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Review of methodologies for addressing permanence

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Review of methodologies relating to the issue of permanence for LULUCF projects

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1. What is ‘permanence’?

One of the main concerns related to the use of sinks as a greenhouse gas (GHG) mitigation option is the question of ‘permanence’, the length of time for which carbon will remain stored after having been fixed in vegetation. In reality, the concern is about lack of permanence, ‘non-permanence’ or ‘reversibility’ of the benefits of storage, as a result of the possible loss of carbon stocks created or conserved by a project, whether on purpose (e.g. timber harvests) or as a result of undesirable events (e.g., natural disasters). Permanence is the main technical issue that differentiates forestry-based GHG mitigation projects from emission reduction projects.

The possible reversibility of carbon stocks, however, does not need to be seen as an insurmountable obstacle to the use of sinks as a GHG mitigation option. Carbon accounting methodologies have been devised especially for sinks projects, taking into account the technical differences in relation to other types of emission reduction projects. The treatment of permanence, therefore, influences and is influenced by the choice of carbon accounting methodologies, the timeframes chosen for carbon accounting, and the approach chosen for dealing with liabilities (i.e., the need to return or replace carbon credits if carbon is released to the atmosphere). It is often the case that the accounting for the environmental value of greenhouse gas (GHG) mitigation projects gets confused with the arrangements for project financing or commercialization of credits. This review will focus only on the former – dealing with and accounting for the issue of permanence.

The objective of this report is to analyze the various methodologies available for dealing with the issue of permanence of carbon stocks in sinks projects to facilitate the process of determining a standard approach. This would remove uncertainty and enable consistency of comparisons between projects. Throughout the report, ‘policy decision boxes’ highlight the issues were further definitions and policy decisions need to be made. In these cases, alternative policy options are listed, their advantages and disadvantages are discussed, and a policy recommendation is made.

2. Why is permanence important?

Carbon trading is increasingly being recognized as a potentially important source of capital to the implementation of GHG mitigation projects. The land use sector is able to play a role through the establishment of projects to avoid emissions (e.g. conservation of threatened forests) and sequester carbon (e.g. afforestation and reforestation). However, the possible reversibility of the GHG benefits accruing from forestry projects has raised questions about the environmental integrity of land-use based mitigation projects, to the extent that the activities currently eligible under the Clean Development Mechanism of the Kyoto Protocol are confined to afforestation and reforestation. This report, however, analyses the issue of permanence for a wider range of activities, irrespective of their eligibility under the Kyoto Protocol.

There is a clear requirement in the Kyoto Protocol that land use, land use change and forestry projects must result in long-term changes in terrestrial carbon storage and CO_2 concentrations in the atmosphere. A series of papers was written during the last years dealing with these issues, including a section in the IPCC Special Report on Land Use, Land Use Change and Forestry (Watson *et al.,* 2000), outlining various carbon accounting methods and their implications on dealing with permanence issues. While this report was meant to assist decision making in the context of the Climate Change convention, it is still unclear what carbon accounting method will be used for land use, land use change and forestry (LULUCF) projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol. Decisions regarding accounting frameworks, timeframes and liability are critical to ensuring climate integrity and credibility of LULUCF projects, as well as their economic viability.

One practical approach for dealing with the problem that carbon stored in biological systems may be released to the atmosphere is to acknowledge that carbon sinks are a temporary means for abating emissions of greenhouse gases and to assess the economic and environmental benefits of temporary storage (Chomitz, 2000). The economic and environmental reasons include: postponing climate change, buying time for developing and discovering alternative technologies to abate emissions, buying time for capital stock turnover, offering limited periods which are capable of being insured and, providing a means for host countries (who may be unwilling to lock up their lands in carbon projects forever) to preserve sovereignty and the opportunity to follow other future development pathways (Chomitz, 2000; Marland et al., 2001).

The choice of accounting methods also affects project developers and land owners in relation to the flexibility of long-term land-use choices. It is desirable that the method chosen does not limit the choices of the project developer and does not require that land be locked into a single land use forever. This is particularly important to developing countries where governments may not desire to commit large tracts of land to any particularly land use, and some have seen this as an ‘impingement on national sovereignty’. Accounting methods need to address the issue of enabling flexible land use management whilst also ensuring that the longer term atmospheric integrity of mitigation options is maintained.

Another relevant question is whether the issue of permanence only relates to sink activities (i.e., those leading to the removal of carbon from the atmosphere), or whether this is also a concern to forest conservation projects. To date, most conservation projects have aimed at maintaining carbon stocks ‘safe’ for long periods of time and, indeed, most of the critics of forest conservation seem concerned with the maintenance of carbon stocks in perpetuity. If forest conservation projects were treated in the same way as fossil fuel emission reduction projects, however, any delay in emissions would be accounted for as having had a perpetual, irreversible effect. This discrepancy in the treatment of projects has been pointed out by some authors who suggest that the delay, rather than avoidance, of emissions from deforestation have an important effect in atmospheric systems (Fearnside *et al*., 2000). This review does not suggest that this argument is right or wrong, but adopts the assumption that conservation projects need to maintain carbon stocks for long timeframes.

3. The Kyoto Protocol and permanence

A requirement of the Kyoto Protocol is that projects must result in “real, measurable and long-term benefits related to the mitigation of climate change”. The definition of “long-term”, however, varies substantially, and there is no consensus regarding how it relates to a minimum timeframe for project duration. Furthermore, the term “long-term” seems to be inconsistent with the Kyoto Protocol, which refers to meeting targets in a 5-year commitment period.

To date, there has been little progress made on how to treat permanence of carbon stocks of LULUCF projects under the Kyoto Protocol. The Conference of Parties has recently requested the Subsidiary Body of Scientific and Technological Advice (SBSTA) to take this issue into account when developing modalities for the inclusion of LULUCF projects in the CDM. The only existing text that makes reference to timeframes for project duration, analysis of GHG benefits and accounting procedures is with respect to the requirement that:

“The reversal of any removal due to LULUCF activities be accounted for at the appropriate point in time” (Paragraph 1 g) of draft decision -/CMP.1).

This text is still open to interpretation on various points. Firstly, how should this reversal be accounted for ? Is the accounting proportional to the period of storage ? Secondly, what is an “appropriate” point in time ? Thirdly, for how long should this obligation to account for reversal of removals lasts ? These issues are treated in more detail in the following sections.

