Soil Carbon Workshop for Research, Industry, Policy and Market Stakeholders

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Background Paper

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1. Background and Purpose

There has been considerable discussion regarding the role of soil carbon sequestration in mitigating greenhouse gas (GHG) emissions. However, in exploring soil carbon issues with various stakeholders, it has become clear that many issues related to (a) science, (b) industry, (c) policy and (d) markets must be resolved before the potential for mitigation through soil carbon management can be understood and, if possible, achieved.

Preliminary research also indicates that there is currently limited interaction between these groups of stakeholders. The groups have very different backgrounds, drivers and perceptions of the issues, yet share a common goal of promoting soil carbon management to mitigate human-induced climate change.

In response to this, The National Centre for Rural Greenhouse Gas Research (NCRGGR) in collaboration with E3 International embarked on a process to support informed discussion and identification of key issues related to soil carbon sequestration. Initial consultation with industry stakeholders during early 2010 indicated the merits of such a process, and for it being independently facilitated.

The result of these efforts is this intensive one-day workshop to enable representatives from these groups of stakeholders to better understand each other's perspectives. The workshop aims to:

- achieve a common understanding of soil carbon issues from the policy, science and industry/market perspectives
- discuss the requirement/options for any follow up process to address these issues and to maintain dialogue between the stakeholders.

The workshop is sponsored by NCRGGR and the National Climate Change Research Strategy for Primary Industries (CCRSPI), facilitated by E3 International and hosted by PricewaterhouseCoopers.

This background briefing paper seeks to provide a brief overview of soil carbon from the science, industry, policy[1] and market perspectives in a way that complements the workshop presentations. It also includes brief contributions from workshop attendees providing their perspective on soil carbon. Finally it includes selected references for further reading.

[1] Reference to policy includes economic perspectives.

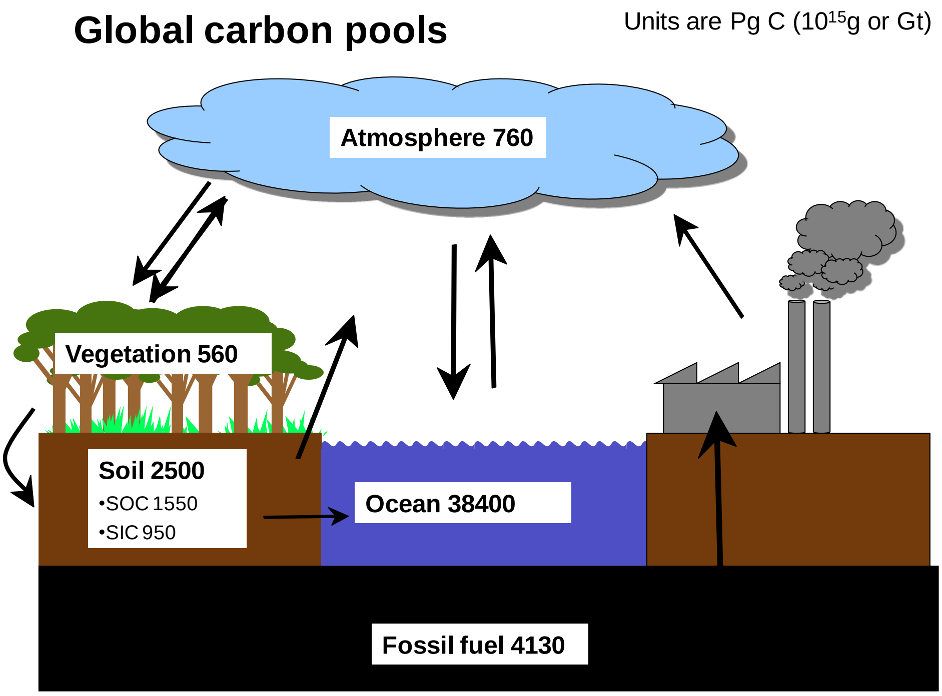
2. Soil Carbon Overview

Carbon is an important component of soils, due to its chemical, physical and biological contribution to soil fertility. Increasing soil organic carbon enhances a range of services provided by soils to humans. These include mitigation of greenhouse gas emissions, food and habitat for soil organisms, storage and supply of nutrients and water and moderation of the effects of acidification and pollutants.

Carbon in soil exists as breakdown products of plants and other living things (organic carbon) as well as in some inorganic compounds.

The carbon cycle, illustrated below, involves the capture of atmospheric Carbon Dioxide (CO_2) by plants and the transfer of animal and plant material to the soil as organic matter.

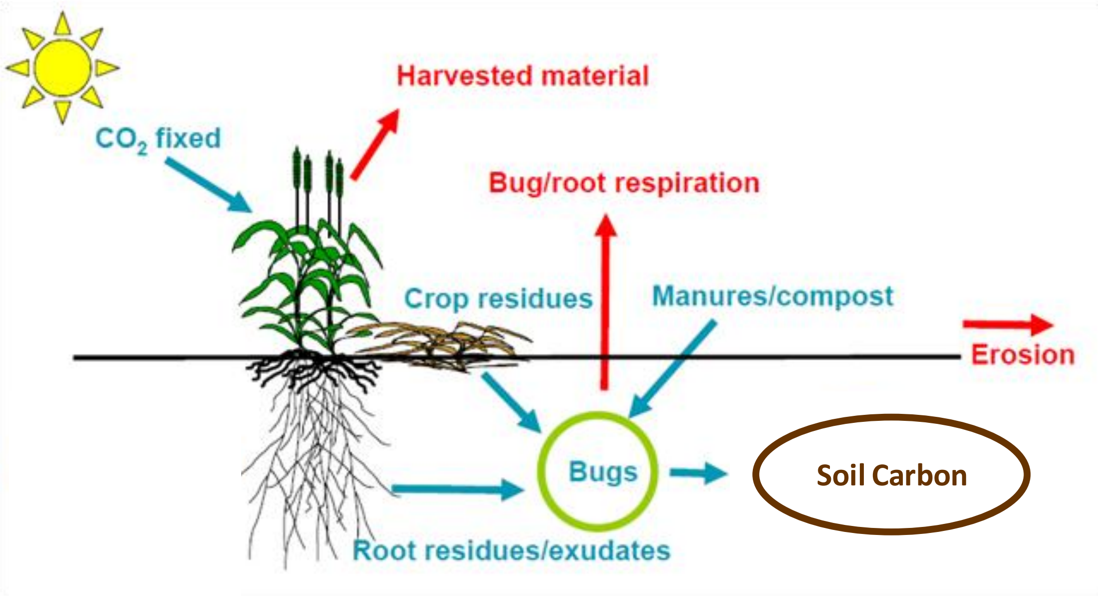
FIGURE 1: THE CARBON CYCLE



Source: Cowie, 2009, based on data from Lal

As illustrated in Figure 2 below, some of this returns quickly back to the atmosphere as the material decomposes, while some is more persistent in the soil. In a natural system, the rate of increase of carbon through the addition of plant material balances the rate of loss through decomposition (or other factors such as fire and drought).

FIGURE 2: SOIL CARBON – GAINS AND LOSSES



Source: Management practices for building soil carbon, Dr John Kirkegaard, Mr Clive Kirkby, Dr Vadakattu Gupta, CSIRO[2] (adapted)

Agriculture changes this equilibrium level and tends to reduce soil carbon content over time. Even a small reversal of this decline, if achieved across a large land area, could sequester a significant volume of carbon. Certain farming practices and growing conditions can increase soil carbon, but the adoption of such practices may also increase production costs. These costs could be offset to some extent if the farmer was able to sell 'carbon credits' to willing buyers. For this to occur, there needs to be an appropriate policy/regulatory and market framework, discussed later in the document.

The other potential terrestrial carbon sink, forestry, already has frameworks and mechanisms in place, which enable accounting for and trading of forestry carbon. However, soil carbon sequestration has complexities that make it far more difficult to incorporate into conventional carbon accounting and trading systems. These complexities translate into a range of issues falling broadly into the areas of science, industry, policy and markets, whose stakeholders have divergent backgrounds and perceptions.

