Garnaut Climate Change Review Issues Paper 1
Climate Change: Land Use – Agriculture and Forestry

NSW SUBMISSION

EXECUTIVE SUMMARY

- In relation to coverage, ideally, all sectors should be included in an emissions trading scheme (ETS) where this provides the most efficient means of reducing emissions, and is consistent with principles of equity, environmental effectiveness, flexibility and investor certainty. Such conditions do not appear to be met for the agriculture sector at this time. This paper considers the technical issues associated with the future coverage of agriculture and forestry in an emissions trading scheme.

- If the agriculture and forestry sectors are not covered in an emissions trading scheme in the shorter term, but are eligible to create offset credits, it will be important to maintain the integrity of the carbon offset scheme by only rewarding *actual, additional* abatement, while ensuring that the eligibility requirements are as practical as possible so as to encourage participation.

- In this respect, recognition of prior mitigation action (i.e. for current bans on land clearing), as contemplated in the Issues Paper, appears to be inconsistent with approaches in the Kyoto Protocol and United Nations Framework Convention on Climate Change in respect of deforestation in the developing world.

- Carbon pooling could be explored as a means to overcome the problems associated with the potentially high diversity and number of entities in the agriculture and forestry sectors (which the Issues Paper identifies as a barrier to mitigation efforts).

- NSW Government agencies have led the world in forestry accounting, including successfully integrating carbon forest sequestration in the Greenhouse Gas Reduction Scheme (GGAS), which remains one of only two emissions trading schemes operating in the world.

- NSW notes that some stakeholders are interested in reviewing existing sequestration activity rules as part of the move to an ETS, including:
    - The GGAS "100 year rule" for carbon sequestration maintenance.
    - GGAS carbon accounting rules and carbon maintenance obligations.
    - Investigation into the "Average Carbon Stocks Approach" for change in land-use and land management.

- While there is no objection to a considered review of components of the GGAS sequestration rules, such views should not prevent consideration of the inclusion of the forestry sector via coverage or offsets using the existing GGAS rules. Any future review of GGAS rules would need to consider a range of issues, including consistency with international frameworks, the availability of technical and other data. (i.e. measurement), additionality, transaction costs, flexibility to respond to emerging science, policy and political developments, investor certainty, and equity.

- The ETS should be designed to enable it to be linked to international schemes at the appropriate time. The ability to link with an international scheme will be dependent on maintaining consistency with international carbon accounting and trading protocols. NSW acknowledges the use of existing national and international standards, definitions and practices (ANZSIC, UN, ISO) under the National Greenhouse and Energy Reporting Scheme. This approach will assist in the crucial task of linking Australia's carbon market to other global markets. There would also be benefits in ongoing research and international negotiations by Australia to facilitate international acceptance of Australia's emissions trading scheme.

- In relation to carbon stored in wood products, further research is required to properly underpin long-term carbon storage claims and achieve international recognition of related sequestration accounting methods, if inclusion of wood products in an emissions trading scheme is to be considered. NSW supports accelerated investigation into the feasibility of accounting for carbon in harvested wood products.

- The NSW Government has invested significant resources into continuing research in the agriculture and forestry area. In particular, the NSW Department of Primary Industries is:

    - leading research on identifying carbon retained in timber products and, where appropriate, identifying methodologies that could be used to account for carbon storage in harvested wood products;

    - working with the NSW Department of Environment and Climate Change (DECC) and other researchers, including the CSIRO and Commonwealth Department of Climate Change, to investigate the potential for land management practices to increase soil carbon for the major land uses and the major agricultural soils of NSW, and to develop a rapid and cost effective method for measuring soil carbon (research is also to be conducted into soil carbon change under tillage systems, and measuring the impact on soil carbon of alternative crop and pasture management systems);

    - researching the application of char (a green waste product) to soil to assess likely benefits, including increased plant production, enhanced fertiliser efficiency, carbon sequestration and reduction of nutrient and pesticide run-off;

    - working with DECC, the Independent Pricing and Regulatory Tribunal and the Murrumbidgee Catchment Authority (CMA) to support and assist the incorporation of greenhouse gas emission abatement measures into land use and land management decision-making by rural landholders and catchment managers; and

    - working with the Lachlan CMA and the CSIRO in a Climate Action Grant project to develop a reliable tool for estimating carbon sequestration by environmental plantings in NSW.

- The NSW Primary Industries portfolio has also prepared scientific papers focusing on climate change and agriculture; fisheries; forestry and mineral resources. Attached are two papers based on the sectors relevant (agriculture and forestry) to this Issues Paper. NSW understands that this Issues Paper is concerned with land use – agriculture and forestry, but requests that fisheries be included in the examination of climate change impacts upon primary industries, noting that this sector has not been addressed in the forums that have been conducted under the Garnaut review. The sectoral paper on fisheries is attached for consideration. Also attached is a paper prepared by NSW Department of Primary Industries for the Ministerial Advisory Council on Primary

Industries Science, titled '*Climate Change Research Priorities for NSW Primary Industries'*.

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KEY POINTS/ISSUES

Adaptation and mitigation are essential for the future viability of the agriculture and forestry industries. A crucial step in developing appropriate strategies is the furthering of research and the development of modelling of the potential impacts of climate change at both the regional and industry levels. Communication of these projections will then be the next focus. Some of this work will need to be coordinated at a Commonwealth and State level with input from key industry stakeholders. It is recognized that the COAG Working Group on Climate Change and Water will provide the chief vehicle for inter-jurisdictional policy development and coordination in this context.

Forests and agriculture have an important role to play in mitigating the impact of climate change, including through:

<u>Agriculture</u>

- Management enteric methane emissions.
- Manure management.
- Management of soil emissions.
- Revegetation.
- Reducing fossil fuel consumption.
- Production of biomass for bioenergy.

<u>Forestry</u>

- Active management of native and plantation forests to increase sequestration and reduce emissions.
- Afforestation and Reforestation.
- Investigation of increased use of wood products for carbon storage.
- Provision of renewable energy.

