PETER WHITE.

Regional Agroforestry Development Project 065281

Graduate Certificate in Forest Science (Farm Forestry)

A preliminary investigation of Swamp Sheoak *Casuarina obesa* Miq. as an Agroforestry option for the Western Australian Wheatbelt.

Peter White

Conservation and Land Management
Wheatbelt Regional Headquarters

7 Wald Street

NARROGIN WA 6312

December 2001

Front cover: Mature *Casuarina obesa*, Toolibin Lake

Regional Agroforestry Development Project

Pre amble

The region being considered for this assignment lies within an approximate 50km range of the Township of Narrogin (fig. 1), located some 180km south east of Perth. This portion of the Upper Great Southern region (Negus, 1989), was selected for consideration of its agroforestry potential because of;

- The existence of several tree growing / harvesting activities in the area. This area is within one of the six Conservation and Land Management's Oil Mallee planting cells (i.e. Wickepin), the first of the Maritime Pine (*Pinus pinaster)* establishment work commenced in the winter of 1999 and a commercial tool handle industry utilising Brown Mallet (*Eucalyptus astringens)* is operative. Fuelwood and fencing material is produced from public lands (Dryandra State Forest) and small sawmills operate at both Narrogin and Wandering. Some Tasmanian Blue Gum (*E. globulus)* plantings have been established at an experimental level on the western fringes of this zone and a large Sandalwood (*Santalum spicatum)* research trial plot established in 1999.

- The existing high levels of activity from government agencies which support revegetation and agroforestry concepts. The Department of Conservation and Land Management (CALM) has Regional and District offices with Rural Advisory and Land for Wildlife positions. Agriculture Western Australia (AgWA) has a major centre with a significant "Trees in Agriculture" group, which is set to expand over the next few years (AgWA, *et al.* 1996b).

- Corporate sponsorship. Lake Toolibin is a wetland of international significance (RAMSAR listing) and is the centre of detailed planning and community consultation work. ALCOA of Australia has had significant input to planning and implementation of revegetation work in the Toolibin area. Toolibin is designated as a Recovery Catchment and hence has a major revegetation component. Also, Western Power (the local energy utility) is focusing on several catchments within this area as part of its revegetation initiatives, aiming to plant 1 million seedlings over the next four years (C. Morris, pers. comm. 2000).

- There is strong local farmer adoption of landcare activities with a number of highly active local catchment groups of which Toolibin, Fourteen mile brook and Yournaning are examples.

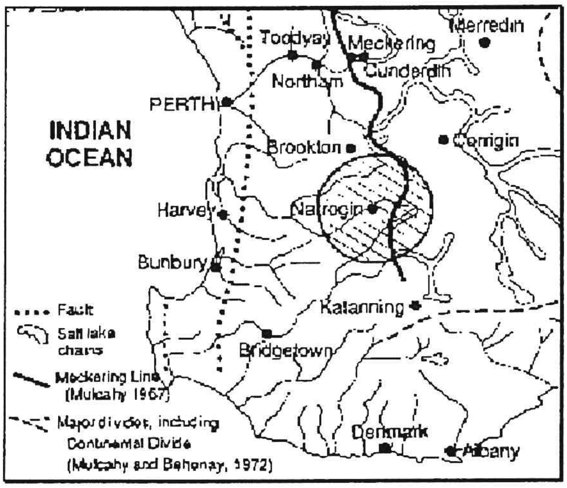


Fig 1: Study area

adapted from Ministry of Education 1989

Introduction

The Farm Forestry Task Force (1995) and the State Salinity Action Plan (AgWA, *et al.* 1996a), identify commercial revegetation as a means for increasing farm profitability while addressing a number of landcare issues. Considerable progress has been made in developing commercial tree crop options for plantation and agroforestry systems in the higher rainfall zones (Shea, Bartle and Inions, 1992). However, there appears to be limited commercial options available for the study area (Wallace, 1992b). This may be due to a number of reasons, including insufficient extension work in promoting available options (Wallace, 1992b) and limited economic information to assist potential growers (Greening Australia, 1996). Soil types, rainfall and its seasonal distribution, tree crop rotation length, fencing requirements, and transport distance all influence tree crop suitability (Bulman, 1995).

There is still a high degree of skepticism about trees and their ability to address landcare issues (Bartle, Campbell and White, 1996). In some instances, landcare groups are focused on engineering solutions as a means to address environmental problems (AgWA, *et al,* 1996a). Revegetation is still seen as a barrier to agriculture and preventing farmers from getting on with the business of farming (Vanclay, 1992). Tree crop options available in higher rainfall zones have proved unsuccessful in this area (J. Humphreys, pers. comm. 1999). This may be a disincentive for farmers to support the introduction of new tree crops (GA, 1996).

Bartle (1991), outlines the magnitude of the revegetation task and the present levels of response in the Wheatbelt. However, to achieve the planting targets outlined in this report and the recent Western Australian Salinity Action Plan (AgWA, *et al.* 1996b), farmers will need confidence in emerging revegetation options. Sound research and effective extension programs will be needed to convey the full range of benefits of integrated plantings (GA, 1996). This assignment gives an overview of wood products, demand trends and local production capabilities and investigates a selected species (*Casuarina obesa*) to assess its commercial agroforestry potential.

Description of the area

The area supports one major and several minor townships and associated infrastructure. Narrogin is the regional administrative centre for several Government Departments as well as an important focus for education (a super senior High school with hostel accommodation and an Agricultural College).

Landforms and soils

The district, located on the Yilgarn block, is bisected by the Meckering Line. It is within part of the area described by Lantzke (1992), as the Zone of Ancient Drainage in the east i.e. "broad flat valleys of low gradient with salt lake chains at their lowest point, gently sloping valley sides, some rock outcrops and large areas of sandplain". The landscape has little relief between ridge tops and valley floors. Drainage is poor because of these low gradients. This changes to the Zone of Rejuvenated Drainage in the west and is characterised by narrower, more steeply incised valleys (Lantzke, 1993). Drainage from the area is via the Blackwood, Hotham and Collie River systems. The soils of the area are highly variable in structure and distribution and are described in full by Stoneman (1991).

Vegetation

This region includes the Avon and Roe botanical districts as described by Beard (1979). Previously, vegetation ranged from Woodland to Succulent Steppe (i.e. samphire communities). Much of the land to the east of Narrogin has been cleared though significant areas of Crown Land exist to the west.

Climate

The climate is classed as Dry Warm Mediterranean i.e. predominately winter rainfall, hot, generally dry summers and low humidity. Frosts are a common occurrence in winter and early spring (Beard, 1980). Rainfall is as high as 700mm in the west decreasing to 450mm in the east.

European history

Early agricultural activity in the western Wheatbelt began as pastoral leases in the 1860's. Agricultural settlement accompanied the development of railway systems (Beard, 1979). Initially, the Woodlands were cleared, but the higher land was only developed after the second World War as machinery, chemical fertiliser and an increased labour force became available - a similar pattern as described by Main (1993). Conditional purchase requirements and rabbit eradication saw many soil types cleared that would eventually be the source of many of the agricultural problems.

Agricultural enterprises

The main agricultural enterprises of the area are the traditional grazing and cropping. Average farm size ranges from 800 ha in the west to 2500 ha in the east. Sheep are the predominant animal herd with some limited cattle production. A number of intensive piggeries (including a 1000 sow operation) are in the Narrogin area, as well as smaller free-range units. A small-scale abattoir operates on the outskirts of Narrogin. Cropping is dominated by wheat and oats, with smaller amounts of lupins, barley, canola and field peas. Additional enterprises such as yabbie production and farm stay accommodation are also a common secondary activity.

Land ownership and stakeholders

There are approximately 785 000 ha of land within this 50km radius with a diverse range of landowners and hence stakeholders, who could be affected by a Regional Agroforestry Initiative (See table 1).

Table 1: Land tenure and stakeholders

Land ownership	Stakeholders
Private Land	The majority of land within the selected area is freehold land managed for the purposes of agriculture
State Government;	Conservation and Land Management: (Nature Reserves, State Forest, Timber reserves)
	Main Roads: (Road verges, gravel reserves)
	Water Authority: (Water reserves, pipeline easements)
	Department of Land Administration: (UCL, unvested reserves)
	Westrail: (Rail line easements)
Local Government	Town Councils (Buildings, infrastructure)
	Shire Councils: (Road reserves, gravel reserves, etc.)
Other groups	Western Power: (Powerline easements)
	Southern Aboriginal Corporation (Cleared and uncleared land)

Though not necessarily land holders, a number of other groups represent stake holders including Agri - businesses (chemical distributors, machinery sellers, livestock transporters, etc.), local towns people and tourism operators.

Landuse issues / problems

Competition for resources on different land tenure is a common land use problem in areas that are well vegetated e.g. towns people wanting firewood from public land that has high nature conservation values (S. Gorton, pers. comm. 1998), as well as issues of gravel removal and rubbish dumping. However, what is discussed here focuses more on the causes of land degradation brought about by agricultural activities.

Nature of the problems and the processes involved

Rising water tables, waterlogging and salinity

Rising watertables have been discussed for many years with comments in print from the late 1800's, the early 1920's (Australian Forestry Journal, 1922) through to the recent State Salinity situation statement (AgWA, *et al.* 1996a). The widespread removal of native perennial vegetation and its replacement with a system based on annual crops and pasture has seen a major shift in catchment hydrology. Previous watertable recharge rates were minimal (0 - 1mm/y), but have increased to <10 - 260 mm/y (George, *et al.* 1997). In some areas, water tables have risen 20m in less than 20 years (AgWA, *et al.* 1996a).

The rising water tables have mobilised considerable volumes of salt, which has accumulated in the soil profile over many thousands of years. The discharge of this saline groundwater at the soil surface results in high levels of salt concentration as the water evaporates. Many agricultural plants are intolerant of even low levels of salt, with those having a degree of tolerance showing signs of reduced production levels. The area affected by dryland salinity in W.A. rose from 264 000ha in 1982 to 1.8million ha in 1996. There is potential for over six million ha to be affected (AgWA, *et al.* 1996a).

Waterlogging severely restricts plant growth and hence eventual crop yield. With the rising watertables occupying much more of the soil profile, waterlogging is a more frequent, prolonged event as the soil has reduced moisture storage capacity for incoming rainfall (AgWA, *et al.* 1996a). Local experience shows that saline groundwater tables are rising by 9cm per year on the Toolibin valley flats (McFarlane and Ryder, nd). Flooding occurs on the flats 1 in 5 years and waterlogging occurs one in two years. Satellite data shows that up to 30% of the crop can be affected by waterlogging, even on an average year.

Wind and water erosion

Soils can be prone to erosion after the removal of vegetative cover. This could be by fire, inappropriate cultivation techniques or overgrazing. Wind erosion costs for one year have been estimated at $40 million (Hunt and Gilkes, 1992), with approx. 20% of the agricultural area affected. Wind erosion events are particularly common on sandy soils. Descriptions of severe wind erosion events by Carter (1995), summarise the problems with wind erosion that affect all parts of the agricultural area. Water erosion is considered by Hunt and Gilkes (1992), to affect over 500 000ha of agricultural land.

Nutrient loss

Nutrient loss is a feature of water and wind erosion, as well as being leached into waterways (Hunt and Gilkes, 1992). Nutrient loss is costly, firstly to the landholder who has to replace lost fertilisers and secondly to those responsible for managing the accumulating nutrient levels in waterways and estuaries (Bott and Humphries, 1997).

Erratic rainfall and high evaporation rates

Rainfall in this area varies from about 700mm in the west to 450mm in the east. Though a winter dominant rainfall, late rains can dramatically affect harvest yields as well as devaluing hay and feed values. Previous years low rainfall means that little stubble and grass cover will be available to bind the soil (Carter, 1995). Higher evaporation rates put crops and livestock under stress, often at crucial times (Sudmeyer, 1997).

Soil acidification

Most agricultural activity has resulted in the gradual lowering of pH - in some areas pH's have reached such low levels that the available nutrients are bound in the soil and unavailable to the plant (Hunt and Gilkes, 1992). Another problems associated with a lowered pH is aluminium toxicity i.e., the low pH allow more aluminium to be available, which can be detrimental to plant growth.

Soil compaction

Subsoil compaction due to heavy vehicle traffic presents a number of problems for plant growth. Root growth may be restricted as the moisture and nutrients in soil cannot be easily utilised (Hunt and Gilkes, 1992).

Non wetting soils

Water repellence is caused by types of soil organic matter that form coatings on soil particles - particularly a problem in sandy soils. Non wetting soils cause water to be absorbed into the soil profile unevenly and leads to patchy plant emergence and growth. This lack of plant growth can lead to subsequent wind and water erosion as there is not enough plant material to prevent soil movement (Hunt and Gilkes, 1992).

Loss of biodiversity, wildlife habitat and landscape values

Valley floors and wetlands are threatened by salinity and water table rise. Salinity poses a major threat to streamlines as well as remnant vegetation, wetlands, unique species and ecosystems (AgWA, *et al.* 1996a).

Commodity prices

Traditionally, market fluctuations in basic commodity prices saw relatively higher prices for wool when grain prices were low. However in 1995, prices for both fell dramatically. General farm incomes have been deteriorating in real terms for many years and farming has suffered badly during this period. Australian Bureau of Agricultural and Research Economics figures quoted by O'Connell (1997), indicate that in the last 25 years, 25% of commercial farms have disappeared. While agricultural production rose by 50%, the net value of production dropped by 10%. Commodity prices determine land use, which impacts on the type of land management problems, e.g. the shift in production emphasis from wool to cereals and grain.

Farming techniques

Recent developments such as minimal tillage practices are attractive, especially from a soil conservation viewpoint - however, it is an expensive proposition to change equipment and it also places an increased reliance on chemical usage. Herbicide resistance is a weakness in this system, but also it means an increase in chemicals potentially entering waterways or in extreme cases, the food chain (Soule'& Piper, 1992). There are numerous barriers to farmers adopting new farming techniques, which are discussed by Gorddard (1992). Whatever the reason, it means that unsustainable farming techniques are still practiced.

Environmental, social and economic consequences of land degradation

Environmental

Salinity and waterlogging are causing a decline in health and vigour of native vegetation on both private and public lands. This progressive decline also causes problems for the fauna dependent on the vegetation for food and shelter (AgWA, *et al.* 1996a). It also severely limits the type of revegetation work that can be attempted. The presence of feral animal and plant species compounds many of these problems

The declining health of much of the native vegetation has both direct and indirect economic significance is more difficult to place a dollar value. There can be differing values i.e. the cost of attempting to replace lost vegetation and plant communities as well as the loss of potentially useful genetic resources. For example, at least one species of tree presently targeted in the oil mallee program is under threat from rising water tables (J. Bartle, pers. comm. 1998).

Social

The cost of loosing land from agricultural production, plus the significant cost of remedial work may make some farming ventures non-viable (AgWA, *et al.* 1996a.). This has the potential to lead to dwindling rural populations as properties consolidate and hence reductions in demand of local and state government support, small businesses and produce merchants.