Although most soils contain only a few percent carbon, this adds up to a large total volume - estimated at 3 times more carbon than is held in the atmosphere and 4.5 times more carbon than occurs in all living things. Relatively small increases in the proportion of soil organic carbon could make a significant contribution to reducing atmospheric carbon dioxide. The improvement in soil fertility resulting from such an increase would also provide significant benefits to productivity, potentially providing a win-win scenario.

[2] http://lwa.gov.au/files/products/healthy-soils-sustainable-farms/pn22241/management-practices-building-soil-carbon-john-kir.pdf

2.1 Science

Soil organic carbon is not an inert material, but has important biological, chemical and physical interactions with soil fertility and consequently with plant growth. It therefore needs to be considered for its role in the overall farming system, not merely as a means of sequestering CO_2. The reduction, or abatement, of atmospheric CO_2 is only one of several potential drivers for increasing soil carbon and little research to date has focussed on maximising soil carbon for its own sake.

The general cycle of carbon in the soil is well understood, with the soil carbon pool categorised into several fractions – plant residues, with a rapid turnover time; humus, which can be stable for decades if undisturbed; and resistant organic matter (charcoal), which can be stable for centuries or millennia. Changes in farming practices or other factors shift the balance between the addition of plant residues and their decomposition. Any such shift will lead to changes in soil carbon stocks. However, robust published information is lacking on the degree to which this occurs.

Importantly, changes in soil carbon interact with many other factors influencing costs and benefits for the farmer and the environment. One such factor is nutrients. There is evidence that stable soil organic matter (humus) contains Carbon, Nitrogen, Phosphorus and Sulphur in predictable and constant proportions. Therefore, in order to increase humus content, the supply of these other nutrients must also be increased, incurring a cost to the grower and, potentially, the environment. (For example, manufacture of nitrogen fertiliser is energy – and greenhouse gas – intensive, and the application of nitrogen can lead to emissions of nitrous oxide, a powerful greenhouse gas. However, nitrogen may be supplied, instead, by leguminous crops, with lower environmental cost).

Another factor is water. Increased soil organic matter increases infiltration and water holding capacity, so long as water is supplied (through rainfall or irrigation). Soil moisture is a driver for plant growth as well as for soil biology, including beneficial microorganisms. Both these factors, in turn, are key drivers for increasing soil carbon. A higher-carbon soil is better at storing water, providing a buffer against unreliable water supply and therefore maintaining this cycle of growth and carbon capture. However, improved moisture storage and plant growth in one area could impact on water availability elsewhere in the catchment zone.

While the general agronomic benefits of soil carbon are well-known, there are significant gaps in our knowledge about the rate of movement of carbon in and out of soil under diverse agricultural systems that vary in soil type, climate, rainfall and crop. A key challenge in studying soil carbon is that neither the material itself (organic matter), nor the soil or landscape of which it is a part are uniform and stable.

Other key research challenges include developing alternatives to existing laboratory analyses and minimising the sampling required to reliably assess soil carbon levels across large areas. Existing soil sampling protocols, designed to assess agricultural productivity, are not suitable for cost-effectively monitoring carbon sequestration.

In 2009, the Department of Agriculture, Fisheries and Forestry (DAFF), allocated $20m to the Soil Carbon Research Program (SCRP). This program brings together soil carbon researchers from CSIRO, State Government Agencies and Universities to deliver a national coordinated program of research, focussed largely on documenting the impacts of key land use practices on soil carbon in major soil types, on a regional basis. DAFF is also funding research into 'biochar', which shows promise as a practice that can sequester carbon and enhance productivity. DAFF also co-funds (along with industry levies) the rural R&D corporations and companies (RDCs). Many RDCs are members of the Climate Change Research Strategy for Primary Industries (CCRSPI), which has a strategic research coordination role in this area.

Other important resources for monitoring and coordinating technical issues related to soil carbon include the Australian Soil Resource Information System (ASRIS) and Australia's National Carbon Accounting System (NCAS). ASRIS provides online access to "the best publicly available information on soil and land resources in a consistent format across Australia". NCAS is designed to account for greenhouse gas emissions from land based activities, including soil management. The NCAS is being developed over several phases, based on the continuing development of scientific understanding and data.

In August 2010, the World Soils Congress in Brisbane will include international perspectives on scientific challenges related to soil carbon. A broad international collaboration, launched at the United Nations Climate Change talks in Copenhagen in 2009 as the Global Research Alliance on Agricultural Greenhouse Gases, now has 29 country members, including Australia.

2.2 Industry

Australian agriculture is extremely diverse with some 100,000 farming enterprises producing an enormous range of food and fibre products under varied circumstances. The farm sector in Australia has always been exposed to significant business risk from climate variability and extremes such floods and droughts. Adaptation to climate change is, therefore, an extension of "normal" practice. Soil and water form the very basis of farming and Australian farmers have had to be innovative in coping with poor quality soils and limited rainfall, using the best technology available at the time. While this has improved productivity, it has been at the cost of declining soil carbon content.

A number of changes to farming practices have the potential to increase soil carbon. These include: zero-till methods of seeding (with minimal soil disturbance compared to traditional techniques); pasture cropping (planting a crop directly into pasture, without ploughing); cell grazing (rotating stock to allow longer recovery time for pastures); and precision agriculture (applying seed and fertiliser according to soil properties, guided by GPS). Potential productivity gains have largely driven the adoption of such practices. However, they bring with them significant soil conservation benefits.

The net returns from the carbon market may only be a marginal driver for practice change, compared to the profit earned on the crop itself. However, growers may also be able to seek market differentiation and/or a price premium for products backed by sustainable practices, including carbon sequestration eg Carbon neutral wool.

Farmers operate in a highly competitive global market and any additional costs must be offset either by gains in market returns, the value of their farm asset, or through government programs designed to recognise the environmental services provided to the community. In addition to market forces, technology, incentives and regulation, there are other important drivers and barriers for practice change in agriculture. These include local and regional factors such as climate and soil type as well as know-how, cultural influences and the scale and financial resources of individual enterprises.

Whatever the driver(s), for large scale soil carbon sequestration to take place, farmers will require cost-effective and user-friendly methods for monitoring and verification. Options for consolidation and marketing (such as the carbon pooling mechanisms used in forestry eg CarbonSMART) will be needed to enable participation by smaller enterprises. Some sectors, such as grains, already have high-level skills in market trading tools/instruments such as hedging and forward contracts that may be required to participate effectively in the carbon market. However, many growers may be wary of engaging in the carbon market, due to concerns over future liabilities - for example if the property changes hands or circumstances result in a future decline in soil carbon.

2.3 Policy

The United Nations Framework Convention on Climate Change and its Kyoto Protocol have catalysed the introduction of mandatory national cap and trade emissions trading schemes (amongst other policies) in Europe (EU ETS) and New Zealand, with national schemes proposed in Australia and the U.S. These regulatory constructs provide frameworks where parties able to reduce GHG emissions can trade those reductions with others who are (a) unable to reduce their emissions, or (b) can only do so at a higher cost. They provide much of the foundation for today's carbon market.

These regulatory developments, plus voluntary commitments by companies and individuals to 'offset' their emissions has led to a market for tradeable 'carbon credits' – the generic term for a range of different instruments that support the international carbon market, including permits (or allowances) to emit GHGs as well as credits arising from GHG emissions reductions.

Article 3.4 of the Kyoto Protocol allows ratifying countries to optionally include sequestration in woody plants and soil through management of cropland, grazing land and existing forests, as well as re-vegetation in their national GHG accounts. The current methodology requires that both human induced and natural emissions are included in the calculation of net sequestration by these activities. Given the risks associated with release of soil carbon due to natural causes (such as fire and drought), Australia has joined most other countries in choosing not to opt-in to this clause. Denmark and Portugal have opted to include grazing land management, while Spain, Portugal, Denmark and Canada have elected to include cropland management.[3]

The Australian Government's proposed cap and trade emissions trading scheme – the Carbon Pollution Reduction Scheme (CPRS) is the centrepiece of its mitigation strategy. However, the scheme has been rejected by the Senate twice, and, in the light of the recent deferral to 2013, its implementation remains uncertain. The Federal opposition's approach to mitigating GHG emissions features tendering for emissions reductions funded by the Commonwealth.

