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**FORESTRY PROJECTS: PERMANENCE,
CREDIT ACCOUNTING AND LIFETIME**

INFORMATION PAPER



FOREWORD

This document was prepared by the OECD Secretariat in October 2001 at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change. The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

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Executive Summary

Reforestation or afforestation activities sequester atmospheric carbon and can thus help offset the environmental impact of greenhouse gas emissions. Forestry projects under the Kyoto Protocol's Joint Implementation (JI) and Clean Development Mechanism (CDM), potentially offer an opportunity to sequester significant amounts of carbon at relatively low cost¹.

Carbon uptake and re-release (i.e. emissions) from forested areas is a natural part of the carbon cycle. However, there are risks that the net carbon uptake from a JI/CDM forestry project may be reduced at some point by re-release into the atmosphere, e.g. as a result of fire or pest attack. This reduction in carbon stocks is referred to here as the "permanence" issue. Re-release of carbon stored in afforestation or reforestation (A/R) CDM projects could result in reversing the climate benefits of projects, and could even increase global emissions.

This paper explores different crediting regimes that could be set up to credit forestry projects. These different crediting regimes affect the crediting lifetime of a project and incentives to encourage long-term sequestration. The design of these regimes can therefore be used to manage the environmental and economic impacts of premature carbon release from a project. Decisions on credit allocation need to be taken at an international level. This paper also identifies the different physical risks to carbon stock reduction and options by which these physical risks, and associated economic risks, could be managed by project participants. This paper focuses on CO₂, although forestry projects and carbon stock reduction can also impact emissions of other gases to some extent.

The risks of unplanned carbon stock reduction can be significant, particularly for some project types, such as monoculture plantations, and in some locations, such as in areas at high risk of encroachment. A reduction in carbon stocks can occur through natural or human-induced causes, and can have a severe impact on carbon stocks. Indeed, at extremes, a carbon stock reduction may entirely reverse the GHG mitigation impacts of a project. However, some of the physical risks to carbon sequestration can be managed or minimised. Assessing the importance of different risks, and planning the project accordingly, are important steps in risk mitigation and management.

There are several different ways in which credits from afforestation or reforestation (A/R) CDM projects could be allocated to project investors over time². How credits are allocated, over what time period, and with what liability provisions influences the economic incentives for investors to maintain a project. The options by which a crediting scheme could encourage long-term sequestration in projects, or reduce the environmental impact of a carbon stock reduction, are to:

- Issue "permanent" emission credits, but with the greatest proportion of credits being generated towards the end of the crediting lifetime;
- Issue "temporary" emission credits (e.g. as in the "Colombian proposal"); or

¹ Forestry projects can also have other (non-GHG) environmental impacts, including benefits such as reduced soil erosion or increased timber/food supply. However, this paper focuses on the GHG (and particularly the carbon) impacts of re/afforestation projects.

² There are fewer possibilities for crediting regimes for energy/industry projects because emission reductions generated by these projects are "permanent", and also because monitoring may take place every year (unlike forestry projects).

- Issue credits that reflect the environmental benefit of temporary sequestration (i.e. by using ton-year accounting).

Most crediting regimes examined would allocate permanent emissions credits for forestry projects. Permanent emission credits would remain valid indefinitely, i.e. would be able to be used for compliance purposes even in the event of a carbon stock reduction. There are different ways in which permanent credits can be allocated to projects. For example, all credits could be allocated in line with actual stock change, or with simplified or average sequestration over a particular time period. Alternatively, some or all credits could be withheld (e.g. under a delayed crediting or buffered crediting regime) until sequestration has been maintained for a specified time period. A third option would be to set up a “ton-year” crediting regime that allocates short-term sequestration activities small credits to reflect the environmental benefit of delaying (rather than reducing) a rise in GHG emissions.

This paper also examines two crediting regimes that would allocate temporary credits for project-based carbon sequestration, such as that proposed in the “Colombian proposal”. The first would require credits to be “repaid” after a specified time period - irrespective of whether or not the sequestration that generated the credits was maintained. The second regime, “renewable temporary crediting”, would allow credits to remain valid (and be used for compliance purposes) as long as the sequestration remained in place. However, if sequestration was reversed, the validity of credits would cease.

Crediting lifetimes of A/R projects may need to be longer - and potentially considerably longer - than crediting lifetimes for projects in the energy/industry sectors. This is because the benefits from A/R projects may accrue over longer periods of time than benefits from energy/industry projects. In addition, long crediting lifetimes may be needed for A/R projects to ensure that their potentially reversible benefits are indeed long-term.

Some potential crediting lifetimes could be established objectively, such as those that mirror the actual timing of carbon sequestration in a particular project. However, some regimes would need subjective choices on crediting lifetime, such as those that require carbon to be sequestered over X years before credits are allocated. The potential use of subjective criteria in determining how long a project should receive credits for can result in wide variations in crediting lifetime (e.g. by more than 100 years, for the example used in this paper).

The crediting regime and associated crediting lifetime for A/R projects also affect the economic attractiveness of projects to investors. In the afforestation example used in this paper, different crediting regimes could result in the net present value of credits from the project varying by a factor of 30 (using the same assumptions for carbon prices and discount rates). While this variation would be smaller for projects that re/afforest using fast-growing species, differences in the value of credits generated by a project could still be significant. However, despite large differences in the net present value of credits (revenue streams), projects similar to the one examined in this paper are likely to remain an economically attractive mitigation option under even the most cautious of crediting regimes.

The Kyoto Protocol and the Bonn Agreement outline certain criteria that need to be fulfilled in order for CDM projects to generate certified emission reductions (CERs). One of these is that projects need to lead to “real, measurable and long-term” benefits. Most of the crediting regimes explored in this paper cannot ensure this in the event of carbon stock reduction occurring (Tables 1 and 3). For example, credits allocated under the actual stock change regime would reflect real and measurable benefits. But if no liability were attached to the credits, the benefits would not be long-term if carbon sequestration was reversed. Under an average storage regime, credits would not represent “real” reductions in any particular year, although they would do over the whole crediting lifetime of a project if sequestration was permanent. And while setting up a ton-year crediting scheme could ensure long-term benefits, credits would not reflect

measurable benefits in any given year of crediting because of the assumptions needed to calculate these benefits.

The Bonn Agreement stipulates that any reversal of sequestration activities should be able to be a) accounted for and b) “at the appropriate point in time”. Unless liability provisions are attached to credits generated from forestry projects, only regimes that allocate short term and temporary credits can fulfil these criteria: permanent credits cannot, by definition, be recalled or rescinded in the event of a carbon stock reduction.