Rationalisation by Government agencies, e.g. the reduced operations of Westrail in Narrogin and private institutions (such as Banks) streamlining operations have already had an affect by reducing population levels in rural town. Closures of schools in rural areas due to low numbers are also an indication of this decline.

Population drift towards cities with more work opportunities, aging farming populations, farming succession, increased farm size and lack of farm labour all have long term social impacts on rural communities (Main 1993). Lack of opportunities for work has seen a decline in the casual workforce available, with labour being difficult to source during seedling and harvesting times.

Low commodity prices from existing agricultural practices clearly limit rural community development - especially if no other forms of income are available.

Economic

The economic effects of land degradation are experienced across a wide front. Losses to individual farmers can be considerable ranging from loss of land from immediate production to reducing the sale value of the property.

Recent work by Lyons (in AgWA, *et al.* 1996a) noted an increase in the amount of salt affected area within 20 shires, with over half of the local authorities reporting problems with water supplies, town buildings and roadworks. Increased drainage works are already putting floodways, culverts and bridges in the Narrogin Shire under increasing pressure, requiring expensive repair works (G. M^{c}Keown, pers. comm. 1997). Sand drift across roads also causes problems to local authorities.

Water erosion is considered by Hunt and Gilkes (1992), to cost the WA farming community over $20 million p.a. in lost production. Wind erosion, causing losses of $4.2 m to the wheat industry, have been calculated for a single event. This loss is similar to that which occurred the previous year across the same area (Carter 1995).

Increased levels of salts/nutrients/sediments entering waterways affect water quality, contribute to algal blooms in rivers and estuaries and contribute to the silting of lakes and estuaries (AgWA. *et al.* 1996a). These problems require costly remedial work.

Increasing salinity and hence widescale loss of vegetation threatens local tourism resources and the potential of inland regions to attract visitors (AgWA, *et al.* 1996a).

Perception of landuse problems

The awareness of landuse problems at a Government level culminated in the recent State Salinity situation statements and subsequent action plan. Many of the stakeholders (farmers) are aware of the problems associated with the present land use and see a need to move towards agricultural sustainability. The concept of "duty of care" is beginning to be considered by both the farmer and the wider community (Coffey, 1997). However, the perception of the severity of the problem varies from being "very aware and concerned" to "it happens a lot in other areas but not much around here" (Lefroy and Hobbs, 1993). At times there is an inclination to link conservation works with lack of productivity, despite evidence to the contrary (Wallace, 1992a).

Many of the agricultural problems are difficult to quantify, as the severity of the land degradation is increasing gradually. The full impact is difficult for some stakeholders to comprehend. e.g. water table rise and wind erosion. Attempts to define the problem often fail as it is usually linked to a definition of "sustainability" and opinions of what is "sustainable" differ greatly. In many cases, the sustainability viewpoint is very narrow - that of micro economic perspective rather than at a landscape level.

Information on some subjects is not always readily available or interpretable. Good alternative practices haven't always been available or presented well. The economics of some landcare activities have not been quantified and farmers are loath to take chances in uncertain economic times (Coffey, 1997). A lack of farm forestry culture exacerbates this reluctance. Gorddard (1992), points out also that even when sound data is presented, there can be a number of perfectly logical reason why the information may be accepted, but is not adopted and implemented.

Agency groups such as AgWA and CALM usually have very detailed knowledge of landuse issues, but there can be problems presenting information to landholders in a workable form. At times, extension services have played a restrictive role in data being assimilated into the rural community (Wallace 1992a).

Potential of revegetation to enhance environmental and economic sustainability of farming systems in the region.

The speed at which trees are being planted in the Wheatbelt is occurring at a very slow pace. At the current rate of planting, it will take nearly 200 years to revegetate 15% of the landscape. Commercial tree crops are seen as the most significant way of dramatically increasing the tree planting activity in the Wheatbelt (J. Bartle, pers. comm. 1997).

The role of vegetation in addressing land use problems

Using vegetation in the form of trees or other perennial plants is one of several options available for addressing land use problems. The use of vegetation attends to many landuse problems and issues (Table 2), differing from most other options that are generally quite narrow in focus.

Table 2: Revegetation Opportunities Matrix (adapted from Wallace 1992a)

Revegetation objective	Agro-forestry	Amenity	Nature conservation	Soil conservation	Timber production	Water conservation
Agro-forestry	10 - 10	0 - 10	0 - 5	0 - 10	5 - 10	0 - 10
Amenity	0 - 10	10 - 10	5 - 10	5 - 10	0 - 10	5 - 10
Nature conservation	0 - 5	0 - 10	10 - 10	0 - 10	0 - 5	0 - 10
Soil conservation	5 - 10	5 - 10	5 - 10	10 - 10	5 - 10	5 - 10
Timber production	5 - 10	0 - 10	0 - 5	0 - 10	10 - 10	0 - 10
Water conservation	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10	10 - 10

Measures to treat one problem e.g. soil conservation can impact (ranging from zero = nil compatibility, 10 = compatibility) on an array of other issues e.g. nature conservation, depending on the site and the methods used.

Water use potential

Water table control can be addressed in a variety of ways e.g. by the use of high water use annual crops, perennial pastures, pumping, drainage or tree planting. Some of the systems mentioned have intrinsic problems i.e. the disposal of effluent water from pumping and drainage. Studies in the Wellington catchment and other places such as Boundain, show that water tables can be drawn down by tree planting (George, *et al.* 1997). Increased water use by vegetation can be seen as a means of protecting agricultural enterprises as well as environmental concerns.

Control of the watertable affects factors such as surface runoff and water logging, which can impair the capacity of the soil to retain phosphorous. Reduced waterlogging increases the plants ability and opportunity to use available phosphorous (Bott and Humphries, 1997).

Soil, plant and animal protection (agricultural)

Wind speed reduction is a significant contribution that revegetation can make to addressing landuse problems. While stubble retention and minimal stock numbers are one approach to alleviating wind erosion, in years of poor rainfall, there may be little stubble to retain.

Where there is a late break to the season, grazing may be extended beyond the duration originally intended. Bicknell (1991), comments that windbreaks are at their most effective under these circumstances. A reduction of sandblasting of crops can result in increase yields as well as contributing to water use. Nutrient loss can be minimised by controlling wind and water erosion. Vegetation has a role to play here by providing the protection needed at crucial times of the year.

Protection and retention of biodiversity

Revegetation offers protection to remnant vegetation, with its respective plant and animal communities, by reducing the effects of salinity and waterlogging and by providing a barrier that minimises the effects of fertilisers and herbicides (Wallace, 1998). Revegetation work can increase the size and connectiveness of remnant vegetation and hence the value to wildlife (Wallace, 1998). The role of revegetation is to maintain biodiversity or to add diversity that will not compromise farming or environmental goals e.g. the ill-considered introduction of *Kochia scoparia*. Individual paddock trees and those on the edge of remnant vegetation will suffer less from windthrow if protected by the planting of more trees.

Protection of landscape values

Writers such as Hall and Brown (1968) and Wallace (1998), consider that aesthetics and nature conservation are not altruistic issues; rather that they are an essential part of farming and managing the land. The presence of vegetation is important for the physical and mental well being of local inhabitants. Current whole farm planning often overlooks the value of landscape values and environmental design (Revell, 1997).

Opportunities for revegetation to enhance productivity

Vegetation presents opportunities to augment production in a number of ways. Agricultural activity has seen a radical change from highly diverse biological systems to those which are very simplistic in comparison (Lefroy, *et al.* 1993). Lefroy, *et al.* (1993) argues that providing systems with high levels of diversity will provide many more options for land managers. Enhancing productivity can be viewed as the direct financial gain or the chance to spend less.

Improved productivity in existing agricultural land

The protective value of windbreaks has been shown to have resulted in a direct dollar increase from improved crops (Bicknell, 1991), with increased production offsetting establishment costs. Protection of stock from strong, cold winds could prevent animal losses, as has occurred along the south coast (Bicknell, 1991). Retention of topsoil, nutrients and chemicals are measurable benefits. Animal health can be maintained by using vegetation to supply shade, shelter and fodder. Improved crop productivity can be expected through reductions in waterlogging, brought about by the plants ability and opportunity to use available phosphorous (Bott and Humphries, 1997).

Other benefits from tree planting may also arise such as reduction in windspeed in agroforestry systems (plus reduced fuel loads from grazing), gives greater control of fire than in open paddock conditions (Lefroy and Scott, 1994).

Gomboso, *et al.* (1997), examined three salinity management options in the north Stirlings; a "do nothing" approach, a limited revegetation option and an alley farming option. The conclusions show that short-term productivity in the alley system may be reduced. However, given that water tables (and the associated problems), are lower, the long-term prospect is beneficial for sustainable production as better soil types are protected.

Improved productivity from utilizing revegetation

The value derived from vegetation needs to equate to that of previous agriculture e.g. Richard Moore's work (outlined in Lefroy and Scott, 1994), with wide spaced pine trees shows the benefits of combining agriculture and forestry. This combination may result in lower yield from each activity, but results in higher combined yield. Bartle (pers. comm. 1998), considers already that on some soil types, oil mallees are of the equivalent value of wheat and wool production i.e. agricultural productivity has not suffered through land being occupied by trees.

Trees and shrubs offer a means to diversify incomes and may help smooth out fluctuations in farm income. Products such as fenceposts, strainers and fuelwood can be produced for on farm use, but also have potential to supply others. Bartle and Reeves (1992) argue using commercially viable species esseential in the quest to achieve the necessary planting rates. Many of the options for influencing water table rise are listed in the State Salinity situation statement (Appendix 1), are presently available in parts of the discussion area.

Management benefits

A farmer who has been experimenting with agroforestry layouts for many years, reported considerably reduced evaporation rates and an increase in the number of days available for spraying within areas protected by vegetation (D. Melvin, pers. comm. 1997). Other reports are of increased trafficability across paddocks in winter because of reduced waterlogging (W. Bessell-Browne, pers. comm. 1999).

Improved property values

Hall and Brown (1968), state that property values are greatly increased by attractive and appropriate tree planting. This applies to both the paddock and the homestead. Local real estate groups also believe this to be the case (G. Donnelly, pers. comm. 1997).

Improved employment opportunities

There is potential to keep or even attract people into rural areas to satisfy a predicted need for skilled planners and designers. Opportunities exist for seedling nursery development, revegetation consultants and plant establishment contractors.

Overview of Commercial Opportunities

Increased demand exists for pulpwood, chipwood for reconstituted products and softwoods for sawn products (George, 1997; Knowbel, 1997). The Australian Bureau of Agricultural and Resource Economic and Jaakko Poyry (1999), also predict that sawnwood and wood based products will rise over the next decade as log availability increases. Industry advocates believe that secure long-term prices for quality appearance and special grade sawn hardwoods are possible (Bird, Jowett, Kellas and Kearney, 1996).

Timber harvesting is moving away from traditional forest areas and into plantation wood (George, 1997). Higher value timbers are also becoming scarce either due to overcutting or by the placement of more forest areas into reserves (ABARE and JP, 1999). With the Western Australian government recently modifying its support for aspects of the Regional Forest Agreement, there is considerable uncertainty over areas available for harvesting and changes to management practices may also occur (Bradshaw, 1999).

Land availability is essential for future plantation expansion (ABARE and JP, 1999). The rising wood supply from the southern hemisphere is made possible by this availability (ABARE and JP, 1999). Plantations are becoming more viable as a source of wood fibre as the costs associated with wood production from native forests increase (ABARE and JP, 1999).

The prospects for a developing forestry industry, which Agroforestry is part of, appears sound. Plantations 2020, a partnership between industry and the State and Commonwealth governments aims to treble the national plantation estate over the next 20 years (Australian Forest Growers, 1999). Greening Australia (1996), gives an overview of the integrated commercial and conservation benefits a farm forestry movement could provide. The Farm Forestry Task Force report (1995), has also made many recommendations designed to promote and assist the development of Farm Forestry in Western Australian.

Summary of Commercial or Promising Tree Crops in the Study Area

(This section deals with tree crops for timber, reconstituted material or industrial extract. It gives no consideration to crops such as olives, quandongs or any of the fodder shrubs.)

Leaf Extracts

The study area is within the Great Southern Oil Mallee Cell (Oil Mallee Association, 1998a). The major interest in oil mallees is in the extraction of cineole rich oil from the foliage (Barton and Greening, 1998). Several species, predominantly Western Australian, are used (OMA, 1998b). The product focus is principally towards the large volume, industrial solvent markets (Barton and Greening, 1998), which exist locally, statewide and internationally.

A major aim for the oil mallee industry is for the widespread distribution of trees across the landscape, rather than focusing on discharge sites (OMA, 1998c). The use of a large number of adaptable species is making this aim possible (OMA, 1998c).

By the end of the 1999 planting season, two million oil mallee seedlings will have been established in the study area over the last five years, with 12m being planted statewide (D. M^c^Fall, pers. comm. 1998). The business plan for this area forecasts a rapid increase in planting rates, reaching 260m seedlings by the year 2025 (D. M^c^Fall, pers. comm. 1998). These plantings will cover approximately five percent of the two million hectares within the Great Southern Oil Mallee Region.

The major thrust of this program is still in planting trees for their landcare potential, while development occurs on the commercial development (AgWA, 1998). However, preliminary figures (OMA, 1998a), indicate that using a range of prices and projected growth yields, oil mallees pay for themselves and the land taken out of agricultural production, over a 20-year period. The comparative figures for not planting, which calculated in a one percent loss of farming land p.a. to rising watertables indicated that the farmer will be $21,000 worse off after 20 years (Collins 1999).

Contracts with growers have been secured with a Profit a Prendre with CALM and, more recently, a Growers agreement with the Oil Mallee Association (OMA, 1998c). Minimum planting numbers are in the order of 10,000 seedlings.

Improved harvesting and processing techniques are being researched and developed (OMA, 1998a). Additional *Eucalyptus* and several *Melaleuca* species are being researched by CALM for cineole, with some promising results (OMA, 1998c). Finding cineole rich *Melaleuca* spp. will allow partially waterlogged and salt affected land, which significantly retards the growth of other genera, to be planted (OMA, 1998c).

Hardwood Sawlog Production.

General construction and stockyard material is cut from native hardwood forests. Small sawmills operate at the townships of Narrogin and Wandering, cutting from both Government and private land. Jarrah (*Eucalyptus marginata)* and Wandoo (*E. wandoo)* are the principle species harvested (CALM, 1998b).

The majority of the timber sawn is used within the study area (J. Mullar, pers. comm. 1999). Demand for some produce has declined in recent years, for example the production of stockyard material has slowed due to reduced sheep numbers and falling prices for wool (J. Mullar, pers. comm. 1999). Logs down to 200mm Small End Diameter (SED) can be milled (occasionally down to 175mm SED if necessary).

