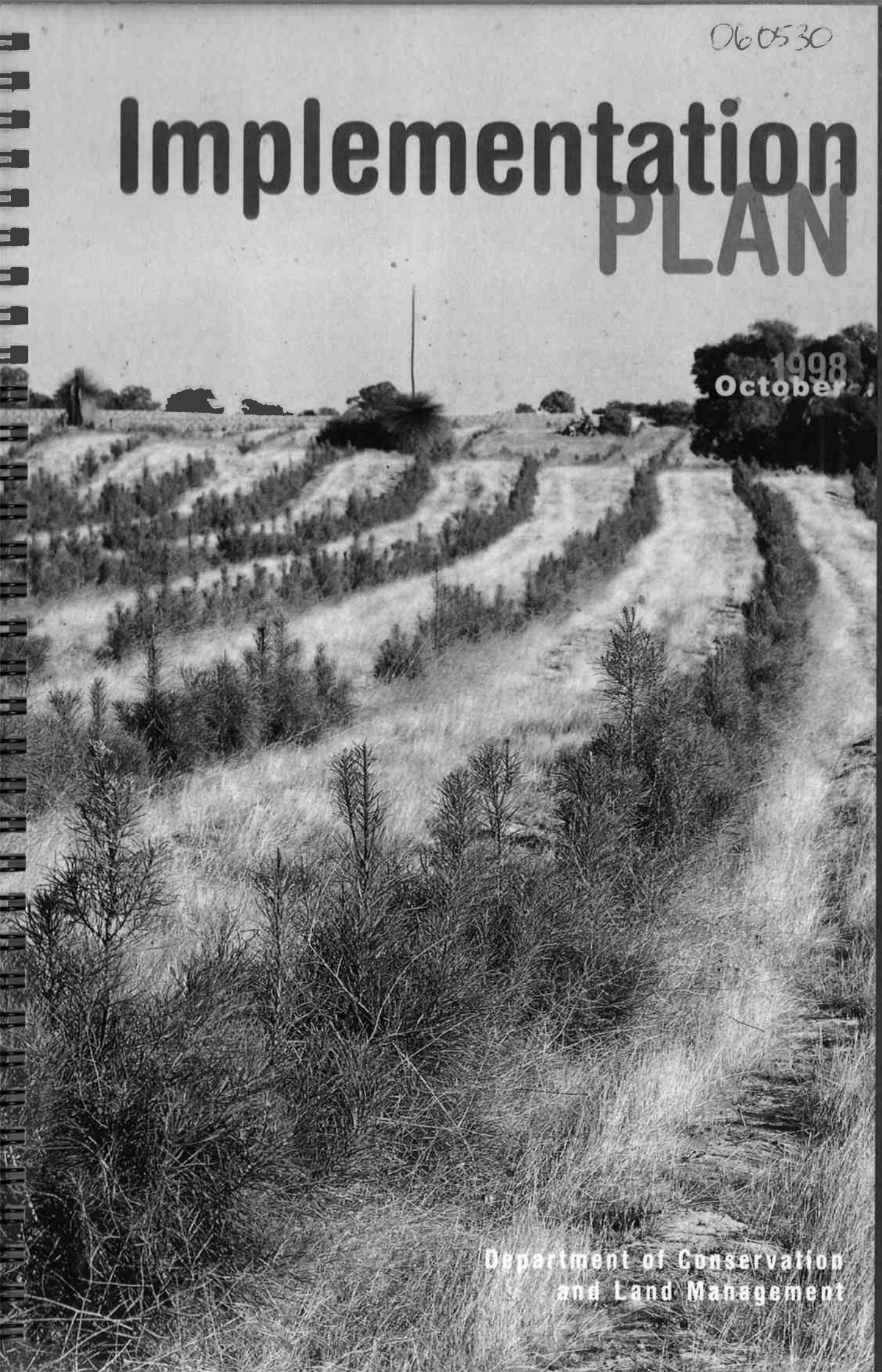
060530

# Implementation PLAN

1998
October



Department of Conservation and Land Management

Phase 2 Gorgon Offsets Study

## IMPORTANT – YOU MUST READ THIS BEFORE PROCEEDING FURTHER

This report relates to the possible development and use of carbon sinks as a means of responding to greenhouse gas issues in accordance with the anticipated scope of the Kyoto Protocol. However, the consequences flowing from the Kyoto Protocol are, and will be for some time, uncertain. In the context of that uncertainty, this report endeavours to provide Gorgon with a **preliminary** understanding of steps that may be taken by Gorgon to implement strategies to respond to greenhouse gas issues. **Further** detailed work is required before **any** strategy is implemented or committed to by Gorgon.

In the circumstances:

1 Opinions and statements contained in this report are or may be based on disclosed or undisclosed assumptions or information which has not been independently verified. By providing this report, CALM does not adopt nor authorise the expressing of those opinions or the making of those statements.

2 CALM, its advisers, servants and agents disclaim any liability, whether arising from negligence, under contract, under any applicable law or otherwise, for any representations contained in, or any omission from, this report.

3 No representation or warranty, express or implied, is made by CALM, its advisers, servants and agents that any statement, estimate, projection or evaluation contained in this report is accurate, complete, or will prove correct.

4 Gorgon should carefully review and consider all available information on the Kyoto Protocol (including this report) and make and rely on their own investigations and inquiries before taking any step, committing to any obligations or incurring any expenses whatsoever. The use of any information contained in this report should be at Gorgon's sole risk.

5 Gorgon should obtain its own legal and accounting advice as to the efficacy of the Profit à Prendre, the impact of native title issues on land, taxation and accounting issues (including the impact of the proposed goods and services tax) and any other matter involving technical expertise arising from the report.

**BY PROCEEDING FURTHER, YOU ACKNOWLEDGE AND AGREE THAT THE CONTENT OF THIS REPORT IS SUBJECT TO THE ABOVE LIMITATIONS**

# Implementation PLAN

1998 October

Phase 2 Gorgon Offsets Study

Department of Conservation
and Land Management

# CONTENTS



◀ *maritime pine litter*

# EXECUTIVE SUMMARY

This Plan has been prepared by the Department of Conservation and Land Management (CALM) for the Gorgon partners. It is a detailed implementation plan designed to sequester an average of 500,000 tonnes of carbon each year for 40 years, creating a total sink of 20 million tonnes.

The Plan incorporates several features that minimise the cost and increase the security of the sink, including:

- use of commercial tree species that will generate timber and other product revenues;
- trees planted on farmland where they are in strong demand to overcome pressing environmental problems;
- the use of joint venture arrangements with landowners to avoid the need for land purchase, but without diminishing security over revenues and carbon offsets.

Based on these features, the plan **estimates** that carbon offsets have a net present cost per average tonne of carbon sequestered of between $5.00 and $6.43.

The Plan proposes creation of a carbon sink consisting of 180,000 hectares of commercial tree crops and landcare trees established progressively over a 30-year period on farmland within a radius of 200 kilometres of Perth in the south-west of Western Australia. The tree species and products are:

- maritime pine, a softwood species already widely planted in the vicinity of Perth, is proposed for 80 per cent of the Project. Maritime pine is a well developed commercial species with advanced genetics, defined management practices and predictable yields. It is a profitable species in the wetter western parts of the Project region, used for panel board manufacture and general purpose sawn timber.
- mallee eucalypts: there are several species suitable for production of eucalyptus oil and low value wood feedstocks for industry. An industry based on these species is being developed to meet the pressing need for a tree crop in the Western Australian Wheatbelt. The eastern part of the project region extends into the Wheatbelt. It is expected that large scale planting and economies of scale will enable eucalyptus oil to be sold at low enough prices to penetrate large industrial solvent markets.
- landcare plantings: there is extensive degradation of agricultural land in Western Australian and a well established practice of remedial tree planting. Non-commercial species have commonly dominated landcare planting, although there is strong emerging interest in long-term commercial species such as sandalwood. A small proportion (less than 10 per cent) of landcare planting is proposed to help attract growers.

◀ *maritime pine*

The Plan details two options comprising a predominant proportion of maritime pine:

- steady annual planting rate;
- steady annual sequestration rate.

Any combination in between could also be chosen. The disadvantage of a steady sequestration rate is that it involves steeply fluctuating annual planting areas in the early years and therefore fluctuating work inputs and log outputs. However, carbon accounting rules may over-ride operational preferences and costs.

The Plan specifies all the necessary implementation steps:

- Land acquisition: including evaluation of land suitability and securing rights to the tree crop and carbon offset using the legal instrument Profit à Prendre.
- Establishment and management operations: will be based on well established practice.
- Monitoring and measuring carbon: land area and carbon sink dimension will be determined by adapting existing forest management techniques.
- Management and verification of timber and carbon: systems developed to provide full accountability for all logs removed from plantations will be applied at harvest. These systems will be adapted to verify carbon sink dimensions.
- Marketing of timber: new processing and market development will be necessary to use production from the project.

CALM is a State Government agency responsible for management of public lands, nature conservation and forestry. The Department has a record of innovation and success in creating commercially viable tree crop industries in Western Australia. It has the necessary infrastructure and can provide the complete range of services to implement the project as agent for the Gorgon partners.

CALM has designed the Plan, to be viable within the operating environment as it is presently understood:

- The project has been designed to be eligible under the Kyoto Protocol;
- Economic analysis is presented to define likely project cost to Gorgon and a range of alternative scenarios are provided to indicate impacts on the net present value of the project, the net present value per tonne of carbon sequestered and sensitivity of the project performance to changes in revenue, costs, and method of access to carbon. A summary of the Project financials is shown below for the two strategies suggested:

| | Strategy 1 | Strategy 2 |
|---|---|---|
| Total cost ($,000) | 523,626 | 533,119 |
| Total revenue ($,000) | 1,137,461 | 1,191,610 |
| Discounted cost ($,000 @ 7%) | 142,006 | 137,540 |
| Discounted revenue ($,000 @ 7%) | 82,110 | 79,443 |
| Average carbon sink (tonnes) | 11,180,345 | 10,293,111 |
| NPV ($,000 @ 7%) | (59,896) | (58,098) |
| NPV/tonne ($ @ 7%) | (5.36) | (5.64) |
| Internal rate of return | 4.1% | 3.8% |

- The owners of land with whom the Gorgon partners enter into joint venture are assumed to be prepared to accept a 20 per cent share of timber revenues and carbon as the return for the use of their land. Mechanisms are proposed for Gorgon to acquire the farmer's 20 per cent share of carbon. Cash payment for this carbon is considered likely to be most successful.
- The mallee eucalypt option has good potential as a carbon sink but the industry is yet to demonstrate commercial viability. Some 10 per cent of planting could be oil mallee and this could be useful in helping the industry achieve commercial scale. The industry is controlled by the Oil Mallee Association with whom CALM has a close working relationship and agreement to work jointly to develop carbon trading arrangements. These arrangements are not yet in place.
- A risk analysis is presented.
- Environmental impacts are shown to be strongly positive. The project region is afflicted by land degradation the most severe form of which is salinity. The most effective treatment for salinity is tree planting. The scale of planting in this project would generate important regional landcare and conservation benefits.
- Social and economic impacts are also highly favourable. It would provide economic benefit as a major expansion in the current timber industry and would provide economic diversification in an agricultural region that has been in long-term decline through over-dependence on a narrow range of products.

*tammar wallaby* ▲

The Gorgon Project is clearly beneficial to both the State and to individual landowners. It is not anticipated that it would attract opposition on environmental grounds.

The Plan proposes a pilot project in 1999 to test and demonstrate key features and initiate the working relationship between the Gorgon partners and CALM. The key objective of the pilot project is for Gorgon to become familiar with the potential for this Plan to achieve its carbon sequestration objectives.

# INTRODUCTION

As a result of the Kyoto Protocol of the 1992 Framework Convention on Climate Change, Gorgon Development Group have examined options to create carbon offsets for their North-West Shelf Gas development. The Department of Conservation and Land Management (CALM) was requested to prepare an evaluation of the potential for revegetation to provide sufficient offsets for various levels of gas production. In July 1998 CALM provided a Phase I report which identified five potential revegetation options: commercial bluegum and pine plantations, landcare plantings, mallee eucalypts and pastoral regeneration. For each option a sequestration rate and cost was identified. A range of planting regimes to satisfy escalating targets was also prescribed. One example was developed to demonstrate the carbon, cost and revenue flows over the life of the plantation.

This report represents the second phase of this study. It looks in detail at the scale and methodology for a sequestration target of 500,000 tonnes per annum for 40 years. It endeavours to examine the feasibility and practicality of this scale of plantation as well as issues arising from its implementation. The background and underpinning for this Project are international agreements that will govern carbon credits.

CALM has a particular role and interest in the establishment of tree crops on farmland. As one of the key strategies of Western Australia's Salinity Action Plan (1996), CALM launched its Maritime Pine Project to revegetate extensively cleared farmland. This Plan would help CALM meet its goals under the Maritime Pine Project.

## GOVERNANCE

The Kyoto Protocol recognised that carbon sinks could be used to offset emissions. Kyoto Protocol sinks are defined in article 3.3 – *"... resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period..."*

Under current international rules for the first commitment period (2008-2012) the amount of carbon sequestered by trees will be determined by measuring the total carbon stocks in 2008 and again in 2012 in tree plantations established from 1990, and determining the average annual sequestration rate for the period. The sink value is added to the assigned amount (in the case of Australia 108 percent of 1990 emission levels) which gives the sink a value equal to an emission in the first commitment period. Any changes in carbon stocks between 1990 and 2008 are not included in determining this value. It is assumed that there will be further commitment periods after 2012.

There is considerable uncertainty about the rules governing carbon sequestration. For example, the definition of forests, reafforestation, deforestation and afforestation and the treatment of forest residues and the carbon in wood products are unresolved. Article 3.4 provides for the possible inclusion of other sinks, such as those found in agriculture soils and in pastoral (rangeland) areas. All these issues are the subject of current negotiations in international forums.

The outcome from these negotiations will have a major impact on the size of carbon sinks that could be credited. For example, the inclusion of carbon sinks formed by rehabilitation of the pastoral (rangeland) land would significantly increase the potential carbon sink in Western Australia because of the large areas involved. Recognition that wood products make a contribution to reducing net carbon dioxide emissions either directly by storing carbon or indirectly by replacing materials that result in high $CO_2$ emissions, would also substantially increase the sequestration benefit of commercial tree crops. To the extent that wood products replace fossil fuels used for energy production or replace energy intensive industrial materials, the carbon displaced is a permanent contribution to $CO_2$ emission reduction. Tree crops could be "farmed" for carbon, and provided the wood products produced have relatively long lives the carbon sink formed over time would be greater than tree plantings that were grown to maturity without harvesting.

The current "Kyoto rules" are inflexible and do not recognise the contribution of temporary sequestration. In addition to "buying time" temporary carbon sequestration does have an effect on potential global warming. For example, a re-released carbon dioxide molecule will have a smaller impact on global warming than when it was first sequestered because of the saturation effect with increasing $CO_2$ concentrations in the infra red spectrum. Each $CO_2$ molecule released in 2010 will have a 10 per cent less effect on global warming than it would have had if it was emitted in 1990 (Houghton *et al.*, 1994).

Bird (1997) derived a method of comparing reductions in $CO_2$ emission with carbon storage. He proposed that carbon-years be considered when evaluating the effect of carbon storage. He concluded, assuming a time horizon of 100 years, that storage of a tonne of carbon for one year was approximately equivalent to a permanent emission reduction of 0.0088 tonnes of carbon.

The most serious deficiency in the current carbon sequestration accounting rules is the absence of a mechanism to deal adequately with the time dimension. All vegetation eventually dies and the carbon formed is returned to the atmosphere. It is possible to sustain a carbon sink forever by perpetual replanting. But this requires carbon sink sellers to accept a potentially large contingent liability.

The areas of uncertainty in the application of the Kyoto rules will be progressively resolved over the coming years. A special (technical) report on land use change and forestry issues prepared by the Intergovernmental Panel on Climate Change (IPCC) is due to be completed by May 2000. There is also potential for national legislation to manage this system under different conditions, or to establish a trading system before 2008.

One further opportunity which may be realised by the creation of a carbon sink is the potential for emissions trading. The Kyoto Protocol recognised several flexibility mechanisms to help countries meet emissions targets. Trading of quotas and the banking of unused quotas were identified as being appropriate. These tools may be of particular value to Gorgon in (i) balancing sinks and emissions and sinks over time; and (ii) earning additional revenue through spot sales of surplus carbon credits should such an opportunity arise.

Some of these matters may be critical to Gorgon's evaluation of the Project, as clearly they underpin the carbon value that Gorgon can expect to attain from this Project.

CALM is taking a prominent role in State and national forums concerning the development and management of Australian obligations under international conventions. CALM will apply this experience and authority to its commercial forestry activities.

# 1. IMPLEMENTATION PLAN

## 1.1 PLAN OBJECTIVE

The primary objective for this Plan is the establishment of plantations to sequester an average of 500,000 tonnes of carbon per annum for 40 years, commencing in 2003. This would result in a sink of 20 million tonnes of carbon in 2042. The methods of creating and measuring the carbon sink need to conform to the requirements of the Kyoto Protocol. In the first commitment period an average annual rate of sequestration would be at least 500,000 tonnes of carbon.

The secondary objective is that the effect of this Plan should achieve positive social, financial and environmental outcomes for Gorgon and the Western Australian community.

## 1.2 PROJECT DESCRIPTION

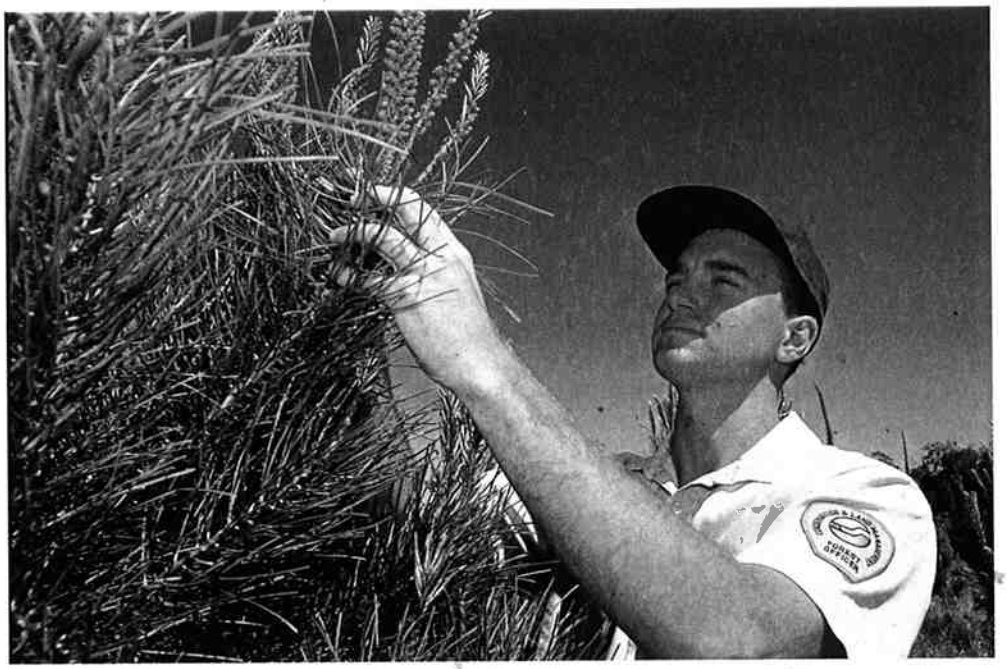
The proposal is to establish plantations on cleared farmland within a radius of approximately 200 kilometres from Perth. The plantations would be made up of three types, each with distinctive purposes:

- maritime pine (*Pinus pinaster)*
- mallee eucalypts (*Eucalyptus* species)
- landcare trees (various species)

The total area of the plantation estate would be progressively established over the first 30 years of the Project, on privately-owned land by agreement with the landowner. A Deed of Grant of Profit à Prendre attached to the land title would define the relationship between the landowner and Gorgon and secure Gorgon's rights.

The benefits of the plantation would be shared between Gorgon and the landowner, as defined in the Deed, and based on the proportionate value of the inputs of both parties. Timber and other products produced by the plantation would be harvested and sold and the proceeds shared between Gorgon and the landowner.

The development of the carbon sink in the plantation would be measured and verified to meet the necessary standards that are yet to be fully defined through international agreements and national legislation. The necessary tools to undertake predictive and monitoring work for timber inventory already exist in CALM.



▲ *CALM Sharefarms officer inspecting maritime pine*

CALM would act as Gorgon's agent to:

- promote the Project;
- liaise with landowners and acquire land for plantations;
- establish and manage plantations;
- monitor and verify carbon;
- monitor developments in the external "Greenhouse environment" as they impact this Project;
- market and harvest timber and other resources; and
- monitor and report on social and environmental benefits.

As well as achieving its primary objective, the Project would bring significant environmental and economic benefits to the Perth region.

The Project would make a vital contribution to the Western Australian Government's Salinity Action Plan, which was put in place to reduce the risk of further salinisation in the agricultural region. Salinity is Western Australia's most serious environmental problem, consisting of a sequence of land and water degradation arising from an adverse water balance and mobilisation of stored salt in agricultural soils. Salinity threatens agriculture, remnant vegetation, conservation reserves, water resources and towns. However, the scale and speed of proposed revegetation under this Project would become a primary driver for the Salinity Action Plan in the Perth region.

The establishment of new plantations at the rate proposed would also develop regional industries and diversify farming income in a rural economy that is currently contracting. Some areas are experiencing social and economic decline as the economic viability of traditional farming enterprises weakens and the impacts of restructuring on the local infrastructure take effect. The Project would help reverse this decline and result in both economic and social benefits to the region.

# 2. PLAN STRATEGIES

## 2.1 CARBON

Trees are recognised as an ideal means of sequestering carbon for long periods. The Kyoto Protocol allows carbon secured through afforestation and reforestation to be included in measurements of the national carbon inventory. New plantations could offer four fundamental opportunities for trees and their products to contribute significantly to the carbon target through the development of carbon sinks and the reduction of carbon dioxide emissions.

*The plantation*

Plantations of trees accumulate carbon progressively through their life. There are several pools of carbon within the living tree – the bole (from which timber products are taken), the crown (branches and leaves) and the root system. Over time a carbon pool develops in dead material shed from living trees. Its major components are dead trees, litter, branches, tops and the root systems from harvested trees. Finally there is the component which is incorporated into the soil as organic matter.

*Timber products*

Periodically trees are felled and a portion of the biomass is removed from the plantation and converted into timber products. While some of the carbon is lost during the conversion process, the bulk of it becomes products with a long in-service life, such building materials and furniture. Even when their life in those products ceases the carbon may take a considerable time to break down and return to the atmosphere, or may be recycled or used for energy production.

*Biomass fuels*

Tree crops or residues may be used as fuel for energy generation. Such renewable fuels make no net contribution to $CO_2$ emissions but meet a demand for energy that might otherwise draw on fossil fuels. In Western Australia there is scope to use biomass to avoid emissions from coal and diesel fuel generators.

*Product displacement*

The use of timber as an alternative to more energy-intensive industrial raw materials such as concrete, steel and aluminium will avoid emissions. This represents a significant potential to generate carbon credits. Table 1 illustrates the extent to which emissions can be avoided by using timber in place of other products.

