JOINT STANDING COMMITTEE ON TREATIES
INQUIRY INTO KYOTO PROTOCOL

Submission from
CRC for Greenhouse Accounting

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Summary
The intention of the submission is first to introduce the CRC-GA, provide relevant background science on the carbon cycle, refer to the related Intergovernmental Panel on Climate Change and how it intersects in several ways with carbon accounting, talk about the IPCC's recent Special Report on *Land Use, Land Use Change and Forestry* and its discussion of several articles of the Kyoto Protocol and then, lastly, discuss the significance of carbon sinks for Australia.

The CRC for Greenhouse Accounting
The partners in the Greenhouse Accounting CRC include the Australian National University, the Commonwealth Scientific and Industrial Research Organisation, Queensland Departments of Natural Resources and Primary Industries, the Bureau of Rural Science, New South Wales State Forests, Western Australian Department of Conservation and Land Management and the Australian Greenhouse Office.

CRC-GA goals are to improve our understanding of the Australian terrestrial carbon cycle; to improve the understanding of forces driving changes in the carbon cycle; to describe and predict the responses of biophysical systems, in particular, carbon dynamics to global change; to develop verifiable methods for measuring terrestrial carbon fluxes, sources and sinks; and to develop innovative ways to manage the Australian terrestrial carbon cycle to achieve greenhouse gas reduction objectives.

There are five programs in the CRC-GA. The 1st program is called *sequestration processes*, which means in this sense taking carbon in the form of carbon dioxide in the atmosphere and *sequestering* it (or storing it away) by converting it into trees or organic matter in soil for example. The 2nd program is on *biomass carbon*. This focusses on innovative ways to estimate the carbon content of living vegetation, including roots. Program 3 researches *soil carbon*. As discussed below, soil carbon is the major form in which carbon exists in the terrestrial system, the land-based system. Program four is about *integrated assessment* - pulling together these earlier programs and assessing the effectiveness and feasibility of management options, and investigating the potential for adaptation and mitigation.. Program 5 covers *education and outreach*.

The CRC-GA also has consultative panels that inform the CRC of the views of stakeholders and other interested parties with regard to areas of research and communication options. Those panels relate to the sectors of forestry and agriculture, energy and emissions trading and policy.

The Global Carbon Cyle
From 1850 to 1998, approximately 270 gigatonnes of carbon-a gigatonne is a thousand million tonnes-have been emitted as CO2, primarily from fossil fuel burning and cement production. In the same period, about 136 gigatonnes were emitted through land use change, predominantly from deforestation. As a result, the atmospheric carbon dioxide concentration has increased from about 285 parts per million to 366 parts per million or about 28%. Forty-three per cent of this 28% has remained in the air and the rest has been sequestered in equal amounts by the ocean and the land. To assess the greenhouse gas implications of land use, land use change and forestry activities, methane and nitrous oxide also need to be accounted for. When we talk about carbon fluxes, we tend to think about *carbon dioxide* but, of course, *methane* is a carbon containing molecule and it is quite strong in terms of its greenhouse effects. It has a large greenhouse warming potential.

The atmosphere has 750 gigatonnes of carbon and it is rising by about 3.3 gigatonnes per year - that is the greenhouse problem. It is driven by fossil fuel emissions, of about 6.3 gigatonnes per year, and by land clearing, about 1.6 gigatonnes per year. The Kyoto Protocol seeks to reduce the emissions by about 0.3 gigatonnes. The oceans and land vegetation are taking up about 4.6 gigatonnes between them; at equilibrium this would have to be zero. There may be some who do not realise the distinction between the units used here and those that are used say, for example, in the National Greenhouse Gas Inventory. Here we are using units of carbon mass - for example, one million tonnes of carbon-and the

conversion from carbon to carbon dioxide is three and two thirds, so that one tonne of carbon is 3.7 tonnes of carbon dioxide.

In terms of global stocks in the land-based areas - the terrestrial systems - there are about 500 gigatonnes of carbon in vegetation and about 2,000 gigatonnes in soil, and so the importance of managing soil carbon becomes apparent. To put it in perspective again, the atmosphere is going up by about 3.3 gigatonnes per year, but against this background of very large pools in soils and vegetation. Of course, there are huge stores of carbon in the ocean - 39,000 gigatonnes.

