

# Potential for Carbon Sequestration and Product Displacement with Oil Mallees

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Oil Mallees - Profitable Landcare  
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## Introduction

Carbon stored in organic matter constitutes one of the world's major carbon pools. Large scale reforestation to form an additional biosphere sink to compensate for input into the atmosphere by the burning of fossil fuels was proposed two decades ago (Breuer 1979). It has been estimated that up to 500 million hectares of tree plantations would be required to absorb the estimated annual increment of 2.9 billion tonnes of carbon (Sedjo 1989) emitted into the atmosphere. Oil mallee plantings offer enormous potential for carbon sequestration (Shea *et al.* 1998).

Oil mallee species formed part of the original native vegetation of the wheatbelt. They are now largely confined to small remnant populations. Several mallee species with high leaf oil content have been identified as a potential short rotation tree crop producing eucalyptus oil within the Wheatbelt. A range of species has been selected to cover most Wheatbelt soils and climate. The oil has many traditional uses, but more importantly eucalyptus oil has been shown to be an excellent natural solvent that could be developed for large-scale industrial use (Barton and Knight 1997). In addition to their commercial potential oil mallees are an excellent general farm tree contributing to landcare and biodiversity.

## The Kyoto Protocol

As one of the Parties to the Climate Change Convention, Australia has made a commitment to limit emissions of greenhouse gases in response to the threat of global warming. As a consequence of the Kyoto negotiations Australia has been allocated an emission allowance of 108% of its 1990 (the base year) emissions. If it is assumed that the level of emissions in 1990 approximated the equivalent of 500 million tonnes of carbon dioxide then Australia is allowed a growth of emissions by the year 2010 of approximately 40 million tonnes. Even though Australia was able to negotiate a position which was significantly better than other countries (some countries such as Japan are required to reduce their emissions by 10%) the emission target will be difficult to achieve. For example, it is estimated that if proposed resource projects proceed in Western Australia their net total emissions will be approximately 40 million tonnes of carbon dioxide.

The primary sources of greenhouse gases are from industrial processes that consume fossil fuels and the removal of woody perennial vegetation for agricultural pursuits. Generating carbon sinks through carbon sequestration is a real option in which organisations or nations can adopt to achieve net reductions in greenhouse gas emissions. The Kyoto Protocol recognised that carbon sinks could be used to offset emissions. Under the Kyoto Protocol sinks are defined in article 3.3 - *"... resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period..."*. It is however widely acknowledged that considerable uncertainty exists on the rules governing carbon sequestration. For example, the precise meanings of afforestation, reforestation and deforestation are the subject of discussion and analysis through the IPCC, and will be negotiated between countries under the Framework Convention on Climate Change. The likely outcome of these negotiations is unclear.

Despite this uncertainty, the proposed international rules for the first commitment period (2008-2012) suggest that the amount of carbon sequestered by trees will be determined by measuring the total carbon stocks in tree plantations established from 1990. The contribution of carbon sinks will be measured by calculating the carbon stored in vegetation established since 1990 in the year 2008 and subtracting that sink from the amount of carbon stored in 2012 and dividing by five. The average carbon sequestered during the first commitment period (2008 to 2012) can be used to offset against greenhouse gas emissions. It is also widely recognised that there will be subsequent commitment periods.

The recognition that wood products make a contribution to reducing net carbon dioxide emissions within the Kyoto framework, either directly by storing carbon or indirectly by replacing materials that result in high CO<sub>2</sub> emissions, substantially increases the carbon sequestration potential of oil mallees.

The mechanism in which wood products displace the consumption of fossil fuels is two-fold. Firstly, wood products may replace fossil fuels that have been traditionally used for energy production, secondly, by replacing materials that requires high energy levels to manufacture. The carbon displaced via this mechanism is a permanent contribution to CO<sub>2</sub> emission reduction.

