Issues in Forest Carbon Crediting

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ABSTRACT

While the Kyoto Protocol was primarily a greenhouse gas emissions reduction agreement, forest sequestration offsets were allowed for new forests, and Article 3.4 allowed for inclusion of offsets from existing forests and agricultural activities. Many forest management activities are documented in scientific papers as sequestering incremental carbon, including pest and disease control, thinning and tree improvement. Carbon trades have already occurred for reduced impact logging and reduced tillage.

Several factors have prevented meaningful market activity. A lack of guidelines on forest carbon crediting and trading has forced buyers of carbon offsets to establish their own, hindering effective trading. There is confusion around the term "business as usual" which is difficult to assess, is often meaningless, and leads to paradoxes. An effective way to account for carbon in plantations and other forestry activities is a methodology proposed by M. Kirschbaum et al, whereby carbon uptake is credited equally and annually over a period until the new long-term carbon storage level is reached. This method eliminates the problems associated with repeated buying and selling of credits over several rotations, and also reduces the need for costly annual measurements.

This methodology has been applied to Domtar's juvenile spacing activity 1991-2000, and the results are being reviewed by Clean Air Canada Inc for effectiveness in carbon trading. Similarly, Domtar's jack-pine budworm spray program for forest protection is about to undergo the same review process. It is anticipated that risks associated with crediting emissions reductions for forest management projects that have short term emissions will be managed using a pool of offsetting forestry projects.

In New Zealand, Dr. Ken Skogg presented an analysis for US waste which showed that 24-28% of carbon in wood products remains as stored carbon in perpetuity, supporting the notion that the wood products carbon pool is increasing in size. This notion is supported by analysis from the EFI website.

Because of the carbon sequestering potential of forest management and wood products, these areas should not be ignored in future climate change agreements or in policy. Uncertainty in the agreement regarding forest management is keeping the price of forest carbon artificially low, hindering an increase in this activity. To promote these activities will require;

- putting forests and forestry into the Kyoto Protocol
- standard carbon accounting system(s)
- understanding and acceptance of forest measurement techniques (sample plots)
- use of amortization methodologies
- recognition of 1991-2007 activities

An International Forest Carbon Accounting Framework: A System for Managing, Measuring, Reporting and Trading Forest Carbon from an Operational to an International Scale

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ABSTRACT

The 'Kyoto Protocol', signed by the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, allows countries to use carbon sequestered in forests as a means to meet internationally binding Greenhouse Gas reduction quotas.

To provide a transparent and verifiable means of measuring and reporting forest carbon, an international forest carbon accounting framework is required. This report outlines and describes a forest carbon accounting framework that is designed to meet the reporting requirements of the Kyoto Protocol. It also provides step-by-step guidance on defining, measuring, managing and reporting carbon stocks while maintaining a link between the operational, national and international levels of reporting. The framework is designed to adapt to the dynamic nature of climate change negotiations, promote emissions trading, interface with existing vegetation inventories, and be useful to all countries interested in establishing carbon markets.

Keywords: Forest carbon accounting, Kyoto Protocol, emissions trade

INTRODUCTION

In an effort to combat the effects of climate change, a pioneering agreement know as the 'Kyoto Protocol' was signed in 1997 by many of the developed (Annex I[1]) nations of the world, committing them to implementing measures in order to meet legally binding GHG reduction quotas. One way that Annex I countries can help meet their quota is by promoting sustainable forest management practices through forest carbon sequestration, conservation and substitution. Interest in such Forest Carbon Projects (FCP's) is growing, as companies are discovering that planting and conservation of forests represents a cost-effective and environmentally sensitive solution to the climate change problem.

To provide a transparent and verifiable means of measuring, reporting and trading forest carbon, an international forest carbon accounting framework is essential. This report describes a forest carbon accounting framework that is designed to meet the reporting requirements of the Kyoto Protocol. It provides step-by-step guidance on defining and measuring carbon stocks at the operational level, while maintaining a link between the operational, national and international levels of reporting. The framework is designed in order to adapt to the dynamic nature of international climate change

1 Annex I countries refer to the countries that are listed in Annex I of the UN Framework Convention document. This is a list of 24 developed countries belonging to the Organisation for Economic Cooperation and Development (OECD) as well as 12 countries classified as 'economies in transition' (UNFCCC 1994).

treaties, promote emissions trading, interface with existing vegetation inventories, and be useful to all countries interested in establishing carbon markets.

The framework has three main phases and eleven steps. The first phase, 'Design and Evaluation', outlines the preliminary planning considerations and actions that must be taken prior to project implementation. In phase two, 'Implementation – Inventory and Management', describes the operational level forest management and inventory practices that should be undertaken in order to efficiently run a FCP. It also explains the methodology for scaling up operational level forest inventory to a regional, national and international level. Finally, phase three, 'Emissions Trade', outlines the procedures needed to commence trade of forest carbon.

PHASE ONE: DESIGN AND EVALUATION OF A FOREST CARBON PROJECT

1. DEVELOP PROJECT PROPOSAL

The planning stages of the FCP are critical to ensure that land, labour and capital resources are allocated to maximum efficiency and climate change benefit. This section provides details on some of the factors that must be considered for inclusion in an operational level project proposal.

1.1 Identify management objectives

The goals of the FCP owner should be clearly stated at the beginning of the project proposal. Operational level management objectives should be devised to describe short-term goals. It is also advised that a section of the project proposal should contain a strategic level plan; describing long-term objectives. Some of the principal management objectives for FCP owners might be to: Maximize climate change mitigation; maximize wood production; maximize profit from the sale of forest carbon credits; increase biomass production; and broaden the range of forest values considered in management. Through careful design, an optimal solution can be achieved for the FCP owner both in terms of revenue flow and positive environmental impacts.

1.2 Outline accounting objectives

The ultimate objective of a Kyoto credible forest carbon accounting system would be to provide an accurate description of the changes in forest carbon stocks, in full compliance with the guidelines, methodologies and reporting requirements as specified by the UNFCCC. This implies that a forest carbon accounting system should be consistent, complete, accurate and verifiable (GHG Protocol Initiative 2000).

1.3 Details of the Project

The project proposal should include a concise description of the nature of the FCP, including details on the relevant sections of the Kyoto Protocol and how the project actually mitigates climate change.

1.3.1 relevant articles of the kyoto protocol

Within the Kyoto Protocol, there are potentially four articles that allow forest owners a means to obtain emission offsets from a FCP. Article 3.3 of the Kyoto protocol allows an Annex I country to receive 'credit' to a country's emission reduction quota for carbon sequestration due to afforestation[2] and reforestation[3] activities; and a 'debit' for deforestation[4] activities. This is restricted, however, to afforestation, reforestation or deforestation [ARD] activities that have occurred since 1990. The full text of Article 3.3 is presented in Appendix 1.

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2 'Afforestation' is defined as the "direct human-induced conversion of land that has not been forested for a period of at least 50 years to forest land through planting or seedling" (SBSTA 2000).

3 'Reforestation' is defined as the "direct human-induced conversion of non-forest land to forest land through planting or seeding, on land that was forested but that has been converted to non-forest land" (SBSTA 2000).

4 'Deforestation' is defined as the "direct human-induced conversion of forest land to non-forest land" (SBSTA 2000).

Article 3.4 of the Kyoto protocol expands upon Article 3.3, by suggesting that a set of 'additional human-induced' forest management activities may be used towards meeting Kyoto commitments. Article 6 of the Kyoto Protocol defines 'Joint Implementation' [JI], which allows Annex I parties to supplement their domestic GHG reduction activities, with emission reduction or sink enhancement activities conducted in other Annex I countries.

Article 12 of the Kyoto Protocol defines the 'Clean Development Mechanism' [CDM]. The CDM provides a means for Annex I countries to fund and implement GHG reduction projects in non-Annex I [developing] countries. This is under the proviso that the Annex I country must contribute to the sustainable development of the developing country. [Eg: By training forest managers in developing countries in advanced silvicultural practices]. At present, it is uncertain whether sink projects will be eligible for inclusion in the CDM. This issue is due for resolution at the COP6 meeting in Bonn, Germany [July, 2001].

1.3.2 Carbon sequestration, conservation or substitution?

There are three main ways in which FCPs can mitigate climate change (Vine et al. 1999): Through carbon sequestration; conservation or substitution. Forest carbon sequestration projects aim to create new areas of forest, or increase the rate and amount of carbon uptake by existing forests. This has the overall effect of increasing the amount of carbon removed from the atmosphere by storing it in the tree biomass.

Forest conservation projects aim to prevent the release of carbon emissions from a forest. This is can be achieved by a variety of means such as preventing deforestation; placing forests in parks and reserves; modification of forest management practices [eg: shelterwood harvesting and utilization of wood protection technologies]; and increased control of fires, insects and disease (Vine et al. 1999).
Forest carbon substitution projects aim to promote the utilization of sustainably produced forest biomass as a direct energy source, or by replacing products that are fossil-fuel intensive to produce. When forests are managed sustainably, forest biomass energy is classified as 'carbon neutral'. [ie: neither a carbon emission nor sequestration]. Thus, if carbon neutral forest biomass is used to replace fossil fuels that are traditionally used for heat and power production, then total carbon emissions are reduced (IEA Bioenergy 2001).

1.4 Address Leakage Concerns

Leakage is defined as the unexpected loss of GHG reduction benefits when activities or markets are displaced, resulting in emissions elsewhere (Schlamadinger & Marland 2000). All potential sources of leakage should be identified, and can be addressed by measuring all carbon pools that are a source of carbon emissions, and by carefully considering the temporal lifetime and company and project boundaries.

1.4.1 Measure all sources of carbon emissions

Leakage becomes problematic when emissions are transferred to a carbon pool that is not measured [see Box 1 for the forest carbon pools that are measured under the Kyoto Protocol]. Therefore, leakage can be addressed by measuring all carbon pools that are a source of carbon emissions.

- Forest carbon pool components that must be measured*:
    - Aboveground Biomass
    - Belowground Biomass
    - Litter
    - Dead Wood
    - Soil Organic Carbon
- Greenhouse Gases that must be measured (expressed as CO_2 equivalents)**
    - CO2
    - All non-CO2 greenhouse gas emissions
- Forest carbon pools that are a source of GHG emissions must be measured***

*At present, carbon storage in forest wood products is not measured in the Kyoto Protocol. However, future COP meetings may decide to include carbon storage in wood products.
**An equivalent of CO_2 may include any of the greenhouse gases (Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons or Sulphur Hexafluoride), weighted according to their global warming potential, to give the amount of global warming equivalent to one ton of CO_2 (Environment Canada 2000).
*** Forest carbon pools that are not a source of GHG emissions do not have to be measured if sufficient proof is provided that the pool is not a source.

Box 1: Forest carbon pools that must be measured to ensure Kyoto compliance.

