Greenhouse, Carbon Trading and Land Management

Agriculture
WESTERN AUSTRALIA

GRDC
Grains Research & Development Corporation

MURRAY-DARLING BASIN COMMISSION

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Contents

Figures

Tables

Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
AFFA	Agriculture, Fisheries and Forestry – Australia
AGO	Australian Greenhouse Office
BfG	Bush for Greenhouse
BRS	Bureau of Rural Sciences
CDM	Clean Development Mechanism
CH_4	methane, a greenhouse gas
COP	Conference of the Parties [to FCCC]
CO_2	carbon dioxide, a greenhouse gas
CO_{2e}	carbon dioxide equivalent
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCCC	Framework Convention on Climate Change
GRDC	Grains Research and Development Corporation
Gt	gigatonne (1000 million tonnes)
IPCC	Intergovernmental Panel on Climate Change
IRR	internal rate of return
LWRRDC	Land and Water Resources Research and Development Corporation
MDBC	Murray–Darling Basin Commission
MOP	Meeting of the Parties [to FCCC]
NLWRA	National Land and Water Resources Audit
NGGI	National Greenhouse Gas Inventory
NO_x	nitrogen oxides, greenhouse gases
NPV	net present value
N_2O	nitrous oxide, a greenhouse gas

Foreword

Global warming, reduction in greenhouse gas emissions, and establishment of a national carbon-trading regime are matters that have received considerable attention in Australia since the signing of the Kyoto Protocol. Australia has a unique greenhouse gas emissions profile amongst industrially-developed countries, in that agriculture, land-use change and forestry activities could make significant contributions, positive or negative, to the overall tally of greenhouse gases. Much has been said and written about opportunities for changes in land use to help us reach our greenhouse gas targets. Several commercial arrangements have already been negotiated, involving in particular reafforestation in coastal, high rainfall regions to offset greenhouse gas emissions elsewhere.

Several opportunities to reduce greenhouse gas emissions or to sequester carbon have been identified, but the status of many remains unclear. Although the Kyoto Protocol established a broad framework for managing greenhouse gases, many of its components have yet to be finalised. In Australia, we need more information on the relationships between, for example, tree growth rates, changes in land management, carbon fluxes and the economics of a possible carbon-trading regime. The problems of managing risks such as drought and fire, and the infrastructural costs of establishing legal ownership in relation to carbon property rights, must also be investigated.

At the same time, there appears to be a significant opportunity for governments to introduce a national carbon-trading regime that could also help achieve objectives in sustainable resource management, particularly those related to dryland salinity, water quality and sustainable agriculture. Given the uncertainties surrounding the Kyoto Protocol, and international and national carbon-trading opportunities, it is not clear how best to manage the relationship between carbon-trading and natural resource management.

Much work is now in progress in this area, through the Australian Greenhouse Office and by many other groups. To help unravel the uncertainties and opportunities in relation to their programs, four organisations agreed to jointly fund the study on Greenhouse, Carbon-trading and Land Management reported here. The four organisations involved are:

- Agriculture, Western Australia
- Grains Research and Development Corporation
- Murray–Darling Basin Commission
- Land and Water Resources R&D Corporation

Our organisations have a shared interest in understanding what the Kyoto framework might mean for a national carbon-trading regime, the implications for changes in land use, agriculture and revegetation, and the implications of these changes for sustainable resource management. This report analyses some of these issues. It will help us in framing our various programs, and will contribute to public debate on the topic.

Phil Price
LWRRDC

Executive summary

General conclusions

In 1998 Australia recorded its hottest year since high quality records began. Now few would doubt that global warming is occurring. The principal cause is the increase in greenhouse gases in the atmosphere, mainly from the burning of fossil fuels. Some consequences for Australian agriculture may be good and others bad. A one degree rise in average temperature can be expected by 2030, but effects on rainfall are far less certain. Most probably there will be little change. Because of increased evaporation, river flows can be expected to decrease. The effects on biodiversity are likely to be catastrophic.

To combat these changes the United Nations has been working towards a reduction in greenhouse gas emissions; the main action to date has been that most developed nations agreed to the Kyoto Protocol. The Protocol has not yet been ratified and may not be ratified in its present form. The Protocol assigns to the participating countries the amounts of emission that will be permitted in the first commitment period (2008–2012), the allocation being based on their emissions in 1990. For Australia the amount is 108% of the Country's 1990 emissions. There are various 'Articles' within the Protocol that are crucial to agriculture and forestry. Of these the most important are:

3.1 which ensures that six of the greenhouse gases are covered, including methane (CH_4) from ruminants;

3.3 which ensures that carbon dioxide (CO_2) is covered in land-use change and forestry (forestry is yet to be defined under the Kyoto Protocol and some parties are pushing for a restrictive definition) in the first and subsequent commitment periods, and allows the counting of 'sinks';

3.4 which covers other sources and sinks from agricultural soils, land-use change and forestry activities that involve CO_2 in the second and subsequent commitment periods, although the parties may elect to count these activities in the first commitment period;

3.7 which determines how emissions, sinks and the baseline will be measured;

3.13 which allows the banking of emissions credits;

6 which establishes trading of emission permits for jointly implemented projects between countries that are party to the Kyoto Protocol;

12 which establishes trading and allows for counting of carbon sequestered between 2000 and 2012, between signatories to the Kyoto Protocol and developing countries; and

17 which establishes emissions trading between parties.

The Australian Greenhouse Office (AGO) is responsible for advising the Commonwealth Government on international negotiations as well as on how to achieve the targets set for Australia, though the Department of Foreign Affairs and Trade is the department responsible for international negotiations. The outcome of these negotiations is not at all clear. The issue of carbon trading is a small part of these negotiations. The AGO is developing and releasing a series of four papers to cover both domestic and international trading in emission reduction units, including the specification of trading in carbon credits by accumulating carbon in biomass.

However, trading in options to buy credits has already begun and mostly involves large plantation owners (mainly state government organisations) and large emitters of carbon (mainly electricity generators). Price estimates per tonne CO_2 equivalent (CO_{2e})[1] vary from \$8 to \$48 per tonne CO_{2e}.

Australian agriculture produces CO_2 and CH_4. Smaller amounts of other gases such as nitrous oxide (N_2O) and nitrogen oxides (NO_x) are also emitted. The livestock sector is the biggest agricultural producer of greenhouse gases, and is responsible for 14% of the total emissions in Australia. These emissions largely consist of CH_4, which is produced by fermentation processes in the digestive systems of ruminant animals such as sheep and cows. CH_4 is significant because it has twenty-one times the greenhouse warming potential of CO_2. Broadacre

1. Permits are likely to be issued to allow the emission of a number of tonnes CO_{2e} to the atmosphere for those who burn fossil fuels. This emission assumes that the CO_{2e} stays in the atmosphere forever. So the expectation is that permits will be issued to those who sequester carbon for the same period. For those who plan to sequester for only one year, an approximate estimate of the value can be obtained by multiplying the current market price by 0.0182.

cropping also contributes to the emission of CO_2, N_2O and NO_x by facilitating the breakdown of organic matter in the soil.

The clearing of forests and woodlands for agricultural purposes, which results in the decomposition of trees, shrubs and soil organic matter, also releases CO_2 and NO_x.

Agricultural emissions can be reduced by minimum till, the removal of herbivores, the prevention of fire and the establishment of woody vegetation. The removal of ruminants has the double benefit of removing both herbivores and a source of CH_4. The development of anti-methanogens may also contribute to a reduction in CH_4 emissions. The National Greenhouse Gas Inventory (NGGI) reports that 57 million tonnes of CO_{2e}[2] were emitted by ruminants in Australia in 199, so major reductions in greenhouse gases from a reduction in ruminant numbers are quite possible. This reduction could be made a tradable item.

To make money from the sale of carbon credits from growing trees (carbon farming) landholders need to know the rate of tree growth (biomass accumulation), which varies with a number of factors, particularly with rainfall. They also need to know the costs that are incurred by selling carbon credits in small parcels as well as the monitoring costs to determine how much carbon is present and how much that changes. The authors' experience suggests that these are likely to be very high, especially in non-uniform, mixed species stands.

Plantations of trees grown mainly for the sale of product are expanding rapidly close to certain ports. These include Albany in Western Australia, Portland in Victoria, Bell Bay and Burnie in Tasmania and Gladstone in Queensland. The Commonwealth and state governments are encouraging this process—at the Commonwealth level by two programs: Plantations for Australia—the 2020 Vision and the Farm Forestry Program. The major cause of this expansion appear to be an increasing demand for wood and paper products in Asia and taxation incentives, such as the superannuation surcharge, in Australia.

Successful investment in Australian plantations requires, among other things, a knowledge of growth potential, of the costs of harvesting and transport, of taxation issues, of when to harvest to maximise returns, of how to produce high quality product and sell at a good price, and of the costs of establishment.

There are considerable risks in pursuing carbon credits as a form of income, especially if this pursuit is not associated with the sale of timber products. Carbon credits may increase the return from plantations, but only by a small amount, depending on the price of carbon, and they may affect plantation management. This increased return may encourage landowners in high-rainfall areas to replace some land currently used for ruminant grazing with plantations. Carbon credits will also be keenly sought by those who own land for non-consumptive purposes (eg. hobby farmers) around major cities and along substantial parts of the coast. Ruminant grazing is considered by many to have caused considerable land degradation.[3] Trees are normally associated with the build up of soils, so where plantations replace ruminant grazing it would be expected that soil depth would increase, rather than decrease.

Carbon farming in the wheatbelt as a stand-alone activity is certain not to be viable. In conjunction with other activities that are already profitable (and this is unlikely to include just timber), carbon credits may provide an additional benefit. Our calculations suggest that carbon farming, even in conjunction with timber, will not compete with cropping and is therefore unlikely to contribute to sustainable land management. This is partly because biomass accumulation rates and the value of timber are low (long distances to processing facilities), and partly because the transaction and monitoring costs per tonne of carbon sequestered are expected to be high.

In the rangelands, the transaction and monitoring costs per tonne of carbon sequestered will also be high and the rules of the Kyoto Protocol will have to be stretched considerably to make carbon credits allowable from the increases in the quantity of rangeland vegetation. There are also questions about the effect of biomass accumulation in areas traditionally managed by Aborigines, on species adapted to frequent fire regimes and about whether fire can be adequately controlled in tropical Australia to allow biomass accumulation at all.

Response to terms of reference

The terms of reference for this study and the authors' responses are detailed below.

> Review the key elements of the Kyoto Protocol, and the Australian Government's greenhouse package described in Safeguarding the Future: Australia's Response to Climate Change. Analyse the implications and opportunities these present for future land management in Australia, including:
>
> - changes in land use

2. CO_{2e} (CO_2 equivalents) is used to signify that the unit covers all the greenhouse gases

3. See for example Lines, W.J. (1992) 'The Taming of the Great South Land: A History of the Conquest of nature in Australia' Allen & Unwin, North Sydney.

- revegetation programs, whether for commercial tree crops and products, or for multiple objectives (eg. including natural resource management);

- revegetation programs, whether for commercial tree crops and products, or for multiple objectives (eg. including natural resource management);

- the potential, if any, for carbon credits to be earned or traded from emission reductions achieved through changed agricultural production or practice (e.g., residue retention, pasture improvement), and the potential amounts of carbon, the practicality of verification and the need for farm-level records and audit; and

- opportunities for carbon trading to be used to support revegetation and other activities to combat resource degradation due to salinity, soil acidification, river/riparian deterioration.

At the prices that can be expected for sequestering CO_2 in trees, the analyses in this report suggest that neither the Kyoto Protocol[4] nor the greenhouse package will have major effects on land use. The beneficiaries of carbon credits are likely to be timber plantation owners in high-rainfall areas, principally the 'larger players', who are already changing land use for other commercial reasons. These include projected shortages in the supply of timber products in Asia, changes in taxation, particularly the superannuation surcharge and government programs aimed at expanding the plantation timber industry. Carbon credits may add a very small amount to the timber income (see Section 7 of the report).

Complex models are needed to look at multiple objectives and the interaction between trees and other landscape elements. This was beyond the scope of the study. Some models are being constructed, but are not yet available. In direct comparisons, carbon farming looks much less profitable than existing enterprises (see Section 7). Bush for Greenhouse (BfG), which is part of the Australian Government's greenhouse package, is a small program with objectives that will be difficult to achieve. It is hoped to encourage the private sector to provide funds for planting trees to preserve biodiversity and achieve sustainable land management, with the promise of carbon credits should trading commence. For those who wish to buy carbon credits in advance in the form of trees, other investments appear to be more attractive. In addition, considerable subsidies will be necessary to make carbon farming attractive to tree growers (see Section 3.1.2 and Section 9.2.3).

The costs of selling and measuring carbon credits in the form of trees appear to be high enough to cancel out most of the income that may come from carbon farming. With the possible exception of ruminant removal, other forms of carbon retention from changed agricultural production will almost certainly have even higher selling and monitoring costs (see Section 4).

Ruminant removal, on the other hand, is easily verified and would amount to a substantial reduction in methane and CO_2 production and is worth further investigation (see Section 9.2.1).

1. Quantify the impacts and opportunities as far as possible, for example by area affected, economic values of costs and benefits. Develop a ranking of issues and opportunities from the perspectives of sustainable land and water management and agricultural production. Project the potential impacts of carbon trading and major land use change, particularly through revegetation, on the value and composition of agricultural production by State and/ or major agricultural region.

With the exception of plantation forestry, which is displacing some high-rainfall grazing industries, few effects are expected on Australian agriculture from the introduction of carbon trading and therefore no ranking of issues has been performed.

2. Identify clearly what steps need to be taken to ensure that development of a carbon trading regime in Australia takes account of these implications and maximises opportunities to achieve multiple objectives for land management. This could include provision of detailed information into the regime development process, direct involvement by organisations active in land management and further R&D on specific topics. The consultant must identify the key priorities and what organisations are best placed to progress them.

The steps proposed fall into three areas: studies to support policy issues, policy interventions and improving physical and biological knowledge.

Studies to support policy issues

The National Dryland Salinity Program, assisted by the National Land and Water Resources Audit (NLWRA), is the main coordinating force in attempting to resolve how to manage dryland salinity in the Australian landscape. To resolve how carbon credits, or any other program to grow trees for salinity control purposes will affect salinity, a few general bioeconomic models would help. We understand that at least one has been developed at the University of Western Australia with the support of the GRDC. These models can also be used to examine in more

4. The authors have distinguished between what the Kyoto Protocol states will occur should it be ratified and what governments may do (including making land clearing more restrictive, or imposing a carbon tax) to achieve the targets set. Only the former has been considered, with particular emphasis on carbon credits and carbon trading as it affects land use.

detail the interaction of prices for carbon, mallee oil and any other wood-based product from a land use which is mainly intended to rectify land degradation. R&D organisations would be the best organisations to support further work.

Policy interventions

The AGO and the Greenhouse Section of the Natural Resources Management Policy Division of AFFA are currently discussing the items to be raised for international negotiation. The AGO also invites submissions on the four papers that it is producing on National Emissions Trading. It also has two discussion groups on these issues, an 'Experts Group' and an 'Industry Group'. The National Farmers Federation and the National Landcare Facilitator have seats on the latter. The issues that need to be put on the table for agriculture include:

1. the current definition of forests to be greater than 20% cover and greater than 2 m high (this considerably limits the application of Article 3.3 to Australian vegetation).
2. forms of biomass, both native vegetation and weeds (natural vegetation, rangelands, etc.) which do not satisfy the current definition of forest, or do not meet the definition of 'additionality';
3. removal or modification of ruminants, and
4. other items from the list in Section 3.1.1.

These will only constitute tradable credits if methods can be developed to reduce transaction and monitoring costs to a level that allows a profit margin to the landholder. In the authors' opinion few items are likely to be added to the tradable list. For example we do not consider it likely that changes in soil carbon caused by minimum till are ever likely to become a tradable item. Ruminant removal seems to be the best possibility.

It is not at all clear what agencies other than AFFA and the AGO should lobby for policy interventions. The National Farmers Federation is a member-based organisation, so a number of members would have to become interested in policy interventions before the organisation as a whole would act. The conservation lobby groups believe that carbon trading should not be permitted, since its existence distracts from the hard decisions of reducing the burning of fossil fuel.

Discussions with lawyers and others suggest that selling costs are likely to be very high for small parcels of carbon credits arising from farm plantations. There are methods that would reduce these transaction costs, including the setting up of a central register, the development of local cooperatives, or other special organisations to consolidate regional sales of carbon credits. It is our opinion that far cheaper and less accurate methods of vegetation monitoring than those proposed in the 'Greenhouse Challenge Vegetation Sinks Workbook' are needed. We argue in Section 5.3 that the buyer needs a guarantee that the carbon present is certainly more than the amount sold. There are many methods that might be developed, including visual estimation by experienced evaluators, aerial photography, and the methods being developed for the NGGI. Efforts to reduce transaction and monitoring costs should be a part of any BfG research program and should be funded by the AGO.

A number of possibilities could be envisaged in a domestic trading scheme, especially in overcoming some of the restrictions that the Kyoto Protocol articles impose on the development of credits for the protection of remnant vegetation and plantings for biodiversity and sustainable land management. But what is needed for domestic trading initiatives is totally dependent on what is included in and excluded by the Protocol. The negotiations that are scheduled to be completed at COP6 in December 2000 (See section 2.5) will determine what is contained and not contained in the Protocol. It is therefore too early to start discussing Australian domestic rules for carbon credits.

Improving physical and biological knowledge

Through BfG the AGO appears to be planning to support the following work program:

- establish a process for measuring and verifying the amount of carbon sequestered;
- develop data collection standards/protocols;
- develop cost-effective tools and methods to assist in measuring and verifying carbon sequestration of environmental plantings (including soil carbon);
- develop a system to manage carbon sequestration data from environmental plantings to support and link with the National Carbon Accounting System;
- establish the balance between the best methods for site preparation that promote plant growth and maximise carbon sequestration; and
- recommend material/workbooks for broad distribution to those interested in carbon sequestration in native vegetation.