## Collateral Benefits of Tree Crops for Carbon Sequestration

The threat of land degradation, especially salinity, is the major motivation for revegetation in the dryer agricultural zone (i.e. less than 600 mm rainfall). The problem of salinity causes much more than the loss of productive agricultural land on the farm. The whole drainage system is degraded, including rivers, wetlands, water resources and biodiversity of native ecosystems retained on the valley floor. Infrastructure suffers chronic damage due to saturated foundations, but more significantly the risk of severe flood occurrences is greatly increased.

Salinity is rapidly expanding. Partial revegetation with perennial plants, including trees, is the most effective way to bring land degradation under control. At present some nine per cent of the 18 million hectares of agricultural land WA is salt affected and this is projected to expand to 32 per cent with four or five decades.

The State Salinity Action Plan calls for some three million hectares of revegetation over the next 30 years. Landowners recognize the desirability of revegetation and participate in State and Commonwealth Government programs to stimulate landcare activities. However, there is now a strongly emerging recognition that the scale and urgency of revegetation is beyond that which can be supported by Government programs or be financed from farm profits. Farmers are therefore seeking commercial species and carbon credits to help drive revegetation on the necessary scale.

## Oil Mallees as a Carbon Sink Option in Western Australia

More than 10 million hectares is situated within the low rainfall agricultural zone (250-400 mm) (Agriculture Western Australia *et. al.*, 1996). Presently, oil mallees have the greatest potential for reforestation within this low rainfall zone due to the limited range of other commercial perennial species.

CALM in partnership with the OMA established six regional growing centres (Canna, Kalannie, Narrogin-Wickepin, Naremben, Woodanilling and Esperance) to facilitate the planting of the target 30 million trees. Currently there are 12 species of oil mallee being planted throughout the state, of which 11 are native to Western Australia. To date, more than nine million oil mallees have been established.

## Growth and Carbon Modelling

Oil mallees, as a survival mechanism regenerate from epicormic buds on the lignotuber. Several species of eucalypts have evolved with this regenerative strategy to survive the dry semi-arid environment which was frequently exposed to the periodic disturbance of fires (James, 1984). The comparative advantage of oil mallees for carbon sequestration is their ability to be continually harvested whilst retaining large quantities of stored carbon. The lignotuber contains a large storage of carbon, which is readily mobilised to promote rapid coppice growth. The above ground biomass can be potentially harvested every two years and the below ground organs will continue to grow. In Victoria, oil mallees have been harvested for almost 100 years, with continual regeneration from the same lignotuber (Noble, 1989).

In Western Australia, four-year old *E. plenissima* contained 2.2 tonnes of carbon, within its root system, for every kilometre of hedge, where one kilometre of hedge is equal to one hectare (Figure 1). The amount of stored carbon in these plantings increased by about 1 tonne per year until age six (McCarthy 1998). Harvesting of 2.5 year old *E. plenissima* does not significantly influence the size of the below ground components compared to unharvested trees (McCarthy 1998).

The proposed harvesting regime for oil mallees involves a first harvest four years after planting. Following harvesting the below ground carbon sink increases by 2.1 tonnes per kilometre of hedge every two years. Therefore, over a 30-year period (assuming 14 harvests) more than 28.8 tonnes will accumulate within the lignotuber for every kilometre of hedge (McCarthy 1998).