**Table 1: Carbon released and stored and fossil fuel energy used in the manufacture of building materials**

| Material | Carbon released (kg/t) | Carbon released ($kg/m^3$) | Carbon stored ($kg/m^3$) | Fossil fuel energy (MJ/kg) | Fossil fuel energy ($MJ/m^3$) |
|---|---|---|---|---|---|
| Rough sawn timber | 30 | 15 | 250 | 1.5 | 750 |
| Steel | 700 | 5,320 | 0 | 3.5 | 266,000 |
| Concrete | 50 | 120 | 0 | 2 | 4,800 |
| Aluminium | 8,700 | 22,000 | 0 | 435 | 1,100,000 |

(Source F.W.P.R.D.C. 1997)

Only the carbon sinks that would be created by plantations and timber products have been used to calculate the carbon sequestered in the proposed Gorgon Project. The potential exists for biomass fuels and product displacement to add significant value either directly to the Project objective if also credited for avoided carbon dioxide emissions, or indirectly through higher financial returns for the products. If Gorgon was credited for additional carbon, then the carbon yield from each hectare of plantation would increase. It would then require less area to achieve the same sequestration target, thus reducing the cost per tonne of carbon. Alternatively, if Gorgon could sell more resources due to their net greenhouse benefit, or their lower cost, it would increase revenue generated by the Project.

At this stage the accounting rules have not been finalised. The actual method finally agreed may affect the strategy adopted (i.e. one measurement method may provide a higher or lower increment of carbon).

Two broad strategies are suggested to meet the carbon sink target:

*Uniform plantation strategy*

This strategy would achieve the target of 20 million tonnes through a plantation establishment program that was constant from year to year. This would ensure the infrastructure to undertake the necessary works was constant over time and the yields from the plantation would not fluctuate widely. The predicted annual sequestration target would be achieved on average over the life of the Project, but not necessarily in each year.

*Even sequestration strategy*

This strategy would meet the annual target of 500,000 tonnes consistently. This would be achieved by varying the area of plantation established each year, so that the predicted net annual increase in the carbon sink was approximately 500,000 tonnes. This would ensure that Gorgon's carbon goal was met every year.

Both strategies are evaluated in this Plan. If necessary, alternative strategies to meet other specific purposes, (e.g. to maximise the carbon sink developed over the first commitment period) can be developed as the objectives for the implementation plan are further refined.

# 2.2 SPECIES OPTIONS

## 2.2.1 Maritime pine

This species is native to the western Mediterranean region, growing on sandy soils close to the ocean, hence its common name. It provides feedstock for industries in France and Portugal where it is now extensively grown in plantations as well as in natural stands.

▼ *maritime pine crop north of Perth*

Maritime pine has been grown in Western Australia for more than 80 years, principally on sandy soils on the coastal plain. It was chosen for this soil type because of its ability to perform well in drought conditions on soils depleted of nutrients.

Since the 1920s a large plantation estate has been established near Perth. This now supports an industry for a variety of forest products, including sawlogs, medium density fibreboard (MDF), particleboard, packaging timbers and fencing. By December 1997 more than 27,000 hectares had been established.

In November 1996 the Western Australian Government announced its Salinity Action Plan to combat the substantial threat salinisation poses to the economic and environmental health of the agricultural region. One of the key measures was to plant trees and deep-rooted shrubs to use the surplus water. Maritime pine is one important species with a capacity to grow in this environment and provide a commercial return. A 10-year planting target of 150,000 hectares was set and to date CALM has established more than 4,000 hectares.

*Plantation potential*

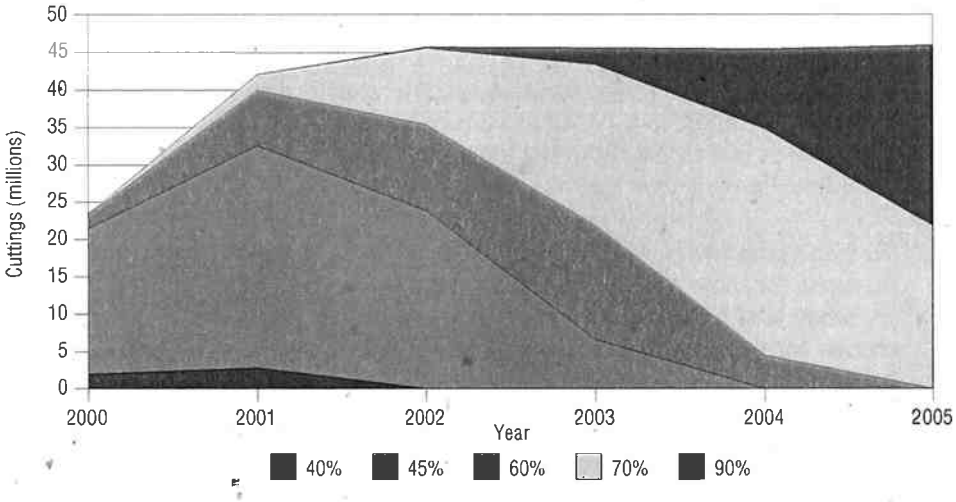
The species and its management have been progressively improved over the period of its use in Western Australia. A summary of current programs and published research is contained in Appendix 1.

*Genetics*

Research on genetic improvement for maritime pine began more than 40 years ago. Ninety seven genetic trials covering an area of 203 hectares and 216,000 trees have been established in Western Australia to provide the base population and database required to quantify genetic parameters of maritime pine. Initial yield trials showed a 36 per cent increase in volume. Recent orchard plantings have shown increases of 50 per cent in volume production over the first seed orchards. For selections now being grafted, an improvement in productivity of 90 per cent if compared to the first seed orchards has been achieved. This equates to 140 per cent improvement in the original unimproved trees imported from Portugal in the 1940s.

These genetic gains are being deployed by vegetative cuttings because it is logistically impossible to protect seed orchards from native cockatoos. The use of cuttings accelerates the use of the most improved seed. It is predicted that by the year 2003 most cutting production will be at least 60 per cent volume improved (Figure 1).

**Figure 1: Projected extent of genetic improvement in new cutting production 2000-2005**




*Site selection*

Soil water storage and salinity are the factors most likely to affect maritime pine survival and growth. For trees to establish successfully and grow in the medium (400 to 600mm/year) rainfall zone, soils must be non-saline, of adequate depth and have fresh water additions from seepage or ground water (Harper, 1996). For soil to be suitable for planting, depth of root-penetrable material must be two to three metres.

Currently CALM is undertaking a major study to refine prediction of site quality, growth and yield of maritime pine on farms in the medium rainfall zone. Some 180 plots have been established in plantings on farms from north of Geraldton to east of Esperance. Map 2 shows the location of study plots in the target area.

Preliminary results indicate that maritime pine can establish and grow in a wide range of soils including duplex and sandy loams, in addition to sandy soils. These stands were not derived from elite seed nor have they been planted with the benefit of new establishment technologies and fertilisation that have been developed over the past 10 years. As a consequence they typically grow at rates between four and 12 cubic metres per hectare per annum.

*Silviculture*

Two regimes have been considered for the Maritime Pine Project.
A conventional regime over a 30-year period (Table 2) and one that involves only one thinning and clearfall at 25 years (Table 3). The second regime is particularly aimed at farmers wanting multiple benefits from maritime pine, because it is suitable for narrow belts which produce timber while also providing shelter and controlling wind erosion.

**Table 2: Maritime pine conventional regime**

| Year | Action | Product |
|---|---|---|
| 0 | Plant 1,515 seedlings per hectare | |
| 12 | Thin to 450 sph | Industrial wood |
| 18 | Thin to 250 sph | Small sawlogs |
| 24 | Thin to 125 sph | Sawlogs |
| 30 | Clearfall | Sawlogs and peeler logs |

**Table 3: Maritime pine single thinning regime**

| Year | Action | Product |
|---|---|---|
| 0 | Plant 1,515 seedlings per hectare | |
| 0 | Plant 1,500-1,800 seedlings per hectare | |
| 12 | Thin to 150 sph<br>Prune to 6 m | Industrial wood |
| 25 | Clearfall | Small peelers and industrial wood |

Only the conventional schedule has been used to evaluate the Project.

*Wood properties*

Maritime pine is valued in Western Australia because of its extra strength and density compared with other softwoods, including radiata pine (Siemon, 1983). The timber is straight-grained, resinous and rather coarse in texture, especially the early growth. Its colour is pale yellow-brown in the sapwood and slightly darker in the heartwood. Table 4 provides details on physical and mechanical properties of maritime pine timber.

**Table 4: A comparison between the physical and mechanical properties of maritime pine and radiata pine**

| Physical properties | Species | |
|---|---|---|
| **Parameter** | **Maritime pine** | **Radiata pine** |
| Green density (kg/m$^3$) | 1,120 | 800 |
| Air-dried density (kg/m$^3$) (~12%m.c.) | 560 | 500 |
| Tangential shrinkage (%) | 5 | 4.5 |
| Radial shrinkage (%) | 3.5 | 3 |

| Mechanical properties (dry) | Species | |
|---|---|---|
| **Parameter** | **Maritime pine** | **Radiata pine** |
| Static bending | | |
| – modulus of rupture (MPa)<br>– modulus of elasticity (MPa) | 82.6<br>11,680 | 81<br>10,000 |
| Compression parallel to grain | | |
| – max. crushing strength (MPa) | 45.1 | 42 |

*Utilisation*

In Western Australia, maritime pine is used mainly as structural grade timber and for panel products such as medium density fibreboard (MDF) or particle board (CALM, 1996). Pruned logs produce appearance grades suitable for furniture and plywood. More recently it has been assessed for a structural veneer board product, laminated veneer lumber (LVL), and found to be highly suitable.

Maritime pine produces good quality paper pulps. Nelson *et al.*, (1973) report that the neutral sulphite semi-chemical pulping process produces pulp yields of up to 76 per cent and strength properties superior to those of radiata pine. De-resination of maritime pine pulp is effective with alkali extraction methods and it is used in kraft pulpmills in France.

Table 5 summarises the properties of maritime pine timber by uses.

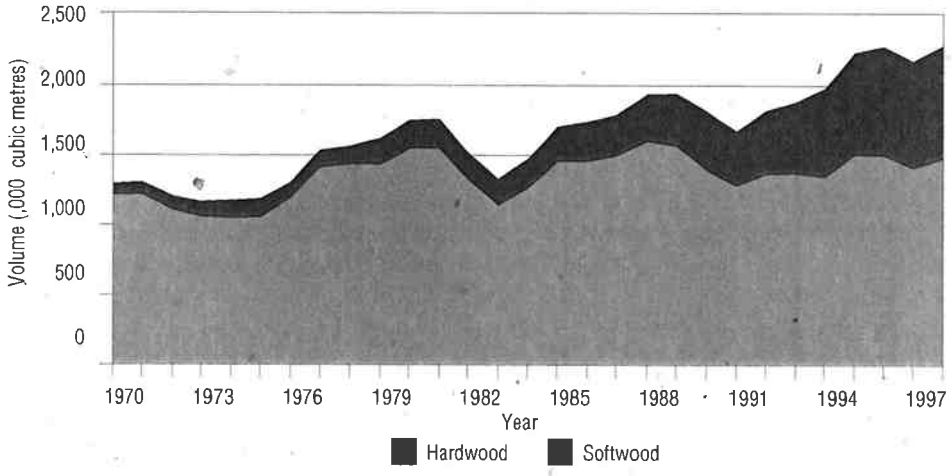
**Table 5: Properties of maritime pine timber by uses**

| Timber use | Properties/qualities |
|---|---|
| Sawn timber | density – 560 kg/m$^3$ (air dry)<br>strength – M.O.R.= 83 MPa<br>– M.O.E.= 11,680 MPa<br>– M.C.S.= 45 MPa<br>– S.D.6 strength group (A.S.2878-1986) |
| Reconstituted wood<br>(MDF and particle board) | suitable for MDF and particle board production |
| Pulp<br>(using NSSC process) | yield – up to 76%<br>strength (tear factor) – 154<br>(60g/m$^2$ oven dry grammages) |
| Plywood<br>(including laminated veneer lumber) | suitable for LVL because suitable for plywood particularly suitable for structure grade because of high density and strength |
| Oriented strand board | suitable for OSB production |
| Posts and poles | durability – sapwood readily treatable with preservative |

*Marketing*

In 1997-98, 805,789 cubic metres of softwood logs were produced from pine plantations in Western Australia, of which 140,121 cubic metres were maritime pine logs from Crown land. Trends in the production of timber from Western Australia (Figure 2) indicate both an increasing quantity and proportion of the timber resource from softwood plantations. This trend is predicted to continue.

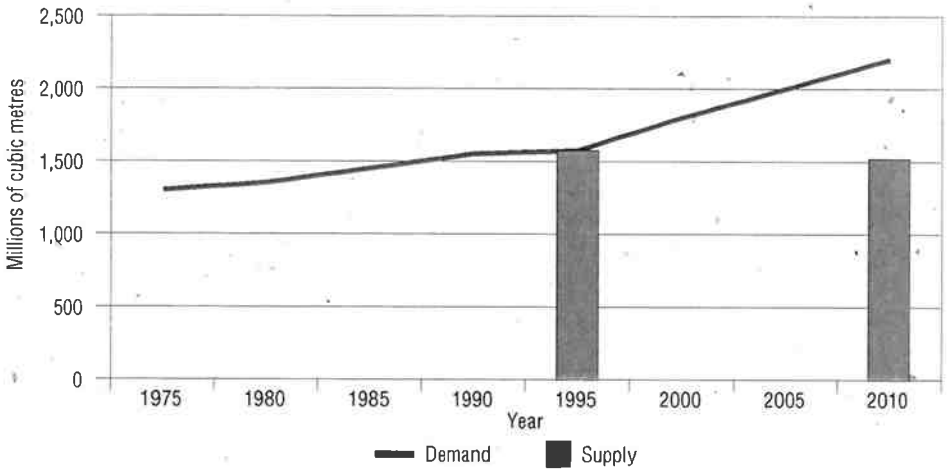
**Figure 2: Trend in timber production in Western Australia between 1970 and 1998**




Future trends likely to influence the marketing of maritime pine resources are:

- alternative supplies of pine resource may be declining locally as there is little private planting of any pine species in Western Australia and CALM is not replanting all pine areas clearfelled – maritime pine on farmland is likely to become a much more important resource;
- the declining supply of wood resources globally, at the same time as the demand is increasing (Figure 3). While maritime pine is not well known in the region it has been assessed by Japanese manufacturers and looked on favourably for board products.

**Figure 3: Global demand and supply for wood products**



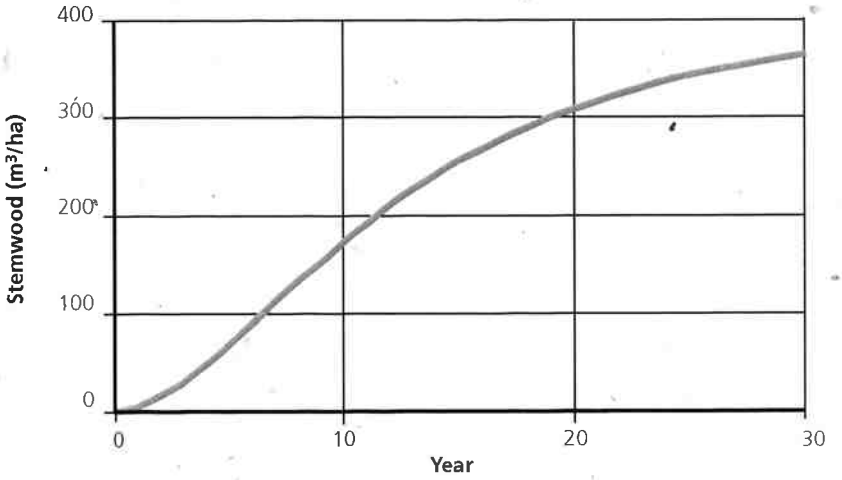

Source: DA Neilson, UN FAO, Apsey and Reed, Jaakko Poyry, Widmans World Wood Review, Xylem Investments Inc.

*Sequestration model*

As the plantations would be established on cleared farmland with very little, if any, increase in biomass on the site, baseline carbon sequestration may be assumed to be nil and need not be monitored (Greenhouse Challenge Office, 1998). This means that the changes in carbon sequestration from the Project could be assumed to arise from tree establishment and growth. No remnant native forest would be removed to establish tree crops.

The carbon sink model is linked to a growth model for maritime pine. Figure 4 shows predicted growth of stemwood in a typical maritime pine stand assuming the stand is not thinned.

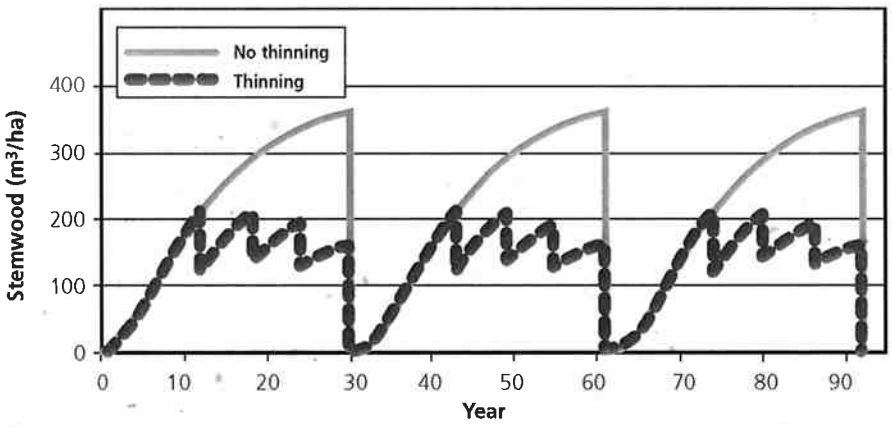
**Figure 4: Growth curve for maritime pine**




This model was developed from study of maritime pine stands on farms, mostly in the 400 to 600mm/year rainfall zone of south-western Australia. Most of these stands were isolated and had not been logged (thinned) since establishment. Past growth of trees in the study plots was determined by stem analysis. This involves felling sample trees and taking discs from the stem at regular height intervals. From measurements of the annual growth rings it is possible to determine past height, diameter and volume growth of the stem. From stem analysis of plots of trees it is possible to indicate the growth trend of the stand that the plot represents.

However, in large area plantations, managed for timber production, thinning is standard. The purpose is to remove and use a portion of the trees in the stand, concentrating growth on the remaining (usually better form) trees by giving them more room to grow. The anticipated schedule for CALM's Maritime Pine Project plantings is thinning at ages 12, 18 and 24 years followed by clearfelling and replanting at ages 30 and 31 years. This schedule, over three rotations, is depicted in Figure 5. Note that the thinning curves were derived from the growth curve for an unthinned stand. It was assumed that gross stemwood production in an unthinned stand would be approximately equal to the cumulative harvests plus unthinned stock in a thinned counterpart. The results of most thinning studies support this conclusion, i.e. that thinning does not generally have a significant effect on gross stemwood production (Clutter *et al.*, 1983). CALM**Science** thinning studies currently in progress in maritime pine stands in the 400 to 600mm/year rainfall zone will test this assumption (McGrath and Adams, 1997).

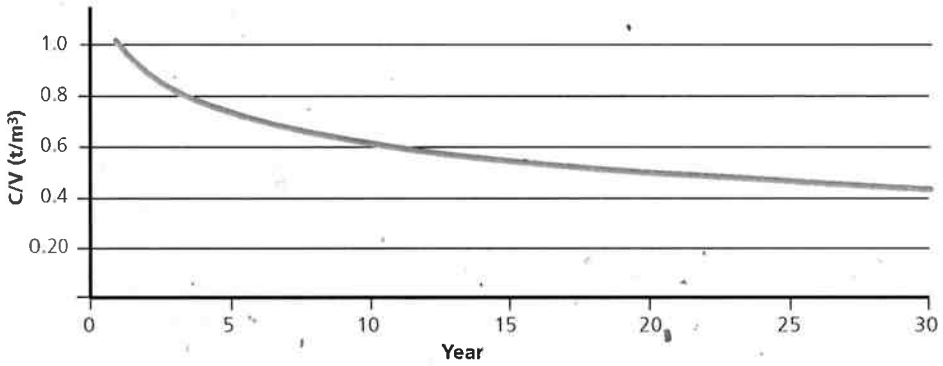
**Figure 5: Growth curves for maritime pine over three rotations, including thinning**




In both the thinning and no thinning cases shown the cumulative production over a 30-year rotation is assumed to be 360 $m^3$/ha of merchantable wood, i.e. mean annual increment (MAI) of 12$m^3$/ha/yr.

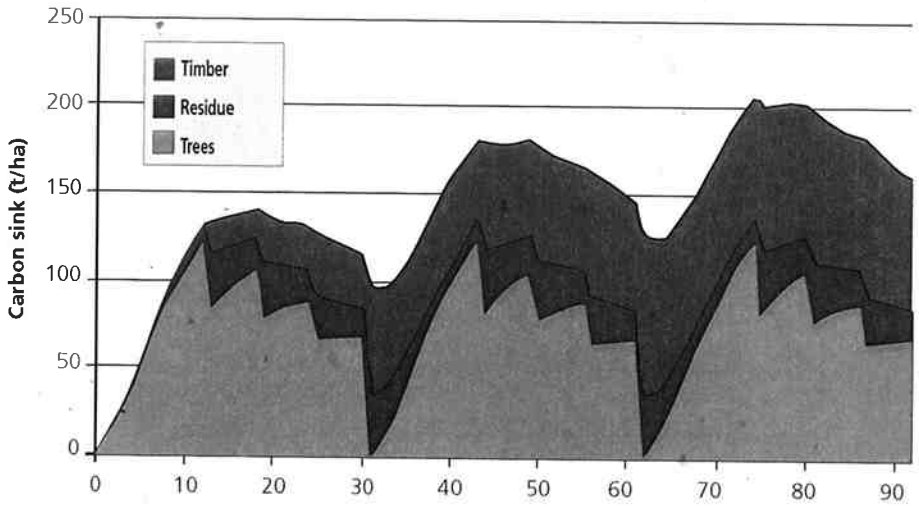
From the stemwood growth model the next step is to estimate the carbon sink in stands of trees. Based on the approach taken with radiata pine in New Zealand (Maclaren *et al.*, 1995) this is done by multiplying stemwood volume at any age in the rotation by the C/V ratio for that age. C/V is the ratio of carbon content of a stand (C) to stemwood volume (V) at that age. It varies with stand age and management factors (planting layout, silviculture). Figure 6 is CALM's best estimate of the trend in C/V ratio for typical maritime pine in the 400 to 600mm/year rainfall zone. An intensive study is underway to refine our estimates for this part of the model.

**Figure 6: C/V ratio for maritime pine**




To complete the model of carbon sequestration, some assumptions are required about the decay rates of residues (tree parts left after logging) and timber products. This is shown in Figure 7. Little is known of the decay rates of wood products but it is the subject of studies world-wide (e.g. Karjalainen, 1996).

**Figure 7: Carbon sinks from maritime pine**




*Note:*
"Timber" is produced from thinning and clearfelling operations. In the above all timber produced is assumed to decay (release stored carbon as carbon dioxide) with a half-life of 30 years.
"Residues" are the parts of thinned trees that are not used, i.e. stem tops, branches and leaves, roots and stumps are all left in the field. It also includes litter from fallen leaves and dead branches. In the above, "residues" are assumed to decay with half-lives of either five years (roots and stumps) or three years (all other residue).
"Trees" are the living biomass part of stands.

From Figure 7 the average carbon sink over one rotation is 89 t/ha in the stand (trees plus residues) or 103 t/ha if timber is also included. Over three rotations the average carbon sink is 93 t/ha (stand only) or 144 t/ha (stand plus timber). However, note that these are predictions based on only the early stages of field measurements to calibrate the model. The model has been assessed to determine the sensitivity of predicted carbon sequestration to variation of the inputs. This has indicated that the parameters used in the growth model (Figure 4) and the C/V ratio have greatest effect on the predicted value.

The carbon sinks predicted under the model for each hectare can be added to produce an estimate for the whole Project.

### 2.2.2 Mallee eucalypts

Several species of native mallee eucalypts are being developed as short rotation tree crops for the Wheatbelt (rainfall range 250 to 400mm/year). These species and their product, eucalyptus oil, were carefully chosen as the most prospective commercial tree crop option available (Bartle *et al.*, 1996). Mallee eucalypts were recognised in the State Salinity Action Plan as the option with best potential to control salinity in the low rainfall zone and the Plan indicated the potential for at least half a million hectares of mallee eucalypts.