At the same time that there are requirements for maintenance of stocks in the long term, the CDM specifications with regards to project crediting periods consider much shorter time frames:

“Project participants shall select a crediting period for a proposed activity from one of the following alternative approaches:

a) *A maximum of 7 years which may be renewed at most two times, …*
b) *A maximum of 10 years with no option of renewal.”*

There seems to be some disagreement as to whether this choice of crediting period will apply to LULUCF projects, since the existing text was written with non-LULUCF projects in mind. However, no reference is actually made in the text to energy or non-LULUCF projects, so its adoption for all project types is still a possibility. If these crediting periods were to be adopted for LULUCF, it could have important implications for accounting and crediting of land use activities. It is not clear whether or not such a crediting period would define only the period over which the credits are awarded, or whether it would also apply to the period of GHG quantification analysis and/or limiting the liability for the GHG benefits. This issue is discussed in further detail in the box Policy Decision 1.

Policy Decision 1: Do the 'crediting periods' of 7, 14, 21 and 10 years apply to LULUCF projects ?

According to the Marrakech Accords, "Project participants shall select a crediting period for a proposed activity from one of the following alternative approaches: a) A maximum of 7 years which may be renewed at most two times, …; or b) A maximum of 10 years with no option of renewal." Given the long timeframe associated with LULUCF projects, it appears inadequate that crediting for such projects be limited to the periods stated. Furthermore, even if the crediting is limited to this period of time, how does it relate to the responsibilities for avoiding "reversals of removals" ? Different approaches can be proposed:

- Use these crediting periods for LULUCF projects;
- Use these crediting periods for LULUCF projects, with additional requirements related to the permanence of carbon stocks created;
- Do not use these crediting periods for LULUCF projects.

The pros and cons of each choice are discussed in the table below.

	Advantages	**Disadvantages**
Use these periods for LULUCF projects (Marrakech Accords)	Simplicity, as it is the same rule used for non-LUCF projects	Reduction of overall volume of credits generated by LUCF projects, in some cases reducing their attractiveness and feasibility. The periods are not compatible with the growth cycles of forestry projects. Furthermore, the simple adoption of these crediting periods do not provide any guidance with relation to the issue of permanence.
Use these crediting periods but maintain requirement for longer duration of permanence	Simplicity (as above), and environmental integrity, given that, irrespective of the amount of credits given, their re-emissions should be accounted for.	Reduces overall crediting potential while maintaining liability for potentially all re-emissions, forever. The carbon stocks at risk of re-emission could be higher than the amount of credits granted to the project, creating a liability disproportional in relation to the incentive.
Do not limit crediting for LUCF projects to these periods	Enable projects to benefit from their full potential of carbon removal and storage	Requires a crediting approach differentiated from non-LUCF projects

4. Key variables related to permanence

To deal with the issue of permanence, and to account for the environmental value of carbon storage, different carbon accounting methods have been devised specially for land use projects. These methods differ in the way that they treat, and are affected by, some key variables related to the permanence of carbon stocks. In particular, the key variables related to permanence are:

a) Should there be a minimum timeframe required for carbon storage?
b) What is the treatment of re-emissions associated with projects that are conducted for periods of time shorted than the minimum timeframe (i.e., liabilities)?

These issues are dealt with, below.

4.1. What is the minimum timeframe required for carbon storage ?

A key factor related to the use of sinks to mitigate GHG emissions, is how this option compares with the direct reduction of GHG emissions. In general, this discussion revolves around the requirement for a minimum period of storage after which we are satisfied that it compensates for the emissions of GHG taking place elsewhere. While the Kyoto Protocol requires that projects must result in “real, measurable and long-term benefits related to the mitigation of climate change”, there is no definition of “long-term”.

During the Activities Implemented Jointly (AIJ) Pilot Phase, projects have been conducted for a variety of timeframes, from 20 years (e.g., the Protected Areas Project in Costa Rica, Trines, 1998) to 99 years (e.g., the Face Foundation’s projects, Verweij and Emmer, 1998). Most projects state that their GHG benefits are expected to be maintained beyond the project timeframe (see list of AIJ projects in UNFCCC website) although their contractual arrangements for maintenance of these stocks are for a finite period. This lack of definition has caused uncertainty to all parties involved, from regulatory bodies to project developers and investors.

There is a need, therefore, to determine on what timeframe should be used as the basis for quantification of the GHG benefits of a project. This should not be confused with the timeframe under which a project will be conducted (see below). Different timeframes or approaches have been proposed:

a) Perpetuity – carbon stocks have to be maintained forever. This argument is based on the assumption that the “reversal” of GHG benefits of a project at any point in time would totally invalidate a project (Maclaren, 1999), and that only maintenance of carbon stocks in perpetuity could counter the environmental effects of GHG emissions from fossil fuel sources.

b) 100 years – carbon stored by a project has to be maintained for a period of 100 years to be consistent with the Kyoto Protocol’s adoption of the IPCC’s GWPs (Article 5.3) and of a 100-year reference timeframe (Addendum to the Protocol, Decision 2/CP.3, para. 3) for calculation of the Absolute Global Warming Potential (AGWP) for CO_2. While this concept has limitations, it has been adopted for use in the Kyoto Protocol to account for total emissions of the greenhouse gases on a CO_2-equivalent basis.

c) Crediting period – the Marrakech Accords fix the crediting periods of projects to either 7 years, renewable, or 10 years. Does it imply that carbon storage is also limited to these periods ? (see box on Policy Decision 1).

d) Equivalence based - the carbon stocks of land use projects have to be maintained until they counteract the effect of an equivalent amount of GHGs emitted to the atmosphere, estimated based on the cumulative radiative forcing effect of a pulse emission of CO_2 during its residence in the atmosphere (its AGWP; IPCC, 1992). Variations of this concept have been developed, proposing minimum timeframes of 55 years (Moura-Costa and Wilson, 2000) or 100 years (Fearnside *et al.,* 2000). If the ton-year method is to be used, this equivalence timeframe must be defined.

e) Variable - acknowledging that different projects may have different operational lifetimes. Given the wide range of timeframes of projects carried out during the AIJ Pilot Phase, it can be implied that this has been the approach adopted during that period.

