Report to Council

Sustainable Land Management Technical Panel

June 1999

WA Greenhouse Council

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DEFINITIONS

CO_2-e In this report, the term CO_2-e is used to describe quantities of carbon dioxide equivalents. This is used to provide consistency in comparing quantities of:

- different gases (e.g. carbon dioxide, methane etc) which have different "global warming potentials" and
- gas emissions and storage of carbon in products.

1 tC (carbon) is equivalent to 3.67 t CO_2-e

Sink The Framework Convention for Climate Change (UNCED, 1992) defines a sink as:

any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere,

and defines a **reservoir** as:

a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.

A reservoir constitutes a net sink as it increases in size.

TECHNICAL PANEL MEMBERS

The members of the Sustainable Land Management Technical Panel are:

Dr Syd Shea	Dept of Conservation and Land Management (Chair)
Dr Paul Biggs	Dept of Conservation and Land Management (Secretary)
Dr Marnie Leybourne	Agriculture Western Australia
Mr John Bartle	Dept of Conservation and Land Management
Mr Graeme Olsen	Farm Forestry Development Group
Prof Murray McGregor	Muresk Institute of Agriculture
Dr Don Burnside	Gascoyne Murchison Rangelands Strategy
Mr Bill Carr	Dept of Minerals and Energy
Mr Ian Knoble	Wesfi Ltd
Mr Bill Crabtree	WA No Till Farmers Asscn
Mr Jeremy Wallace	CSIRO Mathematical and Information Sciences
Ms Rachel Siewert	Conservation Council of WA
Ms Lillias Bovell	WA Municipal Association
Cr Jan Starr	WA Municipal Association
Mr Michael Waite	Department of Environmental Protection
Mr Lawrence Fletcher	Australian Petroleum Production and Exploration Association
Dr Greg Sawyer	Agriculture Western Australia
Mr John Gardner	Chamber of Minerals and Energy
Mr Greg Morris	Chamber of Minerals and Energy

1. EXECUTIVE SUMMARY

The land-use, forestry and agricultural sectors in Western Australia are, in general, already controlling their greenhouse gas emissions. Comparisons between the 1990 and 1995 National Greenhouse Gas Inventories show that emissions due to land-use change (through clearing) are declining, the forestry sector shows increasing negative emission rates (ie increasing sinks) and in the agricultural sector, although emission rates rose, the increase was very small and its overall percentage contribution has declined.

In 1990, the Agricultural sector contributed 30% of the State's emissions, while Land-use Change and Forestry was a net sink equivalent to 17% of the State's emissions. In 1995, these figures were 27% and 15% respectively.

A number of measures to reduce emissions or increase sinks are possible in this sector, and implementation of many of them has already commenced, either directly for the purpose of mitigating greenhouse gas emissions, or for other primary objectives. In this sector there is the possibility of considerable collateral environmental benefits as a zero-cost consequence of greenhouse-friendly land-use practices. Current trends indicate that the State is well placed to lead Australia in meeting its potential obligations with respect to sink activities and emissions from land management. Western Australia is contributing to about half of the area of national revegetation on farms and the State is showing considerable reductions in land clearing, which has already been comparatively low since 1990, and is also increasing protection of native remnant vegetation.

Western Australia has the capacity to provide very large greenhouse sinks through revegetation of cleared farm land. The State also has a proven institutional and social framework in which to achieve and manage those sinks. It is recognised that increased areas of perennial woody vegetation through tree crops and other agricultural crops will deliver many other environmental and economic benefits to communities in rural areas, such as relief of salinity problems. However, establishment of such crops on a large scale requires a large lead time and clarification of rules of carbon emissions trading.

It will be important for both the State and the Commonwealth to promote the conditions and "rules" which will foster the early establishment of these greenhouse sinks in order for them to contribute significantly to meeting the potential targets for Australia in the first commitment period between 2008 and 2012. Rule changes required will include assigning emissions from harvested wood products at the time and place of decay (rather than at harvest), or some other treatment of the time dimension for finite periods of sequestration. Studies are underway but there appears to be little national desire for early resolution of rules and definitions.

A number of measures for Western Australia have been identified in this report. **Measures described in this report for ameliorating emissions are not limited only to those which would meet target within the sector, but are open-ended to show the capacity which this sector could have to contribute to overall State or national targets.** Acceptance of any of them will depend on a number of factors, including the costs and benefits of each, and importantly, their acceptance under international rules for meeting any possible targets into the future.

The following activities are considered by the Sustainable Land Management Technical Panel to be the priority actions in this sector:

- Encouraging increased planting programs of suitable crops with commercial potential such as Maritime Pines, Bluegums and Oil Mallees

  Potential savings could amount to, for example:

  1. Maritime Pine tree crops: Annual gains of up to 7.5 Mt CO_2-e (18 per cent of the 1990 State emissions) possible from a program of 600,000 ha at a cost of $2 to $6 per tonne depending on the sale of commercial products.
  2. Bluegums: Annual gains of 2.3 Mt CO_2-e (5 per cent of the 1990 State emissions) possible from a program of 250,000 ha in higher rainfall areas at a cost of $0 to $20 per tonne depending on log sales.
  3. Oil mallee tree crops: Annual gains of 0.7 to 1.5 Mt CO_2-e (2-3 per cent of the 1990 State emissions) possible from a 500,000 ha program at a cost of up to $12 per tonne depending on commercial uses.
- Providing greater incentives to revegetate areas with non-commercial species ("landcare" plantings), which provide additional benefits such as biodiversity and salinity control.
- Increased protection of native remnant vegetation, not only by fencing it but also through strategic planting of vegetation to provide greater buffer zones and reduce the risk of vegetation loss through salinity. This may be possible through the expansion of the Remnant Vegetation Protection Scheme.
- An extensive awareness-raising campaign for the rural community on collateral benefits associated with greenhouse gas mitigation. This is particularly important due to the possibility of a system of carbon credits being introduced. There will be significant risk-management and transaction-cost issues to be addressed, requiring coherent governance. The Soil and Land Conservation Council, as the State's peak landcare body, could take responsibility for developing and implementing such a communication campaign.
- Greater emphasis on extension work on "best practice" that have beneficial effects on greenhouse emissions, taking into consideration a "whole system" approach. This includes encouraging the most efficient forms of cropping, including no-tillage practices, and improved pasture management practices, which will increase the store of organic matter in the soil and help reduce methane emissions from livestock (improved feed quality).
- Revision of policies concerning destocking of pastoral leases by the Pastoral Lands Board and adoption of "best management" practices including feral animal control and reduced fires, to allow greater flexibility in situations where there are alternative land uses (such as tourism or mining), as long as any policy was flexible enough to allow restocking when conditions allow.
- Research on the optimal management conditions of WA's savannas to ensure that fire is used in the most effective manner and areas not needlessly burned, or burned by hot fires that release larger amounts of greenhouse gases into the atmosphere. This should be coupled with training people in contemporary fire control and best practice land management methods, including incorporation of traditional knowledge systems.

- Substitution of wood materials in buildings in place of more energy-intensive materials like steel and aluminum, may result in annual savings (avoided emissions) of 0.33 Mt CO_2-e at a cost of approximately 10% over the standard house cost.
- Changing the rules to include the pool of harvested wood products can make harvested forests a continuously expanding sink and a more effective use of land available for carbon sequestration than unharvested forests.

In Agriculture, possible gains include:

- Improved grazing management and pasture improvement in both the agricultural and pastoral areas
- Reduced effluent disposal (small amounts), improved animal husbandry management and reduced rumen fermentation may be possible.
- Improved crop management: Annual gains of 2 Mt CO_2-e (4% of the 1990 State emissions) may be possible.
- Land clearing: Land clearing apparently contributed to 4 Mt CO_2-e (8 per cent) to the State's 1990 emissions, although the precision of this estimate is poor. If all clearing ceased by the 2008-2012 period, then the avoided emission would be this amount (less any ongoing emissions from decay of vegetation and soil carbon). There is a cost to individual farmers but gains in soil conservation and environmental protection.
- Increased conservation cropping and no-tillage practices could provide annual savings of 1.8 Mt CO_2-e (4% of 1990 State emissions) at minimal cost.
- Landcare: new plantings of trees under landcare schemes or actions of individual land owners may eventually contribute towards sinks of 8 Mt CO_2-e, or 15 per cent of the 1990 State emissions. This is based on an eventual planted area of 1.75 Mha.

The Intergovernmental Panel on Climate Change has commissioned a special report on land use, land use change and forestry which will be the major scientific instrument leading to resolution of rules in the coming two years. In addition, the Sustainable Land Management Technical Panel recommends the following areas be given a high priority in negotiations at the Commonwealth and international levels:

- A definition of plantations and reforestation is needed that will accommodate the circumstances of relatively recent clearing in Australia.
- Accounting guidelines are required to allow the emissions from harvested wood products to be accounted at the time and place in which the emission (decay) occurs.
- A larger carbon credit, under refined rules, will help build the economic viability of new tree crops and help control land degradation. It is therefore recommended that in Australia's negotiations, this issue be pursued with vigour.
- It is important for both the State Government and the Commonwealth to promote the conditions which will foster the early establishment of greenhouse sinks in order for them to contribute significantly to Australia's targets under the Kyoto Protocol. Unless vegetation is established quickly, growth rates will not be significant by the start of the first commitment period in 2008.

2. INTRODUCTION

2.1 THE KYOTO PROTOCOL

Australia signed the Kyoto protocol to the United Nations Framework Convention on Climate Change in April 1998. The protocol established, for developed (Annex I) countries, targets to limit national emissions of greenhouse gases and a broad policy framework in which to achieve such targets. If sufficient parties ratify the protocol and it comes into force, the targets will become legally binding on those ratifying parties.

Key elements of the protocol are the establishment of 1990 as the base line against which change will be measured, and the establishment of the period 2008-2012 as the 'first commitment period'. Australia is committed to emissions in that period of no more than 108% of the 1990 baseline. This compares with a predicted emission level of 128% (excluding land use change) identified in the Prime Minister's statement of November 1997. Parties to the protocol need to report in 2005 regarding their progress towards the target. It is noted that Australia's estimated emissions target has evolved in an ever reducing manner, particularly in recent times with the inclusion of greenhouse gas emissions savings from land use change and forestry resulting in the Prime Minister's stated 128% to 108% at the Conference of Parties 3 (COP 3) in Kyoto.

For the purposes of this report, the land management sector includes agriculture, forestry and rural land use change. Other technical panels cover energy, industry and waste management, transport and urban land use sectors.

The land management sector makes an important contribution to greenhouse sources and sinks in Australia. It follows, therefore, that this sector will have a large part to play in meeting Australia's targets in the first commitment period. Action will include limiting, reducing or otherwise managing emissions from components such as land clearing, agricultural practices and livestock production, as well as increasing the carbon storage of various 'carbon sinks' across the landscape.

Nationally, governments and other stakeholders have contributed to develop a National Greenhouse Strategy. This strategy includes several actions relating to land management.

The objective of this report is to provide an overview of the issues and implications of the National Greenhouse Strategy for land use change and forestry (LUCF) and agricultural management in WA, to examine the costs and benefits of different measures and responses which may be proposed and to recommend actions which should be adopted in Western Australia.

In this context it must be noted at the outset that Australia is encountering significant difficulties in compiling national greenhouse inventories in the Land Use Change and Forestry (LUCF) sector. The latest compilation (NGGIC 1998 pp xxi-xxii) states:

> *"Due to the higher uncertainties associated with the estimation of land clearing – this sector is currently excluded from the calculation of total net emissions... Once confidence in the estimates from land clearing emissions increases with more accurate data and improved methods, inclusion of these emissions in national totals will take place."*

Under such circumstances, Western Australia must also reserve the right to review its submission and strategic plans if the methodologies or 'ground rules' are altered nationally.

2.2 CONTEXT FOR WESTERN AUSTRALIA

[Note that data in this report have been drawn from the National Greenhouse Gas Inventory, supplemented by "best estimate" information on future sink developments and emission reductions. It is emphasized that uncertainties in the NGGI data, as well as uncertainties associated with future flexibility provisions of the Kyoto Protocol still pose significant risks to Western Australia in terms of calculating the 1990 baseline, and in defining the extent and mechanisms for abatement required in the future. The National Greenhouse Gas Inventory documents should be consulted for any interpretation or definition of the data. In particular, Workbook 4.2 (NGGIC 1997a) provides information on methodology. However, relevant WA Agencies will continue to work with the NGGIC and Australian Greenhouse Office via the National Carbon Accounting System to reduce uncertainties in this sector.

Please note also that comparisons between the 1990 and 1995 data were used during the compilation of this report. More up to date data for 1996 are now available and should be used in the Western Australian Greenhouse Council's final report.]

Western Australia contributed roughly 11 per cent of Australia's net greenhouse gas emissions in 1990 and 12 per cent in 1995 (NGGIC 1997b, 1998). Of this, the agricultural sector contributed approximately 30 per cent of the State's emissions in 1990. While emissions from this sector increased 2.5% up to 1995, other sectors increased more significantly, and the contribution of agriculture dropped to 27 per cent.

Note that these figures do not include the land clearing component due to the uncertainties mentioned above. However, the table below shows land clearing and its magnitude relative to the other sectors.

The 'land-use change and forestry' sector was a net sink equivalent to 17 per cent of the State's 1990 emissions and 15 per cent in 1995. Sink activity arises from increase in woody biomass as well as pasture improvement.

BOX 1 Summary of Agriculture and Land Use Change and Forestry in WA 1990-1995

Both sinks and agricultural emissions increased slightly between 1990 and 1995 but declined relative to the total emissions due to much faster growth in other sectors.

1990 – Agricultural sector 30 % of the State's emissions.

1995 – Agricultural sector emissions up 2.5% but declined to 27% relative to the total.

1990 – Land-use change and forestry a net sink equivalent to 17 % of the State's emissions.

1995 – LUC&F sink increased slightly but declined to 15 % relative to the total.

Table 1. Western Australia's greenhouse emissions in 1990 and 1995.

	1990 levels (Mt CO_2-e)		1995 levels (Mt CO_2-e)	
Emissions from the energy, industrial and waste sectors	35.8	70% of WA gross emissions	42.2	73% of WA gross emissions
Emissions from agriculture	15.5	30% of WA gross emissions	15.9	27% of WA gross emissions
Gross total emissions	**51.3**		**58.1**	**(13% increase 1990 – 1995)**
Forestry changes	-4.5	Equiv. 9% of emissions	-4.7	Equiv. 8% of emissions
'Other' (pasture improvement, burning)	-4.3	Equiv. 8% of emissions	-4.2	Equiv. 7% of emissions
Net total	**42.5**		**49.3**	**(16% increase from 1990)**
Land clearing	4.0		2.1	
Total including land clearing	**46.5**		**51.4**	**(10% increase from 1990)**

Source: Tables 1.3, 1.4, 1.5 in NGGIC 1998

These figures show that the elements of sustainable land management in Western Australia are an important component of the State's greenhouse budget.