All but one of the six species used in this development are native to Western Australia (*see box*).

**MALLEE EUCALYPT SPECIES:**

*E. kochii* subsp. *kochii*, *E. kochii* subsp. *plenissima* and *E. horistes*: all from the oleosa group of eucalypts that occur in the northern Wheatbelt and prefer well-drained light to medium soils.

*E. loxophleba* subsp. *lissophloia*: the smoothed bark York gum, occurs in the central Wheatbelt as far east as Kalgoorlie. Prefers heavy soils and can tolerate some waterlogging and salinity.

*E. angustissima*: from the inland south coast area from Ravensthorpe to Esperance. Is waterlogging and salinity tolerant.

*E. polybractea*: the blue mallee from NSW/Vic. Appears quite adaptable to Western Australian soils in southern agricultural areas and has demonstrated reasonable salinity tolerance.

The oil has traditional uses, especially in non-prescription pharmaceuticals, but this market is small. Barton and Knight (1997) have shown that the natural solvent properties of eucalyptus oil could be developed for industrial use to replace trichloroethane, which was withdrawn recently under the international convention to control ozone depletion. There is a strong preference in the big industrial solvent markets for natural replacement products. Large-scale penetration of these markets would require prices about half those prevailing in traditional eucalyptus oil markets, but this appears achievable given the potential for economies of scale, technical advances in genetics and processing technologies and the potential for commercial uses for residues. Viability would be bolstered if sequestered carbon had a cash value.

CALM initiated development of a eucalyptus oil industry in 1992. Extensive planting began in 1994 with the aim of building an initial resource as the basis of a new industry. Planting was initially confined to six districts to foster local support and reduce the large overhead costs that would be involved in widely dispersed operations. Table 6 indicates the scale of planting and number of growers.

**Table 6: Mallee eucalypt planting statistics**

| Planting year | Seedlings planted (million) | Number of growers | km of hedge (seedlings/1333) |
|---|---|---|---|
| 1994 | 1.10 | 80 | 825 |
| 1995 | 2.05 | 170 | 1,540 |
| 1996 | 2.80 | 250 | 2,630 |
| 1997 | 1.05 | 100 | 750 |
| 1998 | 2.00 | 200 | 1,500 |
| **Total** | **9.00** | **Approx 350** | **7,245** |

Note: a hedge has two rows 2m apart and a within row planting interval of 1.5 m, 1 km ~ 1 ha

There is now a considerable body of research and experience on mallee eucalypt management. Mallees have proved to be robust and adaptable and as they are not very palatable to sheep, mallees do not have to be protected by fences. The range of species has been selected to give good coverage of Wheatbelt soils and climate. The mallee habit is well suited to a short production cycle of two to three years between harvests and large scale mechanised operations. The mallee root is in effect a subsurface stem. It readily sprouts (or coppices) after cutting to ground level. Under a regular harvest regime the above ground carbon sink does not develop but a substantial below ground sink builds up.

There is considerable variation in leaf oil content in natural stands and current seed supply comes from individuals selected for high leaf oil content. These selected individuals are incorporated into a breeding and seed production program conducted by CALM.

The Oil Mallee Association was formed in 1995 to represent the interests of growers as the industry develops. The Association is an incorporated body with a regional structure and publishes a quarterly newsletter. It employs regional managers to provide guidance to growers, manage the logistics of seedling supply and keep records. Most growers have elected to become members of the Association and CALM has representatives in this group. Membership is open to all interested parties not just prospective growers.

▼ *belt planting of mallees*

A professional business plan was prepared during 1997 by an independent consultant. This study indicated that it was commercially feasible to build an industry based on mallee eucalypts but it would take longer than early optimistic schedules had indicated. The plan helped focus sharply on strategies necessary to achieve commercial success, including:

- At least double the resource base in order to reduce overheads to a level where it will be viable to sell into existing markets.
- Take maximum advantage of the existing pharmaceutical market, to provide good prices for initial low volume production and the opportunity

to learn on-the-job to drive future expansion and new market development. An alliance has been formed with a major player in the pharmaceutical market.

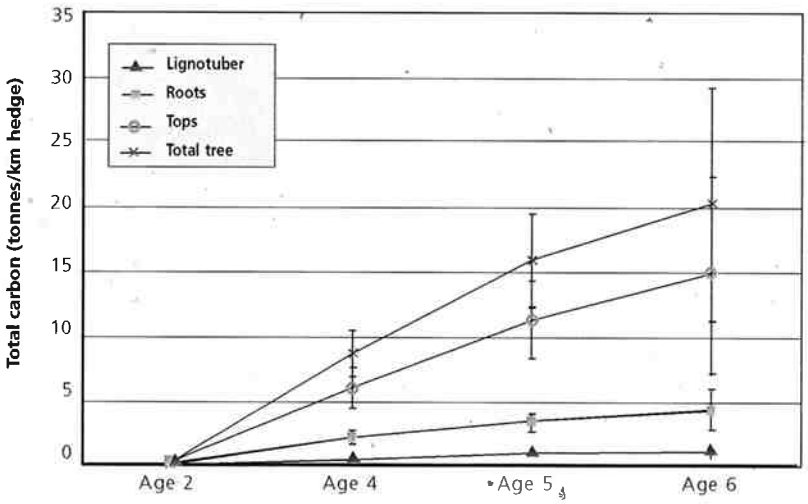
- Increase planting density and area – the Association is now seeking good concentrations of planting anywhere in the Wheatbelt.
- Develop efficient bulk handling systems – considerable design work and prototype testing has now been completed and a set of first generation operational harvest, handling and extraction equipment is under construction.
- Find markets for the residue left after oil extraction. There is potential in reconstituted wood products (panel board) and bioenergy.

The business plan also suggested the formation of a company to work in conjunction with the Association and conduct the harvest, processing and marketing of oil and other products and the Oil Mallee Company was formed in 1997. CALM has a representative on the Board.

*Carbon sink potential*

Preliminary data have been collected from representative sites in a 300 to 350mm/year rainfall area. All data are for belt plantings where one kilometre of belt planting can be equated to one hectare. In belts the trees will have more than just annual rainfall available through exploitation of excess water from adjacent crop and pasture land. The typical routine will be first harvest at age four, then coppice crops taken on a two-year cycle. At age four the above ground carbon mass will average six tonnes/ha (Figure 8) and below ground two tonnes/ha. Each subsequent biennial coppice harvest yields the same as the first harvest. Hence the average standing above ground carbon is maintained at three tonnes/ha. Roots initially grow at one tonne carbon/ha/year (after the slow initial two-year establishment phase) but growth rate decelerates to a plateau over a period in excess of 100 years. Initial data from mature mallee retained in belts in farmland indicates very large root biomass (up to 200 tonnes biomass or 100 tonnes C/ha at maturity). Similarly the wood fraction, potentially a suitable fuel for electricity generation, is available at six tonnes of wood biomass per harvest, or 84 tonnes over a 30-year period. Cumulative totals for a 30-year period and 14 harvests are 84 tonnes of above ground carbon, including 42 tonnes of carbon as wood suitable for use as fuel, and 28 tonnes of roots.

**Figure 8: Total carbon per kilometre for *Eucalyptus plenissima* to age six years for carbon pools with standard deviation**



### 2.2.3 Landcare trees

An integral part of establishing maritime pine plantations on farmland is the additional landcare component. By planting a range of native and other species on land too saline or too rocky for pines, environmental outcomes for both Gorgon and the Western Australian community can be achieved. The benefits obtained from landcare trees largely accrue to the landowner. Species are selected to cover the range of sites and environmental conditions encountered in a typical farming environment. They improve farm aesthetics, provide windbreaks, assist in erosion control and restore natural landscapes. The choice of species to be planted is at the landowner's discretion.

The potential for these trees to sequester carbon will vary with species and management. At this stage relatively simple models have been developed to predict the development of carbon sinks in landcare trees. The sequestration rate is likely to be lower than for commercial species such as maritime pine. Given the lower value of carbon from such species the method of measuring the carbon sink needs to be cost effective and simple. This may be difficult to achieve given the large number of species involved.

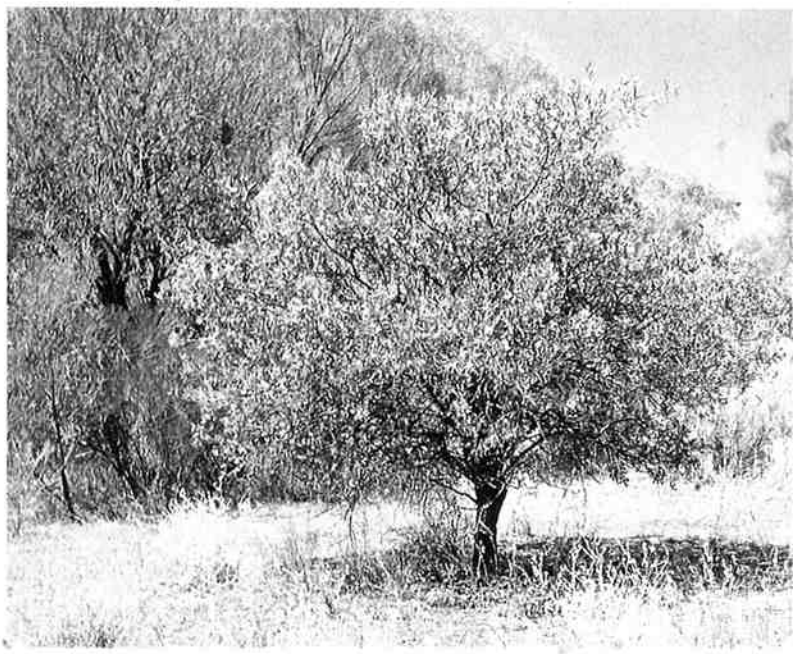
▲ *York gum flowers*

Currently 15 to 20 species are in common use (e.g. *Acacia acuminata*, *Casuarina obesa*, *Eucalyptus wandoo*) for landcare purposes and allocations are based on an amount of up to 10 per cent of the pine plantation area.

Farmers can elect to include potentially commercial species in their selections, including exotic and local species. One species currently grown that has particular potential for both commercial and environmental benefits is Western Australian sandalwood (*Santalum spicatum*). Western Australia has had an almost entirely export-orientated sandalwood industry for more than 150 years – export quantities peaked at 2,040 tonnes in 1993. Sandalwood is mostly used for the manufacture of joss sticks in south-east Asia, however more innovative uses have been developed recently. Sandalwood is the focus of a

research program aimed at understanding its natural regeneration requirements and its establishment in tree farms on agricultural land.

Sandalwood needs a host plant in order to survive more than a few months after germination. *Acacia acuminata* (jam) is the most common host for sandalwood in the Wheatbelt and good growth rates are achieved with this species. Throughout its natural range sandalwood uses a variety of hosts, primarily *Acacia* and *Allocasuarina* species.



▲ *sandalwood*

Sandalwood is a shrub or small tree up to about eight metres high with a bushy growth habit (Hewson and George, 1984; McKinnell, 1990; Barrett and Fox, 1995). It occurs naturally over a large area of Western Australia, from the edge of the high forest zone out to the desert interior. It has virtually disappeared from the 300 to 600mm/year rainfall zone due to widespread agricultural clearing (McKinnell, 1990).

Research into the establishment of sandalwood in the Wheatbelt has been conducted by CALM for more than 10 years, with the objective of establishing sandalwood on farms with a medium to high annual rainfall (400 to 600mm/year). Planting sandalwood forms part of the revegetation program to reduce salinity in the Wheatbelt (Havel and McKinnell, 1993; Bailey *et al.*, 1997).

*Soil types*

Sandalwood prefers lighter textured soil types (loams, sandy loams etc.) with a granite component and most often occurs on neutral to mildly acidic soils. The preferred sites are loams over clay, with *Acacia acuminata* growing near the site.

*Site preparation*

The site is ripped (lines four metres apart) and weeds controlled prior to planting. Once weeds have been controlled, *Acacia* seedlings are planted at the rate of 832 per hectare. Initial field establishment consists of planting six-month-old *Acacia* host seedlings in July, two to three weeks after herbicide spraying. Two or three years after hosts are established, four sandalwood seeds are sown next to every second host, in April. Fertilising and weed control is conducted before the seedlings emerge.

*Growth rate*

Sandalwood is a slow-growing species, although the greater the rainfall the faster commercial size is reached. Establishment success and initial growth rates from field plantings in the Wheatbelt have been encouraging, with a mean annual diameter increment of 7.5mm (at 150mm above ground level). Current research is examining the effects of host species, stocking rates and soil type on sandalwood growth rates.

*Products*

Sandalwood (the highly prized aromatic heartwood) is normally sold as logs to Asia for making incense sticks used in religious ceremonies. When burnt, the aromatic oils released from the heartwood have a distinctive smell that has been used for centuries in many cultures. The remainder is used for ornamental carvings and craftwork. The tree usually begins to fruit after four or five years and there may be potential for marketing the nuts for human consumption, though this is at an early stage and needs further development.

*Value of sandalwood*

The price private landholders receive depends on the quality and size of the timber they supply. For example, if they produce a number of large logs they will receive more than if it is mostly small branches. Wood is processed prior to export and is sold as uncleaned logs, cleaned logs, dead wood pieces, chips (two grades), powder and shavings. These products differ in their value, with cleaned logs fetching the highest price, up to $10,000 per tonne, and the average about $6,500 per tonne.

*Production*

If trees are pulled from the ground, including the roots, there are about 90 commercial size trees to the tonne, and if they are cut at ground level, there are about 150 trees per tonne.

Varying results have been found with sandalwood coppicing, with up to 80 per cent survival after two years in the Shark Bay area, but down to 4.5 per cent survival in the Goldfields. General observations suggest that sandalwood does coppice in the higher rainfall areas of its range (above 400mm/year). If 200 sandalwood trees per hectare reach harvestable size and the trees are pulled, this gives a total income of approximately $14,000 per hectare.

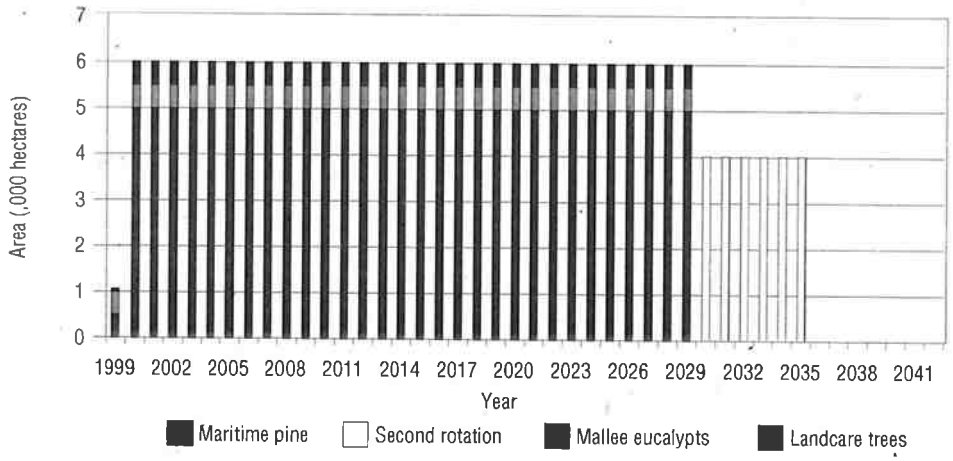
## 2.3 PLANTATION ESTABLISHMENT TARGET

The proposed plantations would comprise the species groupings outlined in Section 2.1. The required area of planting would vary with the composition of species and the strategy adopted as indicated in Section 2. The scale of plantations required is examined for both proposed strategies.

### 2.3.1 Strategy 1: Uniform plantation

Figure 9 illustrates a strategy of uniform plantation establishment over 30 years, with some areas being replanted on clearfelling after 30 years.

**Figure 9: Proposed planting program for Strategy 1**



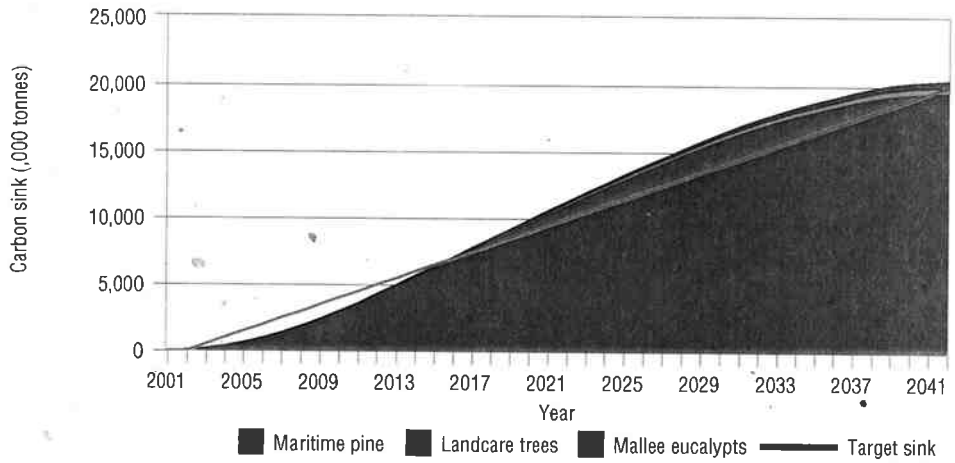

The plantation estate created by this strategy is shown in Table 7.

**Table 7: Plantations established under Strategy 1**

| Species | Area |
|---|---|
| Maritime pine – first rotation | 150,500 |
| Maritime pine – second rotation | 24,000 |
| Mallee eucalypts | 15,500 |
| Landcare trees | 15,050 |
| Maximum area | 181,050 |

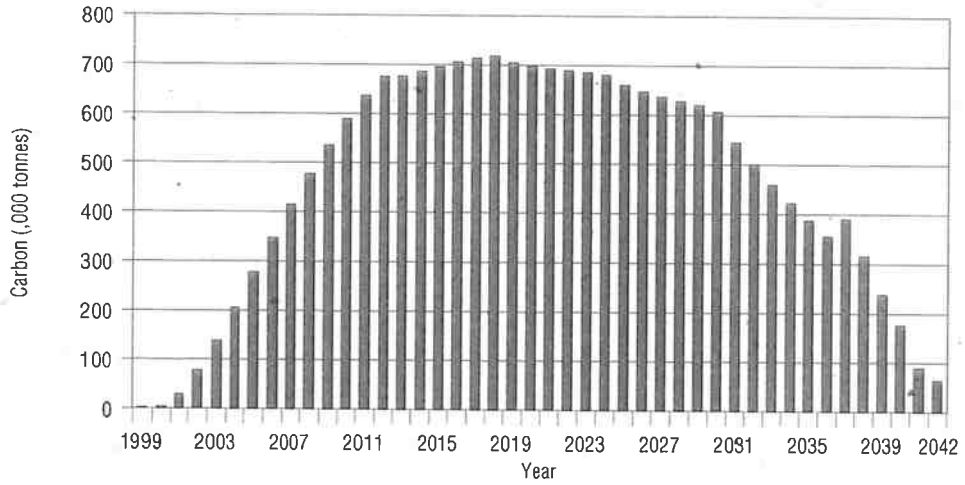
This strategy is predicted to meet the overall carbon goal of sequestering 20 million tonnes of carbon by the year 2042 (Figure 10).

**Figure 10: Carbon sink from Strategy 1**




Through this strategy the Project would have a deficit in the total carbon sink until the year 2016, after which there would be a substantial surplus. The annual rate of sequestration (Figure 11) would be below 500,000 tonnes per annum until 2008 and then remain above 500,000 tonnes per annum until 2033.

**Figure 11: Annual sequestration for Strategy 1**

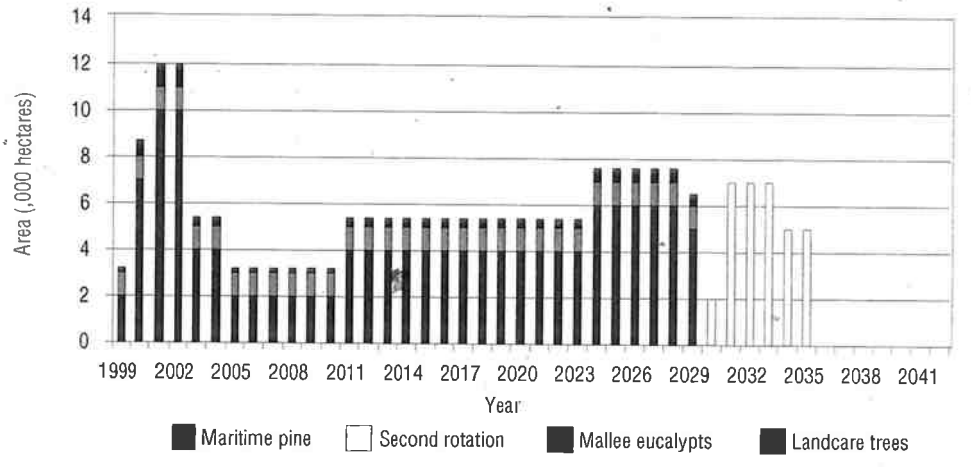



The major advantage of this strategy is the uniform amount of work required to establish the plantations and the even flow of products harvested from the plantation. The major uncertainty with this approach is whether in accounting for the carbon, the sink can be averaged over several years, or whether it must be in balance on an annual basis. This strategy would meet the target during the first international commitment period with a predicted annual average of 580,000 tonnes sequestered between 2008 and 2012.

### 2.3.2 Strategy 2: Even sequestration

Where the annual rate of sequestration is closely matched to Gorgon's annual target, a rate of plantation establishment as illustrated in Figure 12 would be required.

**Figure 12: Proposed planting program for Strategy 2**



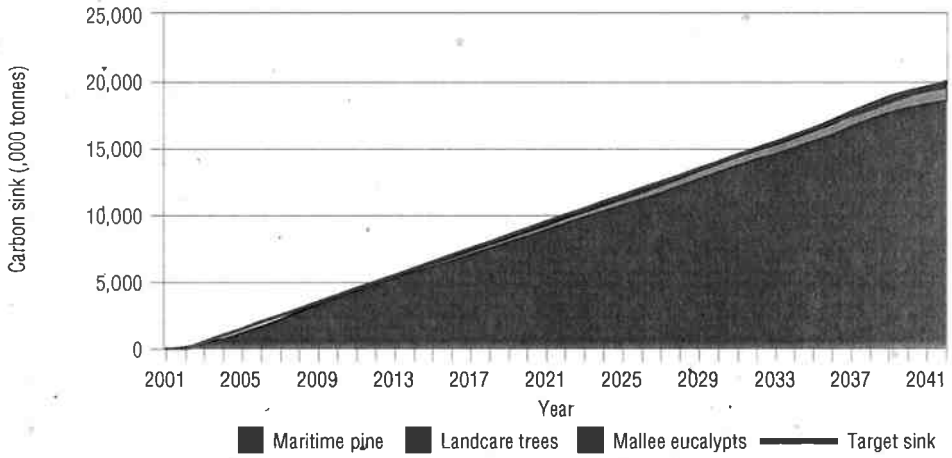

The plantation estate produced by this strategy is shown in Table 8.