As mentioned above, carbon is found in soil, live biomass, vegetation, forests and decomposing organic matter. These storage places are called carbon pools. Carbon moves naturally within and between Australia's ecosystems via processes like respiration, photosynthesis, decomposition and combustion. Human activity such as forestry, other land uses and changes in land use affect these carbon pools, or the stocks of carbon in the carbon pools. Carbon movements or flows therefore affect our natural carbon cycle and, in turn, other natural cycles are affected, those of sulphur, of nitrogen and the hydrological cycle, etc.

Australia's share of the Cycle
In estimating carbon fluxes and stocks in Australia, it is thought that the net primary productivity, that is, the rate at which plants grow each year, is about one gigatonne of carbon per year. That is going into a biomass of about 14 gigatonnes of carbon. The soil carbon is thought to be about 12 gigatonnes if measured to 30 centimetres depth, or 27 gigatonnes at one metre. There are also about four gigatonnes of carbon in the litter. These are background figures to give the scale of the processes and to emphasise that small changes in the management of these fluxes and stocks can have a big impact on the atmosphere.

We do not know how the net primary productivity has changed over the past 100 years, as there are two opposing processes going on. There has obviously been some land degradation. On the other hand, some areas will be responding to the increasing level of carbon dioxide itself, and carbon dioxide promotes growth. There is a process called *$C0_2$ fertilisation* - photosynthesis has carbon dioxide as its substrate and so when the concentration goes up, plants perform photosynthesis faster and grow more quickly. The plants also tend to use less water, which means that in water-limited environments plants are likely to grow faster. Australian desert margins may shrink. The two processes of land degradation and CO_2 fertilisation are in some opposition. On a global scale, the terrestrial biosphere is thought to be taking up now about two gigatonnes of carbon per year more than is being released through decomposition of litter and dying matter. If Australia is an equal partner in that, then net primary productivity will have increased. But it is just possible that, with our fragile soils and problems with soil compaction, salinity and other forms of degradation, Australia's share is not a positive one.

Looking to the future, the atmospheric changes and the changing climate will affect vegetation in various ways. A great deal of research will be needed to plan and adapt accordingly. Future decisions made by policy makers and land managers across Australia must be informed by the best science

The Intergovernmental Panel on Climate Change Greenhouse Gas Inventories
The Intergovernmental Panel on Climate Change was set up by the World Meteorological Organisation and the United Nations Environment Programme in 1988 and it is the body given chief responsibility for preparing independent scientific assessments of our knowledge of global change as it pertains to climate change.

There are three working groups and a task force. Working Group I works on *climate science*. Working Group II on *impact and adaptation* and Working Group III is on *mitigation*. There is a task force on the national greenhouse gas inventories and the IPCC has been charged, until now, with providing the guidelines for the greenhouse gas inventories. This CRC's Deputy CEO, Professor Graham Farquhar is

the convening lead author in the chapter on the carbon cycle in Working Group I. Professor Ian Noble FTSE, the CRC's Chief Executive Officer, is a lead author in Working Group II, as are a number of other members of the CRC. The Third Assessment Report is due out early next year.

An important point is that the IPCC is the table at which the scientific debate goes on. It is an independent body - the scientists are not paid for it and involvement as an author means a great deal of work.

The IPCC deals with all greenhouse gases, but we here concentrate on carbon budgets and carbon dioxide. There are several kinds of carbon budgets and inventories that are related to the IPCC and it is important to distinguish them. There is the full scientific basis as in the IPCC First and Second Assessment Reports, and the Third Assessment Report due out soon. In these Assessments, scientists estimate the fluxes of carbon dioxide and other greenhouse gases without respect to whether they were deliberately caused or not. The First and Second Assessment Reports discuss total global fluxes whatever their source, whatever their cause.

