Revegetation

Revegetation on Farms Information Kit

Eucalyptus Oil Mallees

Agriculture
WESTERN AUSTRALIA

A Project of the Sustainable Rural Development Program of Agriculture Western Australia. Supported by the Salinity Action Plan.

Oil Mallee Association

Australia with less than 600 mm rainfall. Some of the information is valid outside this range.

All information is provided in good faith, to help make informed revegetation decisions leading to sustainable land use

For further information on the Revegetation on Farms Project, and comments or suggestions for the Information Kits, contact:

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Eucalyptus Oil Mallees

October 1998

This information Kit has been compiled by the "Revegetation on Farms Project" in collaboration with the Oil Mallee Association of W.A. Inc. and the Department of Conservation and Land Management. To get the most from this kit, readers should check references and investigate the networks.

Before recommending or planting Eucalyptus oil mallees, we advise clients to contact the Oil Mallee Association Region Managers for personalised advice. Site specific information and revegetation planning is necessary for commercial development.

All information kit sales enquires should be directed to:

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Eucalyptus oil mallees- Contents

To keep the information contained in this kit up to date, visit the Trees in Agriculture website of Agriculture Western Australia at

www.agric.wa.gov.au/progserv/natural/trees/

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Additional Information

- Oil Mallee Association of WA Inc., membership form.
- Oil Mallee Association of WA Inc., subscriber membership form.
- Oil Mallee Association of WA Inc. - Growers Agreement
- *How much oil do I have?* Dan Wildy. Oil Mallee Scientific Update 1, November 1998.
- *Promising products derived from woody species.* John Bartle. & Russell Reeves. 1992. Paper presented at the RIRDC/LWRRDC Planning Workshop on Low Rainfall Agroforestry, Perth, August 1992.
- *Can Trees reverse land degradation.* J.R. Bartle, C Campbell & G White, 1996. A paper delivered at the Australian Forest Growers Conference, Mt Gambier, SA, 1996.
- "The Dinkum Oil" Oil Mallee Association of W.A. (Inc.) Newsletter.

Acknowledgements

The production of this kit was co-ordinated by Colin Holt, Agriculture Western Australia, Narrogin.
Thanks to Wayne O'Sullivan, David McFall and The Oil Mallee Association of W.A. Inc., The Oil Mallee Company of Australia, Peter White (CALM) and David Bicknell (Agriculture Western Australia) for their contribution of information, resource material and review of the information kit.

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Eucalyptus Oil Mallees - At a glance

Cineole production from oil mallees is currently the most promising commercial tree crop for the Western Australian Wheatbelt.

Current markets

- Small specialised pharmaceutical and cleaning markets.
- Approximately 3000 tonnes of cineole per year is traded globally.
- Australia produces about 200-300 tonnes per year.

Prospective markets

- As an industrial solvent in the metal cleaning, precision cleaning and electronic industries.
- As an insecticide and fungicide.

Costs of Production figures

- With current technology it is estimated that harvest and distillation costs will be $1.75/kg of oil. The aim is to reduce these costs to $1/kg of oil.

Farm and Industry returns

- Market price fluctuates widely. In the past 12 years the price ranged from $2.64 to $8.67/kg of oil, with an average price of $5.29/kg. The price at September 1998 was $6.44/kg.
- The industry is aiming to achieve an average ex still price of $5/kg of oil. The return to the farm is estimated at between $0.75 and $1.50/kg of oil.
- Using a range of production, cost and price estimates, the return to the farm is calculated to be between $60 and $630 per hectare per year.

Eucalyptus oil properties

- Eucalyptus oil is a natural product. It is an efficient solvent, easily recycled, readily biodegradable, has low relative volatility and lacks toxic by-products. It could help meet the emerging demand for new environmentally safe materials for industry.

Eucalyptus oil qualities

- The world market is dominated by oil from *Eucalyptus globulus,* which has a total oil content of 0.45-1.5% of fresh leaf weight. Of this 61-69% is cineole.
- Eucalyptus oil production from the nine endemic species currently used is encouraging with total oil content of 2.5% of fresh leaf weight set as the minimum for selection. Seven species have a cineole content in excess of 80% of total oil and the remaining two are over 70%.

Harvest and Processing

- The first harvest occurs when the average weight of plants in the hedge is a minimum of 10 kilograms.
- 10 kilograms of growth by year 4 should be attainable throughout the Wheatbelt. Higher rainfall sites may reach the 10 kg minimum in 2 years from planting.

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- Depending on seasonal conditions and regrowth (to 10 kg), time between harvests will shorten as the root system (lignotuber) matures.
- A batch steam still is the current technology and continuous feed steam stills are being trialed to reduce processing time and costs
- Passive extraction systems are expected to further reduce extraction costs, but are less developed.

Planting design and management

- To help maximise the economic potential of an oil mallee planting, best bet establishment techniques will be needed to maximise survival and growth on the site.
- Many oil mallees are being established in unfenced situations because of their relative resistance to grazing.
- Planning and management advice is available through the Oil Mallee Association Regional Manager network.
- The basic planting configuration is a "hedge" composed of two parallel rows, 2 metres apart. Plants within the rows are 1.5 m apart. Spacing to the next hedge varies to suit the site and farmer needs.
- An initial planting of at least 10 000 trees per farm unit is preferred. New areas outside the original areas should aim for at least 50 000 trees in close proximity to provide economies of scale in harvesting and processing.

Oil mallee industry development

- From 1994 to 1997, oil mallee plantings under the oil mallee program were concentrated in 6 main areas. Canna, Kalannie, Narembeen, Wickepin, Woodanilling and Esperance.
- Through the Oil Mallee Association of W.A.Inc., mallees are now available to all growers in the Wheatbelt with the aim of linking the 6 original areas into broader regional entities.

Species Selection for Oil

- Variation of oil content exists between and within species. Different populations of the same species exhibit different oil qualities/quantities.
- The mallees selected to date are derived from seed from the best oil producing populations. Seed orchards have been established from the best selections of wild material.
- Each species has been subjected to cutting and grown on a range of climatic and soil conditions to measure growth rates and vigour.
- Different species are used by the industry for different soils and locations
- Species selection is ongoing with the aim to improve yield and soil type suitability.

Research needed

- More efficient harvesting, transporting and oil extraction processing.
- The use of woody by-products for energy generation.
- Oil mallee carbon sequestration and potential trading in carbon crediting.
- The landcare benefits of mallees, including site capability and the interaction between the mallees and crops.

Eucalyptus Oil Mallees - Summary notes

The Department of Conservation and Land Management (CALM) initiated "The Oil Mallee project" after a 1992 workshop to access options for low rainfall agroforestry. (Refer to the enclosed paper "Promising products derived from woody species").

CALM co-ordinated the project with funds from the National Landcare Program, Commonwealth Farm Forestry and CALM. The aim is to obtain cineole from the leaves of selected eucalypt species and is designed to create a commercial industry that would also be an attractive, low management landcare option to landholders. The industry has the potential to increase the number of woody perennials in the landscape to levels that will impact on land degradation generally and salinity specifically.

Co-ordination of the project was taken on by The Oil Mallee Association of Western Australia Inc. (OMA) which formed in 1995 by the oil mallee farmer growers. Then in 1997 a limited liability company, The Oil Mallee Company of Australia (OMC) was established to manage the development of the industry, including harvesting and extraction issues.

CALM still has a close working relationship with the industry bodies and now concentrates it's efforts on selection and genetic development of oil mallee species. The early plantings of oil mallees were heavily subsidised by CALM, in a share farming agreement, and contracts still remain in place with those individual landholders.

Agriculture Western Australia assists with the industry by providing extension services and resource support. Financial assistance has been provided through the State Governments' Regional Enterprise Scheme.

Markets

The existing world markets for cineole are small, approximately 3000 tonnes per year. Major producers are China, Portugal, India and Australia, (which produces about 200-300 tonnes per year). China's production appears to be in decline with some reports indicating it may halve it's production.

The main prospective market for Eucalyptus oil comes from the demand for new environmentally safe materials. Eucalyptus oil is a natural product with low relative volatility and no toxic by-products. It is an efficient solvent, is easily recycled and readily biodegradable.

Investigation by CALM, the OMA and the OMC has identified a range of potential markets which can be expanded or developed. The OMC have developed a strategy to use a range of markets during industry development.

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Industrial solvent markets are very large and diverse, and mainly supplied with petrochemical based materials. Many of these materials are subject to stringent health, safety and disposal regulations. Some solvents contain chlorine and their loss to the atmosphere contributes to ozone depletion. However they are generally cheap commodities.

One major solvent, trichloroethane, is being withdrawn from use (to be phased out internationally by the year 2000). The market for this product alone is very large. International consumption is estimated to be nearly 1 million tonnes per year. The produce from 20 million hectares of oil producing eucalypts would be required to fill this market.

A suggested way of dividing the market is on the basis of price, with the bulk of the cineole produced from farmland sold as a standard product:

- 10% of volume into high value $12+/KG
- 30% of volume into specialty solvents $5 - $12/kg
- 60% of volume into standard products $3 -$5/kg

A breakdown of some cineole market segments is are:

Existing Market Segments	**Total Market Size**	**Estimated Market Quantity**	**Trend in Market Size**
Pharmaceutical	Moderate	3000t worldwide 200 t FGB* 400 t Davis	Moderate growth
Industrial			
- Wool washes	Small		Steady
- Janitory cleaning	Moderate		
Perfurmery	Very small		Decline
Potential Market Segments			
Metal Cleaning			
- Preceding electronic surface treatment			
- Routine maintenance	Large		Growth
- Repair and service			
Electronic industry			
- Defluxing circuit boards, etc.	Moderate	500 t in Aust.	Growth
Precision cleaning			
- first stage of parts manufacturing as a result of stamping, pressing, etc	Large		Growth
Dry Cleaning	Small		Steady
Janitory cleaning	Moderate		Growth
Coatings and Inks	Small		Steady
Minor Fractions of Eucalyptus Oil	Unknown		Unknown
Insecticides and Fungicides	Unknown		Unknown

* FGB Felton, Grimwade & Bickford

Costs and Production figures

With current technology it is estimated that harvest and distillation costs will be close to $1.75/kg of oil. The industry is aiming to reduce this cost to $1/kg of oil. With overheads and the costs associated with dispersed plantings, commercial harvesting will probably not begin before the year 2000/2001.

There are a number of factors which affect the likely returns from oil mallees. Inefficiencies within the industry, from seedling establishment to oil extraction, need to be minimised. These include:

- The cost of establishment. More efficient nurseries will see a drop in seedling costs. Best bet establishment methods are needed to produce a vigorous, healthy stand of mallees, with maximum survival, ready for harvest as early as possible.
- Improvements in harvest and extraction methods. Developing new harvest techniques and transport methods for plantation mallees will decrease costs.

Production can also be lifted and harvesting efficiency increased by:

- More Plantings. Minimum forecast plantings is 2 million trees per annum.
- More dense plantings. Each "harvest stop" should ideally mean a harvest of 10 000+ trees in close proximity.
- More species specific plantings in expectation of more consistent oil quality and price enhancement in the future, i.e. a minimum numbers of species at each planting site.
- Planting trees on good sites to maximise tree survival and growth.
- A higher leaf yield in tonnes per hectare harvested. Good sites and continued plant selection work will raise the volume of leaf material produced.
- A higher oil content per tonne harvested. Selective breeding of high oil yielding plants will increase production per hectare.

Farm and Industry returns

There are no existing Australian producers making a profit at the current world price. They remain in production because they are able to value add their product and are not reliant on the price of the crude oil alone for their return.

The market price fluctuates widely. In the past 12 years the price of oil (calculated ex-still in WA) has ranged from $2.64 to $8.67/kg, with an average price of $5.29/kg..

At September 1998 the world price for eucalyptus oil was $6.44/kg. Based on present technology, this price is considered adequate to establish a viable industry in W.A

The industry is aiming to achieve an average ex still price of $5/kg of oil with the at the farm gate return estimated at between $0.75 and $1.50/kg of oil. Using a range of production, cost and price estimates, the farm income from oil mallees is calculated to be between $60 and $630 per hectare pre year.

Harvest and processing

It is estimated that sites will be ready for their first harvest in the fourth year from planting. This is assuming the average weight of plants across a site is a minimum of 10 kilograms. Based on trial work, 10 kg of growth by year 4 will be achieved, with areas in the higher rainfall zones reaching the 10 kg minimum in 2 years from planting.

Subsequent harvests will be occur after the regrowth has reached the minimum of 10 kg. This will depend upon seasonal conditions and other events that impact on growth rates. The period between harvest is expected to be shortened to an annual harvest as the root stock (lignotuber) matures.

A batch steam still is the current method used to process the oil. A continuous feed steam still is now being trialed to reduce processing time and costs. This semi-portable unit requires the leaf to be separated from the wood and the leaf to be broken into finer particle sizes. Passive extraction systems to further reduce processing costs are also being investigated.

Planting design

Oil mallee plantings are designed to provide continuous feed to the harvester. The "hedge" is the basic planting unit and consists of two parallel rows, 2 metres apart. The plants in each row are 1.5 metres apart. The number of hedges and the distance between hedges varies according to the soil type, landscape position, and the farmer's aims. The basic planting configurations are block planting, alley farming and belt planting.

Belt plantings are the key to integrating oil mallees into broad acre farming. They are designed to allow operation of farm machinery for cereal cropping between the belts of trees.

Block plantings cause little interference to broad acre farming and are generally restricted to areas considered to be at high risk or in areas unsuitable for the annual crops. For example on areas to counter a rapidly rising water table or on acid sandplain soils where conventional agricultural practices have low production.

To ensure economy of scale an initial planting of at least 10 000 trees per farm unit is preferred. New areas outside the original 6 cells should aim for plantings totalling at least 50 000 trees in close proximity to ensure efficient harvesting and processing.

Plantation Management

For the best production from an oil mallee planting, a grower needs to have maximum survival and growth on the site. This means best bet establishment methods with adequate ripping and excellent weed control.

Herbicide use in adjoining paddocks or alleys should be carefully managed.

Virtually all oil mallees are being established in unfenced, such as belt plantings below or between grade banks. It is important that grazing be restricted for 9 - 18 months after planting to allow the trees to establish. Planting during a two year cropping rotation of a paddock, or by cutting hay in the inter row allows normal farm production to occur. After this time the unpalatability of eucalyptus oil mallees to grazing makes unfenced establishment a cheap revegetation option.

The farmer is responsible for the preparation of the site including controlling weeds, insects and vermin. They are also responsible for the purchase and planting of the seedlings and ongoing maintenance.

Tip removal and ring barking by parrots is tolerable as it can encourage branching.

Advice is available on all technical and planning aspects of establishment and management through the Oil Mallee Association Regional Manager network.

The large amount of planting planned for the Wheatbelt should enable full time employment of contractors to work in establishment and management of oil mallees. This will help overcome the lack of forestry expertise among the farming community.

Eucalyptus oil quality

Pharmaceutical grade eucalyptus oil requires a minimum cineole content of 70%. Oils of 90% cineole are considered finest grade, and no premium is paid for cineole content above this point.

High cineole content can be achieved by rectification of low cineole oils, or by using high cineole producing species and varieties.

The world market is dominated by oil from *Eucalyptus globulus,* which has a cineole content of 61-69% of total oils. Total oils comprise 0.45-1.5% of fresh leaf weight. Of the nine major species currently used in Western Australia, seven have a cineole content in excess of 80% of total oil and the remaining two are over 70%. A total oil content of 2.5% of fresh leaf weight is set as the minimum for a species to be used in the industry. These figures are encouraging for eucalyptus oil production from the endemic species chosen.

Species screening and development

A screening of eucalypt species in south western Australia for their oil characteristics was performed during the 1980's by Allan Barton (Associate Professor, Murdoch University) and Ian Brooker, (CSIRO).

Using this work as a starting point, CALM searched within the identified eucalypt groups for high yielding species.

Species were selected for a high total oil content and a high relative percentage of 1,8-cineole.

Once proven to have an acceptable level of good quality oil, the species were trialed on a range of climatic and soil conditions to determine growth rates and general vigour. Farmers, nursery operators and revegetation people were consulted to determine relative growth rates of different species.

The mallees were then subjected to cutting trials to ensure that they recovered when harvested. The species selected had to be a mallee form, as mallet and tree forms do not have the regenerative capacity required for prolonged harvesting.

Variation of oil content exists between and within species, with different populations of the same species exhibiting different oil qualities. The mallees so far selected and propagated are derived from seed from the best oil producing populations.

Seed orchards have been established for all major species from the best populations identified. As part of this work, elite lines have been propagated by cutting and grafting, and DNA assessment made to investigate the likely success of hybrid production.

There are many potential oil producing species and work is ongoing to find and test new ones. The aim is to improve yield and to have at least one species that is well suited to every Wheatbelt soil type.

Research needed

The industry Business Plan identifies the need to increase production to make the industry profitable. It also highlights harvesting transport and processing costs as priority areas for development.
Areas of research include:

- The development of cheaper oil extraction processing.
- The use of the woody by-product for energy generation.
- Oil mallees carbon sequestration and potential for trading in carbon crediting.
- Coppicing regrowth to soil types.
- Planting spacing trials to maximise production.
- Herbicide tolerances for inter row weed control.

Association

Oil Mallee Association membership is open to all growers, potential growers and industry supporters. Membership includes a regular newsletter to keep growers in touch with the industry.

Eucalyptus Oil Mallee Industry - Networks

This directory is a list of information sources, industry associations, industry developers and suppliers of seedlings.

Oil Mallee Association of Western Australia Inc.

Membership is open to all growers, potential growers and industry supporters. Membership includes a quarterly newsletter to keep growers in touch with the industry.

- President: Chris Croot, Post Office Canna, 6627
  Tel: (08) 9972 2040, Fax: (08) 9972 2020
- Hon Secretary: Elva Rolinson, Post Office Kalannie, 6468
  Tel: (08) 9666 2069, Fax (08) 9666 2069
- Administrator: Ric Collins, Pastoral House, 1/277 Great Eastern Highway, Belmont, 6104
  Tel: (08) 9478 0330
  Fax: (08) 9478 0333
- Co-ordinator: Wayne O'Sullivan
  10 Houston Ave, Dianella, 6062
  Tel: (08) 9275 3262
  Fax: (08) 9334 0323

Oil Mallee Association Region Managers

Oil Mallee plantings began with pilot commercial scale plantings in six locations across the Wheatbelt. These locations were Canna, Kalannie, Narembeen, Wickepin, Woodanilling and Esperance. Cell managers were appointed to co-ordinate the activities within each cell.

The restriction on plantings has now been lifted, with seedlings available for planting throughout the Wheatbelt under a new regional management structure.

Mid West

Robyn Stephens, PO Box 108, Morawa 6623
Tel: (08) 9972 2044, Fax (08) 9972 2003

Cathy McKenna, PO Box 5, Mullewa 6630
Tel: (08) 9961 5218, Fax (08) 9961 5201

South East

Greg Bannon, PO Box 192, Esperance 6450,
Tel: (08)9079 2085, Fax: (08) 9079 2103.

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Southern

Wendy Bessell-Browne, PO Box 107, Woodanilling 6316
Tel: (08) 9822 8012, Fax (08) 9822 8034

Upper Great Southern

David McFall, 26 Jersey Street, Narrogin 6312
Tel: (08) 9881 5373, Fax (08) 9881 5374

Eastern Wheatbelt

Tim Helder, PO Box 262, Narembeen 6369
Tel: (08) 9064 7166, Fax (08) 9064 7327

Central

Angela and Max Waters, Post Office, Kalannie 6468
Tel: (08) 9666 2131, Fax (08) 9666 2141

Oil Mallee Company of Australia

Ric Collins, Executive Chairman.
Pastoral House, 1/277 Great Eastern Highway
Belmont 6104
Tel: (08) 9478 0340
Fax: (08) 9478 0333

Nurseries

All seedlings are ordered through the OMA Region Managers. Expression of interests are called for each year for nurseries to participate in growing high oil content oil mallees for the OMA

Research and development

- Associate-Professor Allan Barton. Division of Science - Chemistry, Murdoch University, South Street, Murdoch 6150.
  Tel. (08)9360 2132, Fax (08) 9310 1711,
  email barton@chem.murdoch.edu.au

- Bob Greening. Division of Science - Chemistry, Murdoch University, South Street, Murdoch 6150.
  Tel. (08)9360 6052, Fax (08) 9310 1711,
  email greening@chem.murdoch.edu.au

- Dr Jeff Claflin. School of Chemical Engineering. Curtin University. GPO Box U1987, Applecross. 6845.
  email chemengir&d@chem.curtin.edu.au

CALM

- John Bartle, Farm Forestry Unit. Conservation and Land Management, 50 Hayman Road, Como. Tel (08) 9334 0321, Fax (08) 9334 0323
  Email: johnb@calm.wa.gov.au

Rick Giles, CALM Research Centre, Dwellingup 6213
Tel: (08)9538 1323, Fax (08) 9538 1206
Email: richardg@calm.wa.gov.au

- Peter White, Regional Office, Conservation and Land Management,
7 Wald Street (PO Box 100), Narrogin 6312.
Tel: (08) 9881 1444; Fax (08) 9881 3297.
Email: peterw@calm.wa.gov.au

Processors, buyers and exporters

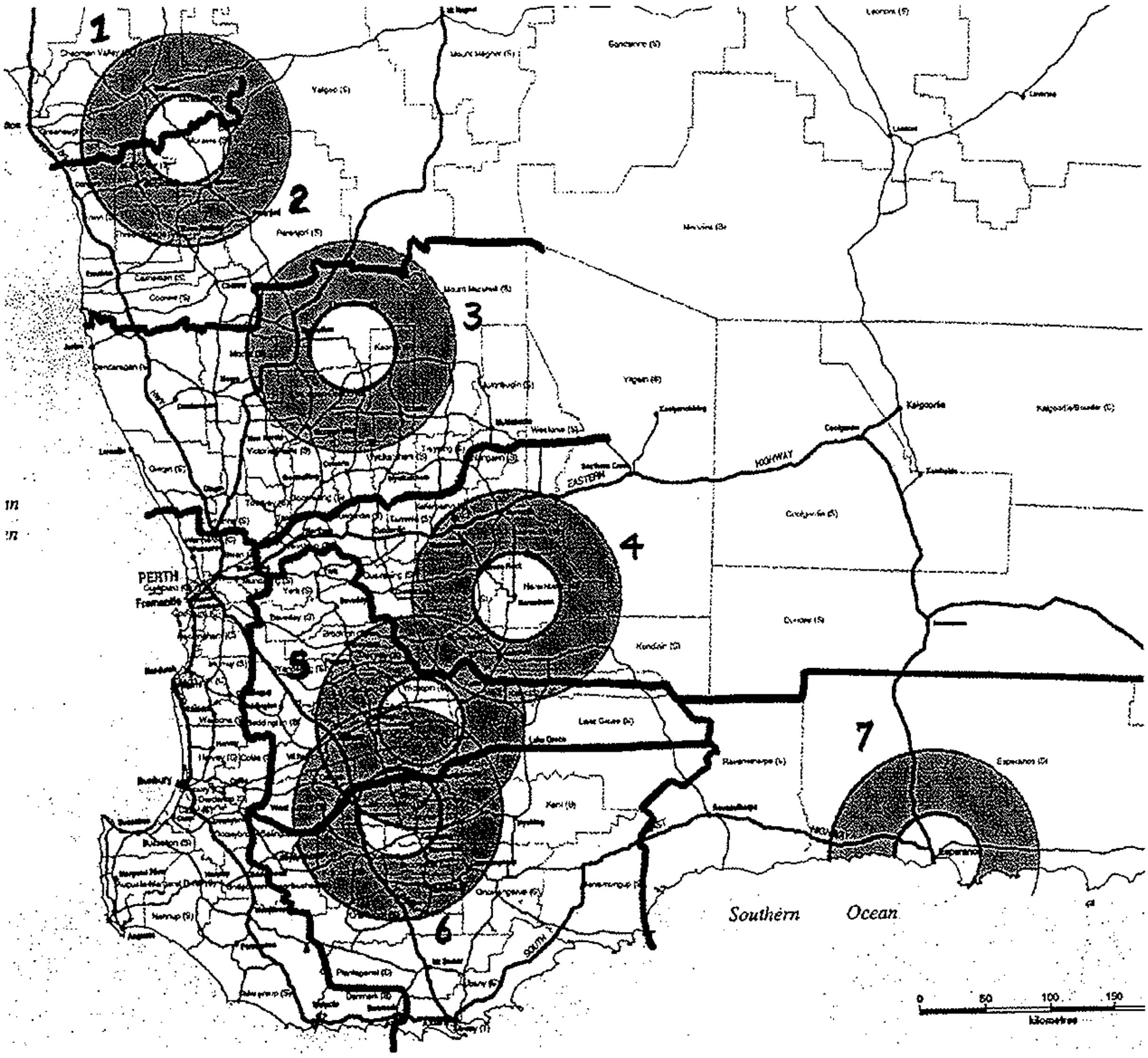
- Felton Grimwade and Bickford Pty Ltd
61-69 Clarinda Rd, Oakleigh Rd South
Victoria 3167
Tel: (03) 9562 7711, Fax: (03) 9562 7291