1.4.2 Determine Temporal Lifetime of the Project

One of the key sources of debate in recent climate change negotiations, has been the issue of temporal leakage, or 'permanence' of emission offsets from FCPs. There is some concern that forest carbon sinks may undermine the integrity of the protocol, since it is possible that carbon sequestered in forests may be released back into the atmosphere [by harvesting or natural disturbance] at a later date (Schlamadinger & Marland 2000)[5].

Carbon should be stored in forests for a sufficient duration such that the warming effect of carbon in the atmosphere is offset (Moura Costa & Wilson 1999). Given that one ton of CO_2 stored as forest carbon for 55 years is sufficient to counteract the effects of a one ton pulse emission of CO_2, it could be argued that FCPs should have a carbon storage lifetime of at least 55 years (Moura Costa & Wilson 1999). This carbon storage is then is equivalent to a permanent removal of CO_2 from the atmosphere. A similar method of solving the permanence issue is the 'ton-year' approach, explained in Section 5.2.3.

1.4.3 Define Company and Project Boundaries

To avoid leakage via geographic displacement of GHG emissions, the company and project boundaries of the project should be carefully defined. 'Company boundaries' include all GHG emissions and abatement activities for which the FCP owner is directly responsible for (AGO 1998). 'Project boundaries' could be defined as the geographic location within which direct[6] and indirect[7] forest carbon emissions and sequestration are affected by FCP activities.

5 Special mention should be made regarding the permanence of FCPs under the CDM. Permanence in CDM projects is especially concerning, since the CDM results in the creation of new 'Certified Emission Reductions' [CER's] in Annex I countries, without subtraction from the assigned GHG amounts in a developing country [since developing countries do not have GHG reduction quotas]. At present, the Kyoto Protocol contains no provisions for the Annex I country to account for potential carbon losses after the project activities lifetime. COP negotiators must be careful to define the accounting lifetime of forest carbon CDM projects, to ensure the integrity of the Kyoto Protocol is not undermined (Schlamadinger & Marland 2000).

6 Direct emissions or sequestration are due to activities within the company boundaries that occur on the FCP site.

7 Indirect emissions or sequestration are due to activities within the company boundaries that occur on lands

In the event of shared ownership of a FCP, or if some of the project activities are to be carried out by outside contractors, the responsibility for carbon emissions and sequestration should be specified in a contract (GHG Protocol Initiative 2000). Concise specification of company and project boundaries is also crucial in FCPs where 'carbon rights'[8] are established (Blair 1999)

1.5 Investigate Management Alternatives

The management implications of the three types of FCP's are described in the sections below.

1.5.1 Managing Carbon Sequestration and Timber Production

One of the challenges in managing a FCP, is to allow for the dual pursuance of the goals of sustainable timber production and climate change mitigation. The following management strategies can be adopted to maximize timber volume and carbon storage:

- Maintain a range of forest age classes such that the amount of carbon sequestered in actively growing stands is equal to or greater than the amount of carbon being emitted due to harvesting (AGO 1999a).
- Harvest at a frequency that emulates the natural rate of disturbance (Kurz et al 1998),
- Thin regularly and at a light to moderate intensity [between 5 to 25% of total biomass] (Thornley and Cannell 2000)
- Consider the price of timber and carbon when prescribing rotation length (van Kooten *et al.* 1997).

1.5.2 Managing Carbon Sequestration and/or Conservation

In addition to consideration of harvesting frequency, age-class distribution and rotation length of forests, there are a number of other forest management activities that are suitable for achieving the goals of carbon sequestration, conservation and protection of non-timber values. These activities [listed below] may or may not prove to be eligible under Article 3.4. This issue is due for resolution at the COP 6 [Part II] meeting in Bonn, July 2001.

- Increase intensity of insect and disease protection activities. This is estimated to be one of the cheapest ways to increase forest carbon storage (NCCS 1999).
- Implement activities that increase the site index of the forest, such as fertilization.
- Increase the use of a genetic improvement program to allow planting of species that are faster growing, disease-resistant species, contain more carbon, or are capable of producing greater quantities of biomass (NCCS 1999).
- Implement density management and commercial thinning regimes to prevent carbon loss due to mortality, promote increment on the fastest growing species, shorten rotation lengths and allow greater carbon storage in wood products[9]. Commercial thinning may also extend wood supply, and therefore may result in reduced harvest activities elsewhere (NCCS 1999).
- Conduct enrichment planting to improve stocking of existing stands
- More careful consideration of matching appropriate species to site and micro-site, thereby maximizing productivity of the stand
- Plant frost-resistant species
- Increase intensity of fire prevention activities.
- Develop wood preservation technology, allowing carbon to be stored in wood products for a longer time[9]
- Remove introduced grazing animals from the forest, thereby allowing greater biomass accumulation in the understory
- Investigate low soil disturbance planting and reduced impact logging techniques.

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not managed by the FCP owner.

8 'Carbon rights' involves the legal separation of carbon ownership from the land and trees.

9 Carbon storage in wood products is not recognized in the Kyoto Protocol at this time.

- Restore degraded forest land [e.g.: management to alleviate the effects of erosion or restoration of salt-affected and polluted lands]
- Investigate use of biowastes to increase forest productivity and soil carbon storage.
- Implement natural wildlife conservation schemes, thereby increasing overall ecological productivity and carbon content of the entire forest system.
- Consider implementation of urban tree planting schemes. Planting trees in city centres has the dual purpose of increased tree carbon storage, and also for the value of urban trees in breaking up 'urban heat-islands', thereby reducing energy requirements and demand for fossil fuels (IPCC 2000).
- Consider disposing of harvesting and mill residues and timber waste, by burying in landfills. This limits the rate of carbon decomposition in wood products to less than 3% per annum (Meil 2000).
- Conduct research and development into improving the efficiency of timber recovery, re-use and recycling processes, thereby increasing the wood product use-life (NCCS 1999).

1.5.2.1.Forest Protection Projects

Forest protection projects may prove to yield the maximum carbon benefit at least cost on some sites. Forest protection projects are particularly suitable to old growth forests, which typically have a high initial level of carbon storage. Forest sites that are low in productivity, sensitive to disturbance, aesthetically or socially significant, or have a high ecological importance are also be well suited to forest protection projects.

One problem is that forest protection projects are particularly susceptible to leakage. Protection projects that do not address the principal causes for harvesting, may simply shift the harvesting to another forest elsewhere. It is crucial that these leakage issues are identified and addressed.

1.5.3 Carbon Substitution Projects

Once a forest is harvested, the biomass can be used as an energy source instead of fossil fuels. This can result in significant *avoided* GHG emissions. This is because biomass energy produced from sustainable forests is classified as 'carbon neutral'. This means that the amount of carbon released when the wood is burned for energy, is equivalent to the amount of carbon sequestered when the forest was planted. There is thus no net carbon effect on the atmosphere. Emissions avoided from carbon sequestration projects will not be re-emitted. Carbon substitution projects can also mitigate climate change though using sustainably produced wood products in place of products which are fossil fuel intensive to produce, such as aluminium or concrete (IEA Bioenergy 1998).

A FCP owner should manage carefully to ensure other forest values are not compromised when undertaking a carbon substitution project[10]. A FCP owner should avoid locating biomass plantations on sites of high aesthetic and ecological significance. Visual buffer zones around biomass plantations can also make the forest more aesthetically pleasing.

1.6 Publish the Project Proposal

Each of the factors outlined from section 1.1 to 1.6 should be addressed in the project proposal, and published as a clear, well-written document to be distributed to all relevant parties.

2 PRELIMINARY CARBON YIELD PROJECTIONS

To determine an appropriate FCP design for the site, preliminary estimates of future forest carbon yields from each of the potential management regimes [Section 1.5] should be produced. Carbon and timber volume estimates produced at this stage will be based on the data which are already available and are therefore intended for use only as a rough indication of expected yields. Preliminary carbon yield projections can be obtained either by using rough estimates from literature (Birdsey & Heath

[10] Forest biomass plantations are generally single-age, single species, short-rotation stands. These stands are generally regarded as being of low ecological and aesthetic value.

1995; Bonnor 1985; Lowe 1996; Penner et al 1997; Rombold 1996; TBFRA 2000;), IPCC default values[11], rough inventory estimates and/or using computer modeling software packages. A number of forest volume, biomass and carbon projection models are currently available (CCRS 1999; Ecosecurities 1999; Harmon et al. 1996; IEA Bioenergy 2001; Kurz et al 1992; Mohren et al. 1990; Mohren et al. 1999, Richards & Evans 2000; West 1997;). These can be divided into three types: Simple allometric models, Growth and yield models, and physiological-based models (Spittlehouse 2000). Simple allometric models[12] are generally used to predict carbon on an individual tree basis using a biomass or volume equation specific to the species, then converting to carbon using a range of expansion and conversion factors, [Section 6.1.1]. Growth and yield models use stand-level biomass tables to calculate carbon yield for a number of trees. Physiological based models use equations to simulate the processes such as photosynthesis, respiration, decomposition, Net Ecosystem Productivity and Net Primary Productivity.

Unfortunately, most of the allometric, growth and yield, and physiological models outlined above do not consider the influence of market demand on future forest carbon levels. Market effects can be taken into account by incorporation of a demand-driven model, which are capable of simulating the effect of social, economic and other demand-side factors on future carbon storage. A forest carbon sink owner would be also well advised to incorporate predictions of plant growth response to climate change in their carbon modeling procedures. A range of climate change simulation models are discussed in Bortoluzzi (2000).

3 DEFINE AND MEASURE BASELINE

In order to quantify the amount of carbon that has been sequestered [or emitted] due to a FCP, changes in carbon should be measured in relation to some baseline or reference (Schlamadinger & Marland 2000). The 'baseline' or 'business-as-usual' [BAU] carbon balance is defined as "the pattern of greenhouse gas emissions and carbon sequestration that would have been expected to take place on a project site over time, without implementation of the new project." (AGO 1998). Comparison of expected carbon benefits of the project [Section 2] to the baseline is useful to ensure that all GHG reductions are real and verifiable. Determination and measurement of the baseline is also necessary for projects registered under the JI or CDM mechanisms, to comply with the 'additionality' specification[13].

3.1 Defining the baseline

A baseline can be defined in either of two ways: A fixed path of emissions, or a dynamic forecast of projected emissions (Pape & Rich 1998). A fixed baseline assumes the rate of emissions remains constant, relative to emissions in a benchmark year (Pape & Rich 1998). A fixed baseline should be calculated based on analysis of historical forest growth trends, rates of land use change, and causes for land use change (Brown et al. 1997).

A dynamic forecast of projected emissions takes into account a range of assumptions about future patterns of emissions, and is continually adjusted as new information and technology becomes available. Defining a dynamic forecast of baseline emissions involves analysis of historical data [as for the fixed baseline]. The baseline is then adjusted over time to reflect anticipated future emissions [or storage] (Pape & Rich 1998). Dynamic baseline projections should be regularly adjusted to reflect changes in laws, regulations, population dynamics, economic growth, market trends and future land use patterns (Vine *et al.* 1999).