The contribution that offsets can make will be influenced by:

- the price of carbon;
- the eligibility and participation requirements under the ETS;
- the creation of international trading linkages; and
- community recognition and acceptance of the role that offsets can play.

1. Adaptation in the agriculture and forestry sectors

1.1 Key message (impacts)

Adaptation policies must be driven by a greater understanding of the likely impacts of climate change along spatial, temporal and biological scales. Currently the majority of studies on the impacts of climate change are at a high level, giving broad estimates with varying error ranges. In addition, the gathering and dissemination of data, information and knowledge on the impacts of, and adaptation to, climate change is not undertaken in a consistent manner. Much of this information is held by numerous Government agencies at the State and Federal levels. Improved organisation, availability and interpretability of the available resources is required to harness the benefits of knowledge and understanding of climate change, and to appropriately plan the action required to adapt to those impacts.

Strategies for gathering data on the impacts of climate change should ideally have the capability of being scaleable to the magnitude, diversity and uncertainty of the challenges ahead. Initial strategies should concentrate on biophysical impacts with consideration of socioeconomic impacts being conducted in adaptation and mitigation analysis. The NSW Government is currently undertaking nine studies under its Climate Change Impacts and Adaptation Research Program which examine the impacts of climate change in discrete policy areas, including: human health; bushfires; conservation planning; invasive species; and water. The outcomes of these studies will inform adaptation policies going forward.

The projected changes in climate will have major impacts on natural and human-influenced ecosystems. Biodiversity is threatened, especially where landscape fragmentation limits the opportunities for species to migrate as climate changes (CBD 2003). Primary industries are also particularly vulnerable. In Australia, variation in crop yield and livestock production from year to year is largely a result of variation in rainfall (Podbury et al. 1998). Australian agriculture, therefore, is very vulnerable to the increased variability and shifts in precipitation patterns that are predicted under climate change scnarios. Livestock are likely to suffer increasing heat stress, as well as a greater incidence of pests and disease, such as cattle tick, buffalo fly and eye cancer. Crop yields are threatened, especially by impacts on rainfall and length of the growing season. Climate change may exacerbate the impacts of weeds, pests and diseases, through increases in their prevalence, changes in their geographic distribution and reduced tolerance by the host.

Within the forestry industries, projected climate changes are not clearly understood, especially for Australian tree species under typical Australian conditions. However, the increasing carbon dioxide concentration is likely to increase plant growth. Where trees are not water-limited, climate warming is likely to expand the growing season in southern Australia. However, increased fire incidence and pest damage may diminish some productivity gains. The productivity of exotic softwood and native hardwood plantations is likely to be increased by carbon dioxide fertilisation effects, although the amount of increase will be limited by feedbacks such as nutrient cycling (Kirschbaum 1999).

The projected rise in sea level, increased frequency of storms and salt water incursion into estuaries will impact on commercial and recreational fisheries, by changing habitats. A further concern for fisheries is the projected increase in ocean acidity, resulting from increased ambient concentrations of carbon dioxide. This will affect the formation of calcium carbonate in shells and corals.

Efficient responses to the impacts of climate change will require a broad base of data, information and knowledge, as well as strategies to organise and communicate those resources. As the impacts of climate change are so far reaching and complex, there must be strategies to rank the likelihood and consequence of impacts so that responses can be prioritised over a range of temporal, spatial and institutional scales. Furthermore, an effective two-way communication strategy must be developed and implemented to ensure that the planned outcomes are being achieved, or to identify where responses may require adaptation.

At a national and state scale there are three core requirements for an effective response to this challenge:

- Integrate and synthesise data, information and knowledge about the resource base of primary industries, and the accompanying projected scenarios of climate change to improve our understanding of the impacts.
- Assess the impacts and prioritise their likelihood and consequence so that the most cost-effective strategies to adapt to, and/or mitigate, these impacts can be developed and implemented.
- Communicate to individuals and institutions the impacts and the responses available to adapt to, and/or mitigate, these impacts in an open dialogue with stakeholders.

This is a top-down approach for the development of systems and the gathering of data. The development of models must have the capability of assessing climate change, climate variability and primary industries production.

1.2 Factors affecting the implementation of adaptation measures in the agriculture and forestry sectors:

Given the varying degree of impact across spatial, temporal and biological scales, a critical issue in formulating appropriate responses is to identify those industry sectors and regions that are unlikely to be able to adapt to the expected rate of change. In these areas an orderly and informed process of transition will be required to achieve structural adjustment. Specific activities that may become untenable in a carbon constrained environment must also be identified and alternative procedures developed.

For the remaining areas in which adaptation and long term sustainability are feasible, the need for adaptation strategies beyond those resulting from ongoing, productivity-oriented R&D must be defined, and the justification for additional investment determined. Farmers quickly adopt changes that reliably provide short-term benefits. Farm managers therefore track optimum practices for the *current* climate. Most farm investment or management decisions only have an impact in the current season or for a few years (you don't plant a wheat variety this year that is developed for the potential climate in 2050). It is thus difficult to justify investment for an uncertain long-term benefit. To be attractive compared to other potential investments, on-farm investments need to fully cover their costs within a decade or less, yet the climate is not likely to change significantly over that period. Impacts from climate change during the 'life' of most (farming) investments will be small compared to impacts from climate variability.

Accordingly, all the adaptation opportunities to agriculture and forestry contained in box 3.1 of the issues paper need a two-tier optimisation strategy, firstly for the current (short-term) climate and secondly, for long-term climate change.

1.3 Addressing adaptation

The requirements to achieve long term outcomes for adaptation include:

- capacity to monitor key ecological indicators for both aquatic and terrestrial environments, and economic or productivity indicators for sectors or regions at risk;
- modelling capacity capable of informing an adaptive, risk-based approach to ongoing management of vulnerable species or ecosystems, or policy development in relation to particular industry sectors;
- development of incentive programs that will ensure that the costs of adaptation and transition initiatives are appropriately shared among private and public beneficiaries; and
- a responsive regulatory and policy environment capable of translating scientific data into effective and equitable adaptive responses.