So this area of activity can be left to the AGO and BfG to finance.

Tree planters in low-rainfall areas need to know a lot more about the quantity and quality of water that will be available to a plantation in any particular location. This will allow better decisions to be made on where to plant trees for best effect, how quickly and from where water is likely to be removed, and how much carbon is likely to be accumulated over the next decade. This may arise from a project funded by the Murray–Darling Basin Commission called ‘Tools to investigate and better manage salinity’. Certainly there is expertise developing in this field.

Also, a considerable amount of effort is going into alternative forms of woody vegetation for areas unsuitable for plantation timber. Among these are oil mallees and tagasaste. These are being supported by a number of research agencies. Their role in generating carbon credits is also being investigated and does not require additional attention.

This is such a rapidly changing field that keeping up with knowledge is a major task. There are several web pages that contribute regularly to the information available but there is none that serves the rural community in the way we have attempted here. This would seem to be a worthwhile activity for the LWRRDC to develop in conjunction with the AGO.

1. Setting the scene

1.1 Global warming including climate scenarios for Australia

In 1998 Australia recorded its highest ever annual mean temperature since high quality data records began in 1910. The Australian mean temperature for 1998 was 22.54ºC, 0.73ºC higher than the average for the 1961–1990 reference period. This departure was greater than the previous highest departure of +0.69ºC set in 1988. Australia's mean minimum temperature departure for 1998 was greater than the mean maximum temperature departure, in consistency with the pattern observed in recent decades. The mean minimum temperature of 16.20ºC was 1.03ºC above the 1961–1990 average, well above the previous highest departure of +0.88ºC set in 1973. However, the mean maximum temperature of 28.88ºC was only 0.43ºC above normal, less than the highest departure of +0.85ºC recorded in 1991[5]. Few would now doubt that the world's climate is changing and that the consequences are far reaching.

1.2 Carbon dioxide and the carbon cycle

The carbon cycle (Figure 1) is fundamental to supporting life on earth. Carbon (mostly carbon dioxide, ie. CO_2) is only a small component of the atmosphere (about 0.3% or 300 parts per million, ie. 300 ppm). Plants absorb CO_2 from the atmosphere during photosynthesis and convert it to complex biological molecules (eg. sugars). Most of this carbon is returned to the atmosphere when the molecules are used in the biochemistry that sustains life (respiration). Much of the respiration occurs in plants themselves or from the animals that consume the plants. Another major route by which carbon returns to the atmosphere is via the decay of plant litter and dead wood. This occurs through a complex series of animal, fungal, microbial and chemical processes, much of it either on the surface of, or deep in the soil. Some carbon is released by fire.

A tiny fraction of the biological material does not return to the atmosphere but instead remains stored beneath the ground and is slowly converted to fossil deposits of oil and coal. In general, however, the entire process is very close to being balanced. About 60 billion tonnes (Gt) of carbon are taken up every year by plants on land and the vast majority returns to the atmosphere after spending hours to millennia in the recycling process. The overall balance fluctuates throughout the seasons, from year to year as climate fluctuates, and on very long cycles such as those associated with the ice ages.

In the past century, human activity has had an important effect on this cycle. We have been tapping the fossil deposits of carbon and releasing them back to the atmosphere very much faster than they are deposited. Every year we release to the atmosphere about 6 Gt of carbon from fossil fuels. Land-clearing activities release an additional 1.6 Gt of carbon from burning and vegetation decay. The atmosphere is a large pool of carbon (750 Gt) and is continually exchanging carbon not only with terrestrial plants but also with the oceans. Currently, about 2 Gt of the excess carbon from human activities sink into the ocean, while about another 2 Gt are absorbed by an increase in the biomass of terrestrial vegetation. So the increase in atmospheric CO_2 is about 3.6 Gt. It is this increase that is the major cause of climate change and global warming.

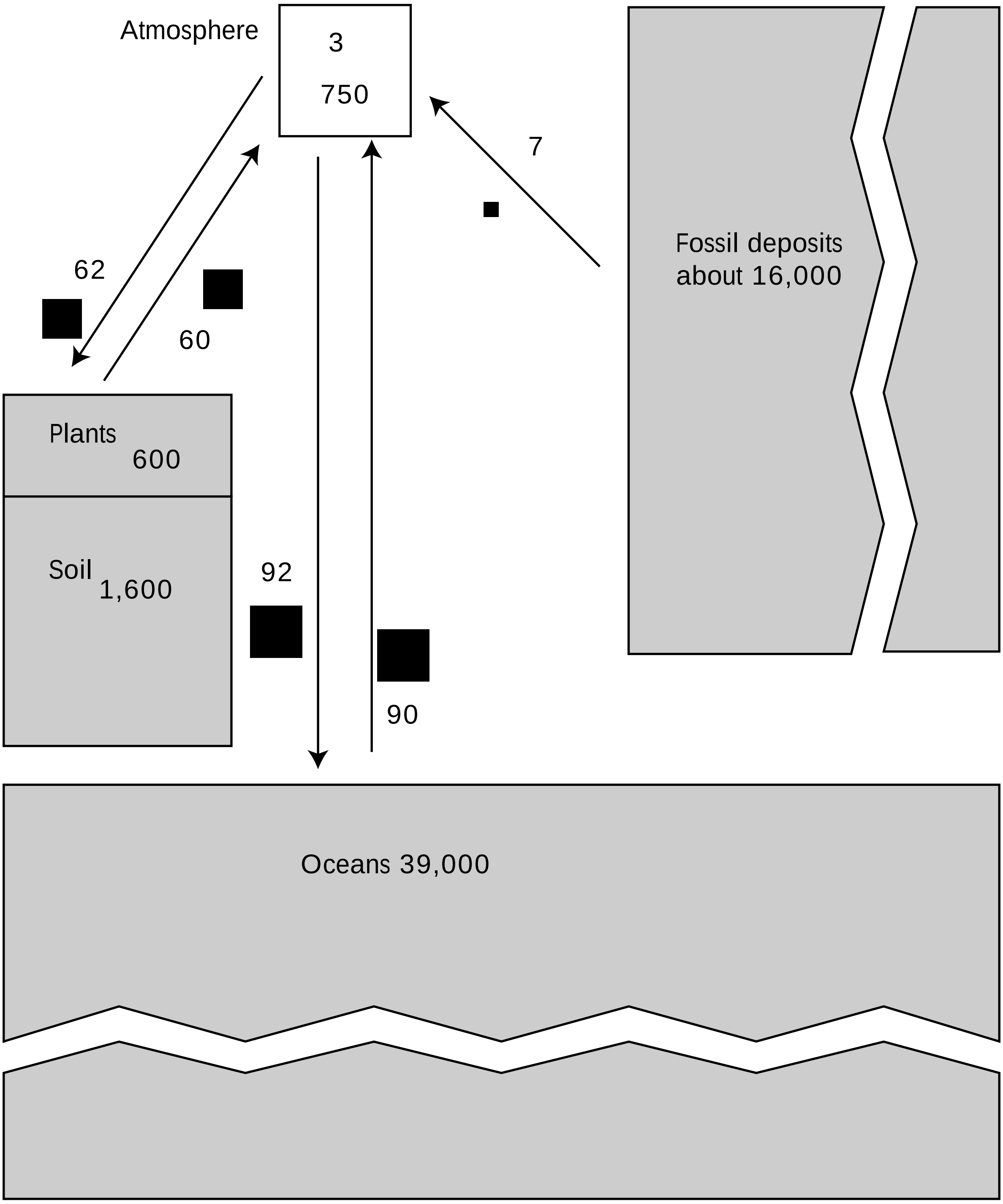
1.3 The need to do something about it

The effects of global warming on Australian agriculture and natural resources are becoming clearer. Some of the beneficial effects will be less frost damage to crops and the ability to grow cotton further south, say on the Murrumbidgee and the Murray. Some of the detrimental effects depend on more than just temperature change. Changes in rainfall and temperature will have combined effects on crop yields and river flows. The most consistent pattern for rainfall in scenarios generated by the CSIRO and others is for less rain in the south-west of Western Australia and uncertain or neutral effects elsewhere.

Very few impact studies have been carried out for Australian agriculture and natural resources. One major study was undertaken on the effects of climate change on the economy and ecology of the Lower Macquarie Valley in NSW. The CSIRO Division of

5. Bureau of Rural Sciences, Volume 11 No 1, 1999. The report is at <www.affa.gov.au/forestry/plantation-studies/ >

Figure 1. The global carbon cycle. The areas of the blocks are proportional to the carbon stored in each of the pools (the fossil and ocean blocks are truncated from their full square size) and proportional to the transfers (fluxes) between the pools. The numbers show the sizes of the pools (italics) and fluxes in Gt (1000 million) tonnes of carbon. (A cubic kilometre of water weighs a Gt.)



Atmospheric Research provided climate change scenarios for 2030. The NSW Department of Land and Water Conservation provided estimations of river flow regimes as a consequence of these scenarios. The NSW National Parks and Wildlife Service provided estimates of the effects of these changed river flow regimes on the Macquarie Marshes. Hassall & Associates estimated the effects on agriculture and produced a report which has now been published by the Australian Greenhouse Office[6]. The consequences can be summarised as shown in Table 1.

A further study partly funded by the Cotton Research and Development Corporation is now being conducted by a consortium lead by Hassall & Associates to estimate the effect of the 2030 climate scenarios on the other rivers of the Murray–Darling Basin used for cotton production (the Namoi, the Gwydir, the Border Rivers and the Condamine–Balonne).

1.4 Contents of the report

How does this relate to sustainable land management? One can envisage many ways in which land management will become less sustainable as a consequence of both a more rapidly changing climate and of actions that might be taken (such as a tax on fossil fuels) to balance the world's carbon cycle better. However, this report is concerned with one small aspect of these global changes in climate, policy and action:[7] the development of a carbon credit market and what this might mean for sustainable land management.

Section 2 of this report is a discussion of how negotiations for global action are proceeding, with particular reference to contributions that Australian agriculture can make. Section 3 explains some of the processes that are being set up to establish carbon credits as a tradable item and how the carbon credit market is developing. Section 4 summarises the agricultural and forestry practices that contribute to greenhouse gas exchange between pools in soils, biomass and the atmosphere. Section 5 discusses what rural groups and landholders need to do to get into the market. Section 6 is a diversion into plantation policy, because the development of timber plantations in high-rainfall areas is the most likely beneficiary of carbon credits, as well as contributing to sustainable land management in the region. Then Section 7 looks at four case studies of how and why carbon credits will or will not change land management in the various agricultural regions of Australia. Section 8 is a risk analysis of these options, and Section 9 proposes what current institutions should do about gaining access to the carbon credit market.

6. Hassall & Associates 1998. *Climate Change Scenarios and Managing the Scarce Water Resources of the Macquarie River*. Australian Greenhouse Office, Australia. For a summary see: <http://www.environment.gov.au/portfolio/esd/climate/fs_macq>.

7. For a recent paper on Australia's position see <http://www.isr.gov.au/science/pmseic/greenhouse.pdf>

Table 1. Effects of various climate change scenarios on the ecology and agricultural economy of the Macquarie Valley, NSW.

Change	Ecology	Agricultural economy
Temperature increase of between 0.4°C and 1.6°C.	Marsh area reduced by a further 33%.	Income reduction of between $38 M and $152 M (6–22%).
Rainfall declines of between 2 and 12%	Breeding events for colonial nesting birds reduced.	Livestock production declines of between $44 M and $138 M.
River flow declines of between 9 & 27%.	Probability of local, regional or global species extinction increased.	Cotton production varies from an increase of $2 M to a decrease of $6 M*.

* This is because studies have shown that cotton benefits from the increased temperature and CO_2 and becomes more efficient in water use.

2. The Kyoto Protocol

2.1 How international agreement on reduction in greenhouse gas emissions is being achieved

In 1988 the United Nations General Assembly adopted resolution 43/53 which recognised that climate change is a common concern to the world community. This followed a series of meetings and conferences that gradually brought scientific concerns about the effects of increasing greenhouse gases in the atmosphere to political attention. In the same year, the Intergovernmental Panel on Climate Change (IPCC) was established to provide scientific assessments of the problem and look for possible solutions.

In 1990 the First Assessment Report of the IPCC noted the inadequacy of existing legal instruments and recommended a ‘framework’ convention on climate change. The Framework Convention on Climate Change (FCCC)[8] was subsequently drafted and, at the 1992 Earth Summit in Rio de Janeiro, was signed by 154 states including Australia. One of the most important aspects of the Convention was a commitment by industrialised countries (often referred to as ‘Annex 1’ countries) to take steps to return greenhouse gas emissions to 1990 levels by the year 2000.

The states that ratified the convention are represented by the Conference of the Parties (COP) whose role it is to undertake negotiations on its implementation of the Convention. At the first meeting of the COP in Berlin in 1995, it was agreed that the commitment to return to 1990 emission levels by the Year 2000 was inadequate and that there was a need to strengthen the commitment by developed countries. Eventually in 1997, at the third COP meeting (COP3) the Kyoto Protocol[9] was agreed. As in many international conventions, the negotiations were carried out under severe time pressure and with incomplete information about the feasibility and effects of many of the points to be decided. The Protocol makes provisions for work to continue on these issues.

The Protocol is yet to be ratified. Ratification requires 55 parties to sign and they must include parties that contribute at least 55% of the total CO_2 emissions of greenhouse gases. In effect this means that the USA or the European Union can prevent ratification. Currently, the US Congress and Senate appear unlikely to ratify. However, negotiations continue and most parties, NGOs and an increasing number of multinational companies believe that it is inevitable that the Kyoto Protocol, or a modification of it, will be ratified.

2.2 Assigned amounts, the 1990 baseline and the 2008–2012 commitment period

Under the Protocol, parties who sign agree to ensure that the emissions of specified greenhouse gases do not exceed the assigned amounts. The assigned amounts, which are listed in Annex B to the Protocol, are expressed as a percentage of the base year (1990) emissions. Parties will be assessed on whether they have met their assigned amount during a series of commitment periods. The first commitment period is set down as from the beginning of 2008 to the end of 2012. It is likely, but not yet agreed, that subsequent commitment periods will be contiguous (ie. 2013–2017, 2018–2022 etc). The gap between the 1990 baseline and the first commitment period causes several accounting problems; these are raised later in this report.

The assigned amount for many countries is 92% but a number of countries negotiated targets above this level and a few below it (see Table 2). The countries of the European Union operate as a single unit within the Protocol (the ‘EU bubble’). Within that bubble many parties negotiated targets above 92%.

The Kyoto Protocol requires Australia to restrict its greenhouse gas emissions to an increase of 8% above the 1990 level by the commitment period, which extends from 2008 to 2012. Estimates of the business-as-usual increase in greenhouse gas emissions over the same period are about 30%, so there is a need to implement policies and programs to reduce the total emissions.

8. See <http://www.unfccc.de/resource/conv/index.html>.
9. For a full statement of the Protocol see: <http://www.unfccc.de/resource/docs/convkp/kpeng.pdf>.

2.3 Counting emissions and sinks

In 1996 the IPCC released its Revised Guidelines for National Greenhouse Gas Inventories. These were developed to guide countries in meeting the annual reporting requirements. They outline a series of minimum requirements and default methods that are likely to be feasible in almost all countries. The Guidelines encourage countries to use better methods and report more comprehensively on them if they can demonstrate that they are justified. In 1997 at Kyoto, these Guidelines were adopted as the basis of reporting emissions to demonstrate compliance when the Protocol comes into effect. It is clear that the Guidelines will have to be tightened and probably extended.

Table 2. Emission limitations for some Annex B countries negotiated at Kyoto

Party (= Country)	Emission limitation (or reduction commitment) (%)
Australia	108
Iceland	110
New Zealand	100
Japan	94
United States of America	93
Parties within the EU bubble	
Portugal	127
Spain	115
Sweden	104
France	100
Netherlands	94

An important, and contentious, flexibility mechanism established under the Protocol allows 'emission credits' to be traded between those who need to acquire credits and those who have reduced emissions beyond their agreed targets. This trading can occur within a country and between Annex 1 countries (often referred to as 'Joint Implementation').

Another important feature of the Protocol is the provision for 'Clean Development Mechanisms' whereby industrialised countries can receive credits in return for investing in emission reduction mechanisms in developing countries.

Rules for measuring and trading credits are set down in several articles in the Protocol.

2.3.1 Article 3 which establishes sources and sinks

A major issue before and during the Kyoto negotiations was just which sources and sinks from land-based activities should be measured in assessing compliance. The negotiators agreed to include a group of activities relating to afforestation, reforestation and deforestation (Article 3.3). The negotiators also delayed a decision on a list of additional activities relating to agricultural soils and other forestry and land-use change activities until they have received advice on whether and how such activities might be incorporated (Article 3.4). This process is continuous thanks to the IPCC Special Report on Land-use, Land-use Change and Forestry and various meetings of technical advisory bodies of the COP. The IPCC Report will be delivered in May 2000 and will be on the agenda of the COP6 meeting in late 2000 or early 2001.

Several problematic issues arise from these clauses. First, the definitions of deforestation, reforestation and afforestation have to be agreed upon. This requires a definition of a forest, which varies from region to region throughout the world. These definitions are especially important to Australia as they will determine whether Australia will have to debit emissions from clearing open forests and scrub lands; whether environmental plantings such as 'Bush for Greenhouse'[10] can be credited; and whether agricultural activities such as minimum tillage and rangelands rehabilitation can be counted.

IPCC Inventory guidelines provide interim working definitions for afforestation, reforestation and deforestation:

> **Afforestation** is defined as 'planting of new forests on land which historically has not been covered by forest'.
>
> **Reforestation** is defined as 'planting of forests on land that historically has contained forest but which has been used for another purpose since last being covered by forest'.
>
> **Deforestation** is defined as 'conversion of land from forests or grasslands to pasture, crop land or other managed uses' (ie. land-use change)[11]

The specific wording of the more important articles and paragraphs is given below:

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed

10. See Section 3.1.2
11. See <http://www.greenhouse.gov.au/>.

their assigned amounts, calculated pursuant to their quantified, emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

This article is important because it refers to all the gases listed in Annex A, which includes methane (CH_4), a major contributor to Australia's agricultural greenhouse gas emissions. It will be under this article that reduction in ruminant numbers may be countable as a carbon credit.