11 The Revised *1996 IPCC Guidelines for National Greenhouse Gas Inventories* published a set of default carbon conversion factors, specific to forest type and country. These conversion factors can be used to convert merchantable biomass to estimates of belowground biomass. The IPCC Guidelines are available for download from the IPCC website: http://www.ipcc.ch/pub/guide.htm

12 Allometric equations provide a means of estimating tree biomass from readily measurable tree parameters such as diameter and height.

13 The requirement for 'additionality' of JI and CDM projects implies that the carbon storage achieved from the FCP must be in excess of the carbon storage that would have occurred under the BAU scenario.

3.2 Measuring the baseline

There are four ways a FCP can measure or estimate the baseline carbon balance: Direct measurement, computer modeling, use of default values or retrospective measurement. In order to directly measure the baseline carbon stocks, , a series of sample plots can be located and measured using a statistically sound sampling method. Regardless of the BAU land-use, carbon pools should be measured according to the regulations specified is Box 1. If the project site is forested, the methodology specified in Section 6.1 should be used. If the BAU land-use is non-forested, then the methodology for the appropriate land use in the *Revised 1996 Guidelines for National Greenhouse Gas Inventories* (IPCC 1996) should be used.

For larger or more complex stands, one of the three types of computer models [Section 2] can be also be used to model baseline carbon balance. Default values can also be used to give a rough estimate of baseline carbon storage. Preferably, regionally specific default values, suitable to the BAU land use should be used. As a last resort, the IPCC Guidelines (IPCC 1996) give approximate carbon storage values for a range of soil types, geographic locations and land uses.

'Retrospective measurement' is necessary if project activities have commenced before the baseline was measured. Retrospective measurement requires the FCP owner to estimate the carbon balance of the former land use. If historical carbon inventory data is available, this can be used. Where no data is available, baseline carbon balance can be estimated by measuring the carbon storage of neighboring lands that are subject to the BAU land use. As a last resort, default values can be used.

4. PROJECT EVALUATION AND REGISTRATION

4.1 Final Project Appraisal – Evaluation of project design

Prior to implementation of project activities, it is useful to evaluate the project according to a number of project eligibility criteria. This is advisable to ensure that the project is Kyoto compatible, economically feasible and does not negatively impact other forest values.

4.1.1 Kyoto Compatibility' of the project

Moura Costa et al. (2000) suggests that there are four elements that should be assessed in determining the 'Kyoto compatibility' of a project: acceptability, additionality, leakage and capacity.

'Acceptability' implies that the FCP must be approved by all countries and parties directly involved with the project, and acceptable in terms of goals such as biodiversity, promotion of technology transfer and aesthetics. 'Additionality' implies that all carbon benefits must be "additional to any that would otherwise occur". The requirement for additionality is only specified for JI and CDM projects (Articles 6 and 12). However, establishing additionality of a project is also useful in context with Article 3, to ensure that the project is consistent with the goals of the UNFCCC[15] and the Kyoto Protocol. In practical terms, additionality is most easily demonstrated by comparing the carbon stock of the baseline scenario [Section 3], with the expected carbon yields accumulated due to the FCP [Section 2]. If the net carbon stock of the project exceeds that of the baseline, then project carbon benefits are said to be 'additional'.

As described in Section 1.4, all sources of leakage minimized, then quantified and subtracted from the total expected carbon stock of the FCP. The final aspect of Kyoto compatibility is to assess the 'capacity' of the project to fulfil expectations. This can be evaluated by appraising the skills of the FCP management team, technology and equipment, as well as considering the ecological, political and economic environment in which the project is undertaken.

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[15] The overall aim of the UNFCCC is the "…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…" (UNFCCC 1992).

4.1.2 Economic assessment of the project

Using the preliminary estimates of carbon yield [Section 2], a FCP owner should conduct an economic analysis of each of the proposed forest carbon management alternatives. Economic analysis should attempt to factor in a range of possible forest products and forest uses. A number of computer models can be used to conduct economic analysis of the project (Stone et al. 1996). Alternatively, a simple cost-benefit analysis, and plotting the NPV of each of the alternative management regimes against the BAU scenario would suffice.

4.1.3 Impact on other forest values

Prior to implementation of a forest carbon sequestration project, a FCP owner should carefully consider other forest objectives, such as recreation, aesthetics, aboriginal land rights and water supply. This is necessary to comply with other objectives of the Kyoto Protocol, as well as achieve public support for the project and therefore ensure temporal continuity (Brown *et al.* 1997).

4.2 Project Registration

Having decided upon which forest management regime to implement, and determined that the project is indeed Kyoto credible and economically viable, a FCP owner can now proceed to 'register' their FCP with a central carbon registry [Section 9.5.3]. Although most countries have yet to establish a national carbon registry, it is likely that a registry will be crucial to the development of an efficient national carbon accounting system. Some countries are also beginning to trial national registries on a voluntary basis[16].

The central carbon registry is managed by a national agency that maintains records of Kyoto-credible forest carbon. FCP owners wishing to obtain official national recognition of Kyoto-credible forest carbon would be required to register and report to the central carbon registry using a national standardized format. Registration will encourage uniformity in carbon inventory methodologies, eliminate confusion regarding interpretation of data, facilitate exchange of information between operational and national level carbon inventory and increase data accuracy, transparency and verifiability. Most importantly, registration provides encouragement for a united, coordinated effort towards greenhouse gas abatement, thereby helping to avoid leakage due to market effects where demand is simply shifted to emitters (AGO 1999b).

The use of web-technology would greatly increase efficiency of data transfer between operational and national level carbon inventory (AGO 1999b). A web-based registry could also provide FCP owners with advice on how to conduct forest inventory, as well as providing default carbon yield curves for region and species.

Once a FCP has been officially registered, the FCP owner can proceed to implement the project.

PHASE TWO: PROJECT IMPLEMENTATION – INVENTORY AND MANAGEMENT

5. DESIGN SAMPLING SYSTEM

5.1 Consider sampling and accounting objectives

In designing a forest carbon sampling system, it is necessary to define either the *specified* level of precision to be achieved by the forest inventory, or the *maximum* level of precision that can be achieved, given fixed inventory costs (MacDicken 1997). Different levels of precision may be

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16 In 1997, the Voluntary Challenge and Registry [VCR] was established in Canada. http://www.vcr-mvr.ca/home_e.cfm. In October 2000, the Pacific Rim Regional Association of RC&D's launched the 'Carbon Technology Transfer Center' for registration and trade of carbon: http://www.pacrimrc-d.com/Aggregator/carbon_technology_transfer_cente.htm. The Environmental Resources Trust (ERT) has setup a GHG Registry for quantifying, registering, and tracking GHG emissions and/or reductions http://www.ecoregistry.org/.

required for each forest carbon pool [i.e.: aboveground biomass, belowground biomass, soils, litter, etc] (AGO 1998). Thus, sample size allocated for each forest carbon pool should reflect the required precision.

5.2 alternative accounting methods

It is assumed that the 'stock change' method will be used to account for changes in forest carbon for projects eligible under Articles 3.3 and 3.4[17]. This method is discussed below. There are, however, a number of alternatives to the stock change method that have been proposed to account for forest carbon sequestered in JI and CDM projects. Three methods are discussed briefly below.

5.2.1 Stock change method

The stock change method of accounting involves calculating the difference between forest carbon storage at two different points in time. The total change in carbon stock is calculated by subtracting the carbon stock at the start of the commitment period, from that at the end of the commitment period. Figure 1 shows an example of how to calculate 'Kyoto credible' carbon for ARD activities over the first commitment period.

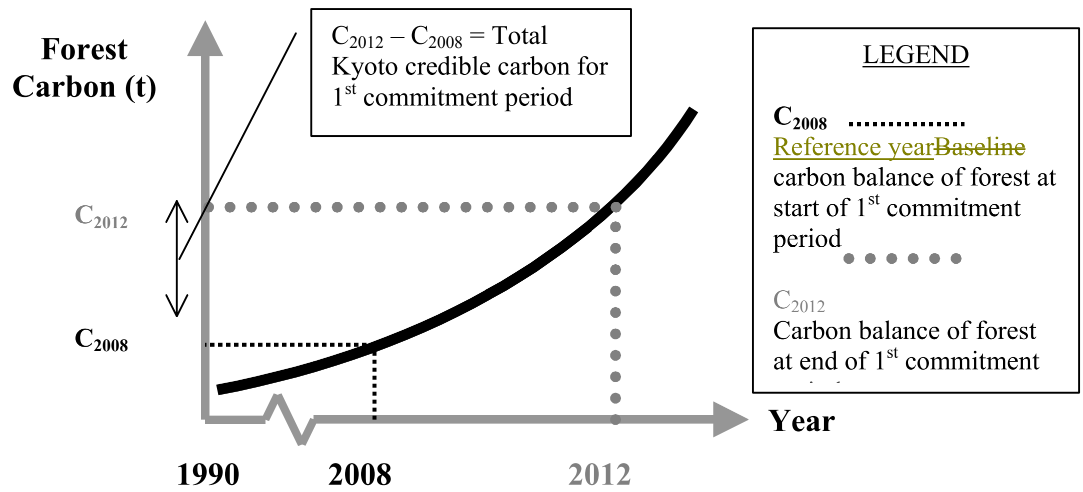

Figure 1: Calculation of Kyoto credible forest over the first commitment period (2008 – 2012)

A disadvantage of the stock change approach is that it may provide disincentive for long-term sustainable forest management practices. This is because the stock change method detects short-term fluctuations in carbon storage. Practices such as juvenile spacing, thinning, and planting of slow-growing species may result in short-term carbon emissions [or slower rates of carbon sequestration]. In the long term, however, these practices result in greater forest carbon storage. In order to address this issue, the 'average forest carbon storage' accounting method has been proposed.

17 The stock change method of carbon accounting (over the commitment period) is the methodology specified to be used to account for carbon storage under Article 3.3: "…measured as verifiable changes in carbon stocks in each commitment period.." (UNFCCC 1997). It is unclear at this stage whether the stock change method is required for Article 3.4. The IPCC *Special Report on LULUCF* (2000) identified at least four ways that additional activities could be temporally accounted for: Using 1990 as a baseline; Stock change over the first and subsequent commitment periods (provided activities were implemented after 1990); Using a BAU baseline; and stock change over the second and subsequent commitment periods (IPCC 2000). For the purposes of this document, it is assumed that the stock change method will be adopted for Article 3.4.

5.2.2 Average carbon storage accounting method

Under the 'average carbon storage' accounting methodology, the amount of Kyoto-credible carbon is calculated as the average forest carbon storage over successive rotations (Moura Costa & Wilson 1999). By calculating the average forest carbon storage, the long-term trend in forest carbon storage is captured, as opposed to the fluctuations [Figure 2].