[3] Initial reports under Article 7, paragraph 4, of the Kyoto Protocol and initial review reports - http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

The CPRS will place a price on GHG emissions in 'covered' (liable) sectors including energy, transport, industrial processes and waste. Tradeable units can be created through eligible reforestation activities. Agriculture is an 'uncovered' sector, meaning that it will not face direct liabilities for GHG emissions. It will however face an indirect impact via costs passed through from covered sectors (for example, higher electricity and fuel prices).

The CPRS also incorporates an offset regime that will yield credits for emissions reductions in uncovered sectors including agriculture, *that count towards Australia's international commitments.* While some activities in the agriculture sector are eligible (for example management of emissions from livestock, manure, fertiliser use amongst others), soil carbon sequestration is not, as it does not count towards Australia's Kyoto commitments. However, subject to approval of methodologies, soil carbon sequestration will be eligible to create offsets under the National Carbon Offset Standard (NCOS), which comes into effect on 1 July 2010 and is designed to support voluntary action by individuals and companies.

The Federal Government notes that abatement from these sources will transition into the CPRS once abatement is internationally recognised, and provided that other CPRS requirements are met. It has also indicated its intent to continue advocating in the international climate change negotiations to ensure the post-2012 accounting rules only require countries to account for emissions and removals of greenhouse gases resulting from human activity.[4]

At a state level, the Victorian Government has initiated an inquiry into soil carbon sequestration, due to report back by 31 August 2010.

On the international front, the EU ETS does not extend coverage to the agriculture sector, and there are no provisions for offsets to be generated within the EU. However, the proposed U.S. emissions trading scheme legislation accommodates offsets from soil carbon sequestration. Although the New Zealand agriculture sector will become liable under the New Zealand emissions trading scheme, there are no provisions to monetise the value of soil carbon sequestration.

In relation to the economics of abatement, calculating marginal abatement costs requires (a) establishing net upfront capital and annual operating and transaction costs, taking into account any cost savings from productivity gains (b) assessing annual abatement and (c) converting these elements into a \$/t CO_2e figure in present value terms. Information on the cost of abatement resulting from soil carbon sequestration in Australia is sparse. A recent analysis by Climateworks concluded that abatement costs range from \$5 - \$94/t CO_2e depending on the current use and condition of the land in which the soil carbon sequestration occurs[5].

Finally, the case for soil carbon sequestration will be strengthened if avenues can be found to monetise the value of other environmental benefits such as biodiversity enhancement, pH buffering and salinity management through other market based instruments.

[4] http://www.climatechange.gov.au/~/media/publications/cprs/CPRS_ESAS/091124oppnofferpdf.ashx

[5] Costs are calculated from a societal perspective. Excludes reduction of soil emissions by reducing tillage, which is estimated to provide a net cost saving (i.e negative abatement cost).

2.4 Market

The international carbon market can be broadly viewed in terms of (a) the compliance market, covering activity associated with carbon instruments eligible under *mandatory* emissions trading schemes (such as the Kyoto Protocol and the EU ETS) and, (b) the *voluntary* market, covering activity associated with carbon instruments that support voluntary commitments.

The carbon marketplace is sophisticated, and is characterised by trading exchanges (for example ECX, BlueNext amongst others), market intermediaries (brokers, traders and information providers), multi-disciplinary project developers/originators (for example Camco, Ecosecurities amongst others) and financiers (banks, investment companies). Prices are influenced by a number of factors including economic activity, weather, regulatory changes, technological developments and the penalty for non compliance. Prices in the compliance market are in the order of €15/t CO_2e (EUA) and those in the voluntary market are in the order of U.S 10 cents/t CO_2e (CCX), €4/t CO_2e (VCU) and €8 (Gold Standard)[6].

Much of the international soil carbon trading activity to date has been in the voluntary space – led by the U.S CCX, a voluntary grouping of companies taking on emissions targets which can be met by the purchase and acquittal of eligible offsets, including from no till and conversion to grassland activities. This has led to interest within the farming sector and the emergence of soil carbon offset aggregators. In Europe, the Government owned Portuguese Carbon Fund will purchase soil carbon sequestration through grassland soil carbon management on 42,000 ha, noting that Portugal has subscribed to grazing land management under Article 3.4 of the Kyoto Protocol. This is expected to yield 0.9Mt CO_2e of abatement purchased at between €150 - 200/ha. In Alberta, Canada, major corporations are required to reduce their emissions intensity, and can do so via offsets, including those from low/no till activities.

The credibility and integrity of carbon offsets is governed by the methodology supporting their creation. Key issues that methodologies must address include a*dditionality* (demonstration that the project would not have occurred under business-as-usual), *permanence* (for how long and by what mechanism will the offset be secured), *leakage* (consideration of emissions that are indirectly attributable to the project and which occur outside the project boundary) and *quantifying reductions, monitoring, reporting and verification* (MRV). How these aspects are addressed is often sector specific, and soil carbon (in contrast to say energy management) presents a number of challenges due to its variability and dispersed nature. In this regard, there are lessons that can be drawn from methodologies developed for forest carbon sequestration under the NSW Greenhouse Gas Reduction Scheme and more recently under the CPRS.

The most credible accreditation bodies in the voluntary carbon market are considered by many to be the Voluntary Carbon Standard (VCS) and the Gold Standard. Current methodologies for soil carbon sequestration include tillage related methodologies under the CCX and Alberta Offset System. A VCS methodology that includes soil carbon is under development. In Australia, the use of a methodology approved under the NCOS is a prerequisite to creating soil carbon offsets under that scheme.

[6] Sourced from Thomson Reuters Carbon Community, 22 April 2010; https://inside.thomsonreuters.com/redirect/carbon/Pages/default.aspx

The integrity of offsets is further enhanced by registration procedures which feature registries which allow tracking and reporting of the lifecycle of an offset (creation, trading and acquittal). Examples of registries include the VCS registry arrangements and the Gold Standard Registry.

Trading of soil carbon offsets will also be facilitated by the ability to secure carbon rights as a property right, which is not addressed consistently in all Australian States. Market acceptance in the voluntary market is likely to depend on buyer perceptions of soil carbon offsets compared to other offsets types.

Australian voluntary soil carbon sequestration market developments include the Australian Soil Carbon Grower Register, a service of grower owned Carbon Farmers of Australia, Carbonlink and Prime Carbon's Soil Enhancement and Carbon Sequestration Programme.

2.5 Issues for Consideration

Our review of literature and discussions with stakeholders reveals many issues/questions related to soil carbon. An indicative list is included below for reflection. Note that while these are captured under a single heading, some may be applicable to more than one category.

Science

- What are the impacts of farming practices on soil C?
- What new methods for measuring soil C are being developed?
- How do we estimate soil C reliably and cost-effectively?
- Is modelling a reasonable approach to estimation?
- How vulnerable is soil C?
- What is the theoretical potential for mitigation through soil C management?
- Should only non-labile soil C be traded?

Industry

- What are the costs/benefits of soil C sequestration?
- How will the diversity of farming scenarios be accommodated?
- What are the drivers for and barriers to change in farming practices?
- How does industry receive a share of the benefit from increasing soil C?
- Does the market value of soil C influence farming decisions/practices?
- Will farmers who have already built up soil C be disadvantaged?

Policy

- Will the NCOS/voluntary market provide sufficient support to encourage practice change?
- How will losses from decline in soil C due to natural causes (eg drought) be accommodated?
- How should the issue of permanence be addressed?
- Is activity-based MRV viable? - is practice change a credible proxy for soil C increase or must soil C be measured?
- Will the cost of measuring changes in soil C be greater than the market value?

Market

- Approved soil carbon methodology for NCOS
- Role of science/industry and the market in developing methodologies?
- What is the incentive to maintain increased soil C long-term?
- Market and investor perceptions of soil C vs other carbon abatement options
- How can soil C on thousands of farms be efficiently pooled on the market?
- State legislation that recognises soil C as property right

3. Perspectives

3.1 Science

Warwick Badgery, Industry and Investment NSW

There are two research projects in Central NSW (Soil Carbon Research Project - SCaRP and Catchment Action Market Based Instruments (for Soil C) - CAMBI) examining soil C under different land use x soil type x climate combinations that I am involved with. These projects aim to determine the average and range of soil C under each combination, and determine the agricultural management practices that increase soil C in different environments.