RESPONSIBILITIES FOR OIL MALLEE SERVICES 1997

SERVICE	STEP	OMA	CALM	MGR	NURS	CONT	FARM
Seed supply	Reconnaissance/sample		■				
	Laboratory analysis		■				
	Field collection		■				
	Seed extraction		■				
	Seed cleaning/germ test		■				
	Sell seed to nursery		■				
Nursery stock supply	Call expressions of interest	■					
	Receive copy levy+deposit inv	■					
	Manage levy+deposit payments	■					
	Collate grower orders	■					
	Place orders with nursery	■					
	Pay nursery deposit	■					
	Grow and deliver miniplugs		■				
	Grow seedlings				■		
	Confirm nursery production	■		■			
	Temporary hold seedlings			▒	■		▒
	Despatch seedlings				■		
	Transport seedlings to farm			▒	▒	▒	■
	Final invoice to grower				■		
Plan & advise	Help decide site/layout			■			▒
	Decide species and numbers			■			▒
	Write levy+deposit invoice			■			
	Pass invoice copy to OMA			■			
	Advise on establishment			■			
	Record and map			■			
	Obtain signed grower contract			■			
	Make payments to manager	■					
Plant	Rabbit control					▒	■
	Rip and mound					▒	■
	Weed control					▒	■
	Plant					▒	■
	Fertilisation					▒	■
	Spring weed control					▒	■
	Return trays to local nursery			▒		▒	■
	Make payment for services						■
Admin	Maintain grower datatbase	■					

LEGEND: The party responsible for each step is shown in solid shading .... ■
The responsible party may sub-contract (or defer to) others shown .... ▒

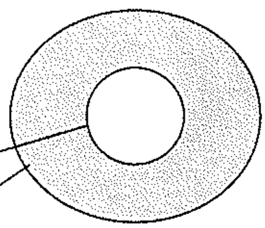
Note: The party allocated responsibility for each step accepts the obligation to have that step done at the appropriate time. The responsible party must meet the cost of that step and may at its discretion arrange for contractors to do the work on their behalf, or, in the case of the cell managers responsibilities, to interact with farmer to ensure completion of the step.



Legend

Oil Mallee Management Areas

1	Mid West upper
2	Mid West lower
3	Central
4	Eastern
5	Upper Great Southern
6	Southern
7	South Eastern



Original Mallee Cells: Inner circle 30km radius
Outer circle 70 km radius

Eucalyptus Oil Mallee References

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Eucalyptus oil mallees - Websites

Agriculture Western Australia

This page is designed to give you quick access to a range of information sources on revegetation options and technologies. Material prepared for this kit is included as a link from this site.
http://www.agric.wa.gov.au/progserv/natural/trees/bo/refnets.htm

A eucalyptus oil and cineole website

A page offering extensive links to other eucalyptus and essential oil sites.
http://www.mallee.com/eucoil.html

Western oil mallee project

An overview of the oil mallee project.
http://www.freeyellow.com/members2/techdev/womp.html

Matcom Eucalyptus oil plantation

An eastern states plantation website with some links to other sites.
http://matcon.com.my/MATCOM/e&b.htm

Agroforestry for the Low Rainfall

Background to industry development

The State Salinity Statement (1996) made dire predictions for increased salinity problems in the Wheatbelt region of WA. It also identified that an increased percentage of perennial vegetation across the landscape is needed to help protect farming land from salinity.

Sensibly designed agroforestry is one way to integrate woody perennials into the current farming system. Agroforestry that complements rather than competes with conventional farming may provide landholders with greater financial security and a landcare benefit.

Forestry product markets have also demonstrated less price fluctuations than wool and wheat over recent years. They are also less likely to be in competition with agricultural subsidies from other countries.

However there are some limitations to the development of commercial farm forestry in the WA Wheatbelt:

Climate

The low rainfall, high evaporation rates, incidence of frost and the ancient soils of the area will limit the species selection and lengthen the rotation in much of the landscape.

Social

Any proposal must be adopted by a community unfamiliar with forestry activities. This suggests that crops should have low labour requirements, be easily mechanised or have contractors available in the establishment, maintenance, harvesting and processing stages. The familiarity with annual crops and returns by both landholders and their bankers means that tree crops with a shorter rotation and a frequent dollar return will be more attractive.

Distance

Due to the Wheatbelt's remoteness and large area, a suitable tree crop should have a high value or a high value to volume ratio. The ability to value add to the product or to use the products on the farm will also be more attractive. If processing part of the crop is to occur, finding a use for the residues will make the crop more profitable.
Sharefarming arrangements or co-operative structures will decrease individual workloads and increase the likelihood of contractors being available in the industry.

Integration

Increased planting of woody perennials into the agricultural landscape (the revegetation target suggested for the low rainfall zone is around 20%) will lead to a high degree of interaction with crops and pastures. Therefore, it is important that tree crops are planted in a way that least interferes with annual production systems. This will include minimal root competition for moisture and nutrients. The non palatability of the crop to stock will be advantageous in reducing fencing and establishment costs.

Weed risk

The use of local native plants will reduce the risk of the tree crop becoming a weed.

With these limitations in mind, oil mallees for the production of cineole to use as a bulk industrial solvent, was identified as the tree crop most attractive for developing as a farm forestry option for Wheatbelt farmers.

Production and financial projections

For the farm

Oil mallees have the potential to generate an extra income for farmers in low to medium rainfall belts.

A recent financial model attempted to combine the known and anticipated features of oil mallee production. The calculations were based on conservative production and price figures. A 25 year period reflects the long term investment in woody perennials. Fortunately, the cash flow for oil mallees is generated much earlier than for most other tree crops.

It is expected that the Oil Mallee Company will arrange the harvest and distillation of the oil mallees and pay farmers a farm gate price for the oil. Conservative oil prices were used assuming that more than 50% of the oil will be sold into high volume, low price markets.

The company is striving to achieve an average distributed product price of $5/kg, and a return to growers of $0.75 - $1.50/kg. However, there are still many unknowns in the industry that can affect this goal.

A summary of the model's results are:

Assumptions

Planting Density 15% of farm (0.15 of each ha) = 400 trees in each ha

Cost per 0.15ha @ 55c/tree planted	$220
Cost/0.15ha (tree cost spread over 10 yrs)	$22pa
Survival ~ 90%	360trees/0.15ha
Lifespan of tree with regular 2yr harvesting	100+ yrs
Harvest volume	
First harvest	10kg-20kg biomass
Other harvests	10kg-20kg biomass
Oil content	
First harvest	1.5% biomass
Subsequent harvests	1.75% biomass

Farm gate oil price (large volume, low price market) $0.75 - $1.50/kg

Returns per farm ha	Year 4	Then every second Year	After 10 yrs
	$40-160	$47-189	$47-189
Costs/0.15ha (spread 10 yrs)	$22	$22	
Surplus	$18-138	$25-164	$47-189
Surplus per ha	$120-920	$166-1093	$313-1260
Surplus per ha each year	$60-460	$83-546	$156-630

NB: The lower end of the range in based on 10kg harvested biomass and an oil price of $0.75/kg. The higher end of the range in based on 20kg harvested biomass and an oil price of $1.50/kg

For the industry

Assuming that the OMA is able to achieve its planting goals and the Oil Mallee Company is able to meet harvest and distillation targets, the potential benefits to rural WA could be significant.

The following table summarises the potential benefits and is based on oil revenue from OMA planting targets

Assumptions	**Year**	**2000**	**2010**	**2025**
Trees surviving (millions)		20	200	500
Trees harvested/year(millions)		10	75	200
Biomass/tree		10 kg	10 kg	10 kg
% Oil in Biomass		1.5%	1.625%	1.75%
Oil Produced (tonnes)		1500 t	12000 t	35000 t
Value to Western Australia	@$5/kg	$7.5m	$60m	$175m
Value to farmers	@$1/kg	$1.5m	$12m	$35m
Average value per harvest per 1000 ha @ 400 trees/ha (15% area)	@$1/kg	$60,000	$65,000	$70,000

Other benefits that may also occur include:

- Sale of spent biomass for fuel, particle board or mulch.
- Extraction of tannins
- Carbon Credits.

It should be noted the principal reason for planting oil mallees is for a landcare benefit, i.e. to impede and perhaps even prevent further degradation of agricultural land resulting from waterlogging and salinity. These forecast financial returns are a bonus above the landcare benefit.

Eucalyptus oil mallee - Planting statistics

When the industry first began as the Eucalyptus Oil Mallee project, oil mallee plantings were concentrated to 6 main areas. (See attached map). Planting of mallees were restricted to a 30 km radius of the 6 cells. In 1996 this radius was expanded to 70 kms. The Kalannie cell was the exception to this, with early plantings restricted to within the boundary of the Kalannie-Goodlands Land Conservation District.

The reason for this confined planting was because of the uncertainty of overhead costs and economies of scale, and the limited portability of extraction equipment.

The planting restriction has since been removed with the aim of linking the 6 areas. Oil mallees are now available to all growers in the Wheatbelt.

At the end of 1997 the number of oil mallees planted in each of the original cells were:

Canna (Midwest region)	1,784,000
Kalannie (Central region)	2,011,000
Narembeen (Eastern Wheatbelt region)	1,306,000
Wickepin (Upper Great Southern region)	962,000
Woodanilling (Southern region)	630,000
Esperance (South East region)	650,000
Total	7,343,000

The cumulative number of oil mallees planted to date and estimated for the future are as follows:

Year	No. of new Trees (millions)	Est. Hectares (@400trees/ha)	Cumulative Trees (million)	Cumulative Hectares (est)
1994	1		1	
1995	1		2	
1996	1.5		3.5	
1997	3.5	17500	7	17500
1998	2	5000	9	22500
1999	4	10000	13	32500
2000	8	20000	21	52500
2001	10	25000	31	77500
2002	11	27500	42	105000
2003	12	30000	54	135000
2004	14	35000	68	170000
2005	16	40000	84	210000
2006	18	45000	102	255000
2007	21	52500	123	307500
2008	24	60000	147	367500
2009	27	67500	174	435000
2010	30	75000	204	510000
2011	30	75000	234	585000
2012	30	75000	264	660000
2013	29	72500	293	732500
2014	28	70000	321	802500
2015	27	67500	348	870000
2016	26	65000	374	935000
2017	25	62500	399	997500
2018	23	57500	422	1055000
2019	21	52500	443	1107500
2020	18	45000	461	1152500
2021	14	35000	475	1187500
2022	10	25000	485	1212500
2023	8	20000	493	1232500
2024	5	12500	498	1245000
2025	2	5000	500	1250000

Eucalyptus Oil Mallee Species

Extract from the Oil Mallee Establishment Manual. Reproduced with permission from the Oil Mallee Association.

Taxonomy and Species Selection

The mallee eucalypts are a complex group and taxonomic description is not complete.

A number of the species in the program have been subject to recent taxonomic revision. For example the review of *Eucalyptus spathulata* subsp. *grandiflora* led to the creation of E. *suggrandis*. The taxonomic revision has also created some confusion with the smooth barked York Gum group. Whether *E. loxophleba* subsp. *lissophloia* and *E. gratiae* are two species and not just provenance variation has yet to be agreed on.

Taxonomic revision is ongoing and impacts to various degrees on the "minor" species (those under investigation for potential use in the program). This aspect of the program is being managed by CALM and while it is of interest, it will not impact on the field management of the mallees.

A fairly comprehensive screening of eucalypt species in the south west of Western Australia for their oil characteristics was performed during the 1980's by Allan Barton (Murdoch University). This work provided the broad foundation of the groups within the eucalypts that warranted closer examination.

The two most significant of these groups to date are the

- Oleosae series, from which we use *Eucalyptus kochii* subsp. *kochii, E. kochii* subsp. *plenissima* and *E. horistes*,

- Loxophlebae series, from which come *E. loxophleba* subsp. *lissophloia* and *E. gratiae.*

- Cneorifoliae series has provided *E. angustissima* subsp. *angustissima.*

Selection Strategy

To achieve maximum growth and flexibility, the majority of the work is targeted towards good generalist species. However, species suited to difficult sites such as sandy soils or waterlogged/saline sites are also being examined closely.

The species selected must be mallees. Mallet and tree forms do not have the regenerative capacity for repeated or regular harvesting.

Oil analysis is done by Gas Chromatography (GC) at Murdoch University and is normally confined to cineole analysis. This saves time, reduces cost and provides a rapid turn around of samples. It does not however give an idea of the total oil yield or information on other components which may be of interest.

Newer species and the occasional sample of the major species, have an extended GC run. This helps build a better understanding of the range of components that may be available in the oil..

Once proven to have an acceptable level of good quality oil, the mallees are taken into a species trial program. They are planted on a range of sites to determine their growth rates and general vigour in a range of climatic and soil conditions. The mallees are then subjected to cutting trials to ensure that they do in fact, recover when harvested.

This more formal trial work is complemented by observation in the wild and where possible in cultivation, if the species has been planted as a farm tree. Farmers, nursery operators and revegetation people are consulted to determine relative growth rates of different species.

Reference Material

The standard reference for the field identification of eucalypts is:

Brooker, M.I.H and Kleinig, D.A. (1990) Field Guide To Eucalypts South-western and Southern Australia. Inkata Press Melbourne and Sydney.

Johnson L.A.S. and Hill K.D. (1992) Telopea Vol. 4 No. 4.

The only species currently in use by the program not covered in this volume is *Eucalyptus polybractea*. This is found in both the following volumes:-

Brooker, M.I.H and Kleinig, D.A. (1983) Field Guide To Eucalypts South-eastern Australia. Inkata Press Melbourne and Sydney, and in

Boland, D.J., *et al*. (1984) Forest trees of Australia. Thomas Nelson Australia and CSIRO Melbourne.

This latter reference also has some good information about the site conditions of *E. polybractea.*

In the notes that follow, the species used in this program are divided into two groups, **major** and **minor**. This ranking is determined by the significance of these species, i.e. by the numbers in the ground at the moment. As the search for new species goes on this relative ranking may change.

The following botanical descriptions have been summarised from Brooker and Kleinig's work (see reference list).

MAJOR SPECIES

These species form the backbone of the program at the moment. They have been selected for their potential to supply good quality oil. These species provides selections for the major wheatbelt soils and landscape positions. They have been planted in large numbers, and their performance has been reasonably well assessed.

Eucalyptus angustissima subsp *angustissima*

Eucalyptus gratiae

Eucalyptus horistes

Eucalyptus kochii subsp *kochii*

Eucalyptus kochii subsp *plenissima*

Eucalyptus loxophleba subsp. *lissophloia*

Eucalyptus polybractea

Eucalyptus angustissima subsp. *angustissima* — Narrow leafed mallee

Description	A small fine leafed mallee with smooth grey bark, peeling on the main stems leave actually look like needles.
Juvenile leaves	Opposite, becoming disjunct, narrow to narrow lanceolate, grey; sessile to very shortly petiolate, 7 x 0.6 cm.
Adult leaves	Disjunct narrow to narrow lanceolate 4.5-13 x 0.2-0.7 cm; petioles 0.2-0.5 cm; lateral veins obscure; oil glands dense, spherical.
Inflorescences	Simple, axillary; umbellasters 7 flowered; peduncles terete or angular, 0.1-0.4 cm.
Buds	ovoid 0.6-0.6x 0.3-0.5; calyptra as long as hypanthium.
Stamens	all fertile; filaments regularly inflexed; anthers basifixed, sub versatile, flattened globoid, dehiscing through short angled slits.
Flowers	white.
Fruit	hemispherical to broadly obconical, 3-4 locular; 0.4-0.7 x 0.5-0.8; calyptra scar flat, c. 0.02 cm wide; staminophore slightly expanded, flat or slightly raised, to 0.05 cm wide; disc flat or slightly raised, 0.05-0.1 cm wide; valves broadly triangular, obtuse, apically (check this) rim level, flat, with small dorsal protuberances.
Seeds	semi glossy, pale red brown, flattened elliptic, regularly very shallowly pitted and grooved (almost smooth), hilum ventral, chaff similar.
Bark	Smooth, dull, pale grey or cream shedding in partly adherent sheets.
Distribution	South coastal and sub coastal areas, west of Esperance, east to Israelite bay. (*Eucalyptus angustissima* subsp. *quaerenda* occurs to the west in the Lake Chinacup area.)
Ecology	Grows in (usually white) sand over saline clay soils in rainfall areas of 250-380 mm.
Site preference	Best suited to moisture gaining sites with sand over clay. The species appears to have a high degree of salt and waterlogging tolerance. However, it is probably not suited to waterlogged grey clays. Suited to southern oil mallee regions.
Ref.	**B & K Vol. 2 #158, Telopea Vol. 4(4) p 597**

Eucalyptus gratiae — Large fruited smooth barked York gum

Description	A tall, smooth barked mallee to 8 m with large blue-green juvenile leaves changing to glossy green adult leaves. Differs from *E. loxophleba* subsp. lissophloia in the greener juvenile foliage and the larger buds and fruits and the relative absence of glaucous bloom on the branchlets. These two species can be difficult to distinguish unless side by side.
Juvenile leaves	Petiolate, alternating, ovate to orbicular, acute to rounded. 8-13 x 5-9 cm, usually dull bluish.
Adult leaves	Petiolate, alternating, glossy, lanceolate to falcate, acute. 8-16 x 1.5-2.8 cm, glossy green; lateral vein at 10-30 degrees to midrib.
Inflorescences	Axillary, unbranched, 7 flowered, or apparently terminal when young, with a terminal, undeveloped vegetative bud, which may later grow forming a leafy shoot beyond the inflorescences or may abort leaving an apparently compound terminal inflorescence. Peduncles 2-angled 3-24 mm long.
Buds	pedicellate, ovoid, 0.9-1.5 x 0.4-0.5 cm, scar present; operculum hemispherical or more rarely apiculate.
Stamens	inflexed, all fertile; anthers versatile, basifixed, cuboid, opening by pores; style constricted at base.
Flowers	white; flowering period September-December.
Fruit	pedicellate, conical, 0.9-1.2 x 0.6-1.9 cm; rim thin disc descending; valves 4 or 5 enclosed.
Seed	dull, dark brown, cuboid.
Bark	Smooth, brownish, yellow brown or greenish to bronze. Upper stems of saplings may be glaucous. Pith of branchlets glandular. May have a low stocking, seldom more than one metre. Distribution seperates it from *E. loxophleba* subsp. *supralaevis* on this characteristic.
Distribution	South-eastern Wheatbelt centred around Pingrup, Lake Grace, Hyden and Newdegate.
Ecology.	Rainfall in natural occurrence 250-400mm. Intergrades and overlaps with the range of *E. loxophleba* subsp. *lissophloia*. Occurs on shallow soils, often associated with granite outcrops, often in depressions. Extensively cleared as they were an indicator of good agricultural land.
Site preference	A good "generalist" species with performance very much like *E. loxophleba* subsp. *lissophloia*, growing on sands to duplex soils through to heavier clays. Some salt tolerance and a degree of waterlogging tolerance, but performs better on well drained sites and heavier clay / loam soils. Suited to all areas within the present oil mallee program, but targeted at those areas closer to its home range.
Ref.	**B & K Vol. 2 #138. Telopea Vol 4(4) 1992 p571.**

Eucalyptus horistes

Description	A medium sized mallee with rough grey bark of varying height. Similar to *E. kochii* subsp. *kochii* and *E. kochii* subsp. *plenissima*, but distinguished by glossier, brighter green leaves and the beaked operculum.
Juvenile leaves	Opposite, sessile for a few pairs then shortly petiolate, alternating, ovate, to 6 x 2.5 cm, bluish grey, glossier than *E. kochii subsp. plenissima.*
Adult leaves	Petiolate, alternating, linear to narrow lanceolate, held somewhat erect, 5-12 x 0.4-1.5 cm, concolorous, dull, blue green when immature, finally slightly glossy, green; reticulation very dense, veinlets thin, with numerous, irregular, intersectional oil glands.
Inflorescences	Axillary, unbranched, (7)9-13 flowered; peduncles terete, 0.3 x 1.1 cm long.
Buds	shortly pedicellate, broadly fusiform, 0.7-1 x 0.3-0.4 cm, scar present; operculum long and beaked. More robust than *E. kochii* subsp. *kochii.*
Stamens	inflexed, all fertile; anthers weakly versatile, basifixed, globoid, opening by broad lateral pores.
Flowers	white. Flowering period December to February.
Fruit	shortly pedicellate, truncate globose to urceolate, 0.5-0.8 x 0.5-0.7 cm; rim thin; disc descending; valves 3, enclosed, apparently exserted due to persistent, fragile style remnants. More robust than *E. kochii* subsp. *kochii.*
Seed	grey, compressed ovoid, smooth and shiny, often with longitudinal grooves
Bark	Rough over whole or most of stems, firm, grey.
Distribution	Far northern Wheatbelt, particularly Morawa, Mullewa and Canna districts and to the east thereof, also north-west towards Yuna.
Site preference	A good robust species, growing on reddish sands through to some heavier loamy clays. Limited salt and waterlogging tolerance, drainage important. Suited to all areas within the present oil mallee program.
Ref.	**B & K Vol. 2 #171.**