Figure 2 depicts the carbon storage of a forest that has been thinned once, then harvested. The solid black line indicates the change in carbon stocks to be reported, using the stock change method. The dashed black line shows change in carbon stocks using the average carbon storage method. This implies that carbon losses due to harvesting [or thinning or spacing] are not debited [providing the forest was immediately replanted] (Moura Costa 2000).

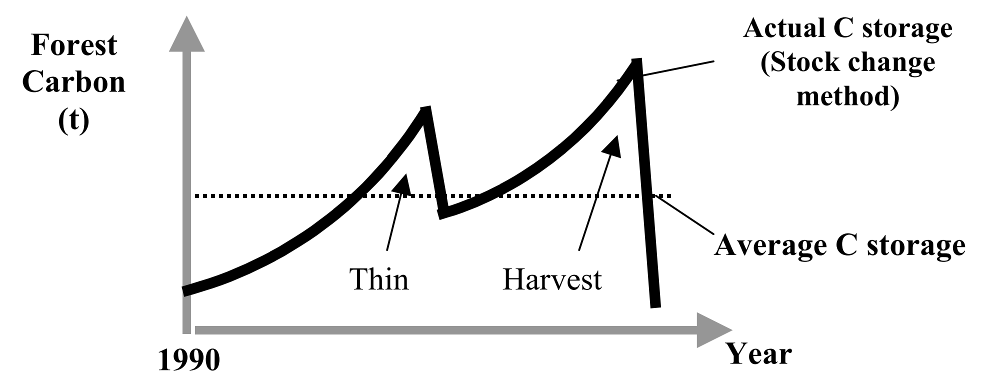

Figure 2: Comparison of average carbon storage accounting method with stock change method.

5.2.3 The ton-year method

The ton-year method has been proposed to address the issue of permanence of forest carbon storage. The method gives a FCP credit for each year of storage, relative to the rate of carbon decay in the atmosphere. It has been determined that storage of one ton of carbon for one year is equivalent to preventing the emission of 0.0182 tons of carbon, regardless of whether it is released again at the end of this year (Moura Costa & Wilson 1999). Therefore, one year of forest carbon storage could generate 0.0182 carbon credits. According to the CO_2 decay curve, storing one ton of forest carbon for 55 years could generate one carbon credit.

6. CONDUCT FOREST CARBON INVENTORY

Forest carbon inventory can potentially be conducted using three main methodologies: Field measurement, modeling and remote sensing techniques, or some combination of the three.

6.1 Estimation using allometric equations

For small FCP owners, it may be most practical and cost effective to use simple allometric equations to estimate forest biomass. Using this approach carbon estimates can be derived from current forest inventory data and data redundancy and high inventory costs can be avoided. The following sections describe how forest carbon can be estimated using field measurements.

6.1.1 Carbon storage in Aboveground Biomass

Tree carbon estimates can be derived from volume. Tree volume is estimated based on height and diameter at breast height, and by applying the appropriate allometric equation[18]. Volume estimates are then multiplied by a species-specific expansion ratio to estimate the total aboveground biomass. The expansion ratio accounts for the volume of the branches, leaves, twigs and other aboveground non-merchantable tree components[19]. For greater accuracy, expansion ratios should be specific to the region and species. Where these expansion ratios are not available, they can be developed by plotting a regression of non-merchantable biomass against merchantable volume and statistically determining the appropriate regression equation. This requires the use of destructive sampling techniques. As a last resort, country specific default expansion ratios can be obtained from the *1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 1996).

To calculate aboveground biomass on a dry weight basis, the total aboveground biomass is then multiplied by the appropriate biomass conversion ratio. This is a ratio to exclude the weight due to moisture in the tree. Biomass conversion ratios again should be species and regionally specific. However, default values are generally available in literature.

To convert biomass to carbon, the proportion of carbon contained in the biomass must then be multiplied by the dry weight of biomass. In general, the carbon content varies very little between species, and the IPCC default carbon content is 0.5 (IPCC 1996). However, species specific carbon contents for most forest species are generally available in literature. This estimate can then be scaled up to produce estimates of aboveground biomass carbon uptake on a per hectare or stand-level basis, by averaging the total carbon storage from a number of statistically significant plots across the stand, and multiplying by the stand area.

To express the total aboveground biomass carbon as CO_2 equivalents, stand level aboveground biomass carbon is simply multiplied by the stochiometric ratio of CO_2, which is $^{44}/_{12}$.

For multi-species stands, stratification may reduce sampling error. In this case, carbon storage for each species can be sampled independently, and summed to give total stand-level carbon storage.

6.1.2 Carbon storage in other carbon pools

Sources of carbon emissions must be reported from the belowground biomass, litter, dead wood and soil unless the FCP owner can prove that the pools are *not* net sources of carbon emissions. If the carbon pool is a sink, the FCP owner has the option of including the pool in their forest carbon inventory. Therefore, it is useful for a FCP owner to have a general knowledge of the processes involved in measurement of other carbon pools. A description of the carbon measurement procedures for each of these carbon pools can be found in MacDicken (1997).

6.2 Estimation using models

Where the stand size becomes too large or the forest too complex in structure, measurement of forest carbon on an individual tree basis may no longer be practical. In this case, the FCP owner may prefer to use a software-based model to estimate forest carbon[20].

To calculate current year carbon storage, the model will utilize simple forest inventory data input. These data are then substituted into a series of equations inherent within the model. Usually, a model

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18. An example of an allometric equation specific to coastal Douglas fir in British Columbia, Canada is:
$\mathbf{V = [4.796550265*10^{-5}]*[D^{1.813820}]*[H^{1.042420}]}$
Where: V = Total merchantable volume of the tree [m^3], D = Diameter at breast height [cm], and H = Tree height [m]. In cases where allometric equations are not available, these can be developed using regression analysis of measurements taken from destructive sampling techniques.

19 Many of the expansion ratios available may also account for below ground biomass. If this is the case, aboveground biomass and belowground biomass should simply be accounted for together.

20 A summary of a range of software-based forest carbon models is available at the following address: http://www.joanneum.ac.at/iea-bioenergy-task38/model/fmodel.htm

will determine the carbon balance in the above and belowground biomass, however models can often also determine the amount of carbon in soils, litter and dead wood (Vine et al. 1999).

6.3 Integration of remote sensing techniques

Remote sensing can be used in forest carbon inventory for three purposes: Direct measurement of carbon, stratification and/or to provide estimates of forest area. Direct measurements of forest carbon can be obtained via SAR [Synthetic Aperture Radar] scanners. SAR scanners are capable of examining the patterns and strength of spectral reflectance of vegetation (Baker & Luckman 2001). Data from the scanner can then be input into a computer model, which can then produce estimates of Net Ecosystem Productivity [NEP] and forest carbon storage. A range of these computer models are available: InTEC, Integrated Terestrial Ecosystem Carbon Cycle Model (Canadian Centre for Remote Sensing CCRS 2000); BEPS, Boreal Ecosystem Productivity Simulator (Liu 1997) and Forest-BGC (Running & Coughlan 1998, Running & Gower 1991);

Remote sensing can also prove useful for stratification of land use and/or forest type prior to field sampling. By examining the crown formation characteristics of forests from aerial photographs or spectral reflectance from satellite images, it is possible to identify forest and non-forest areas, and classify forest according to forest type or species (Avery & Burkhart 1983). Stratification can enhance efficiency of forest inventory by reducing variation between grouped sample plots. Another way remote sensing can significantly enhance the accuracy of a forest carbon inventory, is to provide more precise estimates of forest area. This is beneficial since inaccuracy in forest area estimates has been identified as being one of the major sources of error in forest inventory estimates (NGGIC 1998).

One problem with the use of remote sensing at the operational level, is that the cost can prove prohibitive for a single forest owner. This problem can be overcome by cooperating with other land holders nearby, organizing to have remote sensing conducted at the same time on a larger area of land. Costs are then shared amongst a number of individuals.

7 DETAILED MODELING OF FUTURE CARBON YIELD

Once the FCP has been implemented and forest inventory has been conducted, more detailed estimates of carbon yield can be produced, using the carbon yield prediction models as described in Section 2. The FCP owner will have gained some experience and insight into the limitations associated with the project. This experience should give FCP owner a more realistic idea of the assumptions, constraints and growth trends for input into the carbon and timber yield projection models. More reliable estimates of future carbon yield are especially important if the FCP owner intends to conduct forward trades of forest carbon [Section 11.1].

8 MONITORING, VERIFICATION AND CERTIFICATION

The Kyoto protocol specifies that carbon estimates should be…" reported in a transparent and verifiable manner…" (UNFCC 1997); therefore a well-designed system for monitoring, verification and certification is essential. Monitoring can be defined as the "periodic inspection or measurement of project carbon against reported or estimated values" (State Forests NSW 2000). Verification can be defined as the act of checking the validity of the claims of a project (Moura Costa et. al. 2000). Certification occurs when the verification agency officially confirms that the FCP conforms with specified verification criteria.

8.1 Monitoring

A forest carbon monitoring system involves an analysis of reported values to estimates obtained from the re-measurement of a certain proportion of forest inventory plots. If reported and re-measured estimates differ significantly, this suggests incorrect inventory design or technique, or invalid assumptions. To reduce the costs of monitoring, a combination of ground-based and remote sensing techniques can be adopted. Monitoring and verification costs for small landholders could be minimized through groups of forest owners forming a 'carbon pool' of plantations, thereby sharing costs among a number of individuals.

8.2 Verification and Certification

There are three components that are required for a successful verification/certification system (Moura Costa et al. 2000),: a published standard, an accreditation body and verification/certification agencies that are accredited to use the standard.

A forest carbon verification standard is defined as a set of generally accepted principles, procedures and methodologies for recording the level of forest carbon sequestration and emissions (Meridian Institute 2000). This would allow forest owners to conduct their own forest carbon inventory suitable to their own forest type, geography and technological capabilities. In order to ensure that the standard is unbiased and suitable to all parties, the international standard would be developed by an independent standard setting authority, comprised of representatives from all parties to the UNFCCC. More detailed national guidelines may also be developed for each country. The guidelines should provide standards for each the field measurement, remote sensing and modeling components of the inventory system.

In addition to an independent standard setting authority, an accreditation body is also required. The accreditation body would attest to the integrity and competence of the verification/certification agency, and oversee the performance of the verification agencies to ensure that the published verification standards were being used appropriately. At present, there is no established accreditation body for this purpose. However the Meridian Institute is currently proposing to establish an international standard setting, accreditation and certification system (Meridian Institute 2000). Under a National Carbon Network [NCN] scheme [Section 9.5.5], it is likely that government for each of the parties to the Kyoto Protocol will play a major role as an accreditation body.

