmentally undesirable and is not cost effective. The current practice is to sow couch grass, which has the dual role of suppressing further regeneration of native species and reducing erosion. However, grass is nitrogen-demanding and imposes moisture stress on young hoop pine. A mixture of glyphosate and atrazine, delivered through a Silvan covered spray, is applied over a 1.5 metre radius to eliminate competition. This treatment may be repeated if necessary.

Imbil - Weed control in hoop pine plantations (Senior Technician, M. Johnson)

The continued use of the phenoxy herbicides 2, 4, 5-T and 2, 4-D, either as amine or ester preparations in catchment areas and adjacent to native rain forest, is disturbing. Research is presently aimed at developing alternative methods, although it appears unlikely that more cost effective pre or post-emergent techniques will be developed.

Imbil - Hoop pine silviculture (Senior Technician, M. Johnson)

Trials indicate that establishment costs do not rise greatly above a stocking rate of 900 stems per hectare. Below 900 stems there is a reduction in establishment costs.

Pre-commercial thinning (PCT) is practised in hoop pine plantations. Currently the technique is to inject unwanted trees with glyphosate.

Toolara and Tuan State Forests - site preparation for exotic pines (Technician, M. Podberscek)

The principal species planted in the coastal regions south of Maryborough has been *P. elliottii* var. *elliottii*. However, as *P. caribaea* var. *hondurensis* exhibits both superior growth and superior wood quality, the trend is for it to replace *P. elliottii* as the principal exotic plantation species throughout Queensland.

Initial site preparation research concentrated on developing suitable techniques for growing plantations on wet sites. Site amelioration by a combination of mounding and drainage proved successful. Mounding on ridges did not result in a significant growth response by *P. elliottii*, nor did ripping confer any improvement in growth in the coastal lowlands. The results of these trials showed that *P. caribaea* outgrew *P. elliottii* on well drained sites and mounding was beneficial to *P. caribaea* on these sites. On poorly drained sites *P. elliottii* outgrew *P. caribaea* on small mounds, with the reverse occurring on large mounds.

Management demands that the clearing schedule be six to 24 months ahead of planting. The aim is for a high standard of clearing (plate 18) with all stumps removed and windrows burned out. Current site preparation practices on coastal lowlands are that native vegetation is felled and windrowed by bulldozers for burning. Areas in excess of 15 per cent slope are usually excluded. Shearer Majestic eight-disc stump-jump ploughs pulled by 100 horsepower four-wheel-drive tractors plough all areas where slopes do not exceed nine per cent. The current specification is for three-metre-wide mounds with a height of 60 cm to be constructed on poorly drained soils. Mounding is restricted to slopes of less than five per cent and is carried out six months after ploughing.

Recently the Department of Forestry acquired large areas of grazing land covering a range of soil types from lateritic podzolics to podzolic gleys. The pastures consist of subtropical grasses and legumes, and research aims to develop techniques for the establishment of pines on

these sites. The major problem is to control pasture growth after pines are planted.

Glyphosate or a mixture of glyphosate and atrazine is sprayed in strips along the mounds before planting. Follow-up spot spraying using covered Silvan sprayers is often necessary. Grazing by cattle begins when the trees are approximately one year old.

Tuan and Wongi State Forests - Weed control in exotic plantations on the coastal lowlands (Technician, C. Raddatz)

Intensive site preparation and effective use of 2, 4, 5-T and 2, 4-D have alleviated serious woody weed problems except in localised areas; e.g. on groundwater podzols. Experimental work has shown that exotic pines respond to weed control. Current research is centred on controlling weeds on former pasture land.

In plantations established after clearing native forest the sequence of events for the control of weeds is:

1. Log, clear and burn.
2. Reheap and reburn.
3. Prepare for planting after extensive site preparation involving disc ploughing, disc harrowing and mounding as necessary.
4. Apply pre-plant herbicides; usually by misting with phenoxy herbicides.
5. Apply post-plant phenoxy herbicides applied as foliar sprays or basal treatments.
6. Cultivate inter-row as necessary; mainly on groundwater podzols.

While cultivation remains a major tool for controlling weeds in exotic pine plantations, herbicides are considered fundamental to the weed control program.

Toolara exotic pine nursery (Ranger, R. Henderson)

The production of the Toolara nursery for 1983 was expected to be 4.3 million plants, 80 per cent of which were *P. caribaea*. Stringent hygiene measures are enforced at the nursery, with all personnel required to change footwear and cross a formalin bath. All machinery also passes through a formalin bath.

To achieve accurate seeding rates a Summit precision vacuum seeder is used. This machine, developed and manufactured in New Zealand, allows for infinitely fine adjustment. Good weed control is achieved in the nursery by using mixtures of chlorthal plus propazine or turbumeton/ turbuthylazine (Caragard). However, Caragard is not selective to pine seedlings which have just emerged.

For the successful open root planting of *P. caribaea*, frequent root wrenching to condition stock is necessary. Mechanised wrenching commences when plants are 15 cm tall and continues at four-week intervals. Topping is a routine practice in the Toolara nursery.

Dipping of roots in clay slurry prior to the plants leaving the nursery is a routine practice in exotic pine nurseries.

Tuan and Wongi State Forests - the silviculture of exotic pines on the coastal lowlands (Technician, C. Raddatz)

Planting is by machine at a spacing of three metres by three metres (1 111 stems per hectare). Four-wheel-drive tractors are used as there is less downtime due to bogging and planting can proceed under wetter soil conditions. Ford County tractors are favoured over most other four-wheel-drive tractors because of the true four-wheel-drive design (figure 3). Pre-commercial thinning (PCT) is prescribed for all exotic pines in Queensland. In geographical zones where a commitment to produce pulpwood exists (integrated zones) the prescription calls for thinning at age three to four years down to 750 stems per hectare. In sawlog zones plantations are thinned to 600 stems per hectare at age three to four years.