The key challenge to unlocking the potential for soil C is the high degree of inherent variability at the paddock scale, the likely sampling unit for potential trading schemes. The excessive variability means that a high number of samples are needed to accurately determine soil C stocks, which can be time consuming and expensive. New indirect methods of quantifying stocks need to be developed. Other issues include, the lack of soil C data linked to bulk density, and the lack of long-term data in replicated trials to determine rate of change over time. The dearth of historic data has allowed unrealistic expectations of soil C to develop in some areas.

The main avenue for exchanging ideas is through multi-agency collaborations on the research programs I am involved with (SCaRP and CAMBI).

Jeff Baldock, CSIRO Land and Water

Jeff Baldock researches the composition and rate of cycling of soil organic carbon in agricultural and forestry. He leads the national Soil Carbon Research Program that will define the implications of selected management practices on soil carbon on a regional basis across Australia. Data collected will also provide regional baseline values and will be used to aid the development and testing of soil carbon models.

In addition to offsetting greenhouse gas emissions, building soil carbon can contribute beneficially to a range of soil properties (e.g. provision of energy and nutrients, water retention, pH buffering, etc). This creates a win-win scenario (increased capture of atmospheric carbon and enhanced soil productivity) for farm enterprises where the amount of carbon stored in soils can be increased.

Most, but not all, Australian agricultural soils lost carbon on initiating agriculture. It is suggested that up to 60% of lost carbon may be returned through altered management. Adoption of management practices that increase carbon addition rates and/or decrease carbon loss rates are required to increase soil carbon beyond present values. Where ineffiencies in production can be remedied through altered management or alternative agricultural practices that return more carbon can be adopted, increases in soil carbon can be expected. Barriers to adoption include the issue of permanence, saturation, applicability of practices across variable environments and the relative values of stored carbon and commodities being produced (farmers are paid to harvest carbon).

Brent Clothier, Markus Deurer & Steve Green, Production Footprints Team, Plant & Food Research, Palmerston North, New Zealand (not attending)

The Production Footprints team has been carrying out soil carbon studies for kiwifruit, wine grapes, apples, kiwifruit and berryfruit. Our goals are:

- to understand the role of soil carbon in the provision of soil ecosystem services and the soil's natural capital value,
- to link soil carbon storage processes through life cycle assessment (LCA) protocols to the carbon and water footprint of products.

Using X-ray tomography, we have reconstructed the porous network of soils, and determined the impact of changing soil carbon on the soil's buffering and filtering services. Soil carbon influences macroporosity connectedness.

The only international LCA protocol for carbon footprinting (PAS2050) does not allow for soil sequestration of carbon. Inclusion in a later version is flagged. A Dutch protocol has included it for horticultural products. Standing biomass is not considered either. We have found that kiwifruit can sequester carbon at depth. We are carrying out LCA-based water footprinting, which is quite different to carbon footprinting. Water is a local issue, whereas carbon is global.

Our work links, with others, to the NZ Agricultural Green House Gas Research Centre in their soil carbon theme. Also, there have been trans-Tasman discussions between NZ and Australian green house gas scientists.

Annette Cowie, The National Centre for Rural Greenhouse Gas Research (NCRGGR)

Conservative estimates suggest 18Mt CO2-e/yr could be sequestered through soil carbon management in cropland and grazing land in NSW alone – coincidentally, equivalent to the annual emissions from the NSW agriculture sector. Emissions trading could provide an incentive to achieve this mitigation, while simultaneously improving soil health, agricultural productivity and resilience of farming systems. However, acceptance of soil carbon management as an offset will be dependent on developing, inter alia, practical and effective approaches to 1) estimating soil C change; 2) managing impermanence; 3) handling leakage. Monitoring soil C change on a project scale is not a viable option due to the great spatial and temporal variability in C stocks. Instead, estimation of soil C change could utilise process-based understanding of soil C dynamics, expressed through well-calibrated models that simulate impacts of management on soil C. Accounting for emissions trading should take a life cycle approach, including non-CO2 greenhouse gases and off-site carbon stock changes, to ensure credit is based on true mitigation value. Aggregation may be effective in reducing transaction costs and managing risk arising from vulnerability of soil C. Sectoral level approaches may be the only successful means of addressing leakage while the agriculture sector remains uncovered.

NCRGGR is researching impacts of management on soil C, to inform inventory, emissions trading, and decision-support tools for landholders and resource managers. Our goal is to support integration of mitigation measures with production and resource conservation objectives, to deliver sustainable farming systems that mitigate GHG emissions and are adapted to climate change.

Ram Dalal, Department of Environment and Resource Management and University of Queensland

Ram Dalal has extensive research and development experience for more than 25 years in soil carbon and methane fluxes, and carbon dioxide and nitrous oxide emissions from land and vegetation, especially after forest and woodland clearing for agricultural development. He provides input to the procedures for soil carbon and soil carbon pool measurements and their interpretations in monoculture and mixed-species plantations, cropping and rangelands. Ram has nationwide and international contacts with persons working in soil carbon, greenhouse gas fluxes and nitrogen management and practices affecting it. He has been a Referee for Intergovernmental Panel for Climate Change on Land Use, Land Use Change and Forestry, 1999, Project Leader (joint) Soil Carbon Dynamics, Cooperative Research Centre for Greenhouse Accounting (1999-2001), the Project Leader, Australian Greenhouse Office, National Carbon Accounting System: Estimation of Carbon Stocks following Land Clearing using Paired-Site Approach (1999-2002), and a Reviewer for 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Agriculture, Forestry and Other Land Uses. Recently, he completed comprehensive reviews on nitrous oxide and methane fluxes from agricultural, forestry and wetland ecosystems for the NCAS, Australian Greenhouse Office. He has published over 165 peer-reviewed papers.

Two current projects on C sequestration in cropping lands and rangelands form part of the National Soil Carbon Research Program.

Chris Dowling, Australasian Soil and Plant Analysis Council Inc

ASPAC's objectives in relation to measurement of soil carbon are:

- Provide a national and international focus for promoting excellence in all aspects of soil and plant analysis.
- Encourage and promote the adoption of preferred methods and protocols used in soil and plant analysis within Australasia.
- Facilitate national and international communication
- Stimulate training, research and development in soil and plant analysis.

ASPAC plays a key role in the standardisation and improvement of techniques that measure chemical parameters of soil and plant, by which decisions about agronomic, environmental and engineering fitness for purpose can be made.

In more recent times the requirement for participation in the internationally recognised Laboratory Proficiency Programme (LPP) offered to both member and non-member laboratories by ASAPC has been incorporated in legislated regulation associated with environmental protection (ReefWise). In the past 2 years there have been approaches to ASPAC from diverse sources requesting the inclusion of a greater suite of carbon testing in the LPP. The limiting factor is the need for scientific consensus about the soil fractions that are to be measured and standarisation of the analytical techniques to allow an appropriate assessment of laboratory performance to be made.

Mike Grundy, CSIRO Land and Water

I lead a CSIRO Theme called Landscape Systems and Trends. With this work we are interested in developing our capacity to observe measure and monitor agricultural landscapes, model and measure the full lifecycle of processes and material flows and develop the capacity to assess and predict the integrated outcomes of the various trends, pressures and changes in settings. Soil carbon - its various roles and its latest changes in economic value - has always been an important part of these changes and our research agenda but the emphasis has increased and it has become more central to the process. Recent activities have included a review of the potential for biosequestration in Queensland, a descriptive and predictive analysis of the impact of carbon pricing on land use in southern Australia, lifecycle analyses of carbon footprints in agricultural systems, and support of the NCAS with remote sensing and modelling. The theme is now developing a comprehensive system to measure the land use dimensions of various carbon policy settings.

Alex McBratney, The University of Sydney, Faculty of Agriculture Food & Natural Resources, Australian Centre for Precision Agriculture

My interest is in soil carbon auditing to enable a transparent emission trading scheme and adoption of management practices for soil carbon sequestration.