Upon official certification by the accreditation body, the verification/certification agency would then be licensed to undertake the actual verification procedure. In order to verify the existence of Kyoto credible forest carbon, three main aspects of the project should be examined. First, the project baseline should be assessed in terms of validity of assumptions. Next, the verifier should confirm that the actual project activities have occurred. Finally, the forest carbon inventory system itself is verified. The verifier would then compare their own estimates of forest carbon data to those reported by the project owners. Based on this comparison, uncertainty of forest carbon data could be calculated.

Certification occurs if the verification agency can attest that the carbon accounting data is true as represented, and meets the carbon verification standard (Meridian Institute 2000). This will normally involve the fully accredited verification agency issuing a certificate, giving formal recognition of a specified quantity of forest carbon storage. Certification of forest carbon storage has the benefit of encouraging investor and buyer confidence, and also avoids the possibility of trading of poor quality, non-verifiable carbon credits (Obersteiner et al. 2000).

9 REPORTING OF FOREST CARBON DATA

Reporting of forest carbon estimates should be accompanied by an assessment of uncertainty, assumptions and excluded carbon pools. For verification purposes, it is also prudent to supply adequate documentation and explanation of project activities and inventory methodology. In addition, this section defines a formal methodology for reporting of carbon data to a 'National Carbon Network' (NCN) to facilitate efficiency in data collection; and to provide a means of scaling up of operational level carbon inventory to interface with national level GHG reporting.

9.1 Reporting of Uncertainty

There are two main types of uncertainty associated with forest carbon data: measurement uncertainty, and counterfactual uncertainty (Moura Costa et al. 2000). Measurement uncertainty is due to limited data availability, and limited resources available to capture this data. There are four types of measurement uncertainty: Uncertainty due to averaging and use of approximated values [such as a root to shoot ratio]; Uncertainty associated with the science of forest carbon sequestration; the uncertainty associated with attempting to measure parameters that cannot be directly measured [eg: Using diameter and height to approximate biomass] (Vine et al. 1999). The final type of measurement error arises due to mistakes, systematic biases and accidental errors occurring during the actual forest inventory (Brack & Wood 1998). Measurement uncertainty, is readily quantifiable and should be stated when reporting forest carbon estimates.

Counterfactual uncertainty generally refers to the inability to predict 'what might have been' (Tetlock and Belkin 1996). Counterfactual uncertainty arises due to assumptions that are made in estimating baselines, future forest management regimes and occurrence of risk events. Counterfactual uncertainty is difficult to quantify, and is best dealt with conducting extensive risk management assessment, and using a reputable software package to produce reliable estimates of future carbon yield [Section 2].

Uncertainty can be reported in either of two ways (Vine et al. 1999): Statistically, as the standard error of the mean, or confidence limits around the mean; or qualitatively, where a precision of level of high, medium or low, for example, is assigned to the estimate.

9.2 Documentation of Project Activities

To facilitate verification and certification, each stage of the forest carbon inventory and accounting system should be documented. An 'audit trail' allows an independent third party to verify that the forest carbon inventory is carried out according to a specified standard, and that the claimed amount of carbon storage is a good approximation of actual carbon storage. Given the uncertain and dynamic nature of the Kyoto protocol, extensive documentation will also be useful in ensuring that early FCP emission reductions are officially recognized, ahead of finalization of climate change negotiations (CO2e.com 2000).

9.3 Reporting of assumptions and excluded carbon pools

If a forest carbon pool is not accounted for, "transparent and verifiable proof" must be provided to prove that the unaccounted pool is not a source (SBSTA 2000). It follows that a report on unaccounted pools must accompany all inventory estimates. A list of all assumptions made during the inventory, modeling and calculation stages should also be prepared.

9.4 Post-Reporting Feedback

Review and feedback mechanisms are useful to facilitate flexibility and improvement of a forest carbon accounting system. To facilitate public input and feedback, annual carbon progress reports could be released, both internally and publicly. Sampling systems should be reviewed by experienced forest inventory specialists and statisticians, and verification reports should be noted and adjustments made accordingly. Formulation of a special review board, to assess, recommend and implement the required changes would be advisable for larger FCP owners

9.5 The Concept of the National Carbon Network

The National Carbon Network [NCN] presented in this section is a proposed model to facilitate efficiency in data collection; and to provide a means of scaling up of operational level carbon inventory to interface with national level GHG reporting. The proposed NCN model is divided into six main sectors:

1. Public relations and consultancy
2. Inventory
3. Recording, reporting and tracking of forest carbon [National Carbon Registry]
4. Risk management
5. Accreditation of verification agencies
6. Supervision of emissions trade/brokerage services

Each of these sectors is inter-related as shown in Figure A1 in the Appendix. The role and basic operations of each sector are described in the following sections.

9.5.1 Public relations and consultancy services

The primary means of communication between the NCN and individual forest growers, would be via a web-based national carbon registry [Section 9.5.3]. Forest growers could also communicate with the NCN via a series of regional representatives [Section 9.5.1.4]. The public services sector could be divided into four departments: project evaluation; management advice; legislative services, and public relations. Each of these departments is outlined below.

9.5.1.1 Project evaluation

In order to assess the Kyoto compatibility and economic feasibility of a forest carbon project [Section 4.1], the NCN could provide an evaluation service to forest growers. Using a number of specified guidelines, the NCN could advise forest owners as to whether their proposed project is Kyoto-eligible.

The NCN could provide either basic, web-based evaluations, or conduct in-depth project evaluations. Basic project evaluations could occur via the public-services module in the web-based registry [Section 9.6.3]. Alternatively, the forest grower could elect to have an in-depth project evaluation carried out in person by one of the regional NCN representatives. This would involve a site visit by the regional representative, who would conduct soil and site productivity test, and conduct a personal interview regarding management intentions of the owner, commitment and expected outcomes of the project.

9.5.1.2 Inventory and Management advice

FCP owners are likely to benefit significantly from a well-written manual, providing detailed information on how to conduct forest inventory, and advice on how best to manage a forest carbon project (BRS 2000). The NCN could publish an inventory and management manual via the public services module in the web-based registry. It is essential that the manual be easy to read, and provide detailed illustrations on how to conduct forest inventory. In addition, the regional NCN representative would be available for individual consultations and guidance regarding inventory and management advice.

9.5.1.3 Legislative services

The legislation regarding ownership of carbon is, at this stage, highly uncertain. Prior to commencing trade of forest carbon, it is essential to legally establish separate ownership of the trees, land and carbon (Blair 1999). This will allow trade of forest carbon as a separate commodity, regardless of whether the ownership of the trees or land changes hands. Pending the finalization of appropriate legislation, a forest grower would be prudent to seek legislative advice regarding the formulation of legally binding contracts, to establish carbon rights. The NCN could offer this service, by providing a legally binding on-line carbon rights contract. The contract could also be accompanied by simple explanations of the implications of the carbon rights contract. NCN regional legislative representatives would also be available for personal consultation in legislative services.

9.5.1.4 Public relations

It is crucial to maintain well-established lines of communication between the forest grower and the NCN to overcome distrust of a government agency; to facilitate interest in establishing a forest carbon project, and to inform forest growers about how to manage and maintain a forest carbon project (BRS 2000). The public relations program of the NCN could comprise a number of initiatives, such as:

- A web-based promotional and informational package
- A series of regional seminars and conferences
- A network of regional contact persons, preferably employment of individuals who are local, approachable and well established in the community.

- Informational booklets and pamphlets distributed to secondary and tertiary education institutions.

9.5.2 Inventory

The challenge of any national forest carbon inventory program, is to provide a means of scaling up operational, stand-level forest inventory to interface with the national level GHG inventory, allowing participation of both small and large scale forest growers. In an attempt to meet these requirements, the national forest inventory proposed under the NCN provides a system of incentives to encourage small forest growers to submit detailed inventory information to supplement broad scale forest inventory. This system, described below, would be conducted on two levels: broad scale forest inventory, and detailed operational level forest inventory.

9.5.2.1 Broad scale forest inventory

Broad-scale forest inventory would be conducted by the NCN on all forest land within the country. This would be done using a combination of remote sensing and ground sampling techniques. Benefits of the NCN conducting a broad scale forest carbon inventory are numerous: The per unit cost of inventory is minimized. Carbon data could be obtained for Kyoto forests where the FCP owner is unable to conduct inventory themselves. Utilization of remote sensing data enables carbon data to be reported in a manner that is both timely and consistent (Natural Resources Canada 2001). Inventory data could be used for a range of purposes. However, a major limitation of conducting such broad-scale forest inventory, is that areas of less than approximately 20 metres cannot be measured or mapped accurately (Weir pers. Comm. 2000). Therefore, there is also a need to conduct a more detailed, operational level forest inventory.

9.5.2.2 Operational level forest inventory – The carbon 'refund scheme'

In order to increase the precision of the national forest inventory and enable mapping and measurement of small areas of forest, more detailed, ground-based forest sampling techniques must be implemented. Via a 'carbon refund scheme', individual forest owners are encouraged to cooperate with the NCN and conduct their own detailed forest inventory. This refund scheme could work as follows: In order to claim rights to the carbon ownership of their forest, the forest owner would be required to electronically register their forest on a national web-based carbon registry [Section 9.6.3][21]. By officially registering their forest, a forest owner would effectively enter into an agreement with the NCN. Under this agreement, the forest owner would be required to make a 'payment' to the NCN for conducting the broad scale forest carbon inventory [in much the same way that one might pay taxes to the government]. This 'payment' would obligate the forest carbon owner to forfeit a proportion of their forest carbon ownership to the NCN. If the forest owner decided to conduct their own forest carbon inventory to supplement the broad forest inventory carried out by the NCN, they would be entitled to a 'carbon refund' of a certain proportion of their carbon ownership. The more detailed forest inventory information submitted by the forest grower, the greater amount of carbon that would be refunded by the NCN. In this way, the number of carbon credits obtained by the forest owner would be in proportion to the precision of the forest carbon inventory. Thus, additional costs of inventory are offset by the increase in carbon that is eligible for trade. The concept of a 'variable precision carbon accounting system' is derived from the carbon accounting standard developed by the State Forests of NSW (2000).

9.5.3 Maintain a national carbon registry

As described in Section 4.2, forest owners would be required to register their forest on the web-based national carbon registry. A national carbon registry is also needed to meet the requirements of Articles 6 and 12[22]. The national carbon registry would essentially be a user-friendly, multi-purpose,

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21 If a FCP owner decided not to register their forest, they would not be eligible to claim carbon offsets. The NCN would obtain rights to claim ownership of the forest carbon. The NCN could then decide whether to conduct their own detailed forest carbon inventory, or simply use data from the broad scale forest inventory [Section 9.5.2.1].

