Submissions
Garnaut Climate Change Review
Level 2, 1 Treasury Place
Melbourne VIC 3002

Submission prepared by

Peter R. Grace (B.Sc., Ph.D.)
Professor of Global Change &
Director of the Institute for Sustainable Resources
Queensland University of Technology
2 George St, Brisbane
Queensland 4000.

Phone 61-7-31389283
FAX 61-7-31384438
Email pr.grace@qut.edu.au

3.1 Adaptation in the agriculture and forestry sectors

Questions for consideration

- *How might these adaptation challenges be addressed?*

Directly through strategic sector based impact assessments and subsequent development of adaptation plans. A transparent process must be led (and funded) by industry with substantial government support. This is an ideal issue for major multi-disciplinary projects which are inclusive which requires strong industry leadership.

- *What other factors affect the implementation of adaptation measures in the agriculture and forestry sectors?*

The current governance structure in Australia responsible for agricultural research, development and extension is extremely fragmented across state and federal. This does not provide the required mechanism and cohesion for a truly effective, “systems” based approach to adapting agriculture to climate change. The current governance system is over regulated and bureaucratised to the point of diminishing returns and cost-ineffectiveness. Small scale immediate gains are preferable to large scale incremental change required for adapting agriculture. This is based on the need for short-term returns on what is a long-term problem requiring long-term flexible investments. This has resulted in insufficient information being generated to examine long-term impacts and alternative strategies. Adaptation challenges cannot be made on short-term investment cycles.

- *How should responsibilities be shared in dealing with adaptation?*

Improved dialogue and strategic (joint) investment by the public and private sectors is essential for large scale change and impact. State and federal governments need to make greater use of independent research providors for developing policy and strategic direction, ensuring transparency.

3.2 Mitigation options for agriculture and forestry

Questions for consideration

- *What potential is there for mitigation in the agriculture sector in the short term? What practical options for mitigation are likely to become commercially viable in the near future?*

Grace et al., (2004, 2007) investigated the opportunity cost of soil carbon sequestration for distinct agro-ecological zones of SE Australia and constructed carbon supply curves for each zone. The computational method employed in the IPCC 1996 Revised Guidelines for National Greenhouse Gas inventories, as updated in the IPCC Good Practice Guidance (GPG) for Land Use, Land Use Change and Forestry (IPCC, 2004) was used to provide estimates of soil carbon change to flow into the economic analysis.

To generate the soil carbon stock change estimates for the economic analysis, we applied a Geographic Information System (GIS) procedure to overlay climate, soil and land cover spatial databases to stratify the agricultural (cropland and grazing land) area by agro-ecological zone. An uncertainty analysis was conducted for each management scenario using a Monte Carlo Approach that was adapted from Ogle et al., (2003).

After estimating average carbon rates for the changes in management practices, they were adjusted to account for field based CO_2 and non-CO_2 emissions averaged over the defined time interval of 20 years. The IPCC Tier 1 default values (IPCC, 1997) were used for calculating these emissions based on the inputs provided for each agro-ecological zone.

Specifically, the additional emissions included in the full greenhouse gas account were:

- CO_2 from fuel used in farm machinery used in tillage, harvest or pumping operations, specifically 2.6 kg CO_2 per litre of combusted fuel.
- N_2O from the burning of crop residues, manure application, nitrogen fertilizer addition, crop residue retention, nitrogen fixing crops, volatilization and leaching losses. Specifically, an emission factor of 1.25% from nitrogen applied as either fertilizer, biological nitrogen fixation or crop residue decomposition and 2.0% from nitrogen applied as animal manure. Emission factors of 1.0% and 2.5% respectively were applied to nitrogen assumed to have been lost through volatilization (10%) and leaching (30%) pathways.
- CH_4 and N_2O from the burning of crop residues, rice cultivation and from animals associated with grazing systems directly associated with sequestering technologies. Emission factors of 8 and 49 kg CH_4/head were applied to sheep and non-dairy cattle respectively and 100 kg CH_4/ha for rice.