3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 (annual reporting) and 8 (review of annual reports).
4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice (SBSTA), data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 (a national system for measurement) and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

Article 3.7 describes the technical details about how emissions and sinks will be measured during the first commitment period, but also includes a clause often known as 'the Australia clause'. This clause makes technical changes in how the assigned amount is determined for countries, like Australia, where there are net emissions from land-based activities. The clause affects the setting of the 1990 baseline but does not affect rules governing trading.

7. In the first quantified emission limitation and reduction commitment period, from 2008 to 2012, the assigned amount for each Party included in Annex I shall be equal to the percentage inscribed for it in Annex B of its aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A in 1990, or the base year or period determined in accordance with paragraph 5 above, multiplied by five. Those Parties included in Annex I for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount.

Article 3.13 allows a party whose emissions are below their assigned amount to 'bank' those savings for subsequent commitment periods. Thus, countries in this situation can choose to either trade or bank their excess credits.

13. If the emissions of a Party included in Annex I in a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.

2.3.2 Article 6 which establishes trading for projects 'jointly implemented'

Article 6 describes the rules for trading emissions for projects 'jointly implemented' between Annex 1 countries. The important points are that sinks are specifically included; that the trading must be based on projects that would not have occurred if the trading had not been involved (ie. a so called 'additionality' clause); that the precise guidelines for accounting and reporting are yet to be decided; and that parties may authorise legal entities (eg. individuals, companies) to engage in such trading. Thus, to engage in trading in Australia will require authorisation by the Commonwealth government. This is likely to be granted but has not formally been agreed. The additionality clause, however, is important, and is described later.

Article 6

1. For the purpose of meeting its commitments under Article 3, any Party included in Annex 1 may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that:

(a) Any such project has the approval of the Parties involved;

(b) Any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur;

(c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 (A national system of measurement) and 7 (An annual inventory); and

(d) The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3.

2. The Conference of the Parties serving as the meeting of the Parties to this Protocol may, at its first session or as soon as practicable thereafter, further elaborate guidelines for the implementation of this Article, including for verification and reporting.

3. A Party included in Annex I may authorise legal entities to participate, under its responsibility, in actions leading to the generation, transfer or acquisition under this Article of emission reduction units.

2.3.3 Article 12 which establishes 'Clean Development Mechanisms' to allow non-Annex 1 countries to benefit from trading

The Clean Development Mechanism (CDM) is designed to allow non-Annex 1 countries (ie. most developing countries) to benefit from trading. It is important to note that any activity must be compatible with achieving sustainable development and that only emission reductions are mentioned. It is still unclear whether trading in 'sinks' (eg. new plantations etc.) will be allowed. Again the projects must result in emission reductions that are additional to what would have occurred without the CDM. The Protocol states that credits gained under the CDM can accrue from 2000 onwards. Again, it is unclear how the accounting will be done in this case.

The CDM is unlikely to affect land-holders in Australia. Annex 1 countries or major companies in those countries will use it to buy credits from developing countries. There is still considerable debate about how extensive trading should be, with some parties (eg. China and India) favouring very limited trading and others (including Australia) supporting the maximum flexibility.

Article 12

1. A clean development mechanism is hereby defined.

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The clean development mechanism shall be subject to the authority and guidance of the conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the clean development mechanism.

5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

10. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period.

2.3.4 Article 17 which establishes emissions trading

This clause covers trading in a general sense, rather than jointly implemented projects. In this case 'additionality' has not been mentioned and one could infer that it does not apply in these circumstances.

Article 17

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

2.4 Responses in other countries

2.4.1 USA

The United States has supported maximum flexibility in achieving Kyoto Protocol compliance. An essential component of this is emissions trading, including trading in sinks. Many US agencies have nominated trading as the most cost-effective way of achieving compliance.

2.4.2 Europe

European countries have been less supportive of the unfettered use of emissions trading. Several member states have raised the question of capping the total amount of emissions reduction that can be claimed via traded credits. The EU has accepted a 92% reduction target but this is to be achieved by the EU members as a whole (the 'EU bubble'). Different countries within the EU have different internal targets and these are not subject to international agreement through the COP process. Thus, there is much less need for EU members to trade. The use of carbon taxes to reduce emissions has also been presented as a further alternative to trading schemes.

2.4.3 Non-Annex 1 countries

There is a variety of views among the non-Annex 1 countries. Some, such as the small island states, want to limit trading, thereby increasing the pressure to make immediate progress in reducing fossil fuel emissions. Others, such as India and China, feel that trading will give an unfair advantage to wealthy Annex 1 countries.

2.5 How will the negotiations proceed from here?

The important events leading to a clarification of the opportunities for trading carbon credits include the following.

Over the remainder of 1999 the Australian Greenhouse Office will release a series of discussion papers on a national emissions trading scheme. These will be widely debated and will lead to submissions to the Commonwealth Government for its consideration.

The IPCC Special Report on Land-use, Land-use Change and Forestry will be submitted to the IPCC Plenary (the body representing all parties) in May 2000. The report will be the basis of discussions by technical advisory bodies to the COP (eg. SBSTA) during mid-2000 and will lead to contributions to the COP6 meeting in late 2000. COP6 may make decisions that will clarify just which additional activities will be allowed under Article 3.4 and possibly on the rules for accounting. However, some decisions may be delayed until 2001.

It is likely that the IPCC guidelines on reporting will be revised and enhanced starting in mid- 2000.

Thus, it is likely that the eventual scope and rules for a trading system will become clearer during 2000 and 2001.

All of this is ultimately dependent on the Protocol being ratified, which most observers consider to be extremely unlikely before the 2000 USA elections. Once the Protocol is ratified, the parties assemble as a Meeting of the Parties (MOP). The MOP is authorised to make final decisions on many issues and can consider amendments to the Protocol.

All parties are required to demonstrate progress towards meeting their commitments in 2005. This should also act as a stimulus to interest in emissions trading.

3 Making carbon a tradable item

3.1 Who determines what is a tradable item and why?

An international process to clarify the outstanding sinks issues under the Kyoto Protocol has been agreed. This process includes expert workshops, the IPCC Special Report on land use change and forestry issues and ongoing international negotiation. The process is expected to take a few years to complete.[12]

3.1.1 The role of the Commonwealth Government

The Australian Greenhouse Office (AGO) within the Department of Environment is responsible for advising the Australian Government on Greenhouse Policy in Australia. The Department of Foreign Affairs and Trade is the body responsible for international negotiations. The AGO is responsible for proposing mechanisms for trading in CO_2 permits and carbon credits. The list of items that was on the AGO web page[13] included:

- management of forested lands (regeneration intensity, fire management, harvesting practice and various other silvicultural operations);
- agroforestry (whether land originates from forest, grassland or cropland and changes in grazing patterns);
- wood products (use for energy, wood in landfills and recycling);
- soil management;
- arable land (conservation tillage, reduction of bare fallow, improved intensity of crop rotation and density, productivity enhancement, conversion to perennial crops such as pasturing systems and bush-nut-tree crops, rehabilitation through liming, revegetation, salinity/alkalinity/acidity modification and multiple use management, changes in structure such as the introduction of woody legumes and overlaps into agroforestry);
- pastoral land (reduced carbon emissions by alteration of fires and improved grazing methods, increased carbon storage by better fertility and water management and improved species in mix);
- restoration of degraded lands/prevention of degradation (management of nutrient depletion, physical degradation, biological degradation and toxic soils); and
- protection of land areas (from natural and human disturbance).
- Notably absent from this list is the reduction in methane production by reducing ruminant numbers in Australia. This is not to say that the issue of claiming credits from reducing ruminant numbers is not being investigated; only that it was not included at the time.

3.1.2 Bush for Greenhouse

The Bush for Greenhouse (BfG)[14] program is an initiative of the Prime Minister's greenhouse package *Safeguarding the Future: Australia's Response to Climate Change*. The program aims to enhance greenhouse gas sinks by encouraging greater corporate investment in revegetation for environmental purposes. In addition, the program will help government, the community, and industry to learn about and gain experience with measuring and monitoring carbon sequestration in native revegetation projects. The program has a funding of $5.5m over five years.

The revegetation projects will need technical support, particularly through the development of methods and tools to provide data on carbon sequestration that includes above-ground carbon (mixed native species of varying forms) and below-ground soil carbon. The technical support will also contribute to a better understanding within government, industry and the community about the requirements for measuring carbon sequestration.

One of the challenges for the workplan is to outline the activities that will lead to the development of cost-effective methods for measuring and predicting growth rates/carbon sequestration in mixed native species plantings.

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12. Australian Greenhouse Office, 1999 *Greenhouse Gas Sinks* <http://www.greenhouse.gov.au/>.
13. See <http://www.greenhouse.gov.au/pubs/factsheets/fs_sinks.html>.
14. This list was on <http://www.greenhouse.gov.au/pubs/factsheets/fs_bush.html>, but the contents have now changed.

Recently the Australian Greenhouse Office has advertised for a contractor[15] to fill the role of carbon broker to enhance Australia's greenhouse sinks performance through the following actions:

1. secure corporate financing for funding revegetation for environmental purposes;
2. recruit and channel funds into revegetation activities, build landholder participation, and ensure on ground works take place to best practice standards;
3. collect data on the carbon sequestration performance (including both above and below ground carbon) of corporate funded revegetation activities, and provide these data to the Australian Greenhouse Office; and
4. advise the Australian Greenhouse Office on findings and issues arising from undertaking tasks 1, 2 and 3.

At the time of writing the contract had not been let.

Given the considerable disadvantages that sellers under BfG agreements will have to overcome compared with large plantation companies, we foresee that the Commonwealth will have to devote considerable resources to reducing the costs of transaction and measurement to make BfG carbon attractive in the marketplace.

3.1.3 What is likely to be counted and when

Table 3 summarises the items likely to be included and excluded from trading.

3.2 Establishing the market

In July 1999 the AGO released the second of four discussion papers called 'Issuing the permits'. The official descriptions of these four papers are:

1. **Establishing the boundaries** – This paper, which discusses the comprehensiveness of a national emissions trading system within Australia, focuses on the greenhouse gases and sectors of the economy that could be covered[16];
2. **Issuing the permits** – This will cover issues related to the allocation of permits, including grandfathering, auctioning, and recognition of early abatement action, permit duration, and the transition toward possible emissions trading within Australia[17];
3. **Crediting the carbon** – This will discuss the design of a national emissions trading system that allows for carbon credits, including carbon sinks; and
4. **Designing the market** – This will cover issues such as permit design, measurement and monitoring emissions, reporting emissions, compliance to meet government commitment to international targets, penalties and registry of permits.

The options canvassed in the papers are intended to stimulate discussion on emissions trading. They do not represent the final views of the AGO or the Government.

The discussion papers will be widely circulated for comment to allow the AGO systematically to develop views on the establishment of an emissions trading system in Australia. In addition to inviting submissions, the AGO has two consultative groups, an 'Experts Group' and an 'Industry Group'. The National Farmers Federation and the National Landcare Facilitator are invited to meetings of the Industry Group. The AGO will then submit these views to the Commonwealth Government for its consideration.[18]

Any national emissions trading system should be:

1. developed and operated in the context of an overall policy strategy aimed at enabling Australia to achieve compliance with any international greenhouse undertaking, including the Kyoto Protocol, ratified by Australia;
2. implemented in the least cost way to the national economy and with the aim of maintaining international competitiveness;
3. implemented in a way that distributes the cost burden of the Kyoto Protocol, and any future greenhouse commitments, equitably and in the national interest, across the community;
4. compatible with an international emissions trading system so that trade can occur across and within national boundaries;
5. implemented at the most opportune time and assist in managing the risks and uncertainties facing Australia associated with the need to achieve compliance with its international commitments as they continue to evolve;
6. introduced in a way that facilitates adjustment within the economy necessary to achieve compliance with the Kyoto Protocol, and that recognises the dynamic nature of economic change and investment opportunities;

15. See <http://www.greenhouse.gov.au/ec/bushad.html>.
16. See <http://www.greenhouse.gov.au/emissionstrading/emissions_1.pdf>.
17. Released 30/6/99 see <http://www.greenhouse.gov.au/emissionstrading/paper_2.pdf>.
18. Australian Greenhouse Office, 1999, *National Emission Trading – Establishing the Boundaries* (piii) <http://www.greenhouse.gov.au/emissionstrading/emissions_1.pdf >.

Table 3. Items likely to be included and excluded from trading.

	Sellers	Buyers
Likely to be included in first commitment period	Forests under Article 3.3, those established after January 1 1990 on land which was not forested on that date.	Major emitters, especially the power and metal processing companies.
May be included in the second and subsequent commitment period	Items under Article 3.4	
Unlikely to be included	Methane from ruminants (unless there is considerable lobbying from countries like Australia and New Zealand that are likely to benefit.) Woody weeds. Stem thickening in forests with <20% cover and <2 m high.	Emissions from motor vehicles (a carbon tax is more likely on these emissions).

7. as comprehensive as possible, aiming to cover all greenhouse gases from all sources in all sectors and to incorporate carbon sinks, but adaptable in order to accommodate new technologies and investments, and changes in international agreements;
8. designed to minimise costs through minimising prescriptive regulation, maximising flexibility for participants and maximising private sector involvement in the operation of the system; and
9. open to all legal entities.[19]

Principle 4 could be interpreted as stating that a national and the international systems have to be equivalent and that no internal trading would be possible, except under international rules. This would limit the potential for domestic trading. More seriously, Australia might find it difficult to show ‘substantial progress’ by the year 2005 towards the achievement of targets without a domestic trading scheme.

Principle 7 could be interpreted as encouraging parties to offer means by which trading can be expanded.

As emphasised already, many decisions remain about the rules for inclusion and for accounting tradable emissions. It would appear likely that sinks associated with reforestation and afforestation undertaken on or after 1st January 1990, on lands that were not forested in 1990, will be credited. However, the credit is limited to the average increase in CO_2 stock on those sites over the 2008–2012-commitment period, not to the entire increase in CO_2 stocks from the date of planting. Also, emissions associated with logging, and possibly those associated with fires or other disturbances that occur during the commitment period will be debited in some form. It is not yet clear how these will be treated under the Protocol and these and other items will be matters for resolution at future COPs. It is expected that the IPCC Special Report will provide further information on this issue. Decisions on Article 3.4 are likely to widen the range of activities that may be counted, but they will be subject to similar accounting rules. We expect that accounting costs may well prevent most of the items listed in Section 3.1.1 being traded.[20]

Australia could decide to allow internal trading of sinks and emissions that are not included in the international trading rules. It is possible that only a limited range of activities might be included in international trading because of uncertainties associated with measurements or the possibility of ‘leakage’ leading to unwanted results (eg. emissions forgone in one place are diverted to another location). If Australia could identify a wider range of activities that can be measured accurately within Australia and which contribute to a net reduction of emissions under Australia’s international reporting, then national trading could be allowed. However discussion of domestic trading will need to follow decisions as to what will be covered by international trading, and this is far from being resolved.

3.2.1 Market price of carbon

A range of organisations has estimated the likely market price of CO_2 per tonne. Table 4 is from the AGO paper ‘Issuing the permits’[21].

19. Australian Greenhouse Office, 1999, *National emission Trading – Establishing the Boundaries* (p12) <http://www.greenhouse.gov.au/emissionstrading/emissions_1.pdf>.

20. The items of interest are described in Section 4 and measurement is discussed in Section 5.3.

21. See <http://www.greenhouse.gov.au/emissionstrading/paper_2.pdf>, p14.

Table 4. Predicted carbon dioxide equivalent permit prices facing Australia in 2010 under various Kyoto-consistent scenarios.

Model	Independent abatement A$ per tonne of CO_2	Developed country trading	Global trading
G-Cubed (a)	$44	$38	na
G-Cubed (b)	na	$16	$5
GTEM (a)	$191	$48	na
GTEM (b)	$87	$37	na
SGM	$55	$32–44	$9–11
MERGE	na	$48	$34
POLES	na	$47	$14
World Scan	na	$8	na
GREEN	na	$28	$10
AIM	$40	$27	$18

na: not applicable

Note: GTEM (b) results relate to CO_2 , N_2O and CH_4 emissions and abatement opportunities relating to energy and agricultural activities. Other modelling results reported refer to combustion-related CO_2 emissions.
To convert from $/tonne of CO2 to an equivalent cost per tonne of carbon, multiply estimates by 44/12. Most studies refer to 1995 US dollars, GTEM results are reported in 1992 US dollars. To convert to $A an exchange rate of A$1.54 per US$ was used.
Sources: McKibbin et al. (1998), Tulpule et al. (1998), OECD (1998), Kainuma et al. (1999), IAT (1997), Brown et al. (1999). See <http://www.greenhouse.gov.au/emissionstrading/paper_2.pdf> for reference details.

Prices will be sensitive to many factors such as the type and extent of the system implemented and the method by which the carbon credits are allocated.

Because most permits will be issued to authorise the release of CO_{2e} to the atmosphere for ever, the market values quoted above assume the time unit of CO_{2e} is for ever. Indeed, the Kyoto Protocol does not recognise temporary emissions or sequestration.

While the principles for carbon trading are still in doubt, the Emissions Trading Section of the Australian Greenhouse Office believes that trading will only operate if all carbon trading is carried out in the market for the same intrinsic price. This means that carbon saved through sequestration has the same absolute value as carbon emitted. This also means that sequestration, where carbon cannot be sequestered for ever, must be balanced by an emission when the trees are cut down and used. A range of methods is being considered for the accounting of this carbon but, broadly speaking, these split into payment by the grower when the trees are cut down and payment by the end-user as the carbon is released.

Payment by the end-user places carbon in wood on the same basis as carbon from coal and, at least from a wood-grower’s perspective, is the logical way of accounting for emissions—ie. accounting for the emissions when they actually occur and at a point where the cost can be passed on to the ultimate consumer (the individual or corporation using the goods or purchasing the service).