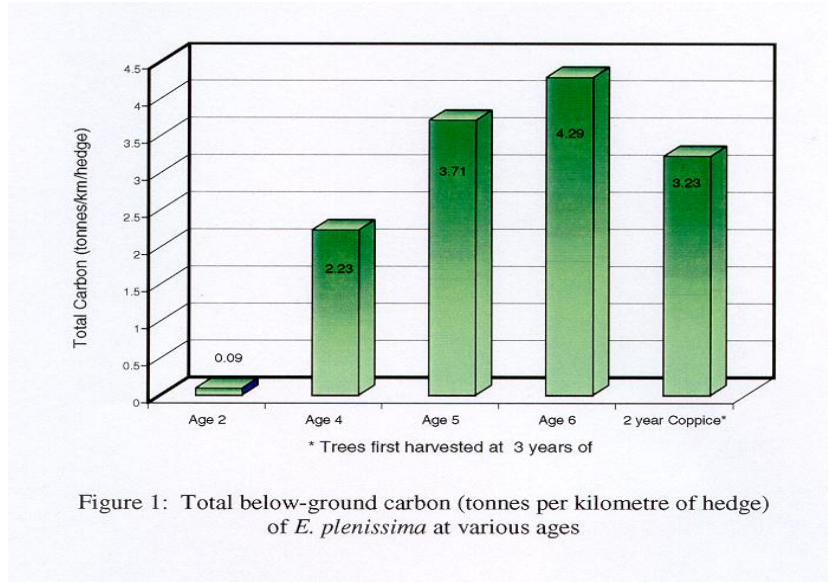


Figure 1: Total below-ground carbon (tonnes per kilometre of hedge) of *E. plenissima* at various ages

## Product Displacement and Biomass Fuels

Oil mallee residues may be used as fuel for energy generation. Such renewable fuels make no net contribution to CO<sub>2</sub> emissions but meet a demand for energy that might otherwise draw on fossil fuels. In Western Australia there is scope to use biomass to avoid emissions from coal and diesel fuel generators. New wood gasification technologies have made electricity production using wood biomass more cost effective. The economics of utilising biomass fuels becomes even more viable when their use is integrated into the production of other wood products. Four-year old *E. plenissima* contained approximately 4.0 tonnes of wood carbon per kilometre of hedge and 2-year old coppice contained 3.11 tonnes of wood carbon per kilometre of hedge (McCarthy 1998). Similarly, after 30- years, assuming 14 harvests the above-ground components 44 tonnes of wood carbon would have sequestered per kilometre of hedge. CALM in conjunction with Western Power and Enecon are undertaking a feasibility study for an Integrated Mallee Processing Plant. This plant would combine oil extraction; power generation and activated carbon production all feed by oil mallee eucalypts.

## Methodologies for Monitoring Carbon Sinks

Three separate stages are identified to establish sequestration projects. Firstly, forecasting and estimating the carbon sink potential of the project is required. This means predicting the amount of carbon likely to be sequestered. The second stage is to monitor over time the actual carbon sequestered within the sink. This means assessing the amount of carbon actually sequestered. The third stage involves verification of the project and the carbon sink. This process performed by an independent certifier. This requires determining that the claimed amount of carbon sequestered has actually occurred (ACCM 199). Generally, the more intensive the measurement and monitoring of carbon sinks, the more expensive it is to undertake the assessment of the carbon sink. The cost and logistics of measurement, monitoring and verification mechanisms for carbon sink projects is likely to be prohibitive and may render small woodlots/projects nonviable. In this respect, CALM offers oil mallee growers the economies of scale to coordinate the three stages of carbon sequestration accounting.

## Development of Allometric Models to Determine Carbon Storage

It is the responsibility carbon sequestration manager to specify methodologies chosen for measurement. These should be appropriate to the scale and nature of their vegetation sinks project. As it is impractical to directly measure every tree for the purpose of determining carbon sequestered in vegetation management projects. Therefore, it will usually be necessary to use sampling techniques and statistical tools to provide measurements of carbon sequestration (ACCM 1998). These include the development of reliable allometric equations. Allometric equations relate tree diameter and height to total biomass. These equations can only be constructed from data obtained by detailed sampling of representative trees. Developing allometric equations for total wood biomass and carbon also requires sampling for root mass. This involves separating the roots from soil, which is a resource intensive operation. For example, to achieve reliable and consistent results it is recommended that fine roots, those less than 2 mm, are not included in root samples as the bulk of root mass is in larger roots (ACCM 1998). This requires careful screening and fine root material extraction. CALM is already developing an oil mallee yield model. This model will estimate the volume of sequestered carbon in all present and future oil mallee plantings.

## Components of Monitoring the Extent of Carbon Storage

Monitoring refers to regular inspection of the project site, as well as actual measurement of carbon sequestration (ACCM 1998). Measurement of carbon pools will need to be performed on a regular basis. In particular, at the beginning and end of the project, and re-calculations performed after harvests, fire or other significant site disturbances. Another approach to monitoring carbon pools may be to measure the woodlots annually. CALM has the expertise, within its Forest Management Branch, to undertake regular inventories of plantings to determine the amount of stored carbon.