Under the United Nations Framework Convention on Climate Change, a system was established for national greenhouse gas inventories. The guidelines were prepared by a joint IPCC-OECD group. Currently, the revised 1996 IPCC guidelines are used. Only *anthropogenic* fluxes are considered. `*Anthropogenic'* is not totally clearly defined but it basically means `human induced'. It is clearly a subset of the first. So when the IPCC, for example, talks about climate change it is climate change for whatever reason, whereas the Framework Convention refers to climate change associated with human induced causes. That subtlety sometimes causes problems. The reason that the IPCC wants to report the detection of climate change and then in a separate chapter address the reasons for it is that the scientists that specialise in detection of change are not necessarily those who examine attribution. Of course, the Third Assessment Report will attempt to attribute causes to the changes that are being observed.

Article 5.2 of the Kyoto Protocol also invokes the Revised 1996 IPCC Guidelines for national reporting under the Protocol. For all the sectors that were reported for the Framework Convention except Land Use Change and Forestry, it is a direct carryover from the Framework Convention reporting to the Kyoto Protocol reporting. With the Land Use Change and Forestry sector, the Kyoto Protocol has taken a still narrower subset thus far. At present, the reporting under Articles 3.3 and 3.7 - those that have been established - is a still smaller subset with greater emphasis on deliberate human action. The words have changed subtly from `*anthropogenic'* to "*direct human induced*" in the case of article 3.3 and to "*human induced"* in article 3.4. This of course has implications for us as scientists in trying to assess causality, because sometimes the distinction between a human-induced fire and a naturally occurring fire is a subtle one.

At the Conference of Parties at Kyoto there was a sense among the participants that they wanted the *direct* human actions to be counted but not necessarily the *indirect* ones. An example would be that carbon dioxide levels are going up in the atmosphere and, as mentioned earlier, this generally makes vegetation grow faster. There could be the kind of reporting where somebody gets credit because their trees are growing faster as a consequence of somebody else's activities, but many felt that that was not the kind of activity they wanted to include in the land-based sector. Similarly, car exhausts and fossil fuel emissions from stationary power plants release a lot of nitrogen that deposits on vegetation, and that fertilises them as well. The idea then at Kyoto was to restrict activities, certainly in article 3.3, to deliberate actions, actions where the words chosen were `direct human induced'.

This is the distinction between *direct human induced* and *anthropogenic*. Certainly there is agreement among scientists that the rise in levels of carbon dioxide are human induced; they are anthropogenic. Whether one would say that the increase in plant growth because of the increased CO_2 level is directly human induced is another matter. It is certainly anthropogenic in the sense that it relates to human activities, but it is not something that has been directly and deliberately chosen.

IPCC Guidelines for reporting on National Greenhouse Gas Inventories
The Guidelines relate to all greenhouse gases, and not just to carbon dioxide. However, in what follows we concentrate on that gas in the context of the biosphere.

The Guidelines consist of three volumes: a Workbook, a Reference Manual and Reporting Instructions. The Reference Manual tells readers that they should account for all carbon changes once an activity is included, gives some guidance about how the accounting should be balanced and tells people to use the very latest scientific methods to achieve those ends. Countries are expected, when using the Reference Manual, to use the best science that is available. Of course, the Framework Convention includes many countries where the scientific abilities to do this are less well advanced and so the Workbook is a subset - it gives the simplest level for achieving the goals.

The Reference Manual, therefore, allows flexibility as scientific technology, expertise and understanding are developed. The Workbook is a rather simplified view of the world. There are some things that are mentioned in the Reference Manual that are not included in the Workbook. Countries are not necessarily expected to be restricted to the Workbook but they are expected to do the accounting as fully as possible. It has caused some debate between parties as to what is actually included in the sector, *Land use, Land use change and Forestry.* Some of the activities, for example, that are in the Reference Manual but not the Workbook would be things like wetland drainage, prescribed burning of forests, degradation of abandoned lands, shifting cultivation and so on. In principle, the Framework Convention wanted to have all these things reported, but the Workbook spells out in the simplest terms only a subset.