After quantifying the average carbon sequestration rate (on a full greenhouse accounting basis) for the changes in practices that are feasible for the agro-ecological zones of each region, we then estimated three key components of the opportunity cost:

- The farm opportunity cost of changing practices, ΔNR_{is}. The ideal method for estimating farm opportunity costs is to collect data from a statistically representative sample of farms and land units. Cursory survey data is only available in many of our case study regions, in which case statistically representative distributions of farm opportunity costs were estimated based on local knowledge. The methodology of Antle & Capalbo (2001) was utilized to construct economic models that simulate the net returns distributions under alternative price and technology scenarios.
- The fixed costs of adoption, f_{is}. It is possible to estimate the fixed costs of investing new capital associated with the conservation practice (e.g., the costs of new machinery and equipment needed for minimum tillage).
- The transaction costs of designing, negotiating, and verifying compliance with contracts, t_{is}. Until the actual implementation of carbon contracts occur, it is difficult to estimate exact transactions costs associated with sequestration projects.

A simulation model was then constructed to derive carbon supply curves for each spatial unit represented by the data. This simulation model draws multiple samples from the spatial distributions of net returns within each spatial unit, and computes the opportunity cost of changing from conventional to alternative practices for each activity in the spatial unit.

Next, for a range of given carbon prices, the model determines the proportion of hectares in the unit that participate in carbon contracts at each price, and then uses the carbon rate for that spatial unit to compute the total quantity of carbon sequestered in each spatial unit at each price.

Finally, the model constructs the supply curve for each sub-region and region by aggregating data across spatial units. Sensitivity analysis was performed on some of the key economic variables in combination with the changes in soil carbon changes to provide some estimates of uncertainty.

SE Australia has a long history of mixed cereal and pasture systems, diversity in soil types and the promotion of conservation tillage and improved pasture systems. Two broadly defined agro-ecological zones exist representing both warm temperate wet and warm temperate dry agriculture as classified by the IPCC, similar to those found in Mediterranean regions of the world.

The case study examines management options within six distinct agro-ecological regions found in these two broader climatic zones i.e. the Mallee, Wimmera, High Rainfall, Mid-North South Australia, Central and Slopes.

Traditional crop-annual legume based pasture systems are generally being replaced by continuous cropping in combination with minimum or no-tillage in the high yield potential Wimmera region, and to a lesser extent in Mid-North South Australia. In contrast, in the High Rainfall region in the far south of the country, annual pastures offer the best returns, with long phases in the rotation.

In both the Central West and the eastern Slopes regions, minimum and no-tillage systems are being favoured for increasing the cropping phases (replacing pastures) within a rotation sequence. In the lower rainfall Mallee, Central West and Slopes, 1-2 sheep ha^{-1} typically graze on crop residues left in the field. Grazing pressure is reduced to zero in no-tillage systems.

Australian farming systems have historically been crop-pasture rotations, with an increased incidence of pastures in either the High Rainfall region, capable of supporting heavy grazing pressures, or the marginal semi-arid regions such as the Mallee and Central West. A shift away from pastures has been the case in recent years in the Wimmera and the Mid-North regions, as the price of wool remains depressed, and grain prices relatively buoyant.

Associated GHG emissions from crop-pasture rotations within the six regions were (on average) 8.8 Mg C ha^{-1} (1 Mg = 1 Tonne) with conventionally tilled systems emitting 14% more than those under minimum tillage, which in turn emit 10% more than no-till systems. The largest carbon offset over 20 years can be found in the High Rainfall region (20.7 Mg C ha^{-1}) with grazing animals contributing 71% of the total emissions from these systems.

Methane and N_2O from grazing animals also contribute heavily to emissions from the Central West region. In the regions where cropping plays a significant role (Wimmera, Mid-North and Slopes), the associated GHG emissions are all relatively similar, averaging 8.3 Mg C ha^{-1} from the conventional systems to 5.3 Mg C ha^{-1} from no-till systems. Nitrous oxide emissions from fertilizer consumption are the major contributors to emissions from these regions.