Short-term goals, devised in conjunction with stakeholders, should be centred on:

- developing a thorough understanding of the implications of plausible climate change scenarios for individual production, natural and wild harvest systems, associated ecological communities and specific species where necessary;
- supporting appropriate transition for those systems and activities that are considered to be no longer sustainable; and
- identifying priority adaptation strategies for those systems and activities that are considered potentially sustainable.

Medium-term goals should include:

- policies informed by sound science to assist transitions in industries at risk under a changed climate; and
- adaptation strategies being extended to all primary industry sectors or regions with the potential for long-term sustainability.

While there is significant research in the public domain on adaptation generally, there is little research focusing on the issue of transition at either a technical (identification of potentially unsustainable industries, sectors or practices) or policy level. This is an area that needs addressing.

The NSW Department of Primary Industries' (DPI) R&D relevant to adaptation in the agriculture sector has focused particularly on seasonal risk assessment, the development of risk management tools, and water-use efficiency in both irrigated and dryland production systems, the latter in particular related to conservation farming technology. Plant breeding programs have provided a wide variety of genotypes for crops and pastures which will remain valuable under future climates even if the spatial distribution of their preferred niche alters.

Relevant research within the Forest Resources Research biodiversity group includes long-term (since the 1980s) forest ecology experiments that will provide base line data for assessing the impact of climate change on forest biodiversity, or for modelling the effect on biodiversity of increased frequency of droughts and wildfire. In addition, studies of the ecology and behavioural flexibility of a range of forest species, and of species distributions in relation to climate, will help in interpreting species' capacity to adapt to climate change, and likely regional impacts. Significant research has also been undertaken into the genetic improvement of tree species used for plantations, and into the productivity potential of these across a range of sites, including dryland areas.

A comprehensive listing of NSW DPI research initiatives for primary industries, both current and proposed, is provided in the attached sectoral papers, and elaborated in the attached paper prepared for the Ministerial Advisory Council on Primary Industries Science.

1.4 Forestry Issues

While the plantation sector has some clear signals to undertake adaptive responses to climate change, there are no such signals for the native forest sector either in terms of industry (processing) or forest management. The imperative for commerciality currently drives any adaptation in terms of the implementation of regulations and the management of infrastructure, whereas 'pure science' drives research. A balance between the two, to develop cost-effective adaptation strategies, is required.

As forest management has not been considered in the context of the 'carbon market', limited research has been undertaken to improve understanding of the likely impacts of climate change on native forest ecosystems or their role in mitigation (addressed further below).

Specific factors affecting the implementation of adaptation measures in the forestry industry include:

- The long timescale for the outcomes of adaptation actions to become apparent in forest ecosystems.
- The scale and variation at which management practices will need to be applied due to variability between regions and ecosystems.
- The need to recognise the place of commercial forests in a broader forested environment.
- The capacity of industry to adapt due to the high cost of upfront investment. It is noted that this issue is not limited to the forest industry, but it is a particularly relevant one due to the long-term nature of plantations/forest management.
- Impacts on communities where industry fails to adapt or climate change is of a magnitude that prohibits adaptation.
- Significant uncertainty regarding the impacts of climate change, which means that the optimal adaptation responses are not clear, and the risk associated with modifying management is substantial.

Approaches to land and water use management practices for forests and forestry must recognise that climate change will create challenges and opportunities.

NSW DPI considers that the anticipated consequences of predicted climate change will be felt most in the areas of:

- plantation survival at establishment due to warmer drier weather;
- seedling survival in the nursery due to water scarcity;
- asset protection in response to more, high intensity bush fires;
- increased risk of damage caused by weeds, pests and pathogens;
- exposure to seed shortages associated with international biosecurity risks; and
- increased competition for suitable land for plantation establishment.

Opportunities exist through:

- An increase in the potential area of suitable land for plantation – e.g. high altitude land will become warmer leaving plantations less exposed to frost/snow damage; more dryland may become available as farming system contract.
- Increases in tree growth rates may occur through the CO_2 fertilisation effect, facilitating shorter rotations and altered silviculture.
- The potential to participate in the trading of carbon credits as domestic and international markets evolve, and to develop products and services relating to environmental management.

2. Mitigation options for agriculture and forestry

There is significant potential for mitigation in both the agriculture and forestry sectors. The commercial viability may be direct and/or indirect through improved production and management efficiencies. The main options for mitigation are:

- Agriculture:
  - managing enteric methane emissions;
  - manure management;
  - management of soil emissions;
  - revegetation;
  - reduced fossil fuel consumption; and
  - the production of biomass for bioenergy.
- Forestry
  - Active management of native and plantation forests to increase sequestration and reduce emissions;
  - afforestation and reforestation; and
  - increased use of wood products and provision of renewable energy.

These options are considered in detail in Section 2.1.

The following comments are made in relation to the mitigation challenges identified in the issues paper:

- *Diffuse sources and sinks*: While agriculture particularly is characterised by diffuse sources and sinks, this is a barrier to monitoring and verification rather than to mitigation per se.
- *High diversity of entities*: While agriculture is characterised by a ‘diversity of entities’, the forestry industry is well structured and a small proportion of the sector represents the majority of the activity undertaken by the industry.
- *High variability of emissions*: While emissions from both sectors are linked to biological processes, there is a high degree of variation between the sectors. For example in the forest sector emissions are more likely to result from fire or industrial processing, whereas in agriculture they are more closely tied to enteric fermentation and nitrogen transformations.

- *Highly elastic consumer markets*: Both agriculture and forestry are constrained in their ability to pass on the cost of mitigation policies to the consumer. In agriculture this is because they are identified as 'price takers' in the global supply chain.

2.1 Potential for mitigation in the short term and practical options for mitigation likely to become commercially viable in the near future

Agriculture options

Potential mitigation measures in the agriculture sector that are practical and commercially viable in the short term include:

- managing enteric methane emissions;
- managing nitrous oxide emissions through modification of fertilizer application practices; and
- increasing sequestration through reforestation and revegetation.