So payment in the year of sequestration in the first commitment period can be expected. But the seller of the permit will have to buy all or part of it back if and when the stock of sequestered carbon that is held is reduced by cutting down and selling, by fire, or by any other means. So the seller always holds this liability while holding carbon stocks. Since it is expected that the market will set the price for permits, the price that the seller will need to pay to cover his liability may be higher or lower than the price at which the permit was sold.

3.3 Who will be the buyers and sellers?

3.3.1 Buyers

Table 5, adapted from Australian Greenhouse Office (1999), gives some indication of the major sources of greenhouse gases and one can infer that the major emitters will be the major buyers of carbon credits. This is demonstrated below where we report on a number of trades by these major sources. Fuel combustion companies will be both the first buyers and the first to be regulated by the AGO.

3.3.2 Sellers

The term ‘sellers’ is not limited to people growing trees (offsets). Indeed, depending on how the licences are issued, companies that have been emitting CO_{2e} and have reduced their emissions, either through efficiency gains or by shutting down all or part of the enterprise, may well have many more credits to sell than plantation owners. For example it is expected that a number of so-called 'rust-bucket economies', notably that of Russia, will have a large number of emission reduction units to sell in the first commitment period.

As is obvious from the reports below, major plantation owners, such as NSW State Forests and the Department of Conservation and Land Management in Western Australia, have considerable advantages in both legal and mensuration (measurement) costs over smaller producers and are already active in the market.

3.4 Current options trading

3.4.1 Domestic trading

In June 1998, State Forests of New South Wales (State Forests) announced two trades, one with Pacific Power and one with Delta Electricity. Both purchasers are electricity generators/suppliers. While the financial details of each transaction are commercial-in-confidence, the *Australian Financial Review* (5 June 1998) indicated that the first trade with Pacific Power was for $35,000 to provide a sink for 2,400 tonnes of carbon over one twelve-month period. If these data are correct, the price paid was $AU4/tonne CO_2.

There are aspects to the trades that provide important clues about their likely direction in the future. Both were for future carbon (not past carbon) and options agreements were integral to both. It would appear that 'options' allow companies to secure the rights to take up carbon in the future when the rules are defined.

The verification/audit was undertaken by Jaakko Pöyry Pty Ltd using the procedures as indicated in the Greenhouse Challenge Vegetation Sinks Workbook (draft). Bankers Trust Australia underwrote the trade.

Delta Electricity

The trade with Delta involved a small (38.5 ha) radiata pine plantation to be established under a joint venture between Delta and State Forests on land surrounding the Wallerawang Power Station which is owned by Delta. The agreement vests all future carbon credits from the plantation with Delta.

Table 5. Likely buyers of carbon credits.

Emission activity (emission output, CO_2e)	Number of emission sites	Direct measurement technically feasible	Cost (per CO_2 equity, tonne) of direct measurement	Reliability of emission estimator	Upstream or downstream focus exists
Fuel combustion					
Coal (160 Mt)	Many	Yes	Low-moderate	Good	Yes
Oil and gas (140 Mt)	Very many	Yes	Very high	Good	Yes
Light emissions					
Coal seam methane (17.6 Mt)	Few	Sometimes	Low	Uncertain	No
Oil and gas flaring, extraction sites and refineries (9.1 Mt)	Few	Yes	Low	Uncertain	No
Pipeline leakage (3.0 Mt)	Many	Yes	Low	Uncertain	Yes
Industrial processors					
Aluminium production (3.4 Mt)	Few	Uncertain	Uncertain	Uncertain	No
Cement production (5.1 Mt)	Few	Uncertain	Uncertain	Uncertain	No
Chemical production (0.5 Mt)	Few	Uncertain	Uncertain	Uncertain	No
Steel production (0.1 Mt)	Few	Uncertain	Uncertain	Uncertain	No
Agricultural activities					
Animal emissions (56.8 Mt)	Very many	No	n/a	Uncertain	No
Manure management (2.0 Mt)	Very many	No	n/a	Uncertain	No
Rice cultivation (0.7 Mt)	Few	No	n/a	Uncertain	Yes
Field burning (10.2 Mt)	Many	No	n/a	Uncertain	Yes
Nitrogenous fertiliser (14.5 Mt)	Many	No	n/a	Uncertain	Yes
Forestry and other (22.2 Mt)					

This arrangement with Delta allows State Forests to practice all normal operations according to an agreed plan of management and for Delta to claim whatever carbon is eventually sequestered. This arrangement is useful as it keeps the costs of monitoring to an absolute minimum (no measurements are required until Delta wishes to bring the carbon to account) and provides Delta with a secure source of carbon credit, when or if it wishes to claim credits in future.

Pacific Power

Pacific Power has purchased the carbon rights for two years as well as the first right of refusal for the following nine years over 1000 ha of plantation eucalypts in Northern New South Wales. State Forests has contracted to provide 25,300 tonnes of CO_{2e} from these plantations for the first two years and 198,000 tonnes CO_{2e} for the remaining nine years. The rights include all soil organic carbon and tree biomass.

The arrangement with Pacific Power that gives Pacific the Option to purchase the CO_{2e} at prevailing market price is useful as it allows Pacific to secure a resource while the trading rules are defined. Unlike the Delta trade, State Forests made conservative projections of the quantity it could guarantee on the basis of a discount from the estimated amount likely to be sequestered. This system provides State Forests with a low risk of being unable to fulfil its contract while it still allows the carbon sequestered above the contract amount to be sold on the open market.

As State Forests do not insure, they are taking some risk of being unable to meet the contract should the forests burn. The distribution of the forests, however, means that such an event is never likely to happen: sufficient conservatism has been applied to the estimates to cover typical losses from wildfire where a whole plantation may be killed.

TEPCO

In July 1999, the Tokyo Electric Power Company (TEPCO) announced plans to plant eucalyptus, pine and other trees on about 1,000 ha during the year 2000, and to expand the scale to 10,000–40,000 ha by 2009[22]. This is estimated to absorb about 100 days of CO_{2e} emissions from a 600 MW power station. NSW State Forests will manage this investment by TEPCO.

Other trades

Other trades are summarised in Table 6.

Table 6. Trades and rumours of trades.

Seller	Buyer	Area (ha)	Price ($AU/t CO_2)
Done deals			
NSW State Forests	Pacific Power	1,000	$4
NSW State Forests	Delta Energy	38.5	
?	Toyota		
WA Department of Conservation and Land Management	BP		
NSW State Forests	TEPCO (Tokyo Electric Power Company)	40,000	
Rumours			
Goulburn River Valley — Victoria	Oji		
Western Australia	Woodside		
Probably NSW State Forests	Macquarie Generation		

[a] TEPCO has committed to 1,000 ha in 2000, with the option of contracting to 40,000 ha in the next decade.

It is already clear that large plantation owners, including state forestry departments, have considerable weight and will set prices and do deals long before farmers can possibly enter the market. Current prices are expected to be lower than what will be paid after licences are issued since they reflect the uncertainty about the definition of product. If the market for sulphur dioxide in the US is used as a guide, then the price should peak soon after the introduction of the trading scheme and then decline steadily as technological advances make current emitters more efficient.

3.4.2 International trading

The activity in the business community to prepare for a carbon-trading market and to actually conduct trades in carbon is not confined to the Australian market. A number of large international carbon trades have been conducted. A small sample of the international market activity is outlined in Table 7.

3.5 When will trading begin?

The issuing of licences or permits, either load-based licences or permits to discharge, is the most likely

22. See <http://www.forest.nsw.gov.au/Business%20 Services/Carbon2/Media_Releases/ 13%20%20Tepco%20Joins%20Australia%20Forestation%20Plan%20To%20Offset%20CO2%20Output.htm>.

mechanism for setting up an official trading scheme. Extensive trading will begin when market confidence is established, and this will occur when some of the 'rules' become more clearly defined. The preliminary trades that have occurred so far are likely to continue and will probably be done for two reasons: to gain experience (determine costs and benefits more clearly) and to gain public relations benefits.

Table 7. International trades.

Buyer	Seller	Project	Price	Reference
Suncor, Canada	Niagara Mohawk Power Corp (USA)	100,000 t CO_2.		www.carbonmarket.com/ whoistrading.htm[a]
Suncor	Niagara Mohawk	Option to purchase 10 million tonnes CO_2.		www.carbonmarket.com/ whoistrading.htm
Tenaska, Nebraska	Costa Rica	Rainforest protection.	$500,000	www.carbonmarket.com/ whoistrading.htm
BP	BP	Internal carbon trading.		www.carbonmarket.com/ whoistrading.htm
Program for Belize – a Belizean NGO	Rio Bravo	Sustainable forestry program. Carbon offsets 2.4 million tons in 40 years: 50% to owners, 50% to investors.	$5.6 million	The Second Australasian Emissions Trading Forum
Sumitomo	Unified Energy System, Russia	Power plant efficiency improvements equal to 10 million tonnes a year CO_2 emission reduction.	Direct credit to Japan	www.carbonmarket.com/ whoistrading.htm
Bolivian Government		300,000 ha added to National Park. Carbon offsets 15 million tons in 30 years: 50% to Brazilian Government, 50% to investors.	$9.5 million	The Second Australasian Emissions Trading Forum
Toyota		Model rainforest to evaluate carbon uptake.	$800,000	www.carbonmarket.cpm/ whoistrading.htm
Tesco, a UK supermarket chain.	Carbon Storage Trust	Trading against fuel production, then marketing fuel as carbon emission free		

[a] This information source was made a subscription item by the Ecos Corporation during the preparation of this report.

4. Agricultural practices that lead to changes in greenhouse gas exchanges

4.1 Greenhouse gases generated by farming

The main greenhouse gases produced by agriculture are CO_2 and methane (CH_4). Smaller amounts of other gases such as nitrous oxide (N_2O) and nitrogen oxides are also emitted[23]. Of the 419 million tonnes of CO_{2e} produced annually in Australia, 20% is emitted from the agricultural sector[24].

The livestock sector is the biggest agricultural producer of greenhouse gases, and is responsible for 14% of total emissions in Australia. These emissions largely consist of CH_4, which is produced by fermentation processes in the digestive systems of ruminant animals such as sheep and cows. Methane is important because it has a higher greenhouse warming potential than CO_2 (see Table 8). Broadacre cropping also contributes to the emission of CO_2, N_2O and NO_x by facilitating the breakdown of organic matter in the soil (eg. as a result of cultivation) and fertiliser application. The clearing of forests and woodlands for agricultural purposes, which results in the decomposition of trees, shrubs and soil organic matter, also releases CO_2 and NOx[25].

Table 8. Global warming potential of major greenhouse gases.

Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O, NO_x)	310

4.2 Carbon dioxide

There are a number of potential strategies that can be employed to help reduce emissions of CO_2 from the agricultural sector. A selection of these is discussed below.

4.2.1 Minimum till

Minimum tillage is a practice that minimises soil disturbance during crop production and usually involves the retention of stubble after harvest to reduce the erosive capacity of wind and water, and to increase the organic matter in the soil. This practice puts more plant material onto the soil surface and reduces the exposure of soil organic matter to oxygen, thereby increasing carbon storage. The use of minimum tillage strategies can reduce greenhouse gases by reducing the amount of cultivation, and hence the amount of soil that cultivation disturbs.

A study by Hassall & Associates[26] examined the contribution of minimum tillage to carbon sequestration in Australia. Their report showed that minimum tillage has resulted in the sequestration of 5.9 million tonnes of CO_{2e} per year in 1990 and, in the year 2000, this could increase to 6.3 million tonnes of CO_{2e} per year. Clearly the continuation of sustainable agricultural practices such as minimum tillage could sequester significant amounts of carbon each year.

4.2.2 Removal of herbivores

The removal of herbivores from grazing lands would lead to increased biomass accumulation in pasture areas and hence greater carbon sequestration in grazing regions. Given that Australia has over 400 million ha of rangeland, even small improvements in per ha carbon sequestration will make a noticeable contribution to overall carbon uptake[27]. Modelling has shown that if 5% of rangeland areas could be restored by better management practices over the next 20 years, it would result in the sequestration of an average 14.3 million tonnes CO_{2e} per annum[28]. Better management practices such as decreased stocking rates could increase carbon sequestration considerably.

23. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
24. Donaldson J. 1999 *Greenhouse, carbon sinks and carbon trading* Seminar on Carbon Credits: Questions and Answers Warrambeen, Victoria May 1999.
25. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
26. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
27. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
28. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.

4.2.3 Prevention of fire

An alternative or complementary method of increasing biomass and hence carbon sequestration is to reduce the frequency of fires. This can be done by implementing stricter controls on burning and using more means of fire management such as fire breaks and fire bans.

However, it should be noted that there are several difficulties and disadvantages with this approach to carbon sequestration. First, the successful control of fire, especially in northern Australia where lightning strikes are frequent, is extremely difficult. Secondly, the enforced control of burning can interfere with the traditional land-management practices of Aboriginal communities and may adversely affect certain plant and animal species that have adapted to landscapes where fire is frequent. Thirdly, reductions in the frequency of fire may result in a buildup of fuel loads and result in fires of greater destructiveness.

4.2.4 Establishing woody vegetation

The establishment of woody vegetation could do much for carbon sequestration throughout Australia. Programs such as Farm Forestry, Vision 2020, One Billion Trees, Bushcare and Landcare have speeded up the rate of tree planting and it has been estimated that ~11.3 million tonnes of CO_{2e} per annum could be sequestered from these sources in the year 2000 in respect of plantings during the period 1990 to 2000[29]. This figure could increase if more incentives are provided for planting trees throughout Australia.

4.3 Methane and the removal of ruminants

The digestive processes of ruminant animals, such as sheep and cows, produce considerable amounts of CH_4. Of the 23% of total CH_4 emissions produced in Australia, ruminant livestock are responsible for 54%. In addition, modelling has shown that the emissions of greenhouse gases from livestock are much greater than those that are caused by crops. For example, the production of meat and milk (and associated products) results in the emission of 6.5 and 6.3 kg CO_{2e} per AU$ respectively. The production of flour and cereal products, on the other hand, only results in the emission of 3.5 kg CO_{2e} per AU$[30].

A shift from the farming of ruminant animals could reduce greenhouse gas emissions considerably. In 1998 there were 26,710,000 cattle and 119,579,000 sheep in Australia[31]. Reductions in stocking rates could produce major opportunities for carbon sequestration. A 20% reduction in stocking numbers on rangeland areas could lead to an average sequestration of approximately 14 million tonnes CO_{2e} over 20 years[32]. In addition, improving the productivity of livestock per ha (eg. by improved animal health and husbandry, strategic use of supplements and improved pasture management) could also reduce CH_4 emissions, by facilitating more liveweight gain per unit emission of methane[33].

The modification of rumen function through the use of anti-menthanogens[34] may be feasible but it may be difficult to verify or measure so as to market any carbon credits that result.

29. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
30. Lenzen M. 1998 *Primary energy and greenhouse gases embodied in Australian final consumption: an input-output analysis* Energy Policy **26**, 495-506.
31. Australian Bureau of Statistics, 1999 *Australian Commodity Statistics* ABARE, Australia.
32. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
33. Hassall & Associates, 1997 *Greenhouse Gas Implications of Sustainable land Management Practices* Commonwealth of Australia, Australia.
34. See <http://www.ah.csiro.au/newsline/press_rel/1994/antiburp.htm>.

5 What does a rural industry, a catchment committee or a farmer need to know and do to get into the market?

5.1 Carbon farming in its various forms

Definition of forests

A forest for carbon accounting purposes has to be within the definition of a forest from the National Forest Policy statement of 1992, namely that it has more than 20% canopy cover and is higher than 2m. As yet there is no definition of what size of unit will be considered when determining what is and what is not a forest. Possibilities include a catchment, a farm, a paddock, or a wood-lot of more than a minimum, as yet unspecified, size. Certainly small groups of trees will be excluded.

How fast will trees grow?

The rate of growth, and hence carbon sequestration, by trees is influenced by a wide range of factors, including rainfall, soils, temperature, species, management styles and the effects of natural disasters such as fire. Modelling by Hassall & Associates[35] attempted to provide indications of tree growth rates for pine and eucalypt species on the basis of those factors. This modelling used an asymmetrical sigmoidal function (the Gompertz equation) to simulate the time course of net carbon accumulation as a forest grows.

The function takes the general form:

$$W = A*\exp[-b*\exp(-k*t)] + z$$

where W is the CO_2 sequestered (tonnes/ha); t is the time (in years); A is the asymptotic value of W; b and k are constants; and z is equal to $-A*\exp(-b)$[36].

Figure 2 illustrates the result of this modeling for both pine and eucalypts species. Pine species are indicated by the curves P1, P2 and P3 and have been developed based on data from several sources[37]. These curves illustrate growth curves for three productivity classes:

- P1 – best growth;
- P2 – good growth; and
- P3 – average growth.

The curves for eucalypt species (E1–E5) have been based on data from several sources[38] that made estimates of above ground biomass accumulation for eucalypts. *Eucalyptus regnans* was taken to represent the best eucalypt productivity class (E1), data for coastal eucalypts were taken to represent average productivity (E3) and box ironbark the lowest productivity (E5). E3 and E4 are both intermediate values. To our original study we have added an E0 productivity class, which represents a very high growth species managed under optimal conditions for growth, such as with an *Eucalyptus globulus* plantation.

From Figure 2 it can be seen that there is a distinct difference in the form of biomass accumulation curve between pine and eucalypt data, with eucalypts growing faster in the early years and then the pine trees growing faster for the rest of the 40 years modelled.

Forest management

Because climate, species and establishment style will also affect growth rate, the effects of different combinations of these factors on forest productivity have been estimated[39]. These are summarised in Table 9.

The CO_2 sequestered in the different productivity classes is shown below in Table 10. These sequestration figures do not take into account losses through thinning, harvest, etc.

