FORESTRY

Plantations and farm forestry represent significant land uses in parts of SWWA, with climate variability and change being major considerations in managing the existing resource and future expansion plans. Impacts of climate change on natural forests are considered in the section dealing with biodiversity.

Development work on carbon sinks is a direct response to changes in international climate change policy, particularly the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).

SWWA's plantation estate

By 1990 approximately 100 000 ha of tree plantations[2] had been established in SWWA. These comprised mainly *Pinus radiata* and *Pinus pinaster*, and were established by converting native bushland and purchasing farmland. This occurred mainly in the Blackwood Valley, the Donnybrook Sunklands and at Gnangara.

A change of Government in 1983 saw a new policy of prohibiting establishment of plantations on native forest lands. Since then considerable work has been undertaken (initially by CALM, and since 2000 by the Forest Products Commission) to establish plantations on farmland—both as plantations but also as plantings integrated with existing farming activities (Shea and Bartle, 1988; Bartle and Shea, 1989). This involved *P. radiata* and then *Eucalyptus globulus,* with the major aims being to provide fibre resources and environmental co-benefits, such as reducing salinity in water resource catchments.

Table 2 **Areal extent (ha) of plantations in Western Australia (55% of softwood and 2% of hardwood plantations in 2005 are owned by the State Government)**

Forest type	Year	
	1990	2005
Plantations	(ha)	(ha)
Pinus radiata and *P. pinaster*	94 000[2]	110 395
Eucalyptus globulus [3]	7 000	259 371

Source: Parsons and Gavran, 1995.

Since 1990 several overseas companies have invested in plantations on farmland, which was followed by Australian investment via managed investment scheme companies. This led to rapid expansion in the amount of *E. globulus* planted on farmland, predominantly in the greater than 600 mm rainfall zone. By 2004, 260,000 ha had been established, representing a major change in land-use. The benefits of this widespread reforestation are now apparent in water catchments such as the Denmark River, where considerable reforestation has improved the quality of previously saline water (Bari *et al.* 2004).

With recognition of salinity as a major problem and acknowledgment that trees can assist in restoring landscape hydrology, there were new initiatives by CALM to extend forestry into drier (300-600 mm per year) regions, with both *P. pinaster* (Shea *et al.* 1998) and mallee eucalypts (Bartle, 2001). These initiatives have been continued by the Forest Products Commission.

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2 Estimate from 1990-1991 Annual Report, CALM.
3 Mainly *Eucalyptus globulus.*

Climate change considerations in forestry planning

SWWA's mediterranean climate has two major features needing consideration to ensure success of plantations. Firstly, there is little reliable rainfall during summer (October to April) and secondly, there are recurrent drought years where winter rainfall is considerably below normal. There have been recurrent episodes of drought-induced tree deaths in a variety of species such as *P. radiata* in the late 1960s, late 1970s and 1987/1988 (McGrath *et al.* 1991), and *E. globulus* in 1994 and 2000 (Harper, McGrath and Carter, 2002; Harper *et al.* 1999; Harper, Smetten and Bartle, cited in Moore, 1998).

Patterns of drought deaths are related to soil and site conditions, and procedures are now in place to avoid sites with inadequate soil water storage capacity (Harper, McGrath and Carter, 2002; Harper, Smetten and Bartle, cited in Moore, 1998; Harper, 1994). Similarly, the amount of water a plantation uses can be manipulated by thinning and fertilisation, with prescriptions developed for major plantation species (McGrath *et al.* 2002). The step-change in rainfall since the 1970s has been taken into account in these prescriptions, as plantations that have been studied have grown during this period of lower rainfall. As a result plantation growth and management techniques are calibrated to this dry period.

Various studies have been undertaken of different regions in advance of plantation development. These studies generally investigate the amount and reliability of rainfall (Butcher, 1986; Harper, McGrath and Maher, 1990), and indeed some studies have taken climate change into account. For example, in 1990 a suitability study of the Esperance area (Harper, McGrath and Maher, 1990) analysed rainfall records from all available stations and redrew rainfall isohyets based on records for the period 1980 to 1989. The rainfall during this period was six per cent lower than in the previous 10-year period. Similar considerations of likely climate changes were made in advance of expanding the maritime pine scheme in 1996.

In addition to the impacts of reduced rainfall, climate change may have other impacts on plantations but the risk of these has not yet been quantified. They include:

- changes in fire hazard because of differences in litter quantity and climatic conditions; and

- changes in the amount of wind-throw (e.g. where trees are blown over) as a result of extreme storms events.

Plantation management and water yield

Catchment water yields can be manipulated by managing forest canopy density, and in the Gnangara region this technique is being used to improve the groundwater resource, which has been impacted by, among other factors, SWWA's drying climate. There has been a significant decline in groundwater in the Gnangara region during the past 20 years. This has been attributed to the drier climate, increased interception by vegetation, and groundwater extraction for horticulture and urban use. The reduction in groundwater recharge in this area has occurred under both pine plantations and native woodland systems. Programs to reduce interception and water use in both these systems are being implemented by thinning and clear-felling pine plantations, and through more frequent burning of woodland vegetation to reduce its density. This example illustrates the competition between various land uses for water.