22 A decision was made at COP 4 to facilitate the development of web-based national carbon registries. This decision specified that: *"Each party in Annex B shall establish and maintain a national registry to ensure the accurate accounting of the issuance… holding, transfer, acquisition, cancellation and retirement of*

web-based computer program. The carbon registry could be divided into a number of separate modules, each to perform a separate role. Some ideas for modules in the national carbon registry might be:

- Land Tenure module: Linked with national tenure records, register ownership
- Inventory module: Contains all historical and current forest inventory data
- Public accounts module: Tracks ownership of carbon for each forest owner, tracks emissions record for each forest owner
- Public Services module: Contains general information, references, links and contact details [Section 9.5.1.4]
- Carbon accounting module: Spreadsheet-based statistical module, to combine all forest inventory data to calculate forest carbon on an operational, regional and national level
- Risk management module: Contains a record of carbon contributions of each forest grower towards a carbon risk management buffer. Primarily maintained by independent risk management agencies [Section 9.5.4]
- Verification/Certification module: Documents verification and certification of the forest by an independent verification/certification agency [Section 9.5.5].
- Emissions trading module: Details of purchase and sale of forest carbon credits, interfacing with the public accounts module. Primarily run by the independent clearing house.
- GIS component: All data within the national carbon registry would be spatially referenced and linked to a GIS system (AGOa 2000).

9.5.4 Risk Management

As described in Section 9.5.2.2, the 'carbon refund scheme' requires the forest owner to forfeit a certain proportion of carbon ownership to the NCN as 'payment' for forest inventory. A proportion of this carbon is automatically contributed to a national carbon risk management pool. The NCN could act as a risk manager for the forest owner, by using a proportion of these retained carbon credits to form a 'risk mitigation buffer' against disturbance events (State Forests NSW 1998). Thus, in the event that the forest was destroyed by fire or insect attack, the losses would be covered by the reserve pool of carbon credits. The buffer of carbon credits would also balance the temporary carbon loss occurring during the harvest/regeneration cycle across the entire carbon pool.

To perform this role, the NCN could oversee the license and performance of a number of risk management agencies. Each of the risk management agencies would compete for the right to manage the carbon pool of forest growers. In the same way that tax payers are required to fill out a tax-return, forest owners could fill out a 'carbon-return'. Level of risk could be assessed in terms of potential for natural disturbances, anthropogenic interventions and socio-political and economic risk (Moura Costa et al. 2000). Under this risk assessment, each forest carbon project could be assigned a 'permanence rating', or likelihood of achieving permanent carbon storage. Based on this permanence rating, the carbon pool manager could then negotiate the amount of carbon ownership forfeited to the national carbon pool [and thus, the level of risk protection required]. In this way, the amount of carbon that is eligible for trade is in proportion to level of risk associated with the project.

The NCN could also provide advice on other means of reducing risk associated with forest carbon projects, such as portfolio diversification or strengthening of insect and fire protection activities. The NCN may also function as a simple insurance agency, whereby a forest grower may choose to make financial payments to insure against risk, rather than setting aside a proportion of their carbon credits towards a carbon pool.

9.5.5 Accreditation of verification agencies

As described in Section 8.2, there is a need for an international accreditation body, to attest to the competence of independent verification agencies. The NCN could perform this role, as well as

(one-ton equivalents of CO_2)" (FCCC/SB 2000). A copy of these guidelines is available at the following address: http://www.unfccc.int/resource/docs/2000/sb/crp22.pdf

overseeing the performance of verification agencies by allowing them access to appropriate records the national carbon registry. The agent could then check their own estimates of forest parameters against the forest inventory data recorded by the NCN and the forest owner in the carbon registry. The agent would then be required to write up a verification report, stating the precision of forest carbon inventory estimates. The verification agent would then file the report in the verification module of the national carbon registry. Upon receiving the verification report, the NCN could then certify the amount of forest carbon that is tradable, according to the precision of the inventory.

9.5.6 Oversee Emissions trade/Brokerage services

An 'emissions clearing house' is essentially a mechanism for trading of CO_2 equivalents. An emissions clearing house should be run by an entity that is independent of the NCN kept separate from the NCN. Otherwise, there is potential for fraudulent activities such as inflated forest carbon inventory estimates to create additional carbon credits (Beil 1999). The NCN could act as the central governing body of the emissions clearing house, described further in Section 11.3

PHASE THREE: EMISSIONS TRADE

Having measured, monitored and reported the amount of 'Kyoto eligible' forest carbon, a FCP owner may wish to participate in an emissions trading market. To do so, the FCP owner must determine the amount of forest carbon that they should make available for trade, and then proceed to enter the emissions trading market.

10 DETERMINE NUMBER OF CARBON CREDITS

Emissions trading will involve buying and selling of one-ton equivalent of CO_2 known as 'carbon credits'. Described below is the process by which a FCP owner can determine the amount of carbon that is eligible for trade as carbon credits, or 'Trade Eligible Carbon', TEC.

10.1 Determine Amount of Trade Eligible Carbon

There are four steps involved in calculating the amount of TEC. First, the FCP owner must determine the net amount of forest carbon for the first accounting period. This can be done using the stock change methodology, as explained in Section 5.2.1. The second step required to calculate TEC, is subtract stock of carbon to account for counterfactual[23] and measurement uncertainty of carbon estimates. This conservative approach will instill market confidence by ensuring that all carbon credits represent real and verifiable carbon storage. The third step in calculating the amount of TEC, is to subtract a buffer stock of carbon to account for risk of unexpected carbon loss[24]. To quantify risk, it is suggested that a FCP owner should undertake a qualitative risk assessment. The forest owner should retain a pool of forest carbon in reserve in proportion to the severity and frequency of risk events over the project lifetime. Another way of dealing with risk is to insure forest plantations. Then, in the event of a risk event occurring, the forest owner would be compensated for lost carbon credits and timber value. Another risk management strategy suited particularly to small forest owners, is the formulation of carbon 'pools', whereby a number of forest owners agree to spread the risk of carbon loss due to disturbance amongst a number of individuals. Responsibility for carbon credit acquittal in the event of carbon loss would then become the shared responsibility of each of the carbon pool members. A similar principle can be applied to a single forest owner, whereby risk is spread across a "diverse portfolio of carbon sequestration projects" (Brown *et al.* 1997). Finally, a FCP owner should account for their own emission reduction quota before selling their carbon to another party. At present, it is uncertain as to how a country might proportion their

[23] Since counterfactual uncertainty is difficult to quantify, the FCP owner should undertake a risk assessment and estimate the uncertainty associated with yield forecasts to calculate the probable error of counterfactual assumptions.

[24] Note that in the event that a NCN has been established and the FCP owner contributes to a national risk management buffer via the 'carbon refund scheme' [Section 9.5.4], subtraction of carbon due to risk will not be required. Until a NCN has been established, a FCP owner would be prudent to voluntarily contribute to their own risk management buffer.

allocated emission reduction quotas. In the event that individual sectors and companies are allocated an assigned amount of emissions, it would be wise for a FCP owner to meet their own emission reduction quota before selling their carbon.

11 EMISSIONS TRADE

The Kyoto Protocol allows carbon to be traded internationally via three mechanisms: Joint Implementation [JI], the Clean Development Mechanism [CDM] and International Emissions Trading [IET]. JI allows Emission Reduction Units [ERU's] to be traded between Annex I countries [via linkage to a specific project, to the approval of both parties]. The CDM allows transferal of Certified Emission Reductions [CER's] to an Annex I country from a non-Annex I country. International Emissions Trading [IET] has been included as a mechanism under Article 17 of the Kyoto protocol, and allows carbon to be traded at market value between Annex I countries.

Essentially, emissions trade enables a party to purchase or sell the right to emit a specified amount of GHG's from another party (CO2e.com 2000). It is proposed that by allowing trade of emissions, parties will be able to meet their allocated emission quotas at least cost[25]. Emissions trade is particularly suitable to FCP's, since the substantial initial establishment costs of a FCP can be financed through profit from the forward sale of forest carbon. The Sections below define the units of emissions trade, how these trading units will be allocated, and proposes a trading mechanism within the NCN.

11.1 Defining the trading unit and trading mechansim

The primary unit of international emissions trade is likely to be one-ton CO_2 equivalent, or carbon credit. In selling of a carbon credit, a FCP owner promises to sequester a one ton equivalent of CO_2 in a specified year, and that this carbon should remain stored in the forest for a specified amount of time. A carbon credit cannot be used to meet Kyoto targets until the carbon is actually sequestered (State Forests NSW 2000). Depending upon the time of sale and storage of the forest carbon, there are three different types of trading mechanisms (CO2e.com 2000): A 'forward sale' of carbon credits occurs when a buyer agrees to purchase a carbon credit from the seller at a specified date in the future. A 'futures contract' is similar to a forward sale, but is tradable in it's own right, and is facilitated by a 'futures exchange' trading platform (CO2e.com 2000). Finally, carbon credits can be sold as 'options', which is entitles a buyer the right, but not the obligation to purchase carbon credits in the future.

11.2 Allocation of permits

Although a formal international emissions trading market is yet to be established, it is expected that companies will be allocated a set number of 'emission allowances', the total of which will reflect the Kyoto target of the particular country. There are two main options for the initial allocation of emission allowances (AGO 1999b): administrative allocation, and auctioning. Administrative allocation (sometimes referred to as the 'grandfathering' approach) would involve distribution of emission permits to companies by the government. The number of emission permits allocated to each company might depend on level of historical emissions and/or the extent to which the industry would be adversely affected by greenhouse gas abatement (AGO 1999b). The administrative allocation of permits should also contain provisions for recognition of early emission abatement action. The alternative approach to administrative allocation, is auctioning. This would involve a system whereby a company would gain emission permits by purchasing them on an open market.

11.3 Emissions trading within the National carbon network

As described in Section 9.5.6, the NCN could act as the central governing body of the emissions clearing house. In order to gain a license to provide emissions trade/carbon brokerage services, a party would need to apply to the NCN. The applicant would need to provide adequate documentation to ensure they had a well-designed system in place that is capable of tracking all

[25] It has also been found that by allowing full trade of emissions, global GDP is expected to decline by 0.2% in 2010. This is compared to the expected decline of 0.5% in 2010 without emissions trading (Reuters News Services 2001).

transactions in an efficient manner. The NCN would then oversee the performance of the clearing house, to ensure all transactions were accountable and legal. To assist the clearing house in providing an efficient, fully verifiable means of trading carbon, the NCN would provide the clearing house with direct access to the public accounts module of the carbon registry. The national clearing house would calculate the number of carbon credits for each forest grower wishing to participate in the market, and assign each carbon credit with it's own unique serial number, linked with the public accounts module of the national carbon registry. In this way, the national clearing house would keep track of carbon credits bought and sold via a simple double-entry accounting system (Lamb 1998). It is anticipated that individuals could actually trade 'on-line' via an electronic clearing house, which would also interface with the national carbon registry [Section 9.5.3]. This would enable prospective buyers instant access to information about the origin and nature of carbon credits on the market.