We need to develop an efficient (in terms of cost and uncertainty) auditing or monitoring system for soil carbon for individual land areas. There is a need for transparency to give the market confidence. An auditing method which costs more to administer than the monetary gains to the landholder in sequestering carbon will not function. We are progressing towards a solution.

Our economically important soils have probably lost half of their carbon under current and past practices. This gives us a fair idea of the upper limit of sequestration potential. A major requirement is understanding the soil carbon sequestration potential of various farming and other landuse systems and how the systems might be tweaked to optimise sequestration, and are efficient in terms of energy and water use and at the same time maintain productivity. A tall order, but I'm optimistic that by posing the problem correctly we can achieve some success.

Andrew Rawson, Brian Murphy, NSW Department of Environment, Climate Change and Water

DECCW is the key NSW State Government agency charged with the protection and management of natural resources in NSW. DECCW provides research, education and policy advice on a range of natural resource management issues, including the measurement and management of soil carbon. Research into soil carbon sequestration and its relationship with land management strategies has been carried out by agency staff for more than a decade. We have active collaborations with CSIRO, universities, BoM and Federal agencies.

Our primary research objective is to help provide the necessary background data on soil carbon stocks and sequestration rates of soils in NSW, and to link these to land management strategies. We have been involved in the broadscale collection of soil data, laboratory analysis and mapping of soil attributes, and development of policy initiatives in relation to soils.

We see soil carbon as one of the key indicators of soil health, as well as a primary store of carbon that could contribute to global warming. Soil carbon is also important for future adaptation to climate change. Effective soil and vegetation management will be critical to draw down atmospheric CO_2 into the future and should be a pillar of any strategy to combat anthropogenic climate change. A key challenge we face is identifying and providing the incentive for farmers to manage land to optimise soil carbon. One method being trialled is to develop a suitable market based instrument (MBI) that enables farmers to be rewarded for good land management that sequesters carbon. A pilot project (in conjunction with DII, Lands and CMAs) is being carried out in the Lachlan catchment.
Michael Robinson, The National Climate Change Research Strategy for Primary Industries (CCRSPI), CCRSPI (on behalf of its partners) is interested in better understanding soil carbon, managing soil carbon for multiple benefits, how we manage it for climate mitigation and adaptation, and its impacts (and vice versa) on any proposed ETS and other mitigation mechanisms. Soil carbon is and will continue to be a part of the University of Melbourne's and Victorian DPI's research portfolio. We wish to ensure that our research informs decision making on the basis of robust science.
Pete Smith, University of Aberdeen (not attending) I have worked on soil carbon for 15 years. Soil C sequestration offers about 90% of the mitigation potential in agriculture which amounts to 1500-1600, 2500-2700, and 4000-4300 Mt CO_2-eq./yr at carbon prices of up to 20, 50 and 100 US$/t CO_2-eq., respectively. Barriers to capturing the potential include saturation of the carbon sink, permanence, leakage/displacement, verification issues, and total effectiveness relative to emission reduction targets. Despite these barriers, it is important to capture the potential as it is globally significant and cost effective. If soil C is not included in future climate deals it could lead to perverse incentives in the land based sectors. Credits for enhancing C sinks could be used to support rural livelihoods and secure a range of other ecosystem services provided in the land based sectors.

3.2 Industry

Ken Bellamy, Prime Carbon

We see the development of incentives for meaningful enhancement of the ability of landholders to manage their holdings with less reliance on external financial, social and physical support as critical to the ability of Australia to adapt to, and later exist under, conditions of changed climate.

Soil carbon represents a relatively simple, commonly understood, simply recognised factor in most agricultural exercises and in the management of any land. People know it is important, gain benefits from its presence which they recognise and struggle with other issues in its absence.

The opportunity therefore exists to use this factor as a means to incentivise behavioural and perception change in the agricultural and land management sector which has co-benefits both for the people engaged in the implementation and the society which depends upon their continuing to do so.

Selling a Unit does this. It makes no sense to us to complicate the matter further.

Soil carbon is the risk management process relied upon by farmers, which determines whether or not they can grow crops consistently. If consistent, (read sustainable) food supply is important, then lets help manage this risk by incentivising good management. If there are risks, let science tell us what they are, let actuaries tell us how to deal with them mathematically, and let social enterprise deal with their support.

It is our view that, egos aside, there is nothing complex about soil carbon or soil carbon units - the complexity lies completely in the fight over who controls it and who brags about it.

Bryan Clark, Grain Growers Association Ltd

Carbon offset products for soil carbon management have precedents in the voluntary and State trading schemes of the US and Canada. We should draw upon the existing market instruments and trading frameworks when developing an Australian equivalent. This is not to say that these schemes are completely transferable but that there are lessons to be learned and where we can use these precedents it will reduce the costs of development to any Australian scheme as well as potentially create immediate market linkages should this be desired.

Not only are the tradable products of use, but also the trading infrastructure. Documentation for contracts, accounting systems, financing arrangements and accreditation for assessors can also be potentially applied and modified for our purposes.

Much emphasis has been placed on soil carbon sequestration opportunities but not so on soil carbon emissions abatement. Is there a prior opportunity to consider a reduction in emissions from soil as a first step? To consider using an avoided emissions product construction may overcome many of the issues with additionality and permanence in an Australian context and so be a more viable product. Sequestration may then be an additional product or somehow incorporated into a greater level of avoided loss. Consideration should be given to credit stacking and farming systems.

We need to develop products that are commercially viable and work with good agronomy (ie herbicide resistance) as well as commercial credibility (multigenerational contracts) to avoid perverse outcomes.

Patrick Clement, Nufarm NZ (not attending)

Nufarm NZ has promoted to New Zealand pastoral farmers the concept of Grassmanship (as opposed to Stockmanship) to focus attention on the skill/technology involved in the establishment, maintenance and renewal of pasture.

Where Australia has 14m hectares of wheat, New Zealand has 14 million hectares of pasture - the biggest crop by far. Pastures require renewal every 10 to 15 years and the process of renewal can involve carbon depleting methods such as cultivation or carbon conserving, such as minimum till using Roundup Transorb and cross-slot seeding drills.

Almost 50% of New Zealand's carbon emissions come from agriculture, influenced largely by the methane from ruminant sheep and cattle. Whilst this source is well measured, little is known about the whole farm effects of the pasture based grazing systems including the effect of soil carbon under various management techniques. Without this knowledge, biased assessments on farm emissions are likely to persist.

Besides it's own R&D programme, Nufarm is sponsoring a research project at Massey University to specifically study to effect of various pasture renewal methods on soil carbon losses.

The knowledge emanating from this project, such as improved measurement techniques, will also be applicable to ongoing soil carbon research.

Nick Drew, Fertilizer Industry Federation of Australia (FIFA)

Soil carbon is interlinked with soil fertility and the fertilizer industry has a keen interest in this area. Soil carbon also has the potential to change the economics of agriculture with subsequent impacts on levels of intensity and input demand also of obvious interest to our industry. Soil carbon is also linked with environmental risk from nutrient loss and has potential benefits in this key policy area for the industry. The significance of the contribution of soil N emissions to total greenhouse gas emissions means that any mechanisms to reduce emissions or provide offsetting sequestration will be of interest to the industry.

Sara Hely, Grain Research and Development Corporation

As a result of Australia's ratification of the Kyoto Protocol and the potential introduction of emissions trading, a critical need exists to underpin policy development and the definition of realistic sequestration options and targets with sound scientific evidence. GRDC is a partner in the Soil Carbon Research Program (SCRP) which brings together soil carbon researchers from CSIRO, State Government Agencies and Universities to deliver a coordinated program of research projects with the following objectives:

1. Provision of a nationally consistent assessment of soil carbon condition across the major land-use/soil type combinations used for agricultural production across

Australia.

2. Identification of land-uses and management strategies with the potential to build soil carbon at a regional level.

3. Quantification of the inputs of carbon to soils under agricultural systems based on perennial vegetation.

4. Development of rapid and cost-effective means for quantifying soil carbon stocks and measuring soil bulk density.

In addition GRDC recognises the multi-benefits of retaining carbon in farming systems by:

- Improving crop nutrition
- Retaining groundcover
- Improving soil health and;
- Providing a potential offset under a carbon trading scheme.