**Table 8: Plantation development under Strategy 2**

| Species | Area |
|---|---|
| ~~Maritime pine – first rotation~~ | ~~150,500~~ |
| Maritime pine – first rotation | 136,000 |
| Maritime pine – second rotation | 33,000 |
| Mallee eucalypts | 31,000 |
| Landcare trees | 13,600 |
| Peak area | 180,600 |

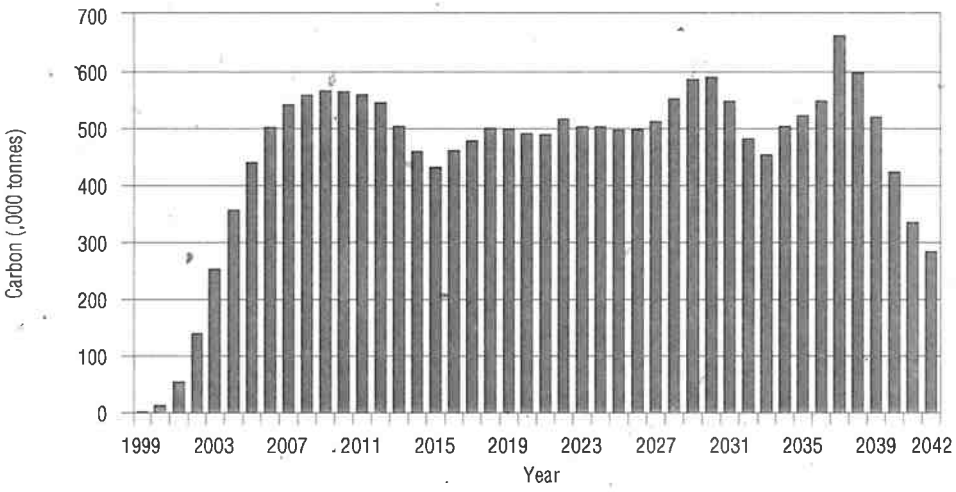
The predicted total carbon sink from this strategy is shown in Figure 13. The total carbon sink would be in deficit compared to target until 2009, after which it would remain in balance with the sink target for the remainder of the life of the Project.

**Figure 13: Carbon sink from Strategy 2**




The predicted annual rate of sequestration (Figure 14) is approximately 500,000 tonnes per annum until the final two years of the Project. A carbon sink of approximately 200,000 tonnes is predicted to be accumulated by the time that Gorgon's carbon dioxide emissions begin in 2003.

**Figure 14: Annual sequestration**



In most years this strategy would run within 10 per cent of the annual sequestration target, and therefore only require a small carryover of carbon between years. Between 2008 and 2012 the average annual rate of carbon sequestration is 558,000 tonnes.

The major difficulty in managing such a program would be the more volatile consequence for work inputs and log outputs. There may be higher costs and uncertainties associated with a fluctuating program.

## 2.4 DESCRIPTION OF THE TARGET AREA

The project area lies within a 200 kilometre radius of Perth, the capital of Western Australia (Map 1). Perth has a population of 1.2 million and the hinterland has a highly developed infrastructure. Transport and energy distribution networks are illustrated on Map 3.

This region is an attractive setting for a project of the size proposed in this Plan. It has a considerable area of land potentially suitable for tree planting, problems of land degradation that require tree planting as part of the remedy and an existing timber industry as a base on which this Project can build. Major timber processing plants are established in the Perth locality of Kewdale. Regional towns also provide suitable locations for the establishment of new processing facilities.

The major land use in the region is agriculture. Some intensive agriculture is practiced in the vicinity of Perth and along the coastal plain north and south of Perth. However, the bulk of agriculture is mixed cereal cropping and sheep and cattle grazing with a predominance of grazing in the west and cropping in the east. Other than in the vicinity of Perth agricultural development has mainly occurred during the present century and much of it in the post war years. There has been continuous decline in the terms of trade for grains, wool and meat for several decades. This has been accommodated by increased efficiency and property consolidation, but the agriculture is not prosperous and farmers are seeking opportunities for substantial diversification.

The region can be subdivided into two parts – a northern and a southern sector. The northern sector will be the major planting area because it has more suitable land (Map 2) and fewer competing uses. A detailed profile of the northern sector follows.

### 2.4.1 The Northern Sector: case study

*Land use*

In areas alienated for agriculture native vegetation has now been mostly cleared and replaced with farming systems, based on rotations of cereal and legume cropping and annual pastures.

European settlement of the study area began in the mid-19th century. Land development, primarily for grazing, progressed along rivers and its tributaries on the floodplain of the Moore River. About 60 per cent of the area has been cleared. Large areas of natural vegetation remain within conservation reserves, Crown land and State forest.

The study area has long been recognised as a pastoral district. Sheep grazing is still the major land use with some cropping of coarse-grained cereals and fodder crops. Irrigated horticulture is also practised, mainly confined to the soils of the Dandaragan Plateau. This is expanding within the coastal plain.

Limestone and sand are mined in coastal areas. Mineral sands are mined near Cataby and Eneabba, from deposits, which lie adjacent to the Gingin Scarp.

*Climate*

The area has a Mediterranean-type climate with hot dry summers and cool wet winters. Many climatic factors show a south-west to north-east variation due to the slight change in latitude and coastal influences. The Dandaragan Plateau also imposes a topographical effect.

*Rainfall*

**Table 9: Mean monthly and annual rainfall (mm) for selected stations in the target area**

| Station | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moora | 11 | 15 | 18 | 26 | 61 | 92 | 89 | 63 | 38 | 25 | 13 | 9 | 460 |
| State Forest 65 (N) | 7 | 16 | 14 | 48 | 96 | 138 | 129 | 92 | 57 | 44 | 15 | 4 | 660 |
| Lancelin | 6 | 11 | 13 | 35 | 83 | 135 | 158 | 90 | 52 | 40 | 16 | 5 | 644 |
| Cowalla | 8 | 11 | 15 | 37 | 99 | 155 | 147 | 106 | 58 | 43 | 15 | 8 | 702 |
| Gingin | 8 | 11 | 18 | 33 | 106 | 156 | 160 | 122 | 71 | 54 | 18 | 12 | 769 |

Summer rainfall is much more variable (i.e. less reliable) than the winter rainfall, and must be considered a bonus rather than as an assured part of the annual rainfall.

*Evaporation*

Annual pan evaporation is 1,700mm near the coastline within the study area and 2,249mm at Moora (Table 10). Evaporation increases with distance from the coast, as the maritime influence decreases, compounding the effect of decreasing water availability with reduced rainfall.

**Table 10: Mean monthly and annual evaporation (mm) for Moora**

| J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 337 | 299 | 276 | 140 | 76 | 58 | 57 | 72 | 106 | 185 | 252 | 316 | 2249 |

*Temperature*

**Table 11: Mean monthly temperatures for Moora**

| Temperature (°C) | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum (°C) | 32.2 | 30.9 | 27.0 | 22.5 | 19.3 | 16.5 | 15.4 | 16.7 | 17.9 | 21.7 | 23.7 | 28.9 |
| Maximum (°C) | 37.4 | 37.8 | 34.1 | 29.4 | 24.8 | 20.3 | 18.5 | 19.2 | 22.3 | 28.1 | 30.5 | 35.5 |

*Frost*

Climatic data on frost frequency are not available within the study area, but it can be inferred from the closest station at Pearce that frost is rare. No frost occurs from November to March, while in winter no more than two frost days can be expected in any month.

*Geology*

The underlying geology of the target area is described in detail by several authors (Johnstone *et al.*, 1973; Wilde and Low, 1980; Carter and Lipple, 1982). In simple terms sedimentary rocks in the Perth Basin are separated from the Archaean granites of the Yilgarn Craton or Darling Plateau by the Darling Fault. This bisects the area in a north-south direction, near Perth forming the Darling Scarp.

*Geomorphology*

The Perth Basin is comprised of two major geomorphic features:

- *The Swan Coastal Plain*
  This has a series of coastal dune systems and alluvia associated with river systems emerging from the Yilgarn Craton. This is further described in several publications (Bettenay *et al.*, 1960; McArthur and Bettenay, 1960)
- *The Dandaragan Plateau*
  This is comprised of uplifted sedimentary rocks, bounded on the east by the Darling Fault and to the west by the wave-cut Gingin scarp (Churchward, 1970). These rocks were deeply weathered (lateritised) in the Tertiary period, forming a deep mantle of clayey materials, surficial ferricrete gravels and sands. This mantle has subsequently been modified. Down–cutting by several rivers, which run in a westerly direction to the coast, has exposed a variety of parent materials in the river valleys.

The Yilgarn Craton is predominantly granitic, and this has also been deeply weathered to depths of up to 100 metres (Gilkes *et al.*, 1973). This lateritic mantle has also been removed to various depths by the local river systems (Mulcahy, 1967). In the target area there are thus broad patterns:

- broad interfluves with soil profiles, which are effectively many metres deep, formed on deep weathering profiles. Deep sand sheets are often associated with these deep weathering profiles, and these often occur in lower areas of the landscape.
- valleys, where the weathering profile has been removed and basement rocks have been exposed (e.g. Bindoon).

*Soils*

Both the soil pattern and the chemical and physical properties of the soils can be related to previous deep weathering and subsequent patterns of stripping. As a consequence of pre-weathering, the soils formed on lateritic profiles have a clay fraction dominated by kaolinite and secondary iron and aluminium minerals, with a low base status, and small amounts of nutrients compared to those formed on fresh rocks (Turton *et al.*, 1962; Robson and Gilkes, 1981). Smectites may occur where soils are derived from mafic rocks.

Upland areas where the deep weathering profile has not been truncated, or only partially so, have soils dominated by ferricrete gravels with a matrix of sand or sandy loam (Mulcahy, 1973). In some areas it is thought that the prior lateritic profile was truncated to the mottled zone, with gravelly soils forming from the mottled zone. Ferricretes may occur as massive duricrusts, with ferricrete gravels becoming finer down-slope. These are underlain by mottled yellow substrates up to three metres thick. Where the deep weathering profile has been stripped, the soils formed depend on the degree of truncation and the lateritic horizon (mottled zone, pallid zone) which has been exposed.

Solodic and podzolic soils dominate, with non-calcic brown soils on mafic dykes. Deposits of varying depth occur on slopes, with the soils often sandy or gravelly (Mulcahy 1960) and these have been described as sandy yellow earths, earthy sands and sands overlying ferricrete gravels (Churchward, 1970).

*Native vegetation*

The vegetation of the study area was mapped at a scale of 1:250,000 by Beard (1979). These studies identified the major communities and indicated the structural formation and dominant species of each strata. Various studies have recognised that the structural and floristic composition of the vegetation is influenced by the general south-north trend of increasing aridity. Conspicuous examples are the absence of *Eucalyptus marginata* (jarrah) and *Allocasuarina fraseriana* (sheoak) in the study area. *Hakea obliqua*, a species more common north of the study area, is present on the Bassendean Dunes.

Major vegetation associations of the target area are described in Smolinski and Scholz (1997).

*adjacent cereal and tree crops, with remnant native vegetation in the background* ▼

### 2.4.2 Calculation of land available for maritime pine

Ensuring there is sufficient land to support the proposed extent of plantations is critical to determining the suitability of the proposed target area to meet the Project objectives. The land base available for maritime pine within 200 kilometres north and east of Perth was estimated on the basis of:

- total cleared farmland excluding native bushland in reserves or on farms and urban areas – 1.28 million hectares;
- soils suitable for maritime pine (non-saline, adequate depth, non-waterlogged) – 0.42 million hectares;
- the trees being dispersed across 20 per cent of the farm, or planted in particular niches – 0.08 million hectares.

The estimate of 20 per cent is derived from the need to revegetate at least 20 per cent of the land to alleviate environmental problems. If 20 per cent of suitable soils is planted, this would represent only six per cent of the total area of cleared farmland.

There are several steps to the process of determining the area potentially available.

1. Soil-landform data sets: The soil landform data used in this analysis was from the 1:2,000,000 scale Atlas of Australian Soils (Northcote *et al.*, 1967).

2. GIS analysis: All analysis and plotting were undertaken using ARC-INFO. The digital soil-landform map was interrogated.

3. Calculation of land suitable for maritime pine using a series of steps:

   (a) Removal of "woody" and urban land cover. "Woody cover" encompassed native bushland in State forests, national parks, nature reserves and remnants on farmland. It also included vineyards, orchards and existing plantations. Urban areas were removed using Metropolitan Regional Planning Scheme boundaries. This remaining area is cleared farmland and is termed "Available land".

   (b) Soil suitability. Descriptions and soil classifications were examined and given a weighting between zero and one for the following factors:

   - salinity and waterlogging
   - soil depth
   - other factors such as excessive slopes (>15 per cent), exposure (i.e. coastal dunes) and miscellaneous factors (beaches, lakes, rivers).

   Maps 1 and 2 depict the area suitable for growing maritime pine. It divides the target area into four soil suitability categories. These indicate the proportion of that mapping unit considered likely to be suitable in four classes (0-25, 26-50, 51-75 and >76 per cent). Each unit contains an array of soils.

   These ratings were combined as a "multiplication factor", with a resultant value between zero (unplantable) and one (no limitations). The area of each unit was multiplied by this factor to provide an estimate of the "Plantable land". For the entire target area the area of plantable land is estimated at 905,000 hectares, of which 418,000 hectares is in the northern sector.

   (c) Rainfall: Rainfall isohyets (mean annual rainfall) from Commonwealth Bureau of Meteorology were used. Areas with an average annual rainfall of above 400mm were included.

   (d) Distance from Kewdale: A series of radial distance zones (50,100,150 and 200 kilometres) from Kewdale were developed. Kewdale is a processing centre for logs and serves as a pivot for the Cell.

*Proportion of farmland planted*

While the Project seeks to establish plantations on cleared farmland it can only be assumed that reforestation would proceed on only a proportion of the available area. At least 20 per cent of the cleared land needs to be revegetated to achieve the broad environmental objectives. If 20 per cent of available land were to be planted evenly a total maritime pine plantation estate of 181,000 hectares could be established in the target area. If a higher proportion of plantings were on suitable soils, the maritime pine plantation area could be substantially greater.

*Area estimates for the Northern Sector*

Tables 12, 13 and 14 show the detail of land available for planting, using the procedures outlined above. Total cleared farmland, excluding native bushland in reserves or on farms and urban areas totals 1.29 million hectares (Table 12). Of this land after removal of non-suitable soils (saline, shallow and waterlogged) 0.42 million hectares are considered plantable (Table 13). Approximately 83,000 hectares can be planted if trees are planted on 20 per cent of the suitable soils (Table 14).

**Table 12: Area of available land: cleared agricultural land in the target area, by rainfall zone and distance from Perth**

| | Rainfall (mm) | | Total |
|---|---|---|---|
| | 400-600 | >600 | ha |
| Distance (km) | Area (ha) | | |
| <50 | 0 | 10,696 | 10,696 |
| 51-100 | 151,751 | 224,814 | 376,565 |
| 101-150 | 333,920 | 170,090 | 504,010 |
| 151-200 | 362,894 | 33,059 | 395,953 |
| **Total** | **848,565** | **438,659** | **1,287,224** |

**Table 13: Area of plantable land: cleared agricultural land with limiting soils removed in the target area, by rainfall zone and distance from Perth**

| | Rainfall (mm) | | Total |
|---|---|---|---|
| | 400-600 | >600 | ha |
| Distance (km) | Area (ha) | | |
| <50 | 0 | 3,221 | 3,221 |
| 51-100 | 85,511 | 61,530 | 147,041 |
| 101-150 | 116,257 | 35,414 | 151,671 |
| 151-200 | 109,545 | 6,447 | 115,992 |
| **Total** | **311,312** | **106,612** | **417,924** |

**Table 14: Net area of land available in the target area, by rainfall zone and distance from Perth, calculated by assuming afforestation on 20 per cent of the plantable land**

| | Rainfall (mm) | | Total |
|---|---|---|---|
| | 400-600 | >600 | ha |
| Distance (km) | Area (ha) | | |
| <50 | 0 | 644 | 644 |
| 51-100 | 17,102 | 12,306 | 29,408 |
| 101-150 | 23,251 | 7,083 | 30,334 |
| 151-200 | 21,909 | 1,289 | 23,198 |
| **Total** | **62,262** | **21,322** | **83,585** |

# 3. PROCEDURES FOR PROJECT IMPLEMENTATION

This section describes the methodology CALM would use in implementing the Project. It details several key processes in the annual operational calendar for the establishment of maritime pine plantations. The mallee eucalypt component of the project may involve different arrangements and these are dealt with separately.

All CALM plantation activities conform to the requirements of the Code of Practice for Timber Plantations in Western Australia (1997).

## 3.1 SECURING LAND

The availability of suitable land is a major constraint to the establishment of tree plantations for large-scale carbon sequestration.

For example, there are legal, political and social impediments that prevent establishing tree plantations on non-cleared public lands. Furthermore under the Kyoto Protocol, clearing existing forests to establish plantations will at least incur an excessive carbon debit and it is possible that carbon sequestered in plantations established by clearing vegetation will not be accredited. Secondly, plantation ventures are a long-term investment and long-term security over these investments is critical. Securing land for plantations in many countries is often fraught with problems due to political instability, legal insecurity and complex land ownership laws.

One of the most important factors in the success of the Western Australian tree crops on farms program is availability of land. Farmers and local government authorities recognised the benefits of tree crops and a legal instrument was developed in consultation with farmers to protect the rights of the landowner and the investor.

### 3.1.1 Publicity and promotion

Securing the land target requires sufficient landowners to be aware of the project and then be sufficiently satisfied to join it. To date CALM's promotional strategies include using existing personal networks through Landcare and other related groups, direct mail, local paper advertising, press releases, local agricultural shows and similar community gatherings. These measures have been satisfactory for the scale of planting achieved to date (4,300 hectares of maritime pine). This strategy will need to be adjusted as the proposed area targets are significantly higher. The low key approach has been appropriate as there was a risk of overstimulating the market, with a limited capacity to fulfil those expectations. This is not likely to be the case with the much larger establishment program.

◀ *sandalwood fruit*

One of the major proposed changes to current arrangements offered to landowners will be an opportunity to directly benefit from the carbon credits accumulated by the plantation. At present both parties share the benefits based on the current value of their inputs. It is proposed that the landowners forego their right to a share of the carbon credits and instead receive a direct payment from Gorgon. If there is such a cash payment in the offer to landowners it is likely to enhance interest in planting trees significantly. Much of the land currently realises very poor economic returns and any carbon benefit is likely to be positively received.

Once the Project began a promotional strategy would be developed in consultation with Gorgon to ensure full community knowledge of the basis of the Project. This would continue to concentrate on the local and personalised aspects of CALM's operations and also seek to maximise awareness through high profile activities in rural communities. It would be equally important to stress the very substantial environment and community development benefits of the Project.

Some lands in the target area are owned by absentee owners, including large mining companies. These groups would be targeted by individual strategies.

CALM has the capacity for undertaking most promotional work through its Corporate Relations Division which produces an array of publications and promotional materials.

### 3.1.2 Land evaluation

Once CALM has contacted landowners and they are aware of the opportunity that establishing a plantation creates, their land is evaluated in detail to ensure it is suitable for plantation establishment.

The primary characteristics assessed are rainfall, soil type and depth, and the salt content of the soil. Other factors are assessed such as presence of any remnant vegetation, weed types, roads and infrastructure.

Potential planting areas are assessed using aerial photography and land management units are identified by examining landform and vegetation features. Soil sampling of different land management units is then carried out using a drill rig, or backhoe if necessary. Sampling intensity varies with changes in land management units, but a minimum of one observation hole every 25 hectares is required.

The selection of land is based on that which is suitable for maritime pine and that which the landowner is willing to plant with trees. The offer for additional (landcare) trees can be used to plant less suitable or unproductive land, or to round out plantation boundaries to existing fencelines. The landowner may need to adjust farm boundaries to meet the needs of the new plantation. As grazing must be excluded for up to three years fencing may have to be adjusted to accommodate both the trees and a grazing land lease. CALM has made a fencing allowance of $50 per hectare planted available to ensure that this is not a major disincentive to plant.

The final design of the plantation takes into account the particular requirements of the landowner, such as windbreaks and aesthetics.

### 3.1.3 Deed of Grant of Profit à Prendre

This Deed would be attached to the land title and secures all Gorgon's direct rights and responsibilities in the ownership of timber and carbon credits, as well as its ability to manage the plantations.

The Deed (Appendix 2) has recently been adapted to ensure that any future rights to carbon credits are available to Gorgon. However, given the uncertainty of the regulations covering carbon, it has been amended to capture all possible arrangements.

The key features of the Deed are:

- the parties agree to establish tree plantations on the landowner's property;
- Gorgon may enter the land to undertake necessary actions to grow the plantations and these costs are borne by Gorgon;
- any financial proceeds of the plantation will be shared in a fixed ratio, or by other agreed means; and
- the landowner may continue to use the land, provided it does not affect the plantations.

By attachment to the land title Gorgon's rights would be retained even if the property's ownership is transferred, is bankrupted or other significant changes occur.

The landowner has responsibility for monitoring the health of the plantation, completing firebreaks and undertaking all normal responsibilities incumbent on a landowner.

Under CALM's Deed the benefits of the plantation would be shared on an 80:20 basis (Schedule 1 of the Deed). This ratio is determined by the proportion of the input costs of each party. Thus the landowner is entitled to a 20 per cent share of the timber revenues and the carbon credits. The small quantity of carbon credits available to each landowner may render individual verification and trading in those credits difficult, and it is considered likely that landowners may be willing to enter into an agreement to transfer those credits to Gorgon. This could be achieved by:

- increasing the landowner's share of the timber revenue to approximately 30 per cent or, periodic cash payment; or
- periodic cash payment for carbon credits as the carbon was measured, verified and accredited to Gorgon.

Other forms of consideration are also able to be included to secure all carbon credits, for example up-front payments. Methods involving some form of cash payment to the landowner are supported as they would assist in securing sufficient land to meet Gorgon's requirements.

The Deed of Grant of Profit à Prendre has been in operation in Western Australia since the late 1980s and has achieved wide acceptance as an instrument for joint ventures in timber plantations. The Western Australian Farmer's Federation helped develop the original document to ensure it protected and served farmers' interests. Since then it has been progressively amended to improve interpretation and cater for unforeseeable circumstances.

## 3.2 MALLEE EUCALYPT IMPLEMENTATION

CALM has a close working relationship with the Oil Mallee Association and Company and agreed to work together in building carbon trading arrangements. CALM also provides support to the Association and the Company in research and development, breeding and seed production.

The Association manages its mallee eucalypt operations under direction of a Growers Council that meets monthly. It has a regularly updated manual of practice to provide guidance to regional managers and growers. Growers finance and manage their own planting and contribute levies to run the Association. Growers enter into a simple contract with the Association in which they undertake to make their mallee crop available for harvest through the Association. The proposed Gorgon project (15,000 hectares over 10 years) is similar in size to current operations and should be readily accommodated within the existing management structure. Hence little additional work in publicity or promotion would be required, and current methods of land evaluation, species selection and site planning would be adequate.

The present contract between the grower and the Association is not adequate to provide secure entitlement to carbon credits to a third party. Also CALM and the Association would need to enter into a formal agreement for CALM to act as the Association's agent in dealing in carbon credits.

Therefore CALM would enter into a Deed of Agency with the Oil Mallee Association. Under this Deed CALM would undertake to manage carbon trading transactions; to measure, monitor and verify carbon sink parameters; and to obtain secure title to carbon under an appropriate form of deed of grant of profit à prendre.

There are two possible foci for oil mallee planting within the 200 kilometre radius of Perth. The Central Region lies to the east of Moora and Wongan Hills (Map 1). The Upper Great Southern region lies in the area around Narrogin. Either or both of these regions could be targeted. The Association will probably want to use this project to hasten the achievement of "critical mass" in mallee resource in one region to help initiate commercial operations. The Upper Great Southern will be the preferred location because it presents better opportunity for residue use. Western Power has shown interest in using residues as fuel for electricity generation. The town of Narrogin is conveniently positioned for low cost access to the State grid. It would be the preferred location.

There are two likely modes of purchase of mallee carbon offsets that should be considered. Firstly, growers finance and own their individual plantings. Hence an option for outright sale of the carbon sequestered in mallee over an agreed term should be available. The agreement for the first term could include the option for second and subsequent terms to be available. Secondly, there will be growers who are not able to finance their own planting and would prefer to sharefarm in a similar way to that proposed for maritime pine. CALM would negotiate with the Oil Mallee Association for these options to be developed.