However a recent sideline of producing boards for flooring is developing. Though a commercially attractive proposition, smaller mills have problems producing enough to gain market access (J. Mullar, pers. comm. 1999). Extreme haulage distances, also means the possibility of re-equipping the mill with band saws to improve the recovery rate and maintain mill profitability (J. Mullar, pers. comm. 1999).

This mill will process logs for individuals at a cost of approx. $100 per hour, but it is difficult to convert that into a cost per m^3, as it depends on the size and quality of the log as well as the dimensions of the timber being cut (J. Mullar, pers. comm. 1999).

Wandoo and Jarrah royalty rates are presently set at $42.85 per m^3 for First Grade sawlogs, 200mm SED; $31.53 per m^3 Second Grade sawlogs, 250mm SED (CALM, 1998a). Stock yard material sells for about $1,150 per m^3.

Hardwood Pulp Production

Some Tasmanian Blue Gum (*Eucalyptus globulus)* plantings have been established in the western fringe of the study area by private landholders. However, as these plantings are outside the minimum rainfall zone recommended by CALM (C. Newman, pers. comm. 1999), their commercial potential appears questionable. Although some of the study area northwards towards Wandering is within the transport distance (200km from Bunbury) and rainfall restrictions (600mm min.), evapo-transpiration rates are too high for commercial plantings (C. Newman, pers. comm. 1999).

Softwood Production

Maritime Pine (*Pinus pinaster)*, a species suited to the lower rainfall areas (Bailey, McNamara, and Shea, 1997), is the principle softwood species planted in the study area (AgWA, 1999). The main products derived are industrial woods and small rounds from the thinnings, with the emphasis on sawlogs in the final harvest (Bailey *et al.* 1997). *Pinus pinaster* is grown on a 35-40 year rotation with thinnings at 12 and 22 years (AgWA, 1999). The maximum transport distance for thinnings is about 200km from a major processing centre in either Perth or Bunbury (Bailey *et al.* 1997). All material produced is processed outside of the study area.

CALM operates a Maritime Pine sharefarming program, with growers entering into a *Profit a Prendre* agreement (Berney and Rado, 1999). Growers can increase their returns by undertaking some of the plantation establishment work. Approximately 120 ha have been planted since 1997 (G. Hansen, pers. comm. 1999), with the aim being to scale up to 1000+ hectares per annum over the next few years. The minimum size area for planting is 20ha per property. In conjunction with the *P. pinaster*, CALM has initiated a Supplementary Species program (Bailey *et al.* 1997). Alternative commercial species or trees for biodiversity are available.

Monterey Pine (*Pinus radiata*) is occasionally planted, both by CALM and private landholders. However, these plantings are concentrated on the western fringe of the study area where growing conditions favour this species (G. Hansen, pers. comm. 1999), and have little relevance to this assignment.

Minor Forest Products and Specialty Material

Tool handles.

Brown Mallet (*Eucalyptus astringens)* is cut from the local Dryandra State Forest (Underwood, 1994). Timber quality varies as the mallet plantation silviculture has not always been implemented (CALM, 1995). A wide array of handles for hammers, axes and spades, as well as specialist tools are produced (Underwood, 1994). Tool handles are marketed locally and interstate (G. Hunter, pers. comm. 1999). Demand is relatively small and being affected by supply from the Eastern States, as well as cheap imports from south east Asia (G. Hunter, pers. comm. 1999). Mechanisation has altered the types of hand tool that are being manufactured, though it hasn't reduced the overall demand (G. Hunter, pers. comm. 1999).

The plantation was originally established for the tannin content of this species (Underwood, 1994). New study trials on the tannin content of this species are underway (S. Gorton, pers comm. 1998).

Fencing material.

Integrated with the Brown Mallet (*Eucalyptus astringens*) tool handle industry in Dryandra State Forest areas, fence posts are produced from residue material. Treated mallet posts compete with steel, concrete and pine posts for market share (B. Gould, pers. comm. 1999). However, each has its own set of values that make it suitable for specific purposes, e.g. treated mallet posts are used predominantly with electric fencing (B. Gould, pers. comm. 1999). Mallet posts are more durable in waterlogged and salt affected areas, as well as being more fire resistant than untreated wood (B. Gould, pers. comm. 1999).

The quality of the wood produced for post manufacture can vary considerably, due as previous silvicultural practices. Late thinned stands having a very thin sapwood layer (CALM, 1995), with adequate sapwood thickness being critical to preservative absorption (Brennan, 1993). Bush operations are all within State Forest areas and are controlled by CALM. The treated posts are marketed throughout the agricultural region of WA depending on demand. There appears to be three factors that have contributed to demand (B. Gould, pers. comm. 1999);

* Historic land releases e.g. Esperance,
* Agricultural catastrophes e.g. 1997 Pingelly - Brookton fire, 1999 Moora floods,
* Market prices for agricultural livestock and associated produce. The falling price of livestock and a changing emphasis to cropping has seen some reduction in demand.

Recent increases in tree planting activity promoted by Natural Heritage Trust funding and the Western Power Greening Challenge revegetation project however, has changed the emphasis of fencing priorities and seen some resurgence in demand (B. Gould, pers. comm. 1999).

Fence post and strainers (*Eucalyptus wandoo* and to a lesser extent, *Eucalyptus marginata*) are also cut from on farm native vegetation, both by farmers for their own use and by contractors for sale (S. Gorton, pers. comm. 1998).

Fuelwood.

Several species of eucalypt are harvested for fuelwood, the principle species being *Eucalyptus wandoo* and *E. astringens*. Fuelwood is generated from three sources (S. Gorton, pers. comm. 1998);

* Integrated with the Mallet / fencepost industry from State Forest areas
* Specially designated areas within State Forest
* From private land.

Fuelwood permits for commercial suppliers and domestic cutting indicate a rise in fuelwood demand (S. Gorton, pers. comm. 1998). There is however, some uncertainty of supply as changes to land tenure in the forest area may restrict cutting (CALM, 1995). Demand for firewood has ranged from 700 - 1600 tonne per annum over that last decade and is steadily increasing (S. Gorton, pers. comm. 1998). Fuelwood provided for sale is usually cut to approximately 250mm length and dried down to 18% MC.

Considerable pressure is placed on Government reserves through illegal firewood cutting (Germantse, 1987). Fuelwood trials have been established by CALM in the Katanning District (outside the study area) in response to perceived wood shortages (Germantse, 1987).

Sandalwood

The Western Australian Sandalwood (*Santalum spicatum*) has helped pay for the development of a number of farming properties within the agricultural area (Kealley, undated report), though its exploitation succeeded in almost total exhausting the supply. What little that is left within the confines of the Wheatbelt is mainly in Nature Reserves, Water Reserves and National Parks (G. Durell, pers. comm. 1999). The wood from this species has principally been sent to China for use as incense joss sticks (Kealley, undated report).

Until recently, only small numbers of sandalwood seedlings were established on private land, according to the numbers despatched from the CALM Narrogin Plant nursery (T. Sprigg, pers. comm. 1999). However, more is being promoted within the Supplementary Species component of the Maritime Pine Program, with nearly 50ha being planted in recent years (J. Brand, pers. comm. 1999).

Development of plantations on private property may eventually affect the commercial exploitation of wild populations as harvesting plantation material is likely to be much more cost effective (P. Jones, pers. comm. 1999). The expansion of the Indian Sandalwood (*Santalum album)* program in the Ord River Irrigation area may eventually affect sandalwood pricing. However, it appears that sandalwood in Western Australia has a competitive edge. Overseas countries have not developed effective plantation strategies and natural stands are poorly managed. Radomiljac, Shea, M^c^Kinnell and M^c^Comb (1998), reports that sandalwood resources outside of Australia are declining rapidly and may be exhausted within the next decade.

A preliminary economic analysis by Haagensen (1998), indicates that at production rates of 3 tonnes per hectare, Internal Rates of Return (IRR) of 14% are considered possible. Three research trials have been recently established in the Narrogin area to determine the preferred sandalwood host, the superior sandalwood seed source (G. Durell, 1999), and the optimal sandalwood - host ratio (J. Brand, pers. comm. 1998).

Craftwood.

Craftwood is produced locally from native forests on private and public land, and used by Noongars (the local aboriginal group) and local cabinetmakers (S. Gorton, pers. comm. 1998) on a small scale.

Brush fencing

Broombush (*Melaleuca uncinata)* has been mooted as a prospective economic species for the study area and work by Bulman (1998), indicates that commercial establishment may be feasible. However, in WA at least, there are several differing forms of *M. uncinata*, with large differences in lignotuber characteristics (R. Cranfield, pers. comm. 1999).

Several other local *Melaleuca* species are being considered for production opportunities (e.g. biomass and cineole) on selected valley floor sites (J. Carslake, pers. comm. 1999). Alley farming trials using *Melaleuca* spp. have been established by CALM in 1997 to compare growth rates of selected species and monitor water table drawdown effects (Baxter and O'Sullivan, 1998).

Integrated Wood Processing

Recent progress has been made on the development of an integrated wood processing plant at Narrogin. At the heart of the project is a plan to convert wood residue (primarily from the oil mallee program) into charcoal and activated carbon products (Stucley, 1999). Western Power, the Western Australian electricity utility, intends to use the heat release during different phases of the processing to generate electricity (Narrogin Observer, 1999). Wood residues from up to a 50km radius could be utilized. Approximately four million oil mallees would be needed for the one-fifth-size demonstration plant. No figures are available on returns to growers, but it is likely to make growing trees for various commercial ventures more attractive if thinning, pruning and harvesting residue can be utilized (Cremer, 1990).

Problems and Opportunities; Diagnose, Design and Implement

Reid (1997a) presents a case for a Diagnose and Design (D&D) approach when contemplating agroforestry systems. The aim is to achieve the design of an appropriate system rather than the promotion of a particular option. The features inherent in such an approach include; a review of present systems, a recognition of problems (both real and imagined) and the identification of opportunities.

The initial portion of this assignment has dealt with the review of present systems and structures. From such a review comes the examination of the role the trees must play if they are to be considered an effective solution. The roles (of which there can be multiple) should be assessed against the landholders objectives, which can then be reconciled with commercial / practical efficiencies.

The revegetation design will need to allow for social, physical, production and financial factors to be integrated (Reid 1997a). The design needs to help people understand what their goals can be and how to achieve them. The design approach will need to be flexible as there are many, often conflicting, factors - a single approach will not produce a multiplicity of benefits. However, the identification of clear goals aids design; highlighting information gaps and helping tailor research.

Choosing a Promising Option

Oil Mallees and Maritime Pine show considerable potential as tree crops for the study area (AgWA *et al.* 1996b). The expansion of these ventures indicates that some landholders are interested in improving economic sustainability by increasing the amount of income that can be generated from the property, diversifying the sources of their income, or both. However, these tree crop options are not suitable for all soil types and revegetation purposes. Landholders are less interested in these broad area revegetation options at this stage, preferring to plant up areas that are perceived to be under immediate threat of environmental degrade (G. Mullan, pers. comm. 1999).

A variety of species (both potentially commercial and those with a principally nature conservation function) are being planted in the Wheatbelt, though sometimes with a scant understanding of their suitability (J Humphreys, pers. comm. 1999). Cremer (1990), also comments that many species lists have evolved as unsuccessful selections have been deleted.

There is scope for some smaller scale tree crop options such as sawn timber, fuelwood, posts and rails, furniture timber and broombush to be attempted. However, Greening Australia (1996), warns of the promotion of "wonder trees" and there are already a few notable examples of this e.g. the Paulownia tree, *Paulownia tomentosa* (Farm Forestry Advisory Service, 1998).

Swamp Sheoak (*Casuarina obesa*), the focus of this assignment, is one that has been reviewed locally by CALM (Wallace, 1992b) and as part of a species Search Program (J. Carslake, pers. comm. 1999) as having potential for commercial development as an agroforestry option.

Overview of the Selected Species

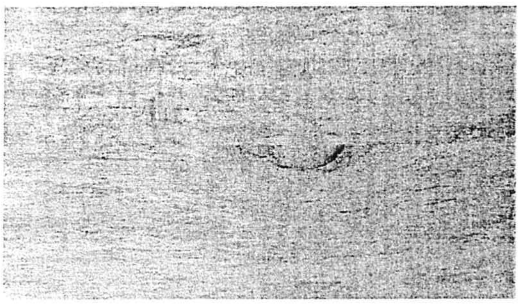
Casuarina obesa Miq. is a species native to southwestern Australia and is widely planted for revegetation purposes on semi saline and waterlogged land (Midgley, Turnbull, and Johnston 1981). The species is comprehensively described by Midgley *et al.* (1981); Marcar, Crawford, Leppert, Jovanivic, Floyd and Farrow (1995); and the Board on Science and Technology for International Development (1984), with an overview of the genus provided by Boland, Brooker, Chippendale, Hall, Hyland, Johnston, Kleinig and Turner (1984). Tree growth information in this assignment is largely anecdotal, though extrapolation may be possible from allied genera e.g. *Allocasuarina huegeliana*. Based on personal observation of the growth of this latter species, it may be possible for selected trees to reach a millable size in 20 - 25 years.

Criteria for screening species for development[1]

Indications that this species may be suited for promotion as a commercial species include;

- Timber qualities. Trial sawing and finishing work of *Casuarina obesa* by CALM (Siemon and Pitcher, 1994), indicated a timber of favourable qualities. A local cabinetmaker, who already uses a number of different *Allocasuarina* species, considers that there would be potential for this species to be introduced into cabinetwork. The coordinator of the Dwellingup School of Wood, indicated that light coloured native timbers (see fig 2) were not readily available and that imports from the Eastern States were necessary to satisfy demand (M. Harris, pers. comm. 1999).

Fig 2: Sample board of backsawn *Casuarina obesa*.



[1] This assignment focuses on the more traditional production of sawlog material. There has been no exploration of *Casuarina obesa* as a reconstituted material - primarily due to its limited coppicing ability. There may be scope for future studies to consider this species adaption to the phase farming concept.