Eucalyptus kochii subsp. *kochii* **Oil mallee**

Description	A medium sized mallee with rough grey bark of varying height. Differs from *E. kochii* subsp. *plenissima* and *E. horistes*, in having a more upright form and generally bluer foliage. Operculum is pointed but not beaked. Existing plantings tend to be inconsistent in height and shape.
Juvenile leaves	Opposite, sessile for a few pairs then shortly petiolate, alternating, linear to lanceolate, to 10 x 1.5 cm. dull, blue green.
Adult leaves	Petiolate, alternating, linear to narrow lanceolate, held somewhat erect, 5-12 x 0.4-1 cm, concolorous, dull, blue green when immature, finally slightly glossy, green; reticulation very dense, veinlets thin, with numerous, irregular, intersectional oil glands.
Inflorescences	Axillary, unbranched, (7)9-13 flowered; peduncles terete, 0.3 x 1.1 cm long.
Buds	shortly pedicellate, broadly fusiform, 0.7-1 x 0.3-0.4 cm, scar present; operculum conical.
Stamens	inflexed, all fertile; anthers weakly versatile, basifixed, globoid, opening by broad lateral pores.
Flowers	white. Flowering period December to January.
Fruit	shortly pedicellate, truncate globose to urceolate, 0.5-0.8 x 0.5-0.7 cm; rim thin; disc descending; valves 3, enclosed, apparently exserted due to persistent, fragile style remnants.
Seed	grey, compressed ovoid, smooth and shiny, often with longitudinal grooves
Bark	Rough over whole or most of stems, firm, grey.
Distribution	Wongan Hills - Watheroo - Dalwallinu area
Ecology.	Rainfall in natural occurrence 280-380 mm. Usually on yellow sand. Currently withdrawn from available bulk lines because of its variable performance. It is a high oil yielder, which will support its retention in the program, but efforts are being concentrated into seed orchard work to produce more vigorous stock.
Site preference	Suited to the reddish sands of the northern and central agricultural areas. Little or no salt or waterlogging tolerance.
Ref.	**B & K Vol. 2 #169**

Eucalyptus kochii subsp. *plenissima* **Oil mallee**

Description	A medium sized mallee with rough grey bark of varying height. Characteristics intermediate between *E. kochii* subsp *kochii* and *E. horistes*. Foliage more upright and duller than *E. horistes*. Operculum is short.
Juvenile leaves	Opposite, sessile for a few pairs then shortly petiolate, alternating, ovate, to 6 x 2.5 cm. dull, bluish grey.
Adult leaves	Petiolate, alternating, linear to narrow lanceolate, held somewhat erect, 5-12 x 0.4-1.5 cm, concolorous, dull, blue green when immature, finally slightly glossy, green; reticulation very dense, veinlets thin, with numerous, irregular, intersectional oil glands.
Inflorescences	Axillary, unbranched, (7)9-13 flowered; peduncles terete, 0.3 x 1.1 cm long.
Buds	shortly pedicellate, broadly fusiform, 0.7-1 x 0.3-0.4 cm, scar present; operculum conical, short. More robust than *E. kochii* subsp. *kochii*.
Stamens	inflexed, all fertile; anthers weakly versatile, basifixed, globoid, opening by broad lateral pores.
Flowers	white. Flowering period December to February.
Fruit	shortly pedicellate, truncate globose to urceolate, 0.5-0.8 x 0.5-0.7 cm; rim thin; disc descending; valves 3, enclosed, apparently exserted due to persistent, fragile style remnants. More robust than *E. kochii* subsp. *kochii*.
Seed	grey, compressed ovoid, smooth and shiny, often with longitudinal grooves
Bark	Rough over whole or most of stems, firm, grey.
Distribution	North-eastern Wheatbelt, north of the Murchison River to between Mt. Magnet and Sandstone extending to east of Southern Cross.
Ecology	Rainfall in natural occurrence 250-330 mm. Flat country usually in sandy loam that may be gravelly.
Site preference	This species appears to have a preference for reddish sandy and sandy loam soils, through in some areas it has proven tolerant of heavier clays. Little or no salt or waterlogging tolerance, drainage important. Particularly suited to the northern Wheatbelt, but all areas have examples of good plantings.
Ref.	**B & K Vol. 2 #170.**

Eucalyptus loxophleba subsp. *lissophloia* — Smooth barked York gum

Description	A tall, smooth barked mallee with large blue juvenile leaves changing to glossy green adult leaves. Differs from *E. gratiae* which has bluer juvenile foliage, larger buds and fruits.
Juvenile leaves	Petiolate, alternating, cordate to ovate, to 12 x 9 cm, usually mealy white.
Adult leaves	Petiolate, alternating, narrow lanceolate to lanceolate, 8-14 x 1-1.5 cm, very glossy, green; intramarginal vein looped and well in from leaf edge; reticulation moderate to sparse, with numerous, round, green and yellow, island oil glands of varying sizes.
Inflorescences	Axillary, unbranched, 7-11 flowered, or apparently terminal when young, with a terminal, undeveloped vegetative bud, which may later grow forming a leafy shoot beyond the inflorescences or may abort leaving an apparently compound terminal inflorescence. Peduncles flattened, 0.8-1.8 cm long.
Buds	pedicellate, clavate, 0.6-0.9 x 0.3-0.4 cm, scar present; operculum hemispherical or more rarely conical.
Stamens	inflexed, all fertile; anthers versatile, basifixed, cuboid, opening by pores; style constricted at base.
Flowers	white; flowering period September-February.
Fruit	pedicellate, obconical, 0.4-0.9 x 0.4-0.6 cm; rim thin disc descending; valves 3 or 4 enclosed.
Seed	brown, compressed ovoid to cuboid, with shallow distinct reticulum.
Bark.	Smooth, grey over rich coppery. Upper stems of saplings glaucous. Branchlets shiny red, glaucous. Pith of branchlets glandular.
Distribution	Widespread but sporadic distribution in the eastern Wheatbelt and Goldfields.
Ecology.	Rainfall in natural occurrence 250-400 mm. Intergrades and overlaps with the range of *E. loxophleba* subsp. *loxophleba*. Occupies the eastern part of the range. Occurs on sandy loams and loams, often with a clay subsoil. Often associated with granite outcrops, often in depressions. Extensively cleared as they were an indicator of good agricultural land.
Site preference	A good "generalist" species, growing on sands to duplex soils through to heavier clays. Some salt tolerance and a degree of waterlogging tolerance, but performs better on well drained sites and heavier clay / loam soils. Suited to all areas within the present oil mallee program.
Ref.	**B & K Vol. 2 #137.**

Eucalyptus polybractea **Blue-leaved mallee**

Description	An upright mallee of medium height with rough grey bark on the lower stems. Leaves of variable width and colour (see note on next page).
Juvenile leaves	Petiolate, opposite for a few pairs then alternate, linear then narrow-lanceolate, up to 10 x 1.5 cm, concolorous, slightly glaucous.
Adult leaves	Petiolate, alternate, narrow lanceolate, up to 10 x 1 cm, concolorous, bluish grey or bluish green, dull, densely reticulate.
Inflorescences	Axillary and simple, 7- (11) flowered; peduncles slightly angular, to 1.2 cm long.
Buds	pedicellate, clavate or diamond shaped, glaucous, to 0.7 x 0.35 cm, no scar (2 opercula intact); Operculum conical or hemispherical;
Stamens	irregularly flexed and all fertile; anthers adnate, basifixed, globoid, opening by small lateral pores;
Flowers	white, flowering period March-June.
Fruit	pedicellate, cupular to barrel-shaped, to 0.6 x 0.5 cm; rim thin; disc descending; valves 3-5, below rim level.
Bark.	Rough and persistent on the lower half of the stems., box type, thin fibrous, tight, grey; becoming ribbony or papery on the stems above, finally dark grey, light grey or pinkish grey.
Distribution	Two disjunct occurrences, near Wyalong in Western NSW and in the Bendigo area of Northern Vic.
Ecology	Rainfall in the areas of natural occurrence. NSW approx. 450 mm relatively even distribution. Victoria approx. 540 mm with a winter maximum. Occurs on red brown loams often with quartz. Also on sandy and shale soils.
Site preference	A good "generalist" species, growing on sandy duplex soils through to heavier clays. Some salt tolerance and a degree of waterlogging tolerance, but performs better on well drained sites. Suited to most areas within the present oil mallee program except for the lighter country in the drier areas.
Refs.	**B & K Vol. 1 #218.+FTOA**

E. polybractea-variation in the leaf colour and shape

A Victorian study from the 1970's (Handmer) recognised five different leaf types in *E. polybractea*.

Type 1 is the common form that accounts for 90% or more of the plantings, with a leaf that is dull bluish green to bluish grey and up to 1.5 cm wide.

Type 2 is the narrow leaf form, still the same colour but generally not much more than 0.5 cm wide.

Type 3 is the dull, green, blunt pointed leaf form. The leaf is tough and leathery to the touch.

Type 4 is also a green leaf, but apple green, and of similar dimensions as type 1.

Type 5 is the glaucous blue leaf variant, a little wider than type one, a smoky blue colour and soft to the touch.

Handmer suggests that types one and two are better oil yielding varieties than the others, although we have not tested this in Western Australia to date.

Although only occurring in small amounts, we will keep an eye on these variants because they have been associated with different site conditions and different yields. These distinctions may help us fine tune our selections in the future.

MINOR SPECIES

These species are considered less significant due to limited availability (as in the case of *E. vegrandis*) or are new to the program and have not been properly evaluated.

The search for new species will continue in an attempt to provide a selection of high oil yielding, vigorous species for all landscape positions, soils and climates in the Wheatbelt.

Some of these species are presented with more information than others. This reflects the degree to which they have been evaluated.

Eucalyptus myriadena subsp *myriadena*

Eucalyptus vegrandis

Other species

Eucalyptus myriadena subsp. *myriadena* Brooker

Description	A tall mallee or small tree with a dark grey stocking on lower half of stems.
Juvenile leaves	Petiolate, alternating, lanceolate to ovate, to 6 x 3 cm, dull grey green.
Adult leaves	Petiolate, alternating, narrow lanceolate, 5 - 12 x 0.5 - 1.8 cm, concolorous, very glossy, green to dark green; side veins very fine; reticulation sparse, often obscured by very numerous round, island oil glands.
Inflorescences	Axillary; unbranched, more than 7 flowered; peduncles slender, terete or angular, 0.5-1.8 cm long;
Buds	pedicellate, clavate to pyriform, 0.4 - 0.5 cm long, 0.2-0.3 cm diam.; operculum hemispherical to conical, scar present.
Stamens	inflexed, all fertile; anthers versatile, oblong, opening by longitudinal slits
Flowers	white, November - April
Fruit	shortly pedicellate, obconical to barrel shaped, 0.4-0.5 cm long x 0.3 cm diam.; rim thin; disc descending; valves 3, enclosed.
Seed	brown, compressed ovoid with shallow distinct reticulum.
Bark.	Rough, usually thick coarse, flaky on lower half of trunk or stems, dark grey to grey black, smooth greenish grey, grey or light pinkish grey above.
Distribution	Widespread in the central - eastern and southern Wheatbelt.
Ecology	Generally occurring low in the profile and with a preference for heavier soils. Some seasonal waterlogging may occur. pH of 10+ at 500 mm depth recorded at one collection site. Rainfall of 350-500 mm. Has good potential due to its site preference and good availability of seed. Performing trial plots in the Narembeen area.
Site preference	A good species for heavier sites, growing well on heavy grey clays. Good salt tolerance and some waterlogging tolerance shown. Potentially suited to all the oil mallee regions.
Ref.	**B & K Vol. 2 #280**

Eucalyptus vegrandis **Swamp mallee**

Description	A small mallee with smooth, frequently coppery bark. Leaves are narrow but still flat which distinguishes it from *E. angustissima*.
Juvenile leaves	Disjunct, linear, 7 x 0.8 cm dull blue green.
Adult leaves	Disjunct, linear, glossy, with distinct bluish sheen from the large translucent stomata, 5-9 x 0.2-0.4 cm; lateral veins scattered; reticulation sparse, incomplete; oil glands crowded, spherical.
Inflorescences	Simple axillary; umbellasters 7 flowered; peduncles flattened, 0.5-1.5 cm long; pedicels flattened or angular, 0.2-0.4 cm long
Buds	cylindrical, 1-1.3 cm long, 0.3-0.4 cm diam., calyptra more than 2 times longer than hypanthium, cylindrical, apically rounded to acute.
Stamens	all fertile; filaments erect; anthers oblong, dorsifixed, dehiscing through parallel slits
Flowers	white.
Fruit	ovoid to obconical or hemispherical, 0.4-0.6 cm long, 0.4-0.6 cm diam.; staminophore broad, flat persistent; disc flat, valves acicular, basally enclosed, apically exserted.
Seed	dark grey brown, compressed ovoid with shallow distinct reticulum.
Bark	Smooth, semi glossy, dark grey to red brown or bronze.
Distribution	Southern Wheatbelt. This is the main area of distribution, but it is also know (three flowered form) from the Wongan Hills area.
Ecology	Landscape position and soils variable. Selections deliberately chosen from low landscape provenances. Occurs on sandy loams, clay loam to clay soils, often seasonally waterlogged, in rainfall of 350-500 mm. Variable performance, not spectacular and will probably remain a minor species due to seed shortages.
Site preference	A good species for heavier sites, growing well on heavy grey clays. Good salt and waterlogging tolerance shown. Suited to the central Wheatbelt areas. Appears to be readily grazed and will probably have to be fenced.
Ref.	**B & K Vol. 2 #81, Telopea Vol. 4 (4) p 577.**

Species examined to 1997

Comments on prospects for further development.

Species	Comments
Callistemon phoeniceus	Initially targeted for potential waterlogging tolerance, however poor oil content results to date. Some opportunistic work may continue and extended GC's
Eucalyptus aequioperta	A rough barked mallee similar to *E. myriadena*, in the Narembeen area. Only minimal amounts of cineole detected. No further sampling of this species anticipated.
E. albida	A possibility for the sandier soils of the central Wheatbelt, however very poor results so far. Difficult to find good populations. Some additional work anticipated if good stand are located.
E. angustissima "Phillip's River"	An intermediate form of *E. angustissima*. While it appears to be as good a grower, both in the nursery and in the field as the subsp. *angustissima*, the very limited distributions is unlikely to yield many more good trees. Potential for inclusion in the *E. angustissima* breeding program.
E. aspratilis	Chance collection from last year with good oil results. Interesting seedling in the nursery (obvious relationship to E. *occidentalis* ie. seedlings grow mainly prostrate for the first 3 months). No knowledge of suitability to field plantings and harvesting work. Some planted in the 1997 trial plots. Collection work ongoing.
E. baudiniana	In the same series as *E. myriadena*, awaiting the opportunity to sample this species.
E. brachycorys	Recent testing has yielded good trees. Given its position in the landscape, it warrants further attention and will now be included in planting trials.
E. burracoppinensis	Given this species' obvious suitability to the yellow sand plain, it will be a target of opportunistic sampling
E. calycogona subsp. *calycogona*	Both the mallee and the mallet form of this species have shown little promise. However, as the mallee form appears to have promise for growing on harsh sites it will be sampled opportunistically. Finding good populations is very difficult.
E. celastroides subsp. *celastroides*	Sampled on previous occasions in the Kalgoorlie area, but with no results for cineole. However, some extended GC's will be run on this subsp. A recent collection from the Narembeen area found a 2.6% tree which should be available for trials in 1998.
E. celastroides subsp. *virella*	In the Calycogone series, as is *E. yilgarnensis* and *E. quadrans*. Some interesting results that may warrant some extended GC's.
E. cylindriflora (White Mallee)	Widespread small mallee from Bendering and Hyden towards Balladonia. Occurring mainly in clay soils on lower slopes. Has been trialed in 1996, but no results available yet. Limited amounts of seed available. Despite one early very high record, little has been forthcoming from subsequent sampling work. Sampling will continue opportunistically.
E. cylindrocarpa	Negligible oil found in this species and no plans to continue sampling.

Species	Comments
E. cylindroidea	Negligible oil found in this species and no plans to continue sampling.
E. decipiens	In the same group as E. cneorifolia from Kangaroo Island. Negligible oil found in this species and no plans to continue sampling. It is probably subsp. *adesmophloia* that was sampled, but as the results were very poor, in is unlikely that subsp. *decipiens* or *chalara* will be sampled.
E. eremophila Subsp. *eremophila* (Tall sand mallee)	Widespread through the Wheatbelt and the goldfields, growing on a wide range of soils. Wheatbelt provenances more suited to heavier clay soils. Some good results from planted specimens at Narembeen, but unsure of harvesting response. Seed supply limited at present. Opportunistic sampling will continue.
E. erythronema var. *erythronema* (Red-flowered mallee)	Small mallee of the southern Wheatbelt through to Southern Cross. Occurring on heavier clay soils on lower slopes. Trialed in 1996. Not a good performer in the nursery and no observations yet from field plantings. Seed supply limited due to the difficulty in finding good quality stands. The northern subsp. *marginata* may be worth sampling.
E. ewartiana	One small planting in the Narembeen area (1995). No observations of growth yet and no knowledge of harvesting. Seed supply very limited.
E. falcata	To be sampled on an opportunistic basis because of its preference for poorer sandy soils.
E. halophila	Would be a good one for the south coast, given its reputation for salt tolerance. However, it is of restricted distribution and very difficult to find good populations. Sampling to continue opportunistically.
E. hypochlamydea subsp. *ecdysiastes*	Reasonable performer in the nursery, but there is scant knowledge of this species' capability once it is planted out. As it grows in a fairly restricted soil type, it may have limited application. Sampling will be on an opportunistic basis.
E. hypochlamydea subsp. *hypochlamydea*	Northern rough barked form. Has promised based on previous anecdotal evidence, although cineole content in the oil is low.
E. incerata	Closely related to *E. eremophila* ; to be sampled if the opportunity arises.
E. leptopoda (Tammin Mallee)	Widespread mallee throughout the Wheatbelt and goldfields and an indicator of deep yellow sands, including the acid wodjil soils. Trialed in 1996, though no results available yet. There are four subsp. in this group, all of which are being considered because of the high priority for revegetating low productive, deep sands.
E. loxophleba subsp. *loxophleba*	Sampling work to date has yielded poorly. Good populations hard to locate. Peter Grayling indicates it has lower cineole contents than the other subsp. No plans for further sampling.
E. loxophleba subsp. *supralaevis*	Peter Grayling indicates it has lower cineole contents than the other subsp.. Opportunist sampling only.
E. mesopoda ms	Another in the Oleosae group, however no longer under consideration due to limited availability of good trees.
E. micranthera	Sampled because of its high MPA content. May be an additional species if MPA becomes desirable. Cineole levels too low for general collection.

Species	Comments
E. obesa	Newly described species, closely related to *E. decipiens*. Grows strongly on deep white sands, but very poor oil results - no further sampling anticipated.
E. oleosa	Very poor cineole content, no further sampling anticipated.
E. "oligocorma" ms	An undescribed mallee form of flat-topped yate, growing in shallow sand over clay. Very poor oil content, further sampling unlikely.
E. olivina	A recently described member of the "foecunda" series, from the Narembeen area - yet to be sampled.
E. ovularis	Related to *E. myriadena*, common north of Esperance. Poor results despite a reasonable cross section of the range being sampled. No further work planned on this species.
E. perangusta	Poor results despite a reasonable cross section of the range being sampled. No further work planned on this species.
E. phaenophylla subsp. *phaenophylla*	Common "mallee white gum", often on sandier soil. Minimal results so far. *E. phaenophylla* subsp. *interjacens* and *E. tumida* are closely related species which will also be investigated.
E. phenax	Previously known as "anceps", it hasn't yielded good results under any name.
E. quadrans	A recently named species, though poorly understood. A species for opportunistic collection at this stage.
E. recondita	One from the north Stirling's area that has potential to survive on very harsh sites. However, previous sampling has not yielded any good results so this remains a species for opportunistic collection.
E. rigidula	No encouraging results so far and no plans to do more sampling work.
E. salicola	No indications that this species has any promise. Sampling work in 1996 yielded only very low oil contents.
E. sp. "F"	Has the manuscript name of *E. sporadica* ms. Closely related to *E. aspratilis* . Will be sampled when good populations can be located.
E. suggrandis subsp. *alipes*	This is not a well described taxa. There are two forms - one is a mallet from the Lake King to Narembeen area while the other is a mallee which is probably the mallee form from the Newdegate area. Samples from either form have not been encouraging and there are no plans to do more.
E. suggrandis subsp. *suggrandis*	None of the samples taken so far are encouraging, no further sampling intended.
E. uncinata	Another member of the Foecunda series, has potential for very light sandy soils. Sampling of suitable population will continue.
E. yilgarnensis	Another in the Calycogonae group. To be tested once good populations can be located.
Melaleuca acuminata	Some high yielding plants found. Will continued to be sampled but there is uncertainty regarding it's regenerative ability
M. brevifolia	Unlikely to sample because of the small leaf size.

Species	Comments
M. hamulosa	Unlikely to sample because of the small leaf size.
M. lateraflora	Some high yielding plants found. Will continued to be sampled but there is uncertainty regarding it's regenerative ability
M. thyoides	Unlikely to sample because of the small leaf size.
M. uncinata	Will continue to sample if good lignotuberous forms can be located.
M. urceolaris	Will consider sampling if the taxonomy is sorted out.

Seed orchards and tree breeding

Extract from the Oil Mallee Establishment Manual. Reproduced with permission from the Oil Mallee Association.

Introduction

The Oil Mallee Association and the Oil Mallee Company of Australia have an arrangement with CALM to supply high quality seed of the major oil mallee species. CALM are able to provide this tree breeding and seed collection service, which requires a degree of specialist expertise and a long time frame.

Plant breeding and seed collection are important to the program for the development of high yielding mallees.

With the development of seed orchards it is important to consider the following:

- Single parent collections do not constitute viable seed orchards. A good seed orchard should ideally have a minimum of three hundred families to reduce inbreeding. This is hard to achieve, but it shows that a single tree (one parent) is a long way from ideal. A single high oil tree, if of good health and showing the other desirable characteristics, should be part of the breeding program.

- There are differences between parent trees and their progeny. Currently the average oil content of our plantings in the field (i.e. the offspring of tested trees) is over three percent. This is excellent, but must be put in context. Many of the tested parent trees have an oil content of between four and five percent, but the heritability of the oil is going to be determined by both parents. CALM therefore collect from populations where there is a large number of high oil yielding trees. This increases the probability of producing offspring with a high oil content.

The current CALM breeding program for oil mallees involves 30 families, each replicated 40-50 times. The construction of these orchards began in 1993 and is ongoing. All the major species are now included.

CALM have also investigated grafting and cuttings for propagation of the best oil producing trees. There is also ongoing work looking at the DNA structure of the different related species to determine the likely outcome of breeding inter-specific hybrids.

Harvesting and transport strategies and costs

Rick Giles, Department of Conservation and Land Management.
Dwellingup

Harvesting strategies

Harvesting and distillation will be conducted by the farmer owned OMC. A single harvest operator will help to hold the WA industry together so it can be a significant player in future markets. It is unlikely that another harvesting and oil extraction operation could be sustained for at least a further decade, as there is only enough resource to support one operation.

The cost of harvesting and transport is one of the major challenges to the oil mallee industry in Western Australia. The present essential oils industries in Australia are focused on concentrated plantation resources. In plantations it is relatively cheap and easy to harvest and transport material to a steam distillation plant on site. The WA resource is dispersed, on a regional scale (the mallee cells) and on the farm scale, where planting may be in one block or several extensive belts. It will be many years before we see mallee plantings continuously dispersed across large areas. Even as this develops, and because of the need to transport by road, there will always be an extra handling step between the harvester and the still or processing plant.

The fundamental requirements of a harvester are low weight, narrow track and ability to harvest the row it is straddling. The harvester must also be either compact enough for transport on a conventional truck or have a high road speed for efficient transport from farm to farm. It should be able to harvest a range of mallee sizes and forms as it will not be economically viable to have two harvesters, one for big mallees and one for small mallees.

