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## Sandalwood- Prospects For Tropical Australia

(Tba)

## An overview of bio-energy prospects on marginal sites using mallees and tall eucalypts.

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#### Abstract:

Eucalypts have considerable potential as a bioenergy feedstock. The circa 700 species are endemic to a wide range of climates ranging from temperate to tropical, and many are also adapted to soils of low nutrient status and poor structure where agriculture is marginal and food security is not threatened. For these reasons, international interest in planting for bioenergy on marginal sites has grown considerably in the last five years. Though most species trialling and domestication research in Australia has focussed on tall tree species suited to higher rainfall sites, where solid timber and fibre crops are produced, there are a large number of species adapted to the relatively hot and dry conditions found further inland. The opportunity is to develop bioenergy tree crops suited to Australia's extensive temperate sheep-wheat belt and subtropical and tropical pastoral zones. A basic research challenge is to identify species and silvicultural systems for these sites. The short-rotation mallee system devel-

oped in temperate Western Australia might be extended to the summer rainfall zone if suitable species can be identified from those that are endemic to the tropics. Another possibility is growing tall tree species on short coppice rotations for bioenergy production on marginal sites in both temperate and tropical regions. These silvicultural systems, opportunities and limitations of eucalypt-based bioenergy production on marginal sites are discussed.

## Introduction

Security of energy supply, reduced dependence on oil and greenhouse gas mitigation are some reasons why researchers are further investigating the feasibility of bioenergy plantations. First generation feedstocks rely on existing agricultural industries like sugar cane and maize, and divert the crop and land away from food production. However, ligno-cellulosic feedstocks used to produce second generation biofuels like synthetic diesel and aviation fuel can be grown on areas unsuitable for food crops, and can use by-products from other crops such as cereal straw, sugar cane bagasse, forest and sawmill residues and organic wastes from land-fill (Sims *et al.* 2010).

Eucalypts are a suitable woody crop for this purpose. They have evolved under Australia's harsh climatic conditions and are well-adapted to a wide range of climates. In particular they can achieve good growth rates on low nutrient, structurally poor soils that experience an extended dry period. They are often planted for their ability to produce useful products on degraded sites that are marginal for agriculture, and it is because of this that eucalypts are widely cultivated in Australia and overseas.

Solid timber and pulp fibre have traditionally been the major products from plantation eucalypt wood, with a recent increase in use as a bioenergy feedstock. At the simplest level, wood is converted to charcoal which is used in the developing world to meet basic household energy needs for cooking. Charcoal is also used in significant volumes by the steel industry in Brazil where eucalypts are specifically grown as short-rotation (circa 5-year) crops (Wright 2006). In America 500 km<sup>2</sup> of short rotation woody crops have been planted for fibre production and in southern China over 70,000 km<sup>2</sup> for biomass (Wright 2006) – eucalypts are a significant component of these totals. In Australia, 120 km<sup>2</sup> of eucalypt mallee trees have been established for environmental rectification (Shepherd *et al.* 2011a) and 8,270 km<sup>2</sup> tall-habit eucalypts have been planted for pulp and sawlog production (Gavran & Parsons 2011).

There are many technical challenges facing governments and commercial companies to convert ligno-cellulosic feedstocks into biofuels, in particular the cost of conversion and the technology used. However having year round supply of biomass feedstock for commercial plants is a major limitation that needs addressing.

## The Opportunity

A significant opportunity may develop in Australia and other places where marginal land is plentiful for the cultivation of hardy bioenergy tree-crops for conversion into combustible pellets or more sophisticated second generation biofuels. Vast areas of land, marginal for food-production agriculture exist in the subtropical and tropical pastoral zones of Australia. Eucalypts are an attractive proposition to plant on these areas and manage on short (less than five-year) rotations due to their hardiness and propensity to coppice – i.e. re-shoot after the above-ground material is harvested. The root system remains intact to store carbon, and as the crop is not re-planted, soil disturbance is kept to a minimum and costs are kept down. Two options exist for dedicated eucalypt systems, tall habit trees managed on coppice rotation and mallee habit trees managed as coppice on less productive land. The use of residues from tree crops grown for other purposes is another source of feedstock. However, there are a number of technical and other challenges that must be overcome to successfully establish eucalypt plantations on marginal land in northern Australia. Some basic research gaps include:

- The northern land-base is highly heterogeneous in terms of climate and soil parameters relative to the southern Australian sheep-wheat belt.
- Systematic plantation capability and suitability assessment of the northern land resource for bioenergy must be undertaken to properly quantify and characterise the opportunity.
- While some tall-tree species suitable for medium rainfall areas have been identified, species suitable for re-

### Possible impediments to development

Though development of renewable bioenergy crops will, if properly planned, have positive environmental effects in terms of displacement of fossil fuels and greenhouse gas abatement, the possibility of negative environmental impacts should be acknowledged and is well documented (e.g. FAO 2008). There are a number of concerns that bioenergy systems will have negative impacts on soil quality, and this is a particular concern in Australia where soils are often fragile and of relatively low nutrient status. The harvesting of biomass removes organic matter that would otherwise be re-incorporated into the soil and there is increased potential for soil carbon depletion resulting in overall reduced site productivity (Cowie *et al.* 2006). Additionally, foliage, small branches and bark are high in N, P, K and Ca which lead to high residual ash, which is undesirable to most bioenergy applications (Cowie *et al.* 2006). Application of fertilizer is expensive and can in some cases may cause overall negative greenhouse gas outcomes (FAO 2008). One option is to leave the harvested material onsite until after leaf fall, to reduce net export of nutrients off-site. Alternatively, ash could be back-loaded to the site at low additional cost. A further option could be to integrate companion crops, e.g. nitrogen fixing species of *Acacia*, however acacias generally do not coppice well when cut at ground level, and generally pose a far greater invasive threat than do eucalypts.

The potential of eucalypts to become invasive is a controversial subject. Booth (2012) provides a summary considering dispersal methods, seed production and predation, germination requirements and the length of time the seed remains viable after dispersal. While there are examples of eucalypts becoming weed species (*E. globulus* in California (Haysom & Murphy 2003)), he concludes their invasiveness potential is limited by short seed dispersal distance, high insect predation, a rapid drop in viability post dispersal and a requirement for minimal competition (*i.e.* a cleared area).

The distance to a processing plant is a significant issue as transport costs can reduce the profitability and negate the carbon balance benefits of bioenergy crops. Small, widely scattered resources situated remote from processing facilities are unlikely to be successful (Evans 1997). However commercial plants are unlikely to be built if there is not sufficient feedstock to supply the plant year round.

### What is being done to address the research gaps?

Basic research is required to answer some of the fundamental biological questions that will underpin the development of eucalypt-based bioenergy cropping systems in Australia. In the southern Australian sheep-wheat belt, particularly in Western Australia, a considerable amount of research has been invested in genetics, management and harvesting technology to successfully integrate mallee eucalypts, which can be harvested on short-rotations, into existing farming systems (Bartle 2009). This system may be broadly applicable to northern Australia's tropical pastoral zones, however identification of mallee eucalypt species suited to these summer rainfall climates has only recently been initiated in a project jointly funded by CSIRO and Rural Industries Research and Development Corporation (RIRDC). Some preliminary findings of this study are reported in Case Study 1. The use of hardy tall-eucalypt species suited to more marginal medium-low rainfall sites (circa 400-600 mm mean annual rainfall) for bioenergy is another option being considered. In Case Study 2 we summarise some findings from a Future Farm Industries Cooperative Research Centre study into genetic control of coppicing of a prospective southern Australian species, *E. cladocalyx* (sugar gum). This is one of a number of tall-habit eucalypts suited to marginal sites (see Table 1). These species might be grown on short rotations for bioenergy, however research on the coppicing ability following the first and subsequent cuts is required. It has been suggested that coppicing ability reduces with age although these reports are confounded with climate conditions and timing of harvest (Hillis & Brown 1984).

### Case Study 1: Sub-tropical/tropical mallees

The mallee eucalypt is a multi-stemmed, small tree that has a lignotuber with embedded vegetative buds (Slee *et al.* 1996). New stems (coppice) emerge from the lignotuber following removal by fire or other disturbance. Once the trees are established, they can be harvested and seemingly coppice without the loss of vigour, therefore do not need to be re-planted. The lignotuber remains underground where in wild specimens has been observed over one metre in diameter