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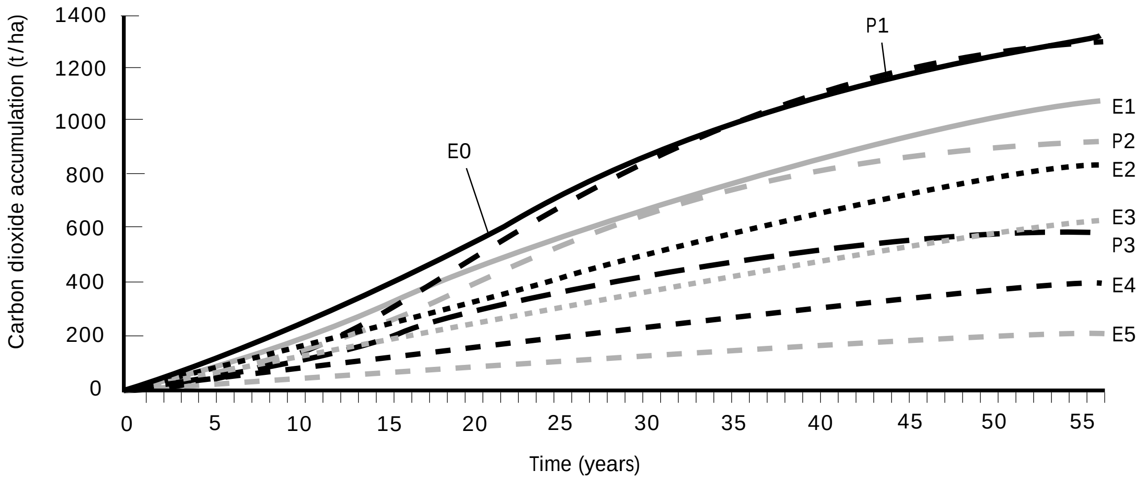
35. Hassall & Associates 1996 *Sequestration of Atmospheric Carbon Dioxide in Trees* Hassall & Associates, Australia.

36. The use of the z parameter ensures that the curve will pass through zero.

37. Grierson P.F., Adams M.A. and Attiwill P.M. (1992) Estimates of carbon storage in above ground biomass of Victoria's Forests. *Australian Journal of Botany* **40,** 631–40.
Madgwick, H.A.I. (1994). Pinus radiata - biomass, form and growth. Published by HAI Madgwick, 36 Selwyn Rd, Rotorua, New Zealand.
Madgwick, H.A.I., Jackson, D.S., and Knight, P.J. (1977). Above-ground dry matter, energy, and nutrient contents of trees in an age series of Pinus radiata plantations. *N.Z. J. For. Sci.*, **7**, 445-68.
Myers, B.J., Bond, W.J., Falkiner, R.A., O'Brien, N.D., Polglase, P.J., Smith, C.J., Theiveyanathan, S. (1994). Wagga effluent plantation project - Technical Report. CSIRO Division of Forestry User Series No. 17. (Unpublished report – permission required to quote).

Figure 2. Carbon dioxide accumulation — eucalypt and pine productivity classes.



5.2 Transaction costs

A general equation for estimating the profitability of trading in carbon credits is:

Y (Return in \$) = Income I (\$) – Cost of transaction T (\$) – Cost of measurement M (\$)

For landowners attempting to gain a return from small areas of plantations or native vegetation, there are a number of factors that mean that I is low and T and M are large. This section discusses the costs of transaction and the next section concentrates on measurement.

There is no doubt that there will be a transaction cost in transferring ownership of carbon credits from sellers to buyers. It is only the quantum of the transaction cost that is uncertain. To give an example of how much such a transaction may cost, a recent paper from a lawyer stated:

> Amongst the property matters are the following:
>
> - a preliminary check on eligibility as to carbon sink or other credit source;
> - a check on land title. The ownership of the land, and the registration of other interests in land, is essential in most states to determining who can trade in the carbon rights;
> - a check on subsidiary interests, such as tenants and, mortgagees;
> - a check of the planning or land use regime relevant to forestry, timber production, or agroforestry. Some states have maximum or minimum land areas, or other restrictions which could impact on the activity;
> - a check on other legislative requirements, compliance with native vegetation controls, forestry codes of practice and environmental regulations;
> - technical matters such as the productive capacity of the land, mensuration and verification programs. Also, what existing vegetation may need to be cleared and off-set against future carbon credits;
> - until a national regulatory arrangement is established, a check of the registration requirements to separate the land and trees, such as a registered profit a prendre in NSW or a forest property agreement in Victoria.[40]

The legal charges are likely to be substantial, and in our analysis we have assumed them to be \$5,000 irrespective of area. On top of these charges there is independent certification or audit of the amount of CO_{2e} present, which again is assumed to be \$5,000, although it is more likely to be over \$10,000 for forests with many 'crop types' (different species, ages, growing conditions, etc.).

38. Grierson P.F., Adams M.A. and Attiwill P.M. (1992) Estimates of carbon storage in above ground biomass of Victoria's Forests. *Australian Journal of Botany* **40,** 631-40.
Myers, B.J., Bond, W.J., Falkiner, R.A., O'Brien, N.D., Polglase, P.J., Smith, C.J., Theiveyanathan, S. (1994). Wagga effluent plantation project – Technical Report. CSIRO Division of Forestry User Series No. 17. (Unpublished report - permission required to quote).

39. Hassall & Associates 1996 *Sequestration of Atmospheric Carbon Dioxide in Trees* Hassall & Associates, Australia.

40. Mulally, J (1999) 'The opportunities for lawyers in an emission trading regime', Paper to the *Australian Financial Review* Emissions Trading Forum, 24-5/3/1999

Table 9. Allocating growth classes by characteristics.

Rainfall	Species	Establishment style	Productivity class
400–600	Best growing species	Planting	E4
		Direct seeding	E4
		Natural Regeneration	n/a
	Local provenance	Planting	n/a
		Direct seeding	E5
		Natural regeneration	E5
600–800	Best growing species	Planting	E2 or P2/P3
		Direct seeding	E3
		Natural regeneration	n/a
	Local provenance	Planting	E3
		Direct seeding	E4
		Natural regeneration	E5
800+	Best growing species	Planting	E0/E1 or P1/P2
		Direct seeding	E2
		Natural regeneration	E2
	Local provenance	Planting	E2
		Direct seeding	E3
		Natural regeneration	E3/E4

Table 10. CO_2 sequestration by eucalypt productivity class.

Curve number	Incremental growth in year 10 (tonnes of CO_2/ha)	Incremental growth in year 20 (tonnes of CO_2/ha)	Incremental growth in year 30 (tonnes of CO_2/ha)
E0	24	28	29
E1	19	22	22
E2	14	16	17
E3	11	12	12
E4	7	7	7
E5	3	4	4
P1	14	24	28
P2	12	19	21
P3	10	14	14

In NSW, registration of a Carbon Title on the Land Title is likely to incur only a small state-government administrative charge (<$100). However, it is also likely that transferring this right (ie. when the carbon credit is sold or on-sold) will incur state government stamp duty. This is on a sliding scale, with the minimum tier of 1.25% of sale or market value (whichever is higher).

In an ideal situation, carbon rights information would be stored centrally much as Land Title or vehicle registration details are stored. Since such a system has yet to be established, individual trading companies may maintain a register, or growers may organise a cooperative or other regional body to act as a central register. An independent carbon-credit trader, for example, would need to maintain a detailed register of all carbon available and all trades made. This would allow an independent auditor to check to ensure that the carbon traded is as represented and has not been sold to other parties.

Most growers regard the concept of ‘additionality’ (see Section 2.3.2) as flawed but it needs to be recognised that it is an important consideration from the viewpoint of a purchaser of carbon rights. The same concept is discussed in the Greenhouse Challenge Draft Sinks Workbook. To comply with the guidelines, it is currently necessary to demonstrate that the activity would not have taken place without the advent of a need to provide carbon sinks. This issue becomes most important when considering existing plantations that have been established partly for timber production purposes and partly for other purposes. Plantations established as part of a normal timber operation are currently excluded under additionality clauses.

To establish additionality for most plantations is particularly difficult as the great majority would have established plantings for commercial or landcare objectives and would have done so without the possibility of greenhouse gas emission trading.

Under the Kyoto Protocol, only carbon sequestered in the period 2008–2012 from trees planted after 1990 can be counted. For this reason, purchasers of carbon credits are likely to prefer to purchase only trees (or the carbon they sequester) planted since 1990. Growers need to be able to back up claims of planting dates with records, photographs etc.

The potential purchaser of the carbon credit needs to eliminate the risk that the carbon will not be sequestered. The trader (who will ‘guarantee’ the carbon) will most likely insist that the plantation is insured so that additional plantation areas can be secured in the event of fire or windthrow. The risk of the plantation not performing through insect attack or from lack of a micronutrient is a risk that the trader is likely to have to bear (in the case of a sale of projected carbon). But this risk is normally minimised by promising to deliver only a proportion of the carbon likely to be sequestered, the balance being accounted for after the sequestration has taken place. Normal forestry insurance is 0.08% of value per year and many plantations are not insured because of this cost.

5.3 Measurement and its effect on the amount sold

In 1998 The Greenhouse Challenge[41] issued the ‘Greenhouse Challenge Vegetation Sinks Workbook’. This sets out a protocol for the measurement of carbon in plantations. The workbook describes in detail the steps to be taken to measure the amount of carbon sequestered in the following steps (Table 11).

41. The Greenhouse Challenge was established prior to the establishment of the AGO to encourage firms to voluntarily work towards reduced emissions through Greenhouse Challenge agreements. The Greenhouse Challenge is now part of the AGO.

A general reflection is that the cost of such detailed measurement is very expensive. In the case of farm plantations, the relationship between the cost of measurement and other variables is given below:

(a) Quantity of carbon per ha—Carbon accumulation is normally a function of rainfall. So the amount of carbon sequestered in farm plantations is likely to be far less than the carbon sequestered in high rainfall commercial plantations. The relationship should take the general form illustrated in Figure 3. Jaakko Pöyry Consulting (personal communication) estimate that it costs about AUS$13 per ha to measure commercial plantations for legal transactions (eg. sale of a forest estate). This is an approximate cost for the cost of measurement of the standing biomass pool (not including soil carbon). So the curve should pass near the point of $13 and 75 tonnes CO_{2e}.

Table 11. Steps in measurement.

Preparation	Step 1	Determine company and project boundaries
	Step 2	Establish the baseline emissions scenario
	Step 3	Identify project emissions
	Step 4	Decide which carbon pools to measure
	Step 5	Design and implement a sampling system based on permanent sampling plots
	Step 6	Select biomass equations or default values
	Step 7	Prepare a management plan
Measurement	Step 8	Periodically sample (measure) carbon pools
	Step 9	Estimate carbon sequestration in years between measurement
Reporting	Step 10	Incorporate results into Greenhouse Challenge cooperative agreement and annual report

(b) Number of species within the plantation—Because different species often have completely different growth forms and because in some cases no simple allometric equations exist, and because there is normally more variability with mixed species stands, cost of measurement per tonne tends to increase in relation to the number of species present. This is illustrated in Figure 4.

(c) Precision—The degree of precision of the measurement will affect the cost of mensuration. The estimate of AUS$13 for a commercial transaction has the precision of 10 percent confidence at the 95% confidence level. To increase this to 5% confidence at the 95% level Jaakko Pöyry Consulting estimate that the cost of measurement would increase fourfold. This is illustrated in Figure 5.

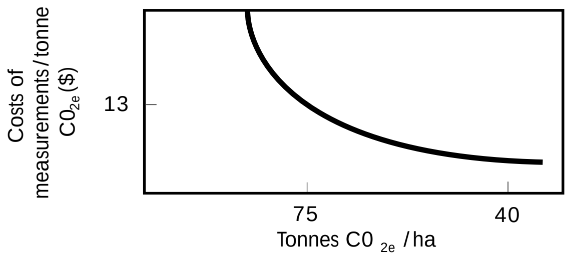


Figure 3. Hypothetical relationship between the cost of measurement per tonne of carbon and the amount of carbon available per hectare.

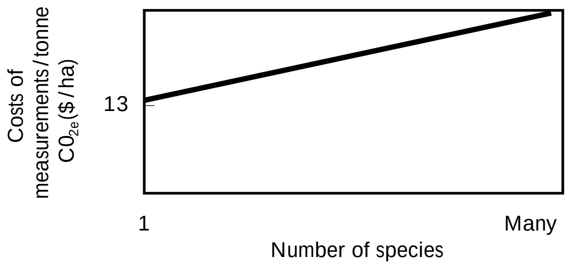


Figure 4. Generalised relationship between the number of species present and the cost per tonne of carbon measured.

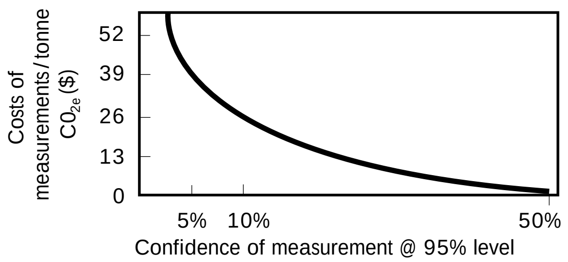


Figure 5. Relationship between precision and cost of measurement per tonne.

All these factors show that the cost of measurement per tonne of carbon of mixed species stands growing in low-rainfall farming areas will be far higher than would be the case for single-species plantations in high-rainfall areas. Is there any way of overcoming these disadvantages?

Two alternative arguments can be used to arrive at the same point. (a) If one believes that all you have to do is to guarantee that there is more than a minimum amount of carbon per hectare, then measurement need only guarantee that this amount is exceeded. (b) Alternatively, if one considers what the marginal return is from more precise measurement, then one can determine the point on the measurement curve where the cost of more precise measurement does not exceed the return from guaranteeing a higher quantity for carbon for sale. This is illustrated in Figure 6.

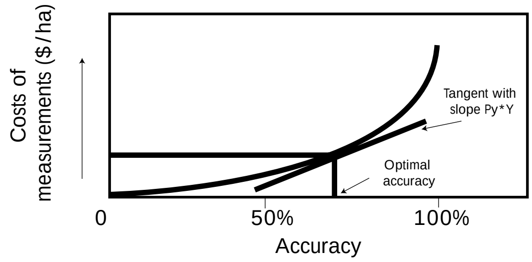


Figure 6. Optimal accuracy as determined by the relationship between accuracy and cost of measurement.

Where Py is the price per tonne of CO_2 and Y is the yield of CO_2 sequestered per hectare .

For example suppose that there was 8 tonnes present then it may only be economically worthwhile to measure to an accuracy that ensured there was more than 5 tonnes present at the 10% confidence interval. One would be able to sell 5 tonnes more profitably than 8 tonnes.

It is important to be able to establish the baseline levels before planting. In practical terms this means whether trees needed to be cleared from the site prior to planting. If the site was heavily wooded, for example, the carbon lost in clearing would need to be debited against the carbon sequestered to derive a "net" carbon. Commonly some trees are removed from a largely cleared site and in this case photographic or other evidence to show the site before planting is required.

The best measure available to predict carbon sequestration is normally stemwood volume. Allometric relationships between stemwood volume, above-ground biomass and below- ground biomass are available, though the quality of the estimates will vary widely. For existing plantations it is thus essential to provide details as follows.

What is the area of each 'crop type', that is, species, management type, site index group, soil type, etc; by age quantitative data on the anticipated or actual stemwood (or biomass) change over time? This is likely to be in the form of a yield function that incorporates planned thinning, pruning and clearfall operations.

For past sequestration, specific measurement data that relate actual performance to prediction is required. This is particularly relevant when the difference between estimated and actual sequestration is to be calculated.

The program of mensuration that is intended to support the carbon sequestered needs to be clearly defined and approved. This may require specific technical assistance to develop the program and select appropriate volume tables or functions and the proposed allometric relationships that relate measurable parameters to carbon. The program needs to define the nature of the measurements to be made, the frequency of measurement and the intensity of sampling proposed; this may include a pre-determined level of precision. The techniques need to demonstrate the effect of each factor in determining precision. For area calculations, for example, the methods used should be defined (eg. aerial photographs with ground control after establishment, differentially corrected global positioning system) and estimates of precision of area should be made. Other components of mensuration require description of the methodology and the precision of the techniques. If it is proposed to sell carbon sequestered below-ground, specific measures will be required.

6 Plantation policy and trends in Australia

Given the difficulty of making the growing of woody vegetation solely for carbon credits financially attractive, it is important to look at the possibility of converting high-rainfall farming country to timber plantations. Significant amounts of high-rainfall country are currently being converted to timber, especially close to ports where land prices are not too high. Major planting activity is currently proceeding around Albany (and to a lesser extent around Esperance) in Western Australia, Portland in Victoria, Gladstone in Queensland, Burnie and Bell Bay in Tasmania, with other areas also being targeted. Trees are normally beneficial to sustainable land management in that the soil is likely to get deeper under them, so in general this can be seen as beneficial. However, the selection of plantation sites is a commercial decision, not necessarily related to sustainable land management, salinity, or any other issue.

There are a number of economic, social and resource management problems in establishing large, commercial, forestry activities. These include a perception that the number of jobs per hectare diminishes[42], the cyclic nature of forestry activities (especially harvest), the aesthetic results of planting large numbers of trees and the possible reductions in stream flow from heavily wooded areas. Many of these issues are covered by local and state government controls on plantation establishment, but some, such as stream flow are not.

6.1 Plantations 2020 and the Farm Forestry Program

Plantations for Australia—the 2020 Vision is a partnership between Commonwealth, State and Territory governments, and industry, launched in October 1997. The goal is to build an internationally competitive, market-oriented industry that is driven largely by increased private sector investment. In the early 1990s, the plantation estate was expanding by about 25,000 hectares a year. Governments and industry are now aiming to treble the current plantation area from about 1 million hectares to 3 million hectares by the year 2020. To achieve this target, planting will need to increase to at least 80,000 hectares a year, a target achieved in 1997–8 and exceeded in 1998–9.

Plantations for Australia—the 2020 Vision sets a target to treble the area of Australia's plantations by the year 2020 and specifies a number of actions to achieve this vision. The Bureau of Rural Sciences was contracted by the Forests Division of Agriculture, Fisheries and Forestry–Australia to review the status of land assessments for plantations in Australia.

