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Development of mallee as a large-scale crop for the wheatbelt of WA

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Introduction

The development of mallee as a large-scale crop for the WA wheatbelt has now advanced to the stage of operational testing of new processing technologies. Western Power Corporation (WPC) has commenced construction of a $6 million demonstration scale facility (20 000 tonnes mallee biomass/year) at Narrogin, 200 km south east of Perth, to test the 'integrated processing' concept. This venture is underpinned by a feasibility study (Enecon 2001) that indicates that integrated processing, the concurrent production of three products (eucalyptus oil, activated carbon and electricity), should be commercially viable. The study showed that the venture could sell products at prices that would open large market volume and strong revenues as well as pay growers a price for mallee feedstock competitive with their other land-use options. Using cautious assumptions of market prospects it was estimated that some 9 full-scale plants (100 000 tonnes/year) could be constructed in the WA wheatbelt (Chegwidden *et al.* 2000).

The Narrogin integrated mallee processing demonstration is the culmination of a decades work in the development of mallee as a crop. This work was carefully planned and involved contributions from many sources. The aim of this paper is to overview the development of mallee and to indicate the major strategic decisions that have underpinned the progress of this development to date.

Historical overview

Mallee eucalypts have been harvested for eucalyptus oil production for more than 100 years. Boland et al (1991) and Davis (2002) review this traditional Australian industry. Production from native stands and more recently from planted stands continues in two areas, i.e. near West Wyalong in New South Wales and Bendigo in Victoria. In the post war period oil from Australian operations became less competitive in world markets, production receded to the high quality end of the market and local producers became specialists in purification, blending and import/re-export of oil. The West Australian work has drawn heavily on the accumulated experience of this industry. Several collections of their major mallee species, *Eucalyptus polybractea*, have been undertaken and incorporated into breeding and operational planting programs in WA (Bartle et al. 1999).

The first significant work on eucalyptus oil in WA was mainly from the products perspective and undertaken in the 1980s by Associate Professor Allan Barton of Murdoch University. He saw cineole, the major constituent of eucalyptus oil, as having chemical properties with undeveloped potential for large volume industrial products. In particular, he identified commercial and industrial solvents (Barton and Knight 1997) and stabilization of petrol/ethanol fuel blends (Barton and Tjandra 1988, 1989) as potential uses for cineole. He helped develop an efficient, small-sample analytical technique for the determination of the cineole concentration of mallee leaves

(Ammon et al. 1985 a,b). This facilitated large-scale screening of native mallee populations for efficient selection of superior oil producing individuals. Along with others he applied this to explore leaf cineole variation, genetics and taxonomy within some species (Barton et al. 1991; Brooker et al. 1988). Barton established small field testing plots at several wheatbelt locations during the period 1985-88. In the late 1980s he established a private company, Botanical Resources Limited, with a view to further commercial development of oil mallees.

The WA Department of Agriculture (DoA) was an active participant in mallee development in the late 1980s and organized a national seminar in 1989 (WA Department of Agriculture 1989).

Another major driving force for development of tree crops has been the problem of salinity. During the 1970s the State commenced major intervention in water supply catchments that were becoming salt affected. Five major catchments (two then already harnessed for water supply) were considered recoverable. Actions included acceleration in R&D, withdrawal of the right to clear land for agriculture, arrangements for acquisition of land and reforestation.

The largest of these resources, the Wellington catchment, supplies water for irrigation and formerly supplied water for domestic use across the great southern agricultural region. Mainly in the post-war period clearing had converted 23% of this catchment to farmland and this was enough to generate a rapidly rising trend in stream salinity (Scholfield et al. 1986). Control of this problem through reforestation was clearly a major option but one that would be much less difficult if the new forests or tree crops could be a commercially viable use of the land.

This was the main motivation behind the WA Department of Conservation and Land Management (CALM) when in the late 1980s they instigated development of bluegum (*Eucalyptus globulus*) as a commercial industry in the greater than 600 mm rainfall zone of the lower south west of WA (Shea and Hewitt 1990; Bartle 1991). By the early 1990s it was clear that the bluegum industry was commercially viable and would continue to develop in the open market. CALM was free to apply its state-funded, natural resource protection capacity to another target. The obvious target was a commercially viable woody crop for the extensive low rainfall (<500 mm/year) wheatbelt region where potential damage to natural resources and infrastructure from salinity is greatest.