<u>1. Managing enteric methane emissions</u>

Options include:

- Herd management, to increase reproductive performance or maximise the rate of product generation (live weight, milk, wool) across the whole herd, will lead to a reduction in emissions intensity. Relevant practices include strategic supplementation, feedlot finishing, parasite control and culling of barren females.
- Changing diet type from a roughage to a cereal-grain base.
- Genetic improvement of cattle.
- Targeted manipulations of rumen ecology. Two rumen manipulation strategies are being developed:
    - Dietary additives of short-term effect: Existing agents include dietary oils (e.g. coconut oil), tannins and monensin®. The long-term efficacy of these agents has not been established, and in the case of coconut oil and propionate precursors, cost may be prohibitive.
    - Agents achieving long-term rumen ecological change: None are yet available, but possible strategies being researched include vaccines against rumen methanogens, agents to eliminate rumen ciliate protozoans, and microbial reductive acetogenesis activated in the rumen by probiotic or chemical means.

<u>2. Manure management</u>

Options (available now) include:

- Modified manure handling to minimise emissions from stockpiles.
- Anaerobic digestion to minimise emissions and recover energy that can be used to displace fossil fuel energy sources.

Future options include pyrolysis of manure to produce biochar, which stabilizes carbon and produces a soil amendment that enhances agricultural productivity.

3. Management of soil emissions

Soil carbon management
Intensively cropped soils have low carbon content, due to disturbance, erosion and regular periods of minimal organic matter input. Because cropping soils in Australia have lost a substantial amount of carbon, there is significant potential to increase carbon stocks through improved land management practices. Evidence from long term trials and modelling indicates that modified cropping practices (direct drilling, stubble retention, controlled traffic) can arrest further decline in soil carbon in cropped soils, but have limited capacity to raise soil carbon (up to 2 tCO_2e ha^{-1} $year^{-1}$). Conversion from cropping to pasture, or inclusion of a pasture phase in the cropping cycle, has greater potential to increase soil carbon. However, such increase should not be considered in isolation from the total greenhouse gas emissions/removals from the enterprise (an increase in pasture area is likely to be accompanied by increased numbers of ruminant stock, increasing emissions from enteric fermentation.)

NSW is undertaking research to quantify the potential to increase soil carbon stocks through land management practices, including tillage practices, opportunity cropping, pasture cropping, revegetation and application of organic amendments.

Initial research into using biochar as a tool to increase soil carbon sequestration is showing promising results. Furthermore, biochar has been found to mitigate non-CO2 greenhouse gas emissions. However, improved understanding at the process level is required so that land-based greenhouse gas mitigation policies are better informed. Char carbon stability and greenhouse gas mitigation ability of biochar in different farming soils and climatic conditions needs to be thoroughly assessed. Indirect benefits of biochar application to soil (e.g. through fertiliser displacement by increased CEC and nutrient conservation) needs to be investigated in a range of farming systems with varying soil types and fertility.

Management of nitrous oxide emissions
Anthropogenic sources of nitrous oxide contribute 3Gt CO2e per year, around 8% of global emissions, and agriculture is responsible for 42% of this total. Nitrous oxide is emitted from soil under both anaerobic and aerobic conditions, mainly through denitrification, but also during nitrification. Nitrogen fertilisers, biological nitrogen fixation by legume species, and the excreta of grazing animals are all sources of nitrous oxide emissions. Emission rates vary widely between different land uses and environments, and are highest from irrigated cropping. There is significant potential to reduce emissions by strategic management of nitrogen fertilisation, including timing application to match crop demands and avoiding application prior to heavy rain.

4. Revegetation
Sequestration through strategic revegetation of agricultural land, linked to Property Management Planning, can provide benefits to agricultural enterprises (e.g. salinity management, shelter). In some situations, the least productive agricultural land can be planted with trees for positive financial gain.

5. Reducing fossil fuel use
Consideration of energy efficiency in selection of farm equipment and design of property management plans can reduce fossil fuel use. Management to increase soil carbon can reduce soil strength and therefore reduce fuel use in tillage operations. The use of biofuels can also reduce fossil fuel emissions.

6. Production of biomass for bioenergy

There is potential for agriculture to produce biomass for bioenergy applications, either through purpose-grown crops, by-products, or residues. Bioenergy options include combustion for heat and/or power, or production of liquid fuels including ethanol and biodiesel.

It should be noted that there are concerns over the sustainability of many "first-generation" biofuel systems such as corn to ethanol and canola to biodiesel, especially in relation to the intensive cultivation systems employed in the USA and Europe. These systems have small greenhouse gas mitigation benefits, and when other environmental impacts are considered (eutrophication, air emissions), their net impacts may be negative compared with fossil fuel systems. Other biofuel systems such as sugar cane to ethanol in Brazil and oil palm grown in South East Asia for biodiesel have apparently greater greenhouse benefits, but indirect impacts of offsite deforestation and loss of soil carbon also need to be considered. Furthermore, many systems have negative socio-economic impacts, such as increasing food prices and displacement of traditional land uses.

Biofuels based on perennial ligno-cellulosic feedstocks show more promise, both in terms of net greenhouse benefit and other environmental and socio-economic impacts.

The systems with the greatest benefit are those based on use of residues for feedstock, and efficient energy conversion technologies such as combustion for heat or co-generation of heat and power.

The sustainability of bioenergy systems cannot be generalised. For any region, any biomass feedstock, and any energy conversion technology there are systems that range in performance. Therefore, full life cycle studies are required for Australian biofuel systems, to establish the greenhouse gas emissions mitigation potential and other environmental and socio-economic impacts. Policy measures need to discriminate between different bioenergy systems and provide incentives only for those that deliver net benefit.

Forestry options

Potential mitigation measures in the forestry sector that are practical and commercially viable in the short term include:

- active management of native and plantation forests;
- afforestation and reforestation;
- investigation into increased use of wood products for storing carbon; and
- provision of renewable energy.