The adoption of standard definitions of the minimum required timeframe for carbon storage, analysis and/or crediting, would greatly facilitate consistency in accounting for GHG benefits of different projects. It would also reduce the uncertainty of all parties involved in project development (project developers, investors, certifiers, regulatory bodies, and the general public). See box on Policy Decision 2, for further discussion. It is important, however, to distinguish between the required timeframe for storage, and the timeframe under which a project will be conducted (see Box 1).

Box 1 : Difference between minimum required and actual project duration

Irrespective of the requirement of timeframes for carbon storage, carbon stocks may in reality be release at earlier points in time. This could be due to various reasons, such as accidental events (fire, invasions, illegal logging, etc.) or voluntary choice of changing the land use adopted by the project (e.g. conversion from forestry to agriculture or urban development).

If this re-emission happens before the minimum time frame required (as discussed in Section 4.1 and Policy Decision box 2), projects will be penalised by having to account for this re-emission somehow (see discussion in Section 4.2 and Policy Decision box 3).

It is important, therefore, to remember that the determination of a minimum required timeframe only serves as a parameter for the analysis of how to calculate the penalty for re-emission of carbon stocks created by the project, and not necessarily a mandate to maintain a certain piece of land locked with the same land use for the required period of storage. This distinction is very important because it provides a feeling of much greater flexibility to project developers, which can select the most appropriate duration of carbon storage and land use, depending on their circumstances and ability to deal with the liabilities associated with re-emission of carbon stored.

This flexibility is very important since it helps to counter some of the criticism of the requirement for perpetual projects, which include: 1) it is impossible to guarantee that a project will be run in perpetuity; 2) maintenance of projects in perpetuity may create conflicts with other land uses in the long term; 3) because of the decay pattern of GHGs in the atmosphere, there may be no need for mitigation effects to be perpetual.

Policy Decision 2: What is the minimum timeframe required for carbon storage ?

A requirement of the Kyoto Protocol is that projects must result in “real, measurable and long-term benefits related to the mitigation of climate change”. The definition of “long-term”, however, varies substantially, and there is no consensus regarding how it relates to a minimum timeframe for project duration. There is a need, therefore, to agree on what timeframe should be used as the basis for quantification of the GHG benefits of a project. Different timeframes or approaches have been proposed. The pros and cons of each choice are discussed in the table below, and a recommendation is provided.

	Advantages	**Disadvantages**
Perpetuity	> Simplicity of analysis, since it does not require more elaborate estimations of the temporal value of carbon storage. > Environmental integrity, given the use of a conservative requirement for perpetual maintenance of stocks > Equivalent treatment to other non-LUCF types of GHG sources.	> Does not reward for duration of storage, by not differentiating projects that run for different timeframes > Depending on the way it is treated, it leads to the need of long term guarantees > Leads to the “locking up” of land in a single land use, an issue strongly objected to by host nations.
100 years	> Simplicity, since it is based on a fixed timeframe. > Finite, reducing the concerns regarding perpetual liabilities and “locking up of land”. > Although finite, it is a reasonably long time frame, ensuring long term maintenance of carbon stocks. > Compatible with the IPCC’s timeframes for GWP analysis.	> The 100 year timeframe is arbitrarily chosen, and does not necessarily reflect the period under which carbon storage reaches equivalence with avoided emissions
Equivalence based	> Fairness - Time frame is accurately defined according to the actual atmospheric “value” of carbon storage and equivalence to avoided emissions.	> Uncertainty related to the environmental value of carbon storage. > Depending on its use, it could reduce incentives for LUCF projects.
7, 14, 21 or 10 years (according to crediting periods)	> Simplicity and ease of monitoring, since storage is restricted to the crediting period, during which the project will be actively managed and monitored.	> Incompatible with requirements for long term storage. > Incompatible with long term growth cycles of forests > Arbitrarily chosen
Variable	> Simplicity and flexibility, since periods of storage are determined in accordance with project’s circumstance and biological cycle.	> Unfairness – it allows projects to select any timeframe, consequently reducing incentive and/or obligation for long term storage > These arbitrary timeframes do not have any link with the period under which carbon storage reaches equivalence with avoided emissions

Recommendation:

While the equivalence-based approach is perhaps the most appropriate, the complexity involved in the determination of its variables, the alleged uncertainties about the scientific base and the desire of policy makers to adopt a simple approach militate against the adoption of this method.

While the perpetual timeframe at first suggests the locking of land forever, if a flexible approach is adopted with regards to the replacement of credits after re-emissions, this may actually provide a flexible and simple compromise. With the same caveats, the 100-year timeframe can be recommended, given that it requires a long timeframe of storage, but allows for shorter timeframes subject to penalties for non-compliance.

4.2. How should projects that store carbon for a shorter timeframe be treated ?

Once the minimum timeframe for carbon storage has been defined, it is also important to decide how to treat projects that store carbon for a shorter period. Two options can be listed:

a) Full liability – in the event of re-emission of carbon stocks, projects or developers should return an amount of credits equal to the total amount of GHGs released. Essentially, projects receive credits as carbon is fixed, and have to return or replace credits if stocks of carbon diminish.

b) Proportional liability - projects should be debited an amount of credits proportional to the difference between the minimum required timeframe and the actual project duration (the "period of non-compliance'). This method is only applicable if a finite minimum project duration is adopted. If, for instance, a minimum timeframe of 100 years is adopted, a plantation project which is harvested without replanting at 60 years (assuming that all carbon is released to the atmosphere), would have to return an amount of credits proportional to the liability for not maintaining carbon stocks for the last 40 years of the required timeframe.

Undoubtedly, irrespective of the method used for calculating the amount of credits to be replaced after re-emissions, it remains the risk of whether the project will be able to meet this liability in the future. In order to mitigate this risk, a series of risk management tools have been proposed for GHG mitigation projects (see Section 8).

Policy Decision 3: How should projects with shorter timeframes be treated ?

Once the minimum timeframe for carbon storage has been defined, it is also important to decide how to treat projects that store carbon for a period shorter than the minimum required timeframe. Two options can be listed, and their pros and cons are discussed in the table below.