Table 1: Environmental and economic implications of different crediting regimes for a slow-growing CDM re/afforestation project

Crediting regime	Does this crediting regime a) ensure that credits allocated are			Can it account for carbon stock reduction?*	Relative economic attractiveness to investors**
	Real	Measurable	Long- term		
Actual stock change	++	++	--	No	++
Average or simplified***	Can vary from – to + (depending on crediting timeline)	Can vary: - or +	Can vary: -- to +	No	+++ to ++
Delayed crediting	++	++	++	Partially	--
Buffered crediting	++	+	++	Partially	+
Ton-year	+	--	++	Yes	--
Expiring temporary credits	+	+	-	Yes	+
Renewable temporary crediting	++	++	+	Yes	Could vary

* Assuming no liability rules are allocated to credits

** Calculated using a 5% discount rate and a constant price of carbon throughout the crediting life. The absolute and relative economic attractiveness of different crediting options vary with different assumptions on discount rates. If carbon prices increase (but at a lower rate than the discount rate) the variation in economic attractiveness between different crediting regimes would be reduced.

*** Credits allocated under the average crediting regime will only represent “real” benefits over the crediting lifetime if sequestration is permanent.

The three crediting regimes that come closest to both encouraging and reflecting real, long-term and measurable GHG project benefits are “delayed full crediting”, “buffered crediting”, and “renewable temporary crediting”. However, the delayed full crediting regime is unattractive, both from an economic and compliance point of view, as credits are only obtained far into the future. The “buffered crediting” regime would encourage long-term sequestration, and be more economically attractive to investors than some other crediting options. It would also result in a low, but non-negligible, risk of issuing permanent credits for sequestration that was subsequently reversed.

Allocating temporary, but renewable, credits for the GHG benefits of forestry projects could result in credits representing both real and measurable benefits. It would also limit the environmental effects of a reduction in carbon stocks. The economic attractiveness of such a project could vary, depending on the relative prices of temporary and permanent emissions credits. Nevertheless, a project that was likely to result in long-term sequestration is likely to be able to command a higher price than a project where risk management strategies have not been developed or implemented. Thus, allowing the validity of credits to be renewed if the sequestration was maintained may also encourage long-term sequestration.

1. Introduction

Reforestation or afforestation activities have the potential to sequester large amounts of carbon at relatively low prices. According to the Bonn Agreement (UNFCCC 2001), forest projects are eligible activities under the Kyoto Protocol's joint implementation (JI) and clean development mechanism (CDM)³. However, the level of CDM-based forestry credits that a country can use in meeting its emissions commitments is capped. As well as mitigating greenhouse gas emissions, forestry projects can also further have other positive environmental effects, such as reduced soil erosion.

As for mitigation projects in other sectors, there are risks involved in forestry projects. However, risk relevant only for forestry sector GHG mitigation projects is that of reversibility, i.e. the premature re-release of carbon stored in biomass. This is referred to as the "permanence" issue. Thus, options –of which there have been many proposed both within and outside of the UNFCCC negotiations – are being considered in order to offset or limit these risks. These include:

- options to deal with the economic consequences of potential reversibility of carbon sequestration;
- options for accounting regimes (as a method to address the risk of changing "lifetimes" for projects); and
- options for different emission crediting regimes .

The environmental impact of carbon stock reduction is different depending on whether it happens in a country with an emissions cap (i.e. in domestic actions or JI projects) or not (i.e. in CDM projects). From a carbon accounting perspective, non-permanent sequestration in a country with an emissions cap need not result in an environmental disbenefit, assuming that the carbon sequestered was re-emitted as CO₂ and that the carbon stock reduction in a forestry project was compensated for by emission reductions elsewhere. However, for projects occurring in CDM countries, a carbon stock reduction could result in significant environmental harm as any re-release would not necessarily be compensated for elsewhere. In terms of instantaneous warming, the damages would be even higher if the releases were of methane (CH₄) rather than CO₂.

This paper examines these different issues, and explores if and how they should be dealt with in rules set up to establish the running of forestry-related GHG mitigation projects. In order to assess these, the paper makes use of an example afforestation project.

1.1 Forest-based carbon stock dynamics

As forests grow, they accumulate carbon from the atmosphere via photosynthesis. This carbon sequestration follows an S-shaped curve (Figure 1). Carbon is contained in several 'pools', including above-ground biomass (trees, litter and woody debris that lie on the forest floor); below-ground biomass (roots and soil carbon) and harvested materials. CO₂ is also released from both vegetation and soils by the process of respiration.

In initial years after planting, carbon accumulation is slow, or can even be negative, reflecting soil disturbance during planting. This is followed by a period of rapid tree growth and associated carbon

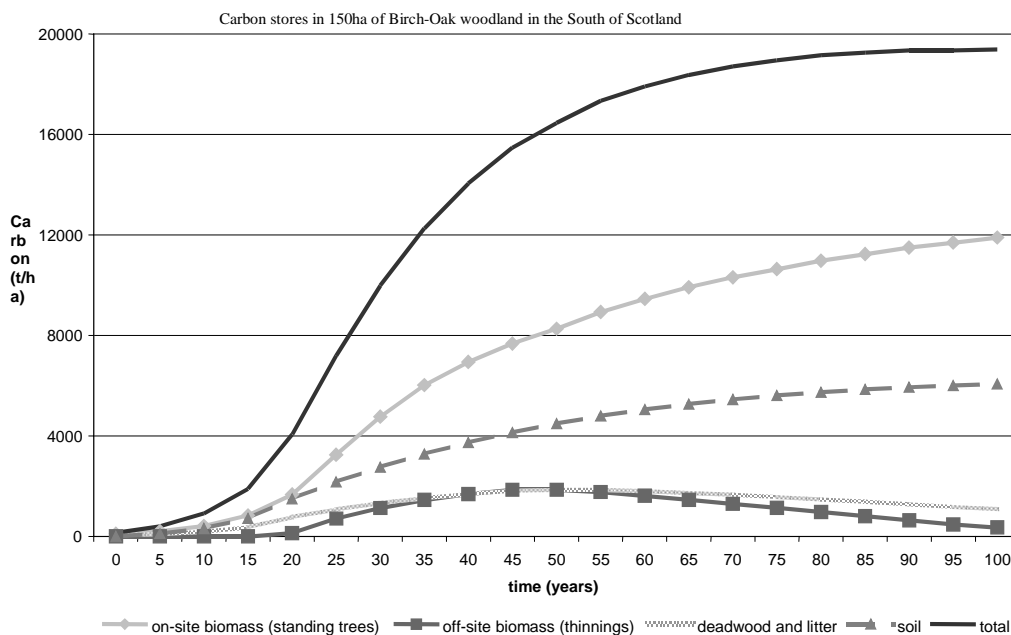
³ Eligible forestry activities in the CDM are limited, for the first commitment period, to afforestation and reforestation.

sequestration. When the trees are nearing maturity, the growth/sequestration rate declines, and net sequestration rate eventually drops to zero on maturity.