The State could well lead Australia in meeting its potential obligations[1] with respect to sinks activities and emissions from land management (Shea *et al.* 1998), providing the rules in the Kyoto Protocol allow such sinks. Western Australia is contributing to about half of the area of national revegetation on farms, and the State is showing considerable reductions in land clearing and also is increasing protection of native remnant vegetation. The State has the potential for massive new areas of plantations of trees and other woody plants which can also contribute to ameliorating the State's critically important environmental problem of dryland salinity. Western Australia also contains large areas of rangelands which have enormous carbon sequestration potential.

1 While Australia has signed the Kyoto protocol, the protocol itself is still being modified. There are significant formalities to occur before the final protocol imposes any obligations on Australia. The rules are also still being negotiated. The Committee recommends that such negotiations give due regard to national benefits that can result from adoption of advocacies in this report.

2.2.1 Offset of Western Australia's emissions growth

Western Australia's thriving economy contains significant resource processing industries and a number of new development projects are planned. Preliminary estimates are that such new export-related industries will far outstrip Australia's Kyoto target of emissions. Under such circumstances, the contribution which the land management sector can play in ameliorating emissions from these projects may be critical in providing offset carbon sinks to such sources.

A well-developed State strategy is essential to optimise such opportunities, as well as ensuring that they are coordinated with other strategies aimed at delivering other environmental or economic benefits.

One of the keys to a successful State greenhouse strategy is an understanding of the Kyoto Protocol, which provides the framework in which the nation, along with other countries, will be working to reduce the rate of emissions of greenhouse gases. As Western Australia is a large player on the national scale in both growth in emissions and growth in sinks, it is essential that its policy makers and professional experts alike be woven efficiently and promptly into the Australian negotiations which are refining and changing the rules of the Kyoto Protocol.

With respect to sustainable land management, the protocol specifically includes emissions from agriculture, including:

- enteric fermentation,
- manure management,
- rice cultivation,
- agricultural soils,
- prescribed burning of savannas,
- field burning of agricultural residues, and
- other (unspecified) emissions.

However, in Article 3.7, the protocol dictates that for those countries where the Land Use Change and Forestry (LUC&F) sector constituted a net *source* of greenhouse gas emissions in 1990, then the net emissions from land use change in 1990 form part of the assigned amount (the 1990 base line). Whether LUC&F was a net source or sink in 1990 is therefore a 'trigger' to the inclusion of land clearing in a country's baseline.

At the time of Kyoto, it was assumed that Australian land use change and forestry was a net source of emissions. The clearing of land, particularly in Queensland and New South Wales, was estimated to be of a magnitude much greater than the sink provided by the forestry sector in the country. As a result, some 100 Mt CO_2 of emissions from land clearing were included in the 1990 inventory. However, as uncertainties are addressed in the estimates of land clearing and 'vegetation thickening', it is possible that large reductions could result in Australia's 1990 baseline. A decrease in the 1990 baseline will lower the carbon-tonnage target in 2008-2012 by 108 per cent for every tonne decrease, which will make it much harder to achieve.

Forest management and other natural resource management activities, are not included in the protocol, except in two circumstances. The first is under Article 3.3 of the protocol which states that the net changes in emissions from *direct human-induced* land use change and forestry activities shall be used to meet the commitments of each country, limited to:

- afforestation;
- reforestation; and
- deforestation

since 1990. This has since been clarified to include activities since January 1 1990, but the definitions of the three terms have not been finally agreed. It is assumed that afforestation refers to the establishment of forests (as yet undefined) on land which has not been forest before, reforestation refers to establishment of forests where there has been forest in the past, but some intervening use has been made of the land, and deforestation is the clearing of an existing forest.

Again, it is important that Western Australia's needs are known to, and understood by, the Australian negotiating team. Western Australia requires the mallee, for example, to be included in the final Kyoto definition of "forest", even though it falls outside a European definition, and is not included in the December 1998 Fortech collation in the Greenhouse Challenge Workbook.

It is relevant to note that any estimates under this Article must be reported in a transparent and verifiable manner.

Secondly, Article 3.4 allows *additional human-induced* activities associated with agricultural soils and land use change and forestry to be considered by the Conference of Parties to the protocol (COP) for inclusion in the future. However, as yet there is uncertainty about what these additional activities may be. Once decided, the decision will apply to the second and subsequent commitment periods, although individual countries may choose to include them in the first period provided that the activities have taken place since 1990.

2.3 THE ROLE OF SUSTAINABLE LAND MANAGEMENT

The Kyoto Protocol was both caused and driven by the initial need to reduce global greenhouse gas emissions to keep greenhouse gas concentrations from becoming too dangerously high. In fact, there is the opportunity now to use the Kyoto Protocol as an exciting and powerful new tool in sustainable land management. At the same time, with clever strategies, sustainable land management can be used to help Australia achieve its difficult and painful emission targets.

Sustainable land management can reduce net national emissions in three ways:

- promote the use of vegetation for increasing carbon sinks
- promote the use of timber as a substitute to replace more energy-intensive products (eg steel, aluminum, housing)
- provide renewable energy sources, "bioenergy".

Sustainable land management can also control national emissions by maintaining carbon in soils and other components of the natural carbon cycle.

The purposes of this report are to articulate the ways that sustainable land management practices can help in themselves towards reducing Australia's net greenhouse gas emissions; and to ensure that such greenhouse efforts in this sector are seen in a total policy context, for example in their possible role in off-setting local emissions, in achieving other collateral benefits (eg counteracting salinity), in negotiations and refinements of the Kyoto Protocol, and in minimising transaction costs in accounting systems such as NCAS and NGGI and any national or internal emissions trading regime.[2]

The cost of mitigation measures must be distributed equitably, particularly in an industry like agriculture, where landowners generally bear the largest proportion of the costs.

2.4 OVERVIEW OF STRATEGIES

2.4.1 Land Use Measures

Several strategies relevant in this sector already exist, including those directly aimed at reducing net greenhouse gas emissions and those that have been developed for other purposes, but which have an impact on emissions.

In the agricultural sector, the Ecologically Sustainable Development Working Group (1991) identified a number of management practices that are consistent with ecologically sustainable agriculture and that could help reduce greenhouse gas emissions. These include:

- improved efficiency of agricultural practices
- improved stock management and increased stock efficiency including use of higher quality pasture
- increasingly efficient use of mineral nitrogen fertilisers
- selectively reducing biomass burning through fire control
- improved animal waste management and disposal
- trash retention and minimum tillage
- improved pastures; and
- increased use of trees.

Each of these practices should have some merit, and emission savings counted, even if there was no move to mitigate greenhouse gases when they were taken up.

The Government of Western Australia released in 1996 and revised in 1998 a Salinity Action Plan for the State. Strategies within this plan include increased planting of trees and various other mechanisms which will reduce the rate at which land becomes saline and in some cases reverse the trend. These mechanisms are likely to both increase the area of carbon sinks and limit the

2 National Carbon Accounting System (NCAS) and the National Greenhouse Gas Inventory (NGGI).

area of land in which soil degradation can have an impact on soil carbon cycles.

Prior to the Kyoto meeting, Australia's strategy for reducing greenhouse gas emissions was explained in the Prime Minister's statement of November 20 1997. This included a package of measures that were designed to reduce Australia's growth in net greenhouse gas emissions from 28 to 18 per cent between 1990 and 2010.

In addition to the $22 million allocated to the Farm Forestry Program and $328 million allocated to the Bushcare Initiative by the Natural Heritage Trust, the Commonwealth Government allocated $180 million over five years for a number of measures, including $20.9 million for revegetation, plantation and land use measures. They include:

i. *Plantations 2020 Vision ($1.9m)* To treble Australia's plantation estate by 2020 by removing impediments to Australian commercial plantations, supporting plantation establishment and enhancing investment in plantation-based industries.

ii. *Bush for Greenhouse ($5.5m)* To facilitate corporate funding of NHT (Natural Heritage Trust) revegetation projects through Bushcare, whereby companies/investors can obtain recognition for the stored carbon reservoir created.

iii. *National Carbon Accounting System for Land Based Sources and Sinks ($12.5m)* To establish a national carbon accounting system through the Bureau of Resources Sciences and Environment Australia.

iv. *Reducing Methane Emissions from Livestock ($1m)* To provide funding to promote a CSIRO developed vaccine which inhibits the production of methane in ruminants.

It must be recognised that a suite of such community-based programs may have various benefits. However, many would complicate a single-minded emissions trading program by making transaction costs intolerable. This issue needs to be addressed at the national level.

2.5 NATIONAL GREENHOUSE STRATEGY

More detailed strategies for reducing net emissions of greenhouse gases are contained in a National Greenhouse Strategy, developed between the Commonwealth and the States. The NGS is directed at advancing action on three fronts: improving awareness and understanding of greenhouse issues; limiting the growth of greenhouse emissions and increasing greenhouse sequestration; and adapting to climatic change.

Several parts of the NGS are relevant to the sustainable land management sector, and these are outlined in Appendix I in detail. It is noted that some strategies in the NGS extend beyond the articles of the Kyoto protocol as it currently stands.

The National Greenhouse Strategy states that, in its development, governments have been mindful that objectives relating to economic growth, social justice and environmental protection and conservation are important community concerns, and that to be effective, the strategies must integrate with these objectives, particularly economic and trade policies. Another important consideration is the review of Commonwealth/State roles and responsibilities for the environment.

There are several particular opportunities that Australia has, for example the scope for improvements in energy efficiency; competitive advantages in renewable energy technologies and the natural land resources that can be used for carbon sequestration.

3. STOCKS AND FLUXES FOR WA IN 1990 AND 1995

3.1 GREENHOUSE GAS EMISSIONS

Greenhouse gases include natural constituents of the atmosphere, which together with clouds, help to maintain the earth's temperature at a habitable level. Increased concentrations of these gases, plus additional "artificial" gases, enhance this effect. Six gases are covered by the Kyoto protocol: carbon dioxide, methane, nitrous oxide, hydroflourocarbons, perfluorocarbons and sulphur hexaflouride. The first three, natural gases, are of importance in the land management sector.

Carbon dioxide (CO_2) is produced by the combustion of fossil fuels and biomass and industrial processes such as cement production. Methane is emitted as a by-product of any fermentation process in the digestive tracts of livestock, fermentation of manure under certain management conditions and fermentation in wetland rice cultivation. Nitrous oxide is emitted from the soil as a result of soil disturbance for cropping and the application of fertiliser and animal excreta. Methane, nitrous oxide and other oxides of nitrogen and carbon monoxide are generated in the burning of organic matter including savanna burning.

3.1.1 Emissions from land use change and forestry

There are still considerable uncertainties in the data in the land use change and forestry sector (NGGI, 1996). However, many of the strategic decisions and findings outlined in this report are robust enough to withstand future corrections to the data.

Table 2. Emissions from the Land-use change and Forestry Sector for WA 1990 (Mt)

	CO_2 emissions	CO_2 removals	Net CO_2 emissions	CH_4 as CO_2-e	N_2O as CO_2-e	Net CO_2-e
Changes in forest and other woody biomass	5.8	10.3	-4.5	–	–	-4.5
Forest and grassland conversion (land clearing)	3.9	–	3.9	0.1	–	4.0
Abandonment of managed lands	NE	–	NE	NE	NE	NE
Other (pasture improvement, prescribed burning and wildfires)	0.0	4.1	-4.9	0.5	0.1	-4.3
Total	**9.7**	**14.4**	**-5.5**	**0.6**	**0.1**	**-4.9**

NE denotes "not estimated" by the NGGIC
Source: NGGIC (1998) Table 1.4.

Table 3. Emissions from the Land-use change and Forestry Sector for WA 1995 (Mt)

	CO_2 emissions	CO_2 removals	Net CO_2 emissions	CH_4 as CO_2-e	N_2O as CO_2-e	Net CO_2-e
Changes in forest and other woody biomass	6.3	10.9	-4.7	–	–	-4.7
Forest and grassland conversion (land clearing)	2.1	0.0	2.1	0.0	–	2.1
Abandonment of managed lands	NE	–	NE	NE	NE	NE
Other (pasture improvement, prescribed burning and wildfires)	–	4.9	-4.9	0.6	0.2	-4.2
Total	**8.4**	**15.8**	**-7.4**	**0.6**	**0.2**	**-6.7**

Source: NGGIC (1998) Table 1.5.

3.1.2 Emissions from Agriculture

In 1995, greenhouse emissions from agriculture constituted 17.9% of Australia's total emissions, but as much as 27% of WA's emissions. Implicit within these figures is the relative 'global warming potentials' (GWP) of various greenhouse gases – which has been determined by the IPCC. For example, methane has a GWP 21 times greater than carbon dioxide, and nitrous oxide 310 times. These gases are significant in the agricultural sector.

3.1.2.1 Percentage of State's Emissions

The National Greenhouse Gas Inventories list sector emissions as percentages of Total (net) National Emissions (excluding land clearing). Agriculture's national contribution was 23.2% in 1990, 21.7% in 1995 and 20.1% in 1996. The "Western Australian Greenhouse Gas Inventory 1990 and 1995" lists sector emissions as percentages of gross emissions (also excluding land clearing), with agriculture's contribution being 30% in 1990 and 27% in 1995. The State and national percentage contributions are calculated on different bases and therefore are not comparable.

The following table presents WA and national sector emissions on comparable bases. The effect of estimates of land clearing is included in the comparisons.

Table 4. Comparing State and National Agriculture Sector Emissions

	1990				1995			
	WA		National		WA		National	
	Mt CO_2-e	%	Mt CO_2-e	%	Mt CO_2-e	%	Mt CO_2-e	%
Gross basis								
Energy	33.7		294.4		39.9		317.8	
Industry	0.7		7.2		0.9		7.5	
Waste	1.4		14.7		1.6		16.4	
	35.8	69.8	316.3	78.5	42.4	72.7	341.7	79.7
Agriculture	15.5	30.2	86.7	21.5	15.9	27.3	87.1	20.3
Gross Emissions	51.3	100.0	403.0	100.0	58.3	100.0	428.8	100.0
Land clearing	4.0		122.7		2.1		84.6	
	55.3	100.0	525.7	100.0	60.4	100.0	613.4	100.0
Agriculture	15.5	28.0	86.7	16.5	15.9	26.3	87.1	14.2
Net basis								
Energy	23.7		294.4		39.9		317.8	
Industry	0.7		7.2		0.9		7.5	
Waste	1.4		14.7		1.6		16.4	
	35.8	84.2	316.3	84.7	42.4	85.6	341.7	85.2
Agriculture	15.5	36.5	86.7	23.2	15.9	32.2	87.1	21.7
Gross Emissions	51.3	120.7	403.0	107.9	58.3	118.0	428.8	106.9
Sinks								
Forestry	-4.5		-23.1		-4.7		-21.1	
Other	-4.3		-6.4		-4.2		-6.5	
Forestry and other	-8.8	(20.7)	-29.5	(7.9)	-8.9	(18.0)	-27.6	(6.9)
Net Emissions	42.5	100.0	373.5	100.0	49.4	100.0	401.2	100.0
Land Clearing	4.0		122.7		2.1		84.6	
	46.5	100.0	496.2	100.0	51.5	100.0	485.8	100.0
Agriculture	15.5	33.3	86.7	17.5	15.9	30.9	87.1	17.9

Note: "Forestry and Other" comprises the removal of CO_2 from the atmosphere due to forest growth, pasture improvement and minimum tillage and the emissions of greenhouse gases (CO_2 equivalent) due to forest harvesting, prescribed burning and wildfires.