Australia uses the Reference Manual. In fact, Australia's Workbook on Land Use Change and Forestry, originally coordinated by Professor Farquhar of the CRC-GA, is used as a model internationally. The actual reporting by each party is supposed to be done in a similar format, but many national reports differ a little from that which is asked for by IPCC and by the FCCC. Australia's is probably closest to the requested style and clarity. Clearly, the techniques for calculating the numbers that fit those final simple formats can be as complex as one likes.

IPCC Special Report on Land use, Land Use Change and Forestry
The Special Report was commissioned by SBSTA - the Subsidiary Body on Scientific and Technological Advice. The commission followed the 1997 Conference of Parties where there was no clear agreement about the meaning of some terms and some activities-whether they should be included and so on. SBSTA asked the IPCC to give a report on Land Use, Land Change and Forestry. This had to be done in short order and there was a tremendous amount of work by the people involved. The key role in this report was played by the Greenhouse Accounting *CEO,* Professor Ian Noble, who was the co-editor, together with Dr Bob Watson, the IPCC Chair and others. Graham Farquhar, Deputy CEO of the CRC was also convening lead author for chapter 6 on the implications of the Kyoto Protocol for the reporting guidelines, and several other members of the CRC were involved in other chapters.

In Chapter 1, the global perspective is discussed. In Chapter 2, there is a discussion of different definitions and generic issues. Chapter 3 directly addresses afforestation, reforestation and deforestation - ARD, as it is called. Chapter 4 addresses additional human induced activities. These are really all the other activities that had been described in the NGGI Reference Manual, and even some that had not been thought of, minus those that were accepted at Kyoto - afforestation, reforestation and deforestation. Chapter 5 is about project based activities, including the Clean Development Mechanism. This is part of the so-called flexibility mechanisms that would allow countries to carry out projects outside their borders. Finally, Chapter 6 looks at the implications of the Kyoto Protocol for the reporting guidelines.

The Special Report examines definitions of base lines, of the biosphere, the carbon flux, carbon pools, carbon stocks and a number of other issues that are important when one considers legally binding

agreements that have financial, economic and social implications. In article 3.3, afforestation, reforestation and deforestation, are terms that were not widely used in the Framework Convention guidelines. Partly that is because, when the Framework Convention was being set up, the term deforestation was a term of such sensitivity with some developing countries that the activity ended up being called “forest and grassland conversion”. For Australia, land clearing is reported under forest and grassland conversion. The Kyoto Protocol, to its credit, called a spade a spade, and so *deforestation* reappears as a term. Of course, deforestation is noted in a footnote in the Reference Manual in describing forest and grassland conversion of forests. It was a politically sensitive issue at that earlier time, if not still.

The Protocol itself gives no definition of forests, and in the Reference Manual and the Workbook etc. there is flexibility in the definition. Clearly the Guidelines could encompass the kinds of definitions that parties choose to make in The Hague in November. One issue is that if the definition were to have a high threshold of canopy cover – for example if, say, 70% cover was demanded in order to be called forest - then some sparse areas could be cleared or increased in cover but remain unaccounted for under Article 3.3. The problem of going for a high threshold is that one could miss sparser vegetation. If a low threshold of canopy cover is used, some fear that dense forests could perhaps be severely degraded and carbon released but not qualify as deforestation.

If, for example, something that had 40% cover was called a forest you could convert from 100 % cover down to 40% cover and still have a forest. In taking that very strict definition the fear is that some Parties might not report the loss of carbon from forests. That was not the intent, but is what people are debating in terms of the usage of canopy covers and how it might play out if the Parties follow the letter rather than the spirit of the Protocol.

Canopy cover differs between biomes. Sparse woodland, has 20 to 30% canopy cover. At the other end of the graph or the scale from 70 to 100% canopy cover, one has moist forests - rain forests and such biomes. By setting a canopy cover at any of these thresholds one could clear potentially down to that threshold and that would not be classed as deforestation, or one could thicken the sparse woodland and get more carbon into that area, but it may not cross over the threshold to be covered under the Protocol.