Chris Kelly, Wheat and sheep producer, Woomelang, Victoria

My wife and I are farming at Woomelang, which is situated in the southern mallee region of North Western Victoria. Our ancestors cleared the land of mallee scrub in the 1890's and although the farming practices have changed, our income is derived from the same enterprise -wheat and sheep. We began testing our soil in the mid 90's and carbon levels have been fairly stable at the low figure of 0.2 to 1.2%. Our average rainfall at Woomelang is around 300mm with a historical growing season rainfall of 240mm. About half the farmers in our district direct drill their crops and a growing number no longer run livestock. I think most farmers realize the importance of carbon and its role as the basis of life. Many of us are also aware that excessive carbon dioxide levels in our atmosphere must be managed to mitigate detrimental climate outcomes. Farmer businesses are extremely vulnerable to hotter and drier conditions but policies to alleviate climate pressures should not jeopardise farm productivity. Future policy could offer incentive driven change in Agriculture. What change? New technologies and practises that harmonise with the goals and aspirations of farmers and land managers. Support for biodiesel and R&D for new crops with an energy focus, more money for research into ruminant animals, establishment of an agricultural offset market and many more innovative actions that may add to the industry's capability for low carbon farming, (e.g.linklater tractor exhaust fertilizer work at Mildura and New Holland's Hydrogen Tractor).

Louisa Kiely, Michael Kiely, Carbon Farmers of Australia

The Carbon Coalition is an advocacy group established in 2006 by 6 farmers. Its mission is to see soil carbon traded and farmers paid fairly for what they grow. Carbon Farmers of Australia is a not for-profit company which represents growers.

Professor Rattan Lal estimates that soils and vegetation can ‘draw down’ the equivalent of 50ppm for long enough for alternative energy sources to reach the capacity to carry a baseload role. There is no other way – immediately available - to manage the airborne fraction, the source of climate change disorder and damage.

The soil carbon solution's triple bottom line return:

1. Financial – supplementing farm family incomes; reducing input costs and boosting profits; increasing farm productivity; recapitalising the soil and lifting the capital value of the land.

2. Environmental - improved biodiversity and landscape resilience; buffering against the impact of climate change; more efficient use of water; increased health of microbial communities.

3. Social –injection into rural economies; morale of farmers; farming more attractive to the young; farming more attractive to city people.

Major challenge: Identifying obstacles to the trade in soil carbon instead of searching for ways to remove these obstacles. No sense of urgency. Inability to reproduce results achieved by farmers. Lack of true collaboration between farmers and scientists.

Collaboration: Three national conferences for scientists and farmers to share ideas. Acknowledged as major influence in research funding for current soil carbon trials.

Fiona Wain, Environment Business Australia (EBA)

EBA is the peak body for the cleantech/low carbon and environmental goods and services sector. Globally this sector was assessed as a $6 trillion industry in 2008 with rapid growth potential. EBA is a not-for-profit business think tank and advocacy group promoting commercial solutions to environmental challenges.

Members of Environment Business Australia's Bio-CCS group say that biological sequestration methods provide cost effective and environmentally beneficial ways of safely drawing vast amounts of 'legacy' carbon from the atmosphere. By 2020, or much earlier with a strong policy framework, more than a quarter of Australia's annual greenhouse gas emissions can be abated or drawn back into biological and terrestrial cycles.

EBA's Bio-CCS group says a price on carbon is vital to ensure that offsets have market value and to cover the initial cost of 'natural infrastructure' development. But once this is developed the lifecycle cost of carbon offsets can be provided for a fraction of the predicted costs of other solutions such as geological sequestration.

The proposed Bio-CCS approaches include algae sequestration of CO_2 from coal-fired power plants; improved rangeland management to encourage photosynthesis of CO_2 to below ground sequestration in root systems; selection of crops that offer high 'plantstone' yield where carbon is encapsulated permanently in silica; application of brown coal, other organic residues, and naturally occurring nutrients/biology to boost soil resilience and improve crop growth and soil carbon; and direct algal sequestration of CO_2 from the atmosphere over deep ocean areas to sequester carbon in the deep ocean and promote fish stocks.

John White, Ignite Energy Resources (IER), Biological Farming and Fertiliser Systems

IER and its partner LawrieCo have developed a biological farming and fertiliser system (BFS) that substantially replaces the use of synthetic chemical fertilisers and fungicides/pesticides.

BFS improves farm productivity and resilience, whilst rebuilding the soil carbon content (via root structures due to increased plant photosynthesis) and biology. The bio-fertiliser system is derived from Victorian lignite (brown coal), which is high in humic/fulvic content.

BFS is now implemented on over 300 farms, on over 300,000 hectares, from the WA wheatbelt, across SA, into SW Victoria and Gippsland and into southern NSW.

BFS on 1 million hectares will deliver over 15 million tonnes per annum of CO2 sequestration.

Resistance from the synthetic chemical farming industry and research community is the main barrier to rolling out BFS, with their claims that soil carbon cannot be built alongside of profitable farming and that soil carbon cannot be measured - both incorrect assertions.

The Bio-CCS Group (a division of Environment Business Australia) is promoting changes in Australian Government policy to recognise soil carbon offsets/credits, to incentivate the rapid roll-out of BFS and other Bio-CCS technologies - to achieve 150 million tonnes of CO2 sequestration per annum by 2020. The Global Carbon Capture and Storage Institute (GCCSI) and Academy of Technological Sciences and Engineering (ATSE) are considering a proposal to provide similar support to Bio-CCS (including soil carbon) as is given to Geo-CCS.

3.3 Policy

Sarah Bruce, Bureau of Rural Sciences, Department of Agriculture, Forestry and Fisheries

The Bureau of Rural Sciences (BRS) has identified soil carbon as an important component in the Australian climate change and carbon trading debates. Potentially, carbon stored in soil may benefit agriculture and the environment. Greenhouse gases would be reduced, productivity improved and other ecosystem benefits provided. Current knowledge on soil carbon is limited; benefits and risks associated with climate change, alternate farming practices and storage technologies are uncertain.

BRS has identified a number of key factors requiring further exploration to progress the soil carbon debate. These include:

- soil carbon may have a role in carbon trading, depending on landholders' potential to participate, and the ability of projects to meet technical requirements
- soil carbon programs require weighing up the associated benefits and costs
- soil carbon can potentially leak from soils
- undesirable environmental consequences may be associated with soil carbon storage methods
- consistent methods for measuring soil carbon need to be developed.

BRS, in collaboration with ABARE economists and policy makers in the Department of Agriculture, Fisheries and Forestry and leading Australian soil carbon scientists from CSIRO and the Queensland University of Technology, has produced papers addressing soil carbon issues (Walcott et al. 2009; Bruce et al. 2010).

Michael Crawford, Department of Primary Industries, Victoria

With a background in agricultural science, I completed a PhD in carbon sequestration under pastures under the supervision of Prof Malcom Oades and Dr Peter Grace at Adelaide University in 1997. I then returned to the Victorian Department of Primary Industries as a soil science and agronomy research scientist. I have since progressed into science management positions and am now Deputy Executive Director of DPI's Farming Systems Research Division.

With the recent increase in interest in this area, I now find myself playing a key role linking the scientific knowledge in our organisation with policy interests, both within and outside of DPI.

A key challenge to unlocking the potential of soil carbon is to ensure that discussions are informed by sound science such that the potential for carbon sequestration is accurately assessed and stated. In overstating the potential, there is a risk that the opportunities are oversold and that losses and liabilities are exposed as the return on investment is not realised. In understating the potential, there is a risk that potential additional revenue and carbon offset mechanisms for farmers are not realised, and that opportunities to reap the multiple benefits of increased soil carbon are not taken advantage of.