Agriculture's emissions, on a net basis and comparable to the national greenhouse gas inventory, were (excluding land clearing) 36.5% of the Western Australian total (23.2% nationally) in 1990 and 32.2% (21.7% nationally) in 1995.

3.1.2.2 Components of WA's Agriculture Sector Emissions

A major reason why WA's agriculture sector emissions are relatively a higher proportion of the total Western Australian emissions than the nation-wide figures appears to be the extent of burning of savanna (releasing the greenhouse gases methane and nitrous oxide) in pastoral areas. The annual burning arising from rangeland management, wildfires and other causes is assessed to be much higher than in the Northern Territory or Queensland.

WA and national emission percentages (on a net state emission basis) for the other agricultural sources, including enteric fermentation (methane from livestock), are very similar. Much higher emissions from savanna burning and agricultural soils account for the difference in the WA/national comparison.

Emissions from agricultural soils (nitrous oxide from improved pasture, crops, animal wastes and nitrogenous fertilisers) also appear higher than in other states. This may, however, be a methodology difference.

Table 5. Comparing Components of Agriculture Sector Emissions

	1990				1995			
	WA		National		WA		National	
	Mt CO_2-e	%	Mt CO_2-e	%	Mt CO_2-e	%	Mt CO_2-e	%
Agriculture	15.51	36.48	86.73	23.22	15.91	32.20	871.15	21.71
Enteric fermentation	7.01	16.49	59.18	15.84	6.59	13.34	58.13	14.49
Manure management	1.12	2.63	9.50	2.54	2.36	2.17	9.36	2.33
Rice cultivation			0.46	0.12			6.49	0.16
Agricultural soils	1.98	4.67	8.31	2.22	2.67	5.40	9.33	2.33
Burning of savannas	5.33	12.54	9.06	2.43	5.53	11.20	9.42	2.35
Field burning of residues	.04	0.08	0.22	1.06	0.04	0.09	0.22	0.05

Further analytical investigation of these apparent higher emission levels is essential. It is strongly suspected that, due largely to data deficiencies, there may be some understatement in the other states and /or overstatement for WA.

Agriculture's easiest option to reduce greenhouse gas emissions, minimising land clearing, has already been taken. Other major greenhouse gas abatement options, including revegetation and soil carbon sequestration under improved pastures and minimum tillage, are also long-standing agricultural initiatives but whose positive greenhouse impacts are credited under the Land Use Change and Forestry Sector.

Table 6. Other (non-CO_2) Greenhouse Gas emissions for WA Agriculture, 1990

	Emissions (Mt)		CO_2-equiv. emissions (Mt)	% of Australia's emissions	% of WA's Agricultural emissions
	CH_4	N_2O			
Enteric fermentation	0.3339		7.01		45
Manure management	0.006	0.003	1.06		7
Rice cultivation	N/O		0		0
Agricultural soils	NE	0.0064	1.98		13
Prescribed burning of savannas	0.1446	0.0074	5.33		35
Field burning of agricultural residues	0.0017	0.0	0.04		0
Total	**0.4862**	**0.017**	**15.42**	**4**	**100**

Note: The data have been rounded
Source: NGGIC (1998) Table 7A 1990

Table 7. Other (non-CO_2) Greenhouse Gas emissions for WA Agriculture, 1995

	Emissions (Mt) CH_4	Emissions (Mt) N_2O	CO_2 equiv. emissions (Mt)	% of Aust. Emissions	% of WA's Agricultural emissions
Enteric fermentation	0.3138		6.59		41
Manure management	0.0068	0.0030	1.07		7
Rice cultivation	N/O		0		0
Agricultural soils	NE	0.0086	2.67		17
Prescribed burning of savannas	0.1498	0.0077	5.53		35
Field burning of agricultural residues	0.0021	0.0	0.04		0
Total	**0.4725**	**0.019**	**15.9**	**4**	**100**

Note: The data have been rounded
Source: NGGIC (1998) Table 7A 1995

For Australia as a whole, methane emitted through enteric fermentation constitutes the most important source of greenhouse gases in the agricultural sector. It also contributes around 12 per cent of the total greenhouse emissions from Australia. Note that in common with NGGI methodology, no emissions are estimated from native fauna such as kangaroos.

However, in Western Australia enteric fermentation, while still the most important contributor to direct greenhouse gases, is almost matched by prescribed burning of savannas.

Enteric fermentation levels can be further broken down by livestock type. The following table provides details on the amount of methane produced by different animal types in Western Australia, and the total amounts for 1995:

Table 8. Methane emissions from livestock in Western Australia, in 1995

Type of animal	Number of animals in WA	Enteric emissions (kg CH_4/head)	Manure emissions (kg CH_4/head)	Total emissions (Mt CO_2 equivalent)
Dairy cattle	0.12 million	113	4.96	0.3
Beef cattle	1.8 million	59	0.01	2.3
Buffalo	400	55		0
Sheep	31 million	6		4.0
Goats	0.03 million	5		0
Horses	0.02 million	18		0
Pigs	0.32 million	1	17.18	0.1
Poultry	5.9 million	0	0.12	0

Source: NGGIC 1998 Table 4A&B 1995
Note: The data have been rounded, and some livestock categories omitted.

Uncertainties remain in these data for various reasons, and need to be addressed:

1. The number of dairy cattle, although reasonably accurate, includes lactating cows and "followers" (calves and heifers). The average annual amount of methane produced by heifers and calves is considerably less than the 113 kg/head for lactating cows. In WA there are approximately 65,000 lactating cows.

2. The number of goats is inaccurate as the data do not include feral goats. The official data in the inventory included camels, donkeys etc which have not been included here as the figures were meaningless. Feral animals have not been considered in the inventory statistics.

3.1.2.3 Impacts of Sinks and Land Clearing

Removals of carbon dioxide through forestry and build up of soil carbon under pasture improvement and minimum tillage are estimated to be substantially higher in WA than other states. It is not clear why the latter might be so.

These high sink capacities have a significant impact on net state emissions and inflate the percentage contributions of other sectors, including agriculture. The emission reductions are credited to the Land Use Change and Forestry Sector, rather than to agriculture.

Theoretically, if WA's sink capacity was in proportion to the national inventory (around -7.9% of net emissions in 1990 rather than -20.7%, and -6.9% rather than -17.9% in 1995), agriculture sector emissions would have been around 4% and 3% respectively lower as a proportion of net state emissions. Further development of sinks, particularly revegetation, would have the effect of further inflating agriculture emissions when looked at on a net emissions percentage basis. In 1995, agriculture's contribution to WA's emissions would have been 29.1% rather than 32.2%.

Table 9. Potential impact of Sinks on the extent of Agricultural emissions

	1990		1995	
	Mt CO_2-e	%	Mt CO_2-e	%
Agriculture	15.5	32.6	15.9	29.1
Sinks	-3.7	(7.8)	-3.7	(6.8)
Net emissions	47.6	100.0	54.6	100.0

The land clearing restrictions introduced in 1990, leading to low and declining clearing over 1990 to 1995, also have the impact of inflating agriculture's sector percentage contribution to state emissions. Land clearing contributed only 8.6% of WA total net emissions in 1990, compared with 24.7% nationally, and 4.1% compared with 17.4% nationally in 1995.

Again theoretically, if WA's land clearing emissions were in proportion to the national inventory, agriculture's emissions would have been 27.4% in 1990 rather than 33.3%, and 26.5% in 1995 rather than 30.9%.

Table 10. Potential impact of land clearing on agricultural emissions

	1990		1995	
	Mt CO_2-e	%	Mt CO_2-e	%
Agriculture	15.5	27.4	15.9	26.5
Sinks	-8.8	(15.5)	-8.9	(14.8)
Net emissions	42.5		49.4	
Land clearing	14.0	24.8	10.5	17.5
Net emissions	56.5	100.0	60.0	100.0

Thus, the high sink capacities in WA and minimal clearing compared with the national inventory might account for an extra 7-8 percentage points for agriculture sector emissions.

The essential point is that WA agriculture sector emissions increased marginally (2.5%) between 1990 and 1995 according to the State's greenhouse gas inventory.

In the Tables above it is indicated that agriculture contributed 21.7% of net national emissions (excluding land clearing) or 17.9% (including land clearing) in 1995. In comparison, WA's agriculture emissions were indicated as 32.2% (excluding land clearing) in 1990 or 30.9% (including land clearing) in 1995. Such a comparison is misleading, with the obvious danger that the agriculture sector could be set an onerous emissions reduction target in terms of percentage of net state emissions.

The percentage (national/WA) differences arise largely because emissions from savanna burning and from agricultural soils are assessed to be much higher for WA, for reasons yet to be fully determined. It is suspected that, largely due to data deficiencies, emissions from these sources in other states may have been underestimated. Furthermore, the relatively high sink capacities in WA and minimal land clearing associated with the Land Use Change and Forestry Sector, have the effect of inflating the percentage emission contributions of all other sectors in WA, including agriculture, in relation to the national and other states' greenhouse gas inventories.

Large areas of the savanna in the north of the state burn each year. The area and timing of fires is regularly monitored using AVHRR (Advanced Very High Resolution Radiometer) satellite data under the Department of Land Administration's Firewatch Program. A fire history database exists for the north since 1995, and is updated twice a month. The program now covers all of Northern Australia. Earlier AVHRR data (to the mid 1980's) have been archived, and historical fire information could be obtained by reprocessing this archive. Estimates of greenhouse gas emissions can be derived by combining these records with estimates of fuel loads.

3.2 LAND USE CHANGE

Land clearing has been a major contributor to greenhouse gas emissions in Australia, contributing an estimated 122 Mt CO_2-e net emissions in 1990 down to 84 Mt in 1995 (NGGIC 1998). These figures have significant associated uncertainties (NGGIC 1998 p xi). The National Greenhouse Gas Inventory (ibid. p241) shows estimates of uncertainties for various components of emissions (eg rate of clearing, soil carbon content, decay rates), many of which have uncertainties greater than 80 per cent.

Western Australia's emissions from land clearing, however, are only in the order of 4.0 Mt in 1990 and 2.1 Mt in 1995 (NGGIC 1998 p xvi).

Land clearing (and burning of woody biomass) also occur for purposes other than agriculture, for example clearing of mine sites and urban development. Mine site clearing is assumed to generate small amounts of greenhouse gas emissions compared with the energy emissions from mining and processing the raw materials, and with modern regeneration practices, carbon is gradually

sequestered in sinks on the rehabilitated mine sites. Mining companies can ameliorate emissions from clearing by minimising the quantities of material burnt and making use of salvaged material for long-life woody products or for energy generation.

Clearing for urban development is covered by the Urban Land Use Technical Panel.

3.2.1 Vegetation Decline

It is also relevant to consider what emissions may be occurring due to decline in remnant native vegetation as a result of salinity and similar forces which might still occur despite the increasing amount of remnant vegetation being locked into on-farm and conservation reserves. The south west agricultural area consists of 20.8 million hectares of privately owned land, which includes some 2.8 million hectares of remnant native vegetation.

The native bush has been the source of land for agriculture under previous policies including conditional purchase, but development, and therefore clearing, has now virtually ceased. Reflecting its historic role, the private native bush has until recently rarely been actively protected or managed. It now occurs mostly as small remnants dispersed throughout the agricultural land. It is inevitably exposed to processes of degradation arising from adjacent agricultural activity. The degrading processes include inundation by groundwater and salination of root zones, disease, annual plant invasion, grazing, excessive fire and harvest of wood products. All of these processes, in the absence of appropriate management, limit natural regeneration, damage the health of the bush and can lead to decline and eventual death of vegetation.

Unless greater effort is made to protect and effectively manage Western Australia's remnants, much of the State's native bush could be under threat in the decades to come. Potential emissions from this source were not included in the WA State and Territory Greenhouse Gas Inventory 1990 to 1995. The following brief analysis indicates that remnant vegetation decline is comparable to other items in the agricultural emissions inventory.

If the current 2.8 million hectares of remnant native vegetation declined linearly to zero (a worst case scenario) over 100 years it would be equivalent to an annual area loss of 28,000 hectares. Assuming total carbon pools (vegetation and soils) average 50 tonnes/ha this would generate equivalent emissions of 1.4 million tonnes carbon/year.

Over 40 per cent of these emissions would be due to salinity alone. The extent of land damaged by salinity is projected to increase from 9.4% to 31.8% during the next 50 years (Ferdowsian et al 1996). Assuming remnant native vegetation is uniformly distributed this indicates a loss of 600,000 ha over 50 years or 12,000 ha/year. Assuming a total carbon pool size of 50 tonnes/ha (vegetation and soils) this would generate emissions of 0.6 million tonnes carbon/year.

There is also roughly 1 million hectares of public land in small sized areas under native vegetation cover intermingled with agricultural land. This area would be vulnerable to salinity damage and could increase the extent of emissions by 50%. There would be additional emissions from soil structure decline.

It will be important to ensure that the current trend of reduced levels of land clearing is not reversed. Land clearing controls have been in place since 1995 and the area of land cleared each year is declining. This has significant benefits both in terms of the reduced amounts of greenhouse gas emissions and the conservation of the State's biodiversity in its flora and fauna.

3.2.2 Estimating emissions from clearing

Estimates of clearing and vegetation death can be developed and updated using satellite imagery. Slow decline of vegetation may be more difficult to monitor. The Australian Landcover Change Project has processed imagery over the five-year period from 1990-1995 (approximately). Results for WA are complete but are yet to be formally checked and published. Preliminary figures indicate an approximate clearing rate of the order of 16,000 ha/year over this five-year period. For inventory and accounting purposes, a sequence of such information is required. The Land Monitor Project is processing the basic data sets to provide this information at two year intervals since 1988.

In order to quantify the emissions from land use, and the effect of land use changes, the following data are required

- the area of change
- the timing of the change
- type of change (from .. to ..)
- estimate of the immediate change in above ground carbon/biomass for that change (e.g. tonnes/ha. lost in clearing or burning, growth rates for plantations)
- estimates of the amount, time interval and rates of change in below ground biomass (e.g. tonnes and decay rates for tree roots following clearing)
- estimates of the time and decay/accumulation rates for soil carbon following the change.

An early decision is required as to the necessary accuracy and increments for verification etc. In general, there are some data on area, timing, and type of land use and its change, but the accuracy and consistency of these data are questionable. Satellite imagery can and is providing more accurate and verifiable information. Satellite monitoring programs using sequences of image data can provide accurate and verifiable information on the areas of land use change over time. WA has two significant operational monitoring programs which can contribute relevant information. Both are based in the Leeuwin Centre in Perth and conducted by DOLA and CSIRO with support from a number of state agencies. The Firewatch program, based on AVHRR, provides regular maps and updates of fire fronts and burnt areas in the north of the state. The Land Monitor program is monitoring changes since 1988 over the entire southwest agricultural area. Maps of vegetation changes (area and timing of clearing, plantations) will be produced by this project. In the rangelands, satellite imagery has been used to demonstrate recovery and changes in vegetation cover. For the latter biomass and soil carbon questions, there is a general lack of quantitative information, and the only option at present is to use some standard acceptable estimates, or to ignore these components.