- Levels of public interest. Public enquiries have been made to the Wheatbelt Development Commission (WDC) regarding the commercial possibilities of *Casuarina obesa* (C. Morrison, pers. comm. 1998). This is thought to be generated by the large numbers being planted for salinity control.
- Demand for seedlings. Of the 1.3 million seedlings produced at CALM's Wheatbelt Plant Nursery, 107,300 (8.2%) were *Casuarina obesa* (T. Sprigg, pers. comm. 1999). Though these seedlings are primarily for landcare planting (Midgley *et al.* 1981), this indicates a good level of familiarity and acceptance of this species. In comparison, the next most popular sheoak species (*Allocasuarina huegeliana)* only achieved demands of 11,200 seedlings (T. Sprigg, pers. comm. 1999).
- Mature size and habit. *Casuarina obesa* grows to a small tree of 14 m high, can be branchless for much of the bole and relatively straight (Midgley *et al.* 1981, BOSTID 1984).
- Natural occurrence, abundance and distribution. *Casuarina obesa* is a widespread species and generally abundant where it occurs (Midgley *et al.* 1981).
    - A widespread native species best meets environmental objectives of revegetation and is more likely to withstand natural disturbances (Wallace, 1992b).
    - A good natural abundance means that there is ample genetic material to select from for tree breeding work. It also means that research work is advantaged if a full range of genotypes is directly available (Wallace, 1992b).
    - With a widely distributed species, seed collection objectives are more easily achieved (J. Carslake, pers. comm. 1999). Populations of other target species located within remnant stands in the agricultural area are often found to be under threat from rising water tables and have poor seed crops (W. O'Sullivan, pers. comm. 1999).
    - A locally occurring species has far less chance of becoming a woody weed (Wallace, 1992b).
    - The unique character of local landscapes is more likely to be maintained (Hall and Brown 1968; Wallace, 1992b; Cremer, 1990) with the choice of a local species.
- Ease of seed collection. *Casuarina obesa* has persistent woody cones (Midgley *et al.* 1981; BOSTID, 1984), which are retained for several seasons, distinct from a species such as Needle Hakea (*Hakea preissii)* which has a collection "window" of about three weeks (M. Graham, pers. comm. 1998). According to Midgley *et al.* (1981), seed extraction is also a relatively straight forward process.
- Ease of propagation. Germination is rapid (T. Sprigg, pers. comm. 1999), with no need for any seed pre-treatment (Midgley *et al.* 1981). Midgley *et al.* (1981), reports the optimal germination temperature is relatively high (approaching 30°C), but this means the species is well suited for use in local climatic conditions, as described by Beard (1980).
- Easy establishment and acceptable growth rates. In general, *Casuarina* and *Allocasuarina* species establish well (Midgley *et al.* 1981) and are moderately fast growers (BOSTID, 1984).
- Environmental tolerances. *Casuarina* and *Allocasuarina* species are well documented as having excellent tolerances of a wide array of adverse environmental conditions (Midgley *et al.* 1981, BOSTID, 1984).
- Special attributes. *Casuarina obesa* is a nitrogen fixing plant (Midgley *et al.* 1981, BOSTID, 1984), which gives an initial advantage in establishment on depauperate sites (Midgley *et al.* 1981).

Timber qualities and characteristics

Compared with a mainstream forest species such as Jarrah (*Eucalyptus marginata*), relatively little is known about the timber qualities of *Casuarina obesa*. However, the timber of the other members of this genus (as well as the closely related *Allocasuarina*) is in high demand (Midgley *et al.* 1981, BOSTID, 1984).

CALM's Wheatbelt Regional office has a strong interest in the use of local species (Wallace, 1992b), and has had *Casuarina obesa* tested for a number of qualities, with the emphasis on its suitability for furniture and craft purposes (Siemon and Pitcher 1994). The examination of saw *C. obesa* timber revealed a light coloured timber that was somewhat uncharacteristic compared with other members of this family according to Boland *et al.* (1984). However, the timber was stable, worked and finished well and readily accepted gluing (Siemon and Pitcher, 1994).

Possibilities may exist for flooring timber (Bulman, 1995), if material is available in sufficient quantity and can be grown to an adequate dimension (D. Donnelly, pers. comm. 1998). Anecdotal information is also available, suggesting this species suitability for tool handle manufacture.

Casuarina obesa is known for its firewood quality (Marcar *et al.* 1995; Midgley *et al.* 1981; BOSTID, 1984). This species has also recently been incorporated into a CALM fence post trial (G. Brennan, pers. comm. 1998).

Establishment

Effective establishment is fundamental to the success of any planting (Fremlin, 1997). Effective first and second year weed control has also proven to reduce mortality but, significantly, to improve growth rates also. A basic establishment prescription based on Fremlin (1997), and personal experience, can be found in Appendix 2.

Site selection and soil types

Casuarina obesa occurs naturally in lowlying areas that are subject to seasonal inundation (Midgley *et al.*, 1981). Soils for this species are highly variable, ranging from grey clay to a duplex sand over clay (Midgley *et al.*, 1981). Preference would be for a gradational soil e.g. a clay loam grading into a medium clay (Cremer, 1990), for several reasons. It is an easier soil type to prepare and seedlings have less problems than if planted on shallow duplex soil (Cremer, 1990). Planting is also much easier (D. M^c^Fall, pers. comm. 1999). However, heavier textured clays would also be acceptable (BOSTID, 1984).

Though tolerant of levels of waterlogging and salinity, Marcar *et al.* (1995), indicate that growth rates are reduced when salinity levels reach 10 - 15dS/m (150 - 200 mS/m using an EM38). Using the EM38 in its horizontal position, a suggested upper limit is 150 mS/m (Marcar *et al.*, 1995).

Access to planted areas is an important issue for site selection. This, and other considerations, are outlined in Washusen and Reid (1996).

Layout

Numerous texts have been written on design and layout of tree crops e.g. Washusen and Reid (1996), Race (1993), and Bird *et al.*, (1996). Poorly designed and managed agroforestry layouts will cause management problems and productivity losses (Reid, 1990). Bulman (1995) details the relative merits of clumps, belts, blocks and wide spaced agroforests.

However, field observations (see fig 3) indicate that trees growing near gaps may not be able to maintain the required form. As a cautionary approach, rectangular or square plantations have been nominated by the author as being most appropriate for this species.

Fig 3: *Casuarina obesa* leaning into canopy opening

Access through fences on long linear plantings may be difficult and the need for space when falling trees may complicate silvicultural operations. Block plantings that could be heavily thinned may be preferable to alley systems, but this would still permit agroforestry practices i.e. grazing. *Casuarina obesa* is a highly palatable species (Midgley *et al.* 1981; Bird *et al.* 1996), and fencing sheep out in an alley system would be a major cost (Race, 1993). Block plantings would also minimize the edge effect that would be reflected in reduced pruning costs (Bird *et al.* 1996; Bulman, 1995).

Propagation material

It appears that *Casuarina obesa* has not been considered previously for a tree-breeding program. Therefore, initial seed collections would need to be from well-selected trees in wild populations (Midgley *et al.* 1981). Barbour (1997), points out the advantages of tree breeding work and indicates that every effort should be made to secure the best seed stock. Race (1993) details guidelines for selection of superior trees targeted for seed collection.

Silvicultural Management

The initial approach would be to favour a pure stand, rather than a mixture of species. Midgley *et al.*, (1981), indicates that this species tolerates full sun, doesn't need a nurse crop (Boland *et al.* 1984) and that growth rates may be compromised by the presence of other species.

Target tree specifications

Information inferred from the literature (Midgley *et al.* 1981), and observations of naturally occurring specimens, log diameters of 360 - 400mm+ and 5m in length are possible (log volumes of approximately $0.5m^3$; see end of Appendix 4). Pruning and thinning will be needed to attain these sizes (Reid, 1997b), though suggestions about wood features from a local cabinet maker indicated that the presence of some knots may add to the value to the saw product (S. Samulkiewicz, pers. comm. 1998).

Yields per hectare are affected by initial tree stocking and thinning regimes (Reid, 1997b). However, recent field observations and comments by Bird *et al.* (1996), indicate that initial wide spacing will not control tree form sufficiently well.

Planting density

Race (1993), indicates that planting densities as low as 209 stems per hectare (6m x 8m spacing) have been used. Reid (1997b), argues that establishment costs are greater for higher density plantings and that aiming for a lower density planting is cost effective. Race (1993), however, comments that most Casuarinas occur in forest stands and generally exhibit poor form when open grown. *Casuarina obesa* can be targeted by grazing animals, with Race (1993), commenting on rabbit browsing damage, with Bird *et al.* (1996) and Marcar *et al.* (1995), referring to sheep damage. Grey kangaroos and Port Linlcon parrots have also been observed inflicting damage on newly established *C. obesa* seedlings (W. O'Sullivan, pers. comm. 1999). A high planting density offers much more selection choice for final crop trees (Bird *et al.* 1996). There is also the opportunity to sell the early thinnings.

In addition a higher planting density may improve the potential water table drawdown in the earlier years of the plantation (Race, 1993). A higher establishment density of 1111stems per hectare (3m x 3m spacing) has been chosen for this assignment.

Pruning

Pruning is necessary to produce high quality sawlogs (Hingston, 1997; Reid, 1997b). However, in producing feature grade wood with minimal load bearing capacity, some knots may be permitted (Rotheram, 1997). It is difficult to gauge the quality of *Casuarina obesa* timber with or without pruning. However, form pruning to remove the worst faults appears to be a suitable option (Bird *et al.* 1996). A proposed pruning schedule is outlined in Table 3. Depending on subsequent branch development, pruning should be instigated to maintain a knotty core of < 100mm (Hingston, 1997). *Casuarina obesa* is not recognised as developing heavy limbs, nor is it known if higher fertility sites will promote excessive branching and "speed wobbles" as happens with *Pinus radiata* (Washusen and Reid, 1996). Low pruning will also improve access into the plantation (Race, 1993) and can minimise the fire hazard (Cremer, 1990).

Table 3: Suggested pruning regime[2] (adapted from Bird *et al.* 1996)

Age (years)	Pruning requirement
2	taking out multiple leaders and larger lower branches
5	taking out multiple leaders and larger lower branches
9	prune up to 50% in height of retained crop trees
12	prune up to 50% in height of retained crop trees
18	prune up to 50% in height of retained crop trees (if necessary)

Debris from pruning may be left to deteriorate. As *Casuarina obesa* is very palatable to stock (Marcar *et al.* 1995), sheep could be introduced (depending on bark thickness and tree height) to reduce the fire hazard (Cremer, 1990). Pruning can be done with secateurs and long handled loppers or long handle pruning poles (Hingston, 1997). The length of bole required in the finished product will negate the use of ladders or cherry pickers.

Thinning

Early thinnings may yield material of fence post dimension or the stand may be thinned to waste (Washusen and Reid, 1996). Later thinnings may also be treatable as posts and provide fuelwood. Suggested thinning practice would be felling with a chainsaw and full length extraction, with a tractor. Alternately, the useful material could be cut up *in situ*, the log material snigged out and the crowns allowed to deteriorate. This final decision on harvesting practice will depend on the value of the wood residue, the grazing requirements, or the assessment of any fire hazard.

[2] nb: periodic pruning may be necessary at other times depending on circumstances, e.g. parrot damaged stems

Table 4 is a suggested thinning regime based on the Spacing Factor technique as described by Reid (1997b).

Table 4: Suggested thinning regime (adapted from Reid, 1997b)

Age (years)	Thinning requirement
Y 0	Planted to 1111s/ha or 3m x 3m spacing
Y 9	The trees average 15cm diameter and are starting to compete. The stand is thinned to 500s/ha or a 4.5m x 4.5m spacing
Y 12	The trees average 22cm diameter and are again starting to compete. The stand is thinned to 250s/ha or 6.3m x 6.3m spacing
Y 18	The trees are again in competition having reached 32cm diameter. The stand is thinned to 100s/ha or a 10m x 10m spacing.
	No further thinning is necessary under this schedule to maintain good tree growth up to the end of the rotation.

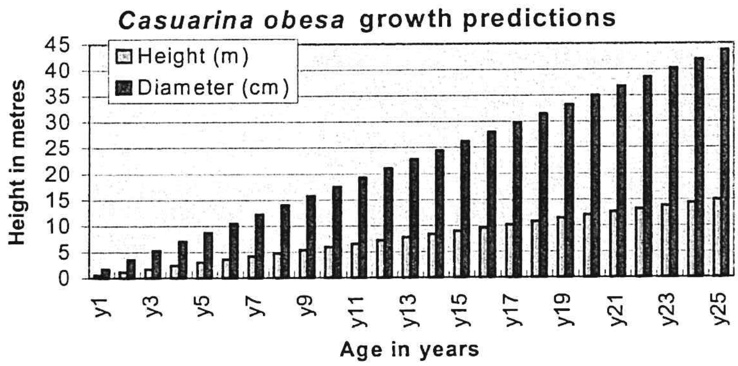
A second option of an initial heavier thinning to 250s/ha will yield a greater portion of wood earlier in the life of the project, and hence an earlier return to the grower (Reid, 1997c). This approach also has the effect of reducing the cost of pruning an additional 250 trees (see Option 2, Page 26).

Fig 4. High density stand resulting from natural regeneration, Toolibin Lake floor (see appendix 4)

Growth Predictions

Measurements of trees of known ages indicate that the sizes nominated in the graph are feasible (fig. 5). The shape of the graph represents the assumption that height and diameter growth can be maintained, providing the stand is thinned appropriately. The raw data for this graph is in Appendix 3.[3]

Fig. 5: Volume / ha has been calculated at age 9 at being $39m^3$/ha giving a MAI of $4.4m^3$/ha/an.



[3] Nb figures from recent measurements (Appendix 6) indicate initial height growth rates exceeding predicted levels.

Production

Based on the thinning regime outlined in Table 4, it may be possible to harvest 47m^3 of fencing material and 70m^3 of sawlogs. Volume calculations (Table 5) include the use of a nominal Form Factor to take into account predicted log taper.

Table 5: Expected round timber volume production

Age	Bole (m)	L.E.D. (mm)	Volume (m3)	m^3 x Form Factor (0.8)	Stems / thinning	Product: fencing	Product: sawlogs	Total m^3
9	2	157.5	0.04	0.03	600	18.69		18.69
12	4	210	0.14	0.11	250	27.69		27.69
18	5	315	0.39	0.31	150		46.73	46.73
25	5	437.5	0.75	0.60	100		60.10	60.10
						46.38	106.83	**153.21**

Returns.

Extrapolating from the range of stumpages paid for other species (Bulman, 1995), a figure of approximately $70/m^3 may be achieved. This is an estimate only as this species has not been proven in the market place. Returns could be higher for certified pruned stands, as buyers would be assured of the quality of the timber that they are purchasing (Agroforestry News, 1996). Stems produced from a properly managed stand are more likely to be defect free than forest grown trees and a higher price for log material should result to reflect the greater return during the milling process.

For some species of *Allocasuarina*, prices of sawn seasoned timber have been as high as $1800/m^3 (R. Gobby, pers. comm. 1998). If this species is suitable as a flooring material (Bulman, 1995), then returns could reach the equivalent of $8000/m^3.

Two thinning options have been assessed to see what differences there may be in returns to growers. The first option is to thin to 500 s/ha at age nine; the second it to thin to 250 s/ha at age nine. Early heavy thinning as shown in Table 6 has the effect of increasing the Internal Rate of Return (IRR), as there is a greater cash flow earlier in the life of the planting (Reid, 1997c). Although the Annuity Equivalent is less with the second option, the increase in IRR and the reduction in labour requirements over the life of the planting, make it a realistic choice (Reid, 1997c). Selling the thinnings is crucial to either option.

An uncertainty in choosing Option 2 lies in the increased exposure of the remaining tree due the heavy thinning (Cremer, 1990). This thinning may result in excessive crown development, requiring heavy, additional pruning to maintain form (Cremer, 1990). Windthrow in heavily thinned stands may be a problem in the year of thinning (Cremer, 1990).