The harvest operation should be completed in one pass to minimise costs and soil compaction, and the product from the harvester must be a bulk material for cheap efficient handling.

When fully developed, the harvesting operation will be conducted by one person to minimise costs and it is expected to become an independent contract operation. The reasons for this arrangement include:

- Each farm will have a relatively small resource, typically requiring less than one day's harvest each coppice rotation. A harvester working at 5kph would harvest a typical planting of 10,000 mallees in about 3 hours.

- The harvest machinery will be very expensive and the capital must be spread over as many mallees as possible.

- Individual farmers can not be expected to invest time in an operation that will yield a small return.

- As the harvester will be moving from farm to farm continuously, it is desirable to make it a self-sufficient operation.

Costs of harvesting

Without harvesting experience, it is only possible to put some estimates on costs. The existing practices in NSW and Victoria have been considered and that experience will be applied in WA where possible. The costs of harvesting in the east are estimated to be about $15 to $20 per tonne of whole mallee biomass. The total harvest and distillation cost is about $60 per tonne (Abbott, 1989). The additional transport step in the local industry will force the entire operation to become as efficient as possible. Some new approaches need to be looked at.

The existing industry chops mallees with a flail cutter or tritter, which smashes up the plants and throws them into a bin behind the cutter (P. Abbott pers comm.). This process collects the whole plant and about half this is leaf. This process does not allow separation of leaf and wood, so the entire plant mass must be transported and put though the distillation step. Density is about 280 kg per cubic metre.

The melaleuca industry uses either a harvester based upon a saw and chipper combination (D. Stanley, pers. comm.) or a double chop forage harvester (R. Overguard, pers. comm.). Both produce a chipped material. The material is packed at about 280 kg per m^3 in the distillation vessel (Colton and Murtagh, 1990) and contains both leaf and wood.

New harvesting options fall into two broad categories. The harvester can cut the mallees and chop them into a bulk material, or it can package the whole mallees into bales or other packages for transport. The whole mallees would then be chipped at the still or processing plant. The most appropriate operation will be reliable, economical at each step and have as few individual steps as possible.

Chipping or chopping the mallees is an essential part of preparation for distillation and is necessary to prepare the mallees for packing into the distillation vessel (Denny, 1991; Colton and Murtagh, 1990). An alternative method of distillation is to grind the leaf into sub-millimetre size particles and distil the oil from a leaf and water slurry. For this method, chipping the bulk material before grinding of the leaf permits separation of leaf from wood.

Baling is an expensive process. A cost of $10 - $14 per bale or $13 to $20 per green tonne is estimated by the Big Bale Association. This price is also based on a local trial in baling mallees (B. Saunders, pers. comm., D. McFall pers. comm.) and experience with baling biomass fuel in Europe (Hudson 1997). A fresh weight tonne of mallee would contain about 16 kg of oil (D. Wildy, pers. comm.) so the cost of this option is prohibitive.

By chipping the mallees as soon as they are cut, materials handling is simplified and leaf separation from the wood chip is possible at the harvester if desired. Current estimates based upon a conceptual harvester design suggest a harvesting, chipping and stockpiling cost of about $15 per tonne of leaf, which is about the same as the cost per tonne of biomass in the existing industry. Biomass is about 50% leaf and a tonne of leaf contains approximately 30 kg of oil.

An analysis of a number of alternative techniques has been undertaken and summarised in Table 2.

Table 2

Alternative techniques for harvesting

Operation step	Preferred method	Other methods considered
Cutting	Single saw blade close to ground similar to tagasaste cutter but with skids to protect blade. Design blade (diameter, speed and number of teeth) to ensure the harvester can travel at 4.- 8 kph and cut butts of mallees without uprooting them. Leaf cut stems off blade and feed whole plants through a chipper.	• Double blade system from cane and salex (willow) harvesters. *Expensive and prone to jamming solid objects between blades.* • Rotary hay mowers, slashes and reciprocating knife systems. *Not sufficiently robust or too slow in cutting action.* • Double cut at two heights with light cutters. *Complex and still have to cut the heavy butt wood.* • Forage harvesters and other flail .*Trials demonstrate that the low front and the rough cutting action will push or pull young mallees out of the ground. Not suited to leaf and wood separation. Produces a very low density product ($280kg^{-3}$).*
Packaging or preparation for hand	Build self propelled harvester to chip the whole plants to produce a bulk material that can be belt conveyed or thrown with air. Leaf and wood to be separated with air at the harvester if wood is a waste product. If wood is a resource, collect chips with the leaves (single product stream) and then separate at the processing plant/still. Harvester initially owned by mallee industry and then sold on to contractor when possible. Harvester must be light to avoid soil compaction and have adequate tyre area on the ground. It must be able to move slowly when harvesting and also have a high road speed for transport from farm to farm.	• Cane harvester producing chopped material into chaser bin. *Very heavy and unstable on uneven sites. Road speed of only about 10 kph.* • Trailed pto or self powered harvester behind tractor. *Would have to harvest offset from the tractor. Cumbersome if there is a to bin behind that again.* • Leaf stripping from the standing plant, then cut and chip the wood either to waste or for collection as a bulk material with the leaf. *Complex machine requiring considerable development. Undesirable complexity if the wood is to be collected.* • Bailing the whole plant and then grind or chip the bales at the processing plant. *Cost of baling alone is more than $1 per kg of Oil.*
Stockpiling	Collect chipped material into harvester bin, either towed or on board harvester. Harvester bin unloads direct into field bins which are 50 m^3 bulk trailers. Prime mover delivers empty bins to the paddock and tows full trailer(s) away singly or as road trains. Harvester built with enough drawbar power to tow the field bin if necessary to minimise harvester travel to the field bin	• Dump material on ground and then use self-loading trucks to collect and transport. *Time consuming and double involved.* • Chaser bins. *Requires an extra operator and tractor.* • Field bins made from old sea containers. *Expensive equipment required for loading.* • Collection of bales from paddock with loaders. *Extra loader and operator; hay transport is very expensive for this reason.*

Transport strategies and costs

The cost of transport is determined by two main factors:

- The cost of moving the material by road, which is a function of distance, load size and weight.
- The cost of loading the truck, which is mainly determined by the amount of time lost by the prime mover standing at each end of the run.

If the material is chipped, densities of 400 kg per m^3 are achievable for wood and leaf mixed, or 330 kg per m^3 for leaf alone. For comparison, oats have a density of about 500 kg per m^3. Therefore it should be possible to get full axle loads in high volume bulk bins. "Pocket" road trains of less than 25 metres overall length could be employed over all the Wheatbelt.

Table 3 summarises the review of three common transport operations that have been considered for use in this industry.

Table 3

Transport costs - existing transport operations

Grain trucks, big bale transporters and sea containers loaded by sidelifter trailers.

			Cost of Transport $/tonne/km			Cost of Transport $ per kg of oil		
Harvest product	**Distance (km)**	**Oil conc. % fr. wt.**	**Grain 24 t trailers**	**Bales 700 kg**	**Sea cont. 17 t bins**	**Grain 24 t trailers**	**Bales 700 kg**	**Sea cont. 17 t bins**
leaf	10	3		0.65	0.27			0.09
	20	3	0.40	0.33	0.20	0.27		0.13
	30	3	0.29	0.26	0.17	0.29		0.17
	50	3	0.20	0.21	0.15	0.33		0.25
	100	3	0.13	0.17	0.14	0.44		0.45
	200	3	0.10	0.12	0.13	0.67		0.85
entire plant	10	1.5		0.65	0.27		0.43	0.18
	20	1.5	0.40	0.33	0.20	0.53	0.43	0.256
	30	1.5	0.29	0.26	0.17	0.58	0.52	0.34
	50	1.5	0.20	0.21	0.15	0.67	0.69	0.50
	100	1.5	0.13	0.17	0.14	0.89	1.13	0.90
	200	1.5	0.10	0.12	0.13	1.33	1.62	1.70

Grain transport

The costs are based upon the normal 24 tonne capacity bulk bin per trailer (I. Blake pers. comm.). Special machinery would be needed for loading mallee biomass. Grain is loaded on the farm by augers, but the chipped harvest material does not auger well. The sides on these trucks are too high for conventional large loaders. The special loading machinery would need to be moved from site to site by a third person.

This option provides a competitive cost but there is a significant cost in loading, as demonstrated by the high cost per kilometre for short distances. The cost of special loading machinery was not included in the table. To avoid the cost of moving another machine from site to site, the best method of loading appears to be a purpose built trailer with bins and a hydraulic truck crane with a grapple, similar to the loading arm on a timber harvesting forwarder. The harvester would dump the material on the ground in large heaps and the truck would load itself from these heaps. Loading times would be similar to grain loading with an auger. A similar system has been used in Sweden for biomass energy projects (Danfors, 1994) but the results of this experience are not known.

Big bales

Big bale (2.4 x 1.2 x 1.2 metre) transport was considered as part of the harvest with baling option. It also provided a valuable insight into the transport implications of any form of packaging into discrete units of about 500 kg -1000 kg.

This form of transport is too expensive for the mallees. A hay transporter employs a loader to collect bales from the paddock to the truck. The cost of hay transport is relatively expensive per tonne per kilometre because of this extra task. Like hay, mallee bales would be scattered and need retrieving. This form of packaging is suited to hay or straw because of the necessity for compaction. Chipping is also a form of compaction.

Sea containers and sidelifters

Sea container transport was considered as it offers a quick and efficient method for loading a truck using a sidelifter trailer. These trailers lift a full container from ground level onto themselves using hydraulic arms. The proposal was to use cheap, second-hand 6m long sea containers with the top removed and hungry boards fitted, giving a capacity of about 17 tonnes. These would act as static field bins filled direct from the harvester bin, with a number of bins used in rotation. At the still, the containers would be lifted sideways onto a tipping bed by the sidelifter truck and the contents tipped into the processing system. The empty bin would then be returned to the paddock. (Jaydee Transport, pers. comm.).

There three disadvantages to this method:

- It would be difficult to move the bins around the farm. A large static field bin will result in time wasted by the harvester travelling to the bin and back to work.
- The harvest operation would not keep a truck fully occupied all day, so the trailer would have to be owned by the harvest contractor. Trailers of this type can cost up to $120,000 new (Jaycee Transport, pers. comm.).
- Recent experience with bridging by mallee chips suggest that emptying sea containers would be difficult and special smooth walled bins would be required.

Bulk trailers filled by the harvester

The most suitable transport method appears to be the use of second hand tandem axle tipper trailers. With hungry boards fitted, the maximum height would be 4.2 metres with a volume of about 50 - 60 m^3. Tandem axle trailers are cheap to buy as most transporters are changing to tri-axle trailers.

The trailers would serve as field bins and be used for road transport. At least three would be required for each harvester. One would be with the harvester and receive the harvested material directly. Each empty trailer would be delivered either to or ahead of the harvester and the next full trailer transported to the still.

The harvester would have an onboard or towed bin of about 5 tonne capacity. The harvester would fill a field bin trailer in about two hours if it was cutting 4kg mallees while travelling at 7 km/h. This should allow the truck to empty a trailer and return it for filling. The third trailer would be necessary to allow some flexibility. The truck will probably be able to move material more quickly than the harvester can cut in most areas, so some "slip" will be required between the harvesting and transporting.

As the trailers are mobile, and if the harvester had enough power, it could tow the trailer being filled to a new location. This would minimise the amount of travelling required by the harvester during the stockpiling.

Anticipated costs are presented in Table 4. These costs demonstrate that with two trailer road trains quite long haul distances are feasible if the circumstances demand it. Experience will help decide how far apart still locations should be to minimise costs. Road trains are cheaper on paper for all haul distances, but it is probable that for short transport distances, the time saved by road trains would be lost in assembling and breaking down road trains in the paddock. As farms develop bigger mallee sites, this cost will be diminished because trailers could be efficiently filled and collected in pairs.

Table 4

Transport costs for bulk trailer system

Using industry owned high volume bulk trailers with 20 tonne capacity. Harvester fills trailers directly from its own bin.

Transport distances (km)	20	40	60	100	100	300
Number of trailers towed	1	1	1	1	2	2
Turn around time (hrs)	1.24	1.81	2.38	3.33	4.00	8.83
Cost per load @ $68/hr	$89.64	$133.95	$178.25	$253.92	$326.50	$764.17
Cost per tonne	$4.48	$6.70	$8.91	$12.70	$8.16	$19.10
Cost of Transport per kg of oil ($/kg)						
Leaf & wood transport	$0.27	$0.41	$0.54	$0.77	$0.49	$1.16
Leaf only transport	$0.15	$0.22	$0.30	$0.42	$0.27	$0.64

Assumptions

- The prime mover costs $68 per hour and travels at 70 - 80 kph average depending upon distance.
- Time to hitch or unhitch trailers is 10 minutes for each operation. 20 minutes to tip a trailer out at the still.
- Trailer maintenance costs $0.10 per km. (G. Rickwood, pers. comm.)
- Trailers cost $15,000 each second hand and depreciate at 10% per year. Opportunity cost is 8% per year.
- Leaf is 55% of biomass and oil is 3% of leaf.

Oil Mallee Association of WA Inc.

MEMBERSHIP INFORMATION

Please return to

Oil Mallee Association of WA
1/277 Great Eastern Highway
BELMONT WA 6104

Phone (08) 9478 0330
Fax (08) 9478 0333

Grower Annual Membership	**$50.00**	*(Please delete whichever not applicable)*
Subscriber Annual Membership	**$25.00**	

(Payable 1st March of each year)

Our membership details are as under:

First Name (Mr/Mrs/Ms)		**Surname**	
Spouse/Partner's name			
Trading Name			
Address			
Town		**Postcode**	
Phone		**Fax**	
Region	Mid West	☐	
	South East	☐	
	Central	☐	
	Eastern Wheatbelt	☐	
	Greater Woodanilling	☐	
	Upper Great Southern	☐	
	Subscriber	☐	

GROWERS AGREEMENT

Location: ....

Year of Planting: ....

I .... Membership Number ....

for and on behalf of ....
(business name)

of ....
(address)

have requested the Oil Mallee Association Inc. ("Association") to procure the supply to me of that number of Oil Mallee seedlings ("Seedlings") referred to in the Association's Seedling Order Form to be signed by the Grower ("Seedling Order Form") at the price also referred to in the Seedling Order Form and in accordance with the following terms and conditions:

- The Seedlings are to be sold to us by a Nursery accredited by the Association ("Nursery") referred to in the Seedling Order Form for planting on my property at the property location shown above in the year also shown above.

- I am aware that the Oil Mallee Industry is in a development phase and accept that in the event of a non-commercial return being achieved that the trees will serve a valuable role as land care plantings.

- I will pay a deposit per Seedling ordered through the Association as shown in the Seedling Order Form which will be allocated by the Association in the manner also as shown in the Seedling Order Form.

- I am aware that when placing an order for Seedlings the Association has the right and authority to alter or terminate any contract with the Nursery to supply Seedlings in the event of poor nursery production, or other failure beyond its reasonable control which results in the Seedlings not being available for the relevant year. In any such event the Association shall have the right to procure the supply of the relevant Seedlings (or the balance thereof as appropriate) in the following year, or alternatively, to return the deposit to me less any proper costs already incurred by the Association, following which neither party shall have any further rights or obligations to the other.

- I agree that upon acceptance by the Association of my order for Seedlings I will have an obligation to pay the balance of the purchase price for each Seedling ordered to the Nursery and that any rights I may have in respect of the failure by the Nursery to supply the Seedlings or to supply adequate Seedlings or to supply Seedlings to specification to me shall be exercisable solely against the Nursery, it being agreed and acknowledged that the Association and/or its Region Manager will be acting solely as my agent in the placing of my order with the Nursery for Seedlings.

- I am aware that the right to place orders through the Association for Oil Mallee seedlings is a right available only to members of the Association and that in placing an order to grow Oil Mallees I am becoming actively involved in the industry and recognise my opportunity to make available my Mallees for processing through services endorsed by the Association from time to time.

- I am aware that where commercially feasible the processing of my Mallee trees from time to time may be carried out under contract arrangements made available by the Association at my cost.

- I am aware that there are special benefits in maintaining membership of the Association for the benefit of the Oil Mallee industry generally and that these benefits include access to regional groups and the advisory support affiliation with the Association including the receipt of a quarterly newsletter.

- I understand that carbon credits may be available in respect of my plantings of Oil Mallees and I hereby authorise the Association to negotiate on my behalf the sale of any carbon credits available to me in respect of my plantings in conjunction with the carbon credits available to other Association members who have planted Oil Mallees. I endorse the principle that the Association would receive a fee for administering this process at a level to be agreed between us at that time.

- I accept and agree to the allocation of the deposit moneys for each Seedling in the manner referred to in the Seedling Order Form to cover the cost of the region manager employed by the Association and to cover the Association's other administration costs. The region manager I understand is available for industry development and provision of certain tree establishment and management service to growers of Oil Mallees.

- To the extent permitted by law I agree that advice provided in good faith by the Association and its region managers in respect of the planting and growing of Oil Mallees by me, will not give rise to any liability to the Association or the region managers in respect of any losses incurred as a result of the implementation of any such advice given in good faith and that I shall satisfy myself in respect of such advice before implementing it to the intent that all warranties, express or implied statutory or otherwise are to the extent permitted by law hereby expressly excluded. I further agree that in the event the law impliedly or expressly prohibits the exclusion of any warranty that the obligation of the Association to me in respect of the services provided hereunder shall be limited to the performance of the services again or at the option of the Association the procurement of a third party to re-supply such services.

SIGNED .... *(Grower)* DATE ....

Endorsed by the President of the Oil Mallee Association.

Under the Common Seal of the Association.

Signed: ....
Date: ....

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

THE UNIVERSITY OF WESTERN AUSTRALIA
A Leading University

Oil Mallee Association of WA Inc.

HOW MUCH OIL DO I HAVE?

ABOUT THIS SERIES

This new series of fact sheets entitled "Oil Mallee Scientific Update" aims to disseminate some of the practical outcomes of the many research avenues currently pursued on oil mallees. It is intended that the topics be of relevance to growers, so that oil mallees may be grown across the state with the best possible information that is currently available. Topics for the future may include

- Carbon credits and oil mallees
- Harvest regimes to maximise long term oil production
- Beneficial and competitive interactions between oil mallees and adjacent crops
- To what extent do oil mallees control groundwater?
- New technologies in harvest and oil extraction.

Dan Wildy

ABOUT THIS SHEET

This update describes a fast and accurate means for measuring the current yield of shoot material and eucalyptus oil for mallees plantings in the wheatbelt, for both uncut saplings and coppice regrowth. This is based primarily upon the dimensions of the canopy of leafy foliage on plants within in the stand under consideration. This is far more reliable than simply using plant age to predict yields.

Firstly, random selections of plants within the stand are measured for their canopy dimensions. This is used to give an estimation of the shoot biomass per plant using the appropriate equations in Table 2. Next, shoot biomass is converted to leaf biomass (using Table 3) and then to oil yield per plant (using Table 4). Finally, these numbers based on individual plants are scaled up to "per km of hedge".

TABLE 1. MALLEE OIL YIELD ESTIMATED BY CANOPY DIMENSIONS.

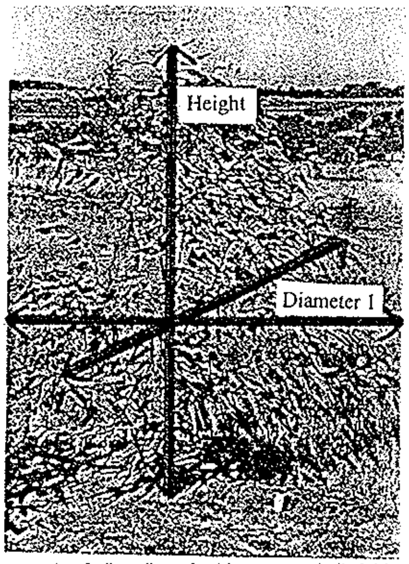
Examples of oil yield per km of hedge based on the average dimensions of the canopy of mallees in a stand. Dimensions are height x canopy diameter 1 x diameter 2 in metres. This assumes survival is a typical value of 90%.

Species	1 x 1 x 1	2 x 1.5 x 1.5	4 x 2 x 2	6 x 3 x 3
E. kochii subsp. *plenissima*	39 kg	152 kg	270 kg	1270 kg
E. horistes	28 kg	106 kg	168 kg	773 kg
E. loxophleba subsp. *lissophloia*	25 kg	93 kg	148 kg	679 kg
E. polybractea	20 kg	77 kg	122 kg	561 kg

ESTIMATING STANDING SHOOT BIOMASS

For a stand of any size of a particular oil mallee species:

- Determine the number of trees planted per km of hedge and the survival percentage throughout the site.
- Measure the canopy dimensions of as many randomly selected trees throughout the stand as possible (at least 20 plants). It is important to measure trees across the greatest proportion of the stand as possible so that particularly good or poor sections do not wrongly influence the results. Dimensions to record (in metres) are height (H) and canopy diameters (D_1 and D_2). These measurements should include the extreme outermost leaf tips.



Measurements of oil mallees for biomass and oil yield calculations

- Note that height (H) refers to the canopy height, not the total tree height (but in most cases the canopy leaves go right to the ground). However, in cases where the lower section of the stem of an individual is devoid of leaves, this should be subtracted from the total height.

- Calculate average H, D1 and D2 for the site.

- Using Table 2, select the appropriate equation and calculate W, the average weight of fresh shoots on each plant in the stand.

- Shoot weight can be converted to leaf weight using the values in Table 3. Note that leaf percentage decreases as plants become larger. For example, plants calculated above to possess 20 kg of shoot would then contain 20 x 45/100 = 9 kg of leaf each.

- The yield of oil expected from each plant is then calculated using Table 4. For example, *E. horistes* mallees (which possesses 3.3% of leaf weight as oil) with 9 kg of leaf would yield 9 x 3.3/100 = 0.3 kg of oil.

- Finally, yields based on individual plants may be scaled up to 'per km of hedge' figures: Oil yield per km of hedge = oil yield per tree multiplied by the number of trees in 1 km of hedge, (which is calculated from the number planted and subsequent survival). For example, in a hedge of trees each currently containing 0.3 kg of oil, and planted in a typical planting density of 1330 trees per km with a 90% survival rate, oil yield per km of hedge = 0.3 x 1330 x 90/100 = 359 kg.

TABLE 2. Equations for calculating current fresh shoot biomass per plant (W) for both uncut saplings and coppice regrowth.

Species	Equation	Approx. average prediction error
Saplings		
E. kochii subsp. *kochii*, *E. kochii* subsp. *plenissima*.	$W = 1.81 \times H \times D_1 \times D_2 + 0.097$	5 %
E. horistes, *E. angustissima*, *E. gratiae*, *E. loxophleba* subsp. *lissophloia* and *E. polybractea*	$W = 1.03 \times H \times D_1 \times D_2 + 0.261$	7 %[1]
Coppice		
E. loxophleba subsp. *lissophloia*, *E. gratiae* and *E. polybractea*	$W = 1.23 \times H \times (D_1 + D_2)/2$	4 %
E. angustissima, *E. horistes*, *E. kochii* subsp. *kochii* and *E. kochii* subsp. *plenissima*.	$W = 1.62 \times H \times (D_1 + D_2)/2$	5 %

[1]As an example of error, this means that the true W is between W+7% and W-7% with 95% probability.

TABLE 3. Leaf percentage of shoot biomass changes according to total shoot weight.