An exception to this lack of data is the forestry industry where a large body of growth data is collected. In combination with satellite monitoring of areas of change, an accurate inventory could be carried out for this sector.

3.3 FORESTRY

NGGI data for Western Australia show the forestry component of the LUC&F sector as a net sink, with -4.5Mt CO_2-e in 1990 (from -10.3 Mt removals and 5.8 Mt emissions) increasing to -4.7 Mt in 1995 (from 10.9 Mt removals and 6.3 Mt emissions).

Under the Kyoto Protocol this component forms part of a country's emission baseline and target only if the LUC&F sector was a net source of emissions in 1990. The Australian negotiating position at Kyoto in December 1997 was that Australia nationally was a net emitter because of extensive land clearing, particularly in Queensland and New South Wales. While the issue is too complex to discuss here, an indication of the extent of recent revisions to the Kyoto figures is that in October 1998, NGGI changed the estimated clearing rate for Queensland for 1991 to 1995 from 308,000 ha/year to 262,000. Further, whereas about one third of land cleared in Queensland was originally estimated to be regrowth forest, in October 1998 NGGI reported it to be some 77 per cent in 1996/97. The 1996 NGGI altered clearing figures for New South Wales for 1994/95 from the 1995 inventory estimate of 150,000 ha/year to only 50,000 ha/year, and that for 1974-84 from 200,000 ha/year to 356,000 ha/year.

Such drastic revisions of a sector that is a major proportion of the Australian total inventory, and the associated uncertainties in 1990 baseline figures, represent one of the major obstacles to rational planning of greenhouse measures in Australia. It is recommended as a matter of urgency that the Australian Greenhouse Office instigate a system of periodic reporting to States of updated 1990 data.

However, the Kyoto Protocol does recognise that carbon sinks can be used to offset emissions where they are defined in article 3.3 *"..resulting from direct human-induced land-use change and forest activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period."*

All forests are carbon reservoirs, in that they contain biomass which comprises about 50 per cent carbon by oven-dry weight (Kinerson et al., 1977; Rowell, 1984). Different forests, however, will vary in their capacity as a net carbon sink, depending on the time period for assessment, and the treatment of harvested wood products which may be removed from the forest.

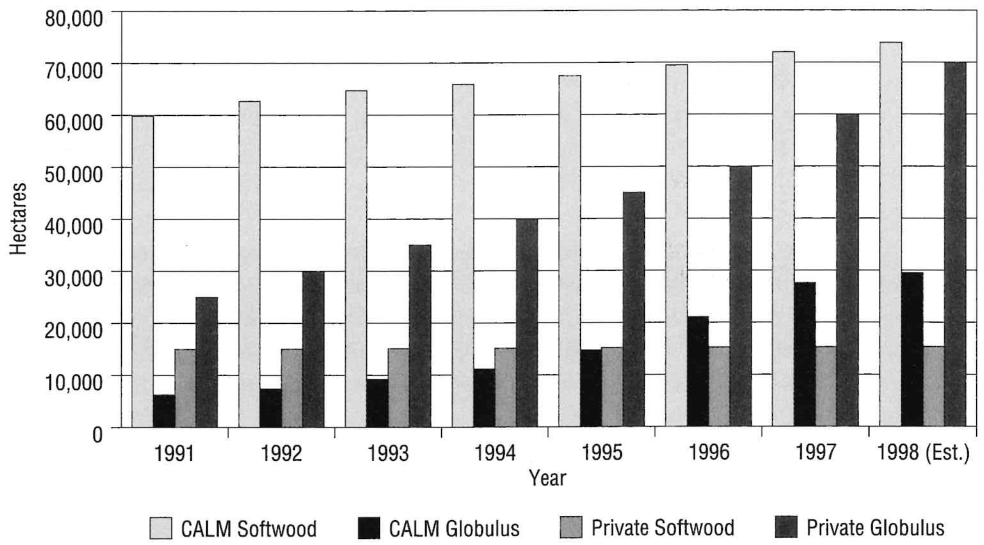
3.3.1 Plantation development since 1990

Under the current international rules for the first commitment period (2008-2012) the amount of accredited carbon sequestered by trees will be determined by measuring the total carbon stocks in tree plantations established post 1990 in 2008 and again in 2012 and determining the average annual sequestration rate for the period.

Considerable confusion has resulted concerning the significance of the term "changes in stocks", in Article 3.3 of the Kyoto Protocol. The Protocol provides credit only for that portion of carbon sequestration that occurs over a specified period of time (the commitment period). That is, credit is envisaged only for the growth in trees that occurs between two points in time, not for the total mass of carbon in the plantation. In other words, for these seeking carbon credits, it is the *addition* to stocks during the commitment period that counts, and then only in "Kyoto forests" (those planted since 1990) (Dobes *et al.*, 1998).

It may seem strange that the Kyoto Protocol gives no credit for carbon sequestered in trees between 1990 and 2008. However, neither does it "penalise" for emissions during this period. The activities during the five years of the first commitment period (2008-2012) that give a benchmark measure for the target emissions rates against the 1990 figures. Under Article 3.7 of the Kyoto Protocol, those countries whose land use change and forestry was a net source in 1990 must include in their 1990 base year the removals by sinks in 1990 from land use change. Thus uncertainties in Australian land use change and forestry estimates for 1990, as outlined above, represent potential leverage of the 108% Australian target figure ("assigned amount") for the first commitment period. Australia is reportedly the only country so placed. If Australia overestimated the size of its 1990 land use change and forestry source, then the assigned amount will be proportionately (108%) times smaller by the extent of that overestimate.

Plantation Establishment in WA



It is understood that Australia must finalise its 1990 baseline for consideration by the Subsidiary Body for Scientific and Technological Advice prior to the first session of the Meeting of Parties in about three years.

Approximately 90 000ha of plantations have been established in Western Australia on cleared agricultural land since 1990 (CALM 1997, personal communications with private forestry companies).

Under International guidelines the plantation areas existing in the year 2008 will be measured. While *Eucalyptus globulus* plantations may be managed on short (eg 10 year) harvesting cycles, those on second rotations will still contribute to carbon sink activity during the first commitment period.

Issues relating to tree crops and wood products are discussed later in this report, but it is relevant to note that any realistic estimate of net emissions for the State in 2008-2012 will have to include a forecast of the rates of planting up to 2008 as well as the rate of sequestration for different species at various ages.

3.4 FIRE MANAGEMENT

The *Workbook 4.2 for Carbon Dioxide from the Biosphere* (NGGIC 1997a) assumes that there is no change in prescribed burning over time, and that therefore, there is no change in the average fuel loads over the region.

Under these conditions, and following recommendations of the Intergovernmental Panel on Climate Change, the NGGIC calculated that the net result from CO_2 emissions during the fires and CO_2 uptake during subsequent regrowth is zero.

Other gases are produced during burning of vegetation and the inventories for 1990 and 1995 show for the whole of Western Australia that the following quantities are emitted (for gases included in the Kyoto Protocol):

	1990	**1995**
methane	4.42 Mt	4.48 Mt
nitrous oxide	0.08 Mt	0.08 Mt

Burning of savannas constitutes an important part of the agricultural emissions for Western Australia, and its percentage contribution to the State's emissions are much higher than the national average. This is due in part to the large area of rangeland and savanna in Western Australia.[3]

Fire management is a major issue in the Kimberley Region. Although fire has been an integral part of the Kimberley environment for thousands of years, current burning patterns are having significant impacts on the environmental integrity of the region.

Burning was traditionally undertaken from early in the dry season, but particularly in yirrma (approximately May to August) under relatively low fire intensity conditions. Burning was undertaken in order to provide ready access, to clear rank grasses and obtain succulent grassy regrowth and to hunt. Burning was highly organised, with the responsibility for burning/fire management with senior men. Burning arrangements would be discussed and planned with neighbours prior to the burning season. Fire drives were planned in advance.

3 The rest of this section is taken from Saint, Peter and Jeremy Russell-Smith (Eds) (1997). *Malgarra: Burning the Bush*, fourth North Australian Fire Management Workshop, Kalumburu, North Kimberley.

The pattern of burning traditionally undertaken over the seasonal cycle was characterised by extensive application of fires, individually of limited size, throughout the dry season. This breaks up the country early in the dry season, restricting the possibility of wildfires burning uncontrolled over large areas late in the dry season.

There is no doubt that the manner in which Aboriginal people occupy the Kimberley, and use fire, has changed since European settlement, with increasing fire intensity (wildfires) and also increasing numbers of fires. Areas that may have been burned one year in five are now, at times being burnt every year. A progressive loss of some plant species and the lack of recruitment have been observed, as annual burning prevents any seedlings from establishing themselves. Traditional knowledge concerning burning is diminishing rapidly but little is being done to assist and retain young Aboriginal land managers.

The types and frequency of fire in the Kimberley have changed from Aboriginal traditional fire regimes to a regime of more frequent, large scale, late dry season hot wildfires, which is impacting generally on the health and viability of rainforest communities and fire sensitive species such as Northern Cypress Pine.

Major issues of concern highlighted by the North Kimberley Land Conservation District Committee include:

- the extent of uncontrolled fires which burn over vast areas of the North Kimberley each year, typically late in the dry season under hot, dry climatic conditions;
- the need for implementing fire prevention programs early in the burning season;
- the use of fire in pastoral management;
- the use of fire for conserving biodiversity;
- the management of bush tucker resources and sites of significance for Aboriginal people;
- infrastructure protection; and
- the perceptions of the increasing numbers of tourists who visit the area each year.

4. STOCKS AND FLUXES IN 2008-2012

Stocks and fluxes of greenhouse gases from the agricultural sector in 2010 will be influenced by increases in agricultural production driven by increasing demand from population (both locally and in export markets), modified by improvements in the efficiency in production and regulated by any limitations imposed by Government (eg in the form of land clearing).

Similarly, in the forestry sector, stocks and fluxes will be influenced by the increase in plantation areas, driven by both demand for timber and demand for landcare plantations, but influenced by the management practices applied.

While these factors can be predicted or modeled, they are intricately tied to policy decisions, including those related to climate change and market forces, and are therefore subject to change which may not reflect underlying drivers such as population growth.

In this report, therefore, a baseline estimate of the stocks and fluxes for 2010 are calculated under the scenario in which changes from 1990-1995 continue in a straight line. Under this scenario, Agricultural emissions in 2010 would rise to approximately 17Mt CO_2-e, or ten per cent over 1990 levels.

Similarly, the forestry and 'other' sinks would increase to 9.2 Mt CO_2-e, a four per cent increase in sink capacity over 1990.

If the target of eight per cent increase over 1990 levels was to apply equally across all sectors and States, then only a small modification would appear to be required within the agricultural sector. However, the allocation of future emission 'permits' has not been settled, and it may be the case that some sources such as agriculture are expected by national policy makers to make larger reductions, or sinks are expected to increase in order to offset projected increases in other sectors such as energy or transport.

For example, the continued growth of secondary industry is considered by some as fundamentally important to the Western Australian economy, and with much of Western Australian industry reportedly already incorporating "best practice" in terms of greenhouse gas emissions, industry will be looking for other ways to offset its projected increase in emissions.

For this reason, the measures described in this report for ameliorating emissions are not limited only to those which would meet target within the sector, but are open-ended to show the capacity which this sector might have to contribute to overall State or national targets. It is recommended that the Western Australian Greenhouse Council ensure a holistic approach between the different sectors, because a strong cooperative State approach could potentially reap rich benefits and minimise losses to the State.

While tree crop options have commercial prospects, aside from sequestering carbon, establishing the areas required quickly enough to make any respectable contribution by the commitment period of 2008-2012 will be difficult. Additional incentives, in the form of "carbon credits", would accelerate the process. The magnitude of landcare plantings and increased carbon sequestration may not be achieved without additional incentives.

5. AMELIORATING EMISSIONS FROM AGRICULTURAL PRACTICE

The National Greenhouse Strategy (1998) contains a number of measures to reduce emissions from agricultural energy use by promoting sustainable management practices such as minimum tillage, improved management of farm energy budgets, reusing agricultural wastes, accelerating the replacement of old machinery and using alternative energy sources. However, energy use in agriculture is considered as part of the overall energy and transport sectors in the National and State Greenhouse Inventories, and is not considered further in this report.

5.1 ANIMAL HUSBANDRY AND GRAZING

Increasing the supplementation to optimize rumen fermentation feed and feed conversion efficiencies could significantly reduce methane production by ruminants. This is demonstrated by comparing methane production in different countries, which ranges from 0.6 tonnes to about 9 tonnes per tonne of meat. The more intensively managed cattle in Europe and the USA, which produce only 16 per cent of the world's methane, produce 46 per cent of the meat. Australia's output is about one tonne per tonne of meat (Carter et al 1997).

Trials have also been undertaken by CSIRO into the feasibility of using chemical compounds, possibly through slow-release capsules, to block the chemical pathway leading to the formation of methane in rumens (Carter et al 1997). CSIRO has patented an anti-methanogen feed additive which suppresses methane emissions by up to 100 per cent, and has also patented a methanogen vaccine which can achieve an 18 per cent reduction in emissions with some production gains, and is suitable for both sheep and cattle. However, while these possibilities appear encouraging, there are several flaws:

1. It has been shown that feed additives and other mechanisms to suppress methane production in the rumen do not have long-term effects, and the micro flora in the rumens eventually adapt to the change.
2. Production gains are minor and the feed additive needs to be fed daily, which may prevent its introduction into the Western Australian livestock production systems.

There is also considerable potential for increased and more effective use of phosphorus, nitrogen and other supplements to be provided to stock (Howden 1995). This could increase the intake of feed, reducing the amount of methane emissions per unit intake. This could permit a decrease in stocking rates for the same level of production.

Box 2 Animal husbandry and rumen fermentation

Best estimates suggest annual reduced emissions of 0.8 to 1.0 Mt CO_2-e (2% of 1990 State emissions) possible, from sheep at approximately $100 per tonne and from dairy and beef cattle, at approximately $35 per tonne.

Ash et al (1994) suggested that adoption of grazing management strategies in northern Australia to increase the perennial grass component could sequester approximately 300 million tonnes of organic carbon into the top 10 cm of soil. Rehabilitating degraded land could possibly store a further 140 million tonnes of organic carbon. However, it is expected that there would be extra carbon sequestered in extra biomass from improved pasture management (Ash et al 1994, Lloyd 1994, Farquhar 1994). These measures are largely considered below under rangelands. However, smaller gains can also be made with grazing management in the south west.

Box 3 Grazing

Best estimates suggest annual emission reductions of up to 0.2 Mt CO_2-e (less than 1% of 1990 State emissions) possible with sheep grazing and similar quantities with beef.

Improved effluent disposal techniques also have the potential to help reduce greenhouse gas emissions. Agriculture WA, the DEP and the WRC have recently published some "Guidelines for the management of farm dairy waste in Western Australia". While they have primarily been developed to protect Western Australian waterways, they will have some effect on reducing greenhouse emissions through improved management practices.