The evaluation of the mallee eucalypt part of the Project has assumed that Gorgon would finance and operate a controlling interest in these plantations. However if other arrangements as suggested above are in place then the actual cost of carbon to Gorgon would probably be significantly less.

# 3.3 ESTABLISHING AND MANAGING PLANTATIONS

There are a number of components required for the successful establishment and management of tree plantations. These are determined on a needs basis from the characteristics of the site as determined from detailed site assessment. These are then formulated into a detailed plantation management plan.

## 3.3.1 Soil preparation

The objective of soil preparation is to alter the soil characteristics to improve tree survival and growth. Most soils in Western Australia, particularly those that have been under agricultural management, require some form of disturbance to reduce bulk density, release nutrients and improve the absorption and retention of soil moisture. The most common practices are:

▲ *ripping*

*Ripping*

Ripping is widely used throughout Western Australia to improve tree growth. Ripping is conducted using a ripping tyne with or without a wing and pulled through the soil by a large horse power tractor. Ripping is carried out at varying spacings between rows and to a depth of either 30 or 50cm, depending on soil characteristics.

▲ *scalping*

*Furrowlining*

Furrowlining is used as a planting site preparation on poor coastal sandy soils, which often have a non-wetting surface. Furrowlining breaks this layer and allows moisture to concentrate in the bottom of the furrow and rip line. It is usual for furrows to be between 200 and 300mm deep and approximately one metre wide at the soil surface. Furrowlines are placed over rip lines. It mechanically removes weed seeds and weed germinants from immediately adjacent to the tree.

*Scalping*

Scalping is a variation of furrowlining. The operation involves the use of a similar implement to make a scalp line. Scalp lines are generally 100mm in depth from the soil surface and 1.2 metres wide. Scalp lines are placed over rip lines and provide a broader weed free zone in which to plant.

▲ *chemical mister for pest control*

*Mound ploughing*

Mound ploughing is the accepted technique to grow seedlings on seasonally waterlogged sites and concentrate surface soil nutrients. A mound plough implement is used to lift soil into a mound. Mounds are generally 400 to 500mm above the soil surface and 1.2 to 1.3 metres wide.

### 3.3.2 Weed Control

It is essential when establishing plantations to control weeds as they compete for vital water and nutrient resources at a critical stage of the tree's development. There are various methods of controlling weeds, however the use of herbicides is the most common and effective. The combination of herbicides used varies with the spectrum of weed species present on the site. Routine operations will combine a mixture of knock down herbicide with residual herbicide.

The herbicide mix is applied over the soil preparation lines at a pre-determined rate prior to tree planting. Herbicide usage guidelines are in strict conformity with regulatory requirements.

### 3.3.3 Planting

Planting is conducted during the wetter months from June to August.
There are two planting methods, machine planting and manual planting.
Planting rates can vary with species, site and soil conditions and rainfall.
Maritime pine is planted at a stocking rate of 1,515 stems per hectare (spha).

Potted stock is grown in containers and planted with their root system intact. There are also two sources of material for these plants, seed and cuttings. Seed is collected from genetically improved seed orchards, whereas cuttings are vegetatively propagated from bush-shaped parent stock – known as a mother plant.

Plants are provided from CALM's Plant Propagation Centre, as either open-rooted stock or potted stock. Open-rooted stock are grown in nursery beds and when removed their roots are not protected by soil, whereas potted stock are grown in containers so when planted their root systems are intact.

*machine planting maritime pine seedlings ▲*

### 3.3.4 Pest control

Eucalypt and pine plantations are susceptible to damage from a range of insects and animals. Insect pests such as grasshoppers require close monitoring during the spring and early summer seasons. Rabbits are a significant pest and are controlled through baiting either prior to planting or post planting in summer. Pests require a system of early identification and monitoring and efficient delivery of control systems.

### 3.3.5 Pruning

*pruning maritime pine ▼*

Pruning operations are usually carried out early in the plantation life, between the fifth and twelfth year, to remove branches close to the main trunk of the tree. It is undertaken to improve access for fire control purposes and in some stands, to improve product options and values.

Pruning needs to be carefully timed to ensure that the growth of the tree is not impaired by the removal of too many limbs. Where pruning is done to produce high quality wood free of knots, the timing is such to ensure that most wood is grown over the branch stubs. The extent of pruning other than for access and fire control requirements is to be determined.

### 3.3.6 Silvicultural management

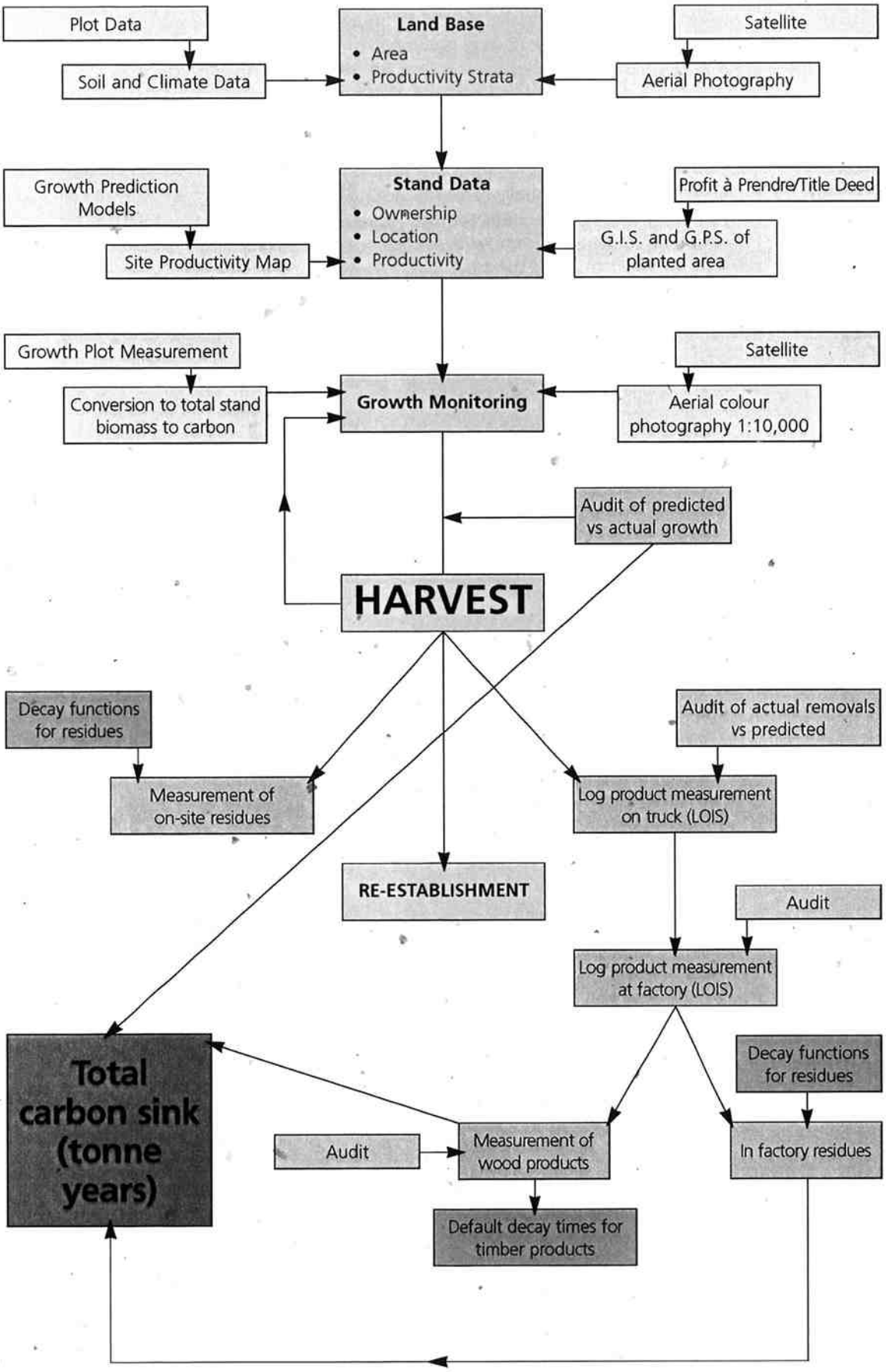
Plantations require second year weed and pest control. Plantations are considered established from year three and management is re-focussed on growth performance and product suitability. Fertiliser will be applied generally at four-year intervals and/or following thinning operations.

Thinning operations occur at 12, 18 and 24 years. Thinning generates harvest income and stimulates growth of the remaining crop trees through reduced competition.

## 3.4 MONITORING AND MEASURING CARBON

One of the reasons given for the reluctance of some signatories to the Kyoto Protocol to agree to include carbon sinks as part of national carbon accounting budgets is the concern that it will be impossible to monitor accurately and verify the amount of carbon sinks. Accurate and efficient monitoring systems, which can be audited, are also an essential prerequisite to the development of carbon trading systems. There are still uncertainties associated with measuring some components of carbon sinks (e.g. soil carbon) and measurement of perennial shrubs. However, procedures to measure and audit commercial tree crops and commercial timber production and processing, which can be readily adapted to quantify carbon sinks, are already in place in CALM.

**Figure 15: Forecasting, monitoring and verification of carbon flows in tree crops from establishment to product decay**



The components of a system which is being developed in Western Australia by CALM to forecast, monitor and verify carbon sequestration by tree crops, based on existing procedures, are illustrated in Figure 15 and summarised below:

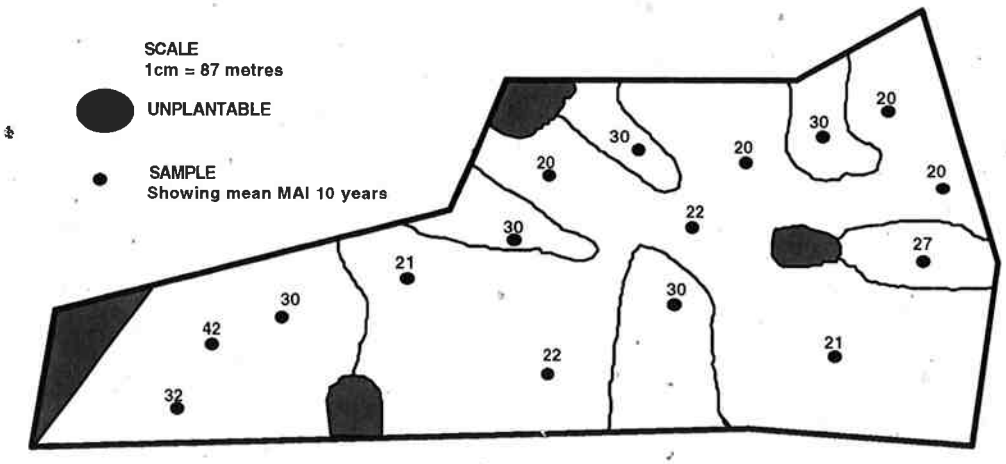
*Land base*

The potential area available for tree establishment is determined from site quality (site index) models and measurement of environmental attributes (climate, soils and landform). Aerial photographic and satellite imagery are used to stratify the target zone and estimate the potential plantable area.

*Stand data*

Growth prediction models, based on correlation of a number of climatic and site factors with stand growth in existing trial plots, are used to provide detailed site productivity maps for each stand. For example, prior to the establishment of bluegums on farmland potential yields are estimated using an *E. globulus* Growth Simulation model (Figure 16) (Inions, 1992).

**Figure 16: Bluegum site productivity assessment for a typical farm**



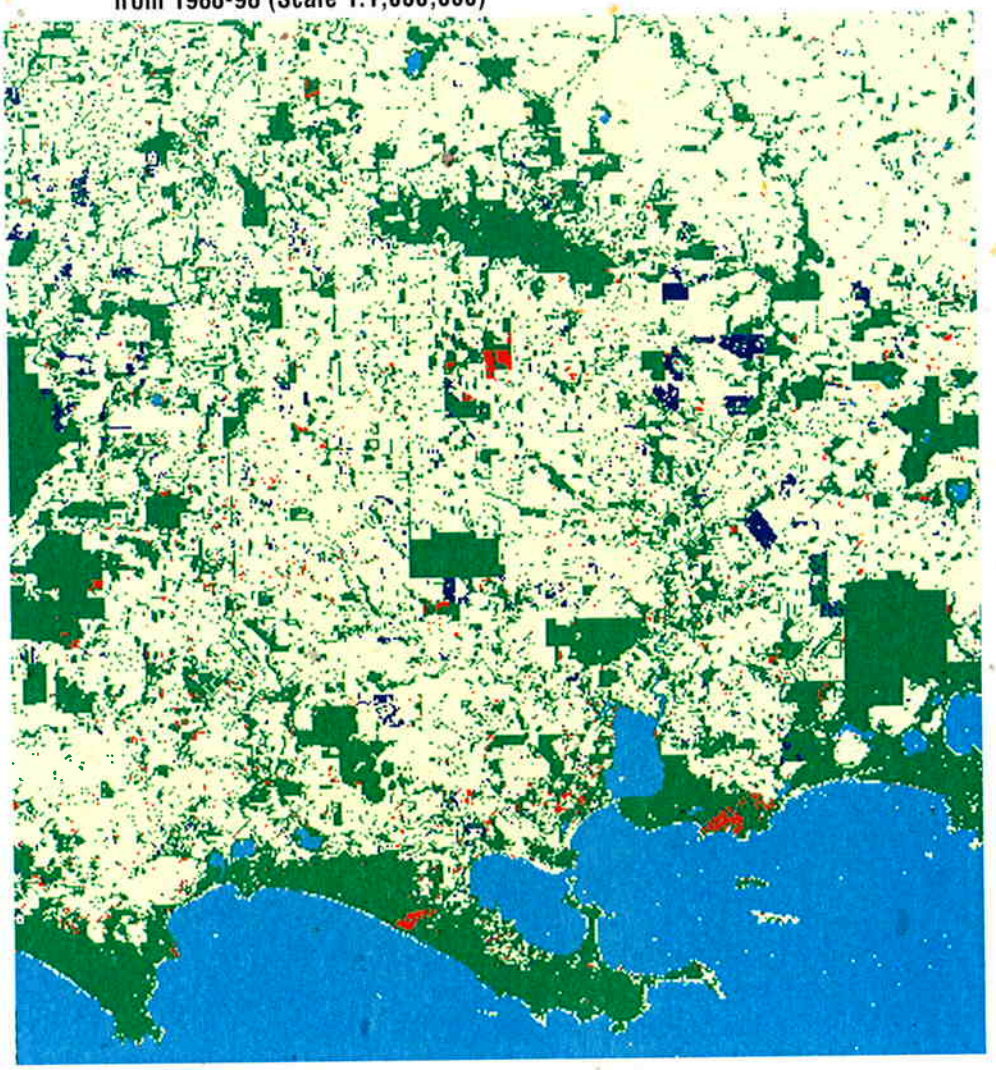

After (Shea *et al.*, 1994)

Once the stand is established, improved predictions of future growth are determined by incorporating stocking density and stand height to that age in the prediction models. The location and area of the stand is delineated in the field using mobile geographic positioning systems and recorded in a geographic information system.

*Growth monitoring*

The crop area can be monitored and audited periodically using satellite imagery (Smith, 1997) (Figure 17).

**Figure 17: Landsat image of Albany-Mt Barker region showing changes in vegetation from 1988-98 (Scale 1:1,000,000)**



(Image provided by CSIRO Land Monitoring Unit)

| | |
|---|---|
| Dark blue | Vegetation recovery, new plantations 1988-94 |
| Light blue | Vegetation recovery, new plantations 1994-98 |
| Yellow | Vegetation loss, clearing, fire 1988-94 |
| Red | Vegetation loss, clearing, fire 1994-98 |
| Green | Vegetation disturbance 1994, then recovery 1994-98 |

Stands are stratified using aerial colour photographs and growth plots are established within each stratum. Growth measures are taken throughout the rotation and compared to predicted growth.

For example, the 27,000 hectares of bluegum plantations established by CALM on privately-owned farmland between 1987 and 1997 have been mapped in detail using aerial photographs and differential GPS ground surveys. Growth is monitored through the establishment of early growth monitoring plots, which both verify the establishment of planted trees and the rates of growth in early years. The plots are measured at 18 months and again at three years; and the data are used to ensure that the correct growth curves are being used for prediction and to identify the need for any remedial action if growth rates are not as predicted. A network of permanent growth plots is also maintained in all strata of the plantations through the rotation.

New technologies, including the use of large-scale video and laser altimetery has the potential to increase the capacity to increase the intensity and frequency of sampling at lower costs. (Tickle *et al.*, 1998).

The relationship between stem volume and total stand carbon varies with species, age and silvicultural treatment and can be determined by empirical measurements. For example, the ratio between bole volume and stand carbon has been established for radiata pine in New Zealand (Maclaren, 1995). Intensive studies of the relationship between stand growth parameters and total stand carbon of several species at different stages of development on different site types are currently being undertaken in Western Australia.

*Harvesting*

Strategies for the scheduling of actual log harvesting operations are simulated using a Pine and Hardwood Scheduling System. These systems have an ORACLE application, with each uniform stand represented individually in database tables describing stand details, yield regimes (including next rotation if relevant), haulage distances and product destinations. Any of these variables may be varied to examine their effect on wood supply options. The system is used to generate both long-term (strategic) plans and short-term logging or fertilising plans.
Unique stand identifiers link the database information to GIS spatial records. Each of these systems can be adapted to predict the impact of any management activity on the current and future status of the carbon sink in all stands.

All log removals (including log product categories) during harvest from each compartment are recorded using CALM's Logging Operation Information System (LOIS) and are subject to internal and external audit at any stage of transport from the field to the factory door. The information is retained on computer and consequently it is possible efficiently and rapidly to compare actual timber removals from each stand with predicted yields.

The proportion of the total biomass left after harvesting can be determined by subtracting the bole volume used from total biomass. Currently, default decay functions have been used to estimate the average life of the logging residues. It is proposed to improve these predictions by determining actual decay rates from field measurements.

*Processing*

The Logging Operation Information System (LOIS) requires measurement of all logs and their separation into different log categories which correspond to different timber products at the factory using weighbridge or log scanning systems and is subject to internal and external audit. It is normal practice for factory or sawmill managers to maintain detailed records of recovery rates for different products and the residue produced for commercial reasons. Most mills and factories processing logs purchased from CALM have, as a condition in their log supply contract, an obligation to provide data on product recovery rates from different log categories. Thus it is possible to determine the amount of carbon that is harvested from the stand in each timber product produced.

*Timber product decay functions*

The decay rates of timber products have been the subject of a number of studies (Hollinger *et al.*, 1993; Arima, 1993; Cannel *et al.*, 1995; Maclaren, 1996; Karjalainen, 1996). Further research is required but it is not unrealistic to assume that it will be possible to determine decay functions for various timber products that are acceptable to the international authorities responsible for the promulgation of greenhouse accounting rules.

The existing system developed to measure, monitor and audit tree growth and timber products in Western Australia could be used to quantify carbon sinks and carbon storage times, with relatively minor modifications. Stringent internal and external auditing procedures are already applied for commercial reasons and they could readily be elaborated to meet international carbon auditing requirements.

## 3.5 TIMBER MANAGEMENT

CALM has a number of systems through which a large volume of timber is effectively marketed and harvested. CALM currently manages the annual sale of approximately two million cubic metres of timber from Crownland and private property. This is achieved through a number of well-developed systems, including:

*Sales*

CALM sells timber by auction, tender or private treaty – the nature of the market dictates the method adopted. In some cases the negotiated sale has been further reinforced through a State Agreement Act, particularly where there is significant investment in processing facilities. There are currently several Agreement Acts related to major investments in timber processing facilities, including the major plantation processing factories.

For large additional volumes of wood it would be necessary to seek some export-based markets.

*Security of supply*

In addition to Agreement Acts, CALM enters into supply contracts for all timber resources sold. This outlines the qualities, prices and terms and conditions in relation to supply. CALM administers a large number of such contracts. These contracts detail the commitment to the supply of volumes over time and the arrangements for setting and adjusting prices. The assurance of a guarantee of supply provides the necessary security for the investment in processing facilities.

*Harvesting*

Timber harvesting from all areas managed by CALM is carried out by harvesting contractors working directly for the Department. This ensures the best use of the timber resource and that the area itself is managed appropriately. This is particularly important on sharefarm plantations where the protection of the landowner's interests is one of CALM's roles.

A key feature of the harvesting system is ensuring the full accountability for all logs removed from the plantation, for payment by the customer, division of payment to any investor and the landowner and the payment of the harvesting contractor.

The LOIS system (as discussed in Section 3.4) is central to this system. It keeps full account of each load of logs removed from each plantation. It is able to report on the quantities and values to the logs, the source of the logs, the customer and the contractor, as a basis for payments and to record the plantation yields.

*Harvest planning*

CALM currently prepares detailed harvesting plans on a one-year and five-year basis, as well as resource level plans for the long-term development of the timber industry. Plantations yield a variety of products that must be matched against customer or demand over the term of any plan.

This uses predictions of future growth based on models and measurements described in Section 3.4 to determine available volume. This is matched against contractual commitments at the strategic level to determine the supply/demand balance.

Short-term plans then consider the operational and logistic issues that might limit actual performance works.

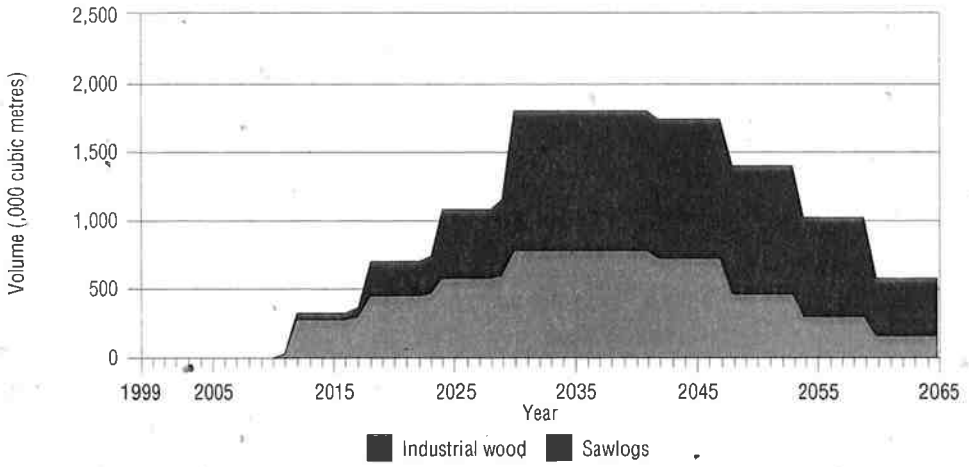
All harvesting operations must conform to the requirements of Timber Harvesting in Western Australia, a document that contains the Code of Harvesting Practice and the Manual of Harvesting Specifications.

*Predicted yields*

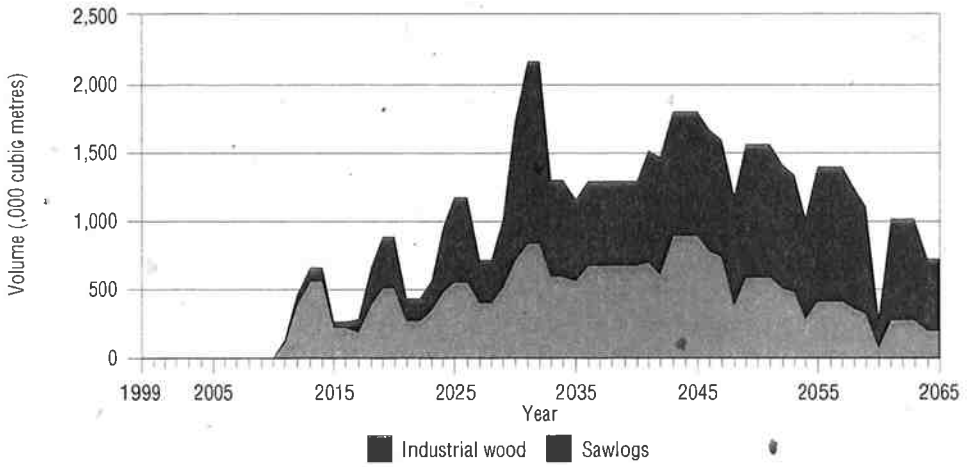
The maritime pine areas proposed in this Plan are predicted to yield the timber as indicated in Figures 18 and 19 based on an average growth rate of 12 cubic metres per annum and a rotation of 30 years. Industrial wood is timber of

lower quality that is used for reconstituted fibre products, such as MDF, particleboard, paper or oriented strandboard. Sawlogs are wood of higher quality used for sawing or peeling.