The time taken for a forest to reach maturity can range from 25 to more than 150 years, depending on the climatic zone and which species have been planted (Face 2001). This means that although plantations of fast growing species, particularly tropical pines, hardwoods and eucalyptus can store significant amounts of carbon within the first 20 years of a project, many other project-based sequestration activities will not.

The importance of the different carbon pools differs markedly for different forest types (IPCC 2000). Thus, the relative proportion of carbon sequestered above and below ground can vary significantly for different forest types (with the importance of carbon stocks in soil being much higher in boreal forest than in tropical forest, for example).

Figure 1: Carbon stores in 150ha of Birch-Oak woodland in the South of Scotland



Source: Tipper et. al. 2001

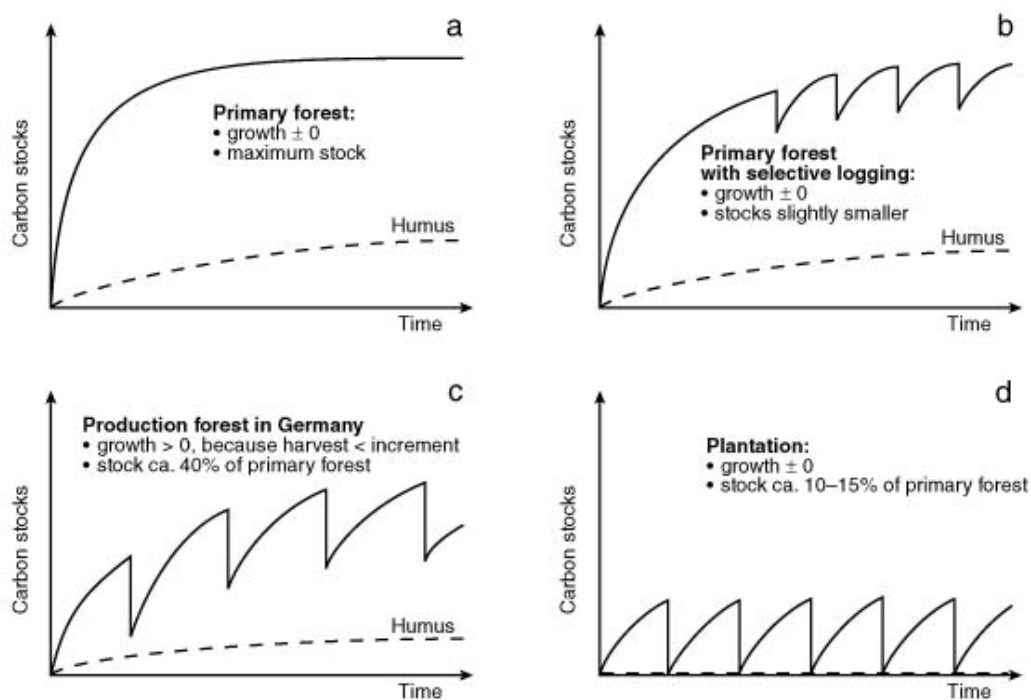
The total amount of carbon stored by a forest of a given area will vary according to:

- which species have been planted;
- climatic conditions (e.g. temperature and rainfall);
- site conditions (wind, pests, slope etc.);
- and site management (thinning, rotation length, felling, weeding).

The impact of different site management regimes on carbon stored is shown in Figure 2.

As well as influencing the carbon stored within a forest, management regimes such as drainage can also influence emissions of other gases (CH₄ and N₂O) in some forest ecosystems. These gases may also need to be taken into account when assessing the environmental benefits of a project. However, this paper will focus on the absorption and potential re-emission of CO₂, which accounts for the majority of GHG impacts in most re- or afforestation projects.

Figure 2: Carbon stocks in plantations, managed and un-managed forests



Source: WBGU 1998

2. Physical risks to carbon sequestration

Emitting one ton of carbon as CO₂ will affect the atmospheric concentration of CO₂ for as long as that CO₂ remains in the atmosphere. Thus, although emissions are accounted for in a particular year, their environmental effect is longer-lasting. According to the accounting rules set up under the Kyoto Protocol, the atmospheric effect of emitting one ton CO₂ in year X can be offset in that year by sequestering one ton CO₂ in the same year. However, the effect of the “offset” on atmospheric GHG concentrations will only remain for as long as the carbon contained in the offset remains sequestered.

Thus, the issue of “permanence” is of primary concern in any forestry-related project. At any point, the forest may burn, be cut or destroyed by pests – and the carbon stored may be re-released at some point (see, for example, Figure 2 which illustrates changes in carbon stocks following different harvesting regimes).

Both natural and human activities can lead to forest loss. For example, during the 1990s, nearly 16 million hectares of the Brazilian Amazon was deforested, and at least twice that surface of boreal forest was affected by fires (Lecocq and Chomitz, 2001). In 1999 alone, severe storms in Europe felled an estimated 193 million m³ of wood, the equivalent of more than 2 years’ harvest, in three days (ECE/FAO 2000).

The relative importance of different types of risk to carbon sequestration and storage in forests varies by project location. It may also vary for different sub-categories of re/afforestation type projects⁴. This section examines the different physical risks to carbon sequestration.

2.1 Naturally-occurring risks

Naturally-occurring events that can partially or completely reverse the carbon sequestration of a growing or mature forest include fires, pest or fungal attack, floods, droughts, hurricanes, volcanoes, earthquakes and landslides⁵. These events may have varying severity for the carbon sequestered in a forest (i.e. different events may reverse different proportions of carbon sequestered). The risk of some of these events, such as hurricanes, occurring on the site of a particular project during a particular period may be more difficult to predict than others, such as pest attack. Consequently, protective (or evasive) action may be more applicable for some risks than for others.