	Advantages	Disadvantages
Full liability	> Simplicity, given that it does not require knowledge of previous duration of storage > Environmental integrity, given the conservatism of this approach Comment: This is the only option possible if the requirement for perpetual storage is adopted.	> Reduces the incentive for longer maintenance of C stocks, given that the liability for re-emissions remains the same irrespective of the period of carbon storage. This is particularly so in the earlier, rather than later years (see comment in the cell below)
Proportional liability	> Fairness – it provides differentiated penalties for re-emissions depending on the duration of storage > Incentivise longer maintenance of carbon stocks, particularly in the early years of the project (in the longer term, financial discounting erodes this incentive) Comment: The use of this option is not possible if the requirement for perpetual storage is adopted	> Reduces incentive for very long term maintenance of carbon stocks, given that the effects of financial discounting on liabilities occurring after 50 years reduces their value to nearly zero.

Recommendation:

In essence, a proportional liability approach is a fairer choice, given that it provides incentives and rewards for longer periods of storage. This decision, however, is intrinsically linked to that of a minimum timeframe for carbon storage, given that the full liability approach is the only possible choice if the requirement for perpetual storage is adopted.

5. Carbon accounting methods

Various approaches have been used to measure the greenhouse gas (GHG) mitigation effectiveness of land use and forestry projects. These approaches differ predominantly in the way in which they treat the variables discussed in Section 4 above. These methods are discussed below, and a summary of the assumptions implicit in each method are shown in Table 2. To illustrate the application of some these methods, this paper will refer to two theoretical forestry-based GHG mitigation projects, as follows:

- Project 1: a forest plantation run for three rotations of 18 years each, in a total of 54 years. It is assumed that at the end of each rotation the carbon stock in the forest reaches 140 t C/ha, that harvesting reduces carbon stocks to zero, and that the baseline is zero. At the end of the 54th year, the project is discontinued and the carbon stocks reverse to zero.
- Project 2: a forest conservation project, avoiding the release of 140 t C/ha that would have been released over a period of 18 years. The project will put in place measures to protect this forest in perpetuity, but a period of 54 years was adopted for the quantification analyses.

5.1. Stock change method

The method most commonly used for expressing carbon storage is based on calculating the changes in carbon stocks of a project and its baseline during a given period of time (either the duration of the project, in the case of CDM projects, or the period 2008-2012, for JI projects). This method is referred to as the *stock change method* (previously referred to as the *flow summation method*), and measurements are usually expressed in $tCha^{-1}$. It provides projects with credits as carbon is fixed (or emissions are avoided), and credits are returned when carbon is released back to the atmosphere, irrespective of the period of storage. In effect, in environmental terms the stock change method produces a ‘zero-sum game’ in which projects may need to return all credits earned if, for example, afforested lands are converted back to non-forest land use.

For the afforestation project illustrated in Figure 1, credits will be earned during the growth phases, and returned when these forests are harvested in years 18, 36 and 54. This relates to a single forest stand. If a project involves the staggered planting of stands on a yearly basis, reaching an even age-class distribution, the debits from harvesting single stands is compensated by the credits earned in the other stands. For the forest protection project shown in Figure 2, credits are earned during the period in which it would have been lost in the absence of the project (initial 18 years), and kept by the project developer (or the investor) unless these carbon stocks are released to the atmosphere at some point in the future.

Stock change is the method currently adopted for carbon accounting in Annex 1 countries (Watson et al., 2000), given that it is consistent with the methods used for national GHG accounting (IPCC 1996). In the context of Annex 1 countries, if forestry activities are maintained forever (e.g., through harvests followed by replanting), project developers will not have to return the credits earned during the establishment phase of the forest. In the context of CDM, however, such forestry activities may be treated as ‘projects’ with limited timeframes, creating an inevitable liability at the end of the project. Depending on the extent of this liability, this could invalidate projects. This inconsistency suggests that different carbon accounting systems may be needed for projects in the CDM.

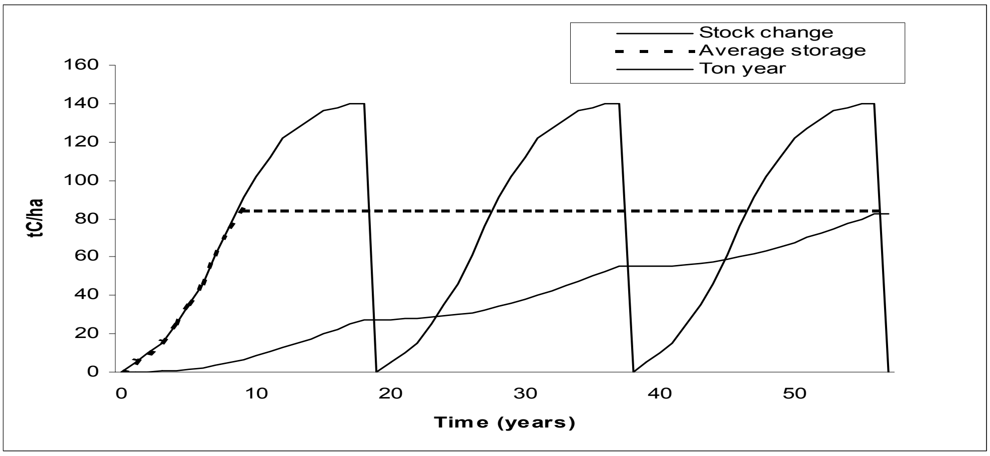

Figure 1. Projection of cumulative carbon credits generated by a hypothetical plantation project over three rotations. For simplicity, it is assumed that the baseline is zero, harvesting leads to an immediate release of all carbon stored, and that equilibrium of carbon pools is reached in the first rotation cycle. The effects of the different carbon accounting methods is shown.

(Note: This example simplifies possible carbon flows on the stand level and is used to demonstrate the application of accounting methodologies on systems with predetermined fluxes over time. In some cases, these fluxes might be less pronounced, for example if a landscape rather than stand level approach is taken, or if slash is left on site. Either way, any accounting methodology must be able to deal with losses and gains in carbon storage over time.)