The highest net gains in carbon in Southern Australia can be realized through conversion from conventional to no-tillage systems in the high clay soils of the High Rainfall and Wimmera regions. In the former, the high levels of primary productivity, in concert with soils of relatively high clay content realize net gains of 12.7 Mg C ha^{-1} over 20 years, even after being heavily discounting due to associated GHG emissions. Conversion to minimum tillage realizes half the benefit of no-tillage in both these regions (6.3-6.4 Mg C ha^{-1}).

In the Mid-North region, relatively large gains in soil carbon (4.6 Mg C ha^{-1}) can be made on converting conventionally managed cropping systems to minimum tillage, with little additional benefit moving to no-tillage (5.4 Mg C ha^{-1}). This trend is reversed in the Slopes region, where carbon gains under minimum tillage (1.7 Mg C ha^{-1}) are one-third of that found under no-tillage (5.5 Mg C ha^{-1}). Gains in soil carbon under minimum and no-tillage are minimal in the Mallee region (0.6 and 1.6 Mg C ha^{-1} respectively).

In terms of the absolute returns in soil carbon (i.e. accumulation rate of carbon, adjusted for associated greenhouse gases, by areal extent of technology), the Slopes region offers a relatively high rate of accumulation and a large area still under conventional tillage and potentially available for a change in technology (Table 1).

With complete adoption of minimum or no-tillage across the six regions of South-Eastern Australia, the latter would yield an additional 18.6 million tonnes of carbon over 20 years (twice the return of minimum tillage). For comparison, this is equivalent to 20% of Australia's annual fossil fuel emissions for the year 2000 (Marland et al., 2003).

The economic analysis for SE Australia considers adoption of either minimum tillage or no-till in a mixed grain and oilseed system. Unadjusted carbon rates were generally quite low (0.1 - 0.2 Mg C ha^{-1} $annum^{-1}$) in several larger regions and higher in two smaller regions (Wimmera and High Rainfall). Economic returns to no-till were estimated to be higher on average than for minimum tillage. Therefore, expected returns (inclusive of carbon payments) would be larger for no-till than for minimum tillage, so the no-till case is likely to be the most relevant one to consider for carbon sequestration analysis.

There are substantial differences in economic potential for soil carbon sequestration across the sub-regions of Australia (Table 2). The Wimmera, High Rainfall and Slopes regions have the highest carbon gains (with these rates adjusted to include other greenhouse gases) under no-tillage, but they are substantially smaller than some of the other regions.

Nevertheless, they are among the sub-regions with the highest total potential for carbon sequestration, whereas other much larger regions have much lower technical and economic potential. The same regional pattern for investment is not evident for minimum tillage systems, but overall the Wimmera region would appear to be the most favourable when considering tillage based returns on investment.

Note that the adjustment of the carbon sequestration rates for associated greenhouse gases and reductions in put use effectively doubles the estimated quantities of carbon (equivalents) sequestered with the change in management (Table 3). For example the total unadjusted amount of carbon sequestered for SE Australia would only be 3.3 Million Tonnes C @ $200 per Tonne C, compared to adjusted value of 7.5 Million tonnes.

In Australian crop-pasture systems, particularly no-tillage, there are significant reductions in external inputs (e.g. fuel) with subsequent impacts on the associated field emissions. Animals are also removed, thus reducing CH_4 emissions and also allowing crop residues to decompose and aid in he maintenance of the soil carbon pool.

It must be noted that in some of the larger Australia regions where crop-pasture systems are in predominance (Mallee and Central West), the total areas reported available for adoption may be slightly inflated. Data reporting in these areas is not detailed enough to differentiate long-term pasture from crop-pasture systems, so they are all considered available for technological change.

The finding of relatively low economic potential for soil carbon sequestration in SE Australia may be due to the fact that conservation tillage practices that sequester carbon have already been widely adopted by farmers because it is already recognized as profitable. Thus, additional adoption to sequester carbon will occur only if carbon incentives are high enough to offset the costs of adoption.

On the other hand, there is also a lack of clarity when growers report data on the use of no-till across all regions. Some growers use no-till only periodically, not permanently. Permanence is essential and any tillage complete negates the positive impacts that no till have on carbon sequestration and its viability for a carbon market.