CALM also has the ability to monitor changes in the product pool by directly supervising production and retaining sales records of products from the stand.

## Verification of Stored

Verification will be performed by an independent third party. CALM could liaise with the third parties to ensure the quantity of stored carbon is verified and coordinate the verification process.

## Conclusion

Several mallee species with high leaf oil content have potential as short rotation tree crops producing eucalyptus oil. Coupled with the economic benefits from oil production oil mallees are also excellent general farm trees contributing to landcare and biodiversity. Preliminary data on growth and biomass production, from oil mallees planted in twin row hedges, has now been collected. The typical proposed rotation is to harvest at age four, then harvest coppice crops taken on a two-year cycle. Based on preliminary measurements at age four the above ground carbon mass will average six tonnes/hectare and below-ground two tonnes/hectare. Each subsequent biennial coppice harvest yields the same as the first harvest. The above ground component of the biomass could also potentially be used as a biomass fuel.

It is impossible that at this stage of the development of carbon trading to make any precise prediction about the value of carbon sequestered by oil mallee crops. Apart from the fact the rules have not been formulated, there is as yet no precise understanding of what will be the market value of a tonne of sequestered carbon. However, even under the most conservative of assumptions (for example, counting only below-ground carbon and assuming an annual carbon production rate of one tonne per hectare) the annual return to an oil mallee carbon owner

could be in the range of \$10 to \$30 per hectare. Of course if the price of carbon is much higher and the costs of measurement and validation are minimised return could be significantly higher.

It is clear that the best approach to commercialising oil mallee plantings is to maximise the returns by integrating the products that can be sold. It is obvious that carbon sequestration can be perfectly integrated with the production of oil for solvents and the use of the above-ground parts of the crop for bio-fuels.

The framework in which carbon sequestration projects utilising oil mallee plantings can operate remains unclear. What is certain, however, is the need for massive scale implementation, good coordination between agencies involved and scientific rigour to develop allometric equations. It is also important to hone our marketing skills to ensure that every potential product that we can derive from oil mallee plantings is exploited. CALM has considerable expertise in these areas and is committed to assisting the Oil Mallee Association to maximise the potential for 'farming carbon' from mallee eucalypt crops.

## References

- AACM International Pty. Ltd. (1998) Greenhouse challenge vegetation sinks workbook: Quantifying carbon sequestration in vegetation management projects. A summary. *Prepared for the Greenhouse Challenge Office, Commonwealth Department of Primary Industry*. Canberra
- Agriculture Western Australia, Department of Conservation and Land Management, Department of Environmental Protection & Water & Rivers Commission (1 996). *Salinity: A Situation Statement for Western Australia: A report to the Minister of Primary Industry, Minister For the Environment*. Government of Western Australia.
- Barton, A. F. M and Knight, A. R. (1997) High cineole eucalypts in degreasing applications. In: *Chemistry in Australia*, 67: 4-6.
- Breuer, G. (1 979) Can forest policy contribute to solving the CO<sub>2</sub> problem?. *Environ. Int.*, 2: 449-45 1.
- James, S. (1984) Lignotubers and burls- their structure, function and ecological significance in Mediterranean ecosystems. *The Botanical Review* 50(3): pp 225-266.
- McCarthy, A. (1998) Honours thesis.
- Noble, J.C. (1989) Fire regimes and their influence on herbage and Mallee coppice dynamics. In: *Mediterranean Landscapes in Australia: Mallee Ecosystems and their Management*. Eds: J.C. Noble & R.A. Bradstock, CSIRO Publishing, Australia.
- Sedjo, R.A. (1 989) Forests: A tool to moderate global warming? *Environment*, 31 No. 1.
- Shea, S., Butcher, G., Ritson, P. Bartle, J. & Biggs, P. (1998) The potential for tree crops and vegetation rehabilitation to sequester carbon in Western Australia. *Carbon Sequestration Conference, Le Meriden Hotel Melbourne*, 19-21 October 1998.