Figure 3: Tractor and planting machine. County tractors are favoured in Queensland because of better efficiency attributed to the true four-wheel drive design.

Although *P. caribaea* and *P. elliottii* are naturally fine-limbed, pruning is prescribed in plantations where the site index is high. *P. caribaea* var. *hondurensis* is given preference.

Selection for pruning is only carried out by certified personnel. First pruning (300 stems per hectare) to between 2.2 metres and 2.4 metres is achieved using light chainsaws. Pruning is commenced when the mean predominant height is 9.5 metres; trees less than 7.5 metres high are not pruned. Carry-up pruning is generally begun two years after low pruning, although a minimum tree height of 9 metres for *P. elliottii* and 10 metres for *P. caribaea* applies. Pole saws are used to remove branches and allow positioning of a 3.6 metre ladder. Pruning to 5.4 metres is completed using a jacksaw.

Tuan State Forest - prescribed burning in exotic plantations (Technician, C. Raddatz)

Prescribed burning is a routine operational practice and is considered to be the most efficient means of fuel management in exotic plantations. The increased efficiency of fire protection is demonstrated by the fact that although the area under plantation increased as did the number of wildfires there has not been significantly greater damage.

Neerdie and Toolara State Forests - agroforestry (Technician, C. Raddatz)

Agroforestry in Queensland is confined mainly to opportunistic grazing in native and exotic forests. In recognition of the mutual benefit, a scheme has been developed for native forest whereby a forest officer marks trees for retention and the lessee is permitted to destroy the remainder. However, there are few examples where improved pastures have been established.

Division of Technical Services, Brisbane - mensuration and biometrics (various officers)

Queensland has a large number of current and completed experiments. While the results of some have been published, most are documented only as termination reports on district files. The retrieval system is based on a series of computer programs and data files. Information includes experiment number, responsible officer, location, subject and other relevant information.

DISCUSSION OF QUEENSLAND STUDY TOUR

Site preparation has been one of the significant factors in the successful establishment of exotic pines on the coastal lowlands of Queensland. Historically *P. caribaea* has been planted north of Maryborough, but in recent years it has been planted in preference to *P. elliottii* on well drained sites south of Maryborough. Early research showed that *P. caribaea* grows faster than *P. elliottii* on all except wet sites. The development of a successful nursery conditioning technique has led to large scale planting of *P. caribaea* in south-east Queensland and a renewed effort to grow *P. caribaea* on wet sites.

High profile mounds impede machinery, especially where there are frequent changes in row direction to conform with the strict gradient prescription. The improved growth attributed to large mounds in Queensland is contrary to results in Western Australia (Fremlin, unpublished). However, the method of construction may be a significant factor. The disc-formed mounds in Queensland are effectively a concentration of top-soil, whereas in trials in Western Australia the mounds were formed by a blade which pushes sub-soil to the top of the mound.

The similarity between the soils of the coastal lowlands of Queensland and the Donnybrook Sunkland has been discussed. Phosphorus is the major limiting nutrient in both regions. The higher phosphorus inputs in pine plantations in the Donnybrook Sunkland (100 kilograms per hectare compared to 60 kilograms per hectare for Queensland) may be a reflection of a higher requirement by *P. radiata* for phosphorus, or of the greater absorption of phosphorus by the gravelly soils of the Donnybrook Sunkland. It is significant that all the phosphorus is applied in the first year in Queensland, whereas in the Donnybrook Sunkland, application is over the first five years.

The lack of sustained response to soil applications of copper is thought to be associated with the strong complexing of copper by the soil organic matter which renders applied copper less available to the trees.

The identification of severe potassium deficiency in plantations of *P. elliottii* in Queensland should prompt a study of the status of this element in pine plantations in Western Australia, as there is a scarcity of information regarding the potassium requirements of our pines.

Intense site preparation is largely responsible for weed-free conditions at the time of planting. The practice of ploughing when conditions are best for eliminating weeds, followed by a period for re-development prior to broad scale misting, makes it relatively easy to keep plantations free of weeds.

The adoption of pre-commercial thinning in all plantations in Queensland and the move towards wider initial spacing recognise the need to maximise tree size and reduce the volume of small diameter material.

The system of collection, storage and accessing of research data in Queensland appears to be highly efficient. However, the computer facilities cannot be viewed in the same way. The use of standard field sheets that eliminates the need to transcribe data is both time-saving and simple. The automatic duplication of all data with provision for easy access is seen as highly beneficial.

The dissemination of information by frequent seminars has proved successful. The relations between different sections within each organisation is good and the opportunity exists for all staff to attend seminars.

RECOMMENDATIONS

Procedures and subjects that require further consideration in Western Australia are:

- Site preparation for the establishment of pine plantations.
- Assessment of weed control including the effect of clover on survival and early growth of pines.
- Assessment of the use of nitrogen in plantation establishment.
- Assessment of the use of concentrated forms of superphosphate.
- Assessment of the role of potassium in the Donnybrook Sunkland.
- Development of a system of research data collection, storage and processing.
- Preparation of a research manual.
- Improvement of information dissemination.
- Development of growth models to compare agroforestry with routine silvicultural procedures.
- Purchase of equipment for second rotation establishment.
- Assessment of the role of foliar analysis in research and operations.

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