<u>1. Active management of native and plantation forests to increase sequestration and reduce emissions.</u>
The sustainable management of forests, both native and plantation, makes a positive contribution to addressing climate change. The contribution of Working group III to the 4th Assessment report of the IPCC on mitigation states that "[i]n the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks while producing an annual sustained yield of timber, fibre or energy from forest, will generate the largest sustained mitigation" and that "[f]orestry can make a very significant contribution to a low-cost global mitigation portfolio that provides synergies with adaptation and sustainable development".

Mitigation actions supported by active and adaptive management of natural resources, as provided by sustainable forestry under a sound regulatory and institutional framework, are an essential component of a response to climate change. In the forestry sector, mitigation efforts have focused on carbon sequestration, which is already a commercial reality for Forests NSW and other forest managers in NSW. See Section 4 for further discussion of practical considerations for inclusion of forest management in an ETS.

Plantation management
The establishment of plantations is well recognized as an effective mechanism to tackle climate change through the sequestration of CO_2. Much of the science has focused on plantation forests because they may be eligible as tradable forestry offsets. However opportunities to expand the plantation base are constrained by other land use practices, competition for increasingly scarce resources such as water, and “the illiquidity of the investment, the high cost of capital establishment and long waiting period for financial return” (Nabuurs et al 2007).

Native Forest management
Native forests also have a significant role to play in addressing climate change through CO_2 sequestration and carbon storage as timber and wood products. Adaptive management of these forests is essential to ensure that they are not in themselves adversely impacted by climate change.

Changed silvicultural practices in both plantations and native forests are capable of enhancing both carbon stocks and carbon sequestration. Methods and tools exist to provide forest managers with the capacity to optimise their management for carbon and wood products. While for plantations the science to support these decisions is well advanced and is already being implemented, further research is required to improve this capacity.

Non-timber forest dependent industries
In so far as there is community demand for timber and wood products, as well the other products and services provided by forests (such as honey and other apiary products, grazing, recreation and tourism, extractive resources and telecommunication infrastructure), legislative and policy responses must be cognisant of the full range of impacts on all forest dependent industries. Mitigation within these sub sectors is not addressed specifically within this paper. However, action undertaken with respect to forestry management and forest products must be mindful of potential impacts on, and potential benefits for, these industries.

Prescribed burning to reduce emissions from uncontrolled wildfire
Forest fires emit large quantities of carbon dioxide, as well as small but significant quantities of the greenhouse gases methane and nitrous oxide, and the greenhouse gas precursors CO and NOx and NMVOC (IPCC 2005). Excluding carbon dioxide[1] , forest fires (controlled fire and wildfire) contributed 4.4 Mt CO_2-e in 2004, and 1.2 Mt in 2005 (AGO 2007c). Thus, management to reduce the incidence of fire could assist in the mitigation of greenhouse gas emissions. However, accounting for the impacts of fire management on greenhouse gas emissions will be complex:

- If prescribed burning is used to reduce the risk of high-intensity wildfire, the emissions from prescribed burns must be balanced against predicted emissions from avoided wildfire.
- Carbon dioxide emissions during fire are assumed to be balanced by sequestration during regrowth, so carbon dioxide emissions are excluded from reporting. However, if fire incidence increases in extent or intensity due to management or climate change, average carbon stocks will be affected, and this impact must be included.

[1] CO_2 loss during fire is considered to be balanced by CO_2 removal during forest regrowth, so CO_2 flux due to fire is not included in the national inventory

- The formation of charcoal should be included in the estimation of greenhouse impacts of fire: approximately 4%–5% of the carbon consumed by forest fires remains on site as black carbon, which has a turnover time of thousands of years (Forbes et al. 2006).

Matching nitrogen fertiliser demand to supply in plantation forests
The establishment of plantations, particularly into pasture lands, with associated silvicultural practices, such as site preparation, N-fertilisation and burning of slash, has the potential to significantly alter the rates of mineralisation and nitrification of soil organic matter, as well as carbon dioxide, nitrous oxide and methane fluxes from soil (Dalal et al. 2003; Tang et al. 2006).

Management of nitrogen fertilizer practices could reduce nitrous oxide emissions from forestry, as indicated above for agriculture. Generally, nitrous oxide emissions from forests are low (BP Singh pers. comm.), so this measure has limited potential to contribute to mitigation.

2. Afforestation and Reforestation

Sequestration from changing agricultural landuse to forestry landuse:
The potential to achieve significant sequestration through land use change from agriculture to forest is well established. Trading of offsets based on reforestation is already occurring in NSW. A review of factors influencing the uptake of reforestation and afforestation offsets is detailed in Section 4. NSW DPI has identified a suite of priority research issues and is undertaking projects to refine greenhouse gas accounting for reforestation including:

- Research on assessing the potential of forestry (plantations as well as native) in mitigating soil N2O and CH4 emissions in different climatic zones in NSW, relative to pastoral or agricultural greenhouse gas emissions.
- Determining under what conditions trees are the most suitable land use option for mitigation of greenhouse gases taking into account other factors such as water use, biodiversity, salinity management.
- Where trees are suitable, assessing how best to incorporate trees into farming systems.
- The development of forest growth models, and simplified carbon accounting methodology for reforestation projects.
- Full greenhouse gas life cycle analysis of current and alternative management practices, identification and development of best management practices that mitigate GHG emissions and enhance carbon sequestration under a range of farming / forestry systems in NSW.

3. Increased use of wood products

Management of forests for timber production can significantly extend the carbon sequestration benefits provided by forests. Wood products play an important role in Australia's carbon balance. The accumulated carbon stock in wood products in Australia (in service and in landfills) is approximately 230 million tonnes of carbon (AGO 2007c), which is equivalent to approximately 1.5 times Australia's annual greenhouse gas emissions.

In addition to the physical storage of carbon in wood products (both in service and in landfills), further greenhouse benefits can be obtained through the use of processing residues to generate energy in lieu of fossil fuels, and through the use of wood products instead of more energy-intensive materials (Ximenes 2006) (refer TAB 3 for further discussion on wood products).