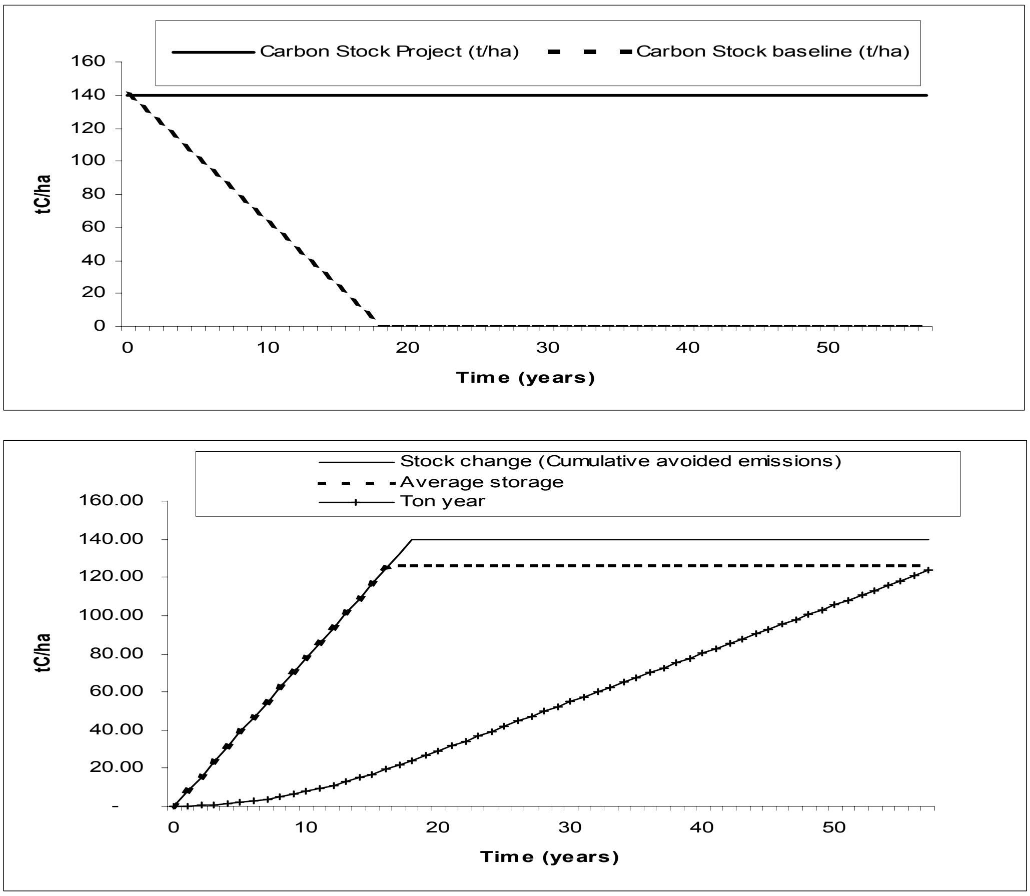

Figure 2 (a and b). Above**:** Projection of carbon stocks in a conservation project and its deforestation baseline. Below: Cumulative amount of credits earned by this project, calculated using the different carbon accounting methods.

5.2. Average storage method

An inherent problem of the stock change method is that it involves frequent exchanges of credits and debits of carbon between project developers and buyers or regulatory bodies. This is particularly so in the case of dynamic systems, e.g., afforestation projects, in which planting, harvesting and replanting operations take place. In order to account for the carbon benefits of such systems, an alternative approach has been used (e.g., Dixon *et al.,* 1991; Masera, 1995) called the *average storage method* (Schroeder, 1992). This method consists of averaging the amount of carbon stored in a site over the long-term according to the following equation:

$$Average\ net\ carbon\ storage\ (t\,C) = \frac{\sum_{t=0}^{t=n} (carbon\ stored\ in\ project - carbon\ stored\ in\ baseline), in\ tC}{n\ (years)}$$

where t is time, n is the project time frame (years), and measurements are expressed in $tC.ha^{-1}$. According to this method, the project receives credits as carbon is fixed, until it reaches the average storage calculated for the whole project timeframe. As long as the project is developed according to its original plan, there is no need to return carbon credits when carbon stocks reduce below the average, as in the case of commercial harvests (see Figure 1). A similar effect can be achieved by managing a range of sites of different ages, thus attaining average carbon storage overall. However, unless areas are evenly distributed in terms of age class, species, growth rates etc. some overall averaging may still be required. In the case of conservation projects, the calculated average storage tends to equal the actual amount of carbon stored (Figure 2), so this method is not commonly used for this type of project.

The advantage of this method is that it simplifies the process of credit allocation, while still accounting for the dynamics of carbon storage over the whole project duration, not only at the times chosen for accounting. However, a weakness of this method relates to the still subjective time frame, *n*, chosen for running the analysis. In the case of Figure 1, e.g., the average net carbon storage would be equal whether the calculation was performed for one, two, or infinite rotations, as long as the denominator chosen for equation above coincided with the last year of a rotation. There is a need for determining a fixed denominator based on a stipulated period of project duration.

5.3. Ton-year approaches

Alternative approaches have been proposed to better address the temporal dimension of carbon storage. Most of these are based on adopting a two-dimensional measurement unit that reflects storage and time, i.e., the ton-C year. The concept of a ton-year unit has been proposed by many authors (Moura-Costa, 1996; Fearnside, 1997; Chomitz, 1998; Tipper and de Jong, 1998; Moura-Costa and Wilson, 2000; Fearnside et al., 2000). The general concept of the ton-year approach is in the application of a factor to convert the climatic effect of temporal carbon storage to an equivalent amount of avoided emissions (this factor is referred to as the *equivalence factor*, E_f, and varies from 0.007 to 0.02) (Dobes *et al*., 1999; Tipper and de Jong, 1998; Moura-Costa and Wilson, 2000). This factor is derived from the "*equivalence time*" concept (referred to as *Te*), i.e., the length of time that CO_2 must be stored as carbon in biomass or soil for it to prevent the cumulative radiative forcing effect exerted by a similar amount of CO_2 during its residence in the atmosphere (Moura-Costa and

Wilson, 2000). Different applications have been proposed for the equivalence factor (Moura-Costa and Wilson, 2000) but in this paper only the straight ton-year yearly crediting method will be used for analyses. Figures 1 and 2 illustrate the effects of ton-year accounting on crediting for the same forestry projects.

If an *equivalence factor* ton-year approach is used, carbon storage could be credited according to the time frame over which storage takes place. Such a crediting system would reduce the need for long-term guarantees and hence the risks associated with long time frames. The main disadvantage of this method is that, depending on the manner in which ton-year accounting is used, it may delay the disbursement of credits to project developers, discouraging the implementation of forestry-based GHG mitigation projects.