Table 6: Two silvicultural options with three discount rates

Option 1: Standard prescription			Option 2: Heavy early thinning		
Discount rate %	NPV	Ann. Equ	Discount rate %	NPV	Ann. Equ
5	$2719	$184	5	$1858	$123
6	**$2196**[4]	**$162**	**6**	**$1431**	**$104**
7	$1762	$141	7	$1083	$86
MAI	6.13		MAI	5.29	
IRR %	**7.77**[5]		IRR %	**10.77**	

Three price alterations were also assessed to determine the greatest return to the grower. The returns were arbitrarily increased for all products; $2 - $3 ea. for fenceposts, $50 - $70 / m^3 for small sawlogs and $70 - $100 / m^3 for larger sawlogs. The results, as shown in Table 7, indicate an increase in IRR for all products, with the most significant being for increased thinning for fencing material. Option 2 showed a slightly higher IRR for increased small sawlog prices, than if the returns for the final crop improved from $70 - $100 / m^3.

Table 7: Comparison of effects of improved commodity prices on the financial returns of two thinning options.

	Opt'n 1: St'd presc.			Opt'n 2: Heavy early thin		
(Discount rate 6%)	NPV	Ann.	IRR	NPV	Ann.	IRR
posts from $2 - $3 ea.	$3065	$226	9.7%	$1960	$142	12.9%
small s/log price from $50 - $70	$2524	$186	7.8%	$1758	$128	11.5%
final s/log price from $70 - $100	$2616	$193	8.9%	$1851	$134	11.4%

Management

Ongoing management includes the control of grazing, fire, insects and weeds (Cremer, 1990). *Casuarina obesa* is highly intolerant of fire, though in its natural occurrence it recovers well by regeneration from seed (Midgley *et al.* 1981). As many of these plantings may occur in conjunction with (or in the midst of) general landcare plantings, fire would normally be excluded for many years as grazing may be used to reduce the fuel load. Significant insect problems have not been recorded with this species (Marcar *et al.* 1995). However, recent personal observation of young trees, indicated that some tip damage is occurring, via an unknown vector (insects?) which is resulting in multi-stemmed plants. The Australian Plague Locust has also been observed to damage *C. obesa,* sometimes killing seedlings, though mature plants generally make a rapid recovery.

Site disturbance may induce root suckering (Midgley *et al.* 1980), which could represent a two-fold problem. Firstly, multiple additional stems may form a barrier to access during harvest (BOSTID 1984); secondly, this growth may divert resources away from the primary stem.

[4] See Appendix 5 for Net Present Value calculations
[5] See Appendix 6 for Internal Rates of Return calculations

Harvesting and Processing

CALM's Code of Practice for Timber Harvesting (CALM, 1999), provides useful guidelines for many aspects of farm forestry work including; protection of crop trees during thinning operations, minimising soil damage if harvesting in wet soil conditions, protection of riparian areas and summer harvesting restrictions.

Winter harvesting operations are favoured for most aspects of harvesting as the cooler conditions appear to offer several advantages over the summer months. Fire ceases to be a problem and the end-checking of logs is minimised. This reduces the need for end coating of logs with preservative. Bark removal is also easier during times of high wood moisture levels (Cremer, 1990). Access to lowlying areas is the only major disadvantage foreseen. However, unless the market is for a one-off supply, a consistent supply to the mill would be an overriding consideration (Race, 1993).

Costs of harvesting and haulage to market are an area of speculation as no industry exists in the study area. It is possible that the present Brown Mallet harvesting contractors will expand into other crops. Harvesting and processing may also be done at a farm level, with some existing farm equipment and portable mills (Cremer, 1990). Selling wood in the standing form is the easiest option for the grower but gives the lowest return (Bulman, 1995). Increased returns are possible if the grower lands the round timber at the mill door (Bulman, 1995). The greatest return to a grower is to do as much processing as possible on farm, even to the point of seasoning the timber (Race, 1993). Higher value logs are less affected by transport distance (Race, 1993; Washusen and Reid, 1993). Sawn material can withstand transport costs over longer distances and can be delivered to a wider range of buyers (Race, 1993).

Marketing Agreements

Oates and Clarke (1987), have produced a checklist for selling timber that may benefit prospective growers in their decision making process.

1. Advance contracts of sale would be preferable as this takes away much of the risk (Race, 1993). However, the actual harvest price would remain uncertain, and these contracts are generally restricted to large-scale industry (Race, 1993).
2. Private marketing negotiation close to when the timber is ready for harvesting is another option, but it requires a good knowledge of markets and trends (Race, 1993).
3. Sale by auction is a system that has been used by small timber producers (Bulman, 1995).

Potential growers also need to consider State Government regulations which cover the supply of log material to sawmills that receive timber from Crown land (CALM, 1993; CALM, 1999).

Opportunities for joint ventures

At present, no joint ventures appear to exist for this species, and with this level of uncertainty, it is unlikely that a project of this nature would attract a major investor. Annuities, which have provided incentives for growers of other species, are not available for this tree crop. Public monies at a State level also tend to be directed to larger scale developments (Olsen 2001). Smaller private investors may choose to become involved, but in either instance it will need the development of suitable Farm Forestry Legislation (GA, 1996), to assure access to the tree crop.

Industry Potential and Development

Waugh (1996) suggests good opportunities lie with hardwood appearance grade products. However in addition to producing timber for furniture or cabinet work, the best prospects may be for the production of flooring material. The world market for timber flooring material is expanding at the rate of around 3%pa (T. Jones, pers. comm. 2000), with a strong emphasis on lighter coloured timbers. The example of the local mill switching its emphasis from general purpose milling to cutting specialized flooring material could be seen to support this view. Race and Curtis (1997) indicate the necessity for the processing to occur within the area where the farm forestry activity occurs for communities to achieve the maximum benefit.

The 107,300 seedlings of *Casuarina obesa* sold by CALM Narrogin nursery in 1998 represents nearly 100ha of established trees (@ 1111 s/ha). If only 50% of the *C. obesa* numbers were targeted onto better soil types and managed appropriately, there is the potential to generate around 7600 m^3 of sawlogs and posts, conservatively worth $378 000. Value adding to the saw component derived from this 50ha of planting (@ $1800/$m^3$) means the possibility of generating over $3,365,000 from one years planting. If even 5% (39250ha) of the study area was suitable for planting with this species (a conservative estimate), these figures extrapolate to $2,641,525,000.

Cooperatives have the potential to assist in the coordination of supply to industry and may be effective in securing better pricing arrangements for growers (Race and Curtis 1997). If local support could be garnered, an approach may be made to the Wheatbelt Development Commission for assistance. The WDC has access to funding opportunities as well as networks to assist with starting new co-operatives or linking with existing ones (C. Morrison, pers. comm. 1999). Any local group would have to show commitment in money, materials and / or time to match incoming funding. Based on the progress of the Oil Mallee program, opportunities exist for the development of cooperative ventures to succeed locally (C. Morrison, pers. comm. 1999). The Australian Forest Growers now publishes a free "Cooperatives" newsletter and has published a "Starter Kit" for new cooperatives (AFG, 1999).

Additional support funding may be available from Rural Industries Research and Development Corporation or through the Natural Heritage Trust. Given the potential economic value to the Wheatbelt and its higher nature conservation outcomes, this may be a project that an organisation such as CALM could pursue. However, in the short term, to promote the growing of *Casuarina obesa* beyond its present general revegetation purpose, it will require an industry "Champion" to emerge. Personal observations and sources such as Guijt *et al.* (1998), indicate that key individuals are needed to promote the potential of a tree crop. This could be a farmer grower, someone within a statutory authority or even an end user.

Factors Influencing Landholders Acceptance of Options

As described by Alexandra and Hall (1996), cited in Greening Australia (1996), there are cultural, economic and public policy impediments to the adoption of farm forestry which need consideration, which are listed in an abbreviated form in Table 8.

Table 8: Impediments to Farm Forestry; adapted from GA (1996).

Cultural	Economic	Public policy
Lack of farm forestry culture - amongst farmers ,	Lack of transparent pricing	Taxation and superannuation
Agriculturists and forester professionals	Long term risk and uncertainty - growers and processors	Distorted markets
Lack of farm forestry culture - amongst state agencies	Differences in scale - independent growers to industrial processors and economies of scale	Infrastructure and transport efficiencies
Poor knowledge to support farm forestry	Lack of wood flow plans	Export controls and codes of practice
Few structured or formal means of progressing farm forestry knowledge	No markets for environmental services - lack of cost sharing frameworks	Landuse controls and planning
A lack of regional farm forestry inventories - knowledge impediment	Industrial forestry companies changing their investments	Tree tenure - lack of clear definition of title to plantations
	Economies of scale - contractors	Overcoming risk and uncertainty for investors
		Landuse controls, uncertain planning and codes of practice

The proponents of forestry and agroforestry programs invariably have a clear notion of the multitude of benefits that can be derived. However, this "vision" is not always shared by the farming community (Reid, 1998). Discussions with co workers and farmers in the local area highlighted what several practitioners saw as important issues.

- Economic considerations

  The economical viability of agriculture in many parts of this region is under severe pressure due to declining commodity prices (K. Parnell, pers. comm. 2000). Consecutive severe frosts have exacerbated this problem for many farmers. Farming margins are very tight (K. Parnell, pers. comm. 2000), and in general, farmers are interested in crops that give a return in the first year of establishment (G. Mullan, pers. comm. 1999).

  Under these circumstances, farmers are less likely to accept such a program with such uncertainty over such a long period (GA, 1996). Proving the economic viability of agroforestry options will be necessary to entice farmers to plant, in particular on the better quality land (D. M[c]Fall, A. Baxter, W. O' Sullivan, pers comm. 1999).

There is a trend for revegetation programs to be supported by grants from funding bodies such as the Natural Heritage Trust (G. Mullan, pers comm 1999). The guidelines for these endeavors (primarily funded through the Bushcare component) do not support the establishment of commercially prospective species (NHT 1998).

- Competition with existing agricultural activities
  The prior land use figure chosen for the economic evaluation in this assignment is comparatively low, even for this rainfall and reflects the value of somewhat waterlogged and salinised land. With the advent of better salt land pastures in recent years (Latta, Casson and Carr, 1999), these sites may regain (or exceed) their previous agricultural productivity. It may be however, that adding a tree component to the pasture may enable the system to become even more productive.

- Cultural change
  The rotation length for *Casuarina obesa* plantings is often a longer period than many of the local farmers have actually been farming (K. Parnell, pers. comm. 2000). It is considered to be easier for landholders to embrace improvements to an existing system than adopt something completely new (K. Parnell, pers. comm. 2000).

  Notwithstanding this, there are examples of new technology and methodology which has been readily adopted in agricultural area e.g. minimum tillage for crop establishment. The 12 million oil mallees which have been established in the last few years are a statement that adoption and integration of new systems is possible. The opportunity to diversify farm income may be a sufficient attraction.

- Labour availability
  In my discussions with farmers, very few have indicated a desire to take on more work. *Casuarina obesa* woodlots however, require time for the implementation of the management regimes.

  Access to trained local contractors, which could resolve this problem, is very limited at this stage. However, this may alter as tree numbers increase. Having well developed prescriptions for management, access to demonstration plantings and some certainty in markets could change growers view as to how they spend their time.

- Knowledge
  Poor knowledge of farm forestry principles and practices may deter landholders (GA, 1996), and the success of future ventures may be compromised (R. Johnston, pers. comm. 1999). Good prescription for growing trees would need to be available to potential growers (K. Parnell, pers. comm. 2000). It would need to be demonstrated that successful commercial establishment of *Casuarina obesa,* as distinct from traditional landcare plantings, could be done with little additional effort. The promotion of learning opportunities such as the Master Tree Growers course may encourage growers to pursue agroforestry options with more confidence.

- Fencing
  In the broad acre farming which occurs in the study area, fencing is a big issue; mainly the cost but also the time taken for construction (K. Parnell, pers. comm. 2000). *Casuarina obesa* plantings would need to be aligned within fenced areas, or be within a paddock that has been excluded from the grazing regime for several years.

Research, Development and Extension

The Farm Forestry Task Force (1995), highlights continued research into new commercial species for tree crops in the drier agricultural area as a pressing need. A considerable amount of research has gone into this and other recent farm forestry assignments, which are focused on revegetation prospects for this area. However, there is still need for a critical appraisal of this information, plus a thorough literature review before a research program could commence. Aspects to be considered are included in Appendix 7.

To be effective, the components of research need to be in priority order and in proportion. Bartle (1999a) outlines a development process which has been used for other industries and appears appropriate for *Casuarina obesa.* Priorities for research may be established by evaluating the perceived and actual limiting factors to adoption of allied projects. For example, one of the stated reasons by farmers for the limited adoption of oil mallees in the study area is the slow pace of research and development of the harvesting and processing systems (G. Mullan, pers. comm. 1999).

Product development is a significant step in testing the research and providing material for extension work. At this stage, very little prepared timber is available for viewing or use by potentially interested parties. Recently, the South East Forest Foundation (SEFF) had the same problem with *Pinus pinaster* (R. Johnston, pers. comm. 1999). SEFF overcame this problem by milling locally grown *P. pinaster* and supplying seasoned timber to local cabinetmakers and craftwood specialists. The products manufactured from this material have been successfully displayed at local shows, considerably raising the profile of this species in this area (R. Johnston, pers. comm. 1999). A similar exercise using *Casuarina obesa* was suggested for the study area.

A good extension model is needed to convey the results of research and development. Extension models as outlined by Fell (1997), have progressed through four stages; Transfer of Technology, the Resource Model of extension, Participative Action Model and finally the Farmer First Model. Establishment of an Agroforestry demonstration project is considered by Irwin and Rietveld (1997), as being an efficient way to increase public awareness, promote landholder adoption and obtain stakeholder support. Various aspects of research could be incorporated into such a planting. However, Vanclay & Lawrence (1995) highlight a number of cases where seemingly good research was not adopted by landholders, underlining the importance of the Design and Diagnose approach (Reid 1997a).

Discussion

For a new tree crop option to be accepted and developed, it must function well at many levels (Bartle 1999b). *Casuarina obesa* is a species with many attributes. It is already widely planted in this part of the Wheatbelt as an adaptable species, capable of maintaining good growth rates under adverse site conditions. It is well suited for revegetating salinized, waterlogged sites which have developed (and are likely to continue to emerge) in the Wheatbelt. The vigour of *Casuarina obesa,* and its demonstrated resilience to fluctuating environmental conditions, means it is likely to survive over the longer-term of its rotation - much more so than a range of other tree crop options from higher rainfall / higher site tolerance requirements. Its status as a local species means a consequential low risk of weediness, which has implications both on and off the farming property. The availability of this species obviates the need to bring in additional species from interstate or overseas.

Hence on a broader level, the planting of *Casuarina obesa* meets many stakeholder requirements. There also appears acknowledgment that this species is meeting farming revegetation and management goals. Using the nursery production figures shown in this document as a guide and comments from individuals, it would indicate that *Casuarina obesa* is already widely recognised by farmers and revegetation promoters.