There are differences between nations with respect to their forest cover. At the 80% mark, one would capture for Indonesia, New Zealand and Canada, between 40 to 50% of their forest cover, whereas for Australia one would be covering perhaps 5%. If the threshold of canopy cover is brought down to 20 %, at the bottom end of the scale, over 80 to 90% of the forests of New Zealand, Indonesia, Canada and Scandinavia would be picked up, whereas for Australia only somewhere around 30%. Thus difference in the types of forests in each country, means that the impacts of setting a strict single threshold also differ among countries.

There are other ways of defining the relevant parameters including the use of national, regional or biome specific thresholds. Biome specific thresholds would need to be developed, particularly as the terminology used in different countries varies. Exactly where you draw the line is a bit arbitrary. For example, as one moves from Darwin down to Alice Springs the eucalypts get shorter and their leaf area index decreases, etc.

The IPCC suggested that without being policy prescriptive, and this was a difficult line to walk, a full system of carbon accounting would include changes in carbon stocks and measurements across all carbon pools. If some pools are difficult to measure, and soil carbon is one that is often alluded to, then the question arises as to whether it is cost effective to do so. That has been an issue of debate, how to get accurate and verifiable measures of changes in carbon stocks. We suggest that the appropriate sampling must be used to match the scale of the areas being considered.

So the accounting system has to be cost effective as well as accurate, consistent, comparable, verifiable and efficient to record and report changes in carbon stocks and changes in emissions from land use,

land use change and forestry activities. There is a variety of research methods to help here - statistical analyses, forestry inventories, remote sensing techniques, flux measurements, soil sampling and ecological surveys. We note that those terms `afforestation' and `reforestation' will probably not be terribly distinct in accounting terms in the sense that they would get treated the same way. The difference would refer to the time before planting that the land was without trees.

Article 3.3 recognises afforestation, reforestation and deforestation activities since 1990 with only verifiable changes in carbon stocks. There are problems in distinguishing between direct human induced, which is the language of that article, and natural disturbances such as fires, pests and so on. For example, fires in Australia are going to occur in many places for all sorts of reasons, including lightning. If a person lights a fire earlier, does that just bring the fire forward in time? If you burn off an area, it is a direct human action but it may actually reduce the loss of carbon that would occur if a big wildfire were to come through. So it is a bit difficult to be clear as to what `direct human induced' and `natural' would really mean in this context.

For the Protocol, the first commitment period is 2008 until 2012. So, under Article 3.3 one compares how much carbon is in an area affected directly by humans if there is a comparison made between 2008 and 2012. In an area where there is deforestation, one looks at the carbon stock in 2008 and determines how much less there is in 2012, and there is a debit. In areas where there has been an activity since 1990 of growing a new forest, one looks once again at the change in carbon stock between 2008 and 2012. So the change in stock is measured over the first movement period, 2008-12, only for those activities that relate to the period since 1990.

Scientists suggest that there should be contiguous accounting periods because with a gap after 2012 before a second commitment period there could be all sorts of anomalies. There seems to be widespread agreement that the second commitment period should start immediately in 2012.

Article 3.4 was written to provide more flexibility since some Parties wanted much more than afforestation, reforestation and deforestation recognised. As mentioned earlier, the National Greenhouse Gas Inventories that are reported under the Framework Convention are much broader in scope. So, summarising the Article, the Conference of the Parties is to decide the modalities, rules and guidelines, as to how, and which, additional human induced activities related to changes in greenhouse gas emissions and removals should be included, and they will be in the agricultural soils and the land use change and forestry categories.

Agricultural soils in this context mean just changes in soil carbon, not activities that may change non-$C0_2$ greenhouse gases from soils because the latter are already covered elsewhere in the Protocol. These changes shall be added to or subtracted from the Party's assigned amount. The agreement was that this would apply in the second and subsequent commitment periods. All Parties would be required to apply them in the second and subsequent commitment periods but Parties could apply the decision on those activities for the first commitment period provided that they were post-1990. This is the area, of course, of greatest debate at present and it will be discussed at length in The Hague in November. Finding the scientific basis for how to make measurements that meet all the criteria mentioned earlier is a challenge for the CRC-GA and others in this area.