Given that the delay in crediting caused by the direct application of the ton-year method would greatly discourage the implementation of forestry-based GHG mitigation projects, variations of this method have been proposed to circumvent this problem (Moura-Costa and Wilson, 2000). These are:

- *Stock change crediting with ton-year liability adjustment* – giving projects credits according to the stock change method, but using ton-years to calculate the amount of credits to be removed in the case of any non-compliance (in the case of occurrence of risk-related events). This would reduce the disadvantage of using ton-year crediting, by allowing early crediting according to the stock change method;
- *Equivalence-adjusted average storage,* using T_e as the denominator of the *average storage* equation. This method could be used to standardize the way in which the average storage method is currently used;
- *Ex-ante ton-year crediting* – giving projects an amount of credits at the beginning of the project, according to the planned project duration, using the ton-year approach. This would reduce the disadvantages that delayed crediting would create to project developers, but increases risks associated with non-compliance to the project's objectives;
- *Leasing – combined ton-year and temporary crediting (Dutschke, 2001)* – combines the ton-year accounting with the temporary crediting approach (see Table 1, below).

5.4. Temporary crediting

A number of proposals have been put forward that explicitly treat sequestration projects as a temporary service. The offset carbon may only be stored for a limited period of time, after which it may be re-released into the atmosphere. Such proposals include:

- expiring CERs (Colombian proposal 2000, Blanco and Forner 2000, Chomitz 2000);
- carbon 'rental' (Marland *et al.*, 2001), and
- carbon 'leasing' (Moura Costa, 1996, Dutschke, 2001).

These are outlined in brief in Table 1. For these approaches, the Certified Emission Reduction (CER) or carbon offset unit, is considered a temporary unit and will further be referred to as a temporary

CER or tCER[1]. Provided that the treatment of re-emissions is appropriate, the environmental integrity of using temporary credits is ensured.

Table 1: - Proposed systems for temporary crediting of land use projects.

Source	**Temporary crediting system proposed**
Blanco and Forner (2000), Ministry of the Environment, Colombia (2000)	The "Colombian Proposal": expiring CERs. Propose that CERs have an associated expiration time, after which the acquiring party has to replace the equivalent amount of CO2 with a permanent CER, new expiring CERs or an extra emission reduction. If carbon is released during the project lifetime, the project proponent is fully liable for the CERs that have been used for compliance. Flexibility remains with the project to specify the period of time over which the carbon will be stored. No strict relationship between the date of certification and the date of use for compliance is proposed, i.e. CERs are fully bankable and can be retired whenever the acquiring party decides to do so.
Chomitz (2000)	Variation on the 'Colombian proposal', bundling LUCF activities with subsequent emissions reduction activities. Assigning a period of 5 years to sequestration-based CERs, based on the length of a commitment period.
Moura Costa (1996)	Proposes that credits are rented (leased) rather than sold, with no established expiration date. The renting contract for emissions credits would establish continuous responsibility for sequestered carbon. Duration of the renting contract is at the discretion of the contracting parties. Price of rented credits to be adjusted in relation to permanent emission reductions.
Marland e*t al.* (2001)	Variation on the 'Colombian proposal' whereby credits are rented rather than sold, with no established expiration date. The rental contract for emissions credits would establish continuous responsibility for sequestered carbon. Duration of rental is at the discretion of the contracting parties.
Loisel / ONF (2001) (see OECD)	Renewable temporary crediting. Credits from certified sequestration activities are valid for 5-year periods, after which they can be renewed or cancelled. Similar to the Chomitz approach.
Dutschke (2001)	Leasing approach is proposed that combines the ton-year and Colombian approaches (i.e. ton-year with temporary crediting). Minimum leasing period of 15 years is proposed.
Schlamadinger *et al.,* unpublished	Includes a review of various temporary crediting approaches, and a proposal for accounting for temporary credits at the Annex 1 country level. Unpublished, but submitted to UNFCCC.

Proponents of temporary crediting have discussed what should be different variables related to the application of this approach, as follows:

a) The rental period, or 'expiry date', of the temporary 'carbon unit' (tCER).

Proposals include:

- *A fixed rental period* – a specified period, e.g. 5, 10, 20 or 100 years, which applies for all LUCF projects.
- *Flexible rental periods* – which would be proposed by the project developers and therefore can have different lengths of time (for example, based on project planning and verification visits).

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[1] Most of the discussions surrounding temporary crediting have applied the concept to land use projects in the Clean Development Mechanism of the Kyoto Protocol. For such projects the carbon unit is the Certified Emission Reduction (CER).

b) How to account for the re-emissions possibly associated with the temporary units (tCER).

Different options have been proposed:

- Extending the tCER on the original project (tCER renewal);
- Replacing the tCER with a tCER from another project;
- Replacing the tCER with a permanent CER or ERU.

c) Project duration

As discussed in Section 4, even though the temporary nature of the carbon product provides an opportunity for projects to sell offsets for short periods of time (e.g. 5 years) and therefore terminate project activities, it is important to determine for how long the responsibility to maintain carbon stocks (or account for remissions) remain.

d) The accounting methodology used to calculate the number of tCER's generated over the rental period.

Irrespective of how to deal with the issues above, the volume of tCERs created has to be determined according to one of the 3 basic accounting methodologies discussed in Sections 5.1, 5.2 and 5.3 above.

The applications of these parameters are illustrated in Figure 1 below.