Plant shoot fresh weight	leaf percentage of shoot biomass
0.5 to 5 kg	55 %
5 to 15 kg	50 %
15 to 30 kg	45 %[2]
30 to 100 kg	35 %[2]

[2]data from Andrew McCarthy, 1998 Honours Thesis.

TABLE 4. Mallee oil abundance in leaves and the proportion of this oil which is cineole.

Species	Leaf % as oil	% of oil as cineole
E. kochii subsp. *kochii*	3.5 %	93%
E. kochii subsp. *plenissima*	3.1 %	92 %
E. horistes	3.3 %	90 %
E. angustissima	3.0 %	92 %
E. gratiae	2.7 %	65 %
E. loxophleba subsp. *lissophloia*	2.9 %	65 %
E. polybractea	2.4 %	87 %

Dan Wildy, Editor
Botany Department
University of Western Australia

This paper was a pivotal presentation in the development of the oil mallee industry.

Promising products derived from woody species

John Bartle CALM, Western Australia
Russell Reeves Apace Research, NSW
Paper presented at the RIRDC/LWRRDC PLANNING WORKSHOP on LOW RAINFALL AGROFORESTRY PERTH AUGUST 1992

Introduction

It is now widely recognised that trees (or perennial woody plants in general) can be used to remedy land degradation and gain improved productivity in most parts of the low rainfall 'wheat and sheep' agricultural areas of Australia (c. 100 million ha). However, there is generally poor recognition of the size and cost of the task of getting this 'multiple purpose' vegetation in place. Estimates of the amount of tree cover that might be required to achieve these benefits range from 10% to 20%. At an estimated all-up cost (including farm planning, fencing, refilling) of $750/ha this amounts to between $7.5 and $15 billion. There is also the cost of on-going management of the new vegetation and replacing or regenerating it on a life cycle of somewhere between 20 and 100 years. This will eventually (depending on the longevity of the vegetation) require an annual expenditure of some 1% to 5% of establishment cost, say an average of 2%.

Given the quickening pace of land degradation the aim should be to complete revegetation as quickly as possible, say within 20 years. Tree planting expenditure between $375 million and $750 million per year for 20 years would be required to reach this target. This would then level out at some $150 to $300 million per year for maintenance. These data are summarised in Table 1.

Table 1: Size and cost of the revegetation task

Total low rainfall farmland area	100 million hectares
Total area to revegetate	10 to 20 million hectares
Total establishment cost	$7.5 to $15 billion
Annual cost (averaged over 20 yrs)	$375 to $750 million
Maintenance per year	$150 to $300 million

These are very large expenditures, especially in relation to present and projected farm debt and profitability. It appears that the term and cost of this revegetation task is simply beyond the financial resources of farmers and conventional agriculture. Even though the trees will enhance the productivity of agriculture, these benefits alone are unlikely to be able to fund the cost of tree planting. Furthermore, it is unlikely that contributions from State and Commonwealth Governments will be anywhere near enough to make up the shortfall.

It is therefore very surprising that so little serious attention has been paid to the products the trees may produce and to the possibility that commercial return could help finance tree planting. The motivation of the farm tree planting and landcare movement has to date been strongly dominated by the landcare and nature conservation benefits. This appears to have diverted attention from the crucial issue of how to finance planting and has diminished the priority of tree product and market development.

Using a biomass yield of 7.5 tonnes/ha/year the crop of trees required to revegetate low rainfall agricultural areas could have an annual yield of 75 to 150 million tonnes . This vast bulk of flowers, fruits, leaves, bark and wood should be enough to provide the resource base for several large scale industries!

Fodder shrubs offer a relatively easy option to increase commercial perennial woody plant cover. Fodder shrubs are easy because they can be incorporated into conventional grazing practice for the production of meat and wool which have an already established management and marketing infrastructure. Tagasaste and *Acacia saligna* are already being used extensively and other species with a wider range of soil preferences and management regimes could be developed. Since they can be readily incorporated into conventional agriculture fodder shrubs are not further considered in this paper.

However, even with a full range of fodder shrubs to choose from, there is still a big potential role for non-fodder species. Other species might offer greater water use, better windbreak value, potential to diversify farm products and income and less demanding management needs. Developing new products and industries from these species is more of a challenge. In most cases new knowledge/infrastructure must be built and on-going marketable volumes of product must be generated.

Our traditional wheat and sheep agriculture is at a cross-roads. The prospect of increasing its profitability and sustainability with a bold and systematic push to develop new woody plant species, products and industries is before us. This paper addresses this challenge.

Potential Products

The first difficulty to be overcome in developing new products is knowing where to start. There is a plethora of possible species and products. Some systematic basis for selection of prospective species is required. Table 2 presents a cursory analysis of potential products. It rates potential products according to criteria which would determine their commercial viability. This approach deals with the obvious constraints and opportunities presented by such factors as scale, rotation length, transport cost, processing cost, value adding potential, compatibility with existing agricultural systems and market factors.

This analysis is presented here mainly for illustration of the value of even a crude reconnaissance of products and as a basis for a preliminary identification of promising prospects for discussion later in the paper.

This exercise needs to be done with much more rigour and analysis in order to identify products and species which warrant more intensive investigation.

Strategy 1: undertake comprehensive, co-ordinated national, state and local product/market reconnaissance using, *inter alia*, the product selection criteria presented in Table 2 to identify the most promising woody plant products and species.

The failure of commercially motivated entrepreneurs to develop any new product/species prospects in recent years, despite the obvious pressing need, does not necessarily indicate that such products/species will not be commercially viable. A more likely explanation is that these types of developments are too complex, large in scale, long term and risky for purely commercially motivated development. Also, while the aggregate benefit of a new product may be large (in terms of total landcare, nature conservation and commercial benefit, both on and off-farm), the purely commercial product return to the developer, financier, investor or grower may be too little to justify the investment. Governments have an important role to play in this situation. One of the most useful contributions Governments could make is to underwrite the R&D required to demonstrate the viability of promising tree product options thus opening the way for commercial development.

Strategy 2: undertake detailed product, market and industry feasibility study for the most prospective products/species which will *inter alia* specify:

- production parameters:
  - yield
  - quality attributes
  - production system
  - complementarity with agriculture
  - cost of production
  - risk and uncertainty
  - stability of supply
  - technical support
  - potential for R&D to improve viability
- community support
  - community/local government support
  - 'environmental' credentials
  - joint venture arrangements
- raw product processing:
  - value added to product
  - processing infrastructure cost
  - economies of scale
  - cost of final processed product
- market potential:
  - is there an existing market
  - can new uses/markets be created
  - present demand and price
  - projected demand and price
  - competitor products and places

New industries will not develop on the scale required without substantial capital investment. The providers of capital must be convinced that the investment in new farm based industries is sound. The results of study into the feasibility of new products and industries should be presented in a form designed to stimulate the interest of the investors and financiers. Since the scale of development is so large and of such national importance the large domestic institutions should be specifically targeted as sources of finance.

Strategy 3: Prepare prospectus quality information defining product and industry feasibility and present in a form designed to stimulate the interest of the large domestic institutional investors and financiers

Brief review of promising prospects

Several promising prospects for development as farm tree products are indicated in Table 2. These will be briefly reviewed to indicate the various types of products, species and industries that could be developed.

1. Eucalyptus oil

Eucalyptus oil is an old established product produced from the leaves of certain eucalypt species and used internationally in the pharmaceutical industry. The opportunity to expand pharmaceutical applications appears limited. However, the major constituent of eucalyptus oil, cineole, is an excellent solvent and could be a competitive alternative to solvents presently used in various industrial applications. With the increasing cost of petrochemical based solvents, emerging recognition of industrial health and safety risks and increasing concern for their damage to the atmosphere, a very large market opportunity for cineole could emerge. Dozens of prospective applications await investigation.

Many eucalyptus species have high cineole content. Species suitable for a wide range of rainfall and edaphic conditions could be developed. This would include mallee species amenable to short cycle harvests (2 years) or tree form species which could be harvested on longer cycles while also providing other benefits such as shelter.

The oil eucalypts appear especially suited to the simultaneous production of other products, i.e. co-products, and this prospect should be given particular attention.

Modern harvest and steam distillation techniques would need to be developed. Preliminary work done in W.A. indicates that some 5 000 ha of oil eucalypt crop would be required for efficient utilisation of such infrastructure (Allan Barton pers comm). This means that only short haulage distances for harvested leaf would be required. Leaf oil contents typically range from 2 to 3% (green weight) and yields of 70 kg/ha of oil can be achieved even with genetically unimproved stock. After local extraction the cost of oil transport to market would be trivial in relation to the product value of $10 to $12/kg.

In many cases native species will be suitable for development as an oil crop providing additional nature conservation benefits.

2. Tannins

Tannins from eucalypt and Acacia species could enjoy a resurgence in market demand. A renewed interest in using natural tanning agents and new uses for tannins in adhesive manufacture will stimulate this interest. Tannin production from brown mallet was formerly a substantial industry in the south west of Western Australia and was the motivation for the establishment of the Dryandra mallet plantations near Narrogin, some 8 000 ha of which were established mostly in the 1940-50s. Similarly a large industry collecting tannin bark from native stands of *Acacia mearnsii* thrived in the south east of Australia for several decades.

3. Timber products

There are many species capable of producing timber products in the low rainfall zone. Low value products such as posts and rails for farm use and sawn timber for construction could develop into significant local industries, although markets for these alone are unlikely to be sufficient to motivate the scale of tree planting that is required. Value added, lower wood volume products such as tool handles, craft wood, laminated wood products such as 'Valwood' for furniture manufacture and reconstituted wood products could be developed for more distant markets, but once again market demand for these products alone is unlikely to be great enough to motivate the scale of tree planting required. High value specialty wood products such as sandalwood also offer some prospect.

Although unlikely to be able to motivate sufficient scale of tree planting alone such products still warrant detailed investigation. All prospective species, especially natives should be systematically evaluated for basic wood properties. Part of this evaluation should include investigation of the potential for co-products.

4. Wood Energy

Australia has enough low-cost biomass production potential to rapidly become self-sufficient in renewable solid and liquid fuels if the economic, political and environmental circumstances favoured this outcome. Under current circumstances there are some situations where energy from woody biomass is now or will soon be economically viable.

Firewood is widely used within economic haulage distance of urban and regional centres. Timber mill waste is used for electricity generation at several locations.

There are several factors which are likely to improve the competitive position of renewable energy sources in the medium term future. These include:

- rapid advance in the 'infant' renewable energy technologies.
- declining reserves of low-cost, low-risk petroleum.
- increasing concern about the negative environmental impacts of the non-renewable fuels.
- the importance of energy in Australia's balance of trade, our declining domestic oil reserves and the national strategic and

economic advantage in maintaining some level of domestic self sufficiency.

- energy uses will usually be less demanding on product quality and could provide a use for residues from the production of other products thereby increasing the overall viability of the tree crop.

The case of ethanol production from woody biomass appears to be most prospective and is dealt with in some detail in appendix 1.

APPENDIX 1: Ethanol and Lignin

Wood is an example of 'lignocellulosic' or woody biomass and such material can be converted to ethanol and lignin. Ethanol is a liquid and it is used as a fuel for transport in various countries throughout the world in addition to its many traditional uses in the food, pharmaceutical, cosmetics and chemical industries. Lignin is a solid and it is used as a fuel for heat/steam/electricity generation. Lignin is also used as a component of construction materials, plastics extender, road binder, surfactant (in oil recovery operations for example) and as a source of vanillin.

The maximum price that can be paid for a specific feedstock for ethanol production under the particular circumstances applying at any given point in time can be calculated from the following equation:

$$C_f \quad = (S_E + \_\, P_j z_j - C_p)\ (\_\, a_i x_i y_i) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: C_f = maximum price for feedstock in $/kg;

S_E = selling price for ethanol in $kg;

P_j = selling price in $/kg of any co-products 'j' produced in the overall ethanol production process;

z_j = yield of co-products in kg of co-products/kg of ethanol

C_p = feedstock to ethanol and co-products conversion or processing cost in $kg of ethanol;

a_i = fractional yield of ethanol compared to the theoretical maximum;

x_i = fraction of fermentable component 'i' in the feedstock;

y_i = absolute maximum theoretical yield of ethanol from component 'i';

Where the first summation is taken over each co-product 'j' ; and, where the second summation is for each component 'i' that is fermentable to ethanol.

The current and future prospects for the production of ethanol and co-products from wood produced either in a re-afforestation/landcare programme, or as a dedicated crop for ethanol production, can be conveniently assessed by a systematic consideration of each of the factors in Equation (1).

Lignocellulosic biomass essentially consists of cellulose (a polymer of glucose), hemicellulose (a polymer of mainly zylose) and lignin. Typical proportions for softwoods are 50%, 28% and 22% respectively.

The basic process for converting lignocellulosic biomass to ethanol and lignin involves pre-treatment (mainly fibrillation) of the feedstock, hydrolysis of the hemicellulose fraction to xylose, hydrolysis of the cellulose fraction to glucose, fermentation of the xylose and glucose fractions to ethanol, lignin recovery, ethanol recovery and liquid effluent waste treatment.

Thus in Equation (1), typically, 'x_1' (cellulose) = 0.5 and 'x_2' (hemicellulose) = 0.28. Analysis of the stoichiometry of cellulose and hemicellulose hydrolysis reactions and of glucose and xylose to ethanol fermentation reactions show that 'y_1' (cellulose) = 0.568 and 'y_2' (hemicellulose) = 0.581.

If we assume that both the cellulose and hemicellulose fractions are converted to ethanol with 90% yield, i.e. 'a_1' and 'a_2' = 0.9, then 'z_1' (lignin) = 0.55, i.e. for every one kilogram of ethanol produced 0.55 kilograms of lignin co-product is also produced.

Lignin is the only significant co-product produced in the actual conversion of wood to ethanol. It has a calorific value similar to that of brown coal or approximately two-thirds that of black coal. Based on the current export price for black coal of around $50/tonne, a selling price for lignin, factor 'P_1', of $33/tonne is assumed. It should be recognised however that it is not lignin that is normally sold but rather electricity which has been co-generated from steam raised in the conversion plant from combustion of the lignin. Thus it is usual to assign a much higher value to factor 'P_1', corresponding to the selling price of electricity to the State grid.

It should also be recognised that, as discussed earlier in this paper, there are opportunities for other co-products to be derived/extracted from flowers, fruits, leaves, bark and wood prior to the 'residue' wood being converted to ethanol and lignin. All such co-products can be expressed in terms of the factor 'P_j z_j' in Equation (1) and contribute to the price able to be paid for the wood feedstock.

The selling price of ethanol (factor 'S_E') varies depending on the ethanol quality and the end-use. If ethanol is used as a transport fuel then under Commonwealth Government legislation it is currently exempt from Federal excise and, on application to State Government authorities, it is usually exempted from State franchise. No significant increase in volumetric fuel consumption is incurred when low levels of ethanol (up to 15% by volume) are added to either diesel fuel or petrol and the resultant blends used as fuels for existing engines/vehicles. Thus, at the present time, when used as low-level blends, ethanol has a wholesale selling price of $0.60-0.65/litre ($0.75-0.82/kg).

Factor 'C_f' in Equation (1) is usually quoted as $/dry tonne. Although 'green' or, at best, air-dry woodchips are used directly as feedstock in the conversion process the ethanol and co-product yields are determined by the mass of cellulose, hemicellulose and lignin.

If, for the moment, we assume that the wood feedstock can be converted to ethanol and co-products at nil processing cost i.e., 'C_p' = 0, then substitution of the above assumed values for all the factors in Equation (1) shows that the maximum price available for wood feedstock is $309-337/dry tonne or $154-168/'green' tonne (assuming 50% moisture).

The above consideration of Equation (1) is designed to highlight the considerable economic potential for farmers of the production of ethanol and co-products from wood, as well as the fact that the real extent of the potential is determined by a rather complex interaction of a number of factors. From the farmer's perspective a return of $154-168/tonne for 'green' woodchip would be and is unbelievable, being dependent as it is on a continuation of Government incentives for the use of ethanol as a transport fuel, limitation of the use of ethanol to low-level blends and, a highly efficient wood to ethanol conversion process which operates at zero cost.

From a Government perspective it will obviously be desirable to limit financial incentives to as short a period as possible while continuing to encourage the development of a domestic biomass fuels industry because of the benefits it delivers in terms of reduced emission of carbon dioxide and air pollutants, re-afforestation, improved land management and value enhancement of existing biomass resources, decentralisation and regional industry development, increased fuel self-sufficiency, improved balance of trade and, improved balance of oil refinery output to market demand for individual petroleum products. Also, over time, it will be desirable in the context of further reducing carbon dioxide and other exhaust gas emissions to move from the use of low-level blends to the use of neat ethanol in specially designed ethanol engines. Such ethanol engines have a volumetric fuel consumption approximately 1.3 times that of a petrol engine and 1.8 times that of a diesel engine due to the lower calorific value of ethanol compared to petrol and diesel fuel.

The primary determinant in realising the potential benefits for all parties is, of course, a low cost process to efficiently convert wood to ethanol and co-products. The desired process would produce ethanol at a selling price at least equivalent on an energy basis to the pre-tax price of petrol and diesel, from a feedstock purchased at a price which returned a profit to the farmer.

Research, development and demonstration work on all the critical cost sensitive areas of the process for converting lignocellulosic biomass to ethanol and lignin is presently underway in the United States, Europe, Japan and Australia. The most extensive work is being conducted by the Solar Energy Research Institute (SERI) in the United States. This is consistent with the pronouncement made in January 1990 by the United States Department of Energy (DOE) of 'a co-ordinated public-private effort to make ethanol fuel from non-food feedstocks a fully competitive alternative fuel by the year 2000. DOE will work with the Department of Agriculture on crop development, and with the private sector for technology transfer and commercialisation.'

Work in Australia has been and continues to be conducted jointly by the University of New South Wales and Apace Research, currently with funding support from the NSW Office of Energy, Forestry Commission of NSW, Boral Ltd and CSR Ltd. The current support followed the tabling in the NSW Parliament in 1990 of a Parliamentary Committee Report entitled 'Investigation Into Ethanol and Alternative Transport Fuels in New South Wales', the main recommendation of which report was that 'a major effort be made to support and co-ordinate the development of lignocellulosic resources and processes for their conversion to ethanol and other products.'

All the present world-wide R&D work on the critical cost sensitive areas of the process for converting lignocellulosic biomass to ethanol can be conveniently summarised in terms of Equation (1) as being concerned with minimising factor 'C_p' and maximising factors 'Pj zj', 'a_i' and 'x_i'. It should be recognised that factor 'C_p' is dependent on both 'a_i' and 'x_i'. Increasing the fermentable content of the feedstock by natural selection and/or genetic engineering techniques and increasing the efficiency of the hydrolysis/fermentation reactions results in very significant reductions in the unit conversion cost.

Factor 'C_p' includes conversion plant operating costs, capital recovery and secondary raw materials. At the current stage of technology and development values for factor 'C_p' are in the range $0.13-0.35/kg. If '$a_i$' = 0.9 as assumed earlier then 'C_p' has a value of around $0.20/kg with current know-how. Substituting this value for 'C_p' in Equation (1) and retaining the same values as assumed before for all the other factors shows that the maximum price available for wood feedstock is $228-256/dry tonne or $114-128/green tonne.

Again this highlights the considerable economic potential of growing trees for the production of ethanol and co-products, subject again to the interaction of a number of factors, in particular Government tax concessions on the use of ethanol as a fuel for transport. If such tax concessions were removed then, based on the current pre-tax wholesale selling price for petrol and diesel fuel of approximately $0.29/litre and assuming use of the ethanol as low-level blends, the maximum price available for wood feedstock would be $72/dry tonne or $36/green tonne.

By the year 2000, Australian crude oil will satisfy less than 40% (presently around 80%) of estimated domestic demand for petroleum products. Substitution of domestically produced ethanol for imported petroleum fuels will increase fuel self-sufficiency and improve our balance of trade.

Growth in diesel fuel consumption is expected to be an average 5.5% a year compared with 1.4% for petrol up to the year 2000. This change in the demand mix of fuels will be difficult to satisfy from existing Australian oil refineries without the need for considerable capital expenditure. It is acknowledged by the oil industry that, in contrast to the situation which arises when ethanol is used as a substitute for petrol, substitution of from 10 to 20% of diesel by ethanol would have a beneficial effect on refinery balance. Extension of diesel with ethanol assists in balancing the output of oil refineries to market demand for individual refined petroleum fuels.

When operating on 'Diesohol E' (hydrated ethanol/diesel fuel blend) containing from 10 to 20% ethanol existing diesel engines exhibit increased thermal efficiency, reduced exhaust emissions and little or no increase in volumetric fuel consumption compared with operation on neat diesel fuel. Diesohol thus provides a rapid, practical and affordable method of achieving extension of diesel fuel with ethanol using the existing diesel engine fleet while retaining complete flexibility of operation on neat diesel fuel.

Current consumption of diesel fuel in Western Australia is approximately 2,020 ML/annum and 10,000 ML/annum in Australia as a whole. Use of a 15% ethanol/diesel blend in the existing WA diesel engine fleet would consume 303 ML/annum of ethanol, and 1500 ML/annum in the Australian fleet.

Because it is not economic to transport biomass over long distances and because biomass feedstocks are highly decentralised, the development of a biomass fuels industry will encourage regional industrial development and so will create employment in rural areas. Economic studies suggest that an economic plant size is one producing 50 ML/annum of ethanol based on a biomass feedstock resource of 150-200,000 (dry) tonnes and requiring a capital investment of around $40M. In Western Australia for example, six such regional plants would be required to produce sufficient ethanol for 15% substitution of the current WA demand for diesel fuel alone.

CAN TREES REVERSE LAND DEGRADATION?

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Abstract

Trees can reverse land degradation but the pertinent question is: how might it be accomplished on the necessary scale?

Farmers have the strong incentives of a treatment for land degradation, enhanced productivity through the complementarity of annual/perennial mixtures and economic diversification to induce them into growing commercial tree crops. Without the commercial return from tree crops farmers win not adopt free planting on the scale necessary to treat land degradation.

The development of agricultural systems incorporating tree crops (agroforestry) is well advanced but not yet able to routinely specify optimum designs in particular situations. This constraint is not nearly so much of an impediment as the general lack of suitable commercial species, products and industries. In the traditional forestry areas commercial wood production species are available but, with the emerging exception of WA, strong agroforestry oriented industries have not yet developed. In the drier agricultural areas, where land degradation is more severe, commercial tree crop species and products do not exist.

The early development on large scale eucalyptus oil production in WA is reviewed to illustrate the strategies necessary for tree crop development in the Wheatbelt

1. Introduction

The conversion of virgin Australian bush to agriculture over the last century or more has caused widespread land degradation. The major forms of degradation arise because the agricultural systems which were adopted do not have the same balances and protective functions previously provided by the bush. Probably the major deficiency in agricultural systems is the altered water balance they generate. Reduced water consumption under dryland agriculture allows a build up in soil water storage and groundwater, mobilising stored salts, causing waterlogging and salinity on low areas, enhanced run-off, salinity and nutrient enrichment of streams and erosion of stream lines. Other major forms of degradation arise from the exposure of soils to the erosive power of the wind and the decline of remnant native vegetation.

These forms of land degradation are theoretically quite reversible by extensive revegetation. Hence the short answer to the question posed by this paper's title is yes.