Analysis of some forestry GHG-mitigation projects has quantified some of these risks (e.g. SGS 2000a, b and c, Sumitomo 2001). Unsurprisingly, there is significant variation in the absolute and relative importance of the different types of risk in different projects/locations (SGS 2000a, b and c, Sumitomo 2001).

Insects and diseases are a natural part of a forest ecosystem. However, damage from pest or fungal attack can be of varying severity for the carbon sequestration potential of the trees. Effects can vary from tree mortality to loss of reproduction/regeneration potential, tree deformities and reduced resistance to other stresses such as drought.

⁴ For example, a monoculture plantation may be more likely to suffer attacks from pests than an agroforestry development.

⁵ Damage to saplings (young trees) from livestock grazing can also be a problem in the early years of a project, but would presumably be picked up by project monitoring activities.

Natural catastrophes such as floods, droughts or hurricanes, can all reverse carbon sequestration although the effect of different catastrophes can be different (both in terms of severity of impact on the standing trees, and in terms of the timing and type of GHG emitted). For example, trees killed by drought may be left standing, at least in the short-medium term; trees felled by hurricanes could decompose, be used as firewood, or be used in wood products, and forests affected by floods would have higher than anticipated methane emissions through increased anaerobic decomposition. In the case of flood damage, the CO₂ absorbed from the atmosphere via a project is re-emitted as CH₄, so the net environmental effect of that project will be negative, as CH₄ is a more potent GHG than CO₂.

The likelihood of some naturally-occurring risks such as floods and droughts may also be influenced by global warming. Global warming may also affect forest dieback (Hogg et. al. 2000) or the “fertilisation effect”. These indirect human-induced risks are not examined in this paper.

2.2 Fire

Fires can be human-induced (e.g. by arson or negligence) or natural (e.g. by lightning or volcanoes). Fire can occur at any point during the development of a forest, although the severity of damage (from a carbon sequestration standpoint) is likely to increase as the trees mature.

In some ecosystems, fire is a naturally-occurring event that is necessary to shape the landscape and/or to initiate regeneration of some types of vegetation, e.g. in northern boreal forests or tropical “monsoon” forests. Alternatively, fire can be a destructive and unnatural force, e.g. in equatorial rain forests (IFFN 2000). For example, equatorial rain forests are usually too moist to allow wildfire propagation, but fires can nevertheless occur in exploited areas in periods of extreme drought. Where fires are not naturally-occurring, they can also prevent forests from regenerating naturally, as burnt areas can be colonised by invasive and easily flammable species (which facilitates initiation of future fires) (FAO 1999). Naturally-occurring fires in tropical forests in Asia happen regularly, often during the El Niño-Southern Oscillation (ENSO) phenomenon.

Although data on forest fires are difficult to obtain, it appears that humans are often the main causes of fire in the tropics and sub-tropics (Landsberg 1999, FAO 1999). FAO/ECE data (FAO/ECE 2000) on forest fires in Europe and countries of the former Soviet Union indicate that in 1997 forest fires extended over 606,083 hectares (ha). The causes of these fires were known for 331,301 ha (55%) of these fires, and 80% (266,193 ha) of fires with a known origin were human-induced.

2.3 Human-induced risks

In addition to fires caused by human activity, direct anthropogenic risks to forests include encroachment and deforestation. Such activities release the above ground carbon (most rapidly when the area is burned) as well as the below-ground carbon (although this latter occurs over a longer time period).

Deforestation occurs for several reasons. These include a need for more food-producing agricultural land, for wood as fuel, and for infrastructure developments. Within a particular region, the risk of deforestation varies with project location⁶. For example, forests near small subsistence farmers and/or roads or rivers are likely to be at more risk of deforestation than forests far away from subsistence farmers, roads and rivers (Table 2).

⁶ The rate of deforestation and other land-use change is influenced by national/regional driving factors, such as population growth, forest ownership, infrastructure development etc.

Table 2: Expected percentage change of carbon stocks over-20 year period within a specified zone

Project location	Predisposing Factor: Distance from existing cultivated land		
	0-500 m	500-1500 m	>1500 m
Forest adjacent to small subsistence farming systems	-50	-30	-10
Forest adjacent to small commercial farming systems	-45	-30	-10
Forest adjacent to medium-scale farming systems	-20	-10	0
Forest adjacent to large-scale farming systems	-10	0	0

Source: *Tipper et. al. 2001*

The issues of permanent sequestration, deforestation and leakage are linked. However, this paper will only assess issues relating to whether sequestration is permanent on a particular project site⁷.

⁷ "Leakage" caused by deforestation may be best addressed when defining project boundaries and monitoring.

3. Risk management strategies

The environmental effect of natural or human-induced carbon stock reduction is identical, but the options used to deal with sequestration reversal may differ, depending on the source of risk⁸. Moreover, who is best placed to initiate risk management strategies will also vary. This section examines means to manage or reduce the physical, environmental or economic risks of non-permanent sequestration, and explores options that could be used by those involved in a particular project to deal with such risks.

There are two main options by which project investors (e.g. companies or governments) could deal with the risk of lower than expected emission credits being generated by a particular project. These are by taking steps to:

1. Reduce the likelihood of carbon stock reduction occurring; or
2. Manage the economic risk of carbon stock reduction, e.g. via insuring the project, or by diversifying project locations.

Managing the environmental risks associated with a reduction in carbon stocks can also be achieved in a number of ways. However, it may be appropriate to undertake this at an international level in order to ensure that similar projects are treated in a consistent, and transparent, manner.

3.1 Reduce the physical risk of carbon stock reduction occurring

Much of the risk that threatens to reverse carbon sequestration from forestry projects can be managed. The process of management requires a multi-step effort:

1. identifying the risk;
2. identifying possible risk reduction/management strategies;
3. implementation;
4. monitoring for effectiveness, and
5. revision of activities as necessary.

Clearly, to be effective, such a process must be ongoing and iterative.

Assessing the importance of different risk factors is an important first step in risk mitigation and management. Of course, risk factors are different for each risk assessed (fire, pests, encroachment etc.). In addition, risks are also different for different species and in different project locations and climates. Determining the importance of each may be a difficult task, and it may not be possible to generalise detailed risk management strategies for different A/R projects in different areas.

However, it is possible to lay out general guidance on risk avoidance. For example, it is important to carry out a risk assessment as early as possible in the planning process for a project, as risks can be minimised by effective planning.