The 15 regions were classified into three sub-groups according to the coverage and status of plantation capability/suitability studies: completed studies covering whole regions; completed studies covering parts of regions; and studies either in progress or proposed. South-west Western Australia, Tasmania, Mount Lofty (South Australia), Central Victoria and South-east Queensland are covered by studies that provide reasonably reliable information on land capability for plantations. The Green Triangle, Murray Valley, East Gippsland/ Bombala, Southern, Central and Northern Tablelands and Northern Queensland are partially covered; and eight regions have studies in progress.

On the basis of the attributes considered and the detail available in completed studies, BRS listed the Regional Forest Areas of South-west Western Australia, Mount Lofty in South Australia, North-east Victoria and South-east New South Wales as regions for which there is a considerable amount of accessible and reliable information.

Most studies used mean annual rainfall and soil types or geology as priority and minimum attributes for assessing land capability. Temperature, aspect, elevation and slope were also considered in some studies. Distance to nominated centres, land price and land use were the most common attributes used in suitability assessment. Most studies were directed to a specific set of species, most commonly *Eucalyptus globulus* and *Pinus radiata* in the southern States and Western Australia.

The areas of land identified in completed studies as capable or suitable for plantations were collated; these areas totalled 13.8 million ha. Not all this land will necessarily be available for plantation

42. This depends on a number of factors, including the land use displaced, the intensity of management of the plantations, etc. When forestry replaces extensive high-rainfall grazing the reverse is often the case, but the nature of the work changes and there is still opposition.

establishment. If 20% were available, 2.7 million ha of new plantations could be established.

Carbon accounting could influence economic returns from plantations, and so will be an important factor in identifying suitable land. For example, by taking carbon credits into account, some areas currently considered unsuitable for plantations may become suitable because of the increase in plantation values.

There is a need to establish a national database that captures the results and progress of plantation potential studies in Australia. The present study provides a good starting point for such a database; regular updates are recommended[43].

6.2 Worldwide demand for wood and wood products

It is critical to remember in all discussions about the prospects for the timber industry that supply will always equal demand and there are substitutes for wood. Importantly, the world is not short of wood, it is just not all in the right places (see Figure 7). There are regional shortfalls, particularly in Asia, which is a plus for Australian forest growers. Asia will continue to import both roundwood and forest products in the future to meet the needs of consumption. For instance, in 1996 FAO reported a shortfall of roundwood harvest to production of forest products of 54 million m^3 in roundwood equivalent terms (over twice the total Australian harvest). This shortfall represented 19% of the total Asian harvest and, while the deficit is expected to grow to 58 million by 2010, the percentage shortfall will decrease.

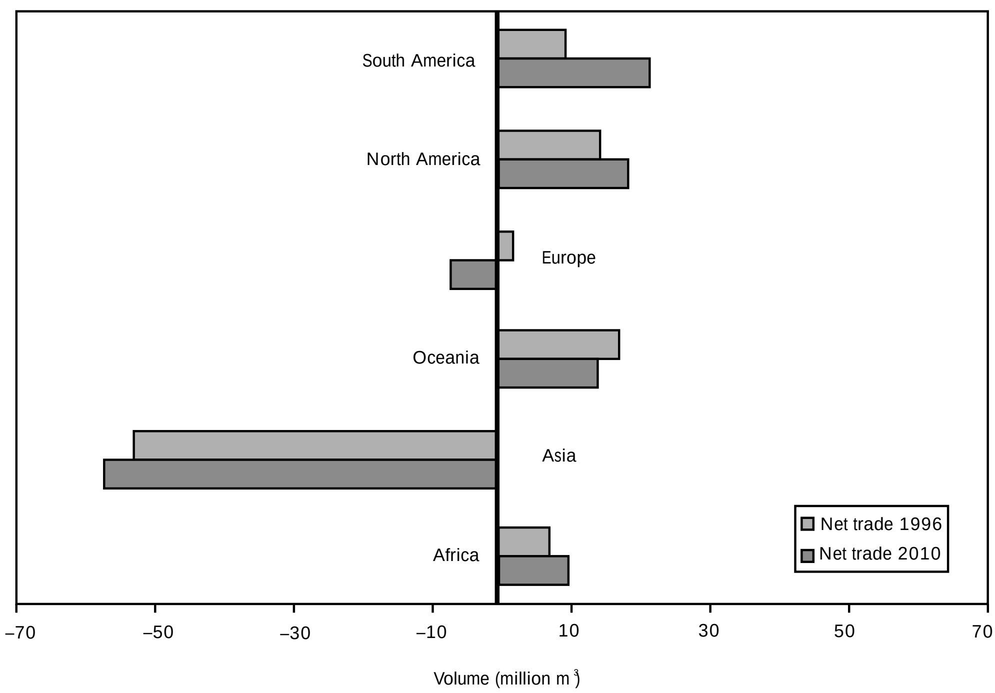
The main sources of demand for forest products are population growth, demographic change (usually associated with economic growth as wealth increases), technological change and environmental trends. Global wood production (fuelwood and industrial wood) has been fairly static over the last 40 years at around 0.6 m^3 per person per year. The split between fuelwood and industrial wood is determined by economic wealth: rich people spend more on industrial wood than fuelwood and poor people do the opposite. Hence there is a strong correlation between developed countries and the demand for industrial wood, and between developing countries and the demand for fuelwood and charcoal.

Australian markets and cost competitiveness

In 1997–98 Australia harvested a record 22.3 million m^3 (54% softwood and 46% hardwood). The market for most forest products in Australia is stable and no dramatic growth in domestic demand is expected. Despite Australia being more or less self-sufficient in forest products, in volume terms it continues to have

43. BRS Volume 11 No 1 The report is at <www.affa.gov.au/forestry/plantation-studies/>.

Figure 7. Global production of industrial roundwood—net trade 1996 and 2010. Source: ABARE 1999. *Asia–Pacific Supply and Demand Outlook for Forest Products*. NAFI Conference, Sydney. Paper presented by Graham Love.



an import bill of $AU 2.7 billion or around 7.2 million m^3 in round wood equivalent terms.

The majority of imports are pulp and paper products with some sawn timber. Exports only amount to $AU 1.2 billion and are generally low value, mostly woodchips; this results in a negative trade balance of around $AU 1.5 billion[44].

A critical issue is whether Australia can be an effective exporter or not. The cost competitiveness of Australian sawmills in both the Australian and export markets is generally good but competitiveness will vary between regions and mills.

Figure 8 illustrates Australia's cost-competitive position in 1997 before the Asian crisis. Both Australia and New Zealand have improved their position against the North Americans since 1997. However, radiata pine is not as readily accepted in those markets as the traditional products (such as oregon and western red cedar) from the Pacific North West and to a lesser degree, the US South, which is currently the most cost-competitive source of timber for the Pacific Rim.

6.3 Financial returns from plantation investment

The returns from plantation investment are dependent on a number of factors. The most important are:

6.3.1 Potential for growth

The potential for growth is a very important factor. Normally many of the costs associated with plantation development are fixed. Of the variable costs, such as land-holding cost, the variation may not represent the improved financial returns that can be achieved.

Rainfall is the largest single determinant of growth although soil type can be important. To compare the effect of growth rates on financial returns, three scenarios for radiata pine are examined (Table 12). In general, the best financial returns are provided by growing plantations on high-rainfall, more-fertile and more-expensive land.

Table 12. Sensitivity analysis—growth potential

Productivity	Land rent ($/ha/yr)	MAI (m^3/ha/yr)	Rotation (year)	IRR (%)
High	160	29	27	9.12
Medium	120	26	30	7.06
Low	80	20	30	5.33

6.3.2 Cost of harvesting and transport

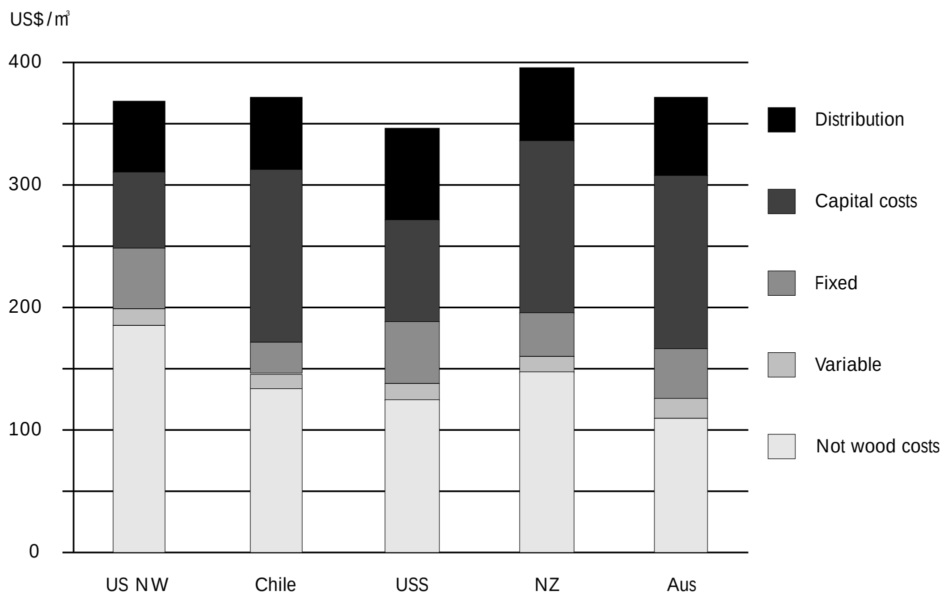
The cost of harvesting and transport usually exceeds the amount of money paid as stumpage. If markets are some distance from the forest, substantial reductions in returns can be hoped for. Blue gum, for example, is likely to have a market as woodchips to Japan. While the stumpage (~ farm gate) price for blue gum woodchips may be $29/green tonne within 50 km of Portland, the cost of road transport to Geelong from an area such as Shepparton may effectively reduce the price by $20/green tonne.

6.3.3 Taxation

While the issue of taxation is complex and a full coverage is beyond the scope of this report, some

44. ABARE, 1999. *Australian Forest Products Statistics, December 1998.* ABARE, Australia.

Figure 8. Sawn softwood cost competitiveness in the Japanese and Korean markets, 1997. Source: Jaakko Pöyry Consulting database.



aspects of it have an affect on effective returns when compared with other forms of investment.

Establishment costs including site preparation, plants, and fertiliser are all deductible in the year of expenditure. Costs for leasing land and acquiring the rights to grow forest are also deductible in the year of expenditure. Where amounts are prepaid, they may be deducted against income over a ten-year period.

Tax considerations will vary widely depending on the investor's profile, and a range of strategies need to be considered when comparing returns from forestry and other forms of investment. The importance of taxation in forestry decisions can be demonstrated by a recent report[45] that companies offering investment in forestry activities by prospectus sold nearly 100, 000 ha in June 1999.

6.3.4 Length of rotation and timing of harvests

The length of rotation is a major influence on returns. The ideal product from a processor's view has been grown slowly over a long period. The cost of holding an investment increases rapidly (the time cost of money) and is more pronounced as the discount rate increases. Forest management is thus a compromise between producing a crop in as short a time as practicable and producing wood of the best quality.

6.3.5 Product out-turn by quality and price

The quality of product and the price are becoming more closely linked. Log quality factors such as straightness, taper, knot size, knot type (bark encased or tight) and wood age are most important in obtaining the best price. In pruned logs, the size of the defect core and the size of the log in relation to that core are key factors. Management regimes can have a big influence on quality.

The price achieved at sale is critical. To achieve the best prices it is important to be able to understand the range of log specifications and cut logs to maximise the return. This has traditionally been relatively unimportant in Australia where most logs were either acceptable or not as sawlogs. As export markets develop, the wide array of log grades will mean that logs need to be cut to maximise log value.

6.3.6 Cost of establishment

The cost of establishment is important, as it is incurred early in the rotation and, depending on the discount rate chosen, has a major effect on returns. In some forestry investments the costs of preparing a prospectus and the costs of marketing are included as establishment costs and these greatly affect returns. In an example for unpruned radiata pine, establishment costs are estimated to be $1789/ha. The effect of increasing establishment costs is shown in Table 13.

Table 13. Sensitivity analysis—establishment cost ($/ha).

Cost of plantation establishment ($/ha)	1789	2789	3789	4789
Internal rate of return (%)	7.06	5.94	5.10	4.42

6.4 The effect on plantations of valuing carbon

Table 14 shows the effect of carbon price on a fast-growing eucalypt enterprise in a very favourable area. The assumptions are listed after the table, and the effect is analysed over a thirty-year period. Clearly the figures in this table will vary according to the assumptions used.

Table 14. The effect of carbon price on income from a eucalypt plantation.

	CO_2 @ $14/tonne	CO_2 @ $28/tonne	CO_2 @ $56/tonne
Carbon only			
NPV/ha	–$3,654	–$2,765	–$970
IRR (%)	<0	<0	0
Timber only			
NPV/ha	–$640	–$640	–$640
IRR (%)	6	6	6
Carbon + timber			
NPV/ha	$146	$1,034	$2,829
IRR (%)	7	9	12

NPV= net present value (benefits minus costs, in today's terms).
IRR= internal rate of return (interest/discount rate where benefits = costs. If higher than the discount rate used (=7%), the project is desirable).

The discount rate used is 7%, which is midway between the long-term interest rate for bonds (~4%) and commercial lending rates for farmers (~11%). Further assumptions are detailed in Appendix 1 section 1.

Table 14 clearly shows that pure carbon farming is not justified at these prices. But carbon trading enhances the profitability of plantations.

45. Chris Borough - personal communication 16/7/99.

7. What effects might this have on agriculture and land management in different regions?

In the Mid-Point Review of the WAPIS funded Farm Forestry Program, Hassall & Associates[46] proposed a framework based on productivity (using proxies of rainfall and growth rates), land costs, current uses of land, current forestry-related activities, relative emphasis on commercial, environmental or social benefits intended, types of ownership patterns, physical factors and proximity to markets. This framework is also useful for considering different types of carbon farming and their geographical location.

Four land types can be identified and these are described below. The list is not exhaustive and there will be local and regional variations in the land types present.

Land Type 1

- High-rainfall areas with high land cost, including land close to cities or coast. Diverse ownership patterns occur. Because of small land parcels there are few opportunities for extensive plantation expansion and there are likely to be high transactions costs for carbon farming. Land is treated as a 'sunk cost' from a commercial forestry perspective. There is a large potential for diverse industrial development, improved environmental management and better use of valuable land resources. Emphasis can be on lifestyle and land-use choice or integration with high-value farming systems. Examples include the coast of NSW, the Southern Highlands of NSW, the Dandenong Ranges of Victoria and the Mount Lofty Ranges of South Australia.

Land Type 2

- High-rainfall areas where land price is determined by broadacre farm prices. This includes land used for industrial forestry. There is increasing emphasis on commercial returns from plantation investments and effective integration of commercial plantation expansion with regional environmental goals, or with farming systems. Examples include South West WA, Western Victoria, the South East of SA, North Coast Tasmania and the central Queensland coast.

Land Type 3

- Lower-value land, including medium-rainfall and drier lands of the wheat/sheep belt, or the steeper and less productive slopes (for agriculture) in higher-rainfall areas. Here there is increasing emphasis on environmental goals. Examples include use of steeper or weed-infested land such as the Strzelecki Ranges in Gippsland, the wheatbelts of Western and South Australia, Victoria, NSW and Queensland.

Land Type 4

- Rangelands. Low rainfall areas with extensive grazing.

Table 15 represents the type of carbon farming likely to be apparent in each of these land types. Carbon farming is again generally depicted as being an additional activity in these regions rather than as an activity in its own right. Attention is also placed on Land type 3 where carbon activities could be an adjunct to environmental plantings.

Data about production in these land types have been sourced from ABARE, from their Farm Surveys[47]. The ABARE data have been broken down into three regions: high rainfall (equivalent to land types 1 and 2), wheat sheep (land type 3) and pastoral (land type 4).

One matter of importance in the studies below is that land-rental costs have been included in the analysis, because this allows for different land-rental prices to be used in the different examples and because this is standard in analyses of plantation enterprises. Many agricultural intra-farm comparisons of enterprises do not consider land rental as a cost.

7.1 Case Study One—land of high amenity value—hobby farms

The area is predominantly coastal and relatively close to major urban centres. The non-farm income is significant and decisions are often based on factors other than direct income (such as lifestyle, aesthetic and taxation considerations in relation to off-farm income).

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[46] Hassall & Associates (1998) *Farm Forestry Program Mid-Point Review of WAPIS Funded Farm Forestry Projects*, Hassall & Associates, Australia.

[47] ABARE, 1999 *Australian Forest Products Statistics, December 1998 Quarter*, ABARE, Australia.

The enterprises are extremely diverse and usually rely on high-value crops on a small scale or intensive production (eg. horticulture). A lot of this type of land is not being used for commercial agriculture per se.

The cost of land is high, which can preclude forestry activities in a normal commercial sense. However, as these landowners have off-farm income, they may be less inclined to demand a return on the land value. That is, the opportunity cost of land can often be considered by the landholder as far lower than its market rents or productive capability. In addition, they are often in a class of income earners who are looking for long-term investment and could view trees as having both aesthetic and long-term income benefits.

These landowners may be particularly interested in gaining carbon credits, as an additional source of income, but they will have decided to grow trees for other reasons and may not make commercial decisions about the species of tree to plant[48]. They have the resources to resolve most of the land-management problems that are contained on their land, but might not be aware of some of them (eg. introduction of noxious weeds, effects of practices on other areas in the catchment, water quality in estuaries, etc.).

Forestry/farm forestry activities include proven species and known silvicultural practices and there are high degrees of certainty about growth and commercial performance. Established species include slash pine or hoop pine in the tropics and rainforest hardwoods (high-grade sawlogs for cabinet furniture and timber). These are generally long-rotational crops (25 to 30 years) and the use of timber is generally in longer-term products (a low decay function for the CO_2 in the wood to return to the atmosphere).