Casuarina obesa could be judged to fit in well with present agricultural operations - give that it is mainly lower value (salinised / waterlogged) land that is set aside for tree planting K. Parnell, pers. comm. 1999). With the potential (uncertain) for heavier branch development in open grown stands and this species palatability to sheep, it is not likely to be used as an alley farming species i.e. more suited to block planting configurations. In the formative years of tree crop development, with only access to unimproved seed, it would be advisable to keep plantings to a block formation; which are a style common in the Wheatbelt. If alternative pasture species are being established at the same time, these will also need to be protected from grazing, so complementary systems could be developed. Any need for more accurate spacing between trees for plantation purposes would not cause problems during the establishment phase.

Susceptibility to browsing pressure from kangaroos and parrots may mean that growing this species would represent a greater challenge than that for other tree crops. Control measures for problem animal species are available, but thought should be given to the strategic siting of plantings away from paddock trees and stands of remnant vegetation.

The acceptance of the silvicultural requirements may not be as overwhelming as first thought. The level of pubic inquiry noted in this report, regarding the direct commercial possibilities of this species also indicates sound levels of interest from growers and potential growers. The availability of silvicultural prescriptions would further simplify management. Silvicultural considerations e.g. pruning, may require increased management input, but don't necessarily make the systems any more complicated. Initial selection from wild populations of smaller branched trees and favourable outcomes from any tree breeding work could alleviate some of the management burden.

The establishment of this and other species in farm forestry options may herald the arrival of professional managers who could organise these tasks, making tree establishment and management simpler for the grower. A clear demonstration of the commercial opportunities could also foster the necessary farm forestry culture; the predicted returns from this species would also be an incentive for timely management.

Adoption could be hastened by the identification of specific groups of landholders that should be targeted for initial development work - it may be the smaller landholder (hobbyists) that have external income sources and are the type of growers who would find these sorts of tree crops and investment opportunities acceptable (Race 1999).

Casuarina obesa is as cheap to establish as any other species presently used for revegetation or plantation work (depending on stocking rates). High rates of post planting survival mean that costly infill is rarely warranted. Planting at higher stand densities may increase initial costs slightly, (Reid 1997c) but would give much more choice in the selection of crop trees. An early culling regime could then be applied to minimise future pruning costs. Fencing, in many instances, may not be an extra cost as it is usually being done for the entire project - not just for a *Casuarina obesa* component. *Casuarina obesa* plantings could be aligned within existing fenced areas, or be within a paddock that has been excluded from the grazing regime for several years.

The sale of early thinnings is an important part of the IRR forecast for this species. However, if farmers have to fund such establishment work unassisted, this return may not be early enough. An alternative is that a mixture of species is planted in any one year, for example using oil mallees as a support species, which could help to satisfy the short term return requirement. This underlines the need to assess individual grower requirements. Nevertheless, is clear by the quantity of seedlings of this species that are being planted, that these returns are either not important or are being realised in another manner (e.g. the landcare benefits are sufficient.).

On a more positive note, parts of the earlier section of this assignment have been already incorporated into another project which also analysed the value of bush products (Safstrom pers. comm. 2001).

The information in this assignment, though based on empirical and anecdotal data has been selected and analysed carefully. Some inferences on growth performance have been gleaned from observations and readings of allied species. Where there has been a dearth of information, accepted silvicultural techniques (basic principles) have been adopted. As can be seen from the growth information in Appendix 4, initial application of the principles outlined in this document has seen some good results. Development of an interim growers manual based on this assignment and these earlier recordings could also provide the necessary encouragement for adoption.

It is still evident, however, that there are a number of impediments to the wholesale adoption of this species as an agroforestry species. Based on the previous discussion, recognition and acceptance of the species and the roles it can fulfill could be viewed as less of a problem than research into markets and end products. There is some good cause to be optimistic in the light of statements regarding the size of markets (T. Jones pers. comm.) and current timber demand trends on a global level (ABARE and JP, 1999). However, there is no clear developmental pathway presently available for this species, only some trial prescriptions and limited observations. It is not at the forefront of any breeding program, the intended log size and suggested management is based on empirical data and the species is dismissed as its timber being somehow inferior to that of other sheoaks. i.e. lacking the distinctive featuring of other members of the genus[6].

Though there is evidence of historic use and one report on timber properties exists, very little product has been developed. At present, there appears to be small markets for sawn timber, floor panels and fenceposts at a domestic level. Indeed, much of the domestic utilization has been of windthrows for craftwood. This does not give a particularly good indication of what the timber quality of a well grown plantation specimen may be like. There has been no attempt to convince either growers or buyers that *Casuarina obesa* would be suited to large scale investment.

In the light of current economic forecasts for agriculture, an untested tree crop such as *Casuarina obesa* may find little support - despite the pressing need. In addition, the majority of newer tree crops for dryland areas appear to be slanted towards reconstituted woods and biomass production (Olsen 2000). Uncertainty about tree growth rates and management requirements may reduce its attractiveness, as will doubts about selling thinnings. Despite its outward attractiveness on many other fronts, the promotion of *C. obesa* may languish due to a lack of research and commercial development.

[6] This often cited argument fails to take into account that the probable large scale end use of *Casuarina obesa*, i.e. flooring material, is one which requires lighter coloured woods with less feature.

Conclusion

Revegetation has the potential to supply multiple social and economic benefits to farmers, the rural community and the state as a whole. Many of the present forms of land degradation may be successfully addressed and a good profit still derived from the land. The demand for wood products, locally and internationally, appears to be increasing. At the same time, supplies from native forest areas are likely to reduce. Alternative sources are required and Farm Forestry has been identified as an important source of future wood supplies. The challenge is to work with landowners in designing systems and providing well researched options that satisfy immediate needs and concerns while incorporating an appropriate, long term, vision.

It is also recognised that limited tree crop options exist for the study area and that there is scope to investigate additional species. *Casuarina obesa* is a well-known local species and is widely planted by landholders. Given the outlook for the increasing risk of secondary salinity in Western Australia, it is likely that demand for *C. obesa* seedlings will continue. *Casuarina obesa* could be used as a complimentary component in agroforestry systems that are designed for mildly salinised land. It has the potential to be an integral part of the species selected for agroforestry development in the study area, supplying a range of wood products.

Casuarina obesa meets many nature conservation criteria as well as exhibiting an array of other attributes. Few, if any other species for the medium rainfall areas display such versatility. As a species, it presents well as one for which further research and investigation is warranted.

References

1. Agriculture Western Australia (1998). Revegetation of Farms Information Kit: Eucalyptus Oil Mallees.
2. Agriculture Western Australia (1999). Revegetation of Farms Information Kit: Maritime Pine in Western Australia.
3. Agriculture Western Australia, Department of Conservation and Land Management, Department of Environmental Protection and the Waters and Rivers Commission. A report to the Minister of Primary Industry and the Minister for the Environment. (1996a). Salinity, a situation statement for Western Australia
4. Agriculture Western Australia, Department of Conservation and Land Management, Department of Environmental Protection and the Waters and Rivers Commission for the Government of Western Australia (1996b). Western Australian Salinity Action Plan
5. Agroforestry News. Vol. 5, Issue 3, September 1996. pp. 18-19, Pruned Stand Certification.
6. Australian Bureau of Agricultural and Resource Economics and Jaakko Poyry (1999). Global Outlook for Plantations, ABARE Research Report 99.9, Canberra.
7. Australian Forest Growers (1999). Getting Started in Farm Forestry, Plant Trees for Profit.
8. Bailey, C., M^c^Namara, K. and Shea, S. (1997). Halt the Salt! pp. 10 - 17, Landscope Volume 13, N°. 1, Spring 1997. Department of Conservation and Land Management.
9. Barbour, L. (1997). Tree Breeding and Genetic Deployment. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.
10. Bartle. J. (1997, 1998). Personal communication. Manager, Farm Forestry Unit. Department of Conservation and Land Management.
11. Bartle, J. and Reeves. R. (1992). Promising Products Derived from Woody Species. RIRDC / WRRDC Planning Workshop on Low Rainfall Agroforestry, Perth
12. Bartle, J. B. (1991). Revegetating the Farm: How Big is the Job. Land and Water Research News. Issue N°. 13.
13. Bartle, J. B., Campbell, C., White, G. (1996). Can Trees Reverse Land Degradation. A paper delivered at the Australian Forest Growers Conference, Mt. Gambier S. A. 1996.
14. Bartle, J. (1999a) The New Hydrology: New Challenges for Landcare and Tree Crops. WA BankWest Landcare Conference - "Where Community Counts". Esperance, 8th - 10th September 1999.
15. Bartle, J. (1999b) New Woody Plant Crops for the Wheatbelt. Paper presented to Greenskills, Denmark W.A. 1999.
16. Barton, A. and Greening, B. (1998). Chemical Properties of High Cineole Eucalyptus Oil, Part one; Cineole and Industrial Solvents. Dinkum Oil Newsletter, Issue 11, November 1998.
17. Baxter, A. and O' Sullivan, W. (1998). Toolibin Melaleuca Alley Farming Trial, Seed Production Area and Direct Seeding Demonstration. Report on Year 1. January 1998. Department of Conservation and Land Management. Unpublished Report.
18. Baxter, A. Personal communication (1999). Landcare Technician, Narrogin.
19. Beard, J.S. (1979). Vegetation Survey of Western Australia; The Vegetation of the Corrigin Area, Map and Explanatory Memoir, 1:250,000, Vegmap Publications Perth.
20. Berney, J. and Rado, A. (1999). A Crop of Forests. pp. 40-44, Landscope Volume 15, N°. 1, Spring 1999, Department of Conservation and Land Management.
21. Bessell-Browne, P. & W. Personal communication (1999). Farmers, Woodanilling Shire.
22. Bicknell, D. (1991). The role of trees in providing shelter and controlling erosion in the dry temperate and semi-arid southern agricultural areas of Western Australia. The Role of Trees in Sustainable Agriculture: A National Conference, 30 September - 3 October 1991.
23. Bird, P. R., Jowett, D. W., Kellas, J. D. and Kearney, G. A. (1996). Farm Forestry Clearwood Production - a Manual for South Eastern Australia.
24. Board on Science and Technology for International Development (1984).

Innovations in Tropical Reforestation, Casuarinas: Nitrogen-fixing trees For Adverse Sites. Office of International Affairs, National Research Council. National Academy Press. Washington, D. C..

25. Boland, D. J., Brooker, M. I. H., Chippendale, G. M., Hall, N., Hyland, B. P. M., Johnston, R. D., Kleinig, D. A. and Turner, J. D. (1984). Forest Trees of Australia. Australian Government Publishing Service.

26. Bott, G., Humphries, R. (1997). Algal and Nutrient Management of River Basins - a Review of Current Approaches. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course. Farm Planning and Sustainable Management. Boyup Brook

27. Bradshaw, F.J. (1999). Trends in Silvicultural Practices in the Native Forests of Western Australia. Australian Forestry Volume 62, N°. 3, September 1999.

28. Brand, J. Personal communication (1998). Research Scientist, Sandalwood. CALM.

29. Brennan, G. K. (1993). Preservation of Round Timber Products, Wood Utilization Research Centre Report N°. 21. Conservation and Land Management.

30. Brennan, G. K. Personal communication (1998). Research Scientist, Wood Technology, Department of Conservation and Land Management.

31. Bulman, P. (1995). Farmtree$ for the Mount Lofty Ranges, A Regional Agroforestry Handbook. Primary Industries South Australia.

32. Bulman, P. (1998). Can Broombush be Part of Your Farm. pp. 12-13. Agroforestry News Volume 7,Issue 3, September 1998.

33. Carslake, J. Personal communication (1999). Research Technician, Search Program, Department of Conservation and Land Management.

34. Carter, D. (1995). "Storm" Wind erosion in the Great Southern. Journal of Agriculture, Vol. 36, N° 3. Department of Agriculture of Western Australia.

35. Coffey, P. (1997). Issues Facing Agriculture from a Farmers' Perspective. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course. Farm Planning and sustainable management.

36. Collins, R. (1999). The Profitability of Oil Mallees Looking Like Being Better Still. The Dinkum Oil Newsletter Issue 12, March 1999. The Oil Mallee Association of Western Australia Inc..

37. Conservation and Land Management (1995). Dryandra Woodland Management Plan (1995 - 2005). Management Plan No. 30. Department of Conservation and Land Management, Perth.

38. Conservation and Land Management (1993). Conservation and Land Management Act 1984, Forest Management Regulations 1993, Government Gazette (N°. 27) of February 1993.

39. Conservation and Land Management (1998a). Schedule of Gross Hardwood Royalties. Published July 1998.

40. Conservation and Land Management (1998b). Annual Report 1997-98.

41. Conservation and Land Management (1999). Code of Practice for Timber Harvesting. Department of Conservation and Land Management.

42. Cranfield, R. Personal communication (1999). Botanist, Department of Conservation and Land Management Herbarium Como.

43. Cremer, K. W. (1990). Trees for Rural Australia. CSIRO Division of Forestry and Forest Products.

44. Donnelly, D. Personal communication (1998). Forester, Wood Technology, Dept. of Conservation and Land Management Bunbury. (retired).

45. Donnelly, G. Personal communication (1997). Manager, Geoff Donnelly Real Estate, Narrogin.

46. Durell, G. (1999). Summary of the Development of the Host and Provenance Sandalwood Trials. Reserve No 41974, Highbury. 7th April 1999. Department of Conservation and Land Management. Unpublished report.

47. Durell, G. Personal communication (1999). Forester, Department of Conservation and Land Management Narrogin.

48. Farm Forestry Advisory Service (1998). Tree Note N°. 9, Paulownia. June 1998.

Agriculture Western Australia and Conservation and Land Management.

49. Farm Forestry Task Force (1995). Farm Forestry in Western Australia. Report of the Farm Forestry Task Force. December 1995.

50. Fell, R. (1997). The extension context - qualitative evaluation of the Certificate in Extension. Chapter 2. Dissertation for Masters in Education, submitted to Southern Cross University pp. 19-32.

51. Fremlin, R. R. A. (1997). Soil Preparation for the Establishment of Plantations. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

52. George, P. (1997). Markets for Wood in WA in the International and National Market Place, Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

53. George, R., McFarlane D. and Bennett, D. (1997). Using hydrology and geophysics to placing trees and other perennials in agricultural landscapes to overcome land degradation. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course. Farm Planning and sustainable management

54. Germantse, B. (1987). ABRI Firewood Coppice Trials. Department of Conservation and Land Management. Unpublished report.