**Figures 18: Projected woodflows: Strategy 1**




**Figures 19: Projected woodflows: Strategy 2**



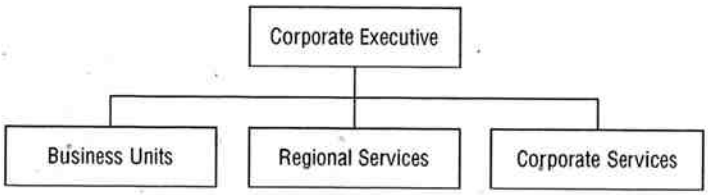

This level of supply from Gorgon's plantations would exceed the current and proposed level of demand in the Perth Cell. A proposed new industry is currently planned for this area with the export market being its main objective. Existing and the proposed new industry have indicated that their demand will reach approximately 500,000 cubic metres of both industrial wood and sawlogs from the Perth region. CALM's timber supply from its own plantations are expected to be significantly reduced by the year 2017 as the area of maritime pine in the Gnangara/Yanchep area is replanted to native vegetation.

## 3.6 PROJECT MANAGEMENT ORGANISATION

The Department of Conservation and Land Management (CALM) is a statutory agency of the Government of Western Australia. The *Conservation and Land Management Act 1984* gives the Department's Executive Director the power to enter into a wide range of business dealings and company structures.

CALM's mission is to conserve and manage Western Australia's wildlife and the land, waters and resources entrusted to the Department for the benefit of present and future generations. The total area under CALM's care is more than 20.51 million hectares, excluding the marine reserves. This is about 7.5 per cent of the land area of Western Australia. CALM employs a staff of 1,200 across its regional network and spent $200 million delivering its core programs in the 1997-98 financial year.

**Figure 20: Simplified CALM structure**




In 1994 business units were established within CALM as a result of the State Government's Commission to Review Public Sector Finances. The business units are semi-autonomous and required to operate on a commercial basis, including full recovery of costs, including depreciation, taxes that would apply to private industry, and a margin for profit. The business units produce their own business plans and financial statements.

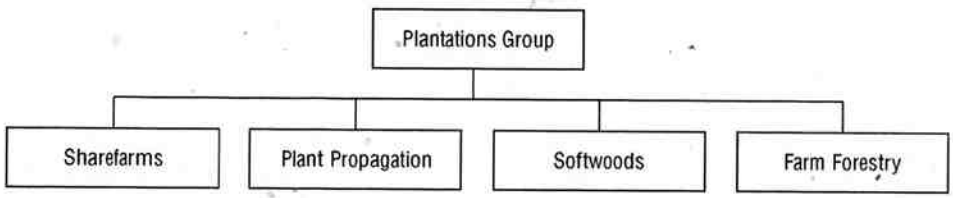
The Plantations Group is the business unit with the responsibility for managing State-owned commercial plantations and acting as an agent for private plantations. CALM currently manages a total of 106,593 hectares of plantations. The make-up of these plantations is shown in Table 15.

**Table 15: Plantation estate managed by CALM at 31 December 1997**

| | CALM-owned | | Privately-owned | Total |
|---|---|---|---|---|
| | CALM land | Sharefarms | | |
| Pines | 62,265 | 9,736 | — | 72,001 |
| Eucalypts | 7,128 | 6,889 | 20,575 | 34,592 |
| Total | 69,393 | 16,625 | 20,575 | 106,593 |

(CALM Annual Report, 1997-98)

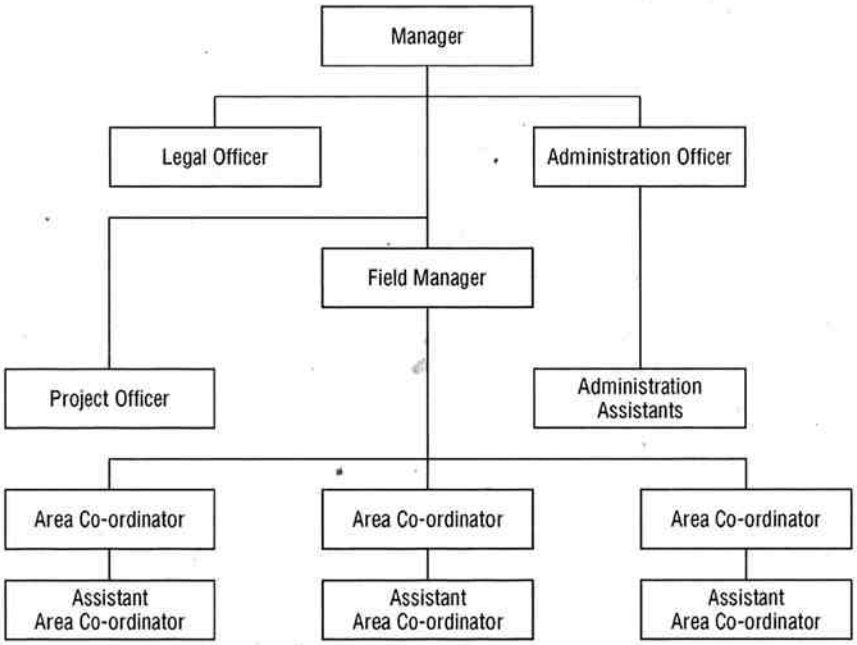
**Figure 21: The structure of the Plantations Group**




The Sharefarming Unit is charged with the responsibility of establishing new plantations on private land. The Unit currently works as agent for Albany Forest Plantation Company, Hansol (Australia) and the Bunbury Treefarm Project, establishing approximately 6,000 hectares of bluegums each year, as well as establishing CALM's own maritime pine sharefarms and managing the existing established estate.

This Unit is divided into several cells to deliver plantation management services within a defined area. The cell based in Guildford establishes plantations in the Perth target area.

**Figure 22: Sharefarm cell structure**




While the cell's base is in Guildford it also planned to operate out of local offices in Gingin, Moora and Narrogin. It is appropriate to maintain a dispersed structure in order to maintain community contacts and be a part of the local community.

The Unit is directly responsible for:

- informing landowners of plantation opportunities;
- acquiring suitable land to meet annual targets;
- establishing new plantations; and
- maintaining existing plantations.

While each cell carries out many of its activities with its own staff, key operations are also undertaken by contractors. CALM establishes contracts for terms of one to three years for land preparation, weed control, planting and fertilising. These contracts ensure maximum efficiency in the implementation of the establishment program.

Other key units in the Plantations Group that will directly support this Project are:

*Plant Propagation Centre*

The provision of plants of the highest quality is the primary goal of the Plant Propagation Unit. The nursery based in Manjimup already has a substantial program for the existing plantation projects. It is currently expanding its capacity from 25 million to 50 million plants to supply CALM's Maritime Pine Project.

This Unit has the role of ensuring the plants supply, both in terms of physical quality, but also with the highest genetic quality. The capture of tree breeding gains into the routine plantation stock is a primary goal of this group.

*Farm Forestry Unit*

The Farm Forestry Unit is the developmental wing of the Plantations Group. It acts as both a community service in the provision of advice and information, as well as initiating new farm forestry species, products and services. A major objective of the Unit is to develop tree crops that will improve both the profitability and sustainability of agriculture.

As a part of the management of Gorgon's plantations CALM is able to provide the background and support from an array of high calibre service groups, each of which has developed effective systems for the achievement of plantation outcomes. These service providers would support the Project both directly and indirectly. These are listed below and a full description of the type of service provided is contained in Appendix 3:

- Forest Resource Services;
- Forest Management Branch;
- CALM*fire*;
- CALM**Science**;
- Information Management Branch;
- Human Resources Branch;
- Finance Branch;
- Corporate Relations Division;
- Corporate Executive.

# 4. PROJECT EVALUATION

## 4.1 ELIGIBILITY OF THE PROJECT

Eligibility criteria for sinks to qualify under Clauses 3.3 and 3.4 of the Kyoto Protocol suggested by Phillips (1998) are used to indicate the suitability of the Project to meet the required international standards. The criteria for assessing suitability are discussed below:

*Additionality*: For the carbon sinks established by this Project to be accepted they must be "new" forests established by afforestation or reforestation (Clause 3.3) – established after 1990 and as a result of additional human-induced activity (Clause 3.4).

All forests established by this Project would be new, resulting from a change in land use being grown on cleared farmland. All plantations would be established after the 1990 date specified in the Protocol.

The second question of whether a project meets the additional human induced activity criteria is less well defined. The Maritime Pine Project was announced by the State Government in November 1996 and is a major new project established after 1 January 1990. From the outset, CALM's tree crops on farms program recognised the potential role of plantations to sequester carbon and was in part a response to the emerging greenhouse gas issue (Shea, 1998).

*Means of measurement*: To qualify as a sink there must be means of measuring the contribution that the sink can make. CALM's procedures (Section 3.4) are well defined.

*Project sovereignty*: This criterion is related to maintaining national sovereignty over development decisions. The State and national governments have both supported the concept of using plantations as carbon sinks.

*Baselines*: To ensure that any offset takes into account the net carbon effect of changing land use.

*Leakage*: Where saved emissions through protection of one forest are transferred to be emitted elsewhere. This criterion does not appear to relate to this Project.

*Monitoring*: The capability of appropriate monitoring and verification procedures are well defined (Section 3.4). Independent auditing of CALM's processes would also be appropriate.

*Sustainable*: To ensure that the environmental and social impacts of the Project are not adverse or unsustainable (Section 4.4 and 4.5)

*Project capability*: To ensure that the Project is able to be implemented successfully (see Section 4.3)

## 4.2 ECONOMIC ANALYSIS

The primary purpose of the economic analysis is to assess the effectiveness of achieving Gorgon's goal to sequester carbon. This is considered in terms of:

- the net cost of the project to Gorgon;
- net cost per tonne of carbon sequestered by Gorgon.

The long timeframe for the Project (1999-2065) renders economic analysis indicative rather than precise. Over such a large time span, trends in costs and revenues may become quite significant, however expenditures and revenues more than 30 years in the future will have very little impact on the current financial performance. Therefore as well as examining the outlook for the whole Project, the value obtained from planting one hectare of each species is also examined. The Project could also be examined in stages, e.g. the investment stage, to look at the key issues affecting Project performance.

### 4.2.1 Cost of carbon for each species

Table 16 indicates the predicted cashflows for each species. These are used in the comprehensive analysis of the Project. The resultant performance of each species on a per hectare basis is shown in Table 17.

This analysis makes the following assumptions:

- The 20 per cent share of carbon owned by the landowner is secured by Gorgon for a cost of $12 per tonne, paid as carbon is verified at five-yearly intervals. The details of these proposed arrangements are specified in Section 3.1.
- No revenues are received for mallee eucalypts or landcare trees.
- The discounted cost per tonne of carbon is determined by the Net Present Value of cashflows divided by the average total carbon sink as defined in the Greenhouse Challenge Office (1998).
- The mallee eucalypt management regime is similar to that of maritime pine.
- Net present values are determined at a discount rate of seven per cent.
- Costs and revenues are in Australian dollars.
- The analysis does not take into account any effect of taxation on the Project. This includes both tax deductibility of plantation investments and the potential impact of the proposed goods and services tax.

**Table 16: Unit costs and revenues**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maritime pine | Operating costs | 1300 | 150 | 30 | 10 | 10 | 10 | 10 | 160 | 110 | 10 | 10 | 10 | 10 | 120 | 10 |
| | Carbon costs | 0 | 0 | 0 | 0 | $92 | 0 | 0 | 0 | 0 | 158 | 0 | 0 | 0 | 0 | 72 |
| Mallee eucalypts | Carbon costs | 1000 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 |
| Landcare trees | Cost | 1400 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| | Carbon costs | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 |
| Maritime pine | Timber revenue | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 710 | 0 | 0 |
| Mallee eucalypts | Oil/biomass $0 | 0 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 |
| Sandalwood | Oil wood $0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*maritime pine* ▲

| 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 10 | 10 | 10 | 120 | 10 | 10 | 10 | 10 | 10 | 120 | 10 | 10 | 10 | 10 | 10 |
| 0 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 | 0 | 0 | 0 | $12 | 0 |
| 0 | 0 | 0 | 1094 | 0 | 0 | 0 | 0 | 0 | 1402 | 0 | 0 | 0 | 0 | 0 | 3312 |
| 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 | 0 | 150 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10000 |

**Table 17: The costs and revenues for one hectare of each species, and the return per tonne of carbon**

| | Maritime pine | Mallee eucalypts | Landcare trees |
|---|---|---|---|
| Total cost | $2,340 | $1,294 | $1,777 |
| Total revenue | $6,518 | $0 | $0 |
| Present value of costs | $1,873 | $1,076 | $1,451 |
| Present value of revenues | $1,262 | $0 | $0 |
| NPV | (611) | ($1,076) | ($1,451) |
| Average carbon sequestered | 103 | 31 | 34 |
| Cost per tonne | $18.18 | $34.70 | $42.68 |
| NPV per average tonne | ($5.93) | ($34.70) | ($42.68) |
| IRR (timber only) | 5.4% | — | — |
| IRR (timber + carbon) | 4.8% | — | — |

The variations used to examine the performance of each species are:

*The value of the timber and other resources*

The base case (above) ascribes no value to landcare trees or mallee eucalypts. In the high revenue case a value of $10,000 per hectare is ascribed to five per cent of the landcare area as the assumed area used to grow sandalwood. This revenue is received after 30 years. For mallee eucalypts a value of $150 per hectare is achieved every second year. Timber revenues are increased by 10 per cent. For the low revenue case the timber revenues are decreased by 10 per cent. Table 18 illustrates the effect of varying revenues on the cost of carbon and the internal rate of return of one hectare of each species.

**Table 18: The impact on cost per carbon tonne per hectare for each species type under high and low revenue scenarios**

| | Maritime pine | Mallee eucalypts | Landcare trees |
|---|---|---|---|
| **High revenue** | | | |
| Total revenue | $7,170 | $2,250 | $500 |
| NPV | ($484) | ($235) | ($1,365) |
| NPV per average tonne | ($4.70) | ($7.59) | ($40.15) |
| IRR (timber only) | 5.9% | 4.8% | -5.9% |
| **Low revenue** | | | |
| Total revenue | $5,867 | $0 | $0 |
| NPV | $737 | ($1,076) | ($1,481) |
| NPV per average tonne | ($7.15) | ($34.70) | ($42.68) |
| IRR (timber only) | 4.8% | — | — |

*Securing carbon*

The base case assesses the strategy of securing the landowner's share of carbon by making five-yearly payments for 20 per cent of the accumulated carbon. For the purpose of analysis a price of $12 per tonne has been included, although it is not suggested to be an appropriate price. It is less than the most recently reported trade in carbon (Costa, 1998), however Gorgon would bear the verification costs and any future liability. The cases where Gorgon does not secure the carbon or pays landowners prices of $8 and $20 per tonne of carbon are evaluated in Table 19.

**Table 19: The effect of the purchase price of the landowner's carbon on the average NPV of carbon over a 30-year cycle**

| | Maritime pine | Mallee eucalypts | Landcare trees |
|---|---|---|---|
| **Does not secure landowner carbon** | | | |
| NPV | ($439) | ($1,051) | ($1,424) |
| NPV per average tonne | ($5.33) | ($42.36) | ($52.37) |
| **Gorgon pays $8/tonne for landowner carbon** | | | |
| NPV | ($553) | ($1,067) | ($1,442) |
| NPV per average tonne | ($5.37) | ($34.43) | ($42.42) |
| **Gorgon pays $20/tonne for landowner carbon** | | | |
| NPV | ($725) | ($1,092) | ($1,469) |
| NPV per average tonne | ($7.04) | ($35.23) | ($43.21) |

This indicates the payment price has a moderate impact on average carbon cost borne by Gorgon.

*Increasing the landowner's cropshare*

The alternative to acquiring the landowner share of carbon by direct payment is to increase the landowner's share of the crop value. Gorgon would then acquire all carbon secured under the Deed of Grant of Profit à Prendre. This only affects the costs of the maritime pine option as it is the only one with revenues.

**Table 20: The effect of cropshare percentage on the NPV per average carbon tonne**

| Landowner carbon cost | Maritime pine |
|---|---|
| $12/tonne | $5.93 |
| 30% cropshare | $5.79 |

This analysis indicates that direct payment for additional carbon or adjusted cropshare proportions could provide a similar costing for carbon as the current arrangement. The advantage of acquiring all available carbon by either method is the capacity to achieve the sequestration target within the potential area available in the target area.

### 4.2.2 Project analysis

The project analysis is undertaken using the same method as for the per hectare analysis. It looks at two project strategies, the uniform planting strategy and the even sequestration strategy. The results of the Project analysis are shown in Table 15.

Both strategies are analysed using the following arrangements:

- the landowners share of carbon is acquired for $12/tonne; and
- mallee eucalypt and landcare revenues are nil.

**Table 21: Financial summary of the Project**

| | Uniform planting strategy | Even sequestration strategy |
|---|---|---|
| Total cost ($000) | 523,626 | 533,119 |
| Total revenue ($000) | 1,137,461 | 1,191,610 |
| Discounted cost ($000) | 142,006 | 137,540 |
| Discounted revenue ($000) | 82,110 | 79,443 |
| Average carbon sink (000 tonnes) | 11,180 | 10,293 |
| NPV ($000) | (59,896) | (58,098) |
| NPV per average tonne | '($5.36) | ($5.64) |
| IRR | 4.1% | 3.8% |

The projected cashflows for each strategy are shown in Figures 23 and 24.

**Figure 23: Project cost and revenue streams – Strategy 1**

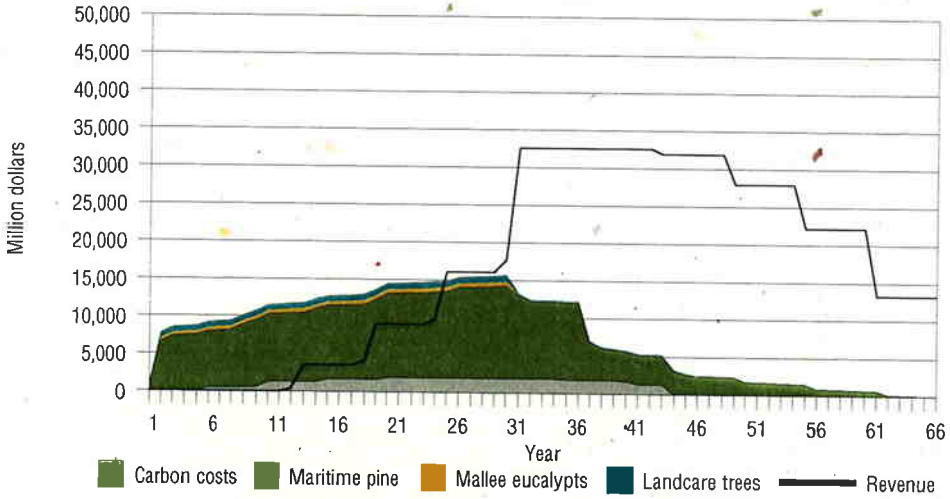
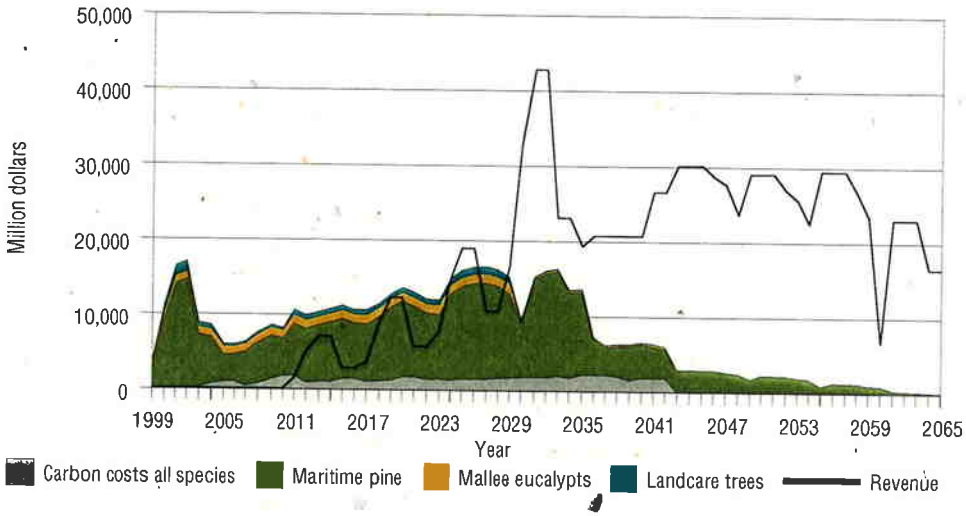



**Figure 24: Project cost and revenue streams – Strategy 2**




*Sensitivity analysis*

The impact of changes to revenue, cost of carbon and method of accessing carbon have been conducted. In addition, the Project is evaluated with an assigned carbon value.

**Table 22: Effect of timber revenue on carbon cost ($ per tonne)**

| Low revenue (minus 10%) | | |
|---|---|---|
| | **Strategy 1** | **Strategy 2** |
| NPV per average tonne | $6.09 | $6.42 |
| | 3.5% | 3.2% |
| **High revenue (plus 10% – includes oil and sandalwood)** | | |
| | **Strategy 1** | **Strategy 2** |
| NPV per average tonne | $4.08 | $3.69 |
| | 4.9% | 4.9% |

**Table 23: Effect of method of securing carbon on carbon cost ($ per tonne)**

| Method | | Carbon price | Project carbon cost | |
|---|---|---|---|---|
| **Timber share** | **Carbon share** | **(per tonne)** | **Strategy 1** | **Strategy 2** |
| 80:20 | 80:20 | $0 | $5.34 | $5.58 |
| 80:20 | 80:20 | $8 | $5.00 | $5.25 |
| 80:20 | 80:20 | $12 | $5.36 | $5.64 |
| 80:20 | 80:20 | $20 | $6.08 | $6.43 |
| 70:30 | 100:0 | N/a | $5.19 | $ 5.43 |

While the increased cropshare method reduces the cost of carbon sequestered when compared to the payment method, it also reduces the IRR of the Project as it reduces income. The actual price paid for the landowner's share of the carbon has only a moderate impact on the overall NPV for carbon. The greatest degree of sensitivity appears to be where other products are commercialised, leading to higher revenues. Table 22 illustrates a substantial drop in the NPV for carbon as additional revenue is realised. The major advantage of mallee eucalypt revenues would be that they occur early in the life of the Project.

As carbon has a direct value to Gorgon, the Project can be assessed based on an assigned value of carbon. These are shown in Table 24 indicating the Project as a whole would be very sensitive to the value placed on carbon and providing a good rate of return.

**Table 24: Effect of carbon value on Project performance (internal rates of return)**

| Value of carbon | Strategy 1 | Strategy 2 |
|---|---|---|
| $12 | 7.3% | 6.8% |
| $20 | 10.5% | 9.8% |
| $40 | 21.8% | 20.8% |

## 4.3 RISK ANALYSIS

The major risks of proceeding with this Project are discussed below and an analysis of their significance, likelihood and measures to reduce risk and consequence are tabulated at the end of this section.

### 4.3.1 Sovereign risk

Australia provides the necessary stable political and social environment for the time horizons under which forestry investments take place. In traditional investment analysis Australia ranks at the lowest ties of sovereign risk.