However, there is a much more profound question implicit in the title which presents an historic challenge to the sciences and industries of agriculture and forestry. That question is: how can we exploit the potential for trees to reverse land degradation? This paper will examine this question, with a focus on the imperative for innovation and the potential for future wood supplies.

2. The motivation from within agriculture

Australian agriculture has some outstanding accomplishments and some serious problems. It has created the dynamic and adaptable ley farming system in response to the constraint of fertility in a landscape dominated by ancient, highly weathered soils (Reeves and Ewing, 1993). In terms of fertility we have arguably a system which is sustainable.

However, in terms of water balance, exposure to wind and coexistence with a significant proportion of the continent's biological diversity the ley farming system is generally not sustainable. Table 1 presents a summary of the degradation problems in the 21 million hectares of private lands in the south west of Western Australia. These problems are more severe in WA but are also evident across the whole of southern Australia.

Table 1: A summary of land degradation problems in WA

Form of degradation	Extent of damage
1. Dryland salinity	9% now, 32% projected
2. Stream salinity	all streams/rivers degraded
3. Waterlogging	variable up to 3 million ha
4. Water erosion	intermittent and universal
5. Remnant native vegetation decline	extensive sometimes severe
6. Loss of biological diversity	all wetlands, rivers and estuaries degraded, 260 rare and endangered species

Sources: Select Committee into Land Conservation (1991).
Ferdowsian et al (1996)

Water balance can be manipulated by the water management practices adopted by agriculture. Water permitted to infiltrate below root systems and enter local and regional groundwater systems becomes the driving force of salinity and related waterlogging and erosion problems. There is scope to increase water use by plants and to drain or pump water to reduce the amount in groundwater systems.

The options to improve water management practice can be grouped into five categories:

- increase the range and proportion of perennial plant species
- increase water use by the annual crops and pastures that dominate current agriculture
- collect, reuse and dispose of surface water
- drain or pump, reuse and dispose groundwater
- improve the health and vigour of remnant native vegetation

These practices are being reviewed in preparation for a WA State Salinity Plan. It is apparent that, in WA at least, the water balance problem will not be solved without major developments in the first category, in particular, by the incorporation of long lived, deep rooted woody plants into the agriculture. The tree and shrub planting must be widely dispersed o give a total cover of some 3 million hectares across the 20 million hectares of farmland.

Revegetation to this extent will also substantially remedy the other forms of land degradation. Hence the problem of land degradation provides a strong incentive for the adoption of extensive tree and shrub planting.

Another major incentive is the emerging evidence from agroforestry research that mixtures of trees and annual plants can be complementary, and that a mixed system might be more productive than a monoculture of trees or annual plants. Hence the incorporation of trees might not only reverse land degradation but also result in greater productivity.

This potential is demonstrated by Moore et al (1991). Using wide-spaced pine trees in pasture in an 800 to 900 mm rainfall area in the south west of WA, they observed a productivity increase of 40%.

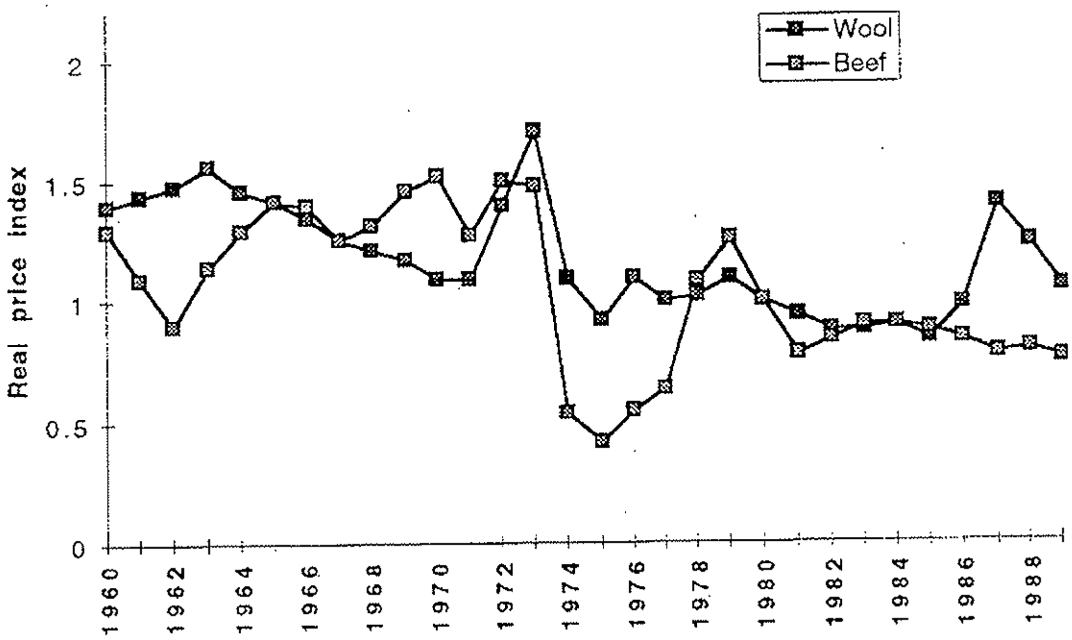
The relationship between the productivity of crop mixtures and the productivity of monocultures of the components is called the land equivalent ratio (Vandemmeer, 1989). In the case of Moore et al (1991) the land equivalent ratio is 1.4, i.e.1.4 ha of monocultures was required to produce the same as 1 ha of mixture. The explanation for this effect is simple in concept: the mixture of tall, perennial, deep rooted trees and shallow rooted, annual legume based pasture makes better use of resources (water, nutrients. sunlight and carbon dioxide), and generates a more favourable local climate for plant production within the tree sheltered area. Clearly the components of the mixture are not fully in competition with each other and can also complement each others performance.

Although the results of Moore et al (1991) relate to wide spaced pine trees the principle will apply to any mixture of diverse plants that achieves complementary, integrated use of the resources of the land (Bird 1988, Knowles 1991, Lefroy and Scott, 1994). The best potential mixtures will incorporate tall species where greater water use capacity and shelter benefits will be provided.

For decades the average real prices of traditional agricultural products have been declining (Fig 1). Over the past 4 decades the gross real value of farm production has not increased despite production increasing two and half times (Chisholm 1992). This appears to be a deep structural characteristic of international agricultural commodity markets and one that calls for serious national policy and individual grower review .

There are two responses that can be made to chronically weak markets:
- become more efficient and tolerate the decline.
- diversify into crops not so adversely affected by weak prices.

Fig 1: REAL PRICES FOR WOOL AND BEEF 1960 TO 1989



Historically improvements in the ley farms system have achieved productivity advances of about 2.5% per year off-setting much of the pain of contracting prices (Chisholm 1992). Unfortunately there has been little serious attempt at diversification of Australian agriculture. To qualify as 'serious' a new crop or product would have to be a major commodity that sells into markets that are not so prone to the structural weakness of agricultural markets e.g. industrial markets which do not attract agricultural subsidies in the developed nations. Since there are other compelling reasons to incorporate trees and woody plants into agriculture, why not also seek species able to achieve the objective of diversification.

There is vast opportunity to diversify into woody plants. Diminishing area and access to native forests around the world has highlighted the opportunity to grow timber on farmland. In contrast to agricultural commodities timber prices have been very firm over the last couple of decades (Shea and Hewitt 1990). There has been extensive innovation in wood products, especially panel board products, to accommodate smaller logs and shorter rotations. There is developing interest in non-wood, natural products and supplies of renewable feedstocks for industry.

It is estimated that the 3 million hectares of woody perennials required to control salinity will cost some $3 billion to establish. It will be difficult to finance this investment solely from the benefits within agriculture under present economic circumstances. Furthermore economic will usually show that the onfarm benefit from non-commercial tree planting does not offset the opportunity cost of withdrawal of that land from crop or pasture production.

If commercial return can be gained from the trees the opportunity cost is reduced (or eliminated) and the potential to finance planting based on the expected revenue of the crop can be pursued. This process has commenced in the high rainfall area of WA (wetter than 600 mm per year). Landowners in this region now have the opportunity to better manage salinity while also maintaining farm profitability. Many options to manage and finance bluegum pulpwood planting have been developed and a competitive market has emerged (Bartle 1991; Eckersley, 1994; Shea et al, 1994).

To remedy land degradation on a national scale within a reasonable time span it will be imperative to develop several commercially attractive woody plant species, products and industries and for these crops to be adopted as a mainstream component of ley farming. The present approach to revegetation, motivated by the landcare benefit alone and subordinate to the income earning activities on the farm, needs urgent review.

It is important to note that tree crops need not give returns that are fully competitive with conventional crops. It is the aggregate costs and benefits that determine whether the tree crop will be competitive. In this respect tree crops may be analogous to the ley phase in the present system, where the direct return from pastures and wool may not be comparable with wheat but other long term benefits, such as the rejuvenation of soil organic matter and the nitrogen pool, makes it attractive.

3. Design of systems incorporating tree crops

The aim of integrating tree or woody plant crops into ley farming is to achieve an optimum of the several potential benefits while also ensuring that the total benefit exceeds the cost and inconvenience. The different benefits may call for quite divergent planting distributions. For example, the ideal layout for wind erosion control is not likely to be the same as that required for maximum water use. Shea et al (1993) illustrate tree crop placement to achieve an optimum of tree products, shelter and salinity control.

Strategic placement of trees for maximum water use will often be a major objective. Skilful placement for water use will grow more tree products as well as give better control of ground water and salinity. New techniques using geology, geophysics and hydrogeology are emerging which should greatly improve the accuracy with which trees can be placed to achieve maximum water use (Engel et al, 1987; George et al, 1994).

The costs and inconvenience of trees to other farm activities will also be a major factor influencing planting distribution. The tree crop must not compromise the large scale mechanisation of conventional cropping or the low management input of extensive grazing.

Two typical tree layouts are likely to emerge:

- concentrated block planting at strategic landscape positions where particular advantage can be gained, for example, where water can be efficiently exploited such as sand plain seeps, valley bottoms or break of slope;

- dispersed belt or 'alley farming' patterns suited to mopping up surplus water across recharge areas, providing extensive shelter and for compatibility with cropping. This option is only likely to be successful where fencing of the belts is not necessary. This will require innovation in grazing management and a focus on unpalatable tree crops.

Alley farming practice is rapidly developing in WA and alley layouts appear likely to become the most popular tree crop planting distribution. Lefroy and Scott (1994) review this development. The major design variables of alley systems are tree species, tree belt width, alley width and belt orientation. These features must be investigated to determine the finer points of the Agronomy of alley systems. Eckersley (1994) presents some economic analysis of bluegum alley systems that indicate the importance of correct design.

4. Species and products

Conventional timber producing species provide some ready options for incorporation into ley farming in the higher rainfall (greater than 600 mm rainfall) areas of southern Australia. In particular, fast grown, short rotation eucalypts for pulpwood (mainly *Eucalyptus globules)* and pine (mainly *Pinus radiata)* are recognised commercial species with large and expanding markets, strong price projections and existing agroforestry techniques.

From the farmers' perspective the impediments to planting are lack of experience and confidence with tree crops, lack of conviction that the optimum agroforestry designs have been developed, the long rotations (greater than 10 years), difficulty in financing such a long term investment and the need for firm arrangements to consolidate individual agroforestry plantings into big enough blocks of timber resource to attract investment in infrastructure and marketing. The Western Australian experience with bluegum has shown that these impediments to be substantial but solvable (Inions, 1996).

A concerted effort to more extensively develop tile agroforestry potential of the traditional timber species could revitalise Australian forestry and arrest much of the land degradation in higher rainfall areas (greater than 600 mm/year) of southern Australia.

However, the bulk of Australian farmland is too dry for conventional timber species and no other tree crop option of any significance exists. The low rainfall wheat and sheep zone has an area of some 100 million hectares, large property sizes, low management inputs, low profitability and long transport distances. Development of tree crops for this area should therefore focus on species which:

- are amenable to large scale, extensive management;
- have products with an economic transport horizon up to 400 km or else be amenable to local processing to add value;
- have products for which large volume markets could be developed;
- produce over as short a rotation as possible to improve the ease of financing;
- have potential uses for any wastes or residues;
- have desirable agroforestry attributes;
- are preferably native plants to reduce risk of introduction of weeds.

Ideally many tree crop species and products should be developed to provide a range of options for all soils, climates, forms of degraded land arid to give economical and biological diversity. Given the land area needing trees the focus for tree crop development has to be on scale. While there may be many options for production for local use (farm timber, fence posts) or for specialty markets (flowers, craftwood, furniture), these options are likely to remain modest in scale and are not seen to justify major agroforestry development effort.

The productivity of shrubs and trees across southern Australia's wheat and sheep lands can be estimated from existing data. Using a productivity of 5 tonnes dry matter/ha/yr (for mallee eucalypts in short rotations yielding 50% wood, Milthorpe et al (1994)), and a planted proportion of 15% indicates potential gross production of 75 million tonnes of biomass per year. For any particular locality a transport horizon of 50 km could tap biomass production of 600 000 tonnes/year.

The likely economies of scale, the highly mechanised low cost practices of wheabelt agriculture and the multiple benefits from tree crops all indicate that the Wheatbelt has potential to be a low cost producer of bulk wood or biomass.

This promise will give rise to a comprehensive search for woody plant species and products which might have commercial potential. Bartle and Reeves (1992) outline a systematic procedure by which the search for and evaluation of potential tree crop prospects could proceed. This procedure was used by the Department of Conservation and Land Management to identify the production of eucalyptus oil from mallee eucalypts as a target for commercial development. This project is outlined here to provide an example of the innovation and analysis that will be necessary to develop new tree crops.

5. The eucalyptus oil project

The market potential of eucalyptus oil is based on its excellent solvent properties. Solvent markets are large and undergoing restructuring of supply to replace a major product called trichloroethane, the production of which has been discontinued under international conventions to control ozone depletion. There is a strong preference in these markets for 'natural' replacement products. Even a modest 10% penetration of world solvent markets by eucalyptus oil would require at least 5 million ha of oil mallee planting. The current pharmaceutical market for eucalyptus oil is less than 3000 tonnes and too small to yield any significant landcare benefit.

The major challenge of solvent markets is price. Historically trichloroethane and its natural product competitors, limonene (from citrus peel) and pinene (from Pinus species) have sold for around $2/kg. Synthetic replacements will be preferred if natural product prices climb too far above this level.

Prefeasibility investigation indicates that $2/kg is an achievable target and that there are several avenues for development of oil mallees to achieve this target.

This investigation was based on an economic analysis for a typical WA Wheatbelt farm incorporating a 10% alley distribution of oil mallee and using the following assumptions:

- a 20 year term with future cashflow discounted at 6.5%.
- a farm with average central Wheatbelt soil types and production parameters.
- 10% of the farm lost from production due to salinity over the 20 year term.
- oil mallee in alley farming configuration occupying 10% of the land i.e. a 10 m wide planted belt every 100 m, each belt consisting of two, twin row 'hedges'.
- planting undertaken over a 5 year period' and, after a 2 year time lag, reduces spread of salinity to half the expected extent (i.e. down to 5% loss of land over 20 years).
- A substitution ratio of 1:1 is assumed i.e. the 10% planted to oil mallee is assumed to displace an equivalent area of crop or pasture production. Benefits in shelter, wind erosion control, waterlogging control are not been included and nor are disbenefits such as a crop or pasture suppression adjacent to mallee hedges. Off-farm benefits are not included in the analysis.

A careful assessment of oil mallee cost and production parameters was made and the following levels were considered to be achievable:

- first oil mallee harvest is taken in year 2, annually thereafter.
- oil content is 4% of fresh leaf weight or 40kgJtonne leaf.
- fresh leaf yield is 5 tonnes/ha/year on a planted area basis or 2.5 tonnes/km/year on a hedge length basis. Leaf is 50% of total biomass, dry weights are 50% of freshweights.

- establishment costs are $500/km of hedge.
- harvest, transport to a local extraction facility and extraction is $60/tonne of leaf or equivalent for leaf/wood mixtures.
- oil price is $2/kg ex local extraction facility.

Table 2 presents results of the analysis of the form of break even levels of performance for each oil mallee parameter i.e. the level of performance that must be achieved for that single variable to maintain the net present value of overall farm production. For example, the farm would suffer a reduction in net present value at $2/kg for oil but would break even at $2.65.

Table 2: Break even production levels for oil mallee

Parameter	Assumed level of performance	Break even
Leaf yield	2.5 tonnes/km/yr or 5 tonnes/ha/yr (freshweight)	11.5 tonne/ha/yr
Oil content	40 kg/tonne of leaf (freshweight)	53 kg/tonne
Harvest/extraction cost	$60/tonne of leaf	$34/tonne
Establishment cost	$500/km hedge or $1 000/ha	no break even
Oil price	$2/kg	$2 65/kg

This analysis shows oil mallee is not viable at the assumed levels of performance. However, the break even levels for oil content and harvest/extraction cost are within striking distance. The oil mallee development has focused on genetic improvement of oil content and modernising harvest and extraction techniques.

The analysis was reworked to evaluate the impact of a market for residue. Minor changes to the underlying assumptions were made in this analysis to make it relevant to the average Esperance farm. This district is not connected to the state electricity grid. Recent withdrawal of access to the diesel fuel rebate has stimulated interest in alternative fuels. A commercial feasibility investigation is underway to establish the viability of biomass fuel and new gasification technology for its conversion to electricity. The results presented in Table 3 indicate that a fuel price of $25/dry tonne, in addition to the oil return, would improve farm net present value and make oil mallee a competitive crop at current levels of performance.

This analysis indicates the synergy possible from a dual product crop, where a high value, low bulk product can be strongly complemented by a residue use. It also suggests that higher value residue uses should be explored. At the prospective volume and price the wood fraction could compete with traditional forestry sources of feedstock for panel board products. However, other major products would be needed to fully utilise the potential production from Wheatbelt tree crops. This will require review and investigation of all the possible uses for low value biomass including energy, chemicals and carbon products.

Table 3: Break even production levels for oil manes incorporating a return from residue

Parameter	Assumed level of performance	Break even
Leaf yield	2.5 tonnes/km/yr or 5 tonnes/ha/yr	4.5 tonne/ha/yr
	(freshweight)	
Oil content	40 kg/tonne of leaf (freshweight)	38 kg/tonne
Harvest/extraction cost	$60/tonne of leaf	$65/tonne
Establishment cost	$500/km hedge or $1 000/ha	$1223
Oil price	$2/kg	$1.89/kg
Residue price	$25/tonne (total dry biomass)	$20/tonne

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Newsletter
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From The President

Chris Groot

Another mallee planting season is now complete. I understand we managed a total planting of 1.8 million seedlings – a figure diminished by continuing problems in getting reliable production from some nurseries. Thanks for a mighty effort.

This edition of Dinkum Oil continues the theme of keeping you up to speed with what is going on behind the scenes to develop the industry. Industry development has turned out to be a much more challenging task than we ever anticipated.

I would like to give you an introduction to this edition of Dinkum Oil. There is mostly good news. However, I would like to start with some not so good news.

You will recall in the last Dinkum Oil that through negotiation with the Natural Heritage Trust we has built up confidence that we would be likely to receive funding for oil mallee planting and that we had set ourselves a target of 4 million mallees to be planted in 1999. Our proposal passed through all stages of approval at regional and State level. However, it was not announced in the first round of projects approved by Senator Hill in October just prior to the election. We understand that there may be another round of approvals but our confidence is dented and the delay compromises our preparation for the 1999 planting season.

In anticipation of difficulty we wrote to Senator Hill in August pointing out that without opening some commercial incentives in revegetation the objectives of the Natural Heritage Trust would not be realized in WA. We made the case that such incentives could be developed in a way that was quite complementary to biodiversity, the major NHT objective, and that oil mallee was a test case of this type. We also invited the Minister to visit WA and inspect our operations. We remain hopeful of success with the application.

Now some better news.

Syd Shea presented a carbon credits seminar to the Growers Council in August. There appears to be good promise of a trade in carbon becoming a reality but there will be a lot of work to be done to set it up. Your Council undertook to work with CALM in exploring how this might be done.

CALM has sponsored a student from Edith Cowan University (Andrew McCarthy) to work on the biomass production potential of oil mallee. This work is turning up very interesting results on the yield of leaf and oil as well as on biomass productivity. Andrew has assessed production on plenissima and lox liss up to age 6 in the Kalannie area. We had previously based our yield estimates on growth in the age bracket 2 to 4 years and had made the assumption that growth at this age was representative of what we could expect from more mature plants. However, the growth performance in the age bracket 4 to 6 years is more than twice as large as what we see at the younger age. We have re-worked all our early economic assessments to include the higher yield and it gives us very much more confidence in the viability of oil mallee. Some of this work is presented by Ric Collins in the following article.

To prepare for assessment of applications for R&D funds the Rural Industries R&D Corporation commissioned a consultant (Brisbane based Agtrans Research) to review low-rainfall tree crop options. Their review, using the latest yield data, showed that oil mallee could be viable and that it was the best of the low-rainfall tree crop options. This independent work gives us great confidence that we are on the right track. It also lifts the profile of our development with R&D Corporations and other funding bodies. We expect increased success with R&D applications.

Another recent advance has come in our pursuit of uses for the residue wood and leaf after oil extraction. We had always considered it to have potential as a fuel for electricity generation, although the wide dispersal of the residue (compared to coal) means that it would have to operate in smaller and therefore more costly plants. With the increasing interest in renewable energy and avoiding greenhouse gas emissions Western Power is now looking seriously at wood residue as a fuel. We are party to an application with Western Power to the Commonwealth's Renewable Energy Showcase, a program which aims to demonstrate innovative new energy production systems. The proposal is to build what we called an 'integrated mallee processing' pilot plant. This plant will produce oil, carbon products and electricity. It will cost about $6 million half of which would be provided by the Commonwealth and the balance by Western Power. Even if we are not successful in getting this project approved it indicates the potential oil mallee has to become a major new crop and create major new industries.

My confidence that we have the opportunity to build something big and important with oil mallee continues to increase. Remember that the basis of any new industry will be your mallee crops. Mallee remains the best multiple purpose tree planting option. I hope mallee features strongly in your 1999 plans.

From The Administrator

Ric Collins

Interest in high oil mallees is blossoming. The input from Region Managers and Wayne O'Sullivan, the OMA Co-ordinator, along with recent advertising and field day attendance are all contributing.

Region Managers particularly are working hard to confirm orders by October 31st. Nurseries are advised in early November of the numbers of seedlings they will need to grow.

Growers should note that to be assured of trees for planting in 1999, orders should be in by October 31st.

The Association anticipates that plantings in 1999 will be close to 4 million trees.

The latest research results show that harvest yields of biomass (leaf plus twig and stem) are likely to be two to four times higher than initially anticipated. If the first harvest is left until year four after planting, the harvest volumes are so much better.

The Association is confident that tree yields will now exceed 10 kg per tree per harvest. The yields may be twice this in high rainfall agriculture areas and on seepage sites.

Based on current knowledge and plausible expectations, OMA now believes:

- a planting density of 15% of the landscape is likely to lower further waterlogging and salinity. That is 400 trees per hectare taking up an effective 0.15 ha i.e.15 ha out of every 100 ha would be planted to 40,000 trees.

Note: a farm of 1000 ha will need to plant some 400,000 trees in total to combat rising water tables, waterlogging and salinity.