The study did not specifically address co-benefits of soil carbon sequestration and potential flow on effects. For example (in Table 3), if we take the total amount of carbon sequestered in SE Australia at $50/Mg C as 2.2 Million Tonnes, if we use a typical soil C/N ratio of 10/1, we have 200,000 Tonnes of additional N sequestered over 20 years, of which approximately 5% (10,000 Tonnes) will be potentially released as mineral nitrogen. At current N fertiliser prices, this represents a saving of $10-20 Million for this region alone.

In summary, the significance of soil carbon sequestration alone as a major mitigation option for offsetting Australia's emissions is perhaps overstated, particularly in cropping systems, but its value in comparison to plantations should not be understated.

For example, if the biomass C estimates in Table 4 (Grace & Basso, submitted) are adjusted for initial losses in soil C and associated emissions in developing and maintaining the plantations, the annual soil C sequestration rates in the mixed crop and pasture systems of Wimmera and High Rainfall regions (under no till) are of the same order of magnitude to some of the large scale plantation returns in low fertility sites across Queensland.

Also, management interventions which provide small incremental gains in soil C over large areas of land may provide substantial gains in soil C which are comparable to biomass returns in low fertility plantations.

Table 1. Distribution of tillage management and total soil carbon sequestration potential (after 20 years) in crop-pasture agro-ecosystems of South-Eastern Australia.

Region	**Land area[1] under system**					**Proportion of area**				**Sequestration Rate[2]**		**Total C seq'ed[3]**	
	ha x1000					%				Mg C ha^{-1}		Mg C x1000	
	*Conv**	*Min-till*	*No-till*	*Conv+ Min-till*[4]	*Conv+ No-till*[4]	*Conv**	*Min-till*	*Conv**	*No-till*	*Min-till*	*No-till*	*Min-till*	*No-till*
Mallee	1647.1	2433.9	806.4	4081.0	2453.5	40.4	59.6	67.1	32.9	0.56	1.64	922.4	2701.2
Wimmera	213.8	342.0	569.3	555.8	783.0	38.5	61.5	27.3	72.7	6.42	8.97	1372.3	1917.3
High Rainfall	98.0	94.8	169.0	192.8	267.0	50.8	49.2	36.7	63.3	6.3	12.72	617.7	1247.2
Mid-North	542.1	581.5	452.3	1123.7	994.5	48.2	51.8	54.5	45.5	4.56	5.41	2472.2	2933.0
Central West	782.2	839.0	652.6	1621.2	1434.8	48.2	51.8	54.5	45.5	1.87	3.49	1462.7	2729.8
Slopes	1299.2	498.4	1083.2	1797.6	2382.4	72.3	27.7	54.5	45.5	1.71	5.47	2221.7	7106.8
TOTAL	4582.4	4789.7	3732.7	9372.1	8315.1	48.9	51.1	55.1	44.9	-	-	9068.9	18635.4

*Conventional tillage is the baseline technology

[1] Total areas include crop and pastures (where applicable) at any time.

[2] Soil carbon sequestration gain per hectare after 20 years in response to management and derived from the adjusted carbon change data (i.e. includes all greenhouse gases)

[3] Total soil organic carbon potentially sequestered after 20 years without economic constraints and all cropping area currently available under conventional tillage and converted to either minimum or no-till cropping.

[4] Total areas differ between conversions from conventional to both min-till and no-till and analyzed separately.

Table 2. Adjusted carbon sequestration (i.e. including associated greenhouse gases) after 20 years for regions of South-Eastern Australia, converting conventional tillage crop-pasture systems to no-tillage.