11.4 Existing Exchanges and trading systems

A large number of trades in forest carbon have occurred already. Initially, trades were largely project-specific [eg: In July, 1999, Tokyo Electric Power company agreed to purchase the carbon sequestered from planting 1000 hectares of forest from the State Forests of NSW]. As the emissions trading market progresses, however a greater number of trades will be facilitated by the ever-increasing number of emissions trading platforms. For example, GERT, A Greenhouse Gas Emissions Trading Pilot http://www.gert.org/; and Climate Partners http://www.climatepartners.com/index.cfm in Canada. In Australia, the . Queensland emissions trading platform, http://www.qetf.org/, and The Carbon Trader http://www.thecarbontrader.com/bottom.htm have been established. In the US, CO2e.com http://www.co2e.com/strategies/default.asp; and Trexler and Associates http://www.climateservices.com/ are large emissions trading platforms. To date, most exchanges occurring through trading platforms involve the buying and selling of options (CO_2e.com 2000). Most of these trading platforms encourage on-line trading, whereby a buyer or seller is required to register on the global trading platform. Once registered, the user can gain access to pricing information, and can proceed to place a bid to purchase carbon, or offer carbon for sale. An example of one of the worlds first on-line emissions clearing houses is CO2e.com, founded by Cantor Fitzgerald in association with Price Waterhouse Coopers. As an indicator of the success of on-line trading of carbon, between 60 to 100 trades had already occurred within weeks of launching the site, trading approximately 160 million tonnes of carbon (CO2e.com 2000).

CONCLUSIONS

The 'Kyoto Protocol', signed by the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, allows countries to use carbon sequestered in forests as a means to meet internationally binding Greenhouse Gas reduction quotas. An international forest carbon accounting framework for measuring, reporting and trading of forest carbon is therefore required. This framework must provide incentive for sustainable forest management practices without compromising the integrity of the protocol, as well as providing a means of 'scaling up' carbon inventory.

An eleven step forest carbon accounting framework, designed to meet the reporting requirements of the Kyoto Protocol, is described in this paper. The process by which an operational-level forest carbon project owner can assess their need for a forest carbon project was discussed, and a range of forest management schemes were suggested. The report described how and why baselines should be measured, and discussed how field measurements, software packages and/or remote sensing can be used to conduct forest carbon inventory. The need for a monitoring, verification and certification system was highlighted. A National Carbon Network was proposed to act as a central carbon manager, to conduct a variety of forest carbon accounting and management roles, and facilitate efficiency in forest inventory and risk management. In order to commence trade of forest carbon, it was advised that risk, uncertainty and emission reduction targets should be taken into account when determining the amount of Trade Eligible Carbon. The unit of emissions trade was defined, and the variety of trading mechanisms and platforms were listed.

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Appendix

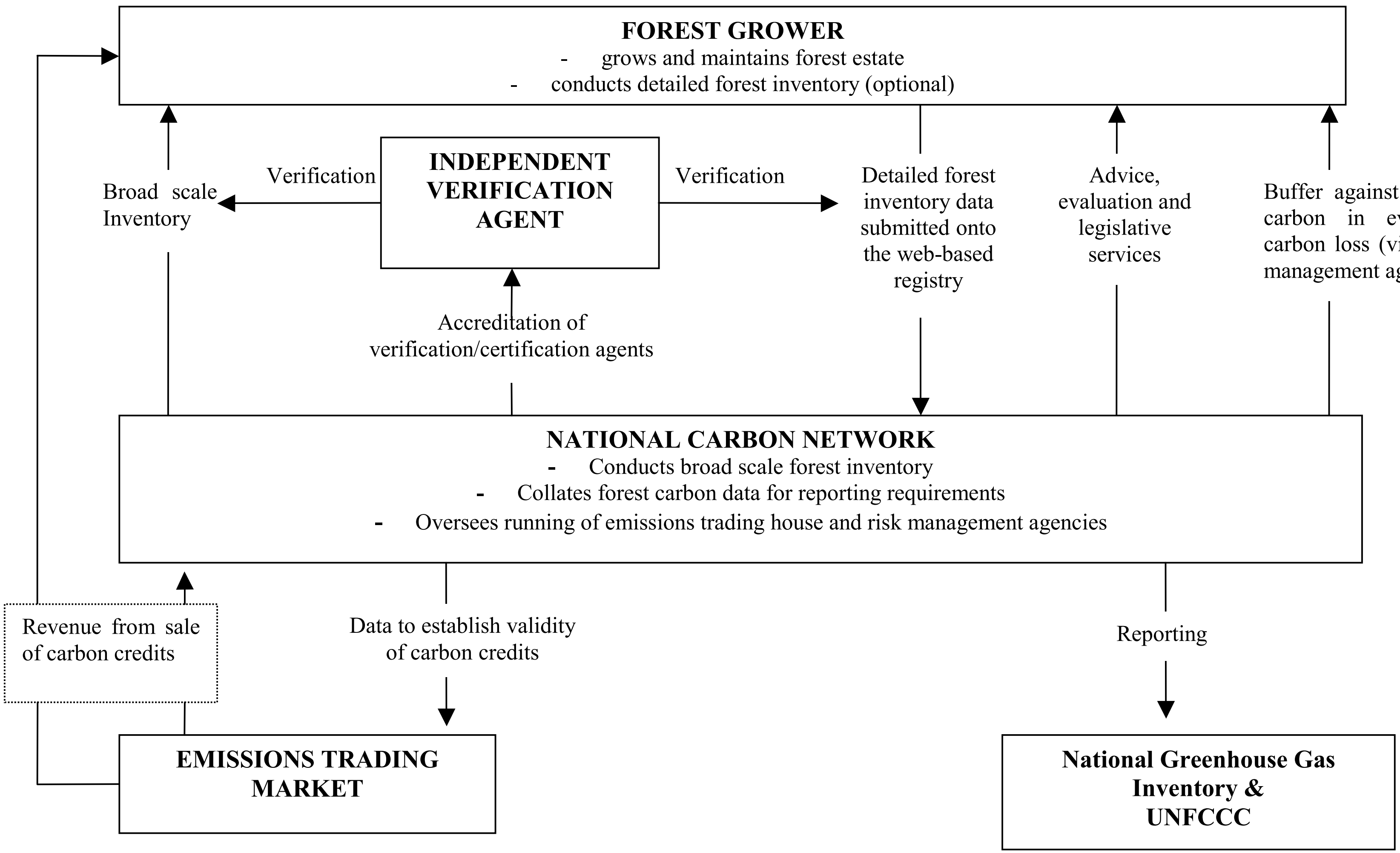

Figure A1: Relationship between the forest grower, the National Carbon Network and the UNFCCC, showing how operational level inventory is scaled up to a national and international level.

Subnational Entity Accounting for Carbon Sinks and Storage under the Kyoto Flexibility Mechanisms Based on Guaranteed Duration of Storage

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ABSTRACT

Legally binding commitment to retention of sequestered carbon provides an appropriate and useful basis for recognition of offsets to greenhouse gas emissions under the Kyoto flexibility mechanisms, and where there is only short-term commitment to retention, credits should be reduced proportionally for periods shorter than 100 years. 100 years has been identified, including by the IPCC Special Report on Land Use, Land Use Change and Forestry, as the period over which sequestration of an amount of carbon will offset an emission of the same amount, expressed in CO2 equivalent terms. The agreed method for measurement of emissions and sequestration to meet national commitments in the first Kyoto commitment period is by verifiable change in stocks during the period 2008 – 2012. However, significantly different approaches are appropriate for national governments compared to domestic and multinational commercial enterprises. There are significant problems with the "verifiable change in stocks" approach at a subnational level. An approach based on Global Warming Potential equivalency, which seems prescribed by the wording of Article 5.3, and on the guaranteed duration of storage of sequestered carbon, is proposed. The approach aims to address concerns regarding permanence of sequestration, minimise the risks in credit ownership, give confidence in the durability of credits, support ecologically sustainable development and facilitate sequestration futures trading. It may also allow a qualitative cap on the use of sinks under the flexibility mechanisms rather than a quantitative cap. An approach to the use of sinks under the Clean Development Mechanism based on country-sectoral baselines is also proposed.

Keywords: Carbon sinks, carbon storage, carbon dioxide equivalent offset, CO_2eo, guaranteed duration of storage.

Introduction

This paper proposes a basis for accounting for carbon sinks and storage, under the Kyoto flexibility mechanisms, that addresses concerns regarding the permanence of sequestration in vegetation and soils, while maintaining consistency with the letter and spirit of the Protocol and the Framework Convention on Climate Change. This necessarily means assisting progress towards ecologically sustainable development and biodiversity conservation.

Much current discussion on accounting approaches for sinks is focused on accounting at the Party level, that is, at the level of nation states in the context of a binding international agreement. This paper addresses some desirable differences between Kyoto Protocol national accounting and carbon credit and debit accounting by subnational or multinational profit focused entities.

A principal concern is to ensure that when financial incentives to sequester carbon eventuate, they operate through a framework that can ensure that Ecologically Sustainable Development, Sustainable Forest Management and biodiversity conservation are furthered.

Two central tenets of this paper are that:

- Sequestration of carbon from the atmosphere is valuable in relation to the duration of storage, and that
- Guaranteed duration of storage of eligible sequestered carbon forms the appropriate basis for issuing credit against greenhouse emissions.

This responds to the stipulation by Lashof and O'Hare (Lashof and O'Hare 1998) that appropriate policies must be designed to minimise the risk of granting emission credits for biotic carbon sequestration that proves to be temporary.

Ownership, trade and accounting system based on guaranteed duration of storage are also more likely to be able to manage the risk of default on obligations to buy permits upon re-emission of the sequestered carbon in the future (over decadal timeframes). This is principally because sustainability becomes the subject of Third Party Verification, which will be required for trade.

When carbon pool managers have to demonstrate sustainability over the very long term, they must take into account both CO2 fertilisation in the short term and climate change impacts on vegetation and soils (which may lead to re-emission of a proportion of carbon sequestered into vegetation and soils) in the long term. Their acceptance of this long-term responsibility as an auditable function may obviate the necessity of attempting to "strip out" the effects of CO2 fertilisation. That is, any early advantage from fertilisation would be nullified over century timeframes by the impacts of climate change on biotic systems.

It is hoped that the rigorous approach proposed may allow for a qualitative rather than quantitative cap on the use of sinks under the Kyoto flexibility mechanisms, and avoid perverse outcomes which could include incentives for investment in short term and potentially unsustainable forests, the creation of unsustainable carbon-related commercial liabilities, and diminution of the climate and other possible benefits.

Some final comments in this paper relate to the effect of the accounting approach recommended here on accounting for carbon storage in harvested wood products, and to the further issue of minimising intranational leakage of LULUCF project benefits under the CDM.