55. Gobby, R. Personal communication (1998). Timbercon, Perth.

56. Gomboso, J.; Ghassemi, F. and Appleyard, S. J. (1997). Dryland Salinity in the North Stirling Land Conservation District: Western Australia. Simulation and Management Options. Hydrogeology Journal Vol. 5 No 1

57. Gorddard, B. J. (1992). Barriers to Adoption of Conservation Tillage in Western Australia. pp391 - 403. 7th ISCO Conference Sydney Vol. 2. International Soil Conservation Organisation Sydney

58. Gorton, S. Personal communication (1998). Senior Operations Officer, Department of Conservation and Land Management Narrogin.

59. Gould, B. Personal communication (1999). Manager, Dryandra Timber Products, Cuballing.

60. Graham, M. Personal communication (1999). Reserves Officer, Department of Conservation and Land Management Katanning.

61. Greening Australia. (1996). Opportunities for Farm Forestry, pp. 28-33. Farm Forestry in Australia. Integrating Commercial and Conservation Benefits. Greening Australia Ltd..

62. Guijt, I. and Race. D. (1998). Growing Successfully, Australian Experiences with Farm Forestry. Greening Australia Ltd.

63. Haagensen, A. (1998). Economic Evaluation of Sandalwood. Southern Sandalwood for Western Australia, Revegetation on Farms Information Kit, Agriculture Western Australia and Department of Conservation and Land Management Sandalwood Business Unit.

64. Hall, N. and Brown, A. (1968). Growing Trees on Australian Farms, Department of National Development, Forestry and Timber Bureau, Commonwealth of Australia, Canberra.

65. Hansen, G. Personal communication (1999). Pine Sharefarms Officer, Department of Conservation and Land Management Narrogin.

66. Harris, M. Personal communication (1999). Director, School of Wood, Dwellingup.

67. Hingston, R. A. (1997). Notes for plot establishment and tree measurement. Paper presented to Graduate Certificate in Forest Science (Farm Forestry), Porongorups.

68. Humphreys, J. Personal communication (1999). District Forester, Department of Conservation and Land Management Narrogin (retired).

69. Hunt, N. and Gilkes, B. (1992). Farm Monitoring Handbook. University of Western Australia, Nedlands Western Australia

70. Hunter, G. Personal communication (1999). AGK Timber Products, Cuballing.

71. Irwin, K. M. and Rietveld, B. (1997). Guide to a Successful Agroforestry Demonstration Project. Agroforestry Notes AF Note 6. June 1997. National Agroforestry Centre.

72. Johnston, R. Personal communication (1999). Chairman, South East Agroforestry Cooperative. Esperance.

73. Jones, P. Personal communication (1999). Sandalwood Business Unit Manager, Department of Conservation and Land Management Harvey.

74. Jones, T. Personal communication (2000) Marketing Manager, Department of Conservation and Land Management Como.

75. Kealley, I. (undated report). Sandalwood. Extract from Landscope Magazine. Department of Conservation and Land Management.

76. Knowbel, I. (1997). Markets and Wood Products: The softwood situation in Western Australia. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

77. Lantzke, N. (1992). Soils of the Northam Advisory District: Vol. 1. The zone of Ancient Drainage. Department of Agriculture of Western Australia.

78. Lantzke, N. (1993). Soils of the Northam Advisory District: Vol. 2. The Zone of Rejuvenated Drainage: Department of Agriculture of Western Australia.

79. Latta, R., Casson, T. and Carr. (1999). Farmnote 26/99. Establishing Balansa and Persian Clovers on Waterlogged, Mildly Saline Soils. Department of Agriculture, Western Australia.

80. Lefroy, E. C. and Hobbs, R. J. (1993). Some human responses to global problems. pp. 33-39 Nature Conservation 3: Reconstruction of Fragmented Landscapes. Surrey Beatty and Sons N.S.W.

81. Lefroy, E. C., Salerian, J. and Hobbs, R. J. (1993). Integrating economic and ecological considerations: a theoretical framework. In Reintegrating Fragmented Landscapes; Towards Sustainable Production and Nature Conservation. Hobbs R. J., Saunders, D. D. (ed.), pp. 209 - 244. Springer-Verlag, New York

82. Lefroy, E. C. and Scott, P. (1994). Alley Farming: a new vision for Western Australian farmland, pp. 119 - 126, Journal of Agriculture, Vol. 35, No 4 1994, Agriculture Western Australia

83. Main, B.Y. (1993). Social History and Impact on Landscape. In Reintegrating Fragmented Landscapes; Towards Sustainable Production and Nature Conservation, Hobbs R.J., Saunders D. D., (ed.), pp. 209 - 244. Springer-Verlag, New York

84. Marcar, N., Crawford, D., Leppert, P., Jovanivic, T., Floyd, R. and Farrow, R. (1995). Trees for Saltland. A guide to selecting native species for Australia. CSIRO Canberra.

85. McFall, D. Personal communication (1998, 1999). Upper Great Southern Oil Mallee Region Manager, Narrogin.

86. McFarlane, D. and Ryder, A. (199?). Groundwater trends in the Narrogin District. Unpublished paper. Agriculture Western Australia, Albany.

87. McKeown, G. Personal communication. 1997. Chief Executive Officer, Shire of Narrogin.

88. Melvin, D. Personal communication. 1997. Farmer, Dowerin

89. Midgley, S. J., Turnbull, J.W. and Johnston, R. D. (eds.) (1983). Casuarina Ecology, Management and utilization. Proceedings of an International Workshop, Canberra, Australia. CSIRO Melbourne.

90. Ministry of Education, (1988). Soils of South-western Australia. Garry L. Duffield, Government Printer, Western Australia.

91. Morris, C. Personal communication (2000) Principle Environmental Scientist, Western Power Corporation.

92. Morrison, C. Personal communication (1998, 1999). Regional Manager, Wheatbelt Development Commission. Narrogin.

93. Mullan, G. Personal communication (1999). Revegetation Development Officer, Department of Conservation and Land Management, Narrogin.

94. Mullar, J. Personal communication (1999). Manager, Wake and Beacham Sawmill, Narrogin.

95. Narrogin Observer, (1999). Wood processing plant, 19th May, p4. West Australian Newspapers Ltd.

96. Natural Heritage Trust (1998) Guide to New Applications 1998-1999.

97. Negus, T.R., (1989). Land classes in the Upper Great Southern of Western Australia. Bulletin N° 4138, Western Australian Department of Agriculture.

98.Newman, C., Personal communication (1999). Softwood Sharefarms, Department of Conservation and Land Management, Collie.

99.O'Connell, D. (1997). Agroforestry - a farmer's view. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course. Farm Planning and sustainable management.

100.O'Sullivan, W. Personal communication (1999). Revegetation Consultant, Perth.

101.Oates, N. and Clarke, B. (1987). Trees$ for the Back Paddock. Goddard and Dobson.

102.Olsen, G., (2000) New large-scale woody plant crops for WA. "Marketing farm forestry 2000" seminar. Albany, August 2000.

103.Olsen, G., (2001) Developing Tree Crops. Unpublished paper presented to Western Australian Agroforesty Working Group

104.Parnell, K. Personal communication (2000). Wheat and Sheep Farmer, Tincurrin.

105.Pigott, J. P. Brown, P. H., and Williams, M. R. (1994). Direst Seeding Trees on Farmland in the Western Australian Wheatbelt. CALMScience 1(2): 131-158 (1994). Department of Conservation and Land Management.

106.Race, D. (ed.) (1993). Agroforestry: Trees for Productive Farming. Department of Conservation and Natural Resources, Department of Agriculture.

107.Race, D. and Curtis, A. (1997). Socio-economic considerations for regional farm forestry development. pp. 233-239, Australian Forestry Volume 60, N°. 4, December 1997.

108.Race, D., (1999). Regional farm forestry industries: Potential dimensions and possible outcomes. Pp 182 - 192, Australian Forestry Volume 62, N°. 2, June 1999.

109.Radomiljac, A. M., Shea, S., McKinnell, F. H. and McComb, J. A. Potential for Irrigated Tropical Forestry in northern Western Australia. Australian Forestry Vol. 61, N°. 2, 1998.

110.Reid, R. (1990). Practical Considerations Affecting the Acceptance of Agroforestry by Australian Farmers. pp. 77-78 A.F.D.I. Biennial Conference, 5-8 October 1990, Bunbury Western Australian. Timber Production in Land Management.

111.Reid, R. (1997a). Agroforestry by design: Diagnosis and design for farm forestry projects, education, extension and regional strategies. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course. Farm Planning and sustainable management.

112.Reid, R. (1997b). The Art of Farm Silviculture. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

113.Reid, R. (1997c). What Silvicultural Regime is Best. 1. Growing Sawlogs. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

114.Reid, R. (1998). Who are the Australian Master Tree Growers? pp. 24 - 31 The Institute of Foresters of Australia Newsletter Volume 39, N°. 2 (April 1998).

115.Revell, G. (1994). Restoring our rural Landscapes. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course.

116.Rotheram, I. (1997). Log Quality, Sawmilling Strategies and Seasoning Timber. Paper presented to Graduate Certificate in Forestry Science (Farm Forestry). Porongorups.

117.Safstrom, R., Personal communication (2001). Environs Consulting. From draft of "Investigating potential bush products in the great southern Western Australia; swamp sheoak feasibility study.

118.Samulkiewicz, S. Personal communication (1998). Manager, Narrogin Joinery.

119.Shea, S., Bartle, J., and Inions, G. (1992). Tree Crops for Farms. pp. 47-53 Landscope Volume 8, N°. 2 Summer Issue 1992-3. Department of Conservation and Land Management.

120.Siemon, G. R. and Pitcher, J. A. (1994). Timber Properties and Market Potential of Selected Wheatbelt Species 1.; Rock Sheoak and Swamp Sheoak.. Department of Conservation and Land Management. Unpublished Report.

121.Soule', J. D. and Piper, J. K. (1992). Ecological Crises in Modern Agriculture, pp. 11-31, In Farming in Natures Image: an ecological approach to agriculture. Island Press, Washington DC, USA.

122.Sprigg, T. Personal communication (1999). Nursery Officer, Department of Conservation and Land Management, Narrogin.

123.Stoneman, T.C. (1991). An introduction to the Soils of the Narrogin Advisory District, Bulletin N° 4221, Western Australian Department of Agriculture.

124.Stucley, C. (1999). Turning Low Value Wood into Carbon. Unpublished paper.

125.Sudmeyer, R., (1997). Tree Windbreaks and Shelter Benefits. Paper presented to Graduate Certificate in Forest Science (Farm Forestry) course

126.The Australian Forestry Journal, (1922), Vol.5, No 2, The Creep of Salt, pp. 43-44, William Applegate Gullick, Government Printer, Sydney.

127.The Oil Mallee Association of Western Australia (Inc.), (1998a). Development Plan.

128.The Oil Mallee Association of Western Australia (Inc.), (1998b). The Oil Mallee Industry, an Information Memorandum.

129.The Oil Mallee Association of Western Australia (Inc.), (1998c). Oil Mallee Establishment Manual.

130.Underwood, R. J. (1994). The Mallet Plantations of Dryandra Forest pp. 16-19, Newsletter of the Institute of Foresters of Australia Inc., Volume 35, N°. 2, June 1994.

131.Vanclay, F. (1992). The Social Context of Farmers' Adoption of Environmentally Sound Farming Practices. pp. 94-121 Agriculture, Environment and Society (Contemporary Issues for Australia.)

132.Vanclay, F., Lawrence, G. (1995) The Environmental Imperative (Eco-social concerns for Australian Agriculture). Central Queensland University Press.

133.Wallace, K. J. (1992a). Services - A Barrier to Achieving Land Conservation Objectives? pp. 459 - 466. 7th ISCO Conference Sydney Vol. 2. International Soil Conservation Organisation Sydney.

134.Wallace, K. J. (1992b). Development of Commercial Uses of Woody Vegetation in the 300 - 600mm Annual Rainfall Zone. Unpublished paper. Department of Conservation and Land Management.

135.Wallace, K. J. (ed.) (1998). Dongolocking Pilot Planning Project for Remnant Vegetation (Phase 1 - Final Report). Department of Conservation and Land Management, CSIRO, Environment Australia, Land and Water Resources and Agriculture Western Australia.

136.Washusen, R. and Reid R. (1996). Agroforestry and Farm Agroforestry. Productive Trees for Shelter and Land Protection in North-East Victoria. The Benalla Landcare Farm Forestry Group.

137.Waugh, G. (1996). Product Opportunities for Trees on Farms. In proceedings of "Yass Region Farm Forestry Conference", Yass, 27th March, 1996. Pp. 19-28.

Appendix 1

(adapted from the AgWA et al. 1996a)

Perennial plant options	Options that may be available immediately	Feasibility
	Sandplain tagasaste	Increased adoption of existing systems required
	High rainfall eucalyptus and pines	Less likely except in the extreme western area
	Medium rainfall tree crops	Options exist already for crops such as *Pinus pinaster*. Other species presently planted as farm trees have significant potential
	Other trees and shrubs	Species for biodiversity and land conservation are already available
	Lucerne	Applicable to higher rainfall areas, but with some limitations on use. More research required to develop systems for lower rainfall soils
	Floriculture (exotic) Floriculture (native)	Opportunity exists in both areas,
	Salt bush	Need to expand existing systems with supplementary shrubs / grasses
	Oil mallees	Commercial package not fully developed, but this industry is seen as representing the best immediate option as a Wheatbelt tree crop
	Fencing and firewood	Present industries based on using remnant vegetation - good opportunities exist for expansion

Option for the foreseeable future	
New fodder shrubs	Potential to develop some acacia species into fodder options
Other grasses	Some perennial grasses available with potential to develop native grass systems
Melaleuca oil and other melaleuca products	Melaleuca oils (cineole rich) have potential to be an adjunct to the oil mallee program. Brush fencing and bean stick are other opportunities

Appendix 2

Establishment prescription

- Site selection; soil survey, EM 38 survey, identify problems e.g. rabbits, waterlogging, etc.
- Rip through hardpan in summer using a dozer / large tractor
- Mound in autumn using a Napier mounder (or other mounder with a press wheel). The mounding may form part of the surface water control system also.
- Chemical weed control using knockdown and residual herbicide. General rates of 1l/ha glyphosate and 4l/ha simazine are applied.
- Planting of containerised stock by hand, using potti - putki tree planting tubes.
- Erection of a stock proof fence.

Notes

Hand planting is a preferred option, as access to many of these planting sites may be difficult for a machine.

The "one pass" planting system using a tractor drawn tree planting machine is not recommended for these soil types.

Direct seedling results are patchy and have a lower success rate in the soil types normally chosen for this species (Pigott, *et al.* 1994). Uniform spacing between seedlings is also difficult to achieve.

Appendix 3

Casuarina obesa: estimated growth rates

Growth estimations based on the assumption of;

1. height growth of 0.6m / ann.
2. diameter increase of 1.75cm / ann.