Jason Crean, Economic Policy and Research, Industry & Investment NSW (I&I NSW)

Economic Policy & Research (EPR) branch of I&I NSW has a number of key involvements relevant to soil carbon sequestration. These include: a project with DECCW that aims to design and pilot an MBI (Market-Based Instrument) that supports the adoption of practices that increase soil carbon in the Lachlan Catchment; overseeing two jointly commissioned (I&I NSW and Victorian Department of Primary Industries) research projects by ACIL Tasman on the potential role of the agricultural sector in GHG mitigation policy, and more recently, the design of a market for carbon offsets; and a new project aimed at enhancing the FarmGAS calculator to enable scenario analysis for on-farm mitigation options including soil carbon.

There are a number of well documented constraints to the development of soil carbon markets. These have been reviewed in the MBI project referred to above and relate to measuring and verifying soil carbon sequestration and issues of additionality, permanence and leakage. While these challenges are real, recent work suggests that the conventional approach (e.g. discounting allowable sequestration rates) taken to dealing with these uncertainties reflect a high degree of conservatism and unnecessarily impose costs in pursuing emission reduction targets. Our immediate research interest is to better understand the importance of particular impediments to soil carbon markets; the extent to which they can be addressed through mechanism design; and the importance of voluntary approaches in trialling longer-term solutions.

Edwina Heyhoe. Australian Bureau of Agricultural and Resource Economics (ABARE)

ABARE has extensive experience in analysing the economic effects of mitigation policies, although we are relatively new to analysing soil carbon specifically. While there are examples of soil carbon markets operating overseas, there are Australia specific barriers that need to be considered including the international rules; the effects of natural disturbance on soil carbon levels and measurement costs.

In the near future ABARE is looking to expand its analysis of the potential soil carbon market in Australia examining both supply and demand issues. We are also interested in understanding the impacts of changing soil carbon levels on land productivity and farm profitability.

Mick Keogh, Australian Farm Institute

The Australian Farm Institute has been very actively involved in discussions about the role of agriculture in future greenhouse emission policies for the past five years. Soil carbon sequestration is an issue beset with challenges, but is also one of the few areas where farm businesses may stand to benefit. Issues such as accounting rules, seasonal and other risks, the effect of different management systems, measurement, reporting and verification (MRV) standards, farm input costs and a lack of robust data over long time periods are all challenges that need to be addressed. Current indications are that soil carbon offsets are unlikely to be profitable at carbon prices below $30-$40 per tonne, which highlights the need for resolution of many of the issues listed above.

Kath Rowley, Department of Climate Change and Energy Efficiency

Australian Government policy on soil carbon is framed by the Government's climate change agenda. Key factors relevant to soil carbon are:

The Government's commitment to reducing Australia's emissions.

The Government is committed to creating a prosperous low-pollution economy in which Australia's environment is protected. Australia will play its full and fair part in global efforts, reducing emissions by up to 25 per cent below 2000 levels by 2020 and at least 60 per cent by 2050.

The centrality of market-based approaches to emissions reduction.

The Carbon Pollution Reduction Scheme (CPRS) will be the main driver to achieving Australia's emissions reduction targets, supported by complementary measures such as research and development assistance where required. The Government remains committed to introducing the CPRS after 2012, provided there is sufficient progress on international climate action. The National Carbon Offset Standard (NCOS) will support additional voluntary action to reduce emissions, and commences on 1 July 2010.

The market opportunities for soil carbon presented by the introduction of a domestic offsets scheme.

Unlike energy and transport emissions, agricultural emissions including soil carbon will not be liable under the CPRS. Instead, subject to the development of robust methodologies, offsets will be able to be generated for soil carbon abatement (both sequestration and avoided emissions). CPRS offsets will be available for abatement counted towards Australia's international commitments; and NCOS will allow offsets for abatement that is not counted towards our international commitments, including soil carbon on cropland and grazing land.

The commitment to a robust offsets framework.

A policy and legislative framework for offsets will be put in place that ensures all domestic offsets (CPRS and NCOS) meet the internationally accepted principles of permanence, additionality, measurability, avoidance of leakage, independent audit, transparency and registration. Soil carbon offset methodologies will need to demonstrate how these principles are satisfied, including how the credited carbon will be permanently maintained, how the emission reduction activity goes beyond 'business as usual' practice, and how the activity delivers net emission reductions (rather than simply displacing emissions to somewhere else).

The need to iron-out the remaining uncertainties surrounding soil carbon.

The potential to permanently increase soil carbon levels across most regions of Australia is highly uncertain due to our low rainfall and variable climate. The Government is exploring the full potential of soil carbon through the $130 million Australia's Farming Future Initiative and a new $50 million on-farm abatement research and development package. Results from these work programs will assist land holders to better assess the economic potential of soil carbon offset opportunities in the CPRS and voluntary markets.

The international climate change rules.

Under current international rules, changes in soil carbon arising from natural events such as drought create a risk of major spikes in our national inventory. As a result, Australia has elected to not report on greenhouse gas emissions and removals for cropland and grazing land management (of which agricultural soils would be a part) under the Kyoto Protocol. The Government is working hard to improve international accounting rules to take better account of natural variability. If these rules improve, Australia may elect to count a broader range of land management activities towards our international commitments, allowing them to be included in the CPRS market.

Tanya Ritchie, Veronica Le Nevez, Department of Environment, Climate Change and Water NSW

Objectives:

- Effective public policy to mitigate climate change.
- Reduce carbon dioxide emissions from soils.
- An effective contribution from soil carbon sequestration to climate change mitigation.
- Credible soil carbon trading.

Challenges:

- Distinguishing between human-induced and natural carbon emissions and sequestration in the international and domestic carbon accounting frameworks - to enable appropriate monitoring and reporting, targeted polices and carbon trading.
- Measuring and verifying soil carbon sequestration to enable soil carbon trading.
- Costs of measurement, verification and compliance.

Collaborations:

DECCW, I&I NSW and Lachlan CMA soil carbon trading pilot project.

Anna Skarbek, ClimateWorks Australia

ClimateWorks Australia recently released an economy-wide Low Carbon Growth Plan for Australia, using the McKinsey cost curve methodology to measure the least cost measures that can enable Australia to reduce emissions by 25% below 2000 levels, a total of 249 Mt CO_2e abatement. Soil carbon sequestration is estimated to contribute 25 Mt CO_2e of this abatement. To achieve this it is estimated that soil carbon practices, which currently occur on approximately 15% of Australian agricultural land, would be extended to a further 15% of Australia's agricultural land area. The costs range from $5/t to $94/t depending on the current use and condition of the land in which the soil carbon sequestration occurs. The weighted average cost of achieving 25Mt is $33/t.

The challenges in unlocking this potential including improving the quality of the data, to

enable a robust system of measurement, incentive and regulation. Data is lacking in key areas such as: i) the productivity improvement from a given set of actions and the costs and sequestration voumes associated with those actions; ii) the existing nutrient content of Australian soil, so as to understand what is needed to boost carbon sequestration volumes; and iii) monitoring costs and tools given that natural fluctuation in soil carbon levels is likely.
Corey Watts, The Climate Institute The Climate Institute is an independent, evidence-based policy analysis, research and advocacy group focused on actions that avoid dangerous climate change. The Institute views credible C sequestration in the landscape generally as a vital part of a broader mitigation strategy. Building C is integral to restoring soil health, and hence building farm resilience in a rapidly changing climate. The extent to which Australian soils can play a prominent role in avoiding dangerous climate change is, however, unclear. Declining rainfall, rising temperatures and economic imperatives will combine to constrain soil C's role in mitigation. Further, the risk of a sudden release of C in the future is likely to grow unless global emissions peak at source within a decade. The movement behind soil carbon is a double-edged sword; aptly demonstrating soil's potential and passionately advocating for action at best, while appearing dogmatic and anti-scientific at worst. This makes it hard to sort reality from over-optimistic claims and may tarnish soil C's credibility in the long run. For the moment, soil carbon is not recognised by international rules. Overseas experience with voluntary C markets suggests that soil is unlikely to offer a competitive prospect for many farmers in southern Australia, especially given the increasing cost of inputs. The rangelands, however, may offer better prospects. The current CPRS Bill seems to provide a good platform from which to test C products in the voluntary market, and to mesh these into the CPRS when and if soils are recognised internationally.