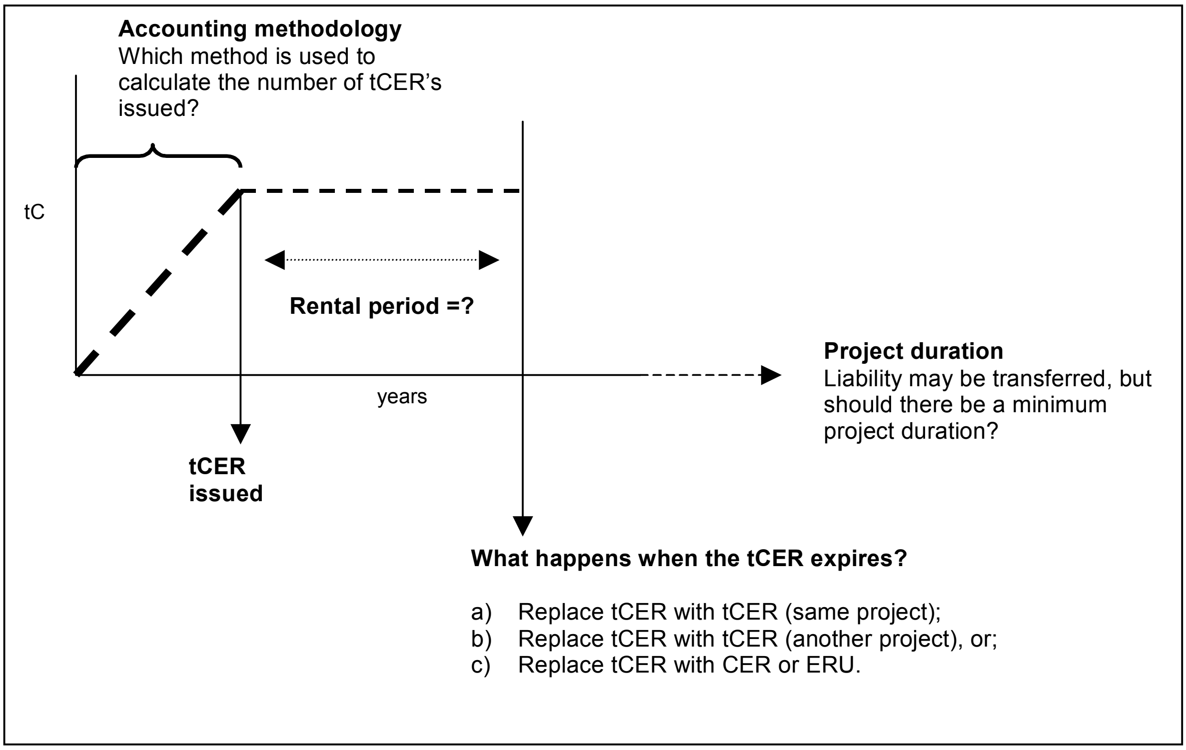

Figure 1: Schematic representation of the questions relating to tCERs and carbon rental:

Table 2: Permanence-related parameters underpinning different carbon accounting methods.

Method	**Minimum time frame for storage**	**Treatment of liability for re-emissions**
Stock change	Perpetual, but could use 100 years or any other period	Currently full liability, but it could be adapted to a system of proportional liability
Average storage	Undetermined	Not determined
Ton years	Not needed, since credits are given proportionally to time of storage	No liability associated with this method
Colombian proposal and other temporary CER methods	Undetermined requirement, but most treat the analysis with a requirement for perpetual storage	Full liability. At the time of replacement, this is done for the full amount of credits originally claimed

7. Financial transactions based on carbon credits

It is often the case that the accounting for the environmental value of greenhouse gas (GHG) mitigation projects gets confused with the arrangements for project financing or commercialization of carbon credits. The objective of “carbon accounting” is to determine the environmental (i.e. atmospheric) value of GHG mitigation projects. While environmental benefits accrue depending on when a unit of carbon is removed or released to the atmosphere and the duration of carbon storage, financial transactions can occur at any point in time, before, during or after the project lifetime. In order to maintain the environmental integrity of the system, however, it must be ensured that:

- Only after carbon has been fixed (or its emissions avoided) can the credits be used for the purposes of compliance to Kyoto targets (i.e., to compensate for emissions taking place elsewhere); never before.
- If financial transactions take place before the full environmental benefit of the carbon credits is fulfilled (i.e., that an equivalent amount of carbon is stored for a given amount of time), there must be contractual obligations to ensure that storage will take place, or determining responsibility for the liability associated with storage periods shorter than contracted.

8. Risk management tools

Risk management tools can be used to complement accounting procedures and prevent the negative impact of non-permanent land use activities. Given the long-term nature of many forestry investments, the idea of managing natural resources for long timeframes is not a new one. In many temperate countries, forests are already managed for very long rotations, reaching up to 120 years for some species (e.g., oak). Furthermore, initiatives that promote sustainable forest management, such as the Forest Stewardship Council (FSC), are becoming more widespread and with their adoption the risk of unpredicted land use change is decreased. Any mechanism that reduces risks will increase the credibility of a project and the value of the carbon credits generated by it, and therefore increases the likelihood of long-term success. Risk mitigation can be done through a variety of internal and external mechanisms to the project. ***Internal methods*** include:

- ***Introduction of good practice management systems*** to control occurrence of damaging events, and reduce the risk of unpredicted carbon losses;
- ***Project design and diversification*** of activities within a project, and spreading of projects in different areas, reducing risks of damage spreading (e.g., fire, pests and diseases, flood.). By diversifying projects to include forest protection, plantations, and bioenergy, multiple risk factors can be reduced through increased social acceptability of the project to hosts and sponsors, diversified income streams, lowered siting costs, natural biocontrols, decreased edge effects, and general ecosystem resilience;
- ***Self-insurance reserves*** or keeping a portion of the project's benefits as a reserve to ensure for any shortfalls. This reserve could be financial or in kind (GHG benefits). This approach was used by the national program of the Costa Rican Office for Joint Implementation, which placed about 40% of the credits derived from this project in a self insurance buffer reserve. In case of non-occurrence of damage, this reserve can be used at the end of the project life time;
- ***Diversification of sources of funding***, reducing financial dependency on a single source;
- ***Stakeholder involvement***, through a consultation and participatory management approach;
- ***Creation of positive local side effects*** of hosting the project, such as the transfer of needed *technologies*, the fostering of local social developments, e.g. by job creation, or the creation of positive side effects on other local or regional environmental goals in the host country;
- ***Project auditing and external verification***, which may serve as a way to highlight project risks early on;
- ***Timed allocation of GHG benefits*** – if GHG benefits are only credited to project partners after they are fully realized, there will be less need for long term guarantees, and a lower perception of risk. This could be done by staggering sequestration and crediting, in order to sell carbon credits in the spot market.