Long term storage of carbon in wood products is not currently recognised under existing rules for emissions trading, nor is it counted as sequestration in Australia's national emissions accounting. However, wood products are recognised in the recent Australian Standard "Quantification, monitoring and reporting of greenhouse gases in forest projects" (AS 4978.1—2006) as a pool that may be included in reporting GHG emissions and removals from forestry projects.

In order to inform Australia's position and influence on the development of international accounting rules, investigation should be taken into:

- the feasibility of accounting for carbon in harvested wood products; and
- the capacity to develop workable accounting rules.

4. Provision of renewable energy

It is widely agreed that a robust response to mitigate the effects of emissions from energy, and to adapt to a carbon constrained future, is through a portfolio of options to meet future energy demands. Non-hydro renewables, in particular wind and biomass, will play a much more substantial role in energy supply than they currently do if further emission abatement policies are implemented, and as their relative costs fall. It is likely that a rich set of non-hydro renewables including wind and biomass will be taken up in addressing Australia's future energy needs (CSIRO 2006).

A major constraint to date has been the availability of appropriate land for wind infrastructure. However, there are opportunities for development through land use change in both forestry and agriculture. Existing information on site suitability is already available and with site specific monitoring this obstacle could be overcome in the short-term.

For the generation of energy through residual forest biomass, the constraints are largely legislative and social. The utilization of residual biomass from legal, licensed forestry operations, within sustainable limits that ensure principle ecological functions are not affected is a real option to support a developing renewable energy sector in the medium term (refer TAB 3 for further discussion on bioenergy).

While the utilization of forest based residues is an under-developed sector, the use of sawmill residues for energy generation is already happening. This results in improved product utilisation and cost saving through on-site power generation, with the potential to on-sell excess energy.

Research and Development

Prioritising research efforts towards alternative mitigation options should be based on analysis of the potential mitigation that can be achieved through these measures. Potential mitigation will be influenced by the magnitude of the emissions attributable to that source, and the technical and economic capacity to achieve reduction in emissions from that source. The assessment should consider:

- the whole farm system, which may include a variety of land uses (e.g. conversion from cropping to pasture may improve soil carbon but increase emissions due to livestock);
- full life cycles, including indirect as well as direct emissions (e.g. emissions associated with fertiliser manufacture);

- off-site impacts (land use change at one location can have positive or negative impacts elsewhere e.g. destocking of one property may lead to increased stock numbers elsewhere to satisfy demand); and
- the probable impacts of climate change on the viability of the options being considered.

The net greenhouse reduction from different options must be quantified by rigorous life cycle analysis. This analysis is needed to inform policy development, and to devise incentives to optimise and accelerate mitigation activities.

2.4 What incentives, policy innovations and/or market-based mechanisms would guarantee an optimal contribution to the national mitigation effort?

A review of the National Forest Policy Statement is required to better reflect all issues relating to the impacts of climate change on forestry and the potential for mitigation.

Careful consideration must be given to those market-based mechanisms that are used to 'guarantee' optimal contribution, including the interaction between the diversity of mechanisms that are evolving for different objectives (e.g. for mitigation as opposed to biodiversity).

3. Practical considerations for including agriculture and forestry in an emission trading scheme

3.1 Coverage

As a general principle the three stage approach to coverage that was identified in the Issues Paper is supported, namely:

- Research & Development.
- Baseline-credit voluntary.
- Full coverage participation.

Forestry

The plantation forestry sector is an example where carbon stock may be ready to move to full participation having largely completed stages one and two within NSW. Plantations represent only 1% of Australia's forests and as such are well placed to serve as a pilot for the broader forestry sector.

Over the past ten years nearly all of Australia's plantation expansion has been focused on short rotation forestry for pulpwood export. One of the anticipated benefits of full coverage for the plantation sector would be the creation of a financial incentive for long rotation forestry.

Agriculture

Further research as a basis for development of accounting methodologies, and demonstration and trial of these are required in the agriculture sector. See further discussion of coverage of agriculture in section 3.5.

3.2 Point of Obligation.

One of the obstacles to inclusion of agriculture and forestry in an emissions trading scheme is the potential transaction costs that could arise under different options for the point of obligation. This is particularly the case for agriculture.

If these sectors were to be actively considered for inclusion in the coverage of an emissions trading scheme, one possibility for point of obligation would be to examine the New Zealand approach to this issue. This is essentially the assignment of emissions liability to points in the agricultural supply chain that involve small numbers of liable parties, and which may have some capacity to pass emissions price signals on or back to the agricultural producers. New Zealand is considering both upstream points of obligation (e.g. fertiliser manufacturers or importers) and downstream points of obligation (e.g. meat or dairy processing factories). The advantage of having a small number of points of obligation is that it will reduce aggregate monitoring and verification costs. The disadvantage is that it may not provide a clear price signal to an agricultural producer to adopt practices that will reduce greenhouse gas emissions.

This type of point of obligation would be analogous to that proposed by the Task Group on Emissions Trading in 2007 in respect of emission permit liability for petroleum combustion emissions. In that case, the Task Group suggested that a point of obligation be set at the refiners and importers of petroleum products.

If this approach were adopted and the points of obligation were able to transmit a clear price signal to agricultural producers, the actual (as distinct from legal) incidence of permit acquittal costs would fall on the producer. At that point, all the major emission sources from agricultural activity would be covered by the scheme and hence would be subject to emissions pricing. This is likely to place financial obligations upon the sector that are difficult to pass on.

In respect of sequestration activities, provision for inclusion of carbon pools across several holdings, as occurs in the forest sector under the NSW GGAS, is a useful approach that minimises transaction costs without diluting the management incentive. Carbon pooling involves grouping individual sequestration projects and managing them on a larger 'pooled' basis. A carbon pool manager would manage the bundled carbon sequestration projects.

3.3 Monitoring and verification of emissions and mitigation

Emissions

Determination of baselines may require consideration of a longer historical period than will be available from the National Greenhouse and Energy Reporting System (NGERS). The capacity of NGERS would need to be expanded to allow reporting of emissions and removals in the agriculture sector.