The Government of Western Australia has welcomed international investment in local plantations and has endorsed the establishment of substantial plantation developments by six Japanese and Korean investors in three major projects. It has done this through those companies working with CALM as their agent. At the same time it has signed State Agreements for each project that have been passed through Parliament to reassure the investors of the State's support for the projects.

These agreements provide assurance to those companies that it will not introduce legislation that will discriminate against them.

### 4.3.2 Land risk

*Security*

The land for plantations secured by the Deed of Grant of Profit à Prendre provides a high level of certainty over Gorgon's ownership of the plantation into the future. The land title system adopted in Western Australia provides a very stable basis for guaranteeing long-term security of Gorgon's rights. The Profit à Prendre document is registered on the land title and secures Gorgon's interest through transfer of ownership of land. It clearly sets out the relationship between the landowner and the Grantee.

*Availability*

A key feature of this Plan is the method of acquiring land on a large scale and over a long period. The availability of land is function of social, environmental and economic factors influencing the decisions of a diverse range of landowners.

The experience in land acquisition for bluegum plantations has been spectacular over the past 12 years. More than 100,000 hectares have been established on a restricted land base in the high rainfall south-west of Western Australia. In the bluegum model, the incentive of regular annual rental or annuity is very competitive in relation to alternative competitive uses for the land.

*site preparation for tree crop* ▲

For this proposal it is proposed that the landowner only receives a share of future revenue, including a payment for carbon credits. However this benefit is attained at little or no cost, but with substantial additional benefits. The Project would provide the potential to integrate trees into the farms in patterns suitable to ameliorate land degradation and at the same time diversify farm revenues. Land degradation and the narrow and declining viability of current land uses are two major threats to farm viability.

In summary, while it is not possible to provide certainty about the availability of land over a 30-year horizon, the weak competitiveness of alternative uses and the pressing need for

revegetation, provide some confidence that there will be an ongoing supply of land. Actions such as adjusting financial arrangements with the landowner, or increasing the target area, are also possible to counter shortfalls in land availability. For a successful start to the Project, it would be essential for Gorgon to consider carefully the offer for landowners' carbon, including the price to be paid.

### 4.3.3 Plantation performance

The ability of the plantation to perform at the predicted levels is subject to risks in relation to growth rates, fire and insects:

*Growth rates*

CALM's proposals for maritime pine are based on a predicted average stemwood growth rate of 12$m^3$/ha/yr. This is derived from experience in existing plantations, the benefits of improved silvicultural practices and genetic material, as well as the enhanced growth achieved on farmland as opposed to the original plantations on cleared native woodland. CALM is currently assessing a range of plantings across the Cell (Map 1) and throughout the agricultural zone to help calibrate potential growth in the region. Once new plantations reach a sufficient age, growth rate projections can be confirmed to a greater precision.

*Fire*

The Mediterranean climate in the target planting area is conducive to wildfires and any plantation owner in Australia needs to be aware of the potential risk. The degree of risk and exposure can be controlled by preventative measures. The impact of any fire occurrence can also be minimised by a number of strategies.

Each Shire requires that the landowner undertake certain measures in the design and maintenance of those plantations (i.e. firebreaks). Local volunteer fire brigades are established through local government authorities with the assistance of the Bushfires Board.

While this places no direct obligation on the plantation owner, some contribution to support the fire control infrastructure to ensure there is the capacity to suppress fires would be beneficial. CALM, on its own

concentrated estate, undertakes these works itself. The direct cost of these activities is approximately $20/ha/year for fire prevention and suppression. Some of CALM's agency arrangements take the alternative path of insuring their plantations.

CALM's management fee provides for assistance in the planning and broad direction of any fire prevention program. There is a range of options and degrees of risk that can be adopted, which would need to be determined by Gorgon and included in the Project design.

CALM's existing plantations are located in very large blocks, surrounded by native forest. The Project plantations would be dispersed across a wide area in farmland and face quite different fire situations. This increases potential exposure to fire, but at the same time reduces the total area put at risk from fires, thereby reducing the potential consequences to the Project. One of the greatest advantages of the Project arrangements is achieved through landowners' direct interest in the welfare of the plantations. Landowners play a key role in the detection and initial suppression of fires.

The period of greatest risk is before age 10. After this time, even if all or part of the plantation is damaged, the timber products can be salvaged. This would not realise the full potential of the plantation, but some financial return and some of the carbon sequestered into the product pool are recovered. Replanting of ongoing plantations would be possible.

*Insects and pests*

The management system seeks to reduce the exposure to potential damaging agents. In Western Australia there are few known pests that have a major impact on maritime pine. The time of greatest exposure is when the plantations are young and susceptible to insects and rabbits. Protective programs and regular inspections are a routine part of plantation establishment, ensuring prompt attention to any attack.

### 4.3.4 Market risk

The timber and other products would need to be absorbed by the market to provide the financial returns and net cost of sequestration. These are existing and imminent processing industries in the Perth Cell which have the planned capacity to use products from the project plantation. These are the existing medium density fibreboard (MDF) plant at Welshpool and the currently proposed and negotiated laminated veneer lumber (LVL) plant.

The surplus wood would then be available for expanded plantation timber industries beyond about 2018. It is anticipated that a proportion of this wood needs to be exported, either as roundwood or in processed form. The demand for these additional resources cannot be explicitly defined. The positives that suggest there will be demand for such timber are:

- declining supplies from native forests throughout the Region (see Figure 25);
- growing demand and use of wood by south-east and eastern Asian countries is likely to continue;
- the high quality of maritime pine for wood products (it is preferred over radiata pine for MDF and LVL);

- the good relationships CALM has developed with Japanese trading companies and their interest in expanding reliable long-term supply contracts;
- the potential for increased demand for wood products to replace other products with high energy demand in their manufacture (e.g. aluminium, steel).

The direct effect of unused timber resources is a reduced area of harvesting in the plantation. As a consequence the carbon sink in trees would remain undiminished and the area required to be planted would be less.

### 4.3.5 Carbon accounting

*Baseline risk*

The changes to baseline levels of carbon due to the change in land use to plantation forestry from agriculture are considered to be low. While it would seem self evident that a plantation will store more carbon than under agriculture, there may be some components of the system which are depleted when converted from agriculture. The only likely impact is to stored soil organic carbon. It may be on some soils that organic carbon is initially lost from the site as a result of plantation establishment methods. The scale of this effect is likely to be minimal.

*Carbon accounting*

The Project appears to qualify in accordance with criteria as set out by the Greenhouse Challenge Office (1998). However, there are still considerable uncertainties in:

- the accreditation of wood products in the carbon sink for the life of this Project. The inclusion of the product will have a significant bearing on the scale of the Project required to achieve the sequestration target. There are a number of groups lobbying for the inclusion of wood products in the carbon sink.
- the risk associated with any debit due to a reducing carbon sink that arises beyond the horizon for the Project.

The question of the permanence of the sink needs to be considered by Gorgon. For mallee eucalypts and landcare trees it is expected that the trees, even if harvested, will be permanent. However for maritime pine once clearfelling begins the carbon sink on any one hectare will begin to decline and may present a future liability to the Company. After the 40-year period the total sink will also reduce.

The question of whether a permanent sink can be created needs further investigation. Western Australia's agricultural areas need permanent revegetation otherwise reforestation will only provide temporary relief from its environmental problems. There may be some prospect for replanting at clearfelling and repeating the first commercial rotation, or to enable Gorgon to walk away with a sink in a steady state.

The other approach of dealing with the permanence of sinks is through the rules by which carbon is credited. If the beneficial effect of temporary sequestration were recognised, the withdrawal of carbon dioxide from the atmosphere for a period would still gain some credit. CALM is lobbying in Australian forums to have this option considered.

**Table 25: Summary of risks analysis**

| Risk type | Significance of possible effect | Likelihood of occurrence | Systematic risk control | Other impact reduction |
|---|---|---|---|---|
| SOVEREIGN | High | Very low | Agreement Act | |
| LAND<br>Security. | High | Very low | Monitor political environment | Increase payments to landowners |
| Availability | Moderate | Low | Advertising and promotional activities | |
| PLANTATION<br>Growth | Moderate | Moderate | – Growth modelling<br>– Site evaluation procedures<br>– Improving genetics | – Remedial fertilisation<br>– Improved site selection |
| Fire | Low | Moderate | – Fire prevention activities<br>– Fire risk planning and minimisation<br>– Self interest by landowner | – Fire suppression<br>– Timber salvage |
| Insects | Low | Moderate | – Crop monitoring<br>– Quarantine<br>– Research | – Control measures<br>– Replant affected areas |
| MARKET<br>Demand | Moderate | Moderate | – Product development<br>– Product marketing overseas<br>– Overseas linkages | Reduced planting rate |
| CARBON | Low | Low | Measurement of | Change establishment |
| Baseline | Moderate | Moderate | soil carbon pool | rate |
| Product pool<br>Performance | Unknown | High | Lobbying of national and international level | Review Project design |

*Conclusion*

Many of the risks facing the Project are effectively countered by the systematic operational controls as defined in Table 19. The greatest impact on the Project will be the national carbon accounting regime that will determine the carbon benefit achieved. When regulatory measures are finalised there may be a need to review Project design as it may impact on the scale rate and species planted.

The actual rate of growth experienced by the plantations may be of equal importance, as this impacts both the timber and carbon yields. Once predictive models are fully calibrated, CALM will be able to reduce any adverse effect by routine plantation silviculture.

The other important risk would appear to be the capacity to sell the large increase in timber products on the market. Since timber products begin to be marketable from 2012 this would then provide sufficient lead time to find appropriate industries and markets.

The other major risk to Gorgon arises from not proceeding quickly, as the task of establishing the target sink in the timeframe becomes more difficult. There is a significant lead-time until an individual plantation becomes most effective in sequestering carbon. There is also the logistical difficulty associated with building up a sufficiently sized plantation estate for Gorgon's sequestration target.

## 4.4 ENVIRONMENTAL IMPACTS

### 4.4.1 Natural environment

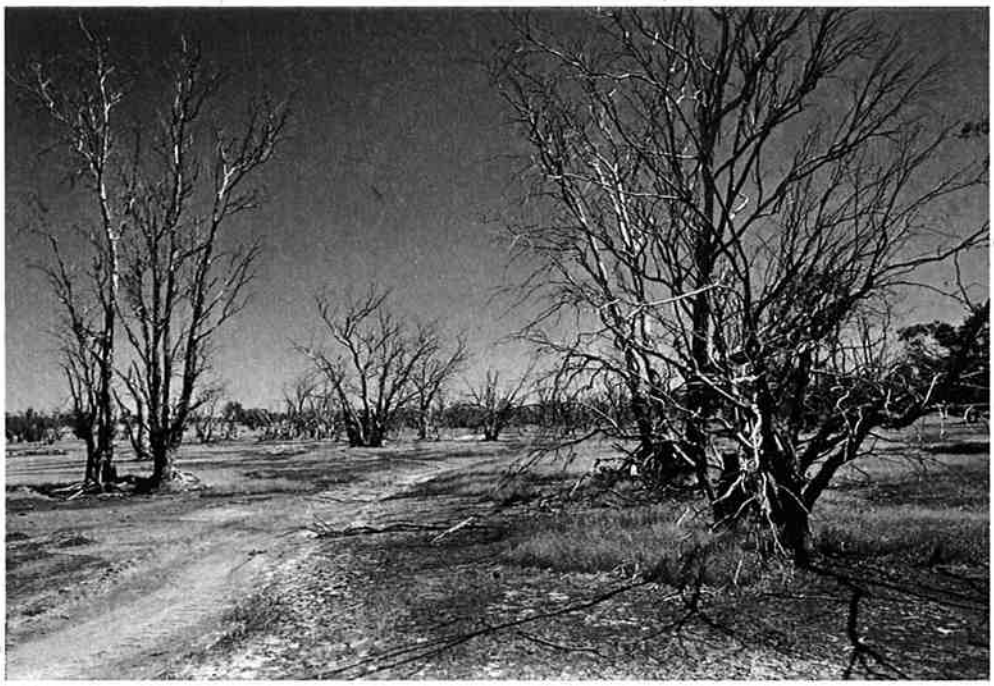
The region straddles two major geological environments. The Perth Basin lies along the coast and is a deep sedimentary basin consisting mainly of sandy sediments of post Permian age. It ranges from 30 kilometres wide in the south up to 100 kilometres wide in the north. It carries a mantle of Quaternary deposits of low relief and is commonly called the Perth coastal plain. The Perth Basin is bounded in the east by the Darling Fault a major geological divide and western boundary of the Yilgarn block comprised of Achaean crystalline rocks. The Darling Fault is visible as the Darling Scarp, some 300 metres elevation in the south but less in the north. The Yilgarn block forms an ancient plateau of low relief with deep weathered (about 20 metres) lateritic profiles and some younger soils formed over exposed basement rocks. The soils reflect the geological origin with infertile sands predominating of the coastal plain and more fertile lateritic gravels and loams over clay subsoils on the plateau.

Plateau soils have considerable cyclic salt storage and groundwater systems confined to the weathered profile which averages 20 metres thick. The coastal plain has deep regional groundwater systems that are complex due to extensive faulting and often fresh. Due to the low relief both landforms have incoherent surface drainage and frequent wetlands.

The native vegetation is commonly low heath on the plain and open woodland to forest on the plateau and is of exceptional diversity, particularly on the plain. Several conservation reserves, some of international renown, are located in the north of the region.

### 4.4.2 Managed environment

Agriculture is the only substantial land use in the region. The more fertile soils of the plateau attracted earlier and more extensive development for agriculture than the coastal plain. Virtually all agricultural development has occurred this century with much of the plains lands being developed in the past 30 years. The proportion of land cleared ranges from more than 90 per cent on the plateau to as low as 60 per cent on the plain. There is some horticultural activity in the area close to Perth but the majority of agriculture is cereal cropping and sheep and cattle grazing.



*salinity damage* ▲

Clearing for agriculture has resulted in serious land degradation, the most important form of which is caused by the reduction in water use by the annual crops and pastures. The altered water balance enhances entry of water into groundwater systems and mobilises stored salts. This gives rise to the sequence of problems called salinity, i.e. salinisation of land and streams, waterlogging of low land, water erosion, contamination of water resources, loss of remnant native vegetation and biodiversity especially in valley and wetland habitat, increased flood risk and loss of infrastructure. These problems are rapidly increasing in extent and severity. Ferdowsian *et al.*, (1996) projected that salt encroachment on northern agricultural area soils would increase from the current nine per cent to 30 per cent in the absence of remedial action. This would be accompanied by a similar level of increase in the other aspects of degradation related to salinity.

Land degradation due to salinity is unequivocally the State's major environmental problem (State of the Environment Report, 1998).

Salinity is more serious on the plateau than on the plain. This is because the plain does not have the same extent of salt storage. However, it does have areas with saline groundwater, rising groundwater level and soil salinity. Also salts flushed from the plateau cause damage on the plain.

The plain is also subject to another agricultural water balance problem. The infertile sandy soils are not able to retain phosphorus fertiliser efficiently. With the surplus of unused rainfall, phosphorus is readily leached into groundwater and surface drainage systems. This contaminates potential groundwater resources and enriches the nutrient content of wetlands giving rise to prolific algal growth.

Agricultural land also suffers wind erosion due the inadequate perennial vegetation cover.

### 4.4.3 Impact of farm forestry

Extensive adoption of farm forestry in the region will have major impact on water, salt and nutrient balances and on the microclimate of the agricultural landscape. These impacts will have substantial effects on the biota, both within the agricultural systems, and within those parts of the landscape that retain native vegetation. These changes will generally turn water, salt and nutrient balances back towards those that prevailed under the original native ecology and the change will therefore be strongly positive. Indeed revegetation is actively promoted as the primary treatment for land degradation within agriculture (Western Australian Salinity Action Plan, 1996). The Salinity Plan indicates the need for some three million hectares of revegetation across the agricultural area as a whole. This suggests a desirable planting area for the project area of some 300,000 hectares, about double that proposed in the project.

There are two potential negative impacts from extensive farm forestry with maritime pine. Firstly, there is a risk that maritime pine, an exotic species, will disperse seed, colonise native bush and other land thus becoming a weed and diminishing conservation values. However, this does not appear to be a substantial risk. Maritime pine has been extensively planted across the Perth coastal plain for several decades and no significant weed problem has emerged.

Secondly, the high water use of maritime pine may consume potentially exploitable groundwater supplies. The CALM plantations in the Wanneroo/Yanchep region must be thinned to economically sub-optimal densities to reduce their water consumption and avoid conflict with the developed groundwater resources in the region. There are potential shallow groundwater resources in the project area that could be compromised by farm forestry. However, these resources are also compromised by nutrient contamination under agriculture and partly forested agricultural land may present a more attractive water management option than pure agriculture. Alternatively, the agricultural land would have to be acquired by the water supply authority to maintain water quality and quantity.

While at the macro-scale there are clearly significant positive environmental benefits to be found through the Project as indicated in the Salinity Action Plan, the benefits on the micro-scale are equally spectacular. Appendix 4 contains a case study illustrating how trees when planned and placed on a farm can achieve the goals of revegetation and improved local environment, as well as economic benefit to the landowner.

Landowners also work together in groups based on local catchments to ensure that their actions are integrated to benefit the whole area. These groups are called Land Conservation District Committees (LCDCs) and ensure that the efforts of farmers work towards the same catchment goals. This approach is of particular importance where the efforts of several owners are required to be effective. CALM and other government departments may also be represented on LCDCs to ensure cohesion with across programs.

## 4.5 PROMOTIONAL OPPORTUNITIES FOR GORGON

The proposed Project is expected to generate significant promotional opportunities for Gorgon. Increasing Western Australia's plantation estate is strongly supported by a wide range of community groups from farmers looking for ways to diversify their incomes, to those who see it as a way to reduce the demand on timber from native forests.

Planting tree crops on already cleared farmland is also vital to prevent further rises in salinity levels and the subsequent loss of productive land, water quality and natural environments. Western Australia's Salinity Action Plan set a 30-year planting target of three million hectares of trees and shrubs across the State's agricultural area to combat salinity and other landcare problems. The Government committed significant funds to implement the Salinity Action Plan, but recognised that much of the investment to achieve this massive area of new plantings would have to come from landowners and in particular, private industry.


The West Australian

Blue gum seedlings promise rich harvest

Many landowners are highly motivated and looking for support to expand their landcare activities. There is an organised network of catchment groups and Land Conservation District Committees (LCDCs) in the Project's target area.

▲ *the official launch of plantation projects in Western Australia has attracted strong media interest*

Overseas investors working with CALM to establish bluegum plantations in the south-west have already won recognition for their contributions to the local environment. Albany Plantation Forest Company of Australia Pty Ltd, for example, was presented with the 1995 Landcare Australia Award for Western Australian Business (*below*) and the 1998 Asia Pacific Marketing Federation's inaugural gold marketing award. Hansol Australia was the 1997 finalist for the Landcare Australia Business Award.

▲ *quenda*

Large-scale tree planting lowers water tables, preventing increased salinity levels and waterlogging, as well as controlling soil erosion and pollution caused by excess fertiliser leaching into waterways. It is also possible to plant commercial tree crops strategically to help protect native vegetation on farms and in neighbouring conservation reserves. Together with plantings of native landcare trees under the Project, this would increase wildlife habitat areas and could create wildlife corridors to link nature reserves in the Project area. CALM would look for opportunities to expand its award-winning wildlife recovery program, Western Shield, in areas protected by the Gorgon Project. Two of the species targeted by Western Shield are pictured.

*chuditch* ▼

# 5. COMMISSIONING THE PROJECT

This schedule is based on the Project commencing in the year 2000. Any delay in the start-up time would delay the timing as shown in Table 26 by one year.

**Table 26: Schedule of activities**

| | LEGAL | | OPERATIONS |
|---|---|---|---|
| 1999 | | May–August<br>Sept – Oct | Set cuttings in nursery |
| | | | Sow seed in nursery |
| November | Potential signing of Deed of Agency | C<br>o<br>n<br>t<br>i<br>n<br>u<br>o<br>u<br>s | Commence land promotion<br>Initial owner contacts<br>Assess land in detail<br>Drill for soil depth<br>Assess for salt<br>Define suitability areas<br>Negotiate terms with landowner |
| 2000 Jan-Feb | Renew/Relet forest management contracts | | |
| April-May | Latest date for signing of Deed of Agency<br>Set Power of Attorney<br>Finalise individual Profit a Prendre | April-May | Commence land preparation<br>Advise contractors of targets<br>Weed control commences |
| June –August | Initiate State Agreement if required | June –August<br>Oct – Dec | Planting commences<br>Planting completed<br>Monitor for insects |
| 2001 | | March<br>May-June | Survival assessment<br>Weed control, infill as needed |
| 2003 | | | Early growth monitoring |

*Approvals*

The extent of Government approval required for such projects is not rigidly set. It is likely that the following approvals may be required:

- State Agreement Act – Parliamentary approval is required. A State Agreement may be necessary for the commercial development of Gorgon's gas reserves. As a part of that Agreement it may be appropriate to include State support for a plantation project. This is not essential but may be of advantage to Gorgon. The Department of Resources Development has responsibility for the preparation of such Agreements.
- Agency arrangements – Cabinet approval is required for CALM to enter into long-term commitments to Gorgon for the management of plantations. The Government has already given approval for CALM to enter three such arrangements.
- Environmental approvals – the intention of fostering the development of farm forestry over a large proportion of the agricultural area has been widely circulated and its broad impacts identified. In the case of existing plantation schemes there has been no requirement for detailed environmental impact studies. A decision on whether to proceed with such studies would rest with the Environmental Protection Authority.

- Individual plantation approvals – the primary decision maker is the plantation owner. However in some circumstances external approval may be required. Most Shires require notification of the intention to establish plantations, but there has been no difficulty in gaining approval provided they conform to existing land use zoning and design requirements and comply with the Plantation Code of Practice. The Commissioner for Soil Conservation must approve the removal of native vegetation, however, it is not the intention of this Plan to clear land for plantations.

Where landowners have mortgages or other encumbrances on the title, approvals of those parties may be required.

*Operational commencement*

The first commitment required for the commissioning of the Project is the ordering of plants, up to 12 months prior to planting. In the absence of such an order the project may be able to proceed but it is not certain that there would be sufficient plants to enable it to start at the scale required by Gorgon.

For CALM it is desirable for an appropriate agreement be made with Gorgon prior to entering into tenders or committing to contracts for plantation works so that CALM is protected in the event of the Project being deferred or not proceeding.

# 6. PILOT PROJECT

A pilot project could be started in 1999. The initiation of such project would enable Gorgon to assess fully the value of reforestation as a means of achieving its sequestration objective.

Its key objectives for Gorgon could include:

- to better understand the costs and benefits of offset opportunities;
- to take an active role with Government in defining systems, rules and procedures for future carbon accounting and trading;
- for Gorgon to gain familiarity with the processes of land acquisition and plantation establishment;
- to appreciate the different opportunities that exist with the each of the species types;
- to gain an understanding of the target area, its features and communities, and develop future promotional strategies;
- to develop the offer to be made to landowners for their share of the carbon;
- to develop an appreciation of the community benefits which would arise from the Project; and
- to establish working relationships with CALM staff and view CALM work processes, for the purpose of refining the objectives to apply to plantations, and to clarify the long-term relationship with CALM. It would then put Gorgon into a strong position to move quickly to a large-scale offsets program as both Gorgon and the offsets regime develop.

The suggested specific targets for the pilot project are:

- establish 100 to 150 hectares of new maritime pine plantations and their associated 10 per cent of land care trees; and
- establish working relationship with members of the Oil Mallee Association and examine the potential for investment in of mallee eucalypts.

*Steps in Project implementation*

**1. Agency agreement**

Gorgon would need to enter into a formal agreement for CALM to act as its agent. This defines the roles and responsibilities of each party, defines the term of the agreement and the arrangements for termination. This agreement may be entered into by CALM's Executive Director.