METHODS

Sequestration units

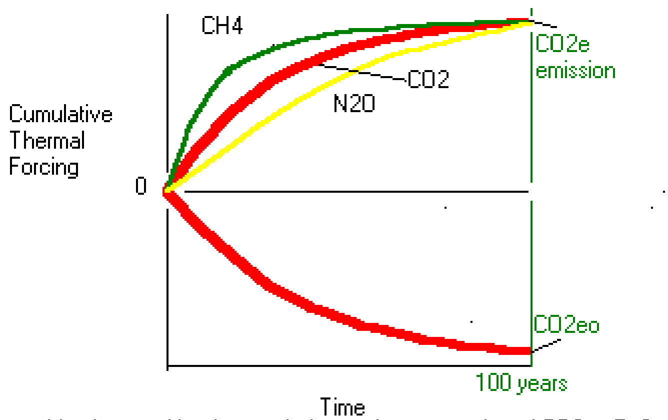
There is an obvious need for a unit to offset emissions, which are expressed in CO2 equivalents, on a purely "apples with apples" basis. The need is recognised in the Kyoto Protocol in Article 5.3 which states: "The global warming potentials used to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of greenhouse gases ……….. shall be those accepted by the Intergovernmental Panel on Climate Change….." (UNFCCC, 1997).
We must therefore examine the nature of global warming potentials and carbon dioxide equivalence in order to define a unit of sequestration that is consistent with accounting for emissions. We find that both mass and time are important.

Carbon dioxide equivalency is defined by the relationship between the cumulative thermal forcing resulting from the pulse injection of any greenhouse gas, with that resulting from the pulse injection of an equivalent mass of carbon dioxide, over a given timeframe. (HOUGHTON ET AL., 1994) Article 5.3 states that the global warming potentials used shall be those determined by the IPCC. These are based on a 100 year timeframe. It is on the basis of these global warming potentials that we say that methane has a global warming potential of 21 and nitrous oxide, 320.

100 years was identified by the IPCC Special Report on Land Use, Land Use Change and Forestry (WATSON ET AL , 2000), (P88) as the period over which sequestration of an amount of carbon will offset an emission of the same amount, expressed in CO_2 equivalent terms).

This is sketched in Figure 1, which illustrates the contributions to cumulative thermal forcing of equal CO_2e emissions of carbon dioxide, methane and nitrous oxide. The reduction in thermal forcing caused by the withdrawal of an equivalent amount of CO_2 from the atmosphere is also shown. As can be seen, to offset the effects of an emission of a CO_2 equivalent amount of any greenhouse gas, the same amount of CO_2 must be withdrawn from the atmosphere, and held for 100 years. This unit can be appropriately termed a carbon dioxide equivalent offset, or CO_2eo.

Figure 1: Cumulative thermal forcing of equal CO2e emissions of carbon dioxide, methane and nitrous oxide.



Thermal forcing resulting from emission and sequestration of CO2 at T=0, and emission of CO2equivalent amounts of CH4 and N2O.

It has been asserted that carbon held out of the atmosphere for a required equivalence time could be released back into the atmosphere without penalty or the necessity of recording an emission. (Moura-Costa and Wilson 1999) However CO_2 persists and continues to exert thermal forcing well beyond the 100-year timeframe used to compare the thermal forcing effects of the various greenhouse gases. This is even more the case in respect of the longer-lived greenhouse gases such as HFCs and nitrous oxide, which may also be offset by sequestration of atmospheric carbon. Further, biotic storage of carbon will in most cases be offsetting emissions of fossil carbon that has been in geological storage for millions of years.

Therefore, it is suggested that 100 years of storage be seen as the period required to earn a full offset a CO_2e emission, and that within the limits of this policy instrument, proportional credit be awarded for shorter periods of guaranteed sequestration. Release of the carbon back to the atmosphere at any point in time should result in the reversal of all credit gained.

The role of carbon pooling

Carbon stocks sequestered in vegetation and soils are vulnerable to fire, changed management practices, and the effects of climate change. This vulnerability can be best managed through pooling individual sequestration projects, combined with the retention of an appropriate buffer of credit to meet obligations to cover any decrease in the size of the managed pool.

Also, carbon pooling allows for the evening of carbon flows by, for example, covering emissions from periodic harvest with sequestration in other projects. Ideally a carbon pool where harvest is a feature of management would eventually have, like a “normal forest”, an even distribution of age classes up to the age of harvest.

It is proposed that carbon sequestration should be counted only up to the point at which the average carbon density over multiple rotations of a harvested forest is reached. Carbon pooling where a normal forest structure is approximated allows for this level of credit to be claimed at the pool level, notwithstanding that individual forest stands may at a point in time be below their sustainable level.

This sustainable increase in landscape carbon density is the maximum which could be safely claimed without the contingent liability of permit purchase to cover shortfalls at the pool level.

The future price of emission permits, and therefore of carbon credits, is unknown, but likely to rise steeply in response to tighter emission reduction targets in future commitment periods (in pursuit of the objective of stabilising greenhouse gas concentrations). Self-insurance at the pool level through retention of a buffer of credits is seen as a more practical risk management strategy than conventional insurance, because of the timeframes and uncertainties involved. A 20% buffer below measured and verified storage in a saturated pool might be reasonable. The buffer could be built up over time such that the relative security of early years' sequestration is recognised.

Following from the above, pooling of sequestration projects, measurement and verification at the sub-pool level, and pool managers assuming responsibility for maintaining the pools integrity, are seen as practical ways of ensuring the environmental and economic integrity of credits against emissions.

Legal arrangements

The risk of accidental or deliberate release of carbon stocks stored in forests is inherently greater than that of carbon stored in geological deposits stored in the Earth's crust. This is particularly the case bearing in mind the serious impacts of climate change likely to occur on both biodiverse forests and timber production monocultures.

Any legal system to enable trade of credits against emissions must effectively manage this risk to provide any real equivalence between biotic offsets (carbon credits) and emissions. It must also be based on complete and balanced accounting of sources and sinks.

Legislation and contracts should therefore be based on the guaranteed duration of storage rather than the fact of absorption.

It is therefore suggested that legislative and contractual arrangements must give appropriate cognisance to all relevant carbon pools and that:

- Legislation should enable commitment to retention of sequestered carbon in the form of covenants or easements on titles where the obligation is (essentially) to maintain an average change in landscape carbon density over a given timeframe, through the carrying out of an agreed management plan.
- Where there is only short term commitment, credit allowed should be reduced proportionally for periods shorter than 100 years
- Carbon pooling is a necessity for risk management and normalising carbon flows, and that therefore,
- Carbon pool managers must have enforceable rights to ensure that an agreed management plan is carried out over the timeframe of a sequestration project.

A proposed convention regarding carbon pool managers responsibilities is that their responsibility to ensure ongoing carbon storage would only last for the 100 years proposed as the period over which a credit is earned, with subsequent responsibility for any re-emission reverting to the owner/s of the forest and land at the time.

This would enable contractual arrangements between land/forest owners and carbon pool managers to have a finite period, rather than perpetuity, which is a fairly vague legal concept.

Effects of the proposed system on accounting for harvested wood products

The 1998 Dakar Workshop on "Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide from Forest Harvesting and Wood Products", (IPCC, 1999) sponsored by the IEA, IPCC and OECD defined three different logically consistent and scientifically defensible approaches. These are the “Stock Change”, “Production”, and “Atmospheric Flow” approaches.

These are examined in turn in relation the accounting approach outlined above, assuming that their effects at a national level would be mirrored in their effects on subnational entities. That is, producing and consuming country obligations and rights would be the same as for the project or pool level producer and consumer.

Stock Change approach

Under this approach changes in carbon stocks are accounted for by the producer, while changes in the wood products pool are accounted for by the consumer. Adoption of a time based accounting approach as outlined above would mean giving credit for carbon storage to both the producer and consumer. As with the approach as proposed at the Dakar workshop, reduction of carbon stocks in the hands of the producer (or representing pool) through sale would result in emissions being recorded. However, to the extent that ongoing sequestration in wood products could be underwritten by guarantees, credit could then be claimed by the consumer, again in proportion to the 100-year time horizon.

The approach generally has the benefit of giving credits and debits to the parties who actually own and control the relevant pools.

Production approach

Under the production approach changes to both the forest and wood products pools are accounted for by the producer. Adoption of the approach outlined in the paper would give an additional benefit to the producer in proportion to the actual or deemed additional storage time of carbon in the wood products. However, it would provide this benefit for storage in a carbon pool that is under the control of another party.

Atmospheric Flow approach

Under this approach credit is given for sequestration and debit for re-emission when, where, and in whose hands they actually occur. The approach has the probably undesirable effect of driving production of wood while providing a disincentive for its use. As this approach focuses on the moments of sequestration and emission, it is generally incompatible with an approach which gives credit in proportion to the duration of carbon storage.

Clean Development Mechanisms (CDM) issues

Projects under the Clean Development Mechanism are unique in earning credit in nations without quantified emission limitation and reduction objectives. This raises the possibility of nations benefiting from carbon credit income from “sinks projects” while rates of deforestation nationwide accelerate.

In order to remove the possibility of such undue credit being earned, it is proposed that countries seeking to host project-based activity under the CDM should be required to negotiate a national LULUCF baseline, and that the sum of project credits within the country would be limited to the quantum due to improvements on the baseline case. The proposed rule could also be seen to represent movement towards non-Annex B nations taking on national commitments under the Protocol, a precondition of the United States’ participation.

It is hoped that a combination of the guaranteed duration of storage approach to accounting for sequestration and emissions in the LULUCF sector and this proposed rule for CDM implementation can overcome some substantial objections to inclusion of sinks projects under the CDM at all.

Conclusion

It is recommended that sequestration credits for domestic and international trade should:

- be underpinned by comprehensive and long term management plans attached to the titles of the land and vegetation through covenants binding all subsequent owners for the full term,
- be the subject of clear contractual arrangements between all parties to a project, defining roles and responsibilities, and share of project inputs and outputs,
- be issued preferentially to carbon pool managers where the carbon pool under management is sufficiently large and diversified to allow for risk management and appropriate internal hedging.
- receive credit in proportion to the guaranteed duration of storage (up to 100 years) of the sequestered carbon, discounted against 100 years,
- claim only up to the average biomass and soil carbon pool increase which can be sustained over extended timeframes e.g. for 100 years,
- claim only net project benefits in any year, with all associated emissions deducted.
- be risk managed through pooling and maintenance of a hedge of credits, and/or through insurance, to cover loss by fire, pests, climate change etc.

This approach will minimise the risks in credit ownership and trade, give confidence in their durability, and enable trading of future sequestration. It also requires compliance with sustainability principles as an auditable function of carbon pools.

In respect of LULUCF projects under the CDM, the following rule is proposed:

Credit for CDM projects in the LULUCF sector in a country shall be limited to the credit due at a national level in improving on an agreed national LULUCF emissions baseline.

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