One example from the Special Report is that one could take a narrow definition of an activity like, for example, fertiliser management or minimum tillage or salinity control and just add up those bits of the country that have particular activities that were approved. Other Parties want a broad definition of an activity - say, for example, crop land management. That would be all practices on an area of land. To prepare ourselves for those two eventualities, one has to have different approaches. We and others are keen to provide information that would inform Australia and the world about what can be done here. The CRC-GA could give more information on Article 3.4. because it is obviously a very important issue.

Some possible rates of carbon sequestration in Australia, which would require considerable effort to achieve, are perhaps three megatons of carbon per year in agricultural soils, five megatons of carbon per year in improved pastures, and more in range land rehabilitation. This compares with activities under Article 3.3 and 3.7 of three to 10 megatons of carbon a year in plantations and 10 to 20 megatons of carbon a year potentially saved by reduced clearing.

Carbon sequestration in agricultural soil
When soil is ploughed the lower parts of the soil are exposed to oxygen and the decomposition of organic matter to carbon dioxide is accelerated. One possible action for increased carbon storage is minimum tillage. There are quite separate arguments for and against minimum tillage itself in terms of combustion of fossil fuels in the actual act of tilling the soil. There are issues in relation to keeping water in the soil; there are issues to do with disease if one does not get rid of the straw and so on. From the carbon point alone, if you do not plough and expose the underlying layers of the soil to the air, then they do not oxidise as quickly.

Other activities could be, for example, improvement of pasture with species having deeper roots. If you grow legumes, for example, that have deeper roots, when those roots slough off and die, creating soil carbon at some depth. There are various agricultural practices that could be applied that could change the carbon levels in soils. In Australia it has been a source of concern, over large areas growing wheat across the country, that soil organic carbon levels have been going down. That is an issue that arose long before we were thinking about `carbon sequestration' and `greenhouse'. It is another case where there could potentially be win-win situations, where we reduce land degradation and maintain or increase, hopefully, the carbon content of the soil. We could then have a win for the environment in two senses.

Clean Development Mechanism
Article 12 talks about the `clean development mechanism', which is to assist non-Annex I countries in achieving sustainable development, to contribute to the Framework Convention on Climate Change's ultimate objective and to assist Annex I countries in complying with their Kyoto Protocol commitments, through voluntary participation in projects that result in real measurable and long-term benefits related to climate change mitigation, with emission reductions additional to any that would occur in the project's absence. Certified emission reductions obtained between 2000 - 2008 can be used to assist in achieving compliance in the first commitment period. The issue here is the extent to which activities in *Land use, Land use change and Forestry* come under this clean development mechanism. These issues are being debated now.

There are many potential benefits in such schemes. There are also costs in terms of monitoring the change. There may be some cases where what is desirable from a carbon point of view may not be desirable from some other perspective. Obviously, in this context, the *Land Use, Land Use Change and F*orestry projects in mitigating climate change would be designed to reduce carbon emissions and increase carbon sinks. They may have other socioeconomic and environmental benefits. There can be negative effects if the local stakeholder is not included in the project design and management. Abrupt reductions in access to food, fibre, fuel, timber and land resources cause carbon leakage as supplies are found elsewhere. Potential global barriers to *Land Use, Land Use Change and Forestry* projects - projects under the clean development mechanism; these are activities in non-Annex 1 countries - could include, in some cases, inconsistency with national sustainability goals, technical capacity to implement projects and the fact that there are no current standards for assessing the baselines or additionality. `Additionality' means that there has to be some activity that is increasing the carbon stocks in addition to what would have occurred without such an activity.

Accuracy of accounting for land use, land use clearing and forestry compared with estimating fossil fuel emissions, what is the difference in precision?
It is easier to record the emissions of carbon dioxide from, for example, petroleum used in cars or coal in power stations than in assessing those associated with land clearing. On the other hand there are

emissions that are included in the Protocol that have more uncertainty than those in the LULUCF sector. Examples include the emissions from waste, and methane emissions from coal mines. Each country has to work to reduce those uncertainties. The uncertainties are small in some areas of the land use change and forestry sector and large in others. Typically, for example, one expects that it may be easier to achieve precision on the forest side than on the soil side. However, it probably just means putting more effort into more sampling and that comes down to a question of cost effectiveness. If there is a certain standard deviation around a mean value, one just takes more measurements and brings the standard error down.