The productivity of trees planted in these areas is very high. The potential land areas available (especially on each landholding) mean that aggregation to sufficient parcels for a carbon buyer will be difficult (high transactions costs). Monitoring costs are uncertain—low areas force the costs up but the landholders might be prepared to do more monitoring themselves.

Conclusion: Timber production in this land type is attractive for aesthetic, lifestyle, investment and taxation reasons. Carbon credits will add a small margin to the returns from timber and will probably be actively sought by landowners who can defray the high transactions and monitoring costs.

48. As such they should be ruled out of any carbon credits, because their actions are strictly not ‘additional’.

7.2 Case Study Two—high-rainfall grazing

This land type is predominantly on the tablelands and the upper slopes on the eastern coast, as well as in areas of Western Victoria, South Australia and Western Australia. The area can often be characterised as having considerable degradation problems (erosion especially, salinity in lower-rainfall areas, etc.).

The land cost is lower than for coastal land and hence does not exclude forestry activities in a commercial sense. The land is suited to industrial forestry and farm forestry. Growth rates are reasonably high (E2, or P2, or higher). Large areas in the south west of WA have been planted to monocultures of Blue Gum (*Eucalyptus globulus*) ultimately destined for woodchip export. Some estimates are in the order of 50,000 ha planted around Albany[49] and the areas have been increasing steadily. The effects of carbon credits are likely to add only a small amount to the plantation income.

ABARE estimates the national area used for grazing in this zone, in 1996–97, to be 22.3 million ha. The gross value of production is $2,530 million. The average farm size is 1,000 ha and the average farm business profit was reported to be minus $20,871.

Current incomes from sheep (particularly wool) are low or negative and have been declining steadily. The national sheep flock has declined from 180 million at its peak to 118 million in 1997–98 and numbers are predicted to decline further. ABARE reports that ‘farms are expected to continue to adjust their enterprise mix away from sheep and wool in favour of cropping’[50]. Some of the decline in sheep numbers is occurring in the higher-rainfall areas, especially as the decline in fine wool prices has been more pronounced than the decline in coarser wool.

The five-year average gross margin for sheep, based on 19-micron wool production, is $94/ha. Overheads, including labour, are $70/ha (not including any returns on land value). Over 30 years, the NPV at a 7% discount rate for sheep grazing in this zone is in the order of –$180 per ha, assuming no productivity gains. The internal rate of return is 2%. The assumptions are given in Appendix 1.

The comparison between sheep and timber (with and without carbon credits) is shown in Table 16 (assumptions for these calculations can be found in

49. T002, Albany, pers.comm. 1998

50. ABARE (1999) *‘Fibres’*, *Australian Commodities* 6 (1):45. See also ABARE (1999) *Australian Farm Surveys Report: Financial Performance of Australian Farms* 1996–97 to 1998–99: 7

Table 15. Land types.

Land type	Likely type of carbon farming	Highest weighting for farm forestry and forestry activities	Case study industry enhanced or displaced	Productivity classes (E1–E5) and (P1–P3)[a]
Land type 1 High value land. Diverse ownership patterns. High rainfall.	Additional activity to higher rainfall forestry (e.g. sawlogs for timber, etc).	Social/ aesthetic	n/a	E0–E1, P1
Land type 2 Broadacre land suitable for industrial forestry. Medium-high rainfall.	Additional activity to commercial woodchip and sawlog farm forestry. Some displacement of high rainfall sheep farming.	Economic	High rainfall grazing	E2, P2
Land type 3 Lower value land, medium rainfall and drier lands, sheep wheat belt or steeper slopes in high rainfall areas.	Additional activity to environmental plantings. Commercial opportunities from *Pinus pinaster* and oil mallee (400–600 mm zone of WA).	Environmental	Medium rainfall cropping	E4–E5, P3
Land type 4 Rangelands	Reductions in clearing, limited scope for plantings (e.g. saltbush).	Environmental or social	Low rainfall grazing	E5 (¥50%)

* Productivity classes are as defined by Hassall & Associates (1996) *Sequestration of Atmospheric Carbon Dioxide in Trees*. E0 to E5 are six productivity classes for Eucalypt species, where E0 represents the fastest growth possible (more than 1000mm rainfall with good soil conditions) and E5 represents slow growth (less than 400 mm rainfall). P1 to P3 are three productivity classes for Pine species.

Appendix 1). The potential additional greenhouse gas benefit arising from reduced methane emissions, by removing sheep, is not considered here.

Table 16. Comparison between sheep and timber in the high-rainfall zone.

	NPV ($/ha)	IRR (%)
Sheep	–$180	2
Carbon only	–$1,381	4
Timber only	–$1,596	6
Carbon + timber	$1,149	9

The table shows that carbon plus timber has a much higher IRR than sheep and is viable in its own right[51]. It is much stronger than the returns from sheep farming, under the modelled scenarios. The strongest statement is that carbon by itself, without timber, is not a viable activity. The analysis shows that substitution between sheep and carbon farming is plausible.

The gross margin of sheep needs to be $108/ha before the activity reaches a 7% internal rate of return. The timber plus carbon activity has a NPV of $1,149 and IRR of 9%, which makes the investment appear worthwhile should carbon credits be at $28/tonne. Indeed the price only has to be above $17 to make the return on this activity 7%. However, the important issue is the value of the timber products rather than the rather limited value of the carbon. For the carbon-only enterprise to be viable, the price of carbon needs to be $41/t$CO_2$, which is in the plausible range.

As an aside, it should be noted that there will be complementarities between forestry and grazing, for example through the provision of shelter-belts. These potential benefits have not been modelled and indeed are the subject of a protracted debate[52].

Conclusion: Carbon farming is only profitable when associated with timber production. However, with very low returns from sheep production there are considerable possibilities for enterprise substitution to plantation timber, especially where transportation costs to processing facilities or ports are reasonable.

7.3 Case Study Three—medium-rainfall cropping

This land type roughly equates to the wheat–sheep zone. The area has serious salinity problems in some

51. The reason why sheep seem to lose less money than timber is that the income from timber is further into the future, but is higher.

52. Lefroy E.C and Stirzaker R.J. (1999) *Agroforestry for water management in the cropping zone of southern Australia*, in press.

parts and much larger erosion, soil acidity and other degradation problems.

Recent prices for crops, particularly canola, have meant that the farm income has been reasonable. The land price does not exclude forestry in a normal commercial sense but the growth rate and time to maturity, as well as the large distance to timber markets, mean that forestry enterprises have traditionally not been as profitable as timber production in higher- rainfall areas.

The tree growth is moderate, and has been modelled as an E3 productivity class.

In terms of statistics, in 1996–1997 the area for wheat/sheep belt cropping was 51.5 million per ha. The total farm income was $8,789 million. The number of farms was 27,976 and the average area operated was 1,841 ha. The average farm business profit was $27,526. The average wheat gross margin is $120/ha. It is worth noting that for the top 20% of farmers, the gross margin is $270/ha.

7.3.1 Comparison of carbon farming with mixed farming

The comparison between cropping and timber (with and without carbon) is shown in Table 17 (assumptions for these calculations can be found in Appendix 1).

Table 17. Comparison between cropping and timber in the wheat/sheep zone.

	NPV ($/ha)	IRR (%)
Cropping	–$125	5
Carbon only	–$2,043	<0
Timber only	–$2,425	<0
Carbon + timber	–$1,652	<0

On all measures, cropping comes out better and it seems unlikely that it will be replaced by carbon or tree farming.

The GM for wheat had to be $135/ha for it to have a positive NPV, which is well within what the top 20% of producers are achieving. The price of carbon had to be $80/t$CO_2$ before carbon and timber turned out a positive NPV in the cropping zone, where trees have lower growth rates. Where there are no timber values, the price of carbon needs to be $93/t$CO_2$ before carbon farming shows a positive NPV. The value of the timber product is not very high, given the long distances to processing. The analysis shows that the external[53] investment needs to be very considerable to promote changes in land use in the wheat/sheep zone.

7.3.2 Costs of treating salinity and effects of carbon values on salinity

Hassall & Associates (1999)[54] estimated the costs and benefits of major land management issues in the Weddin area (located near Grenfell, in the wheat/ sheep zone of NSW). The results of the cost–benefit analysis of major issues are presented in Table 18 (assumptions for these calculations can be found in Appendix 1).

Hassall & Associates also considered the ratios of public and private benefits and hence possible cost-sharing arrangements for investment in natural resource management. For salinity in this catchment, the resulting cost-sharing ratio between public and private investment was approximately 80:20.

The treatment considered for salinity management included using electromagnetic surveys to consolidate property plans, fencing off recharge and discharge areas, establishing perennial pasture and planting trees (as part of a vegetation management plan), and grazing management. The main conclusion from the analysis was that treating salinity is not in the farmer's financial interests. This adds further pressure to obtain public investment or capture other benefits

53. Investment either by sponsors of BfG, by the Commonwealth Government, or others.

54. Hassall & Associates (1999) *Weddin Catchment Action Plan*, prepared for Weddin Landcare Steering Committee Inc. and Department of Land and Water Conservation.

Table 18. Costs of treating land degradation in the Weddin district of NSW.

Issue	Area affected (ha)	Benefit–cost analysis for whole study area (366,000 ha)			Total cost for study area $ (PV)	Cost $/ha affected (PV)
		NPV ($/ha)	IRR (%)	BCR		
Dryland salinity	4,507	–7.1	N/A	0.5	4,987,800	1,107
Sheet erosion (Class II, III)	32,913	2.89	8	1.05	22,738,562	696
Sheet erosion (Class IV–VIII)	63,471	–67.32	N/A	0.18	30,183,607	475
Gully erosion	177.5	–3.27	0	0.18	1,467,000	8,265
Soil acidity (Class II, III)	200,637	95	10	1.21	169,438,962	845
Soil acidity (Class IV–V)	49,930	–89	N/A	0.25	43,276,618	867

(such as carbon storage) before this particular set of land-management actions can occur.

When the analysis was reworked to give the trees a carbon value of \$2.5/tCO_{2e}/5 years and adding in the transactions (\$100/ha) and monitoring costs (\$20/ha), the NPV for salinity measures did not change. If the carbon price was doubled to\$5.0/tCO_{2e}/5 years then the NPV for salinity treatment would rise slightly to \$7.0/ha.

Timber values were not included, as it is assumed that the distance to processing is too great to make this a profitable activity in its own right.

Public investors in salinity management have been interested in the scope for changing the cost-sharing ratios by having an additional private benefit. Our analysis shows that the change is likely to be very minor. Carbon credits may not be able to be obtained if the crown cover of the plantings is less than 20%. Also, if an additional market can be developed for the tree products, such as for eucalyptus oil (eg. oil mallees from WA), then greater private benefits can be modelled.

Conclusion: Carbon farming, with or without timber, does not compete with cropping. There appears to be little possibility that combinations of cropping and carbon farming will help to rectify the degradation problems of this case-study area.

7.4 Case Study Four—pastoral country

The area is characterised by extensive sheep and cattle operations. The area of pastoral land in Australia, as identified by ABARE survey data, was 328 million ha in 1996–97. The gross farm income in 1996–97 was \$1,039 million. There were 3,700 establishments. The average farm size was 88,751 ha (which includes large cattle ranches) and the average business profit was \$21,344.

The five year average gross margins for grazing sheep is \$0.68/ha. The assumed stocking rate is 0.1 DSE/ha.

The area is characterised by very low timber growth rates. The interest in rangelands for carbon storage arises because of the large area available and the presence of some important carbon emitters, notably oil and natural gas and mining interests. The low returns from wool also drive graziers to look for alternative enterprises.

The comparison between growing eucalypt trees and sheep farming is shown in Table 19 (assumptions for these calculations can be found in Appendix 1). Growing eucalypt trees is extremely unlikely in any case.

Of the potential carbon credits mentioned in Chapter 3, it is likely that accumulation of native biomass through de-stocking, counting woody weed invasions and stem thickening in savannah woodlands will not count. The active planting of saltbush does not meet present definitions for forest cover. Some shrubs (eg. *Acacia* spp.) might meet the definitions, but it is unlikely to be economical to plant these over such a broad area. Research is being conducted between Curtin University (Kalgoorlie Campus), Japanese universities and some landholders to investigate active tree planting in arid environments (<400 mm rainfall). This project, based around a 25 ha degraded site, might reveal further potential. At first sight it appears likely that the trial cannot avoid the use of watering or the high costs of establishment.

Conclusion: There are a number of serious administrative hurdles to overcome before it will be possible even to consider carbon credits from pastoral regions. There are also considerable physical problems, such as fire, feral animals and insect herbivores, which are difficult to control and will limit the accumulation of carbon in any measurable way. Mensuration costs could be very high unless aerial or satellite measurements are accepted.

Table 19. Comparison between sheep and carbon in the pastoral zone.

	NPV (\$/ha)	IRR (0%)
Pastoral sheep	–9	0
Carbon only	–2,448	0
Timber only	–2,465	0
Carbon + timber	–2,428	0

7.5 Summary of case-study sensitivity studies

The CO_2 prices needed to give a positive return in the case studies are shown in Table 20. Should the changes in land use be desirable, then the level of public investment needed is equal to the needed price minus the actual market price for CO_2 minus (plus) the returns from traditional enterprises.

Table 20. Summary of threshold CO_2 prices.

	Carbon only activity Price of CO_2 (\$/tCO_2)	Carbon plus timber Price of CO_2 (\$/tCO_2)
High rainfall sheep	41	17
Wheat (wheat–sheep zone)	93	80
Pastoral grazing	514	510

8. Risk analysis

The risks listed in Table 21 are identified and classified according to the following procedure:

1. Identify context.
2. Identify areas of risk.
3. Assess the likelihood of that risk.
4. Assess the severity of possible effects if the risk eventuates.
5. Determine actions to minimise or mitigate risks.
6. Implement these actions.
7. Monitor these actions.

Risk management involves the process of anticipating, evaluating and acting on different forms of risk. The risks arising from carbon sequestration are described in the following table, in which a score of 1 equates to a low risk, 2 to a moderate risk and 3 to a high risk. The risk score is calculated by multiplying a likelihood score by a severity score. The risk score then dictates the significance of the risk. Methods for controlling, reducing, avoiding, transferring or accepting the risk are also outlined.

The results of the risk management analysis are shown in Table 21.

Table 21. Results of risk management analysis.

	Likelihood (L)	Effect on objectives (I)	Total risk score (L) ¥ (I)	Methods for controlling or accepting risk
Kyoto Protocols not ratified	2	3	6	*Accept risk*—Do nothing about carbon credits unless the Protocol is ratified
Carbon credits only applicable to certain forestry activities (limited to Article 3.3).	3	3	9	*Reduce the risk*—Work towards a package that includes a wider definition of forests as well as Article 3 inclusions.
Carbon credits not allowed for biomass.	2	3	6	*Reduce the risk*—Lobby for biomass to be included as a credit.
Transaction costs and taxes make carbon trading in small parcels unprofitable	3	3	9	*Reduce the cost*—Lobby for standardised certificates heavily subsidised by the Commonwealth Government
Mensuration costs make carbon credits unprofitable to all but commercial timber operators.	3	3	9	Reduce the cost—Negotiate with the AGO for more simple forms of mensuration, or regional mensuration associated with NGGI.

Notes: 1 = low risk; 2 = moderate risk; and 3 = high risk

9. What needs to be done

The situation that appears to be unfolding is that carbon credits and even 'Bush-for- Greenhouse' credits as they are currently envisaged are not focused on and will probably not be a sufficient stimulus to sustainable land management. The Visions 2020, the Farm Forestry Program and the current interest in plantation production are limited to regions of high rainfall, close to ports and are taking place in response to commercial imperatives, not land management.

For owners of small areas of trees on farms carbon credits will not be worth pursuing unless the Commonwealth reduces transaction and mensuration costs and probably also subsidises the value of CO_2 sequestered. Alternative carbon sinks are likely to be more attractive to buyers, and alternative land uses will be more attractive to sellers. There may well be better and more direct incentives to achieving the objectives of preserving biodiversity and promoting sustainable land management than chasing after carbon credits.

At the same time it is becoming clearer[55] that the area required to be planted to trees and woody vegetation for groundwater management is much larger than previously thought. Should no financial gain be obtained from these planted areas, then 'living with salt' may be the best thing to do.

Our recommendations are divided into three areas: studies to support policy issues; policy intervention and physical and biological studies.

9.1 Studies to support policy issues

One of the more important questions that we, as a society, are trying to answer is 'What is the role of trees in the Australian landscape?' The answer has to be that there are many justifiable roles, from salinity management to biodiversity and habitat protection, from wind and water management to aesthetic considerations. Trees also act as a temporary sink for carbon and this is going to interact with the other roles and will need to be investigated.

Quite obviously the major task that sustainable land management in Australia faces is the development of a clearer understanding of how salinity is going to be 'managed'. Interest in carbon credits is a small subsidiary of the much larger question for which the National Dryland Salinity Program[56] is the main coordinating force, assisted by the National Land & Water Resources Audit (NLWRA)[57]. In particular, the recently awarded contract to study the social and economic motivations for land-use change[58] in four salt-affected catchments should clarify the role of trees in salinity control.

To resolve how carbon credits, or any other program to grow trees for salinity control purposes, will affect salinity a few general bioeconomic models would help. We understand that at least one has been developed at the University of Western Australia[59]. These will allow more detailed examination of the integration of landscape processes and economic returns. These models can also be used to examine in more detail the interaction of prices for carbon, mallee oil[60] and any other wood-based product from a land use whose major purpose is to rectify land degradation.

9.2 Policy intervention

9.2.1 Negotiating changes to or better definitions in the Kyoto Protocol

The debate over the rules of what will be and what will not be counted under the Kyoto Protocol is taking place now (see Section 3.1.1). In what ways can the agricultural community, including the many agencies, influence this debate?

The issues that need to be put on the table for agriculture include:

- the current definition of forests to be greater than 20% cover and greater than 2 m high (this

55. Hatton, T. J. and Nulsen, R. A (in press) *Achieving functional ecosystem mimicry with respect to water cycling in southern Australia*. in Lefroy E C, Hobbs R J, O'Connor M J and Pate J S (eds) *Agriculture as a Mimic of Natural Ecosystems*, Kluwer and; Lefroy T. 1998 *'Why marketing won't help if you've got nothing to sell:* A response to the Western Australian Government's Salinity Action Plan.