Standardised rules for issuing credits for agricultural and forestry emissions

NSW supports development of simple, standardised rules for accounting for agriculture and forestry emissions and sequestration in order to minimise transaction costs and encourage participation, while remaining consistent with the monitoring and measurement accuracy required to ensure confidence in the ETS. Conservative estimates should be used to minimise criticism that certain sequestration credits or emissions liabilities are not representative of physical outcomes. Rules applicable to Australian systems, probably stratified by region and soil type, will most likely need to be developed.

Accounting models
The NCAT version of FullCAM is reasonably user-friendly. It is unlikely that landholders will participate individually as providers in the scheme. It is more likely that a pool will operate, to spread transaction and compliance costs. The model is being improved (e.g. additional capability, additional calibration data), to remove current innaccuracies. Effort should be applied to resolve any remaining problems, and to educate all users that as long as it is correct (or conservative) on average, the model is suitable for trading. The establishment of a pool manager and possible parties who could take on this role should be further investigated.

Best practice benchmarks
Use of benchmarks based on regional and sectoral 'best-practice' emissions intensity levels is one way that the agriculture sector could generate credits, or alternatively be brought into the scheme as a covered sector without needing permit allocation. However, more thought needs to be given to this issue, as there is potential for incompatibility with the national accounts if agriculture is considered in this way at the project level. To overcome this, the emissions intensity benchmarks used to determine offset credits must correspond with the calculation methods used for the national inventory.

Proxies - Role of satellite imagery and self reporting
Utilizing satellite imagery and self-reporting to initially quantify the area of afforestation or reforestation could fit with the average carbon stocks approach. However, remote sensing is less likely to be effective for the assessment of changes in forest and agricultural management.

3.4 Sub-sectoral coverage
Determining the extent of coverage within the forestry sector requires careful consideration of a range of issues, including:

- equity between sub-sectors in terms of the costs and benefits associated with coverage;
- mitigation incentives, including for innovation in the take up of actions or technologies that reduce emissions;
- the economic and environmental consequences of adaptation strategies; and
- the current lack of financial incentives to invest in research and development to inform carbon accounting for some sectors, which would also improve an understanding of the likely impacts of climate change on forests, and therefore adaptive capacity.

3.5 Phasing and time of inclusion of agriculture and forestry within an emissions trading scheme:

There are inherent problems with project-based offsets due to the difficulties of defining base-lines and avoiding leakage and double-counting. There is a risk that allowing sink projects in agriculture and forestry sectors, rather than bringing them in as covered sectors, could lead to unbalanced accounting due to leakage, or failure to capture subsequent losses that have previously been awarded offset credits.

Allowing the agriculture and forest sectors to generate offset credits will possibly create complications for accounting and credit trading if the sector is later covered. This issue needs to be considered at an early stage of developing an emission trading scheme.

Full coverage of forestry and agriculture sectors would require an acceptable resolution of carbon accounting issues and the potentially large number of liable parties that would be created by the coverage of these sectors. As with other sectors, emissions trading coverage should be the preferred solution if it is likely to lead to the most efficient emissions reduction outcomes, and is consistent with principles of environmental effectiveness, equity, flexibility and investor certainty.

For the forest sector, there has been significant R&D and experience gained through voluntary schemes and the mandatory GGAS, which would support consideration being given to early, full participation of the forest sector.

The same is not true for the agriculture sector. In some fields (e.g. non-CO_2 emissions from soils) further R&D is required to acquire sufficient understanding to develop emissions accounting methodologies. In other areas (e.g. soil carbon) there is considerable knowledge from which models are being developed, but a phase of voluntary participation would allow proposed methods to be trialed.

Whether or not the agriculture sector is covered from the start of the scheme, the same research data and models mentioned above will be required to estimate soil carbon stock change to calculate emissions / removals for the sector.

A further point to note is that the Kyoto's CDM and AGO's Greenhouse Friendly "life cycle" approach is not suitable for domestic project-based emissions trading in countries that have a Kyoto target: these methods count all indirect emissions such as from fuel use, which would result in double counting with the energy sector.

4. Recognition of carbon sinks and offsets

Reforestation and Afforestation Offsets

Forest offsets arising from reforestation and afforestation are widely recognised as an effective way to cost effectively reduce emissions.

Within Australia there has been limited research on the contribution that forest offsets could play in mitigating the nation's greenhouse emissions. Analysis by Forests NSW suggests that 500,000 hectares of reforestation or afforestation would be required to offset 1% of the Australia's emissions up to the year 2050. This analysis presumes an emissions reduction target of 60% below 2000 levels by 2050.

The opportunity for uptake of offset projects will be influenced by a range of factors. The carbon price is perhaps the most significant factor:

- At low carbon prices:
    - There may be limited financial incentive to undertake reforestation or afforestation activities for carbon offsets.
    - Opportunities may be limited to projects that are close to being commercially viable, without the returns from carbon being factored in. These are projects that are driven by factors other than carbon.
    - Large publicly-owned plantation growers who can meet Article 3.3 eligibility criteria may be expected to be the principal participants.
    - Private sector participation may be limited by the eligibility requirements (e.g permanency).

- At moderate carbon prices:
  - There may be some financial incentive to undertake reforestation or afforestation activities for carbon offsets. Opportunities will emerge for large scale dedicated carbon offset projects.
  - Small-scale carbon specific projects are likely to remain unviable.
- At higher carbon prices:
  - There is a strong financial incentive for broad scale reforestation and afforestation to occur.
  - Broad scale reforestation and afforestation activities may be expected to deliver a suite of environmental co-benefits.
  - Carbon-specific offset plantings will be viable and may be integrated into farming systems. Broad-acre farmers and pastoralists are likely to engage in the business.
  - Farm-scale plantings are likely to be managed under a carbon pooling arrangement (analysis suggests that carbon pool managers may need to charge between $15 and $20 per tonne of CO2-e to register and maintain the carbon sequestered from farm-scale plantings).
  - The management of commercial plantation forests could be modified to optimise carbon sequestration benefits.
  - There will be an incentive to shift away from short rotation plantations for pulpwood toward longer rotation plantations for carbon and solid wood products. It should be noted that 90% of the plantation expansion currently occurring in Australia is in short-rotation plantations.
  - In this carbon price bracket the issue of permanency (100 year or 70 year rule) may be accommodated. In particular, the discounted value of land encumbered by a requirement to maintain forest cover may be offset by the income received from carbon offset credits.