Carbon Price $/MgC	Total Australia	Mallee	Wimmera	High Rainfall MgC	Mid-North	Central West	Slopes
0	0	0	0	0	0	0	0
10	389614	5748	80304	101890	38429	14307	148935
20	833217	28741	160609	179521	69172	78687	316488
30	1323711	45985	230875	295967	92229	100147	558508
40	1790765	68978	361370	402709	122972	164527	670209
50	2180338	68978	491865	475488	146029	178834	819145
60	2598483	80474	542055	567674	199829	221754	986697
70	3089795	91970	692626	645305	215200	271827	1172866
80	3449810	114963	782969	718084	245943	321900	1265951
90	3770368	126459	863273	781159	261315	379127	1359036
100	4258268	143704	973692	873345	307429	414894	1545205
110	4620921	183941	1053996	926716	345858	472121	1638290
120	4988015	195437	1104187	970383	384286	565114	1768608
130	5296606	212681	1194529	994643	415029	636648	1843076
140	5624997	229926	1284872	1033458	438086	665261	1973394
150	5909354	229926	1335062	1067422	476515	715334	2085096
160	6335331	247170	1405328	1086829	514944	772561	2308499
170	6566858	258666	1455519	1101385	545686	822634	2382967
180	6979441	281659	1505709	1120793	576429	851248	2643604
190	7278192	298903	1575975	1154756	614858	915628	2718071
200	7500649	310400	1646242	1169312	637915	944241	2792539

Table 3. Participation rates, annual sequestration rates and total sequestration after 20 years for South-Eastern Australia, converting conventional tillage crop-pasture systems to no-tillage.

	Unadjusted Carbon			Adjusted Carbon		
Carbon Price $/MgC	**Participation rate**	**Carbon MgC/yr**	**Total Carbon MgC**	**Participation rate**	**Carbon MgC/yr**	**Total Carbon MgC**
0	0.0%	0	0	0.0%	0	0
10	0.7%	8283	165663	1.1%	19481	389614
20	1.6%	17727	354538	2.3%	41661	833217
30	2.4%	27621	552419	3.5%	66186	1323711
40	3.4%	39074	781477	4.9%	89538	1790765
50	4.2%	49552	991040	5.9%	109017	2180338
60	5.0%	59051	1181014	7.0%	129924	2598483
70	5.8%	66903	1338063	8.3%	154490	3089795
80	6.5%	75743	1514860	9.3%	172490	3449810
90	7.3%	84434	1688685	10.2%	188518	3770368
100	7.9%	91057	1821144	11.5%	212913	4258268
110	8.9%	104088	2081763	12.5%	231046	4620921
120	9.8%	114811	2296212	13.5%	249401	4988015
130	10.3%	121476	2429525	14.4%	264830	5296606
140	11.0%	128314	2566275	15.2%	281250	5624997
150	11.6%	135891	2717822	15.9%	295468	5909354
160	12.1%	141038	2820759	16.8%	316767	6335331
170	12.7%	148526	2970515	17.4%	328343	6566858
180	13.1%	155026	3100518	18.2%	348972	6979441
190	13.6%	160974	3219488	19.1%	363910	7278192
200	14.1%	165609	3312171	19.6%	375032	7500649

Table 4. Estimates of carbon sequestration rate (per annum based on 30 year rotation) for forestry plantations (stem + roots + foliage) in regions of NE Australia as simulated by the 3PG model of forest growth.

	Biomass Carbon ($t\ ha^{-1}\ annum^{-1}$)					
Species	NQ[e] Low[f]	NQ High	CQ Low	CQ High	SQ Low	SQ High
Euc[a] Wet[b]	4.5	10.5	1.0	6.9	1.9	9.7
Euc[c] Dry	1.6	3.0	1.9	2.6	3.7	4.5
Hoop Wet	2.8	9.0	1.3	7.3	1.5	8.1
Hoop Dry	0.5	3.6	0.2	3.1	1.1	7.2
Pinus[d] Wet	5.4	9.8	3.9	8.1	4.3	9.6
Pinus[d] Dry	1.9	4.2	2.3	4.2	4.8	7.0

[a] *E. cloeziana*

[b] Wet regions are coastal and hinterland and are in contrast to dryer regions further west

[c] *E. argophloia*

[d] *P. elliottii*

[e] North Queensland (NQ), Central Queensland (CQ), Southern Queensland (SQ)