Community consultation sessions during the study also highlighted the competition between forestry operations and water supplies. For example, on the South Coast it is reported that dams near plantations are drying up as a result of decreased rainfall, and water interception and extraction by trees. This is an issue for fire management as the dams would once have provided sufficient water in the event of a fire. However, water tanks are now being built alongside plantations to ensure an adequate water supply in case of wildfire.

Additionally some plantations on the South Coast are planted at the margins in terms of their rainfall requirements for optimum growth. If the rainfall continues to decrease at these locations there will be a major impact on an industry in which people have invested hundreds of millions of dollars.

Carbon sequestration

The promotion of plantations as carbon sinks under Article 3.3 of the Kyoto Protocol is a direct mitigative response to climate change (Schlamadinger and Karalainen cited in Watson *et al.* 2000). It can also act to mobilise capital, as afforestation in higher rainfall areas does, through attracting investment into carbon trading sequestration for the purpose of trading carbon credits. Additional land management benefits will flow from such investment, including improving land and water resources, biodiversity enhancement and protecting rural infrastructure from salinity.

Work to take advantage of this approach commenced with CALM before the Kyoto Protocol was signed in 1997. Two groups of Japanese scientists visited Western Australia in 1994 with a plan for increasing rangeland productivity to sequester carbon and overcome desertification. This interaction led to the concept that profitable plantations could be established in the medium rainfall zone to be used as carbon sinks, which would encourage the widespread reforestation needed to restore landscape hydrology. A scoping document in CALM outlined the benefits of carbon sequestration:

> *"…a solution would be to encourage the move of the {proponents} afforestation programme to the wheatbelt: here increased carbon fixation would also mean more water use, less salinity and wind erosion… The real bonanza from these proposals will come if we can encourage the Japanese to directly fund large scale afforestation in the wheatbelt as a means of rectifying their environmental concerns (i.e. global carbon imbalance)."*[4]

4 Memo from R.J. Harper to Executive Director, CALM, 30 November 1995.

A number of discussion documents followed and Australia's first carbon sequestration scheme (involving BP Australia) was established at Katanning in 1998 with afforestation of farmland using *P. pinaster*. This approach has now been adopted elsewhere in Australia and forms part of the basis of the Forest Products Commission's ongoing 'Infinitree' program.

In response to the opportunity this approach provides, considerable investment has been made in determining the amount of carbon sequestered by various tree species. Research on carbon sequestration has been undertaken by CALM and the Forest Products Commission, and through partnership with the now defunct Cooperative Research Centre of Greenhouse Accounting. The research considered forestry aspects of carbon sequestration (Ritson and Sochacki, 2003; Harper, Smetten and Tomlinson, 2006; Harper *et al.* 2003) and impacts on agricultural systems (Webb *et al.* 2000; Harper and Gilkes cited in Lal *et al.* 2001; D'Souza *et al.* 2002; Murphy *et al.* 2002; Harper *et al.* n.d.). Various consultancies have also been completed, including one for Griffin Energy, which extended the carbon sequestration concept and advocated using carbon sinks for restoration and replacement of natural bushland (Harper, 2002) in catchments where biodiversity was at particular risk.

Another response to climate change is to consider alternatives to fossil fuels for energy production. The Forest Products Commission is undertaking considerable work on developing systems of biomass production from farmland (Harper *et al.* 2000; Sochacki, Harper and Smetten, n.d.) and plantation residues (Buckton, 2005) for the production of bioenergy.

The future

It is difficult to determine the impact that climate change has had directly on forestry, both in terms of how it impacts on forestry activities, and how it might drive investment in plantations for carbon sequestration. While climate change and increasing concern about greenhouse emissions seem to have supported forestry to some degree, there have been other major influences such as declining wool prices and consequently availability of pasture land, consolidation of farm holdings, deregulation of national and international capital markets and favourable taxation policies.

It is also difficult for forest managers to plan for future climate change in the absence of clear indications about its direction; that is will it be wetter or drier, hotter or colder? Furthermore, likely climate change interactions, such as the effects of increasing CO_2 concentrations on tree growth rates and susceptibility to frost risk are largely unknown.

In order for forestry to maintain profitability and continue providing a host of environmental benefits, it is essential the likely impacts of climate change on forestry are determined. The forestry sector would benefit from information regarding the effect of changes in rainfall, evaporation and temperature. These are likely to impact growth rates and thus the areal extent of plantations' profitability. Future scenarios also need to consider the impact of fatal events such as drought and how climate changes may increase the risk of disease, fire and wind-throw. With declining rainfall, an additional important issue for forestry with declining rainfall will be competition with other land uses for increasingly scarce water resources in water resource catchments.

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CLIMATE CHANGE, VULNERABILITY AND ADAPTATION FOR SOUTH WEST WESTERN AUSTRALIA 1970 TO 2006

PHASE ONE OF ACTION 5.5, WESTERN AUSTRALIAN GREENHOUSE STRATEGY

Department of Agriculture and Food