The eligibility requirements for participation in an ETS are another important factor that will be a strong determinant of uptake. Within NSW, considerable practical experience has been gained by Forests NSW in the creation and trade of forest offset credits under the NSW GGAS. This experience has revealed that a fine balance exists between maintaining the integrity of the carbon offset scheme, and ensuring that the eligibility requirements are sufficiently workable to encourage participation.

Existing Forests as Carbon Sinks

Australia's State of the Forests Report 2003 states that 10.5 Mt of woody carbon biomass is stored in Australian forests. A further 12.9 Mt of carbon is stored in Australia's forest soils.

From a carbon accounting perspective, this stock of carbon is independent of the forest carbon accounting that is recognised under the Kyoto Protocol. Under Articles 3.3 and 3.4 the aim of forest carbon accounting is to demonstrate 'additionality' and the focus of carbon measurement is on sequestration.

Australia's forests are managed under six different forest tenure types as shown in Table 1:

Table 1: Area of Australia's forest by tenure

Forest Tenure	Area in 2003 (million ha)	Area %
Leasehold	75.6	46%
Multiple-use forest	11.4	6.9%
Nature conservation reserve	21.5	13.1%
Other Crown-Land	13.1	8.0%
Private	38.9	23.7%
Unresolved tenure	2.1	1.3%
Plantation	1.7	1.0%
Total	**164.3**	**100%**

Data Source: Department of Agriculture, Fisheries and Forestry, Bureau of Rural Sciences (2003)

Only about 1% of Australia's forest carbon is stored in plantations while 46% is stored in Eucalypt woodland that is integrated with agriculture.

The amount of carbon stored in Australian forests can change as a result of natural factors such as variations in climate, the successional dynamics of the vegetation and disturbances from fires, storms, or pest and disease outbreaks. The anthropogenic factors that can change the amount of carbon stored in forests include silviculture, prescribed burning, fertiliser application and harvesting.

Understanding and quantifying the contribution that natural and anthropogenic factors make to changing forest carbon levels is crucial in determining the best way to manage them.

Renewed examination of whether to include activities under Article 3.4 within Australia's national greenhouse accounts, hence making them potentially eligible to create sequestration credits for use in the ETS or international emissions trading, should be viewed as a priority by the Australian Government for the second Kyoto Commitment Period.

Agricultural offsets - Soil carbon

Small increases in soil carbon over large areas can contribute significantly to mitigation of Australia's greenhouse gas emissions. Furthermore, increases in soil organic matter will improve soil health, fertility and resilience. However, the inclusion of soil carbon offsets in an emissions trading scheme cannot occur until several barriers are overcome:

- Credibility: Quantification of the extent to which specific land management practices can sequester carbon in different environments will provide the basis for promotion of the concept. Current research across Australia is addressing this need.
- Cost-effective and accepted methods of estimating soil carbon change must be available. It is important to minimise transaction costs to encourage participation. On the other hand, there needs to be acceptance from all stakeholders that the estimates are sufficiently accurate. Monitoring soil carbon to document change on a project scale is not viable due to the enormous variability in carbon stocks on micro and macro scales. Instead, estimation of soil carbon change could be undertaken through a combination of baseline measurement to assess the vulnerability of soil carbon pools, and modelling informed by baseline measurements and good understanding of the factors driving soil carbon dynamics. Current research efforts will provide some data, but increased effort is needed in this area.
- An effective system for assessing compliance is required. This could be based on evidence that practices have been implemented, rather than an audit of soil carbon stocks.

- Mechanisms to deal with non-permanence (because soil carbon is vulnerable to future loss)

Ideally, credits should be awarded for permanent LUC (temporary sinks are not beneficial and can even be detrimental to mitigating atmospheric CO_2 (Kirschbaum, 2006)). GGAS requires landholders to commit to maintaining carbon stocks (and therefore avoiding cultivation of afforested land) for 100 years as a proxy for permanence.

NSW is aware of alternative approaches. One alternative is that used by the Australian Soil Carbon Accreditation Scheme, which allocates one hundredth of the credit for each year that the practice is applied. Difficulties with the approach are: (1) it generates very low returns from carbon trading, and would therefore provide minimal incentive; (2) it does not encourage permanent land use change; (3) it does not create a fungible credit.

A second alternative, using the Average Carbon Stocks accounting approach, operates by determining the average soil carbon across the new rotation, compared with the previous rotation. Ensuring permanence with this approach would require the landholder to commit to maintaining the new rotation (e.g. with a specified ratio of green manure or pasture phases to conventional cropping). Landholders are likely to take some interest in this approach as it would increase the certainty of returns (compared with the approach of selling credits as carbon stock increases and buying them back at unknown future cost when carbon stock decreases), and allow some flexibility in land use.

Offsets and international frameworks

International frameworks and emission trading linkages are typically assessed from a national compliance perspective. However, there is merit in considering them as an important driver of global forest offset investment.

Once created, international emission trading linkages may be expected to provide strong incentives for large scale uptake of forest offsets. In particular, Australian investors would be likely to invest with more confidence if they knew that international marketing of their product were an option. At present over 80% of global emissions trading occurs through the European Union's ETS. Prices in Europe are also attractive with December 2008 forward settlement sales of EU Allowances currently trading at around A$40 per tonne of CO2-e.

International linkages are also important for international investors with forest offset investments based within Australia. In this case the carbon credits may be transferred to meet the investor's emission reduction obligations within their home country. Since 2000, over $35 million has been invested by international investors in 'Kyoto compatible' planted forests with Forests NSW. The absence of an approved mechanism to realise the carbon values from these investments is currently inhibiting further new investment.

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[2] *For full referencing see sectoral and MACPIS papers; details of references not listed in those documents are given here*