⁸ The risks associated with investing in a forestry JI/CDM project are not limited to the physical and economic risks of carbon stock reduction. Other risks include uncertainties in the project baseline, which can substantially change the number of credits a project may receive. Political risks (e.g. non-enforcement of contracts) and institutional risks (e.g. change in policies or land tenure) may also be important. This section focuses on the physical risk of carbon sequestration being reversed, and does not treat the uncertainty-related risks associated with the calculation of a project's baseline or assessment of a project's performance, or with institutional, political or financial risks.

For example, general guidance on risk-avoidance for fire would include:

- Assessing the risk of fire (e.g. by investigating local fire history);
- Determining the likely sources of fire (because managing the risk of fires caused by different sources may be different);
- Collecting information on the prevailing winds, as this will influence the direction of the fire threat; and
- Establishing appropriate fire protection measures (e.g. organising the layout and management of an afforested area so that there are sufficient fire/windbreaks and low fuel zones⁹).

Susceptibility of re/afforested areas to pest attack can vary with age. In general, older stands are more susceptible to damage (Pöyry Consulting 1992), but some pests may attack younger trees only. This means that harvesting – which may form part of A/R projects - will increase the likelihood of some pest attacks, while reducing the risk of others (Pöyry Consulting 1992).

The likelihood of pest-attack in re/afforestation projects could be reduced by:

- Increasing diversity of species planted: monocultures, such as plantations, are more susceptible than a polycultural system, such as a natural forest, to pest attack (Schneider 1999, Phillips et. al. 2001).
- Ensuring that only healthy seedlings are planted, and that the species planted are suitable for the climatic and soil conditions of the project site (FAO 1989);
- Ensuring that the site is maintained effectively¹⁰.

Should a pest attack occur, there are various control methods available (e.g. biological, chemical, silvicultural or mechanical) to limit damage.

Methods needed to limit intentional deforestation of a re/afforested area will be somewhat different. Deforestation occurs because of social and cultural – as well as economic – pressures on land, so a project will need to be planned taking these different pressures into account. A good way of ensuring that a project is consistent with local development needs may be to involve the local population in a project development. Moreover, ensuring that the local population benefits directly from a project's continued operation (e.g. through income generation, food production, reduced soil erosion etc.) will increase the likelihood of an A/R project continuing into the future. The use of a physical buffer, e.g. two rows of fast-growing trees planted round the edge of a re/afforested area, may also be helpful in reducing the impact of encroachment on that area (providing the fast-growing trees are replanted).

The Kyoto text establishing CDM establishes a dual goal of contributing towards sustainable development as well as mitigating climate change. Many CDM projects, including those related to forest activities, may thus have benefits in addition to those related to carbon storage. These ancillary benefits may be local or

⁹ In order to propagate, fires need a supply of fuel (e.g. dead vegetation) at ground level. “Low fuel zones” are areas at ground level that are poor in the supplies of such fuel - either naturally, or through regular site maintenance/clearing.

¹⁰ This would include training those involved in maintaining the forest on how to limit damage during thinning operations.

regional in nature, e.g. soil conservation, creation of rural jobs and income. If ensuring carbon sequestration is permanent also maintains these ancillary benefits, involving the local population in project management may help by giving local people a strong incentive to maintain the project (see e.g. FAO 1999a, CIFOR 2000)¹¹, and finding ways to link these two objectives is important. However, such an analysis is a development issue and beyond the scope of this paper.

Avoiding siting re/afforestation projects on areas at risk of natural catastrophes, such as volcanic eruptions, earthquakes, floods or landslides, during a period of e.g. 100 years can reduce the risk of such catastrophes damaging a project. However, enough data will not always be available to carry out such an assessment.

3.2 Manage the economic risks of carbon stock reduction

Carbon stock reduction can also have economic effects on the “buyer” and/or the “seller” of emissions credits from forestry projects if a reduction in carbon stocks at the project site results in fewer emission credits being generated than expected.

Project actors can alleviate the economic impact of a carbon stock reduction by two main means. These include:

- Insuring a re/afforestation project against damage; and
- Diversifying emission mitigation activities.

While insurance would not change the likelihood of a project being damaged by particular risks, it could protect the investor from non-compliance with any emissions target even in the case of carbon stock reduction. Insurance would result in a payment being made to the project investor in case of damage. This payment could be used to buy emission credits from somewhere else. In some areas, e.g. Australia, it is possible to insure plantations against carbon stock reduction caused by certain risks (STTFN 2000).

Diversifying emission mitigation activities can help reduce both the economic and environmental impacts of carbon stock reductions from A/R projects. Diversification could include investing in A/R projects in different locations (which would reduce the economic impact of damage to one project). It could also include investing in other activities, e.g. those aiming at emission reductions.

3.3 Manage the environmental risk of carbon stock reduction

Strategies of physical risk avoidance and economic risk management may best be developed by those involved in the design and running of a project. However, decisions on how to reduce the environmental risk of forestry projects generating non-additional credits may be best addressed by the international community.

These strategies could include limiting the credit provided for a particular project in a manner commensurate with the risk of carbon stock reduction. This would reduce the likelihood that non-permanent sequestration credits were generated.

A number of allocation methods might be developed to limit the risk of a re/afforestation project generating non-additional credits, or credits that do not reflect long-term environmental benefits. These include:

¹¹ On the other hand, if the impacts of a JI/CDM project are predominantly negative on the local population (e.g. reducing access to sources of food or fuel), they will be no incentive to maintain the forest.

- excluding the areas of a project most at risk from carbon stock reduction, e.g. sections of afforested land nearest roads, as eligible to generate emission credits. However, this may be difficult and/or costly to put into practice, because it would need a detailed assessment of which parts of a particular project are most at risk, to which extent, and from what¹².
- incorporating the likely impact of carbon stock reduction activities such as deforestation in a project's baseline. This is feasible in theory (see e.g. Table 2). However, it will be easier to quantify some risks than others. Thus, incorporating a risk-analysis step during baseline development will complicate the already complex process of setting a baseline for a forestry project¹³.
- setting liability rules for the credits generated by JI/CDM projects. Many of the credit accounting schemes proposed in the literature and discussed below do not have liability consequences for either buyer or seller in the event of a carbon stock reduction. This means that if an afforestation project generated emission credits in year X, and the forest was destroyed and all sequestered carbon re-released in year X + 1, the "buyer" would still be able to use the emission credits generated in year X to offset emissions. Thus, if neither buyer nor seller is liable in case of carbon stock reduction, it would essentially mean that the environment carries the cost of a reversal in carbon sequestration.
- setting up a crediting regime in such a way as to encourage long-term sequestration and/or reduce the environmental impact of shorter-term sequestration. This will be examined in Section 4.