At present up to half of the dairy farms in Western Australia do nothing to manage dairy shed effluent effectively and many management systems do not prevent off site drainage of nutrients (in total about 75 per cent of farms do not manage dairy shed effluent acceptably). Adoption of any program to change this is going to result in farmers having to spend money on improving their effluent management. Costs of this will vary from farm to farm in the range of $2000 to $20 000. There is general acceptance in the industry that these costs will have to be born. It will be important to consider greenhouse implications in the adoption of these practices.

Box 4 Effluent disposal

Best estimates suggest annual emission reductions of 0.02 Mt CO_2-e possible.

The Australian fertiliser industry is developing a fertiliser spreading accreditation program and codes of conduct that should improve the efficiency of fertiliser spreading and handling. This will have the combined advantages of reducing the amount entering waterways and reducing greenhouse gas emissions from fertiliser.

Box 5 Crop management

Best estimates suggest annual emission reductions of 2 Mt CO_2-e (4% of the 1990 State emissions) are possible.

5.2 LAND CLEARING

Land clearing controls operate mostly through Agriculture WA. Greater controls on land clearing have been gradually put in place in Western Australia: since 1990 the Commissioner of Soil and Land Conservation has had the authority to object to clearing applications on the grounds of land degradation, and since 1995 applications could be objected to on broader environmental grounds. In April 1997 a Memorandum of Understanding on the protection of native remnant vegetation was signed between a number of State Government Agencies which effectively prevents clearing in Shires where there is less than 20 per cent remnant vegetation remaining, and provides strict requirements for clearing in other areas.

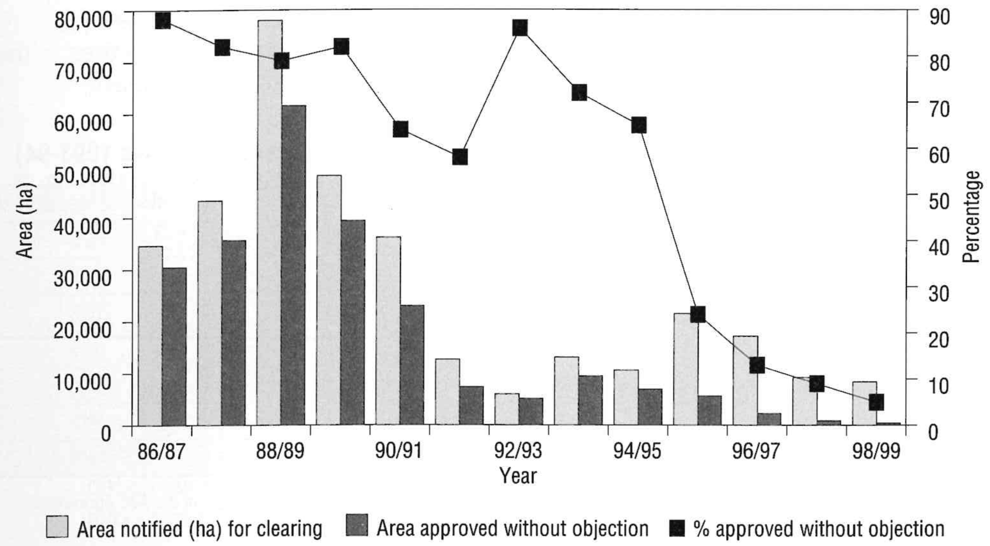
The land clearing controls have resulted in a rapid decline in land clearing in the State. For example, in 1986/87, clearing was approved on over 30,000 ha of land, compared to only 872.4 ha in 1997/98 (which includes 685 ha of non-rural land clearing). More importantly, the percentage of land that is bei, g approved for clearing compared to the area applied (notified) for, has declinea from 88% in 1986/87 to 9% in 1997/98. The table below shows in particular the effect of the controls on broader environmental grounds since 1995.

Table 11. Areas of land notified and approved for clearing in WA, 1986-99

Year	Area Notified (ha) for clearing	Area approved without objection	% approved without objection
86/87	34,632	30,467	88
87/88	43,259	35,624	82
88/89	78,030	61,541	79
89/90	48,041	39,356	82
90/91	36,138	22,954	64
91/92	12,640	7,342	58
92/93	5,967	5,110	86
93/94	13,078	9,443	72
94/95	10,587	6,917	65
95/96	21,504	5,624	24
96/97	17,132	2,258	13
97/98	9,214	872	9
98/99	8,360	420	5

Source: Commissioner of Soil and Land Conservation

Trends in land clearing controls in WA, 1986-1999



Box 6 Land clearing

Land clearing apparently contributed to 4 Mt CO_2-e (8per cent) to the State's 1990 emissions, although the precision of this estimate is poor. If all clearing ceased by the start of the 2008-2012 period, then the avoided emission would be this amount (less any ongoing emissions from decay of vegetation and soil carbon, and less any losses for vegetation decline). There is a cost to individual farmers but gains in soil conservation and environmental protection.

The focus in this report is on rural land clearing. It should be noted that clearing also occurs for urban development and this should be included in the urban planning and land use report. Clearing also occurs prior to mining. Emissions from this source may be balanced over time by re-growth on rehabilitated mine sites, depending on the nature of the mining and the potential for rehabilitation. While this is an issue for the mining sector to address, the following comments are relevant. Emissions from mine-site clearing are generally small compared to the energy costs in extraction and processing of minerals. Particularly in clearing of forest areas, maximum use of the cleared timber for wood products is encouraged, and emissions will be reduced to the extent that this utilisation can be increased.

5.3 MINIMUM AND NO-TILL PRACTICES

The use of alternative tillage systems may reduce overall rates of emissions of soil carbon by about 2.5 million tonnes per annum (Lloyd, 1994). Howden & O'Leary (1995) suggested that wheat cropping systems in Victoria emitted between 1.35 and 2.15 tonnes of carbon dioxide per hectare per year. Stubble retention wheat cropping systems could reduce the average net emissions per hectare by up to 37 per cent.

Minimum and no-till cultivation methods have been rapidly taken up in Western Australia, with an estimated 75 per cent of cropping farmers in the State having now adopted these practices (Edmondson, 1997). The table below gives some indication of the uptake of minimum/no-till practices in the State in 1993/94, showing about a 33 per cent uptake at that time.

Table 12. Final results of tillage practices question (ABS Agricultural Census 1993-94)

Practice	Area (ha)	Number of respondents
Conventional tillage	2,079,071	5025
Minimum or reduced tillage	2,215,402	4054
No cultivation prior to seeding	1,092,170	2018
No tillage seeding using narrow points (pasture)	23,797	133
No tillage seeding using narrow points (crops)	110,590	226
No tillage seeding using disced seeder (pasture)	34,459	218
No tillage seeding using disced seeder (crops)	127,857	315

Source: Soil and Land Conservation Council of Western Australia Annual Report 1994/95, after results of the ABS Agricultural Census 1993/94

While minimum/no-till practices have been adopted principally for reasons of soil conservation, lower fuel costs and timely seeding (and its uptake is largely attributed to the strong landcare movement in the State (Edmondson, 1997)), it has some benefits in terms of greenhouse gas emissions, largely through having crop stubble returned to the soil.

However, there are two issues that should be considered. No-till is heavily chemically-dependant and may not provide as much saving in terms of emissions if considered in its full cycle. Chemical development uses energy, and they must also be transported to the farm.

The second issue relates to soil carbon levels. Soils have equilibrium carbon levels, so no-tillage practices will only "sequester" carbon in the soil until that equilibrium is reached.

Box 7 Conservation cropping/tillage

Best estimates suggest annual savings of 1.8 Mt CO_2-e (4% of 1990 State emissions) are possible at minimal cost.

5.4 ASSOCIATED MEASURES

In order to achieve support for measures to ameliorate greenhouse gas emissions, it will be important to increase awareness of the issue and education of managers of rural enterprises. Such programs should bring forecasts of greenhouse climate effects into perspective against the prevailing and much stronger natural climate effects, but should also note that the high public profile of these may assist collateral benefits.

Another measure will be to consider the impacts of any future climate change and any resultant change in the dynamics of pests and weeds which may arise. Arthropod pests, plant pathogens, weeds, livestock parasites and disease vectors usually have high reproductive rates, short generation times and

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efficient dispersal mechanisms which enable them to respond rapidly to changes in both weather and climate. Arthropod pests, weeds and diseases may, therefore, be responsible for some of the earliest and most significant impacts of climate change on human society (Sutherst *et al.*, 1996), although the predictions of this, similar to those for rainfall, are very uncertain.

5.5 MONITORING LAND USE CHANGES AND GREENHOUSE EMISSIONS

The international Greenhouse policy and Australia's Greenhouse Response Strategy take as their baseline the levels of carbon dioxide emissions and sequestration in 1990. Clearing and other impacts on native vegetation are being assessed under a National "land cover project" coordinated by the Bureau of Resource Sciences. It uses satellite imagery and other data to assess land cover in 1990 and 1995, and the change between these two dates. Western Australia is participating in this project and the results are expected to be available in the first half of 1999.

Meanwhile the State is commencing its own "land monitor project" using the same remote sensing technology to monitor change in remnant vegetation, revegetation and salt-affected land. This is a collaborative project coordinated by Agriculture WA across key Government agencies, CSIRO and other organisations.

Historical land clearing data were mostly inferred through modeling, but analysis of satellite imagery is beginning to confirm that the National Greenhouse Gas Inventory assessment of recent land clearing rates is reasonably sound. There are uncertainties in estimating the emissions per unit of area of land cleared, especially for the carbon that is released over many years from soils. Considerable effort is being invested in strengthening the methodology and data inputs used to determine emissions due to land use change (National Greenhouse Strategy, 1998).

6. NEW SINKS

6.1 MANAGING THE RANGELANDS

The Bureau of Resource Sciences has estimated that an additional 315 Mt of organic carbon could potentially be sequestered through the rehabilitation of deteriorated pastures in the northern Australian rangelands, with a further 144 Mt of carbon sequestered if seriously degraded land was rehabilitated (Rossiter and Lambert, 1998). To this could be added the reduction in emissions through more effective fire management practices in the Kimberley.

Grazing in many areas of Australia's pastoral land has resulted in a deterioration of vegetation and soil condition. Noble et al. (1996) summarise the results of several pastoral land condition surveys in Western Australia. From 50 to 94% of the land is in a 'deteriorating' or 'degraded' condition. Destocking of this land and removal of feral herbivores will result in an increase in biomass, particularly on the 'deteriorating' land. 'Degraded' land may require more active management intervention (re-seeding, cultivation) to help restore vegetation.

In a modelling exercise, Moore et al. (1997) adapted a pasture production model (GRASP) to simulate the effect of changing stocking on carbon pools in a semi-arid rangeland dominated by mulga *(Acacia aneura)*, in south-western Queensland. They incorporated estimates of root pools, termites, livestock production and greenhouse gas emissions. This site had an annual rainfall of 489 mm, with 70% falling in summer. With grazing the system acted as a net source of carbon (16-54 kg C/ha/year), whereas Aboriginal management with regular burning acted as a sink of 4 kg C/ha/year. Grazing also acts as a source of methane and nitrous oxide. Suppression of fire and grazing resulted in thickening of the mulga stands with the system potentially acting as a sink of 270 kg C/ha/year, until a new equilibrium is achieved.

Measurements of 'woodland thickening', due to changing fire frequency through grazing has recently been reported from Queensland (Burrows et al. 1998), with an estimated annual accretion in woody biomass of 460 kg C/ha/year. With different rainfall distribution, soils and vegetation communities these values are possibly greater than what would be achievable in Western Australia.

Walker and Steffen (1992) suggest that the Australian rangeland soils could be used as a sink for carbon. They suggest that the most carbon would be fixed in soil organic matter with the move away from practices causing land degradation. Ash et al (1995) measured the soil carbon content in soils under rangeland pastures of different conditions in north-east Queensland and the Northern Territory. They estimate that up to 3,200 kg C/ha of carbon could be added to the soils with optimal improvement in rangeland condition.

Although responses to destocking have been reported, these have not been quantified in terms of changes in biomass (roots and tops). It is expected that destocking would change both plant and soil carbon pools. Simply destocking domestic animals may not be enough to increase carbon sinks. De Salis

(1993) suggests that the rate of carbon accretion could be increased by feral herbivore control, whereas the modelling of Moore et al (1997) indicated that fire suppression would also be important. Significant changes in carbon accretion may be possible by active management such as re-seeding, local cultivation and other restorative techniques developed for rangeland grazing systems (Williams and Shepherd 1991).

Box 8 Rangelands

Best estimates suggest annual gains of 5.2 Mt CO_2-e (10 per cent of the 1990 State emissions) are possible, although statistical uncertainty is high at this stage and the certainty of accreditation under the Kyoto Protocol is low.

6.2 COMMERCIAL TREE CROPS

Shea *et al* (1998) showed how a rapid planting program of Maritime Pine, Bluegum and landcare plantations over 3M ha together with 8.5 Mha of rangeland restoration could sequester approximately 34 Mt CO_2 annually during the first commitment period. Against the State's net emissions of 49 Mt CO_2 in 1995, this would clearly be a significant contribution to the State's and Australia's carbon balance, provided it was accredited.

The cost of the carbon sequestered could vary from almost nil to $52 per tonne of carbon ($15 per tonne of CO_2) depending on the commercial returns from harvested wood products and the treatment of carbon sinks in those products in future international negotiations.

Plantations on this scale would make a significant contribution to the restoration of water balances in agricultural landscapes, with collateral benefits to both the regional environment and agricultural industry.

Under the provisions of the Kyoto protocol, such plantations should be credited as reforestation since 1990. However, the detail of which plantations can be credited will still depend on definitions which are to be resolved, including the period through which the land must have had a non-forestry land use. Much of Western Australia's agricultural land has been cleared in recent decades but is already showing the signs of land degradation and salinity. A long period (e.g. 50 – 500 years) would preclude much of Western Australia's agricultural land from been credited for reforestation. It would remove from Western Australia the ability to use carbon sinks to both offset carbon emissions from a new and growing industry as well as significant collateral benefits. A period of ten years (i.e. cleared pre 1980) would be of benefit to Western Australia.

In Australia's participation in Kyoto Protocol negotiations and scientific reports, therefore, it is recommended that a definition of reforestation be pursued which would accommodate the circumstances of relatively recent clearing in Australia.

Box 9 Maritime Pine tree crops

Annual gains of up to 7.5 Mt CO_2-e (15 per cent of the 1990 State emissions) possible from a program of 600,000 ha at a cost of $2 to $6 per tonne depending on the sale of commerical products.

Box 10 Bluegums

Annual gains of 2.3 Mt CO_2-e (5 per cent of the 1990 State emissions) possible from a program of 250,000 ha in higher rainfall areas at a cost of $0 to $20 per tonne depending on log sales.