CALM spent the period from 1992-94 evaluating tree crop prospects (Bartle and Reeves 1992; Bartle 1993). The work on oil mallee products done by Barton in the 1980s had not sparked any planting or industry development activity. However, the salinity control potential of mallee, its long history of commercial utilization and Barton's groundwork made it the best prospect for development as a low rainfall crop. CALM decided to put its investment capacity behind commercial development of mallee. CALM assembled all parties interested in furthering mallee development including farmer representatives, the Barton/Murdoch group and DoA. This group prepared a pre-feasibility review that indicated sufficient promise to proceed with further development (Bartle *et al.* 1994, unpublished internal report).

Resource establishment commenced in 1994 at 6 regional centers selected to represent the full range of wheatbelt conditions from the northern wheatbelt to the southeast. CALM provided or attracted the financial resources to cover development costs and provided the leadership and administrative capacity. Six million mallees were planted during the period 1994 to 1996 and a large contingent of committed growers emerged. In 1995 growers formed an incorporated industry association, the Oil Mallee Association (OMA) and assumed control of development in 1997. In 1997 with the promise of commercial operations on the horizon OMA formed the Oil Mallee Company (OMC, ACN 079 355 445). OMA investigated alternative commercial structures including a cooperative. A company was chosen because it was perceived to be more attractive to capital investment and to be more responsive in decision-making. The OMA retains control of general industry interests including publicity and promotion and is a 20% shareholder in OMC. In 1998 OMC was able to attract support from Western Power Corporation and the Rural Industries R&D Corporation to conduct investigation of the feasibility of mallee processing. Up to the winter of 2001 some 900 growers had planted 21 million mallees (Table 1).

Table 2: Mallee planting statistics 1994 to 2001

P year	No. planted (10^6)	No. growers	Area planted (ha)
1994	1.10	80	412
1995	2.05	170	769
1996	2.80	250	1050
1997	1.05	100	394
1998	2.00	200	750
1999	2.85	273	1069
2000	4.72	429	1770
2001	3.65	370	1369
TOTAL	**20.22**	**900[1]**	**7583**

1. Many growers have planted over more than one year hence total is not the column total.

Reviews of the development of mallee are available from Barton (2000) and Bartle (2001).

Why is CALM involved in commercial development?

CALM's commitment to mallee development was primarily based on the dire prognosis for biodiversity arising from salinity in the wheatbelt. In particular, the prediction that the potential extent of salinity would encompass the entire valley floor component of wheatbelt landscapes or some 30% of all farm land (George *et al.* 1999) means that entire communities of the remaining wheatbelt valley floor biota, including many hundreds of endemic species, are at risk of extinction.

Over the past decade there have been many investigations of the salinity issue in WA. The two most recent and most substantial are the Salinity Taskforce Report (2001) and the Review of CALM's Programs under the 1996 Salinity Action Plan (Wallace, 2001). A consistent finding in all such reports is that the State must develop commercial perennial crops for agriculture to be able to moderate the salinity problem. These reports indicate that commercial perennial crops will be the only effective means to reduce groundwater recharge on the necessary scale.

Although, recharge reduction is a preventative treatment, its response time is slow and it must be complemented by more rapidly acting ameliorative treatments on discharge areas. These treatments include subsurface drainage and groundwater pumping (including safe disposal of saline water) but they are expensive to install and maintain. They are especially necessary where there is major impending loss of key infrastructure or natural resources such as towns, biodiversity hot spots and water resources. Long-term solutions will consist of both recharge and discharge control components: recharge control to mininise the amount of discharge, which in turn will make discharge control (to mop up the surplus) more feasible.

Mallee development – a model for new woody crop industries?

CALM's investment in mallee industry development since 1993 exceeds $6 million. This commitment was based on a recognition that in the absence of any existing commercial wheatbelt crop a substantial effort was required to create one. CALM has also helped gain financial support totaling some $3 million from other State and Commonwealth programs on behalf of OMA/OMC. However, the majority of the investment (in excess of $10 million) has come from growers who received only modest financial assistance in planting some 21 million mallees.

This investment has required strategic decisions about fundamental aspects of industry design - how the ideal new woody crop industry might be developed, owned and operated. This section reviews the major strategies that have been applied. Given the need for many more large-scale woody crop industries there is potential for wider application of these strategies.