Age	Diameter (cm)	Height (m)
1	1.75	0.6
2	3.5	1.2
3	5.25	1.8
4	7.0	2.6
5	8.75	3.0
6	10.5	3.6
7	12.25	4.2
8	14.0	4.8
9	15.75	5.4
10	17.5	6.0
11	19.25	6.6
12	21.0	7.2
13	22.75	7.8
14	24.5	8.4
15	26.25	9.0
16	28.0	9.6
17	29.75	10.2
18	31.5	10.8
19	33.25	11.4
20	35.0	12.0
21	36.75	12.6
22	38.5	13.2
23	40.25	13.8
24	42.0	14.4
25	43.75	15.0

Appendix 4

Measurements of natural stand, Toolibin Lake floor (fig 4). Age of stand unknown. (30+? yo)

Nº	dbhob (cm)	radius (m)	BA(m^2) / tree	Ht. (m)
1	10.2	0.0510	0.0081671	8.0
2	9.0	0.0450	0.0063585	8.0
3	10.1	0.0505	0.0080078	8.0
4	8.0	0.0400	0.0050240	7.5
5	7.0	0.0350	0.0038465	7.5
6	6.0	0.0300	0.0028260	5.0
7	9.0	0.0450	0.0063585	8.0
8	7.0	0.0350	0.0038465	8.0
9	10.0	0.0500	0.0078500	8.5
10	9.0	0.0450	0.0063585	8.0
11	8.0	0.0400	0.0050240	8.0
12	9.5	0.0475	0.0070846	8.0
13	9.4	0.0470	0.0069363	7.0
14	12.0	0.0600	0.0113040	7.5
15	9.2	0.0460	0.0066442	6.5
16	8.3	0.0415	0.0054079	6.0
17	7.5	0.0375	0.0044156	7.5
18	11.2	0.0560	0.0098470	8.0
19	6.8	0.0340	0.0036298	6.5
20	9.8	0.0490	0.0075391	8.0
21	9.7	0.0485	0.0073861	8.0
22	10.6	0.0530	0.0088203	8.5
23	10.0	0.0500	0.0078500	9.0
24	7.5	0.0375	0.0044156	8.0
25	12.5	0.0625	0.0122656	8.5
26	4.9	0.0245	0.0018848	5.0
27	7.2	0.0360	0.0040694	8.0
28	12.2	0.0610	0.0116839	8.0
29	6.5	0.0325	0.0033166	6.0

Total BA	0.1881684m^2
Ave. / stem	0.0064886m^2
Ave. diam.	8.9cm
Ave. height	7.5m

Measurement of managed planted stand, Mt. Barker. Approx. 3½ yo.

Nº	dbhob (cm)	radius (m)	BA(m^2) / tree	Ht. (m)
1	3.9	0.0195	0.0011940	3.4
2	6.1	0.0305	0.0029210	4.0
3	6.4	0.0320	0.0032154	3.6
4	6.3	0.0315	0.0031157	3.8
5	8.0	0.0400	0.0050240	4.2
6	9.2	0.0460	0.0066442	5.0
7	6.7	0.0335	0.0035239	3.7
8	7.6	0.0380	0.0045342	3.8
9	5.7	0.0285	0.0025505	4.3
10	5.0	0.0250	0.0019625	3.6
11	8.2	0.0410	0.0052783	4.8
12	5.4	0.0270	0.0022891	4.4
13	7.3	0.0365	0.0041833	4.0
14	7.8	0.0390	0.0047759	4.4
15	7.4	0.0370	0.0042987	4.6
16	8.8	0.0440	0.0060790	4.6
17	6.0	0.0300	0.0028260	4.3
18	6.0	0.0300	0.0028260	3.5
19	5.9	0.0295	0.0027326	3.8
20	4.8	0.0240	0.0018086	4.5
21	9.2	0.0460	0.0066442	4.4
22	9.5	0.0475	0.0070846	4.7
23	7.5	0.0375	0.0044156	4.6
24	7.4	0.0370	0.0042987	4.4
25	4.3	0.0215	0.0014515	3.7
26	6.4	0.0320	0.0032154	4.3
27	7.5	0.0375	0.0044156	3.7
28	9.1	0.0455	0.0065006	5.3
29	6.7	0.0335	0.0035239	4.3
30	9.3	0.0465	0.0067895	5
31	8.3	0.0415	0.0054079	5.2

Total BA	0.0942259
Ave. / stem	0.0030396
Ave. diam.	5.4cm
Ave. height	4.3m

Appendix 4 (cont.)

Summary of measurements of natural stand, Toolibin Lake floor (fig 4). Age of stand unknown. (30^{+}?yo)

Plot size	length	width	area (ha)
	10m	10m	0.01
Stand density	N° trees	plot area (ha)	s/ha
	29	0.01	2900
{BA = 0.1881684 ÷ plot area (0.01ha)			
	BA (m^2) / ha = 18.82		

Summary of measurements, managed planted stand, Mt. Barker. Approx. 3½ yo.

Plot size	length	width	area (ha)
	30m	15m	0.045
Stand density	N° trees	plot area (ha)	s/ha
	32	0.045	711
{BA= 0.0942259 ÷ plot area (0.045ha)			
	BA (m^2) / ha = 2.09		

Measurement of selected trees, natural stand, Toolibin Lake floor. 1999.

Total height (m)	Bole length (m)	dbhob (mm)	Volume m^3
12	6	440	0.80
14[7]	5	550	1.04
11	5.5	366	0.51
9	4.5	360	0.40

[7] Front cover specimen

Appendix 5

Casuarina obesa: Net Present Value Calculations

Prior land use	$/ha/yr.	$25.00	grazing @ 1 DSE/ac @ $10/DSE margin

Est' ment costs	Year	$/ha
Total	$0.00	$695.00
Fertiliser	0	$10.00
Ann. maint.	0 - 30	$20.00

Stocking	1,111 stems/ha
1st Thinning Year 9 to 500/ha	
2nd Thinning Year 12 to 250/ha	
3rd Thinning Year 18 to 150/ha	
Clearfall Year 25	
MAI	6.13 m^3/ha/yr

Tree returns Harvest volume (cu m/ha)

	Year 9	Year 12	Year 18	Year 25	$/cu m	N° / m3	$ea.
Fenceposts	18.69	27.69	0.00	0.00	$70.00	35	$2.00
Strainers			0.00	0.00	$0.00		
Sawlogs			46.73	0.00	$50.00		discount rate
Sawlogs				60.10	$70.00		**6.00%**
Waste				0.00			

	Financial analysis	Costs $/ha	Sales $/ha	Grazing $/ha	Net $/ha	Present Value	NPV $/ha	
0	1997	$695.00		$25.00	-$670.00	-$670.00	-$670.00	
1	1998	$120.00		$0.00	-$120.00	-$113.21	-$783.21	form prune
2	1999	$20.00		$0.00	-$20.00	-$17.80	-$801.01	
3	2000	$20.00		$0.00	-$20.00	-$16.79	-$817.80	
4	2001	$20.00		$1.00	-$19.00	-$15.05	-$832.85	
5	2002	$120.00		$2.00	-$118.00	-$88.18	-$921.03	prune
6	2003	$20.00		$3.00	-$17.00	-$11.98	-$933.01	
7	2004	$20.00		$4.00	-$16.00	-$10.64	-$943.65	
8	2005	$20.00		$5.00	-$15.00	-$9.41	-$953.06	
9	2006	$150.00	$1,308.58	$6.00	$1,164.58	$689.31	-$263.75	thin/prune
10	2007	$20.00		$7.00	-$13.00	-$7.26	-$271.01	
11	2008	$20.00		$8.00	-$12.00	-$6.32	-$277.33	
12	2009	$150.00	$1,938.64	$9.00	$1,797.64	$893.37	$616.04	thin/prune
13	2010	$20.00		$10.00	-$10.00	-$4.69	$611.35	
14	2011	$20.00		$10.00	-$10.00	-$4.42	$606.93	
15	2012	$20.00		$10.00	-$10.00	-$4.17	$602.76	
16	2013	$20.00		$10.00	-$10.00	-$3.94	$598.82	
17	2014	$20.00		$10.00	-$10.00	-$3.71	$595.11	
18	2015	$200.00	$2,336.75	$10.00	$2,146.75	$752.10	$1,347.21	thin/prune
19	2016	$20.00		$10.00	-$10.00	-$3.31	$1,343.90	
20	2017	$20.00		$10.00	-$10.00	-$3.12	$1,340.78	
21	2018	$20.00		$10.00	-$10.00	-$2.94	$1,337.84	
22	2019	$20.00		$10.00	-$10.00	-$2.78	$1,335.07	
23	2020	$20.00		$10.00	-$10.00	-$2.62	$1,332.45	
24	2021	$20.00		$10.00	-$10.00	-$2.47	$1,329.98	
25	2022	$500.00	$4,207.11	$10.00	$3,717.11	$866.08	$2,196.06	Clear fell
	Total	$1,815.00	$9,791.07	$200.00	$7,676.07	$2,196.06		
	Annuity equivalent			($8)		**$162 /ha/yr.**		

adapted from a model supplied by P. Eckersley, AgWA Bunbury

Appendix 6

Financial analysis; Internal Rates of Return. Options based on two differing silvicultural regimes

Option 1: Standard prescription

		Costs $/ha			Sales $/ha			
0	1997	$695.00	1.0000	$695.00				
1	1998	$120.00	0.9223	$110.67				form prune
2	1999	$20.00	0.8506	$17.01				
3	2000	$20.00	0.7844	$15.69				
4	2001	$20.00	0.7235	$14.47				
5	2002	$120.00	0.6672	$80.07				pruning
6	2003	$20.00	0.6153	$12.31				
7	2004	$20.00	0.5675	$11.35				
8	2005	$20.00	0.5234	$10.47				
9	2006	$150.00	0.4827	$72.41	$1,308.58	0.4827	$631.66	thin/prune
10	2007	$20.00	0.4452	$8.90				
11	2008	$20.00	0.4106	$8.21				
12	2009	$150.00	0.3787	$56.80	$1,938.64	0.3787	$734.07	thin/prune
13	2010	$20.00	0.3492	$6.98				
14	2011	$20.00	0.3221	$6.44				
15	2012	$20.00	0.2970	$5.94				
16	2013	$20.00	0.2739	$5.48				
17	2014	$20.00	0.2526	$5.05				
18	2015	$200.00	0.2330	$46.60	$2,336.75	0.2330	$544.47	thin/prune
19	2016	$20.00	0.2149	$4.30				
20	2017	$20.00	0.1982	$3.96				
21	2018	$20.00	0.1828	$3.66				
22	2019	$20.00	0.1686	$3.37				
23	2020	$20.00	0.1555	$3.11				
24	2021	$20.00	0.1434	$2.87				
25	2022	$600.00	0.1322	$79.34	$4,207.11	0.1322	$556.31	Clear fell
	Total	$2,415.00		**$1,290.45**	$9,791.07		**$1,290.38**	
		7.774%		$0.07				

Option 2: Heavy early thinning

		Costs $/ha			Sales $/ha			
0	1997	$695.00	1.0000	$695.00				
1	1998	$120.00	0.8923	$107.07				form prune
2	1999	$20.00	0.7962	$15.92				
3	2000	$20.00	0.7104	$14.21				
4	2001	$20.00	0.6339	$12.68				
5	2002	$120.00	0.5656	$67.88				pruning
6	2003	$20.00	0.5047	$10.09				
7	2004	$20.00	0.4503	$9.01				
8	2005	$20.00	0.4018	$8.04				
9	2006	$400.00	0.3586	$143.42	$1,785.00	0.3586	$640.02	thin/prune
10	2007	$20.00	0.3199	$6.40				
11	2008	$20.00	0.2855	$5.71				
12	2009	$20.00	0.2547	$5.09				
13	2010	$20.00	0.2273	$4.55				
14	2011	$20.00	0.2028	$4.06				
15	2012	$20.00	0.1810	$3.62				
16	2013	$20.00	0.1615	$3.23				
17	2014	$20.00	0.1441	$2.88				
18	2015	$200.00	0.1286	$25.71	$2,336.75	0.1286	$300.41	thin/prune
19	2016	$20.00	0.1147	$2.29				
20	2017	$20.00	0.1024	$2.05				
21	2018	$20.00	0.0913	$1.83				
22	2019	$20.00	0.0815	$1.63				
23	2020	$20.00	0.0727	$1.45				
24	2021	$20.00	0.0649	$1.30				
25	2022	$500.00	0.0579	$28.95	$4,207.11	0.0579	$243.58	Clear fell
	Total	$2,435.00		**$1,184.06**	$8,328.86		**$1,184.01**	
			10.771%	$0.06				

Appendix 7

Research requirements, adapted from BOSTID (1984), Barbour (1997), and Midgley *et al.* (1981).

Research requirements	Priorities
• Agricultural aspects	Design and planning of shelter belts
	Competition with agricultural crops
	Competition with other agricultural pursuits
	Palatability / toxicity
	Length of crop rotation
	Duration of crop
	Labour requirements
• Economic evaluation:	How the economics of *Casuarina obesa* plantings compare with the available agricultural options
• Genetic improvement:	Search for superior individuals as a basis for a tree breeding program. Included in this process is;
	Taxonomic validation of species, subspecies and provenance
	Parent tree selection e.g. branch size, internode length
• Produce / marketing	Value of produce
	Size of market
	Transport radius
	Opportunity for value adding
• Physiology and Environmental Tolerances	Response to; high salinity waterlogging extremes in pH
	Water table drawdown
	Nitrogen fixing capability, including; level of fixation effects of soil fertility on fixation inoculation for root nodulation and mycorrhizal infection
• Silvicultural options	Vegetative propagation from mature superior trees
	Planting density
	Pruning and thinning regimes
	Product target
	Coppice cropping
	Rotation length
	Accurate growth and measurement
• Utilization:	Use of Casuarinas for; biomass production pulp and particle board conversion to firewood and charcoal veneer production
	Drying and seasoning schedules
	Fodder values

Appendix 8

Development process for perennial wood plant crop industries (outlined by Bartle 1999).

1. Search

Screen plants and product attributes to identify.

2. Prefeasibility assessment

Confirm search indications by more rigorous evaluation of key performance parameters i.e. cost of productions, yield / quality, market/prices, economies of scale, biodiversity / landcare/social values, initial economic analysis. Select best bets.

3. Industry Exploration

Commence building industry foundation with R&D in the following areas:

3a. Technical

- taxonomy
- breeding/propagation
- seed production
- establishment
- silviculture/hydrology
- harvest/process
- product science
- residue utilisation

3b. Environmental

- integrated design inc. land, water, biodiversity
- carbon sequestration
- species mixtures
- economics of environmental values
- green products

3c. Commercial

- form grower group
- establish a resource
- demonstration sites
- farm business plans
- market research
- attract buyer interest
- attach investors
- industry analysis

4. Full Feasibility Investigation

Assemble committed parties. Conduct feasibility investigation, design industry structure, legal arrangements and capital sources. Generate bankable industry business plan.

5. Promotion and Adoption

Expand the extension, education and publicity activities commences in stage 3.

photo by Wayne O'Sullivan

Back page; Rod Safstrom and author (RHS) measuring 3½ year old planted *Casuarina obesa*, Mt. Barker 2001.