3.4 Market

Penny Baalman, GHG Offset Services GHG Offset Services provides advice in relation to forest activities in climate change mitigation, including the development of policies and programs, accounting systems and methodologies and especially standards for accounting. While Penny specialises in forest activities this includes the potential of soil carbon accounting in reforestation, forest management and avoided deforestation projects. Coming from a farming background she maintains an interest in potential climate change mitigation and other benefits that soil carbon increases can allow in agricultural systems. Penny has undertaken applied research programmes measuring soil carbon changes on forest and non-forest lands and assessed the accounting implications in her previous work with Forests NSW where she was responsible for the development of a carbon accounting system and related requirements under the GGAS. She also oversaw the development of soil carbon models utilised for this system including its uncertainty assessment. She has worked for the main auditor of CDM projects where she gained a perspective on the review and auditing of reforestation baseline and monitoring methodologies and project documentation and developed universal auditing templates for reforestation CDM activities. She believes the key challenge for soil carbon is the mode of inclusion and its specific design, especially in regards to cost-effective and reliable monitoring requirements. The Greenhouse Gas Management Institute provides an expert forum for issues in GHG accounting. See http://ghginstitute.org/join-ghgmi/ghgmi-forum/
Ian Conrad, Boulton Cleary & Kern Lawyers Prime Carbon has developed a methodology to create tradeable carbon credit units in respect of CO_2 sequestered by landholders, based on measured changes to equilibrium carbon content of soil of land managed by those landholders. Prime Carbon has also developed a methodology to aggregate those units, to provide emitters of atmospheric carbon with opportunity to purchase units in the voluntary market, to offset against their carbon emissions. Units have been listed on the National Environment Register operated by the NSX Ltd and have traded on the voluntary market. I have worked with Prime Carbon to develop the contractual framework between Prime Carbon, landholders and emitters, to implement the methodology mentioned above. In recent months I have worked with Prime Carbon to develop a contractual framework to support the configuration and trading of units that would comply with the National Carbon Offset Scheme. I am also working on the contractual framework that would support soil carbon based Joint Implementation or Clean Development Mechanism projects developed by Prime Carbon and under the Carbon Pollution Reduction Scheme (CPRS) if and when it is introduced. The lack of a legislative framework that implements the policy of the Commonwealth

Government to permit trading of offsets arising from the sequestration of soil carbon under a CPRS, has been the obvious barrier to developing a framework for creating tradeable units based on soil carbon sequestration by Australian landholders.

Joel Fleming, Climate Friendly (Not Attending)

Climate Friendly is focused on independently verified carbon projects in the voluntary market. For quality assurance, there is a high focus on quantification of the carbon abatement and the methodologies that enable this. For renewable energy carbon credits methodologies are well established and highly accurate. Soil carbon projects have clear emotional appeal and could be a new source of carbon credits. The development of rigorous methodologies is critical so that soil carbon can generate trusted tradable carbon credits.

In certain overseas examples “no till” credits were issued using a desk based formula and without first checking first whether the farm had already converted to no till farming.

Elements of a robust methodology would include

1. A methodology established through international bodies such as the Voluntary Carbon Standard.
2. Field measurement at individual farms with a statistically reliable sample size.
3. Quantification of variability in soil carbon on a within farm basis.
4. The establishment of a baseline and ongoing monitoring.
5. An independent objective way to set the baseline year.
6. Carbon abatement figures would be adjusted to allow for uncertainty.

With a robust, accurate and affordable methodology, soil carbon has significant potential in Australia.

Iain MacGill, Centre for Energy and Environmental Markets, University of NSW

The UNSW Centre for Energy and Environmental Markets (CEEM) undertakes interdisciplinary research in the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks. Its research areas include the design of electricity markets, market-based environmental regulation including emissions trading and renewable energy targets and the broader policy context in which all these markets operate.

CEEM work relevant to soil carbon includes research to develop tools that can identify and assess potential opportunities for bioenergy plants in agricultural areas to deliver waste management, renewable energy and soil carbon benefits. There are potential synergies yet also tradeoffs between these value streams that need to be better understood. Other key research interests are the potential opportunities, challenges and impacts of incorporating soil carbon into national and international carbon markets that currently trade almost exclusively energy and industry emissions.

Ilona Millar, Baker & McKenzie

We are working with a range of institutions, project developers, and investors to explore the opportunity for soil carbon projects to be developed for voluntary and compliance carbon markets. Effective management of soil carbon has the potential to contribute significantly to the reduction in gobal GHG emissions. However, realising this potential faces a number of technical, policy and regulatory barriers.

A key issue relates to the current accounting of carbon stocks under the Kyoto Protocol national inventory system. Annex I parties to the Kyoto Protocol are able to elect whether to report on grazing land management, crop land management and native forest management. With the exception of a few European Member States, most countries do not report on these categories of land management. This is largely due to concerns about the difficulty of measuring carbon stock changes and the fact that natural disturbance events must be included in those accounts. The international negotiations are seeking to address these issues through amendments to the Kyoto Protocol for its second commitment period (and more broadly the regime for international climate change post-2012). As a result of this, these sectors are largely excluded from market based emission reduction schemes, such as Joint Implementation and the proposed Australian Carbon Pollution Reduction Scheme (CPRS). Exclusion from these schemes limits incentives in investing in developing soil carbon methodologies and projects as the only potential market for such projects is presently the voluntary carbon market.

Nick O'Brien, New Forests

New Forests manages investments in sustainable forestry and associated eco products, such as carbon, biodiversity and water, for institutional and private equity clients.

Maintenance of soil organic matter is obviously a very important consideration in the establishment and management of forests. However, soil carbon is generally a relatively small component of the balance sheet when estimating carbon sequestration in forestry projects. As such, we either estimate changes in soil carbon using generic models rather than doing detailed measurement of soil carbon, or ignore soil carbon entirely (assuming no net loss over the project life).

The key barrier to having a greater emphasis on soil carbon in forestry projects is the cost-benefit return - changes in soil carbon are relatively expensive to measure accurately, particularly in comparison to estimation of changes in tree carbon stock. Implementation of new technologies (at low cost) is critical in gaining greater focus on soil carbon.

Andrew Petersen, PricewaterhouseCoopers

Our current focus for clients are the key challenges, being:

- Potential large-scale growth in the soil carbon market following post-Kyoto climate agreement and growth in domestic carbon markets, eg US.
- Land use ecosystem valuation and market opportunities with increased recognition of the economic value of ecosystems and biodiversity, eg soil and water regulation.
- Sustainability of soil carbon operations of increasing concern for stakeholders,

including investors and financial institutions.

- Investment opportunities in farming community.
- International recognition and potential growth in sustainable soil carbon investment funds. Need for appropriate measurement, reporting and assurance around Soil Carbon, to give confidence to the general, business and finance community.

How we intend or are supporting opportunities for clients in this area:

- Structuring afforestation, reforestation and forest conservation and soil carbon ventures
- Feasibility studies and risk assessments
- Carbon credit transactions
- Regulatory support
- Carbon accounting and reporting policies
- Assurance for performance reporting.

Justin Sherrard, Rabobank

Rabobank Australia & New Zealand is a part of the international Rabobank Group, the world's leading specialist in food and agribusiness banking. Rabobank is structured as a cooperative and operates in 46 countries, servicing the needs of more than nine million clients worldwide through a network of more than 1600 offices and branches. Rabobank Australia & New Zealand is one of the region's leading rural lenders and a significant provider of business and corporate banking and financial services to the food and agribusiness sector. The bank has 83 branches throughout Australia & New Zealand.

The bank's Food & Agribusiness Research and Advisory team focuses on agri-commodity markets - trends in supply and demand and price outlooks. The research agenda also covers those issues that will shape the success of the food and agribusiness sector in the medium term, such as climate change, water scarcity, demographic change, etc.

Rabobank believes carbon offsets - soils and trees - represents both an opportunity and risk to the food and agribusiness sector. Soil carbon is a topic that frequently arises in the bank's regular engagement with farmers and agribusiness.

4. References

4.1 Science

This background paper is not designed to be a comprehensive review of the scientific literature regarding soil carbon. Instead, some useful general overviews are listed, many of which include further references. Many of the links included in the main body of this paper also lead to other sources of information. We will endeavour to make available a full list of references provided by contributors after the workshop.

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