[f] Low fertility site (model parameters: fertility rating 0.2, sandy soil, 50 mm maximum available soil water); High fertility site (model parameters: fertility rating 0.8, clay loam soil, 150 mm maximum available soil water)

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

Returns in investment for changing management are essential, however this can be achieved through improved community education which promotes the clear win-win in accumulating soil carbon in terms of sustainability (and profitability) of farming systems through improved soil structure and potential reductions in fertiliser (nitrogen) needs, and nitrogen use efficiency, or shifts to organic (slower release) sources of N. The latter reduction also significantly, and permanently reduces the potential for N_2O emissions, which are approximately 300 times as potent in terms of Global Warming Potential (GWP) than CO_2. Note the emphasis on permanence of the intervention, as soil carbon sequestration alone is costly to accurately monitor and maintain over 70-100 years. Reducing N_2O emissions is permanent.

- *What is the best way to deal with trade exposure if policy measures are implemented to reduce emissions from the agriculture and forestry sectors?*

Trade exposure is minimal if the linkage between sustainable agricultural practices and emissions reduction is tightened. There is no evidence presently available that runs counter to the fact that sustainable agricultural practices such as no tillage and improved pasture management are both profitable and less greenhouse gas intensive.

Mitigation policy options

Questions for consideration

- *Accepting existing practical limitations, is direct inclusion in an ETS the most appropriate mechanism for encouraging mitigation in the agriculture and forestry sectors?*

Inclusion of agriculture in an ETS is in the countries best interests if these sectors are provided the opportunity to be major providors of offsets which are also beneficial to sustaining Australia's natural resources and prosperity e.g. soil carbon sequestration for increased soil health and increased nitrogen use efficiency.

- *What policy mechanisms would be more appropriate for these sectors? How would these measures interact with an ETS covering other emitting sectors?*

The transport sector plays a major role in agriculture and the creation of a fragmented ETS would make it difficult for future inclusions. The (later) modification of a comprehensive, but inclusive system is easier than finding space for new comers at a later date.

- *What would be the economic impacts on the agriculture and forestry sectors of a domestic ETS covering stationary energy and transport?*

The agriculture and forestry sectors would be significantly disadvantaged if they were included in such a system (e.g. transport), without the opportunity to offset these emissions through there own land-based mitigation interventions.

Providing opportunities

Questions for consideration

- *What are the opportunities available to the agriculture and forestry sectors as a result of mitigation policies?*

Australia's current policies provide minimal opportunities for agriculture and forestry.

- *How should uptake of these opportunities be maximised?*

The tight synergy between sustainable and profitable agricultural production and mitigation opportunities must be promoted amongst the community.

- *Do these opportunities create perverse outcomes and, if so, how should these be managed?*

Biofuel production will provide a perverse outcome if producers do not recognise the need to restore carbon levels in soils where biomass is being removed. Biomass return underpins sustainable and profitable agriculture, if it is all removed for refining and processing, soil C levels will decline and a source of native nitrogen will be reduced, with major impacts on soil structure, reducing infiltration and increasing runoff and stream pollution. Increased nitrogen inputs to maintain high yields, coupled with increased waterlogging due structural decline will also increase nitrous oxide production.

3.3 Practical considerations for including agriculture and forestry in an emissions trading scheme

Questions for consideration

- *Do the economic efficiency gains from including small emitters in an ETS justify the costs of compliance?*

Aggregation of small emitters would be only practicable if agricultural offsets are allowed.

- *How could transaction costs be minimised?*

Transaction costs will be high unless suitable proxies are available. Remotely sensed monitoring of land use change and registration of fields can be made online. Transaction costs could also be minimised by reducing the number of financial “middle men” and placing a cap on costs.

- *What should be the point of obligation for agriculture and forestry industries in an ETS?*

No comment

- *Should a threshold for liability be applied, and how should it be defined?*

No comment

Monitoring and verification of emissions and mitigation

Questions for consideration

- *What ‘proxies’ would be appropriate for the estimation of emissions in the agriculture and forestry sub-sectors?*

Model based estimates of soil C are quite advanced throughout the world. Inclusion of remotely sensed information on yield combined with climate information provides the necessary drivers for reliable estimates. At this stage, accurate estimation of N_2O loss from agricultural systems via models is still difficult mainly due to the lack of data on these emissions from agricultural systems. However, simple, relatively inexpensive sampling protocols are available which would allow farmers to monitor their own N_2O emissions, or be part of a monitoring network which would provide the basis for both data collection (for improved model estimates in future) and benchmarking of management impacts of N_2O emissions.