1. The conceptual plan

Mallee development has been conducted within the planning framework shown in Fig 1. This provided the conceptual basis to guide coherent mallee industry development. While the first two stages, search and pre-feasibility investigation, are self-explanatory the third stage, 'industry exploration', requires some elaboration. The title was selected to deliberately highlight the speculative, pre-commercial character of this activity. The objective was to create the conditions to make the mallee prospect attractive for commercial investment, and for this to emerge through stage 4, feasibility investigation. The final stages of implementation and adoption would then become routine commercial operations.

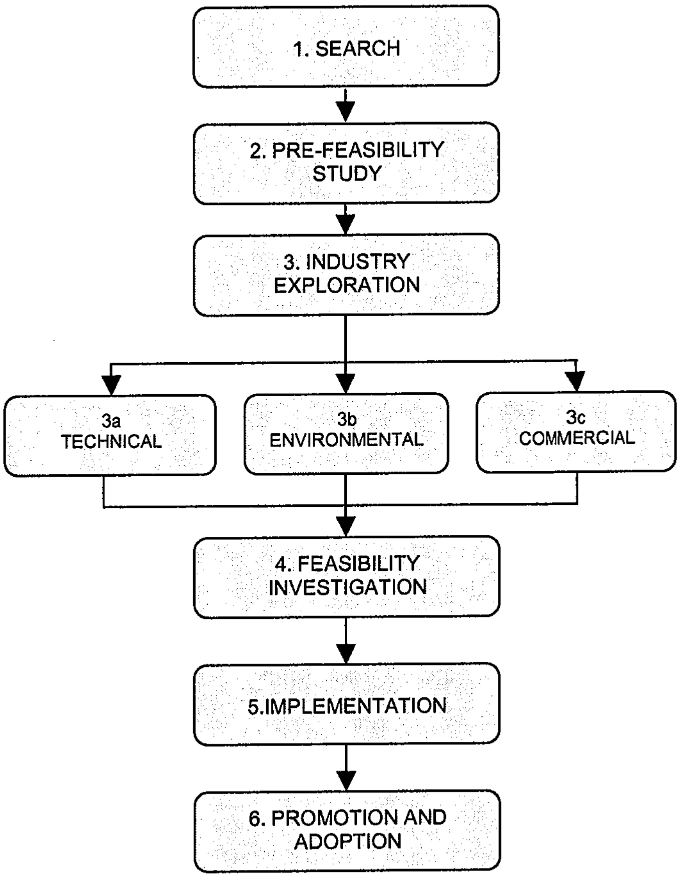
Industry exploration consists of the range of activities necessary to build a whole industry foundation from which commercial operations might arise. It provided every WA wheatbelt farmer with the option to participate in planting mallee, attend regional and state industry forums, take an active role in decision-making and to invest in industry R&D and infrastructure. This stage took several years and involved at least some consideration of virtually every conceivable aspect of mallee production, harvest, processing, products and markets. Given the limited resources close coordination of activities and continual revision of priorities was undertaken to ensure that at any time all the most critical aspects were receiving attention.

The activities can be divided into three categories:

- Technical development ranged from long term projects and publishable R&D, to on-the-spot assessment, trial and error, informed guesses and included:
  - species selection, seed production and genetics
  - crop establishment and management practices

- ➢ creation of harvest and handling technologies
- ➢ processing technology
- ➢ product science
- ➢ marketing.

Figure 1: Industry development framework



- Environmental design and management: involved the design of systems of mallee planting that could also capture collateral benefits in natural resources management and included:
  - ➢ designs to ensure efficient integration of mallee crops into agricultural systems
  - ➢ carbon sequestration
  - ➢ designs to protect biodiversity
  - ➢ use of a wide range of species
  - ➢ a preference for native species

- Commercial development included:
  - ➢ formation of a single united grower association with equity in the industry
  - ➢ building proto-commercial structures with strong grower equity
  - ➢ development of legal instruments to facilitate investment on mallee

- economic and financial analysis
- establishing sufficient resource to attract commercial interest
- product and market reconnaissance

2. Assured 'pre-commercial' investment

The absence of woody crops in the wheatbelt might be taken to indicate that no such crop could ever be commercially viable. Alternatively, it could indicate that the risk and uncertainty of new large-scale woody crop development presents an insurmountable barrier to even the most venturesome entrepreneur. Mallee industry development was predicated on the latter assumption. The working hypothesis was that with sufficient start-up investment a commercially viable industry could be created. However, the speculative nature of the investment and the fact that a significant proportion of the expected return was public benefit, dictated that the investment should come from the public sector.