There are also some advantages in the land based sector. Each Party can look into each other's backyard these days with remote sensing, so at least there is reasonable transparency.. Parties can come to some agreement about acceptable levels of uncertainty and, provided the rules are clearly laid out and everybody is exposed to everybody else's verification, the accounting should work. Of course, scientific research will have to be carried out to improve methods .

Permanence, or lack thereof, of sinks?
We understand the permanence of fossil fuels - as long as we leave them under the ground, that is where they will stay. But we are talking here about quite different proposals: whether you till, whether you grow trees, whether a fire burns them down or whether we cut them down and use them for paper, then burn the paper and so on. In what part of the process will the Parties deal with that lack of permanence? Is there a mechanism that assists in identifying it?

Provided the carbon accounting is complete, once a bit of land enters into accounting under the Kyoto Protocol, it has to remain there. If carbon credit is sought for growth of a forest, then there is a debit if it burns down. The issue of whether something is directly human induced comes may matter in determining whether an activity is counted, but, once the land itself is included, anthropogenicity no longer matters. It is going to have to be the change in carbon stocks. At least that is the view that the IPCC has taken in the Special Report.

The CRC-GA does not see climate change or atmospheric change leading to large losses in the forests that are now being planted. That is unlikely to happen over the next few decades. If anything the evidence globally is that plants and trees will grow a little faster.

So the question has to be answered in two senses. From an accounting point of view permanence is not a problem; that is, you get debited if the sink is removed. From a national perspective, in terms of how a country meets its requirements, countries will have to plan. The underlying fear of some people might be that activity in the land based area might lead to inaction in other areas and that it all could come to a head if suddenly there were disastrous climate extremes and all the forests were to burn down. That is not very likely. In the foreseeable future, our ecosystems, as a whole, will continue to take up carbon dioxide.

Old-growth forest.
We often hear that forests are the source of oxygen for what we breathe and so on. That is true while they are growing. The oxygen and carbon dioxide fluxes are basically symmetrical. While a tree is growing, it is taking up CO_2 and giving off oxygen in net. When it falls over and decays, it gives off CO_2 again and takes up oxygen. There is a cycle. So an old growth forest which is in balance in terms of CO_2 is also in balance in terms of oxygen. That is something that seems to be not well understood.

Article 3.7
There often seems to be confusion between carbon *stocks* and carbon *flows*. The IPCC Guidelines, and all sectors under the Kyoto Protocol apart from LULUCF refer to emissions, that is to *flows*, *flux* and so many tons per year. The language of the Protocol when it comes to Land Use Change and Forestry is a bit confusing because it assesses the flux as a change in stock. Starting from a zero base, if you have zero flux in year 1990, then the increase in stock from 2008 to 2012 (the first commitment period) is the

same as the average flux at that time and, since the flux at 1990 was zero, that is equal to an increase in flux.

So in that sense, the way the Protocol treats "*sinks*" works the same way mathematically as it works for emissions from fossil fuel and so on. However, with respect to *emissions* of CO_2 in the land-based sector, that is deforestation, the change in language is really problematic. With emissions in 1990 from land clearing, for example, there is a change in stock already, so one cannot apply the same accounting of the change in stock in the subsequent period as being a fair comparator with the changes in flux that occur in the fossil fuel sector. That is why, to be fair, the emissions from land clearing need to be included in the base, and that is the basis of article 3.7. Article 3.7, which people often refer to as the `Australia clause', brings the accounting back closer to what the IPCC had originally envisaged for the sector – a net-net approach with all emissions in the base. For uptake of carbon from activities since 1990 it does not matter because there is no flux in 1990, but for deforestation, there is a flux and one needs to put that into the base line.