6.2.1 Oil mallee production

There are several species of native wheatbelt mallee eucalypts being developed as short rotation tree crops for the wheatbelt (rainfall range 250 mm to 400 mm). These species and their product, eucalyptus oil, were carefully chosen as the most prospective commercial wheatbelt tree crop option available (Bartle et al 1996). Oil mallee was recognised in the State Salinity Action Plan as the best potential commercial option to help control wheatbelt salinity. The plan indicated the potential for at least 0.5 million ha of oil mallee. Planting commenced on an operational scale in 1994 with 7000 ha established by 1998.

Mallee coppices prolifically and can be harvested on a two-year rotation from age four onwards, when it yields an average harvest of three tonnes of above ground carbon per year (i.e. six tonnes/harvest) and a harvested stand maintains an average above ground carbon sink of three tonnes/ha. After oil extraction the biomass residue can be used as fuel, thereby avoiding emissions from fossil fuels. Root carbon increases at a steady one tonne/year for many decades as the plant builds up its root stock from which the coppicing stems rise.

Projections by the oil mallee industry indicate that planted area will increase from 100,000 ha to 200,000 ha during the 2008 to 2012 period. Total carbon maintained above ground will increase from 0.3M tonnes to 0.6M tonnes, total below ground carbon will increase by 0.7Mt and carbon in residues available for fuel will total 2.1M tonnes. Hence total carbon sink increase over the 5 year commitment period is 1 Mt without fuels or 3.1Mt with fuels. Hence the annual average sequestration rate during the commitment period is 0.2Mt carbon (0.734Mt CO_2) in biomass pools plus 0.42Mt (1.54 CO_2) in avoided emissions.

Box 11 Oil mallee tree crops

Best estimates suggest annual gains of 0.7 to 2.3 Mt CO_2-e (2-4 per cent of the 1990 State emissions) possible from a 500,000 ha program at a cost of up to $12 per tonne depending on commercial uses.

6.2.2 Soil Carbon under tree crops

6.2.2.1 Albany Pinus radiata study (ref: Harper unpublished)

Thirty seven Pinus radiata plantations on farms in the Albany-Rocky Gully area of Western Australia were examined to determine the effects of the trees on the soils. Soil samples were taken in 1990 from the surface 10 cm under the trees and from adjacent pasture paddocks. The plantations ranged in age from 11 to 43 years (mean 20) and had been established on either bushland or pasture.

There were no differences in the values of organic carbon, pH, available phosphorus, or exchangeable cations (Mg, Na, K) with land-use.

6.2.2.2 Accumulation of organic carbon under blue-gums in the Esperance area (Harper et al. 1998)

Soil samples were taken from under six year old Eucalyptus globulus plantings and adjacent farmland at eight sites in the Esperance area, in September 1998. The plots had been established within large paddocks and the agricultural samples were selected from within the original paddock boundaries.

There were highly significant differences in soil organic carbon content and bulk density under the trees compared to the adjacent farmland. At least one tonne/ha of organic carbon had accumulated under Eucalyptus globulus in the Esperance area in the last six years, compared to adjacent agricultural land. This is in an area with annual rainfall of 500-600 mm and modest blue-gum growth.

Land Use	Bulk Density (g/cm³)	Organic Carbon (per cent)	Organic Carbon (t/ha)
Trees	1.31	1.12	7.4
Agriculture	1.41	0.89	6.4

6.3 OPPORTUNITIES FOR WOOD PRODUCTS AS CARBON SINKS

The amount of credit available for reforestation will depend on the treatment of harvested wood products. Wood products remain as a carbon store for various periods, ranging from very long periods (building materials, furniture) to short periods (paper, panel products). The National Greenhouse Gas Inventory *Workbook 4.2 for Carbon Dioxide from the Biosphere* includes treatment of harvested wood products, allocating them to four pools of different decay times:

1. Decay in the year of harvest, including the slash which may be burnt in a regeneration burn and short lived products such as paper,
2. The fraction of timber with a short-medium term life (10 years) such as panel products,
3. The fraction of timber with a medium-long term life (25 years) such as sawn timber for packing crates and furniture, and
4. The fraction of timber with a long life (50 years) such as building timbers, fence posts.

It is important to remember that wood products which reach the end of their service life (and are not recycled) – end up in the waste stream and emissions from their decay must therefore be included in the emissions from the waste sector. Under current international guidelines, wood products are counted as an emission at the time of harvest, leading to a double counting of emissions from this source. This anomaly needs addressing. It should also be noted that there is a rapid increase in technology and practice for the recovery of energy from urban, agricultural and industrial waste streams. This is addressed by other technical panels, but once again, the issue of double-counting needs to be addressed where part of that waste stream comes from tree crops.

In Australia's participation in Kyoto Protocol negotiations and scientific reports, therefore, it is recommended that accounting guidelines be pursued which allow the emissions from harvested wood products to be accounted at the time and place in which the emission (decay) occurs.

This would make equitable treatment to fuels such as gas and coal, where emissions are accounted for when the fuel is burned, not where it is mined.

As outlined in the following section, wood products can make an important contribution to the reduction of greenhouse gas emissions by:

- storing carbon for longer periods than in plantations alone;
- increasing the size of the overall plantations + products pool;
- removing carbon dioxide from the atmosphere for a period which will allow time for new technology to be developed, adaptation to occur, and knowledge of climate change to improve;
- substituting for high-energy use products (e.g. steel, aluminium) and fossil fuels, allowing emissions from those sectors to be avoided; and
- providing a greenhouse-neutral source of fuel (bioenergy) which if replacing fossil fuels can result in 'avoided emissions' from that source.
- storing carbon while the warming potential of the carbon dioxide molecules get smaller as the atmospheric concentration increases.

The size of the carbon pool in a forest reaches a plateau at maturity. Hence the land available for reforestation imposes a constraint on the total amount of carbon that can be sequestered in living biomass. Regular harvest of forests presents the opportunity to create additional, long-lived pools in wood products and to avoid fossil fuel emissions, both by use of biomass as fuel, and through substituting wood products for more energy intensive metal and masonry products. **Including these pools can make harvested forests a continuously expanding sink and a more effective use of land available for carbon sequestration than unharvested forests.**

Long-lived wood products include solid and reconstituted products for construction, fittings and surface finishes in buildings and furniture. These products may have lives in excess of 100 years and decay rates (as defined by half-lives) of more than 30 years. Even if only a proportion of the harvested tree is converted to products with lives of this duration an expanding pool can result. For example, from Shea *et al* (1998) shows the progressive growth in total sink size of maritime pine over 3 rotations through the accumulation of carbon in long-lived products.

The markets for timber products are large and have enjoyed strong growth rates in recent years. It is implicit in discussing major new initiatives in carbon sequestration by harvested forests that considerable expansion in demand for wood will emerge. There are two reasons for confidence in increased demand for wood products and both relate to the greenhouse gas and climate change issue. Firstly, the wood production process creates new carbon sinks that under the Kyoto protocols will have value and this will effectively reduce the net cost of wood production. Secondly, wood's major competitor products (metals, masonry and concrete) are all very much more energy intensive in their production process and their cost will increase by having to meet their Kyoto obligations to offset carbon emissions. For these reasons the outlook for wood products is an improved competitive position in the market place, which should lead to strong growth, depending on the continued strength of a greenhouse-driven carbon market.

Bioenergy is unique amongst the renewable energy options in that it can provide solid, liquid and gaseous fuels that can be stored and transported, and substitute more-or-less directly for fossil fuels in the existing energy infrastructure. Renewable energy accounts for about 20% of world energy consumption with three-quarters of this coming from biomass. Most of this is in the developing nations where wood and charcoal dominate energy supply. Such traditional uses tend to be very inefficient and the energy is largely wasted. In the developed world Sweden and Finland have the highest rates of bioenergy use at 16 and 18% respectively and they lead in the endeavour to modernise bioenergy. A review of bioenergy potential by Hall and Scrase (1998) found that with improved technologies bioenergy could generate nearly half of world energy supply and level out atmospheric carbon dioxide by 2100.

Electricity generation is currently the most attractive option for biomass fuels. Close to source and in the form of residues from other industries (e.g. forestry and sugar) it is available at a cost comparable to coal and large-scale utilisation is well established (Turnbull, 1993). Urban refuse is another form of biomass waste where a large negative cost (for landfill disposal) has made energy recovery attractive. Many nations in Europe have reduced landfill to less than 50% of the waste stream through development of combustion and energy recovery systems (Patel and Gordon 1998). Dedicated energy crops are only viable where fossil fuel taxes provide protection (Bohlin, 1998). The major constraint for bioenergy is that biomass in the form of forestry and agricultural residues is generally widely dispersed, is less competitive than coal in transport and therefore requires smaller scale plants. Such plant sizes (10 to 100MW) using conventional steam generation methods have low efficiency and high capital costs. Booth and Elliott (1993) indicate that this is prime area for the development and application of new technology.

While the products pool and bioenergy appear to qualify as a part of sinks their treatment under the Kyoto protocols is not entirely clear. Article 3.3 appears to comfortably embrace wood products. Article 2.1a(iv) implies that biomass fuels can either not be counted as emissions, or can be counted as sinks. The status of wood product substitution is less clear, but it appears to sit within the spirit of the protocols. In addition, the potential for energy recovery from urban and industrial waste to provide a 'catch-all' such that all harvested biomass, including that temporarily detained in product pools, would qualify as avoided emissions has far reaching implications.

The uncertain status of wood products and avoided fossil fuel emissions is major issue in WA. There is a large land area available for revegetation, several new tree crop options and potentially large residue flows. **A larger carbon credit will help build the economic viability of new tree crops and help control land degradation. It is therefore recommended that in Australia's negotiations, this issue be pursued with vigour.**

It is likely that a potential tree crop like oil mallee that will generate a large biomass will only be viable if some commercial use is found for that residue. Detailed investigation of the commercial feasibility of using oil mallee residue has commenced. There are also a range of other forestry, agricultural, mining and urban residues or wastes that could in the future be used for bioenergy. Oil mallee bioenergy potential could be taken as a very conservative estimate of avoided emissions in the 2008-2012 period (see estimates and discussion under the oil mallee section above).

Box 12 Bioenergy

Best estimates suggest annual gains of 1.5 Mt CO_2-e are possible from oil mallee at commercially viable costs.

6.3.1 Harvested wood products in the building industry

In order to maximise the storage of carbon in harvested wood products, it is desirable to use as much as possible in long-life products. Such products are found in residential and commercial buildings, were timber can also substitute for high-energy materials such as aluminum or steel. This provides an additional advantage in avoided emissions from those materials.

To quantify this, the Building Material Ecological Sustainability (BES) Index was developed by the University of Sydney and described in a paper by the FWPRDL (1998). It uses a life cycle analysis process to rate products according to their sustainable development, pollution and energy use. Appendix II provides detail on this issue, and much of the data used in the Appendix draws on the FWPRDL paper.

Box 13 Substitution of materials in buildings

Best estimates suggest annual savings of 0.33 Mt CO_2-e (less than 1% of 1990 emissions) are possible at a cost of approximately 10% over the standard house cost (see Appendix II).

6.4 LANDCARE AND VEGETATION PROTECTION

In addition to the plantations outlined above, additional enhancement and protection of carbon reservoirs can be achieved through landcare measures and protecting areas of remnant vegetation. However, it must be appreciated that diffuse and individualistic approaches to greenhouse mitigation usually have large transaction costs and can be detrimental to efficient authorised emission trading systems. Accreditation of these measures under the Kyoto protocol will depend on the treatment of additional activities under Article 3.4 of the protocol, and on the definition of reforestation under 3.3.

Landcare is a generic name now widely used to cover a broad range of activities which promote sustainable management of Australia's land, water and vegetation. It is also used to describe the network of community-based Landcare groups established under the National Landcare Program.

In Western Australia, landcare activities of most interest from a greenhouse perspective are:

- Protection and enhancement of remnant native vegetation.
- Revegetation of cleared land.
- Adoption of reduced tillage and no-tillage methods of crop establishment.

The first two are discussed separately below. No till agriculture is discussed elsewhere in this report.

6.4.1 General initiatives

6.4.1.1 Landcare movement

In Australia, over 4,000 community Landcare groups are supported by Commonwealth government funding and State government participation. A recently published survey indicated that 43% of Western Australian broad acre and dairy farmers were members of a Landcare group in 1995/96 (Mues, 1998). The survey found that members of Landcare groups shared a number of characteristics which distinguished them from other farmers:

- More likely to protect remnant native vegetation and to revegetate.
- More likely to protect and establish perennial vegetation.
- More likely to direct drill (42% to 19% in WA).
- More likely to have a farm plan (65% to 22% in WA).
- More likely to participate in training.
- More likely to adopt "best practices".

The survey also identified that willingness to revegetate was strongly correlated with farmer attributes such as having a farm plan and participating in training.

These characteristics of Landcare group members suggest that the Landcare movement, which is largely community driven in Western Australia, could be an effective forum for increasing awareness of greenhouse issues and promoting the uptake of practices aimed at reducing greenhouse emissions or increasing carbon reservoirs.

However, the landcare ethic is difficult to measure (Carey, 1993). While farmers tend to empathise with landcare, they must balance conservation and production. For example, tree plantations would provide larger benefits than improved pasture or cropping practice in terms of greenhouse, but farmers are generally more reluctant to plant trees. Improved pastures provide both short term economic benefits and longer term conservation ones, whereas tree plantings have mainly longer term benefits.

6.4.1.2 Natural Heritage Trust

A large part of the $1.25 billion spent each year under the Commonwealth government's Natural Heritage Trust is allocated to rural projects with the potential to enhance greenhouse sinks. Many projects within the Landcare, Bushcare and Farm Forestry components of NHT involve revegetation, or the protection and enhancement of existing native vegetation.

6.4.1.3 Salinity Action Plan

The WA State government's Salinity Action Plan (1996) is aimed at preventing further rises in saline groundwater in agricultural areas, to prevent further loss of productive farmland, native vegetation and habitat, and damage to infrastructure. Key strategies described in the plan include a greater use of perennial plants in agriculture, and the revegetation of three million hectares with trees or other woody perennials. As well as combating salinity, these strategies also enlarge carbon reservoirs for greenhouse gases.

Local Governments, in conjunction with Land Conservation District Committees also carry out projects, often under NHT funding, for protection of remnant vegetation, revegetation and 'streamlining'.

6.4.1.4 Protection and enhancement of remnant vegetation

Protection and enhancement of remnant vegetation can encourage higher densities of younger trees and a build up of understorey. Carbon storage can increase in protected remnants in the form of woody material, litter and organic matter in the soil. Degraded remnants have the potential to show the greatest increase in carbon storage, while remnants which are healthy at the time of protection may show little increase in carbon storage.

In the last decade, the main strategy to protect remnant vegetation protection has been fencing to restrict grazing. Now, the threat to remnant vegetation from rising saline groundwater is also being addressed.

Quantifying any increases in carbon storage will be difficult, since there is a variety of different remnant vegetation types, which respond in different ways to protection. Also, not all remnants start from the same level of degradation before they are protected or enhanced. Remote sensing offers the most feasible way for quantifying carbon storage in the large number of small remnants scattered through agricultural areas, if appropriate techniques can be developed.