CALM chose to make this 'pre-commercial' investment. Other state and commonwealth government agencies, the Rural Industries R&D Corporation and dedicated students undertaking university projects also made an important contribution. Farmers who were prepared to meet most of the cost of establishing the mallee resource without any assurance that it would prove to be commercially viable, were also crucial.

However, the investment of CALM resources and capital was substantial, continuous and adaptable to short-term emergency. It had a whole industry development focus and integrated the other disparate investments. It built the confidence that something could be achieved. It is difficult to see how new industries based on woody crops in the wheatbelt can emerge without being underwritten by this sort of investment.

3. Woody crop integration

The development of mallee production systems anticipated that it would need to be integrated with conventional agricultural practice to achieve best performance. For this reason there has been a strong preference for using mallee in belt or alley farming systems and much of the planting has been in belt form on cropping land. The common current layout is for belts to be 10m wide with a 100m interval or 'alley' between belts.

Yield from long-term woody crops in plantation form in the wheatbelt will be low. The likely yield in such plantations can be estimated by extrapolation of bluegum and pine rainfall-yield relationships developed in higher rainfall areas (McGrath *et al.*, these proceedings). These estimates show whole biomass yields of about 10 green tonnes/ha/year for 350 mm rainfall and 2100 mm pan evaporation (typical of the north eastern wheatbelt).

In plantation form the woody crop will ultimately have only rainfall as its water source. A woody crop dispersed in belts or alley farming systems has the potential to capture water in addition to the rainfall that falls on the belt area. The extra water comes from lateral roots occupying the immediately adjacent annual crop land (called the competition zone) and from inflow of surface run-off, and subsurface perched or deep groundwater flow, into the root zone of the belt.

These sources of water contribute to the high yields of mallee observed in belt planting, i.e. up to 30 green tonnes/ha/year (McCarthy, pers com). Note that this yield estimate is taken from belts younger than 7 years old and will reflect utilization of stored water present prior to planting. Robinson *et al.* (2002) present data that show the considerable lateral and vertical extent of depletion of stored water by mallee belts. The influence of this transient water source needs to be excluded to estimate sustainable yields. This will require detailed long-term work. On sloping 'light land' soils with less than 15% of total coverage of mallee belts it is expected that the depth of depletion of stored water and groundwater will generate water deficits and hydraulic potentials and lateral flows large enough to maintain yield potential. This can be reasonably inferred from the work of White *et al.* 2001.

However this is only one of the issues that require resolution to assess the full cost/benefit of belt planting. Fortunately, a theoretical framework within which to analyze the interactions between belts and adjacent crop or pasture is now available (Stirzaker *et al.* 2002). The major issues are:

- the balance of reduced annual crop yield in the competition zone and its enhancement beyond that zone, expressed as an equivalent 'no yield' zone
- benefit of wind break protection on erosion control and other aspects of farm management
- water use of the belt expressed as an equivalent 'no-leakage' zone
- relative size of the no-yield and no-leakage zones
- variation in the no-yield and no-leakage zones with soil and site type
- opportunity to manipulate belt and alley width to optimise yield and leakage zones
- opportunity to manipulate yield zone width by root pruning
- impact of season and frequency of harvest on yield and leakage zones

Even with the limited present data it can be said that it unlikely that mallee plantation yield will be commercially viable. In contrast belt yield is promising. However, the discussion above indicates that optimization of mallee performance will require belts to be managed as an integral component of a complex agricultural system. The research required to develop this capability has commenced (Wildy and Pate 2002), and more is planned by the Salinity CRC and the Joint Venture Agroforestry Program (JVAP).

4. Farmer ownership

The previous section showed that the challenge of achieving efficient integration, and therefore more competitive mallee performance, will require active participation by the farmers who are responsible for the conventional annual plant agriculture in the alley between the mallee belts.

There are other pressing reasons why farmers need to be actively committed to mallee crop management. The dispersal of belts, currently commonly in 10m wide belts on 100m interval, exposes the mallee to potentially adverse impacts from herbicide and other farm chemical application, grazing, and fire (stubble burns or wildfire) conducted in the alley. Mallee harvest will need to be an all-year-round activity and will require careful management to avoid damage to soils and crops during winter.

These factors make it prudent to plan for a significant share of ownership by the farmer in the mallee component of integrated systems. This is reflected in the structure of mallee industry development. Growers keenly sought corporate control of the mallee production.

Such control also built grower confidence that they could deal in the industry 'beyond the farm gate' and this fed back into ambitious design of integrated systems and commitment to industry development. It has also facilitated efficient dealing in the development of harvest and processing aspects of the industry.