- tree costs will approximate 55c per seedling planted (tree cost plus site preparation and planting). This is $220 per 400 trees planted on 0.15 ha.
- provided rabbits are controlled and sheep are not allowed to graze the mallees for about 18 months, then 90% survival can be achieved without ever fencing off the trees.
- first harvest will occur at year four and yields should comfortably exceed 10 kg biomass per tree (biomass is leaf plus stem and twig).
- oil content at first harvest should be 0.15% of the biomass if OMA high oil content mallees have been planted.
- second harvest will occur at year six (two years later) and yields should comfortably exceed 10 kg biomass unless the season is very dry. In higher

rainfall areas and seasons and on seepage sites, the yield should be higher still, perhaps allowing a harvest every year once the lignotuber (root) is well developed.

- oil content at second and subsequent harvests is likely to be more than at the first harvest; 1.75% is anticipated.
- net to the grower price for oil should be in the range of 50c - $1.50 per kg of oil.
- harvest costs will be borne by the company but the price paid to growers for the oil will reflect the harvest costs on their site. Small and difficult to harvest sites will cost much more per kg of oil to harvest
- a cost effective planting will be at least 10,000 trees per farm per annum with at least 5 neighbours working in together to give a harvest volume of at least 50,000 trees per year.
- the profitability of oil mallees per 100 ha is likely to be as follows:

100 ha planted @ 15% density of 400 trees/ha = 40,000 trees
40,000 trees cost $22,000 spread over 10 years = $2,200 pa *
40,000 trees take 15 hectares out of production

At 90% survival 36,000 trees will be harvested
First harvest 36,000 trees cut 10 kg biomass @ 1.5% oil = 5400 kg oil

5400 kg oil at $1.00/kg	=	$5,400
Less tree cost 4 years	=	$8,800
Deficit from 15 ha	=	($3,400)
Deficit per ha	=	($227)

At subsequent harvests 36,000 trees cut 10 kg biomass @ 1.75% oil = 6300 kg oil

6300 kg oil at $1.00/kg	=	$6,300
Less tree cost spread over 10 years	=	$4,400
Surplus from 15 ha	=	$1,900
Surplus per ha	=	$127
Surplus per ha per year (assumes harvest every 2 yrs)	=	$63

After 10 years, when trees have been paid for, the

Surplus from 15 ha	=	$6,300
Surplus per ha	=	$420
Surplus per ha per yr (harvest every 2 years)	=	$210

* **Note:** It could be argued that the cost of the tree is spread over the harvest life and the tree life which is expected to be over 100 years.

OMA also believes that:

- members will get a return for carbon credits which will increase over time as the root mass per 1000 trees increases by one tonne per annum. OMA is already seeking customers who need to off set carbon emissions by buying carbon credits. A key to the success of OMA's negotiation is carbon credit volume (trees planted).

Members will get a return from surplus biomass sold either for energy or composite board (reconstituted timber). More on this in another issue of Dinkum Oil.

It is time to get dinkum about planting trees.

OMA understands that landcare is not just about oil mallees and is working closely with all landcare groups in support of biodiversity plantings, protection of remnant vegetation, implementation of catchment plans.

OIL MALLEE COMPANY REPORT

Ric Collins

The Oil Mallee Company is currently engaged in or has proposals for Research & Development totaling almost $2.5 m.

This R & D is crucial to the development of the $150 - 200m oil mallee industry in WA, an industry which WA farmers can own.

Current R & D

Harvester development - $646,000

This project is on track to provide a prototype for trialing this summer. A full report was provided by Rick Giles in the last Newsletter.

It is anticipated that it will take two more years to turn the prototype harvester into a cost effective commercial harvester capable of harvesting 25,000 mallees per day.

The Company has submitted a detailed application for funding totaling $646,000. The company will be expected to contribute $301,000 in capital to the project. The harvester currently under development represents some of this capital contribution.

Distillation - continuous flow, semi portable - $60,000

A recent capital injection from the Oil Mallee Association using funds held in reserve as harvest credits will allow further work on the new still to enable more trial distillation in conjunction with harvester trials this summer.

A detailed application for funding has been lodged with RIRDC for $562,000 to take this prototype through to commercialization. This is also a two year project and the company will contribute $235,000 capital to the project. The still, as commissioned, represents some of this company capital contribution.

<u>Distillation - evaporative cell - $264,000</u>
R & D on this exciting prospect which may provide for very cheap distillation, began recently with the first installment of RIRDC funds ($75,000 in all).

This project aims to use solar energy to distil eucalyptus oil from mallees.

Preliminary investigations show the project has potential.

OMC will contribute $107,000 in capital to this project.

New R & D
The projects currently under way are being carried in conjunction with Curtin University.

New R & D projects involve other parties.

- Integrated Mallee Processing - $259,000

  A consortium of Enecon, CSIRO, Western Power and OMC have been invited to put a full proposal to RIRDC for funding to investigate the use of mallees to produce oil, carbon, energy and carbon credit benefits at a series of sites throughout the wheat belt.

  Provided such a project appears feasible then a series of power + carbon + oil producing plants could be built in the wheat belt. Each plant would use the biomass from about 10 million mallees annually.

  If RIRDC agree to fund this project OMC will contribute $25,000.

- Product Development - $325,000

  Various markets exist for eucalyptus oil; some pay more than others.

  OMC and Murdoch University have a preliminary proposal before RIRDC to investigate a series of markets which are expected to provide the best prices for eucalyptus oil initially.

If the full application is eventually successful the company will contribute $105,000 to this R & D.

- Cost effective multi purpose agroforestry systems - $135,000

This R & D will, in time, offer farmers a range of tree crop options. CALM and the University of WA will conduct most of this research if the funds are granted.

- Short rotation silviculture practice for oil mallee and melaleuca - $270,000

This R & D will provide a better understanding of the management of these tree crop species to optimise returns. CALM and the University of WA will conduct most of this research if the funds are granted.

Why all the R & D?
The motivation behind all the R & D is to provide growers with a commercial return on trees planted for landcare.

Clearly there is a long way to go, but the potential for the industry warrants the attention currently given to R & D.

Based on forecast plantings by the OMA, the eucalyptus oil industry could be generating significant returns within the next two decades.

Consider the following table which shows possible returns from oil:

- Three snapshot years are shown
- Not all planted trees are harvested each year
- Biomass per tree is considered conservative
- Gross price is price paid by the customer
- Net price to the farmer is based on current anticipation. There are no harvest costs to be deducted from this price.

Possible Production and Revenue Scenario for Oil Mallees in WA

ASSUMPTIONS	YEAR		2000	2010	2025
Trees Surviving (millions)			20	200	500
Trees Harvested per year (millions)			10	75	200
Biomass/tree			10 kg	10 kg	10 kg
% Oil in Biomass			1.5%	1.625%	1.75%
Oil Produced (tonnes)			1500 t	12000 t	35000 t
Value to Western Australia	Gross Price @ $5/kg	$7.5m	$60m	$175m	
Value to farmers	Net Price @ $1/kg	$1.5m	$12m	$35m	
Average value per harvest per 1000 ha @ 400 trees/ha (15% area) @ $1.00/kg			$60,000	$65,000	$70,000

The Board of OMC believe it is well worth while putting in the effort to complete the R & D to get the industry on a firm footing.

Enormous amounts of time go into preparing full applications for funding and the rewards for principals involved in the R & D project are quite slim (if the project is funded).

The company is fortunate to have a dedicated team who individually see that achieving the vision is a very important part of their professional input at this early stage.

TECHNICAL TOPIC

Chemical Properties of High-Cineole Eucalyptus Oil

Part One: Cineole and Industrial Solvents

Allan Barton and Bob Greening

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Eucalyptus Oil

A few Eucalyptus species, mainly "mallees" (plants with multiple stems, woody lignotubers and the ability to regrow after repeated harvesting) produce a leaf oil for which there is an existing limited world trade as a pharmaceutical product and a large potential market as an industrial solvent. These oils are composed of mixtures of volatile organic compounds including hydrocarbons, alcohols, aldehydes, ketones, acids, ethers and esters. Most are monoterpenes and sesquiterpenes which consist of two or more isoprene (C_5H_8) units. They are products of photosynthesis, with functions for the plants that are still poorly understood. Currently the most important of these is 1,8-cineole (Figure 1), but even in high-cineole eucalyptus oil there are small quantities of other compounds which have existing or potential specialised uses.

The Australian industry peaked in the mid-1940's when annual production was about 1000 tonnes. Since then the establishment of eucalypt plantations in countries with lower labor costs has reduced our competitiveness. Although some mallees (particularly *Eucalyptus polybractea*, the "blue mallee") are still harvested in the traditional way in eastern Australia, most of the world's production is derived from the byproduct of wood production from plantation *Eucalyptus globulus* (Tasmanian bluegum). However, this yields a leaf oil with a lower cineole proportion than in the oil mallees, and the oil must be refined or blended with a cineole-rich product to meet most pharmaceutical standards. The history of this industry has been reviewed recently.

Currently somewhere between three and five thousand tonnes are traded each year on international markets, with only two or three hundred tonnes being produced by Australia. Prices fluctuate widely (depending on many factors including type of oil, quality, demand) from US$2 to about US$10 per kilogram.

Eucalyptus oil based products have been used as a traditional non-ingestive treatment for coughs and colds, a topically applied medication for relief of muscular pain, and as a solvent/sealer in root canal dentistry.

It has uses as a fragrance in soaps, detergents and perfumes and as a flavoring in food. Household uses include spot and stain remover and a wool wash component. It has also been used as a flotation agent in the mining industry.

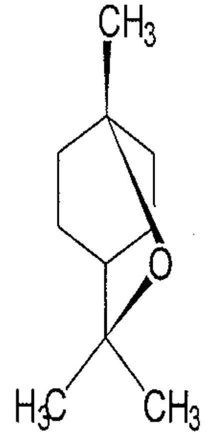


Figure 1. Molecular structure of 1,8-cineole, showing the system of "fused rings": the cyclohexane ring with 6 carbon atoms and two cyclic ether rings of 5 carbon atoms and an oxygen atom.

1,8-Cineole

1,8-Cineole (often called just "cineole") is the pharmaceutically active component of eucalyptus oil. It occurs in complex mixtures with numerous other terpenoid compounds in the leaf oils of many eucalypts, but to differing extents - usually 60 to 70% in the case of bluegums and up to 95% in some oil mallees. Cineole

(Figure 1) is a cyclic ether with empirical formula $C_{10}H_{18}O$ and systematic name 1,3,3-trimethyl-2-oxabicyclo[2.2.2]octane. It is sometimes traded commercially as "eucalyptol". The carbon atoms linked to the ether oxygen are fully substituted and this fact plus the chemical saturation (no carbon-carbon double bonds) endow cineole with stability and low chemical reactivity. These properties include resistance to oxidation, polymerisation and thermal decomposition, in contrast to most other terpenoid compounds.

It is a colourless liquid over the temperature range 0 °C to 177 °C with a vapour pressure of 69 mmHg at 20 °C and a strong characteristic odour. Its flash point is reasonably high (48 °C). It is slightly less dense than water (0.927 g mL^{-1} at 20 °C). Cineole's ether oxygen atom is moderately polar, making it either fully or partly miscible in a wide range of other liquids from hydrocarbons to polar organics. Cineole has a limited solubility in water (0.4% by weight at 20 °C).

Carboxylation and hydroxylation of cineole have been described by various processes, including enzymatic, biological and metabolic routes. It has an odour which at low concentration is considered pleasant by most people and is used in aromatherapy applications as well as for deodorising waste sludges. Cineole's combination of cleaning properties and pleasant odour have resulted in its incorporation into a wide range of household cleaning products.

Cineole therefore has a future as an industrial and commercial solvent as well as the potential to control insects and weeds in an environmentally acceptable manner, in addition to its existing use in pharmaceuticals. In particular, in many situations cineole may well replace 1,1,1-trichloroethane, previously widely used for metal degreasing and other cleaning operations.

Eucalyptus oil has been demonstrated to have potential as a fuel component and cineole used as an additive in ethanol-gasoline fuel blends ("gasohol") prevents phase separation in the presence of water. This is another potentially large application, likely to attract interest after world petroleum production peaks, which is predicted to occur in the first decade of the twenty-first century.

Bioactivity of Cineole

Cineole and other components of eucalyptus oil are readily biodegradable, unreactive and relatively non-toxic. Eucalyptus oil carries the US Food and Drug Authority classification GRAS (Generally Regarded as Safe) and is approved for incorporation into foods such as chewing gum and throat lozenges at low concentrations.

Cineole can readily penetrate tissue, one of the reasons for its efficacy in various decongestants and pain relief products. It also has mild bactericidal properties and has been used in herbicidal, insecticidal and allelopathic applications. All these properties are presumably associated with its unique compact chemical form, with the cyclic ether linkage spanning a structure based on cyclohexane (Figure 1).

Essential oils containing cineole demonstrate antimicrobial and pesticide qualities, including effects demonstrated by cineole on its own as well as synergistic effects when cineole is used as a carrier solvent Examples are:

- *Eucalyptus* trees with a high cineole content show less susceptibility to herbivory by Christmas beetles, and cineole is a mosquito feeding and egg-laying repellent.
- Treating the western honey bee for the parasitic mite *Varroa jacobsonii* with a terpene based solution containing cineole gave a mite mortality of 96.7% against a 4.4% mortality in the control colonies.
- Cineole is a natural repellent to the American cockroach and results of tests for the use of eucalyptus oil and cineole as a mosquito larvicide also indicate it has insecticidal potential.
- Cineole has been investigated as a fumigant against stored-product insects.

To put cineole's chemical properties in the context of the future of this compound as a substitute solvent, it is necessary to consider briefly the background of the solvent trichloroethane and of wider environmental issues, which include the greenhouse effect as well as the wheatbelt salinisation.

1,1,1-Trichloroethane

The vapour of the chlorohydrocarbon 1,1,1-trichloroethane (CCl_3CH_3)is now known to be both an ozone-damaging and a "greenhouse" gas and this solvent has been effectively phased out for all but essential purposes. Worldwide annual production has fallen dramatically from its peak in the early 1990's. Trichloroethane has a relatively low ozone depletion potential (ODP) of approximately 0.11. (The ODP is the ratio of the impact due to the release of a particular molecule on global ozone loss compared to the impact of a molecule of CFC-11, $CFCl_3$.) However trichloroethane's stability in the lower atmosphere (atmospheric lifetime of about 6 years) and widespread use as a degreaser and general all purpose solvent since the late 1950's means that it is a significant contributor to ozone layer depletion. Despite its adverse environmental record and poor occupational health standing, trichloroethane was the degreasing solvent of choice, with annual international sales of the order of a million tonnes in 1993.

Renewable Biomass Fuel and Carbon Sequestration

Australian initiatives to reduce global atmospheric carbon dioxide levels include mandatory generation of a proportion of energy production from renewable rather than fossil sources. These legislative requirements match practical issues in Western Australia, which has communities remote from the existing electricity grid. The woody residue from eucalyptus oil production as a feedstock for steam and electricity production could provide a component of this requirement.

Adequately long time scales for carbon sequestration in plantation vegetation are still the subject of debate, with a range from a few years for woody fuel production to thousands of years for some timber trees. Oil mallees can contribute at both extremes:

- Leaf oil (and associated biomass fuel) harvesting cycles are typically two years, providing a rapid renewable biomass fuel cycle.
- At the same time the lignotuber or mallee root continues to grow in the ground. Areas near Bendigo in Victoria have been producing oil from the same lignotubers for over a hundred years and some of these lignotubers were probably hundreds of years old when the process started. These carbon sinks will meet even the most stringent definitions of permanent carbon sequestration.

Industrial Solvents

Eucalyptus oil has numerous traditional uses, especially in non-prescription pharmaceuticals, but the market is small. The existing annual pharmaceutical market for cineole worldwide totals no more than a few thousand tonnes (to which Australia contributes only a few hundred tonnes). More importantly, the natural solvent properties of eucalyptus oils (long familiar in Australian households) can be applied for industrial uses.

High-cineole eucalyptus oil has a combination of chemical and physical properties that makes it suitable for several solvent applications. It is

- a good solvent for a wide range of materials
- chemically stable, not deteriorating on storage or heating
- liquid over a wide range of temperatures with a moderate vapour pressure at ambient temperature
- slightly soluble in water and has the ability to steam distil
- relatively safe, with minimal environmental and occupational health implications
- a "familiar" but unexploited product worldwide.

Several market sectors have been identified:

- solvent degreasing: low price and high volume. Although there is significant competition from petroleum-based solvents, there is a growing popular demand for "natural" solvents, and high-cineole eucalyptus oil has advantages over other natural solvents like pinene and limonene. Both have development and production constraints as by-products of other industries (wood products and orange juice, respectively), and cineole has an inherent chemical stability compared with the unsaturated terpenoids such as pinene and limonene.
- carrier solvent: medium price and moderate volume. Synergistic efficiency improvement and more controlled application of pesticides have been demonstrated but not yet fully explored.
- extraction solvent: medium to high price and moderate volume. Cineole has been investigated for a few specific applications, but again there is considerable scope for investigation.

There is a significant market opportunity for eucalyptus oil in industrial degreasing and solvent applications. Best practice is changing rapidly in response to the phasing out of trichloroethane under international conventions (the Montreal Accord) to arrest ozone depletion. Solvent systems have been replaced by

- solvent-free systems
- aqueous detergent systems
- natural products which have other industrial ecological advantages over petrochemical products.

Parts Two (Degreasers) and Three (Murdoch University Chemical Research Publications) will appear in subsequent issues.

NEWS REPORTS AND VIEWS FROM REGION MANAGERS

CENTRAL OIL MALLEE REGION REPORT

Max and Angela Waters

Since the last Dinkum Oil it has been a busy and hectic period. As antipated in excess of 450,000 seedlings were planted with seventy five percent in the ground by early July. The later ones were mainly low in the landscape which in a year like this were rather wet.

Contour sites predominated this year, possibly because the farmers now have confidence in the ability of the mallees to come back even if they do sustain sheep damage. The other factor being the logical site to have an impact on water making it's way to the valley floors. Seepage blocks and alley farming made up the bulk of the rmaining sites. *E. loxophleba s.sp. lissophloia* and *E. plenissima* were the two main species used at approximately fifty/fifty.

Max assisted Wyalkatchem District High School to plant alleys on their farm and the students had the opportunity for a real hands on experience. They handled the Potti putki's admirably and obviously weren't frightened by hard work as they have placed a further order for 1999.

With the planting season slowing, the field days and meetings began and it sure was "hit the road Jack". Interest in Oil Mallees is certainly building – in addition to areas already under way, new ones such as Trayning, Calingiri, Miling, Badgingarra, Wyalkatchem, Bencubbin, Muckinbudin and Goomalling have made contact.

With an ever increasing area to cover and mindful of the service we provide the farmers, we are trialing the use of a "subbie" in one of our Shires. We feel this will be the way to expand in the future. Our estimated plantings for 1999 is one million.

A Regional Managers "washup" was recently held in Northam and these are very valuable in sharing experiences and ideas and planning for the future.

The initial Ag. W.A. "still" has been in Kalannie and apart from the excitement of bottling some "home grown" Eucalyptus oil it has assisted with the verification of having an average of 10kg of biomass per 4 year old tree. Those cut during the week ranged from 43kg to 12 kg depending on the availability of moisture.

Work is still continuing on Carbon Credits in our Region and the word is that Oil Mallees store more than was anticipated.

Mid West Oil Mallee Association

Robyn Colum and Cathy McKenna

Opening up the cells has created further interest in the region with new areas looking to establish in Northampton, Coorow and Three Springs in 1999 and Perenjori in 2000. Knowing that the Oil Mallees do not require fencing has encouraged many people to become Oil Mallee growers. Growers are now able to place their trees further up the landscape in contour and ally farming designs without the additional cost of fencing. With careful management of the young trees this should see a greater spread of trees throughout the landscape. Therefore intercepting the water before it reaches the water table in the lower areas, helping to reduce the landcare problems associated with rising water tables such as salinity and water logging.

All seedlings for the region were dispatched by the middle of August. Seedlings were of a high standard and all growers seemed very happy. The bulk of the seedlings planted were *Eucalyptus horistes*, few *E. loxophleba* subsp *lissophloia* and *7000 E. kochii* subsp *plenissima* were trialed on sandier sites. *Eucalyptus horistes* is popular in the region because it is endemic therefore it establishes well and is less prone to insect attack than the other species. The plantings I have seen are establishing extremely well and have benefited by the good season and late rains.

Orders for the 1999 season close on the 31st of October, 1998. As your Regional Manager I am available by appointment to discuss the planning of plantings, site assessment (including the measurement of conductivity using the EM38), general advice on best practice establishment and management of seedlings and advice on industry advancements. Please do not hesitate to contact me.

Upper Great Southern Oil Mallee Region Report

David McFall

Congratulations!
Congratulations all round to four local oil mallee growers who achieved Landcare honours at the recent Narrogin Landcare Show on October 10th.

Bob and Mary Taylor - Award Winners for the Wickepin Shire and Kevin and Lyn Sexton - Award Winners from the Cuballing Shire.

Bob and Mary are long term supporters of the Oil Mallee Project, having joined the scheme in 1993. Kevin and Lyn joined the program in 1996 and have maintained an active planting program since then.

Well done!

Promotions
Growing oil mallees is not all about farming. Due to the increased awareness to the exciting prospects of this industry, a couple of growers have found new talents - as media stars!!

Recent Landline and Countrywide film crews have captured Keith Parnell and Audrey Bird sprooking the wares of oil mallees.

On another note Norm Quicke (Kulin oil mallee grower) has been spotted carrying the Olympic flame down a Sydney Street in an AMP Advert!!

Management Committee
The Upper Great Southern Management Committee is taking shape. Keith Parnell chairs this group which comprises of Audrey Bird (Toolibin LCD), Andrew Borthwick (proxy Narrogin LCD), Gordon McDougall (OMA executive rep), and Mark Conley (Treasurer). The group is awaiting representatives from Wickepin LCD, Pingelly LCD and Yornanning LCD to further bolster numbers.

Capital Fund
The Upper Great Southern is forming a Capital Fund (1c levy per seedling from oil mallee orders) to advance the local oil mallee project. Expenditure areas will include capital items, i.e. planting tools, promotions, R&D and administration support.

1999 Orders
The order book is open and filling up. Expectations for the 1999 season is beyond 500,000.

Boosting the uptake is funding from the Toolibin Management Committee and Western Power Greening Challenge. Our thanks to these groups.

Eastern Wheatbelt Oil Mallee Region Report

Tim Helder

1998 planting season saw 340,000 seedlings planted on 35 sites. One third of these were contour systems high in the landscape, another third were allies and blocks in good loams and clays and the last into semi saline valley floor situations. Weather conditions have been ideal for good establishment and survival.

It is always interesting to look at different grower's interpretations of good site preparation or acceptable measures taken to instigate a plantation. Time and time again I see where different strategies result in varying results. One thing is quite evident. The more you put in, the more you get back. Those who choose to prepare their sites out of season with a good deep rip, exercise weed control and hand plant seem to achieve the best establishment numbers and growth, with declines occurring as inputs reduce. All too often, what appears to be the cheapest and quickest measures are adopted. If you look deeper it is not always the case. Survival and growth rates are never usually written into this equation, so the issue is quite often clouded at planting time. The fact that second year weed control can be minimised and costly infilling (if attempted) become unnecessary, with a little extra at pre-planting time.

Southern Oil Mallee Region Report

Wendy Bessell-Browne

Our Region was previously known as the Greater Woodanilling Oil Mallee Group. The name change was decided upon because our area has increased to become a truly Regional entity and the word Southern identifies with all our growers.