6.4.2 Specific Initiatives

6.4.2.1 Remnant Vegetation Protection Scheme (RVPS)

Agriculture Western Australia has administered the Remnant Vegetation Protection Scheme (RVPS) since 1988, distributing between $300,000 and $500,000 each year to partially cover fencing costs to protect remnant vegetation. Fencing grants are conditional on landholders accepting a 30-year covenant over the protected area on their land title. Full details of the amount distributed, and the area protected are in the table below.

Table 13. Grants allocated and areas protected under the RVPS, 1988-1996

Year	Funds disbursed	Number of projects approved	Hectares protected	Length of fencing (km)
1988/89	285,880.00	110	7,899.20	348.20
1989/90	448,512.00	185	6,587.20	422.94
1990/91	425,799.00	174	6,421.50	406.15
1991/92	359,926.50	115	6,121.70	369.97
1992/93	256,449.00	93	4,341.10	251.97
1993/94	251,616.00	98	3,423.36	246.15
1994/95	232,861.50	61	3,334.70	230.03
1995/96	513,741.20	183	11,092.19	758.44
1996/97	502,173.00	118	14,072.46	540.07
1997/98	539,176.00	98	6,971.80	497.47
Total:		**1,234**	**70,265.20**	**4,071.39**

At least 70% of the area protected under this scheme has been protected since 1990, and may be eligible for inclusion in greenhouse gas accounting subject to the notes below.

In addition, there have been 62,044 ha of bushland protected under Agreements to Reserve since 1990. These have mostly been taken out as a result of objections to clearing proposals under the Soil and Land Conservation Regulations.

It should be noted that under the Kyoto Protocol Article 3.4, emissions from land clearing form part of the 1990 baseline for those countries in which land use change and forestry is a net source, and in these countries, such emissions then form part of the 2008-2012 target. Reduced emissions from this source may assist Australia in meeting its national target, but it is not certain as yet how or if any 'carbon credit' will flow to the land owner for what are essentially avoided emissions. Protected areas may not increase sink capacity, and are not likely to fall within the definitions of afforestation or reforestation.

6.4.2.2 Regional Enterprise Scheme

Between 1995 and 1998 the State government provided $250,000 a year for projects aimed at encouraging broad scale revegetation. Agriculture Western Australia administered this scheme through the Soil and Land Conservation Council. Funding went to projects such as the Oil Mallee Association, a feasibility study into the use of blue gums as an energy source and a log milling enterprise.

6.4.3 Non-commercial revegetation

Non-commercial native tree and shrub species are widely promoted for revegetation on cleared farm land. These 'landcare plantings' are very diverse in species composition, planting density, management input and quality of land. They are frequently planted on poorer sites to avoid good cropping land, for example adjacent to salt-affected land or on eroded soils. This reduces their growth (and carbon sink) potential. However, unlike commercial tree crops, landcare trees are not harvested and therefore build up a standing biomass that is retained for long time-periods. Landcare trees are also commonly protected from grazing and may develop larger litter and soil carbon pools. They have a sigmoidal growth curve with sink size plateauing at age 30 to 50 years. There are no detailed local growth data available for landcare plantings. Growth rates of 2.5 m³/ha/year may be typical. (adapted from Shea *et al.* 1998)

6.4.4 Measurement and accountability

Since centralised record keeping has not been part of the ethos of Landcare, no inventory of the work done to enhance and establish vegetation is readily available. Individual LCDCs, landcare groups and catchment groups maintain records in various formats, and to various standards, to suit each group's goals and method of operating.

6.4.4.1 Australian Bureau of Statistics

The best information available on the rate of tree planting for the last five years comes from the Census of Agriculture conducted by the Australian Bureau of Statistics. Unfortunately the census questions have differed from year to year making it difficult to interpret the data. It is also unclear whether the information incorporates commercial plantings by large plantation companies.

The 1995/96 Agricultural Census received responses from 13,329 WA farmers. At that time, a total of 24,947 ha was planted on farms for Timber or Wood Pulp, and 61,110 ha was planted for other purposes. In addition in 1995 3,500 km of windbreaks were planted.

Table 14. Number of Seedlings planted on cleared agricultural land in Western Australia, 1995 and 1996

Year	Seedlings Planted	Purpose	No. of Farms	Area Planted (ha)
1995	12,916,389	not specified	3,750	na
1996	4,563,872	timber and pulp	159	3,475
	6,247,156	all other purposes	1,235	15,159

Source: 1995/96 Agricultural Census

6.4.4.2 Case study

A method for recording landcare activities has been developed by Agriculture Western Australia, and applied to the Swan Coastal Plain, within the Peel-Harvey catchment. This method could be assessed for its usefulness as a recording system for carbon storage, and its applicability to other agricultural areas. Details of this project are given in Appendix III.

6.5 DIFFICULTIES IN RECORDING CARBON SEQUESTRATION

Landcare projects usually contain mixed tree and shrub species, and are often spread widely over the landscape in small patches. While such features can be useful from a biodiversity and land management perspective, they make carbon sequestration difficult to estimate and expensive to measure. Again, guidelines are required as to what quanta of carbon storage are sensibly required for Australia to meet its international validation and verification commitments.

Survival and growth rates can vary. A large number of monitoring plots would be needed to accurately assess the carbon sequestration in landcare plantings. It is unlikely that sampling could be stratified by year or by species, as a variety of species mixes are used, and survival and growth can vary greatly between areas and between years.

Satellite monitoring (the land monitor project) can provide verifiable information on areas of revegetation since 1988 over the southwest. This will include significant areas of timber plantations and on-farm revegetation. The ALCC project has calculated an average revegetation rate of approximately 23000 hectares per year over the period 1990-95 for the southwest agricultural region. A large proportion of this figure is made up of the timber plantations in the high-rainfall southern areas. These figures are yet to be verified and officially released by the Project.

Box 14 Summary for landcare

New plantings of trees under landcare schemes or actions of individual land owners may eventually contribute towards sinks of 8 Mt CO_2-e, or 15 per cent of the 1990 State emissions. This is based on an eventual planted area of 1.75 Mha. Protecting remnant vegetation will assist in reducing emissions from clearing, but may not generate additional credits in its own right.

7. COST BENEFIT ANALYSIS OF AMELIORATION AND SINK MEASURES

Note that these are best estimates given a number of assumptions and are presented to give provide an indication of the relative magnitude of various measures and actions.

Measure	Range of CO_2 benefit 2008-2012	% of WA 1990 gross emissio (51.3 Mt CO_2-e)	Range of expected costs	Additionality of carbon credits in financing the mechanism	Collateral benefits	Risk/certainty under Kyoto	Implementation issues incl verification	Priority for national COP negotiations	Capability	Final priority
Sinks Plantations and farm forestry (NGS 6.1)										
Maritime pine up to 600,000 ha	2.0 Mt C 7.5 Mt CO_2-e	up to 15%	\$5-20 \$2-6 depending on sale of wood products	Carbon credit increases IRR to attract investment	Landcare, salinity action plan	Reforestation under 3.3 but risk with harvested wood prod, and time under alt land use	Capital investment, lead time to start up, time dimension of C storage. Verification through inventory	High for time dimension, harvested wood products	High	
Bluegum up to 250,000 ha	0.6 Mt C 2.3 Mt CO_2-e	up to 5%	\$0-70 \$0-20 depending on sale of wood products		ditto	ditto	ditto	ditto	High	
Mallee eucalypts up to 500,000 ha	0.2 – 0.6 Mt C 0.7 – 2.3 Mt CO_2-e	2-4%	\$42 \$12	Alt revenue may be low until markets dev for oils etc	ditto	Definition of forest an issue. Major store under ground, so HWP less of an issue	ditto		Medium	
Landcare plantings up to 1,750,000 ha	2.2 Mt C 8.2 Mt CO_2-e	up to 15%	\$52 \$15	No alt revenue planned.	ditto	Little risk under 3.3	Verification needs to be improved for non-commercial species		Medium	

7. Cost benefit analysis of amelioration and sink measures (continued)

Measure	Range of CO_2 benefit 2008-2012	% of WA 1990 gross emissio (51.3 Mt CO_2-e)	Range of expected costs	Additionality of carbon credits in financing the mechanism	Collateral benefits	Risk/certainty under Kyoto	Implementation issues incl verification	Priority for national COP negotiations	Capability	Final priority
Pastoral regeneration (grazing, fire)	1.4 Mt C 5.2 Mt CO_2-e			Some action already under Gascoyne Murchison Rangelands Strategy	Nature conservation values	May not fall under 3.3 – need to consider under 3.4			Low	
Encourage use of carbon friendly products in building	0.09 Mt C 0.33 Mt CO_2-e	<1%				Creates avoided emissions in the energy sector			Medium	
Bioenergy										
NGS 6.4 sustainable use of managed forests	small changes cf 1990 baseline					Not included in Kyoto actions at this stage except to determine trigger under 3.7			Medium	
NGS 6.9 Agricultural management practices										
Animal husbandry/ rumen fermentation	0.8-1.0 Mt CO_2-e 0.03 Mt Dairy 0.15 Mt Beef 0.4 Mt Sheep	2%	\$35 \$100		Environmental Production efficiency				Low	
Grazing/pasture management	.02-.05 Mt CO_2-e (Dairy) 0.1-0.2 Mt (Beef) 0.2 Mt (Sheep)	<1%	\$0-\$40		Pasture quality Reduced grazing Area per head				Medium	
Effluent disposal	0.02 Mt CO_2-e		–						Medium	

7. Cost benefit analysis of amelioration and sink measures (continued)

Measure	Range of CO_2 benefit 2008-2012	% of WA 1990 gross emissio (51.3 Mt CO_2-e)	Range of expected costs	Additionality of carbon credits in financing the mechanism	Collateral benefits	Risk/certainty under Kyoto	Implementation issues incl verification	Priority for national COP negotiations	Capability	Final priority
Land clearing limitations	Avoided emissions of 4.0 Mt CO_2-e cf 1990 baseline	8%				Counted unless 3.7 trigger does not apply	Opportunity cost for farmers		High	
Conservation cropping/tillage	1.85 Mt CO_2-e	4%	Minimal/ no regrets	Higher yields, reduced costs	Soil structure, land care	Low risk	Already occuring, indiv. farmers. Verify through ABS 5-yr surveys		High	
Energy use in agriculture	Covered in energy sector									
Crop management (fert, rotation mgt systems, crop residues, yields)	2 Mt CO_2-e	4%	Minimal/ no regrets	Higher returns	Improved yields, exports	Low risk	Verification difficult, surveys required.		Medium	
Awareness/ education for farm managers									Medium	

8. RECOMMENDATIONS REGARDING PRIORITIES AND POLICY IMPLICATIONS FOR WESTERN AUSTRALIA

The land use, forestry and agricultural sectors are, in general, already controlling their greenhouse gas emissions. Comparisons between the 1990 and 1995 National Greenhouse Gas inventory show that emissions due to land use change (through clearing) are declining, the forestry sector shows increasing negative emission rates and in the agricultural sector, although emissions rates rose, the increase was very small and its overall percentage contribution to Australia's greenhouse gas emissions declined significantly. Furthermore, many of the measures to reduce greenhouse gases relating to changes in agricultural practices are already occurring to some degree.

Western Australia has the capacity for creating large new greenhouse sinks, and the institutional and social framework in which to achieve them. It is also recognised that increased areas of perennial woody vegetation will deliver a number of collateral environmental and economic benefits to the State, so a high priority should be placed on establishing perennial vegetation projects in targeted areas.

The following activities are considered by the Sustainable Land Management Technical Panel to be the priority actions in this sector:

- Encouraging increased planting programs of suitable crops with commercial potential such as Maritime Pines, Bluegums and Oil Mallees
- Providing greater incentives to revegetate areas with non-commercial species ("landcare" plantings), which provide additional benefits such as biodiversity and salinity control.
- Increased protection of native remnant vegetation, not only by fencing it but also through strategic planting of vegetation to provide greater buffer zones and reduce the risk of vegetation loss through salinity. This may be possible through the expansion of the Remnant Vegetation Protection Scheme.
- An extensive awareness-raising campaign for the rural community on greenhouse gases. This is particularly important due to the possibility of a system of carbon credits being introduced. There will be significant risk-management and transaction-cost issues to be addressed, requiring coherent governance. The Soil and Land Conservation Council, as the State's peak landcare body, could take responsibility for developing and implementing such a communication campaign.
- Greater emphasis on extension work on "best practice" that have beneficial effects on greenhouse emissions, taking into consideration a "whole system" approach. This includes encouraging the most efficient

forms of cropping, including no-tillage practices, and improved pasture management practices, which will increase the store of organic matter in the soil and help reduce methane emissions from livestock (improved feed quality).

- Revision of policies concerning destocking of pastoral leases by the Pastoral Lands Board and adoption of "best management" practices including feral animal control and reduced fires, to allow greater flexibility in situations where there are alternative land uses (such as tourism or mining), as long as any policy was flexible enough to allow restocking when conditions allow.
- Research on the optimal management conditions of WA's savannas to ensure that fire is used in the most effective manner and areas not needlessly burned, or burned by hot fires that release larger amounts of greenhouse gases into the atmosphere. This should be coupled with training people in contemporary fire control and best practice land management methods, including incorporation of traditional knowledge systems.
- A mechanism will need to be developed to ensure minimal transaction costs in any emission trading system to allow areas of vegetation on individual properties to be counted.
- A mechanism will also be required to allow revegetation activities that are currently occurring (for example, through the Salinity Action Plan), to be counted if and when an emission trading system is implemented.

9. SUGGESTIONS FOR NEGOTIATION PRIORITIES

The Sustainable Land Management Technical Panel considers the following areas have a high priority in negotiations at the Commonwealth and international levels:

- A definition of plantations and reforestation is needed that will accommodate the circumstances of relatively recent clearing in Australia.
- Accounting guidelines are required to allow the emissions from harvested wood products to be accounted at the time and place in which the emission (decay) occurs.
- A larger carbon credit will help build the economic viability of new tree crops and help control land degradation. It is therefore recommended that in Australia's negotiations, this issue be pursued with vigour.
- It will be important for both the State Government and the Commonwealth to promote the conditions which will foster the early establishment of greenhouse sinks in order for them to contribute significantly to Australia's targets under the Kyoto Protocol. Unless vegetation is established quickly, growth rates will not be significant by the start of the first commitment period in 2008.
- It is imperative the Australia's 1990 base line is accurately verified and set as quickly as possible.

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APPENDIX I

EXTRACTS FROM THE NATIONAL GREENHOUSE STRATEGY RELEVANT TO SUSTAINABLE LAND MANAGEMENT

Module 1 Profiling Australia's Greenhouse Emissions Pattern

The strategy will require States to develop further their inventory and forecasting capacity and contribute to the development of internationally acceptable guidelines on carbon accounting. Specific strategies include:

1.3 *Reducing the uncertainties in the inventory:* Improvement in the accuracy of estimated emissions and removals by sinks in the inventory. An area of high uncertainty in Australia is the land use change and forestry sector.

1.4 *Reducing uncertainty in the land use change and forestry sector:* Improving methodologies and accurately determining carbon sequestration rates, in particular the rate and location of clearing, the size of the above and below ground carbon pool and determining variation in response to management.