¹² It could also complicate project monitoring activities by partially segmenting a project (e.g. if roads run through the project site).

¹³ It may also be difficult to agree at what degree of confidence in a risk potential credits should be discounted.

4. Credit accounting regimes and project lifetime

There are several different ways in which sequestration credits from a reforestation or afforestation JI/CDM project could be allocated to the project's investor's over time¹⁴. Which regime is used will influence the environmental and economic performance of the project through the use of various crediting lifetimes and means to allocate credits. Different crediting regimes can also influence the risk of a project's carbon sequestration in a project being reversed or not.

The options by which a crediting scheme could reduce the risks of or account for potential reversibility of carbon sequestration are to:

- Issue "permanent" emission credits based on carbon stock changes, but e.g. with most credits being issues towards the end of a long crediting lifetime;
- Issue "temporary" emission credits that are only valid for a limited time period (e.g. as in the "Colombian proposal" submitted for SB13 (UNFCCC 2000); or
- Issue credits that reflect the environmental benefit of temporary sequestration (i.e. by using ton-year accounting).

This section examines how many emission credits would be generated by an afforestation project under different crediting regimes and when they would be allocated to the project developer¹⁵.

4.1 "Permanent" credits based on stock changes

IPCC (2000) outlines several potential stock-based crediting regimes for forestry projects. These crediting regimes can be divided into two general methods: those based purely on carbon stock change and those based on stock change but also accounting for risk of non-permanent sequestration. Both methods allocate "permanent" credits (i.e. once issued, the credits cannot be recalled). This means that it would be the environment - rather than the seller or buyer - who would be the loser in the event of a carbon stock reduction.

4.1.1 *Crediting regimes based purely on changes of carbon stocks*

Crediting regimes based purely on carbon stock changes include:

- Actual stock change;
- Simplified crediting; and
- Average storage crediting.

All three crediting regimes (outlined below) would result in the same number of credits being generated by a particular project, but at somewhat different times.

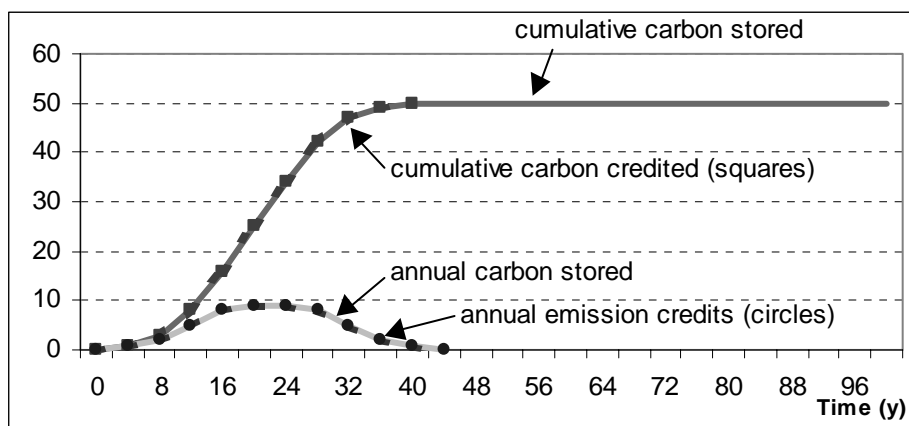
¹⁴ Fewer crediting regimes are applicable to crediting energy/industry projects because emission reductions generated by these projects are "permanent", and also because monitoring takes place every year.

¹⁵ The examples do not specify which carbon pool(s) are being monitored and credited. It could also be possible – although perhaps unnecessarily complex - to credit forestry projects using a mixture of crediting regimes for different pools. However, these possibilities are not examined in this paper.

Emission credits for non-forestry projects are likely to be generated on an annual basis, following monitoring and verification of the project output and performance. A potential regime similar to this, i.e. based on **actual stock change**, could be set up for forestry projects.

Under an actual stock change regime, project developers would become eligible for credits equivalent to all carbon sequestered in a project as soon as that sequestration has occurred (Figure 3). This type of crediting would have the advantage that any credits would be based on real and measurable carbon stock changes. However, actual stock change with “permanent” carbon credits would not ensure the permanence of the sequestration activity, as the investor would not have a financial incentive to maintain sequestration after the end of the crediting lifetime. Moreover, it could involve considerable monitoring efforts, if credits were to be monitored, and allocated annually (rather than on a 5y average, for example). It may also mean that investors would favour re/afforestation projects based on plantations of quick-growing species (whether or not those species are best adapted to the local conditions and population), as this would result in the quickest flow of credits to an investor¹⁶.

Figure 3: **Actual stock change crediting regime**



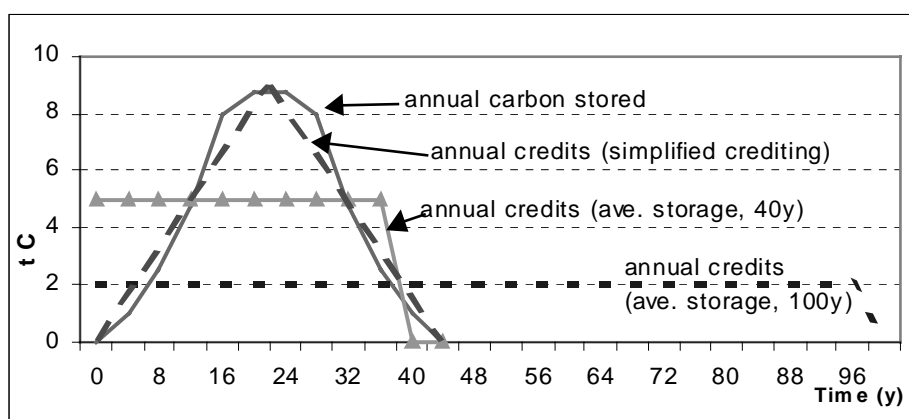
Simplified crediting (Figure 4) would be a simplified form of actual stock change crediting, with annual credits accruing linearly rather than following the curved pattern of actual carbon sequestration. Compared to the actual stock change regime, a few more credits would accrue at the beginning of a project, and a few less towards the end. Simplified crediting would be slightly more attractive to investors than carbon-year storage as the partial “front-loading” of credits increases the net present value of the project. Simplified crediting may also help reduce monitoring costs (which would need to be carried out once the forest reached maturity, but perhaps only periodically beforehand). However, this crediting regime would not encourage permanent sequestration once the forest was mature, and would even allocate credits over and above the carbon sequestered in the early years of a project.