Sinks and the point of storage equilibrium

Another misconception about stocks and flows is that because the flow of CO_2 into a fast growing crop is faster than into a forest, one could justify forest conversion to another land use for greenhouse purposes. Australia must be careful to look at the total picture. It is true that, for example, sugar cane grows faster than trees. However, if trees are taken away to grow the sugar cane, one must take into account the carbon that was lost when the trees were first felled. At the end of the day, it is very easy to see what has happened to the atmosphere - that is, how much biomass and how much soil carbon there are. There is a lot less carbon in sugar cane than there is in the forests that were there before.

Significance of Land-based Sinks for Australia

A question is sometimes raised about the possibility that farmers might be forced to grow trees rather than raise food. However, the projected value of carbon is much less than the projected value of food. There have been estimates of around $20 a tonne of carbon. Most food - the dry food - is 50 % carbon, so that is like getting half a tonne of food for $20. Food is generally much more valuable, and a farmer would probably not stop producing food, if he or she had an economically viable unit, and grow trees except in marginal agriculture. It is the case that there are many areas (including areas of Australia) that are marginal in terms of agriculture, and land users are going to have to make sensible decisions. If carbon is traded, farmers are going to have to make projections about the cost of carbon and weigh that against other activities on the land.

A lot of these issues are discussed in working group III of the IPCC, which deals with *mitigation*, because it goes into the other social, cultural and economic aspects. Australia, in its land uses, will have to make balanced decisions.

If sinks are well managed - there is the potential for improving biodiversity, improving water quality and river flows, increasing quality and quantities of forests, soils and grazing lands and fisheries, increasing sustainable access to fibre, fuel and shelter, and improving health and social equity and reducing poverty.

The main message is as follows: as far as the atmosphere is concerned, reduction in the level of greenhouse gases by enhancing sinks or reducing emissions from the land sector has equal validity with reduction of fossil fuel emissions. We have the opportunity for better management of Australia's land surface, in partnership with land users, to reduce greenhouse gases and reverse land degradation.

From the atmosphere's point of view, what is meant is that if one is looking at the greenhouse effect *per se*, then, if one can reduce the concentration by reducing land clearing, the reduction in infra-red absorption by the carbon dioxide in the air is the same as that caused by reducing emissions from a coal fired power station.

The same is true for other non-greenhouse problems that are related to the rising levels of carbon dioxide. A worrying aspect of increasing carbon dioxide concentration is its effects on the acidity of the ocean, the pH. There is a limited ability of the oceans to buffer the pH. As the pH drops, as water becomes more acidic, the extent to which our reefs and other systems can cope will be sorely tested. That is not a greenhouse issue in the direct sense of infra-red absorption by the atmosphere but in a broader context of the effects of changes in the atmosphere, it is an important one.

We should take all available options and take them in a sensible manner. In the long run, of course, fossil fuel emission is the major source. If Australia was to put all its effort into sinks alone, we would only be buying a little bit of time, so one has to plan ahead. The CRC-GA view is that reducing emissions from land clearing and promoting the land as a sink for carbon dioxide does enable a more sensible approach to be taken to the greenhouse problem, a problem that is economically expensive to solve at present. For example, there is the time taken because of the economic life of various stationary energy producers: to suddenly close down something that has an economic life of another 30 years is rather difficult. This is in no way to deny the need for energy efficiency. There is a tremendous amount more that can be done. Nevertheless, “sinks” are important. If we did not have them included in the Protocol it would be a shame *environmentally*.

Planning for changes to the land

Having written about efforts to reduce greenhouse emissions, the CRC-GA wishes to emphasise that it is important to start assessing the likely impact on Australia of climate change in its broadest sense (including other direct effects of changes in atmospheric composition) because we will not halt the rise in carbon dioxide levels in the foreseeable future. Carbon dioxide levels and other greenhouse gas levels will continue to rise and this will affect the hydrology and growth of not only crops but natural ecosystems and will have all kinds of impacts. In a narrow sense, one can say that we need to do that research in order to understand what our national carbon stocks may look like. But of course the CRC-GA hopes that Australians will take the broader view and say that they would like to see how their land may or may not respond to the atmospheric changes and to the responses that land managers make to these and various other pressures.