- *What systems are available that would allow for efficient and accurate monitoring of emissions at the operator level?*

Peer-reviewed software packages exist that provide user friendly estimates of emissions and are entirely compatible with more complex modelling packages. Specifically for Australia, the soil C estimates provided by the SOCRATES package (Grace et al., 1995, 2006) have been shown to compare favourably with estimates provided by the same soil C model which now underpins the National Carbon Accounting System (See RIRDC Project CSO-5A).

Web-based calculators using the SOCRATES approach to estimate soil C change are already available for the cotton industry of Australia (http://www.isr.qut.edu.au/tools/index.jsp), coupled with latest data on N_2O emissions for that industry. Full greenhouse gas accounting approaches have already been detailed by Robertson and Grace (2004).

The same generic approach (using SOCRATES) has also been translated to US cropping systems (http://lter.kbs.msu.edu/carboncalculator/). Using the same approach in different countries also facilitates comparisons of emissions profiles in different economies (e.g. emissions per kg C produced as grain). Web based tools such as COMETVR (http://www.cometvr.colostate.edu/) are also receiving exposure and acceptance in the US.

- *What are the implications if the stringency of monitoring, reporting and verification requirements vary between sectors and sub-sectors?*

The inherent spatial variability in soils in terms of soil C and N_2O emissions do make accurate monitoring and verification extremely costly unless proxies can be provided. The soil C protocols developed by CCX (using expert panels from tertiary institutions) provide heavily discounted returns and do not consider the permanence required for international trading.

There are few detailed studies of soil C variability in Australia, but the most detailed assessment of soil C variability in long-term conventional versus no till systems from the US (Kravchenko et al., 2006) found that without any prior information on the spatial characteristics of soil C distribution on the site, a statistically valid estimate of soil C change in the no till system would require 4 times as many soil samples to be taken in that system compared to an adjoining conventional tillage system. Considering the cost of soil C and bulk density analysis is at least \$10-20 per sample, multiple samples to 30 cm (minimum) would quickly equate to a large transaction cost.

Sub-sectoral coverage

Questions for consideration

- *Should all agriculture and forestry sub-sectors be included in an ETS?*

No comment

- *What sub-sectors might be better suited for inclusion?*

No comment

- *How should economic distortions within the sectors be dealt with?*

No comment

Phasing and timing

Questions for consideration

- *If a domestic ETS excludes agriculture and forestry initially, but includes them at a later point in time:*
- *What are the advantages/disadvantages of involving these sectors in the scheme through the inclusion of offsets, or an 'opting in' baseline and credit trading scheme?*

No comment

- *What sort of transitional arrangements should be incorporated in the initial design?*

No comment

3.4 Recognition of carbon sinks and offsets

Questions for consideration

- *What types of carbon sink and mitigation measures should be included as offsets or within an ETS? Are there practical and cost effective monitoring solutions available for these measures?*

Plantations, vegetation management, soil carbon sequestration through reduced tillage or pasture improvement, N_2O reductions through improved nitrogen management, CH_4 reductions in animal and rice-based systems.

Cost effective gas analysis exists for monitoring nitrous oxide and methane from cropping and pasture systems, but frequency and timeliness of measurement needs to be carefully considered. Remotely sensed monitoring is possible for plantation and pasture improvement and to a lesser extent tillage practice.

- *How should positive incentives to reduce emissions or perverse incentives to increase emissions prior to inclusion in an ETS be managed?*

No comment

- *Should offset regimes recognised under an Australian ETS be limited to those that satisfy international carbon accounting protocols?*

Yes, this is a logical step with recent changes in Australian government and ratification of the Kyoto Protocol.

<u>Literature cited</u>

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