Rapid adoption of large scale planting will be necessary once commercial operations emerge. Farmer confidence in the industry will then be especially important. Even so it is unlikely that farmers will be able to finance planting on the necessary scale and complete it over the rotation period necessary to generate a sustainable flow of resource to any particular processing plant. At this stage off-farm investment in planting may be necessary. OMA/OMC recognize the imperative for them to achieve the level of commercial maturity necessary to facilitate this transition to full commercial operations based on integrated planting. Legal arrangements for effective sharing of ownership of mallee plantings will be essential and they have invested heavily in this area.

CALM and other public sources made substantial investment in many aspects of mallee industry development. However, the major contribution has been by farmers who have embraced planting mallee on a scale large enough to create a commercially attractive prospect. In the process they committed more investment than all other parties combined. CALM has fostered an environment of open collaboration and participation for all aspiring mallee growers, shared endeavour and shared outcomes, to create the mallee industry. Arrangements for access to and sharing of intellectual property (IP) are developing. The industry requires access to IP as part of its capital base, credibility and security, all potent factors in the establishment of a new business. CALM must also manage IP prudently as security for the State's investment and as a source of revenue to fund on-going R&D.

5. Scale in production, processing and markets

The extent of woody perennial cover required to control salinity is probably in excess of 20% of all agricultural land and may be as much as 40%. This assumes that there will also be extensive use of herbaceous perennials and engineering treatments on discharge areas. This amount of woody perennials will generate a very large volume of biomass, which in turn will require very large volume markets to minimize risk of oversupply. Mallee development has aimed not to be a victim of small thinking on this score! New mallee crop based industries set out to deal in large volume commodities at world competitive prices to provide the base load of perennial plant cover in the wheatbelt.

The need for market scale and the potential for products from mallee has been presented elsewhere (Bartle, 1999, 2001). The rationale for large-scale production has several other aspects. Australian wheatbelt farmers are world leaders in the production of low cost bulk commodities. It makes sense to apply this competitive advantage to large new sustainable industries. Large volume and scale operations mean economies of scale in production systems that will enable the industry to reduce costs and to develop previously inaccessible industrial markets for its products.

This focus on scale explains the reason why mallee growers in WA now have what may be the largest substantially untapped, high quality eucalyptus oil resource in the world. The present potential yield is well in excess of 1000 tonnes/year, or more than 30% of present world consumption. To tap the resource in the short term would require use of costly, small scale harvest, handling and extraction systems (large scale integrated production/processing systems are still under development) and would need selling prices at present world market levels to be commercially viable. Yet the volume that could be produced, while trivial in relation to salinity control, would be enough to cause oversupply in the existing market. The industry's approach to this conundrum is to reduce the cost of production using new technologies, produce at globally competitive prices and create new much larger volume markets. The integrated mallee processing feasibility investigation (Enecon 2001) shows that eucalyptus oil production would be viable at well below current world prices.

However, in this process eucalyptus oil is simply a by-product of mallee. Large-scale viability will also require commercial use of mallee wood and residues. The only markets able to absorb the potential scale of production are the world wood products (panels and paper) and domestic energy markets. Bartle (2001) forecast that extensive salinity control in the wheatbelt would not be achieved without very large-scale penetration of electricity and transport fuel markets.

We are unlikely to achieve sufficient scale in new perennial crop industries unless we also scale-up our thinking.

Conclusions

After more than a century of small-scale productive use and large-scale eradication for agriculture, mallee eucalypts have in the last decade made it to the brink of recognition as a large-scale wheatbelt crop. This arose from a combination of serious public spirited institutional entrepreneurship and the determination of many hundreds of WA farmers to find a way to make sustainable agriculture also be commercially viable. The decisions taken and lessons learned in this development could be extended to other woody crop species and to other locations.

There is an exploration stage to new woody crop development that ranges from specialist R&D to practical evolution of technique across the full spectrum from genetics to new products and markets. Its internal rate of return cannot be calculated and it is hard to anticipate how long it will take. It is pre-commercial but imperative and unless there is some patient money around it won't happen. The woody crop must evolve as an integral component of a complex agricultural system. This in turn demands that the farmer have a strong if not dominant say in the management of the woody crop. The best way for this to happen is through ownership or part ownership of the crop and for the owners of the resource to cooperate to instigate downstream processing. It is clear that where the underlying objective is to improve the sustainability of agriculture then new crop development is dealing with salinity, very large scale change and bulk commodity products.

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