¹⁶ This could have negative effects for biodiversity, particularly if the fast-growing species are not normally found in the project area.

Average storage crediting (Figure 4) would mean that annual credits from a particular project reflect the average carbon sequestered over a specified time period, n , rather than the actual carbon sequestered in that period. Many different time periods could be chosen (e.g. time taken for the forest to reach maturity, time until first harvest, 100 years), some of which would be subjective.

If sequestration is permanent, the sum of credits allocated to investors will reflect the total amount of carbon sequestered. However, the difference between average and actual sequestration can be significant in a particular year, so using this method would mean that in the early years of a project most of the credits allocated to investors would not reflect actual sequestration. This will not encourage long-term conservation of sequestered carbon, particularly if neither buyer or seller of credits need to “make good” any credits that were allocated but that did not reflect permanent carbon sequestration. Moreover, the period of time considered, n , could even make a difference to the number of credits allocated for some afforestation projects¹⁷. The advantages of this approach for investors include that the yearly flow of credits obtained would be predictable at the outset, and that the “front-loading” of credits greatly increases the net present value of a project.

Figure 4: **Simplified and average crediting regimes**



4.1.2 Carbon stock-based crediting regimes that also account for risk

Setting up a stock-based crediting regime that also takes into account the risk of non-permanent sequestration is also possible. Such regimes would include:

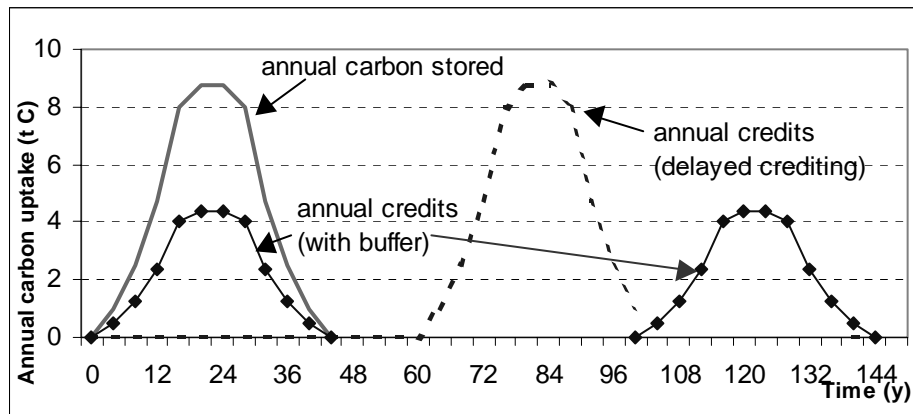
- Delayed full crediting;
- Buffered stock-change crediting.

Delayed full crediting (Figure 5) illustrates a situation where a project developer would be eligible for credits equivalent to all carbon sequestered in a project, but only after a specified time period. This would mean that carbon would need to be sequestered for the whole of a specified delay period (e.g. 10, 50 or 100 years) before being credited to the project developer. The advantage of this method is that it would encourage a greater degree of “permanence” than methods based solely on carbon stock change (depending on how long or short the specified time period was). However, choosing a long delay would also be likely

¹⁷ The choice of “ n ” could make a difference to the number of credits allocated to an afforestation project that involved harvesting and re-growth depending on whether n reflected a complete or partial growth/harvest cycle, or part of a growth/harvest/re-growth cycle.

to discourage investment in projects where credits would only be obtained far into the future, and would also “lock” land use into the sequestration activity for long periods of time, which may cause sovereignty concerns. Also, the length of any delay period would be a subjective decision.

Figure 5: **Delayed full crediting and stock change crediting with buffer**



Buffered stock change crediting (Figure 5) would allocate credits equivalent to a proportion of the change in carbon stocks. Thus, investors’ credits would reflect only a part of the stock change during the growth phase of the forest. The remaining, uncredited, stock change could be held in a buffer, and released at some future date (e.g. half of the credits accruing during the growth phase, and half after being sequestered for 100 years, as shown above). This effectively lengthens the crediting lifetime. This regime would have the advantage of limiting credits from non-permanent mitigation activities, while allowing a certain number of low-risk credits to be generated over the project lifetime. Of course, the disadvantage of this crediting regime to project investors would be that obtaining the number (and value) of credits contained in the buffer would be uncertain.

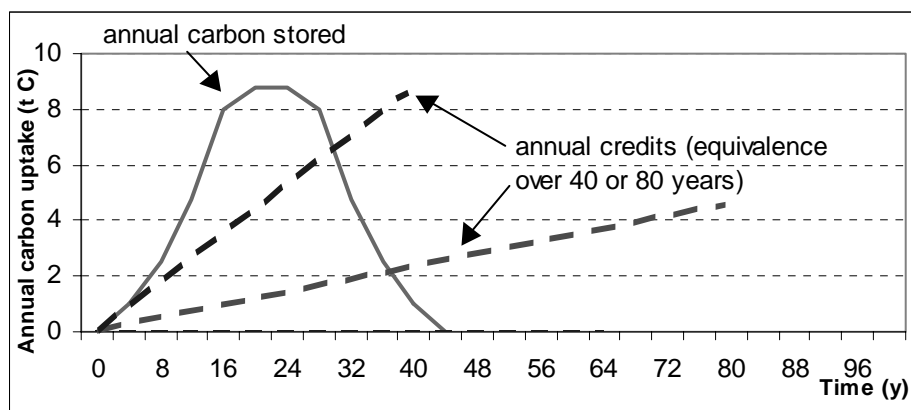
The buffer could be expressed either in percentage terms or in terms of land. The size of the buffer could be decided upon following an assessment of the different risks to carbon stock reduction by the project. This approach has been used to calculate the benefits of a few forestry-related projects (SGS 2000a, b and c), and buffers of significantly different size were found to be needed. The buffer for two of the projects above were 24% and 60% of total carbon sequestered (or 0.6 and 5.6 million tons of CO₂ respectively). Alternatively, which proportion of the credits should be held in the buffer could be decided subjectively (which would be cheaper, but may be difficult to reach agreement upon).

Although establishing a buffer is a simple exercise in theory, establishing a project-specific buffer built upon a quantitative assessment of different risks would be costly. It is also likely to be untransparent, because such an assessment is likely to involve expert judgement as well as detailed data. Moreover, given the potential variation in risks from site to site and the large scale of some projects, there could be significant economic incentives for the investor to reduce the size of a buffer. Alternatively, establishing a generic buffer would be arbitrary and the value chosen may not be appropriate for individual projects.