56. See <http://www.lwrrdc.gov.au/ndsp/index.htm>
57. See <http://www.nlwra.gov.au/>
58. See: <http://www.nlwra.gov.au/minimal/10_news_and_adverts/18_advertisements/advertisements_previous.html>
59. Abadi Personal Communication 20/7/99.
60. See: <http://www.agric.wa.gov.au/progserv/natural/trees/treecrop/oilglance.htm>.

considerably limits the application of Article 3.3 to Australian vegetation);

- forms of biomass, both native vegetation and weeds (natural vegetation, rangelands, etc.) which do not satisfy the current definition of forest;
- removal or modification of ruminants, and
- other items from the list in Section 3.1.1.
- These will only constitute tradable credits if methods can be developed to reduce transaction and monitoring costs to a level that allows a profit margin to the landholder. For example, for this reason, we do not consider it likely that change in soil carbon by means of minimum till is ever likely to become a tradable item.

The avenues for parties who wish to enter the debate are:

- submissions to the AGO in relation to the four papers (Section 3.2) being presented on National Emissions Trading;
- representations to delegates (including NFF and the National Landcare Facilitator) to the Expert and Industry Committees set up by the AGO; and
- direct discussions with AGO staff and, for the state and territory governments only, the Standing Committee on Agriculture and Resource Management.

9.2.2 Domestic trading

Domestic trading includes the methods that will be used and approved for measurement and trading within the Protocol, plus any changes involving carbon sinks developed within Australia in order to meet its international obligations for emissions in the 2008–2012 period.

Transaction costs

As mentioned in Section 5.2 above, it is our opinion, on the basis of discussions with lawyers and others, that transaction costs are likely to be very high for small parcels of carbon credits arising from farm plantations. There are methods that would reduce these transaction costs, including the setting up of a central register and the development of local cooperatives, or other special organisations, to organise regional sales of carbon credits.

Monitoring costs

It is our opinion that far cheaper and less accurate methods of vegetation monitoring are needed than those advocated in the Greenhouse Sinks Workbook. As we argued in Section 5.3, the need is not accuracy, but to guarantee to the buyer that the carbon present is certainly more than the amount sold. There are many methods that might be developed, including visual estimation by experienced evaluators, aerial photography and the methods being developed for the NGGI.

Broadening the accounting base in domestic trading

A number of possibilities could be envisaged here, especially overcoming some of the restrictions that the Protocol articles impose on the development of credits for protection of remnant vegetation and plantings for biodiversity and sustainable land management.

What is needed for domestic trading initiatives is totally dependent on what is included and not included in the Protocol. The negotiations that are scheduled to be completed at COP6 (see section 2.5) will determine this. It is therefore too early to start discussing Australian rules for carbon credits.

9.2.3 Negotiating the Commonwealth’s role in Bush for Greenhouse (BfG)

Although a considerable amount of work has been done on BfG in recent months, including the development of contracts for a research program and a carbon broker, we are still not clear how it will work. Because it is designed to sell potential credits to investors in the private sector, it will have to satisfy the current rules set by the Protocol and the credits will have to compete with other commercial sellers (see Section 3.3). This will mean that the plantings will have to be post-1990. If the objective of BfG is to protect Australia’s biodiversity, the plantings will have to meet certain criteria for local provenance of locally occurring species and a minimum level of species mix. All these criteria will increase monitoring costs (see Section 5.3). Alternatively, BfG may relax these criteria and support less diverse plantations.

In other capacities we are working with major companies on their carbon strategies, and BfG does not look very promising when set against other available options. Our experience has clearly shown that potential emitters wishing to invest in revegetation for sequestration want a reasonable return on capital invested as well as being able to project a ‘green’ image. These emitters would like a ‘package’ of sequestration investments, which includes commercial forestry, landcare-based plantings and regeneration of native vegetation. A package of initiatives that contains components of BfG may be very attractive as the increased cost and reduced rate of carbon sequestration from BfG initiatives may be offset by lower costs from other activities.

9.3 Improving the physical and biological knowledge base to make better decisions

There appears to be a rush of funds going to better measurement of the carbon sequestered. For example, a recent consultancy let by the AGO for a strategic plan for BfG stated,

> The work plan is required to define activities to achieve the following:
>
> - Establish a process for measuring and verifying the amount of carbon sequestered.
> - Development of data collection standards/ protocols.
> - Development of cost effective tools and methods to assist in measuring, and verifying carbon sequestration of environmental plantings (including soil carbon).
> - Development of a system to manage carbon sequestration data from environmental plantings to support and link with the National Carbon Accounting System.
> - Establish the balance between the best methods for site preparation that promote plant growth and maximise carbon sequestration.
> - Identification of material/workbooks required for broad distribution to those interested in carbon sequestration in native vegetation.

So this area of activity can be left to the AGO and BfG to finance.

9.3.1 Quantification of biomass accumulation and geohydrology

Some of the early indications from the National Dryland Salinity Program and the work of the National Land & Water Resources Audit is doing (see Section 9.1 above) are showing how much water has accumulated in the landscape since clearing occurred and how slow the response will be to reductions in infiltration rate from planting trees. In low-rainfall areas, trees are famous for growing rapidly while fresh water (in terms of the tree) is available and then suddenly stopping growth, and in some cases dying, when they run out of water[61]. Tree planters in these areas need to know a lot more about the quantity and quality of water that will be available to a plantation in any particular location, so that better decisions can be made on where to plant trees for best effect and how much carbon is likely to be accumulated over the next decade and especially between 2008 and 2012. So the work currently contracted should yield useful information.

9.3.2 New land use enterprises with production, carbon and landscape management potential

A considerable amount of effort is also going into alternative forms of woody vegetation for areas unsuitable for plantation timber. Among these are oil mallees[62] and tagasaste. These are being supported by a number of research agencies. Their role in generating carbon credits is also being investigated and probably does not require additional attention.

9.3.3 Potential services

This is such a rapidly changing field that keeping up is a major task. There are a number of web pages that contribute regularly to the information available but there is none that serves the rural community in the way that we have attempted here. This would seem to be worthwhile.

9.3.4 Biomass energy

There is now a Biomass Taskforce[63] formed in July 1997 by the Energy Research and Development Corporation, in collaboration with the RIRDC (Rural Industries Research and Development Corporation representing the Joint Venture Agroforestry Program), the Grains Research and Development Corporation, Environment Australia (now the Australian Greenhouse Office) and the Bureau of Resource Sciences (now Bureau of Rural Sciences) to facilitate the development of a biomass industry in Australia. Subsequently the CSIRO Divisions of Energy Technology and Forestry and Forest Products, the Forest Products Association of New South Wales, Pacific Power, Delta Electricity, Macquarie Generation, Waste Service NSW, Energy Developments Limited, Sustainable Energy Research and Development Corporation, Southern Pacific Petroleum/Central Pacific Minerals N.L., Forestry Tasmania, State Forests of NSW, Western Power Corporation, ABB Power Generation Ltd, Western Sydney Waste Board, and Stanwell Corporation have joined as Associate Members. Macquarie Generation in the Hunter Valley of NSW is already experimenting with the use of biomass fuels to supplement its coal stream to generate electricity. No doubt other generators are doing the same thing. You cannot have your carbon credit and burn it, so the choice is in which direction a landholder should proceed. This will depend very much on location and the prices offered for the alternative uses.

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61. See Hassall & Associates 1998 *Carbon sequestration in low rainfall areas: the measurement of plantations of trees in Victoria.* Environment Australia, Australia.

62. See: <http://www.agric.wa.gov.au/progserv/natural/trees/treecrop/oilglance.htm>.

63. See <http://www.users.bigpond.com/steve.schuck/abt>.

Appendix 1. Assumptions

This appendix contains many of the assumptions for the following calculations:

- Timber and carbon
- Grazing and Cropping
- The Salinity Case Study.

1. Timber and carbon

Assumptions for highest productivity Eucalypt (E0). See Section 6.4.

Financial

Discount rate = 7%.

Carbon prices and sales:

Sell CO_2 sequestered before 2008 (y/n)	No
Sell CO_2 in all commitment periods up to 2027 (y/n)	Yes
Buy back above ground CO_2 at harvest	Yes
Value losses from harvesting and processing (y/n)	No
Price of CO_2 for all commitment periods	\$28/tonne CO_2
Price of CO_2 at repurchase	\$28/tonne CO_2

Timber yield and prices:

Operation	Year	Green volume (m^3/ha)[a]	Standing price (stumpage) (\$/m^3)[b]
T1 – first thinning	14 (2014)	100	20
T2 – second thinning	20 (2020)	100	20
Clearfall	30 (2030)	622	50

[a] Uses E0 growth curve modified from Hassall & Associates (1996).
[b] Distance: <100 km from port.

Carbon sequestered (E0):

Year	Cumulative CO_2 sequestered (t/ha)
2000	0
2008	184
2012	300
2017	458[a]
2022	615[a]
2027	765[a]

[a] Thinning will occur in Years 14 and 20, but plantations increase growth rates following thinning and these losses have not been counted in carbon accounting.

Costs:

Item	Year	Cost (\$/ha)	Comments
Establishment	0	2300	
Management and maintenance p.a.	All	50	
Roading	2014, 2030	200	
Pruning	–	0	Self-pruning
Harvesting and transport	–	0	Included in stumpage prices
Land rental per year	All	125	
Carbon transaction	0	100	
Monitoring – 1	2008	13	
Monitoring – 2	2011	6.5	(less detailed than first monitoring)

Assumptions for high productivity Eucalypt (E1). See Section 7.2.

Financial

Discount rate = 7%

Carbon prices and sales:

Sell CO_2 sequestered before 2008 (y/n)	No
Sell CO_2 in all commitment periods up to 2027 (y/n)	Yes
Buy back above ground CO_2 at harvest	Yes
Value losses from harvesting and processing (y/n)	No
Price of CO_2 for all commitment periods	\$28/tonne CO_2
Price of CO_2 at repurchase	\$28/tonne CO_2

Timber yield and prices:

Operation	Year	Green volume (m^3/ha)[a]	Standing price (stumpage) (\$/m^3)[b]
T1 – first thinning	14 (2014)	100	20
T2 – second thinning	20 (2020)	100	20
Clearfall	30 (2030)	494	45

[a] Uses E1 growth curve modified from Hassall & Associates (1996).
[b] Distance: 100–125 km from port.

Carbon sequestered (E1):

Year	Cumulative CO_2 sequestered (t/ha)
2000	0
2007	148
2012	240
2017	363[a]
2022	487[a]
2027	606[a]

[a] Some carbon is lost through thinning, but growth rates accelerate after thinning, so the net effect is small.

Costs:

Item	Year	Cost (\$/ha)	Comments
Establishment	0	2300	
Management and maintenance p.a.	All	50	
Roading	2014, 2030	200	
Pruning	–	0	Self-pruning
Harvesting and transport	–	0	Included in stumpage prices
Land rental per year	All	25	
Carbon transaction	0	100	
Monitoring – 1	2008	13	
Monitoring – 2	2011	6.5	(less detailed than first monitoring)

Assumptions for medium-low productivity Eucalypt (E3). See Section 7.3.

Financial:

Discount rate = 7%

Carbon prices and sales:

Sell CO_2 sequestered before 2008 (y/n)	No
Sell CO_2 in all commitment periods up to 2027 (y/n)	Yes
Buy back above ground CO_2 at harvest	Yes
Value losses from harvesting and processing (y/n)	No
Price of CO_2 for all commitment periods	\$28/tonne CO_2
Price of CO_2 at repurchase	\$28/tonne CO_2

Timber yield and prices:

Operation	Year	Green volume (m^3/ha)[a]	Standing price (stumpage) ($/$m^3$)[b]
T1 – first thinning	14 (2014)	0	0
T2 – second thinning	20 (2020)	0	0
Clearfall	30 (2030)	265	12

[a] Uses E0 growth curve modified from Hassall & Associates (1996).
[b] Distance: 400 km from port.

Carbon sequestered (E3):

Year	Cumulative CO_2 sequestered (t/ha)
2000	0
2007	70
2012	130
2017	194
2022	259
2027	323

Costs:

Item	Year	Cost ($/ha)	Comments
Establishment	0	2300	
Management and maintenance p.a.	All	50	
Roading	2014, 2030	200	
Pruning	–	0	Self-pruning
Harvesting and transport	–	0	Included in stumpage prices
Land rental per year	All	25	
Carbon transaction	0	100	
Monitoring – 1	2008	13	
Monitoring – 2	2011	6.5	(less detailed than first monitoring)

Assumptions for low productivity Eucalypt (E5). See Section 7.4.

Financial:

Discount rate = 7%

Carbon prices and sales:

Sell CO_2 sequestered before 2008 (y/n)	No
Sell CO_2 in all commitment periods up to 2027 (y/n)	Yes
Buy back above ground CO_2 at harvest	Yes
Value losses from harvesting and processing (y/n)	No
Price of CO_2 for all commitment periods	$28/tonne CO_2
Price of CO_2 at repurchase	$28/tonne CO_2

Timber yield and prices:

Operation	Year	Green volume (m^3/ha)[a]	Standing price (stumpage) ($/$m^3$)[b]
Clearfall	30 (2030)	83	2

[a] Uses E5 growth curve modified from Hassall & Associates (1996).
[b] Distance: >500 km from port.

Carbon sequestered (E0):

Year	Cumulative CO_2 sequestered (t/ha)
2000	0
2007	23
2012	41
2017	61
2022	81
2027	101

Costs:

Item	Year	Cost ($/ha)	Comments
Establishment	0	2300	
Management and maintenance p.a.	All	50	
Roading	2014, 2030	200	
Pruning	–	0	Self-pruning
Harvesting and transport	–	0	Included in stumpage prices
Land rental per year	All	0.50	
Carbon transaction	0	100	
Monitoring – 1	2008	13	
Monitoring – 2	2011	6.5	(less detailed than first monitoring)

2. Grazing and cropping activities

Assumptions for high rainfall grazing. See Section 7.2.

Item	Value
Discount rate (%)	7
Stocking rate (DSE/ha)	6
Micron	19
Stock build up over 2 years, wethers	
Stock purchase ($/DSE)	30
Gross margin ($/DSE)	15
Farm infrastructure ($/ha)	100
Maintenance (2.5% x infrastructure p.a.) ($/ha/year)	2.5
Land rent ($/ha/year)	25
Management fee ($/ha/year)	20

Assumptions for medium rainfall cropping. See Section 7.3.

Item	Value
Discount rate (%)	7
Yield (t/ha)	2
Price ($/t)	150
Rotation: cropping over 3/4 farm (or crop 3 years in 4)	0.75
Gross margin ($/ha)	120
Farm infrastructure ($/ha)	700
Maintenance (at 2.5% p.a.) ($/ha/year)	17.5
Land rent ($/ha/year)	25
Management fee ($/ha/year)	20

Assumptions for low rainfall grazing. See Section 7.4.

Item	Value
Discount rate (%)	7
Stocking rate (DSE/ha)	0.1
Micron	23
Stock build up over 2 years, wethers	
Stock purchase ($/DSE)	20
Gross margin ($/DSE)	6.8
Farm infrastructure ($/ha)	2
Maintenance (at 2.5% p.a.) ($/ha/year)	0.05
Land rent (+ levies) ($/ha/year)	0.5
Management fee ($/ha/year)	0.5

3. Salinity case study

Uses carbon sequestration and price details as per E3 timber. Timber is not valued. The discount rate is 7%.

- The total land in the catchment is 366,751 Ha. Of this, the salt affected land is 4507 ha. All observed symptoms on land capability classes III, IV and V land. The area affected is approximately 1/3 of each of these three land classes.
- Treatment/rotation:
  - *Year 1* Undertake EM surveying, drilling, geological and soil surveying; strategically plant trees, lime and establish salt tolerant pastures.
  - *Year 2* Graze, fertilise
  - *Year 3* Graze, fertilise (25% of lost income attained through increased production)
  - *Year 4* Graze, fertilise
  - *Year 5* Graze, fertilise (25% increase in crop yield will not give a positive

crop gross margin, hence continue grazing Class III land this year)

- *Years 6–10* Crop class III land. Graze class IV & V land. Fertilise (100% of lost income attained through increased production)
- *Years 11–13* Graze, fertilise, apply lime in year 11.
- *Years 14–17* Crop Class III land. Graze class IV & V land. Fertilise.
- *Year 18* Undersow crop with perennial pasture (Class III). Graze class IV & V land. Fertilise
- *Years 19–21* Graze, fertilise, apply lime in year 19.
- *Years 22–25* Crop Class III land. Graze class IV & V land. Fertilise.
- *Year 26* Undersow crop with perennial pasture (Class III). Graze class IV & V land. Fertilise
- *Years 27–29* Graze, fertilise, apply lime in year 27.
- *Year 30* Crop Class III land. Graze class IV & V land. Fertilise.

• Dryland salinity affects a 'halo' area of 10% around the salt affected area and production is reduced by 10% on this area (451 ha)

• Investigations (EM surveys, etc) cost $3.75/ha across whole study area

• Trees are planted strategically up to 10% of the area affected (not necessarily in the discharge areas). Total tree planting costs are $3,400/ha planted, which allows for fencing, site preparation, tree purchase and replanting in Years 2 and 3 (local Grenfell data).

• Salt tolerant species established on 90% of area affected by salinity. Costs of establishment are $133/ha. Liming at 1 tonne/ha costs $55/ha. Fertiliser costs $22.50/ha.

• Class III land is 50% wheat and 50% Canola. The no plan scenario assumed a current loss of 100% of cropping income for class III land; and grazing is substituted for cropping and has a 25% loss in carrying capacity

• Class IV and V land is 100% sheep; with opportunity cost of lost grazing income at 30% of production.

• Benefit stream commences in Year 3 when 25% of lost income is attained. For cropping, full production is restored in Year 5. For grazing, 50% of lost income is attained in years 6–9 and 100% in year 10 (ie. full production restored).