External methods include*:*

- ***Financial insurance*** – some insurance companies are already offering services related to risk mitigation for carbon-offset projects. It is important to note that a series of project risks are common to non-GHG specific activities, and have been traditionally covered by standard insurance schemes, (such as forest insurance, fires, country risk insurance, etc.). No insurance company is presently offering insurance for non-permanence or non-delivery of carbon offsets;
- ***Cross-project insurance*** – through direct arrangements in which projects would guarantee each other, in kind.
- ***Guarantees*** – by combining guarantees among various parties, financial burden and risk of any one party will not be onerous. Guarantees are the life blood of most project endeavors resulting in the use of debt to finance the project. Guarantees can be provided by either of the various parties involved, in order to facilitate project implementation, credit creation, and the long term environmental integrity of GHG benefits;
- ***Hedging –*** hedging techniques desire to combine assets with options, forwards and futures (derivatives) to create a payoff profile that minimizes risk or maximizes the return payoff. In the area of JI/CDM, credit streams can be combined with derivatives to reduce risk. For example, the

seller of future credit stream can buy a call option to ensure the delivery of the credits to fulfill a forward contract. Options can also be used to hold a speculative position. Both call and put options for credits are available in today's nascent emissions trading market, though pricing remains highly differentiated.

9. Conclusions

The issue of permanence or non-permanence of GHG benefits associated with carbon storage remains one of the key technical difficulties related to land use and forestry projects. Whilst there is a lack of clarity at the policy level, a range of methodologies have been proposed for dealing with the problem and what remains is for decisions to be taken as to the appropriate method to be adopted. It may be the case that not one single methodology will be adopted, but a more flexible approach taken based on project typology.

This paper has reviewed the key variables involved in accounting for non-permanence and looks at the different methodologies proposed to date. A number of review articles on the topic of non-permanence of land use activities exist (OECD, 2001; Leining and Kerr, 2001; Sussman and Leining, 2002), some of which try to compare the methodologies for different project typologies (Moura Costa, 2002; Schlamadinger *et al.*, unpublished). In the second phase of this research, the methodologies outlined in this review report will be applied to a number of existing projects to compare the effects on carbon credit flows and financial outputs.

References

Blanco, J., Forner, C. 2000: Special Considerations Regarding the 'Expiring CERs' Proposal, The Ministry of the Environment, Colombia, for presentation to the International Forum on Enhancement of Japan's Private Sector's Re-afforestation Cooperation.

Chomitz, K.M., 2000: Evaluating Carbon Offsets from Forestry and Energy Projects: How do they Compare? World Bank Policy Research Working Paper 2357, New York, p25.

Dixon, R.K., P.E. Schroeder and J. Winjun (eds), 1991: *Assessment of promising forest management practices and technologies for enhancing the conservation and sequestration of atmospheric carbon and their costs at the site level*. Report of the US Environmental Protection Agency No. EPA/600/3-91/067. Environmental Research Laboratory, Corvallis, Oregon.

Dobes, L., I. Enting and C. Mitchell, 1998: Accounting for carbon sinks: the problem of time. In: Dobes, L. (ed.) *Trading Greenhouse emissions: some Australian perspectives*. Occasional papers No 115. Bureau of Transport Economics, Australia.

Dutschke, M. 2001: Permanence of CDM Forests or Non-permanence of Land use-related Carbon Credits? Hamburgisches Welt-Wirtschafts-Archiv (HWWA) Discussion Paper #134. Available at: http://www.hwwa.de/

Fearnside, P., 1997: Monitoring needs to transform Amazonian forest maintenance into a global warming-mitigation option. *Mitigation and Adaptation Strategies for Global Change* 2: 285-302.

Fearnside, P.M., D.A. Lashof and P. Moura-Costa, 2000: Accounting for time in mitigating global warming. *Mitigation and Adaptation Strategies for Global Change* (in press).

IPCC, 1992: *Climate Change 1992: The supplementary report to the IPCC scientific assessment*. Houghton.

IPCC 1996: *Revised 1996 Guidelines for National Greenhouse Gas Inventories.* Houghton, J.T., L.G. Meira Filho, B. Lim, K. Treanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, (Eds.). IPCC/OECD/IEA.

IPCC, 2000: Intergovernmental Panel on Climate Change Special Report on Land Use, Land Use Change and Forestry. Cambridge University Press.

Leining, C. and S. Kerr. 2001: Deciding the Eligibility of Land Use, Land-Use Change, and Forestry Projects Under the CMD: Negotiation Issues at COP6-bis. Washington, DC: Center for Clean Air Policy, July. Available at <www.ccap.org>

Loisel 2001.

Maclaren, P, 1999: Carbon accounting methodologies - a comparison of real-time, tonne-years, and one-off stock change approaches. Unpublished manuscript.

Marland, Fruit and Sedjo, 2001: Accounting for sequestered carbon: the question of permanence, Environmental Science and Policy 4: 259-268.

Masera, O.R., 1995: Carbon Mitigation Scenarios for Mexican Forests: Methodological Considerations and Results. *Interciencia* 20: 388-395.

Moura Costa, P. 1996. Tropical Forestry Practices for Carbon Sequestration. In: Dipterocarp Forest Ecosystems – Towards Sustainable Management. A. Schulte and D. Schone (Eds). *World Scientific*, Singapore, pp 308-334.

Moura-Costa, P. and C. Wilson, 2000: An equivalence factor between CO_2 avoided emissions and sequestration – description and applications in forestry. *Mitigation and Adaptation Strategies for Global Change* 5: 51-60.

Moura Costa, P. 2002 in Press. Carbon accounting, trading and the temporary nature of carbon storage. The Nature Conservancy and USAID.

OECD 2001.

Schlamadinger B. and G. Marland. 2000: Land Use and Global Climate Change: Forests, Land Mangement, and the Kyoto Protocol, Pew Center on Global Climate Change, Arlington VA. www.pewclimate.org/projects/land_use.cfm, pp. 8.

Schroeder, P., 1992: Carbon storage potential of short rotation tropical tree plantations. *Forest Ecology and Management* 50: 31-41.

Sussman and Leining, 2002

Tipper, R. and B.H. de Jong, 1998: Quantification and regulation of carbon offsets from forestry: comparison of alternative methodologies, with special reference to Chiapas, Mexico. *Commonwealth Forestry Review* 77: 219-228.

Trines, E., 1998: Assessing and monitoring carbon offset projects: the Costa Rican case. *Commonwealth Forestry Review* 77: 214-218.

Verweij, H.J.A. and I.M. Emmer, 1998: Implementing carbon sequestration projects in two contrasting areas: the Czech Republic and Uganda. *The Commonwealth Forestry Review* 77(3): 203-208.

Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken (eds.). 2000: Land Use, Land-Use Change, and Forestry. A Special Report of the IPCC. IPCC, Cambridge University Press, United Kingdom and New York, N.Y., USA.