1.7 *Emissions projections:* Coordinate preparation of greenhouse gas emission projections through a working group.

> WA's strategy in this module should be to work with the National Carbon Accounting System; undertake targeted survey work; and participate in developments at the Commonwealth level.

Module 3 Partnerships for Greenhouse Action: Governments Industry and the Community

3.9 *Emissions trading* To enhance Australia's carbon sink potential, the development of an emissions trading system will need to consider linking vegetation and forestry programs through a credit purchasing system.

> WA's strategy in this module should be to encourage early action at the Commonwealth level; and investigate facilitation at the local level.

Module 6 Greenhouse Sinks and Sustainable Land Management

Enhancing Greenhouse Sinks:

6.1 *Plantations and Farm Forestry programs* The Strategy proposes to facilitate reforestation elements of existing initiatives such as the Plantations for Australia – The 2020 Vision, Farm Forestry program and the National Forest Policy Statement by:

- removing impediments to commercial plantations, assessing the availability of suitable land, supporting plantation establishment and encouraging investment in plantation-based industries;
- identifying situations and regions best suited to farm forestry and providing information to those landholders on: the benefits of forestry as an agricultural pursuit; the range of incentives and concessions available to producers; and suitable markets and market intelligence;
- expediting farm forestry through appropriate Commonwealth and State programs and initiatives (e.g. Natural Heritage Trust, regional plantation committees) in association with industry;
- supporting the expansion of regional plantations and farm forestry resources on land that has been cleared in the past for other purposes and of timber industries by using structural adjustment packages (e.g. Forest Industry Structural Adjustment Package) and an appropriate facilitation mechanism (e.g. regional planning committees) for the purposes including timber supply, non-wood forest products, and ground water recharge;
- facilitating small forest grower cooperatives and similar marketing arrangements (e.g. through extension programs);
- undertaking product and market development research for timber and non-timber forest products;
- supporting the recognition of carbon sequestration in plantations and wood products.

WA's strategy in this area should be to lobby for greater encouragement for plantation and other sink development; work to create conditions and markets to encourage private investment; develop centrally funded partnership programs linked to the State Salinity Action Plan to demonstrate viability and the ability for plantations to work as sinks.

6.2 *National revegetation programs* Implementation of national revegetation programs including Bushcare – the National Vegetation Initiative, the National Landcare program and extension programs will be accelerated. Packages will be developed, including those which:

- encourage on-farm tree management plans to promote revegetation of cleared land, improved management of existing perennial vegetation (trees and pasture), and an increase in the area of deep-rooted perennials;
- encourage retention and management of native vegetation for benefits including shelter, amenity and groundwater recharge control and, where applicable, for commercial non-timber products;
- supporting the recognition of carbon sequestration in revegetation activities.

WA's strategy in this area should be to work with the NHT.

6.3 *Bush for Greenhouse* To promote investment into the establishment of greenhouse gas sinks, in particular, by facilitating corporate funding of revegetation projects.

The WA Landcare Trust has been set up to facilitate corporate funding of revegetation projects.

Encouraging Sustainable Forestry and Vegetation Management:

6.4 *National principles for sustainable native vegetation management and retention:* To reverse the long term decline in the quality and extent of native vegetation cover.

6.5 *Giving effect to national principles for sustainable native vegetation management and retention:* Guidelines and policies to give effect to the national principles established through measure 6.4. Interpreted and implemented at a regional level, recognising existing State and Territory guidelines and statutory processes, and involving:

- encouraging primary producers and landholders to take account of greenhouse issues as well as land capability, agricultural suitability, biodiversity and other sustainability issues in making decisions and/or applications for land clearance.
- review of policies to clarify and standardise the incentives which are available and most appropriate for use by primary producers and land holders.
- other mechanisms such as funding, covenants etc.
- recognition of carbon sequestration in sustainable native vegetation management.

WA should continue to provide input into the development and implementation of these national principles.

6.6 *Forest sustainability indicators:* Incorporate forest sustainability indicators and criteria developed under the international Montreal Agreement process.

WA should continue to work through the Regional Forest Agreement.

6.7 *Sustainable management of private forests* Encourage management of private forests on a sustainable basis through inventory, codes of practice and education.

6.8 *Forest products as a carbon store* Long-term storage of sequestered carbon is enhanced if harvested timber is used for long-lived timber products, and when sawmilling and other forest waste is minimised. Measures to increase the utilisation of forests as a carbon store include studies to increase the production of forest products as a carbon store and promoting the production of value-added wood fibre products.

WA should continue to lobby strongly at the Commonwealth level.

Reducing Greenhouse Gas Emissions From Agricultural Production:

6.9 *Incorporating consideration of greenhouse issues into agricultural management practices* Sustainable agricultural management practices, which deliver reductions in net greenhouse gas emissions, will be promoted through the delivery of programs addressing the following issues:

- opportunities for reducing energy use in agricultural production;
- conservation cropping;
- opportunities to improve animal husbandry;
- manure management and the use of biogas and other technologies by intensive animal industries;
- reduction of biomass burning (noting that further research may be required to determine the most appropriate practices in different regions, and that reduced burning is not always an appropriate strategy for all areas in Australia – with burning needed for strategic reasons such as wildfire management).

Particular issues to be encouraged and promoted through measure 6.9 include:

- Reducing energy use in agricultural production – eg expanding the use of minimum tillage and traffic management techniques (precision farming); expanding the use of renewable energy on farms, particularly in remote locations; introducing farm energy budgets; re-using agricultural waste especially for on-farm applications; accelerating replacement of old machinery with newer more energy-efficient equipment; promoting the use of alternative fuels.
- Conservation cropping including minimum tillage and controlled traffic; significant reduction of cultivated/bare fallow; direct drilling; ley systems and crop rotations; stubble retention; strategic use of inorganic fertiliser and legumes; use of deep-rooting plants.
- Improving animal husbandry through improving feed conversion efficiency through breeding and culling programs; farm management practices including supplementary feeding, herd health, improved pastures, optimal stocking rates and feedlotting (depending upon net feed conversion efficiency); farm management practices which promote stocking rates that minimise the risk of degrading pasture cover, root material and soil carbon; consideration of alternative and new animal species for production.
- Reduction of biomass burning including adoption of green cane harvesting; strategic native pasture management and practices including stocking strategies; stubble mulching and conservation tillage practices in cropping industries; increased strategic management of woody weeds; alternative use of crop residues (eg. cane trash for mulch etc).

Management practices which enhance soil carbon will be promoted.

> WA's role in this strategy should be to continue to promote "best management practices" at the farm level and work with catchment and landcare groups to facilitate greater adoption of these practices.

6.10 *Development of policies for sustainable land management* Considering the findings of the Industry Commission Inquiry on Sustainable Land Management including (but not be limited to) taxation incentives, interest reductions, rate relief, financial institutions, cross-compliance, rewards/recognition and penalties/legislation.

> Investigation into the potential for legislative change to facilitate faster change.

6.11 *Rumen modifier research* CSIRO to continue work to develop and make commercially available a vaccine inhibiting the production of methane in the rumen of livestock.

Module 8 Adaptation Strategies for Climate Change

In a changing climate, various sectors may experience significant impacts. In sectors such as forests or agricultural production, plant species will be reacting to direct and indirect effects caused by climate change, and by rising atmospheric CO_2 concentrations.

Several key sectors or areas have been identified as sensitive to the direct effects of climate change including coastal and marine environments and resources; agriculture (including agricultural pests and diseases); biodiversity; forests; and human health (e.g. through vector-borne diseases).

8.4 *Assessments to assist the development of sectoral adaptation strategies* As part of the national framework for adaptation to climate change, adaptation strategies will be developed for identified sectors.

8.6 *Improving use of climate forecasts and climate change scenarios in agriculture*

8.7 *Adaptation strategies for biodiversity conservation*

8.8 *Adaptation strategies for forests*

> WA should maintain consideration of the potential for climate change in all planning.

APPENDIX II

POTENTIAL USE OF WOOD PRODUCTS IN THE BUILDING INDUSTRY

Greenhouse effects

i) *Carbon balance during manufacture*

The FWPRDC(1998) report recognises that:

- Steel making liberates 2 tonnes CO_2 for each tonne of steel produced (depending on the fuel used in electricity generation).
- Timber stores 15 times the amount of carbon that is released (as CO_2) during it's processing (manufacture). Steel and aluminium store none.
- A steel framed house required products with a combined emission of around 3.5 tonnes carbon but a timber framed house can store 3.1 tonnes carbon.

Table 15. Carbon released and stored by building materials during their formation.

Material	CO_2 Released (kg/t)	CO_2 Released (kg/m³)	CO_2-e Stored (kg/m³)
Rough sawn timber	30	15	250
Steel	700	5,320	0
Concrete	50	120	0
Aluminum	8,700	22,000	0

ii) *Energy use*

The energy levels needed to obtain, process and produce building materials are well documented.

Table 16. Fossil fuel used in the manufacture process

Material	Fossil Fuel Energy (MJ/kg)	Fossil Fuel Energy (MJ/m³)
Rough sawn timber	1.5	750
Steel	35	266,000
Concrete	2	4,800
Aluminum	435	1,100,000

Generally speaking the manufacture of sawn timber uses 10-30% of the energy needed to make steel and 6% of the energy needed for aluminium.

There will be significant greenhouse gas emission reductions through use of timber products particularly given the fact that much of the energy usage in drying sawn timber is from waste materials rather than fossil fuels.

iii) *Emissions during manufacture*

The FWPRDC(1998) report also suggests that during the manufacturing process timber products contribute lower emissions of CO_2, CO, SO_2 and volatile organic compounds than for steel.

Whilst timber produces more weight of solid wastes than steel some of these wastes can readily be used in the manufacture of other wood panel based products such as particleboard or used as fuel.

iv) *Recycling of products*

Many wood products can be recycled into furnish for wood panels such as particleboard. This can be powered by other wood wastes such as bark.

Steel and aluminium can also be recycled but the costs are higher and the process will again emit additional gases.

Opportunities for substitution in WA

Total number of building commencements for the five year period 1994 – 1998 averaged 14,500 per annum. BIS Shrapnel (1998).

The March Quarter 98 WA Housing Industry Association data for private sector houses gives a breakdown by building material.

Material of Outer Wall		Material of Floor	
Double Brick	89.0%		
Brick Veneer	5.2%	Concrete	98.0%
Timber	2.4%	Timber	1.8%
Cement Fibre	1.6%	Other	0.2%
Steel	1.1%		

i) *Substitution of steel framing*

NAFI (1998) suggest that the average NSW house contains the following:

	Timber Frame	Steel Frame
Frame Only	13 m³ wood	5 tonnes steel
Total House	21 m³ wood	6.7 m³ wood
Total CO_2 stored	9.7 tonnes	3.1 tonnes (wood only)
Total CO_2 released to atmosphere in production	2.2 tonnes	6.0 tonnes
Balance of CO_2	7.5 tonnes stored	-2.9 tonnes stored

Assuming a similar average house size in WA there is a saving of 10.4 tonnes CO_2 with the replacement of every steel framed house with timber framing. It is difficult to distinguish the total number of houses with steel vs timber framing for the internal walls and so meaningful estimates of CO_2 savings are difficult. It is assumed later in the report that approx. 10% of all house frames are of steel.

As a general comment for every 1000 steel framed houses substituted with timber frames there will be an additional saving of 10,400 tonnes CO_2.

ii) Substitution of concrete floors

The NAFI (1998) data suggests that on average there is 0.46 tonnes carbon stored for every cubic metre of wood used in house construction.

This means that for every concrete floor substituted by a timber floor there will be a saving of 3.1 tonnes carbon per house.

iii) Substitution of double brick walls

WA has an almost exclusive reliance on double brick outer walls in housing. Again, using the NAFI (1998) data, and assuming 40% of the timber frame was used in the outer walls and 40% was used in the roof, there would be an additional 5.2 m^3 of wood used to replace the double brick. This equates to a carbon saving of 2.4 tonnes per house.

iv) Potential carbon saving in house construction

Using the WA HIA data the complete replacement of double brick and concrete and steel construction to at least brick veneer and timber standard will yield the following carbon saving:

12,900 double brick houses per year @ 2.4 tonnes	= 31,000 tonnes CO_2
14,200 concrete floors @ 3.1 tonnes	= 44,000 tonnes CO_2
10% steel = 1450 @ 10.4 tonnes	= 15,000 tonnes CO_2
Total saving	= 90,000 tonnes per annum.

Costs of substitution

It is estimated that a brick veneer house in Western Australia costs approximately ten per cent more than double brick, roughly $9,000 on an average house cost of $90,000.

Particleboard or timber floors are roughly 15-20 per cent more expensive than concrete floors, an increase of $2700 on an average house.

However, timber floors in two storey houses cost roughly $1000 less than those with concrete upper floors.

APPENDIX III

RECORDING LANDCARE ACTIVITIES

Scope

The project area, some 250,000 hectares, covers five Land Conservation District Committees (LCDCs) and one separate landcare group. The LCDCs are further subdivided into a total of about 40 catchment groups.

The project has multiple aims. As well as recording landcare works, the data is used to monitor the results of different funding initiatives, and the recording maps are used as planning tools for the next year's landcare projects. The project helps maintain group enthusiasm for designing and implementing integrated landcare projects.

Format

GIS maps, with associated data stored in spreadsheets. The maps show:

- roads,
- water bodies,
- drainage lines (natural and constructed),
- property boundaries,
- remnant native vegetation,
- fences to protect remnant vegetation,
- four classes of revegetation:
  - "streamlining" – narrow strips along watercourses and drains,
  - "multi-function revegetation belts" – windbreaks, wildlife corridors, etc,
  - "alley farming" – rows of trees with grazing or cropping between,
  - "tree lots" – larger belts or blocks of trees.

Data recorded for each project include the year of revegetation and the funding source.

Method

1. Maps (1:33,333 scale) are distributed to LCDCs in November.

2. Catchment group members correct any errors (or establishment failures) in previous data, and draw the latest planting year's information on the map, using memory, funding applications, and aerial photos as sources of information. Planting boundaries are estimated rather than measured.

3. Agriculture Western Australia officers update the GIS maps and the linked information in spreadsheets.

In this recording project, the boundaries of revegetated areas are estimated, not measured. If more accurate data were needed, GPS technology could be used to map revegetated areas, or remote sensing could be used once the plots were old enough to be detectable.

Costs

The project took 50 days of a project officer's time to set up, and takes a further 40 days per year to maintain, or about one day per catchment group (not counting unpaid community input).

The area of revegetation recorded since 1992 is about 900 hectares, out of a total area of about 250,000 hectares.

Although the cost of record keeping appears high, it is partly due to the large number of catchment groups, and the small size of most of the individual projects. The same level of effort in an area with larger farms and less groups would probably cover a much larger area.

Other projects

It is estimated that by the start of the next planting season, Alcoa will have distributed one million plants to landcare groups in the Peel-harvey region. Other regional initiatives e.g. in the Swan-Avon catchment and the Blackwood catchment have resulted in significant revegetation. The carbon sequestration from these ongoing works needs to be quanitified through the coordinating groups.