**2. Land target**

To achieve the objectives of the pilot study effectively, it is essential to nominate an area of land that would be achieved by the study. CALM is aiming to establish 2,000 hectares in the Perth Cell in 1999, therefore Gorgon's goal would form part of that target.

To provide a meaningful assessment of the procedures and methods applied a scale of at least 150 hectares is suggested. This would then encompass several farms and enable Gorgon to gauge the reaction of the landowners to the offer.

CALM already has significant contacts in the area and these are likely to be confirmed into signed contracts. Potential sites are shown on Map 2.

### 3. Project budget (until 31 December 1999)

A budget of between $130,000 and 195,000 is estimated to establish a plantation area of 100 to 150 hectares (at $1,300 per hectare). This would be a fixed budget to cover CALM staff and corporate services and be variable for costs associated with actual plantation field costs. CALM's normal financial arrangement provides for quarterly payments in advance with reconciliation against actual costs at the next payment.

### 4. Publicity and promotion

CALM's promotional efforts will increase as the scale of land acquisition increases. The question of whether Gorgon wishes to be openly associated in broadscale publicity would need to be determined.

### 5. Deed of Grant of Profit à Prendre

Once Gorgon has nominated its target and suitable land is located, CALM would seek to secure Profits à Prendre in Gorgon's name. Gorgon will need to give CALM a Power of Attorney for this purchase.

Prior to this Gorgon will need to determine the arrangement by which it will secure the carbon credits. That is whether Gorgon will seek to gain 100 per cent of the credits and compensate the landowner by direct payment or increased share of timber revenues. This arrangement needs to be finalised before CALM speaks to landowners on Gorgon's behalf.

### 6. Establishment

Establishment works would begin once the contract is agreed and signed. This work would be carried out by existing CALM contractors and monitored by CALM staff.

### 7. Measurement of carbon

There is little merit in attempting to measure the quantity of carbon sequestered in the first year after planting a tree crop. However CALM has other plantations where these processes could be better assessed.

### 8. Reporting

At the end of the first year CALM would provide a complete report on the operations and expenditures incurred during the year. At the end of the first summer, the planting success will be determined and reported.

*Timing*

To proceed effectively with the pilot project it needs to be commenced quickly for Gorgon to get best value for its efforts. A target date for the agreement should be set for January.

*Other opportunities*

CALM is willing to discuss assignment of existing plantations to Gorgon, which would enable it to assess the management of older plantations. CALM has plantations up to four-years-old that might be suitable of re-examination of later issues.

# 7. REFERENCES


Arima, T (1993). Carbon dioxide emission and carbon storage for building materials and construction in Japan. *Wood Design Focus, 4(2):9-12.*

Bailey, C, McNamara, K and Shea, S R (1997). Halt the Salt : Western Australia's Salinity Action Plan. In: Landscope Spring edition. pp. 10 – 17. Department of Conservation and Land Management.

Barrett, D R and Fox, J E D (1995). Geographical distribution of *Santalaceae* and botantical characteristics of species in the genus *Santalum*. pp. 3 – 23. In: Gjerum, L, Fox, J E D and Ehrhart, Y (eds), Sandalwood Seed Nursery and Plantation Technology. FAO, Suva, Fiji. Field Document No. 8. RAS/92/361.

Bartle, J R, Campbell, C, White, G, (1996). "Can Trees Reverse Land Degradation? Paper Presented to Australian Forest Growers Conference, Mt Gambier SA". Department of Conservation and Land Management, Western Australia.

Barton, A F M and Knight, A R (1997). High cineole equcalypts in degreasing applications. In: *Chemistry in Australia Vol 64 No. 1 pp 4-6.*

Beard, J S, (1979). The vegetation of the Perth area, Western Australia. Explanatory memoir. Vegmap Publications, Perth.

Bettenay, E, McArthur, W M, and Hingston, F J (1960). Soil associations of the Swan Coastal Plain, Western Australia. CSIRO Australia Division of Soils, Soils and Land Use Series 35.

Bird, D N (1997). The relative value of storage of carbon in forests and wood products. In: *Annex 1 – Carbon Sinks Workbook: Discussion Paper for the Greenhouse Challenge Office. A.A.C.M.*

Bootle, K R (1983). Wood in Australia. *Tippers, properties and uses. McGraw Hill.*

Cannel, M G R and Dewar, D C, (1995). The carbon sink provided by plantation forests and their products in Britain. *Forestry 68(1):35-48.*

Carter, J D and Lipple, S L (1982). 'Moora, Western Australia.' 1:250 000 Geological Series—Explanatory Notes. (Geological Survey of Western Australia: Perth, Western Australia.)

Churchward, H M (1970). Erosional modification of a lateritized landscape over sedimentary rocks. Its effect on soil distribution. *Australian Journal of Soil Research* **8** 1–19.

Clutter, J L, Forston, J C, Pienaar, L V, Brister, G H, and Bailey, R L (1983). Timber Management: A Quantative Approach. John Wiley and Sons, New York, 353pp.

Costa, P M (1998). Forestry-based greenhouse gas mitigation: A short story of market evolution. In: *Asian Timber.*

Ferdowsian, R, George, R, Lewis, F, McFarlane, D, Short, R and Speed, R (1996). The extent of dryland salinity in Western Australia.Proceedings 4th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Lands. Promaco Conventions. pp 89-97.

Gilkes, R J, Scholz, G, and Dimmock, G M (1973). Lateritic deep weathering of granite. *Journal of Soil Science* **24** 523–36.

Harper, R J (1996). "Site Selection Prescription for the Establishment of Maritime Pine Plantations". *Department of Conservation and Land Management, Western Australia. Unpublished Report.*

Havel, J J and McKinnell, F H (1993). A review of the commercial management of sandalwood. Paper presented at the 15th Biannual Conference of the Institute of Australian Foresters.

Hewson, H J and George, A S (1984). *Santalum.* In: Flora of Australia, Vol. 22. Bureau of Flora and Fauna. Canberra, Australia, Australian Government Publishing Services.

Hollinger, D Y (1993). Carbon sequestration by New Zealand's plantation forests. *NZJ For. Sci. 23(2):194-208.*

Houghton, J T (1994). Climate Change 1994. Radiative forcing of climate change and an evaluation of the IPCC IS92 emission scenarios. *Published for the Intergovernmental Panel on Climate Change. Cambridge University Press.*

Inions, G B (1992). Studies on the growth and yield of plantation *Eucalyptus globulus* in south-west Western Australia. *PhD thesis,The University of Western Australia.*

Johnstone, M H, Lowry, D C, and Quilty, P G (1973). The geology of southwestern Australia—a review. *Journal of the Royal Society of Western Australia* **56** 5-15.

Karjalainen, T (1996). Dynamics and potentials of carbon sequestration in managed stands and wood products in Finland under changing climatic conditions. *For. Ecol. Man. 80: 113-132.*

Loneragan, O W (1990). Historical review of sandalwood (*Santalum spicatum*) research in Western Australia. Research Bulletin No. 4. Department of Conservation and Land Management, Como. pp. 53.

Maclaren, J P (1995). Plantation forestry in New Zealand – concepts methodologies and recent calculations. In: *roceedings of the 1995 Invitation Symposium: Greenhouse abatement measures: No regrets action now, pp 216-237, ustralian Academy of Technological Sciences and Engineering Melbourne.*

McArthur, W M and Bettenay, E (1960). Development and distribution of soils of the Swan Coastal Plain, Western Australia. CSIRO Australia Division of Soils, Soil Publication 16.

McGrath, J and Adams, M (1997). ARC co-operative research grant application.

McKinnell, F H (1990). Status of management and silvicultural research on sandalwood in Western Australia and Indonesia. In: L Hamilton and C E Conrad (eds.), Proceedings of the symposium on sandalwood in the Pacific; April 9-11, 1990, Gen. Tech. Rep. PSW-122, Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Honolulu. pp. 19 – 25.

Mulcahy, M J (1960). Laterites and lateritic soils in south–western Australia. *Journal of Soil Science* **11** (2), 206–25.

Mulcahy, M J (1967). Landscapes, laterites and soils in southwestern Australia. In 'Landform Studies from Australia and New Guinea.' (J N Jennings, and J A Mabbutt Eds), pp. 211-30. (ANU Press: Canberra.)

Mulcahy, M J (1973). Landforms and soils of southwestern Australia. *Journal of the Royal Society of Western Australia* **56** 16–22.

Nelson, P J, Watson, A J, Bain, R B and Balodis, V (1973). An assessment of the resing and a comparison of the pulping properties of *Pinus pinaster* and *Pinus radiata*. Appita 27(2): 99-106.

Northcote, K H, Bettenay, E, Churchward, H M and McArthur, W M (1967). 'Atlas of Australian Soils. Explanatory data for sheet 5. Perth—Albany—Esperance area.' (CSIRO Australia and Melbourne University Press: Melbourne.)

Notley, R and K; Winchcombe, J and Speed, R (1997). The West Coast Pine Timberbelt Project – The "Western Nodes" Experience. State Landcare Conference, Geraldton, 1-4 September.

Robson, A D and Gilkes, R J (1981). Fertiliser responses (N, P, K, S, micronutrients) on lateritic soils in southwestern Australia – a review. In 'Laterisation Processes.' pp. 381-90. (A.A. Balkema: Rotterdam, The Netherlands.)

Siemon, G R (1983). Strength properties of *Pinus pinaster* Ait. In Western Australia. *Forests Department of Western Australia. Research Paper 72.*

Shea, S R, Inions, G B, Bartle, J R, and Crawford, H (1994). The potential for the integration of tree crops into Australian agricultural systems: *Paper presented at Australian Association Consultants Conference, Agreculture: Growing Business, Perth, February 1994.* Department of Conservation and Land Management, Western Australia.

Shea, S R (1998). Western Australia's Development and Future Prospects for Tree Crop Industries. *Paper presented at Australia's Paper and Forestry Forum 18-19 May 1998.*

Smith, R C G (1997). Applications of satellite remote sensing for mapping and monitoring land surface processes in Western Australia. In: *Journal of the Royal Society of Western Australia, 80: 15-28, 1997.*

Smolinski, H J and Scholz, G G H (1997). Soils of the West Gingin area. Western Australian Department of Agriculture, Land Resources Series 15.

Tickle, P (1998). The application of large-scale video and laser altimetry to forest inventory. *Proc. 9th Australian Remote Sensing and Photogrammatic Conference, July 1998 (in press).*

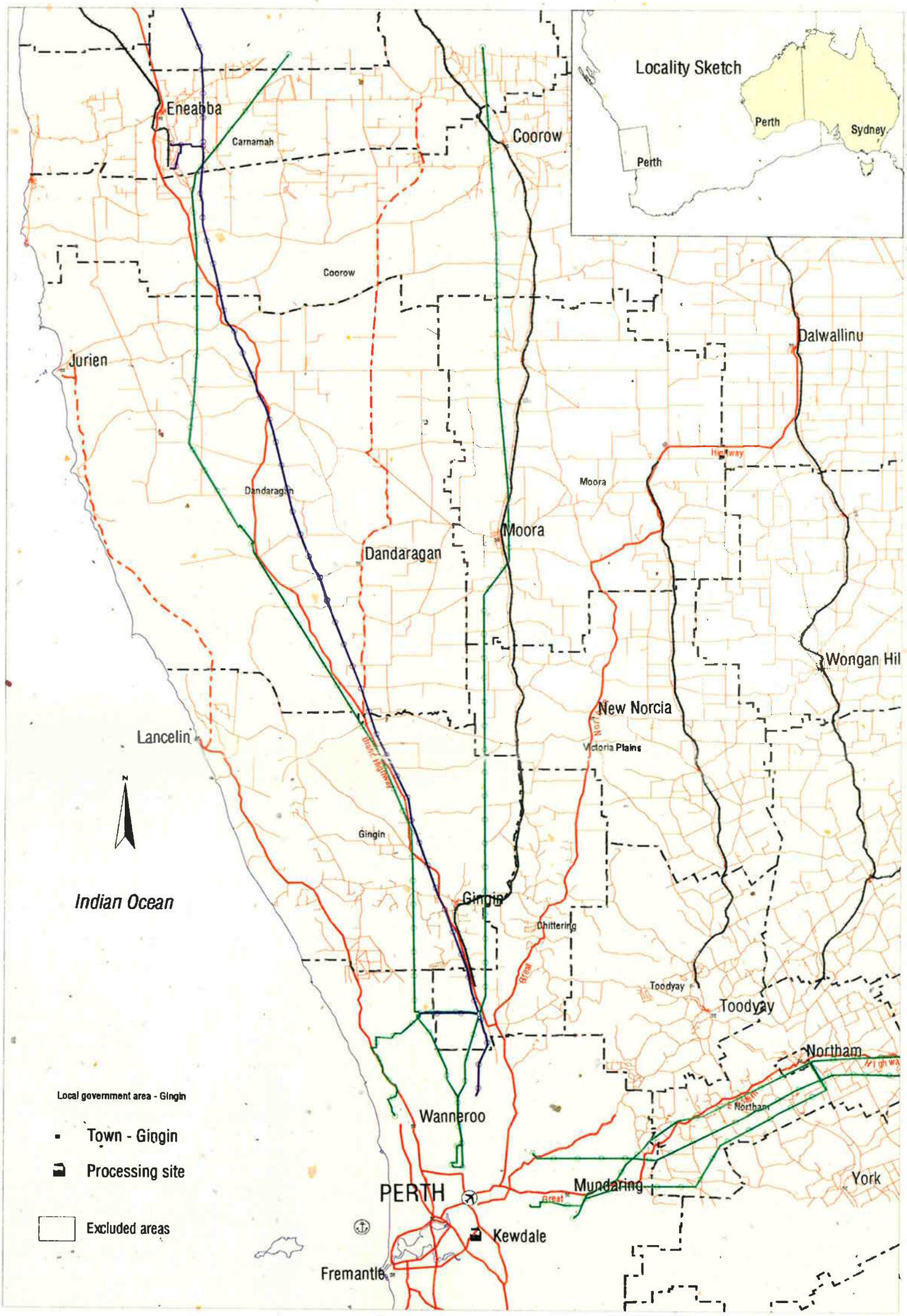
Turton, A G, Marsh, N L, McKenzie, R M, and Mulcahy, M J (1962). The chemistry and mineralogy of lateritic soils in the south–west of Western Australia. CSIRO Australia Division of Soils, Soil Publication 20.

Wilde, S A and Low, G H (1980). 'Pinjarra, Western Australia.' 1:250 000 Geological Series—Explanatory Notes. (Geological Survey of Western Australia: Perth, Western Australia).

FWPRDC (Forest and Wood Products Research and Development Corporation) 1996. Environmental Properties of Timber. *FWPRDC Brisbane.*

State of the Environment Reference Group (1998). Environment WA 1998: State of the Environment Report. Department of Environmental Protection.

Western Australian Salinity Action Plan (1996). Action Plan and Situation Statement prepared by Agriculture Western Australia, Department of Conservation and Land Management, Department of Environmental Protection and Water and Rivers Commission.




## Other features

- Major roads
- Proposed major roads
- Other roads
- 132 kv power transmission line
- Natural gas pipeline
- Railway line
- Local Government boundary

Scale 1:1000000

Projection: AMG(Zone50)

Date: 6/11/1998

**Conservation and Land Management**

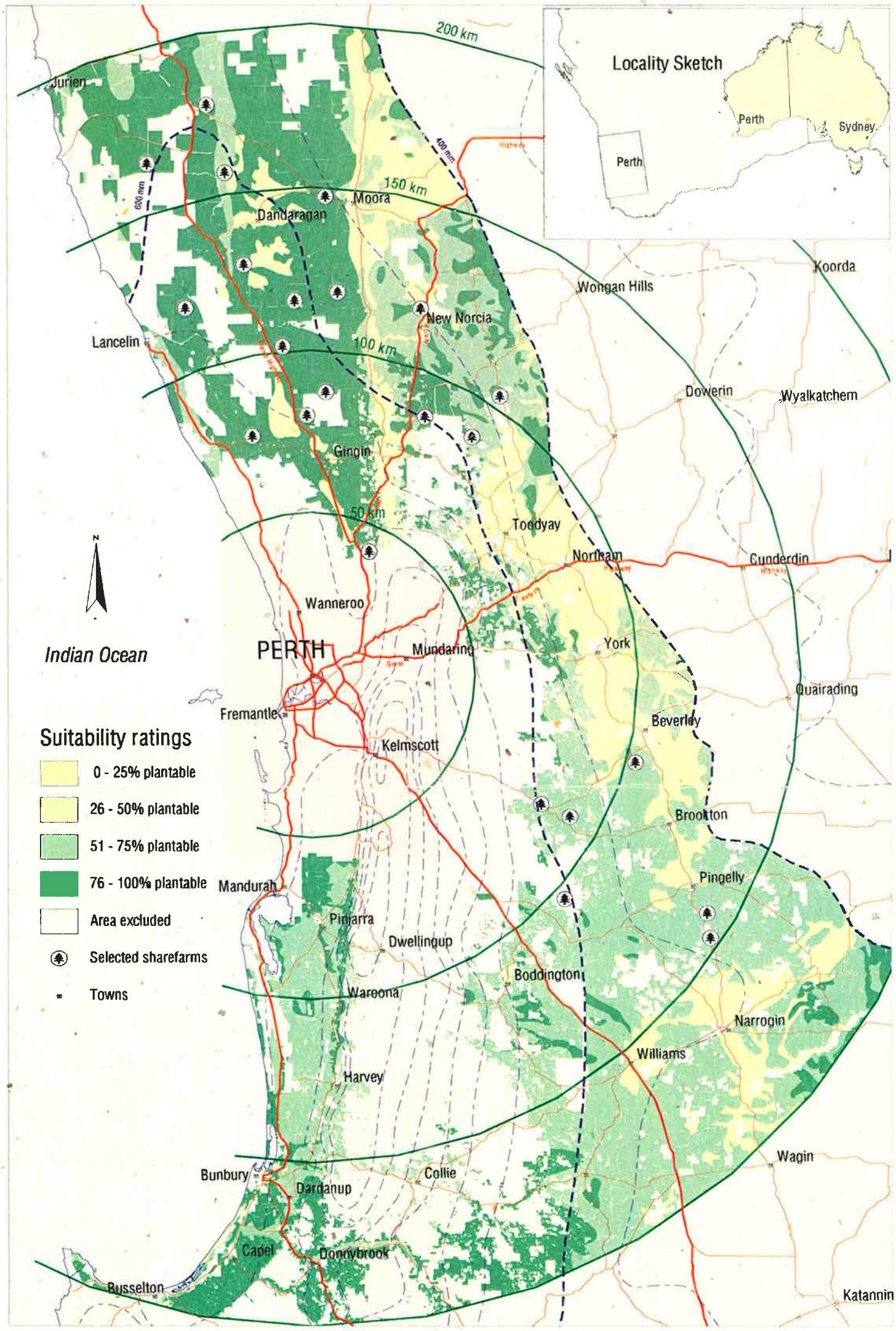
IMB/GISS Job No.98042104-pe3n

## Data sources used

ROADING - MainRoadsWA

UTILITIES - WesternPower and AlintaGas

ADMINISTRATIVE - Min. for Planning




## Other features

- Major roads
- Proposed major roads
- Other roads
- Radiating buffers
- Key rainfall isohyets
- Other rainfall isohyets

Scale 1:1500000

Projection: AMG(Zone50)

Date: 6/11/1998

**Conservation and Land Management**

IMB/GISS Job No.98042104-pe2

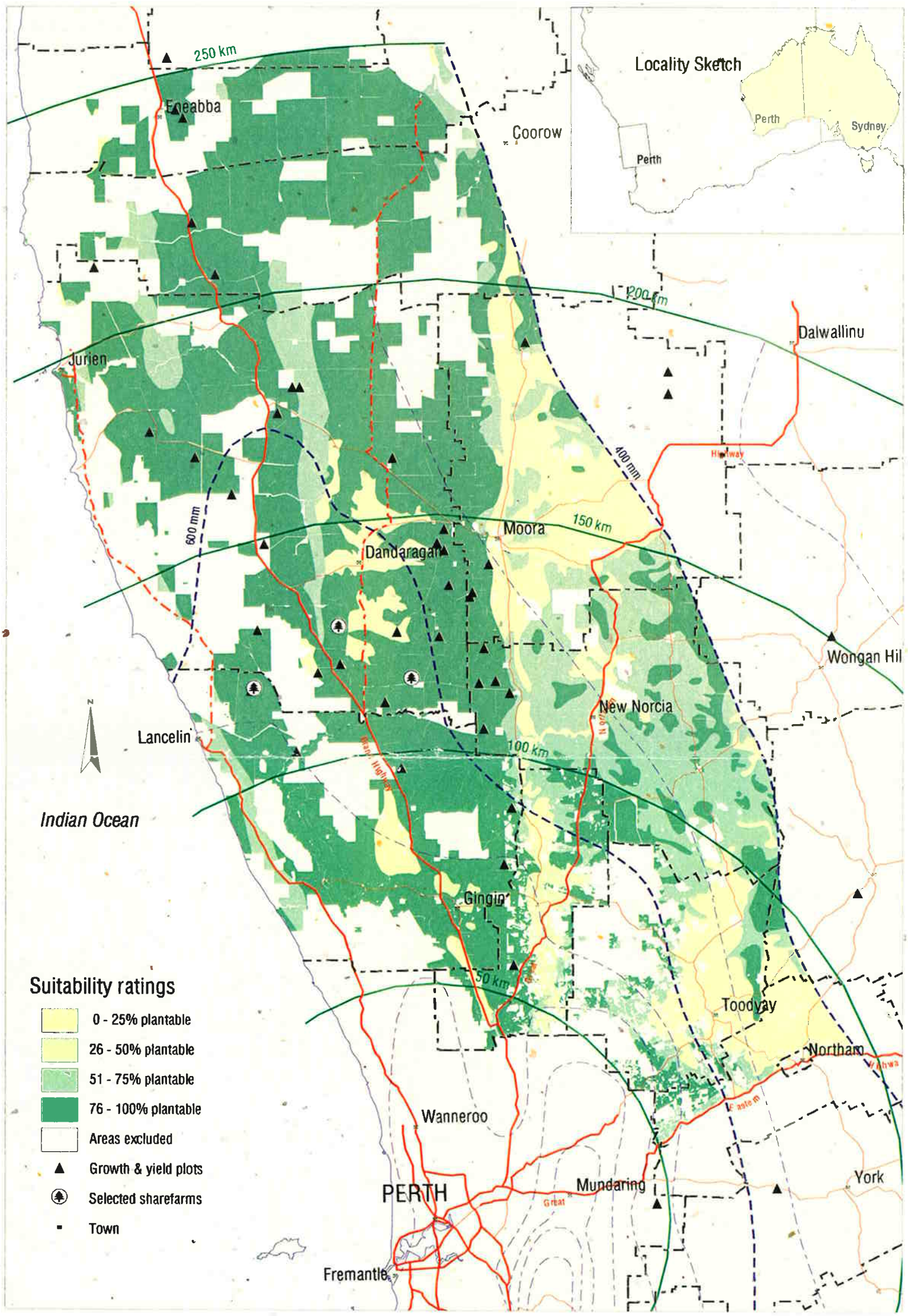
## Data sources used

TENURE - Dept of Land Admin.

VEGETATION - Conserv. and Land Mgmt

SOILS - AgWest

RAINFALL - Min. for Planning




## Other features

- Major roads
- Proposed major roads
- Other roads
- Radiating buffers
- Key rainfall isohyets
- Other rainfall isohyets
- Local Government boundary

Scale 1:1000000

Projection: AMG(Zone50)

Date: 6/11/1998

**Conservation and Land Management**

IMB/GISS Job No.98042104-pe2n

## Data sources used

TENURE - Dept of Land Admin.

VEGETATION - Conserv. and Land Mgmt

SOILS - AgWest

RAINFALL - Min. for Planning