We held our AGM in August and followed with a visit to Dumbleyung Engineering to inspect the construction of the purpose built harvester where Rick Giles, Harley Pederick and Mike Dennett explained its components. During the AGM the group decided to form a sub committee to convene and formulate the Regional Business and Development plan. Thanks to Sonya Harcourt-Smith, Trevor Young and Dave Guthrie for their time and dedication to take this task from the planning stage into a workable document.

I visited the South and North Stirlings, Broomehill and Tambellup/Cranbrook groups recently for field days with enthusiastic response. Newdegate Field Days and Katanning Shows were manned (or womaned). I will attend Dumbleyung Gymkhana in November with a display.

Thanks to Trevor Young, Eric Crossley, John Pepall and Andrea Chapman for their valued support. John Pepall also did a talk to an LCD Bus Tour in the Katanning Area and proudly demonstrated his alley plantation of Oil Mallees. We ran a competition at Katanning Show with a prize of a basket of Eucalyptus Oil Products worth $50 as a promotion. This proved to be very popular with the public, not only attracting farmers to enter but consumers of Eucalyptus products too.

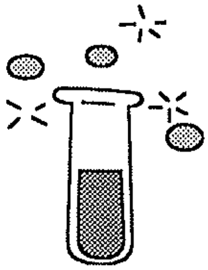
The farmers in the Southern Region were dealt some severe blows this year weather wise. The people in the lower part were inundated with heavy rains and were bogged out. Other areas have been badly affected with the recent frosts experienced. Fortunately only minimal damage to newly planted Oil Mallee seedlings have been reported. It is evident that the better quality seedlings we received from Nurseries this year have faired well. The weed problems of Spring are upon us again – if it is not one thing it's another! Please try to spray now to prevent seed set for next year.

We managed to plant about 160,000 seedlings in 1998 in the Southern Region. Considering that the original order was 127,000 it is an admirable effort of the farmers here and thanks to the availability of surplus seedlings from another Region.

It's time now for gathering orders for the 1999 season and we need them in as soon as possible please. This is necessary so that we can give the Nurseries ample lead time to grow good quality seedlings. Nurseries for the coming season are: Esperance Farm Trees, Greenscene Nursery, Bandicoot Nursery, Forrest Nursery and Hamel. Prices vary from 29c – 35c.

On 29th October the South Stirlings Group are coming to the Woodanilling Shire to partake in a Field Day.

Recently I was very honoured to be included in a field trip to the South East of the State along with Peter White, my son Lee, Wayne O'Sullivan, Karen Greening and Mark Golding. It was a very well worthwhile excursion as we came home having collected tested Mallee seed from thirty trees plus sample another 192.



These field trips are very necessary for the Oil Mallee program due to the increasing demand for high quality seed to ensure maximum returns from the trees we will be growing in the future.

Louise and Peter from Woodanilling - unloading oil malleeseedlings for the 1998 planting season

Esperance Region Report

Greg Bannon

The last two months have seen a number of activities in the district directed at oil mallees.

On the 20th of September, the second annual Esperance Aborfest was held at the arboretum about 15km north of Esperance. This is developing as a focus and showcase for farm forestry industries and local forestry projects and will build up in future years to a major event on our calendar. Next September Esperance will host the National Landcare Conference.

For the second year, the South East Oil Mallee Growers had a stand and created a lot of interest with the AG WA mobile distilling plant in operation. The display was set up am run by local growers Brendan Freeman, Rod and Marg Agnew and Ben and Steph Hatter. Ric Collins and Wayne O'Sullivan were also there explaining the philosophy of oil mallees and answering queries. As the "dinkum oil" flowed, the air was filled with the concentrated aroma of the Australian bush, which proved an irresistible lure to all the "eucophiles" walking past.

The still is a valuable demonstration item at days like these and has been put to good use while down here. It was taken to Salmon Gums for the Research Station field day on 8th of October, and then set up a week later for the two day Esperance Agricultural Show. There was a lot of interest and enquiry which will hopefully convert to committed mallee growing in 1999. This year has been a bit disappointing in terms of how many trees were planted, and we have high hopes of raising the numbers considerably next year.

Gavin Wornes, our regional manager is talking some well deserved long service leave at present and is due back in the new year. In the next few weeks we look forward to seeing Wayne Burton back to help with grower inquiries, site inspections and orders for the coming season. Wayne was CALM's man on the ground when the oil mallee industry started in Esperance in 1993, and he brought a lot of enthusiasm and expertise to the project. It will be good to catch up with him again have him see how the plantings have progressed in recent years.

We are still waiting to hear the success or otherwise of our applications for NHT funding, and if we are smiled on favorably from on high, we may be able to look at the position of a full time Regional Manager for our area. Gavin's role involves not only oil mallees, but bluegums as well and next year there is a big project involving maritime pines that will make further calls on his time. It would be good for our region to have someone fully involved with oil mallees, and look to introducing new plantings into neighbouring areas, such as Ravensthorpe and across the south coast. This would give Gavin the opportunity to concentrate more on R & D trial sites, species selection etc.

Finally speaking of species selection it was good to meet up with Peter White, Wayne O'Sullivan and others, to collect seed from the *E. Angustissima* that were sampled earlier in the year. This time, seed was collected from the individual trees that showed the highest oil content from those sampled in April. This parent seed forms the start of the selection process to breed superior, high oil content trees. As has been said before, "oils ain't necessarily oils". This screening and selection process is vital to the project.

PERSONNEL PROFILE

on

Gary Brennan

Glenda Godfrey

CALM Timber Technology Researcher working on Oil Mallees

In May this year, research scientist Gary Brennan was seconded from CALM Timber Technology to work on oil mallees. CALM has a wood utilisation research centre in Harvey, 140 km south of Perth, where Gary has worked for 15 years. He has worked in the areas of log stockpiling, sawmilling, timber seasoning, processing, wood preservation and natural durability. Over this period Gary has principally researched, regrowth jarrah, regrowth karri, plantation grown Tasmanian blue gum and some high density species from the Goldfields and Wheatbelt Regions.

Working with oil-mallees is completely new to Gary, although in 1982, he supervised tree planting on 700 ha of farmland in the Wellington Catchment, east of Collie. Currently he is helping with the establishment and management of the seed orchards located from Mullewa to Lake Grace. This has involved sharpening up his planting skills and heading out to the back blocks of the Wheatbelt with Glenda, Wally, Dean, Lee and Yana. Different families from the Oleosa group of eucalypts, smooth bark York gum (*Eucalyptus loxophleba* spp *lissophloia*), *E. angustissima* and blue-leaved mallee (*E. polybractea*) have been planted this year. Under the watchful eyes of Glenda and Wally, Gary was also initiated into the fine act of leaf sampling, which are assessed for their cineole content at Murdoch University.

The major project Gary is working on is developing a culling plan for each of the orchards. With the assistance of CALM tree breeder Richard Mazanec, nett breeding values (NBV's) were calculated for each family. NBV's are calculated from the cineole content of the parent trees, provenance or geographic location of the parents and other breeding factors. Provenance data were derived by plotting the latitude and longitude coordinates of each parent tree onto maps, then grouping the parents into provenances. A culling program will be based on the NVB's of each tree in the seed orchards.

The seed orchards have up to 30 different families, selected from parent trees located throughout the Wheatbelt. These families have been randomly planted in plots throughout the orchard, using a block design. We are at the stage of marking and culling the trees no longer required. Seed will be collected from any trees that are culled. By culling the trees with low cineole contents and low NBV's the remaining trees can cross pollinate, which will produce trees with higher cineole contents.

Gary is also working on a method of estimating the amount of seed produced, flowering patterns and seed production characteristics of the different families in all seed orchards. These assessments are on-going and require regular visits to the seed orchards.

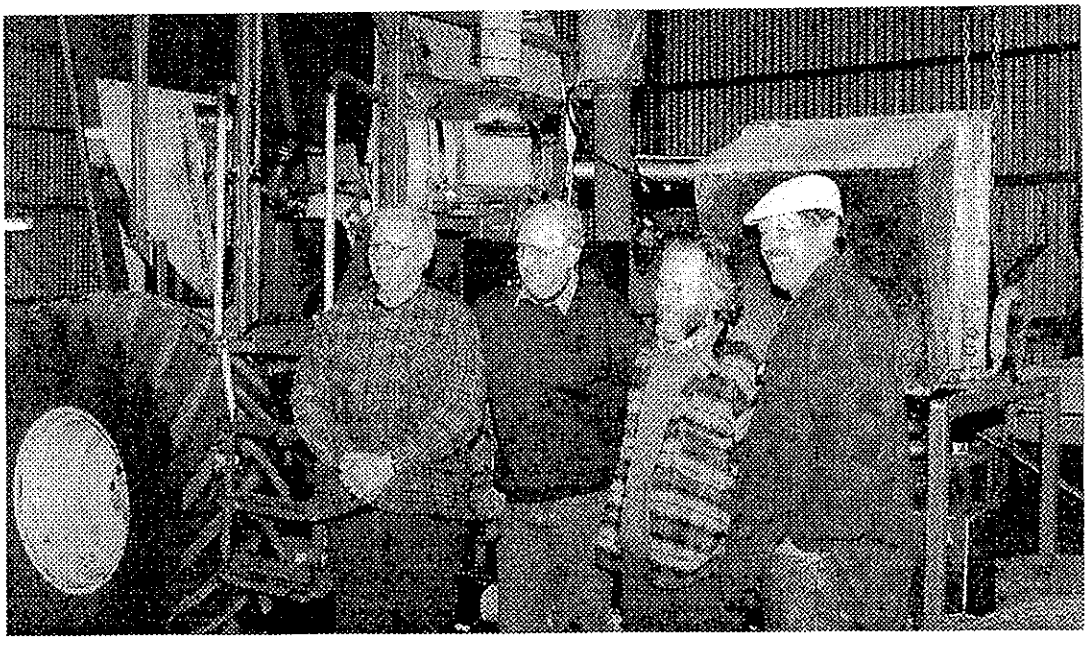
Gary's experience in wood utilisation will also be used by the Busselton and Albany sections of the Farm Forestry Unit. He is assisting in designing a sawmilling and processing studying for 19-year-old Tasmanian blue gum logs and lecturing on the Master Tree Growers Course on sawmilling, seasoning and wood preservation.

Technical Topics

Rick's World

Rick Giles - Dwellingup CALM

I had hoped to be able to report some early harvesting experience for this newsletter, but we are still not in the paddock with the harvester. Work has progressed well but not as quickly as hoped. We intend to have it



Harley Pedrick, Mike Dennett, Rick Giles and Chris Croot in front of the prototype harvester being built at Dumbleyung running in the workshop by the time this newsletter is published.

We are in the final stages of preparing for the inaugural run of the harvester. The saw and chipper assemblies are both built and installed on the front of the harvester. The construction of the saw assembly was comparatively straightforward. The chipper was much more complex to design and construct because of the adjustments built into it to optimise the chipping on the range of mallee species available to us. Harley Pederick has put a lot of effort into the chipper and we are fortunate to have his engineering design and practical skills available for this project.

We are about to upgrade the hydraulic rams for lifting the cutter/chipper head and an accumulator will be added to provide some cushioning for the lifting mechanism. An accumulator is a pressure chamber partially filled with gas connected to the hydraulics and it provides a shock absorbing function. Originally it was intended to use springs to take a lot of the weight off the hydraulic rams, as was done with the cane harvester. However lack of space makes this too difficult and an accumulator will provide greater flexibility for future changes in design.

The bulk of the hydraulic system has been built and we are in the process of dismantling most of it for a thorough cleaning before final re-assembly. The hydraulics have been very challenging and it is a relief to see the system going together at last. The cutter/ chipper head at the front of the harvester raises and lowers and side-shifts to either side. This movement of the head has presented some problems for the hydraulics because the oil flow to the chipper's hydraulic motor is large and requires hoses that are so stiff they can only just be described as flexible. Working with these large hoses in the confined space under the harvester's cab is something of a frustrating experience as each hose appears to have a mind or two of its own.

Instruments for the cab are also near completion. In addition to the gauges for the motor, we have installed two hydraulic oil level indicators, an oil temperature sensor and alarms. The 300 litre hydraulic oil tank is turned over by the oil pumps every 30 seconds. In the event of a hose burst or other major oil leak, the operator may only have 15 to 20 seconds to shut down the machine before the pumps suck air and begin damaging themselves, so we are attempting to provide as much warning in the cab as possible.

Our first paddock trial will involve running the saw through a range of mallee forms and species to observe how they fall off the blade. The blade is almost completely covered so that the teeth are the only moving parts protruding from under the edge of the guard. By observing the movement of the severed mallees, we will have a better idea of how to build the conveyor required to carry the mallees to the chipper. The chipper can also be fed by hand during these early trials to test its operation and try the adjustments to the chipping action required for the different mallee species. The harvester will then be returned to the workshop for construction of the crop lifters in front of the saw and the conveyers to carry the cut stems to the chipper.

I appreciate very much the efforts of Mike Dennett and Harley Pederick during the construction of this machine. Apart from the technical skills they provide, I have found it very helpful, when confronted with some apparently insurmountable hurdle, to be in the company of people who can maintain a sense of humour.

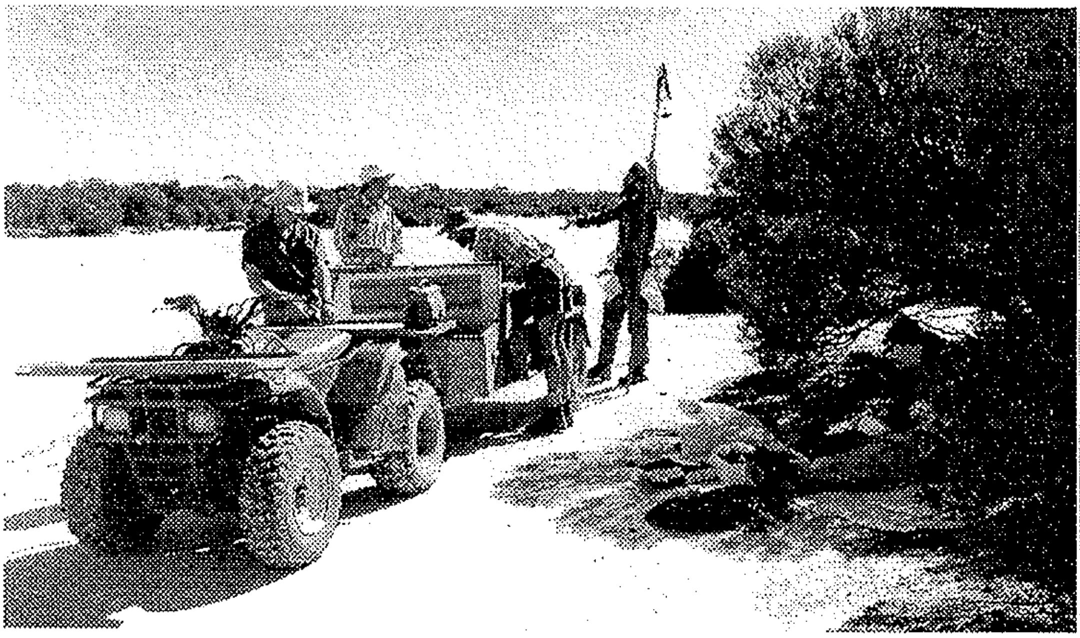
Karen's World

JOURNEY TO THE OTHER SIDE
by Karen Greening

I usually spend my days in a laboratory doing sample preparation and analysis for the Oil Mallee project. So it was a welcome relief when I was given the opportunity to "journey to the other side" and see what exactly goes on in the field.

The trip began at 7.30am on Saturday the 10th with a smiling Wayne O Sullivan and my slightly hung over self heading towards Narrogin. Once there, Wayne took care of matters fauna at the local show while Peter White and myself picked up another vehicle and the all important food!! After a delicious lunch and the arrival of another victim-er-volunteer, we packed the vehicles and headed in separate directions. Wayne and Mark went straight to set up camp while Peter and I went to Woodanilling to leave a vehicle for Wendy Bessell Browne, her son Lee came with us.
A few hours and not too many kamikaze kangas later (fortunately we were unscathed) we found ourselves, seemingly in the middle of nowhere......and rightly so! A couple from Esperance were also there when we arrived and to everyone's delight they had brought with them a telescope. When beds were set up and bellies were filled everyone sat back with their desired beverage and had a peer at the stars I never get to see living in Perth.

Sunday morning was a bit slow on the take off, but after a bit of a look around and some brekky we were off. With the use of two 4 wheeler bikes and trailers attached we headed for the River Lort, there were some very valuable lessons learnt that morning. The first being, how to sit in, and not be



Seed collecting and sampling team on a recent expedition in the south east wheatbelt!

thrown out of the trailer when it goes over a bump. The second, is unless you're NOT in the trailer you are going to be sprayed with what can only be described as "bike poo". The substance to which I refer is the black stinky layer of who knows what, rotting under the first few layers of salt and clay on a salt lake. Another important lesson that day was remember not to launch yourself out of a trailer while it is moving, this however was demonstrated to us by Mark who thought he saw something he liked. At the end of the days seed collecting I was looking forward to a hot meal and bed. Greg and Janet who had helped us for the day packed up their telescope and headed back to Esperance.

The first half of the next day was spent finishing the seed collection. Lee went back to camp to pick up his mother and on the way back it seems, he gave the bike some flying lessons. The afternoon we spent seeking out new populations, I walked for about an hour and a half and a few times was so taken by the silence and scenery I had to remind myself what I was doing. Among all the trees we tagged I managed to locate a somewhat unique spider, so adapt to its environment it was as white as the salt lake and surrounding sand. We tormented the poor thing for a while taking photos and the like and eventually let it have its peace.

From here on in it was sampling all the trees we had tagged the day before, a sizable task. This is the part where my day to day work is involved. I prepare samples, numbered and weighed, for the sampling and when they return with leaf in them I analyse the oil content. A small amount of leaf is taken from the tree, the desired amount is weighed and broken up into small pieces to sit fully immersed in the solvent. Sounds simple enough.... just try doing it when there is a raging wind and not a lot of shelter!!

Each day when we returned there were a few things that needed seeing to immediately, like were did that cask of red go?? After a few days we all got to know each other a bit better and Marks seemingly endless scorpion stories (not to mention other things!!) certainly helped. Working out in the bush is relaxing for me, it's also a great opportunity to gain experience and knowledge, its a lot easier to identify things if you're standing in front of them. OK there is always a down side or two, so here's my opinion..... I cannot hate flies enough, so to quash that torment I was killing march flies and feeding them to the ants. Next is the cold nights, so cold that nearly every morning there was ice on the vehicles and on one or two occasions the moisture on the tarp above our beds was frozen. To remedy that I was sleeping in four layers of clothes, next time I will take a blanket or seven!! The only other downside is that I was the tick bait for the trip.

Back to Narrogin on Thursday, a grueling 7 hour drive towing a rather heavy load but a hot shower and comfortable bed was all the encouragement I needed. After I washed all the salt, mud, sand, ticks, sticks, toothpaste and suncream out of my hair I found my hat no longer fit!

All in all it was a very productive and enjoyable 6 days I will definitely do it again when the time permits.

Wayne's World

Wayne O'Sullivan - Oil Mallee co-ordinator

THE ROADSHOW

The roadshow has been in full swing over the last few months. The presentation usually runs for around two hours with time for questions. This time goes very quickly (for the presenters at least!) and soon makes you aware of how much information we have to present.

It is difficult in a single session to give people all the information they need to make a decision about becoming involved in the industry. For this reason revisiting the established areas and presenting an industry update is still very important. Existing growers have been particularly responsive to the new economic data, where we can show that planting oil mallees is a potential opportunity to diversify income without a proportionate increase in workload. It also helps growers see the amount of work that is required to get this new industry across the line.

The roadshow has been busy in new areas, those outside existing planting areas. There has been a variable attendance at these shows from a handful to a few dozen people. Often the roadshow meetings have been followed up by groups of farmers travelling to look at trees in the ground, have a tour with the Regional Manager and meet existing growers. Feedback has been good and after this next planting season there will be few gaping holes in the continuity of plantings across the Wheatbelt. Farmers seem to like the notion of having potentially commercial local species of trees available, despite the reluctance of the funding authorities to support us.

The down side of the roadshow is the amount of time it has taken up in travel, preparation and presentation. Next year we may try a series of well publicized bigger meetings in the established areas, rather than trying to respond to all the calls at catchment group or LCDC level.

Whatever the audience, we are presenting a good news story in sometimes bleak times. The association's role is to grow good trees, and above all growers must remember that success is based on good healthy trees in big numbers with a high survival count. On the farm it is a false economy to be looking to save money on site preparation. Whether the aim be the financial or landcare benefits, it is best addressed by high survival rate and healthy trees.

AgWA Revegetation kit

Colin Holt from the Revegetation on Farms group from the Narrogin office of Agriculture WA has compiled an information kit on oil mallees. This is at the printers now and the first edition will be issued to Land Care Co-ordinators, CALM and AgWA revegetation advisors and offices. The kit will be a saleable item, available from AgWA and through the OMA office and Managers. The kit will join earlier publications by this group on crops such as olives, jojoba and sandalwood, and should significantly raise the profile of oil mallees in the agricultural region.

New research projects

A couple of new projects are underway. David Hall and Rob Sudmeyer from Agriculture Western Australia are commencing a tree-crop interaction study using oil mallees in the Esperance region. This a GRDC funded project over five years. We will present the outline of this work in a later Dinkum Oil.

The other new study is being undertaken by Masters student Don Cooper at UWA, looking at the economics of fuelling a biomass energy power station for the Wheatbelt on oil mallee residues. This is an exciting development in the use of the woody component of our harvest. Don is doing a very thorough job of examining the sensitivities of a huge range of variables that can impact on the bottom line of this venture. Again, we will bring you a summary of this work in a later Dinkum Oil.

Seed for the 1999 planting season

The seed collection work is ongoing. Some material is being harvested from the seed orchards, not enough yet to impact on our search in the wild for good trees for our bulk lines. This work will continue for some time to come as we will always be looking for the best species to suit the new areas coming aboard, as well as fine tuning the selection for different soils and regions. A meeting is scheduled with CALM for December to discuss the status of the seed collection program and the development of the seed orchards.

EDITORS NOTES ....

I would like to acknowledge and thank Elaine Hudson from Kalannie for her amazing dedication and effort as being the Dinkum Oil's first Editor. Elaine collated and edited articles for this important information link for three years. It is an honour to follow in her footsteps as the present Editor.

Thank you to all those who did get their articles to me on time in the appropriate format. It is difficult to collate articles which arrive late or on the "death knock" which are hand written or faxed to either Glenda Godfrey or I. **Please, please** present your articles on a disc in plenty of time. Faxed or hand written articles do need somebody to type them and its just another job to do for either myself or Glenda .

I would appreciate articles to be posted to me **by FEBRUARY 1ST** for the next edition of Dinkum Oil. Alternatively please email them to Glenda at Farm Forestry Unit on glendag@calm.wa.gov.au. and then please post or fax me a copy **as well**. All photos are to be posted to me or to Glenda.

The deadline date above is exactly that...... **the DEADLINE**.........please get your articles in before that date. Articles arriving after the deadline date will not be included in the next edition.

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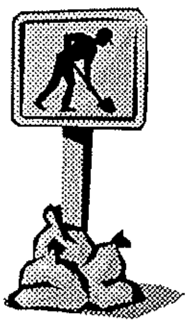
EDITOR



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