Another form of simplified crediting, **cautious simplified crediting** would allow projects to generate emission credits as soon as a project begins to mitigate emissions. Credits could accrue at a constant or non-constant rate (two different constant rates for different crediting lifetimes are shown in Figure 6). Thus, the number of credits accruing in the early years of the project would be lower than the carbon effects of the project, but the project would continue to accrue credits after the project in question had

reached a steady carbon state. This method has the advantage of crediting certainty, while maintaining the incentive to project developers to maintain the carbon storage effect of the project for a long period of time.

Figure 6: **Cautious simplified crediting**



4.2 “Permanent” credits based on ton-year accounting

The lifetime of greenhouse gases in the atmosphere is limited. The radiative forcing capacity of these gases is therefore also limited. Sequestration, even if temporary, delays carbon release into the atmosphere, and therefore can also delay increases in CO₂ concentrations and radiative forcing. Some argue that short-term sequestration should therefore be credited. This would be done by using a ton-year approach (e.g. Chomitz 1998, CIFOR 2000, IGPO 2001). Others argue that ton-year accounting could be environmentally harmful and run counter to the aims of the Convention (e.g. Maclaren 2000, Pingoud et. al. 2000).

Under the ton-year approach, the period over which a ton of carbon has to be sequestered in order to have the same environmental effect as not emitting a ton of carbon is determined. This “equivalence factor” is then used to determine credits for re/afforestation projects. Credits would therefore accrue in proportion to the amount of carbon sequestered and how long it is sequestered for. Under the ton-year concept, one ton sequestered for an entire “equivalence factor” period is directly equivalent to one ton of avoided emissions. Thus, if the equivalence factor is set at 100 years (a subjective choice, but one often used), one ton sequestered for 100 years would be assumed to have the same environmental effect as reducing emissions by 1t. Similarly, using ton-year accounting, sequestering a ton of carbon for less than 100 years will have an effect equivalent to sequestering a fraction of a ton of carbon permanently¹⁸. Under ton-year accounting, the effect of sequestering 1 t for 100 years would not be reduced if the sequestered ton were released at the end of this period (Moura Costa and Wilson, 2000).

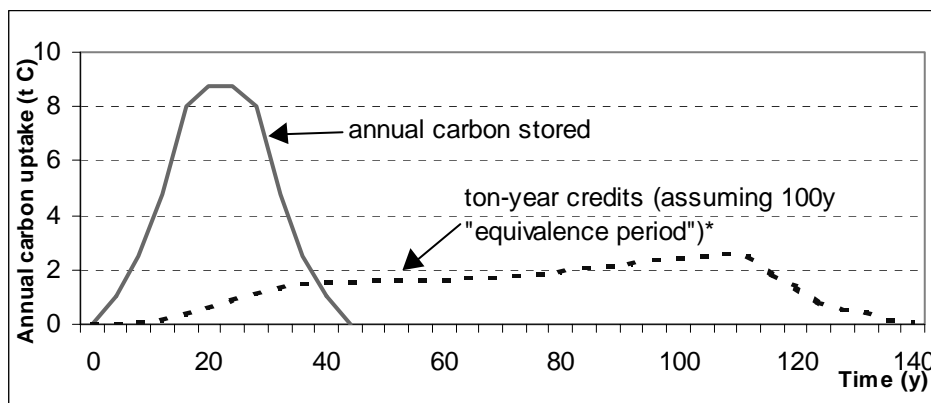
The advantages of rewarding a delay in carbon emissions include that sequestration projects would not need to guarantee a constant land use for a particular plot of land indefinitely (although a larger number of credits would be obtained the longer the land use remained constant). This in turn may increase acceptance of re/afforestation projects by the local population as it would give them the flexibility to alter land use at some future date if needed. Heightened local acceptance of “temporary” restrictions on land-use change via ton-year crediting may therefore help to increase the number of successful projects initiated. However, it

¹⁸ For example, the environmental effect of sequestering one ton of carbon for one year (with an equivalence factor of 100) has been estimated as 0.00726t C (IGPO 2001).

may also mean that the effects of such projects are not maximised if the carbon sequestered is re-released before the end of the equivalence period.

Disadvantages of the ton-year approach include that there is no agreement on the length of time (e.g. 55, 100 or more years) that a ton of carbon has to be sequestered in order to have the equivalent effect as reducing one ton of emissions¹⁹ (see e.g. IPCC 2000). Of course, different values have very different implications for the risk of carbon stock reversal and on project value. Moreover, there are wider land-use, biodiversity and other implications of assuming that sequestering 1 t CO₂ for N years has the same effect as sequestering N t CO₂ for 1 year or reducing emissions by 1 t CO₂²⁰. In addition, the number of credits resulting from ton-year accounting in the first few decades of a project is very low (Figure 7), although credits are generated over a very long time period. Under ton-year accounting, the crediting lifetime of a project would be equal to the equivalence factor plus the time taken for the forest to reach maturity (e.g. 125 years for a fast-growing species if an equivalence factor of 100 is assumed).

Figure 7: **Ton-year crediting**



* Credits would accrue at a different rate if a different equivalence period was used.

A variation on the ton-year approach would be to allocate credits according to the actual stock change method, but with ton-year liability. Thus, in the event of carbon stock reduction, a developer would be liable for the difference between the number of credits allocated (solid line in Figure 7), and the ton-year value of those credits (dashed line).

4.3 “Temporary” emission credits

Given that the greenhouse gas benefits from forestry projects may be temporary, it may be appropriate for such projects to generate temporary credits (TCERs). There are different ways in which a temporary crediting regime could be set up (e.g. that proposed by Colombia in UNFCCC 2000). One way would allocate temporary and expiring credits to forestry projects, i.e. sequestration projects would generate credits that were valid for a fixed amount of time and that could not be renewed. Another regime could be for forestry projects to generate credits that were valid for a fixed amount of time, but whose validity

¹⁹ Since accounting for the Kyoto Protocol uses global warming potentials (GWP) for gases over 100 years, the equivalence factor is often assumed to equal 100 years. However, this choice of GWP is also arbitrary.

²⁰ Also, if sequestering 1 ton of CO₂ for n years is equivalent to reducing 1 ton of emissions, it would imply that sequestering the same ton for a period of 2n would be twice as good.

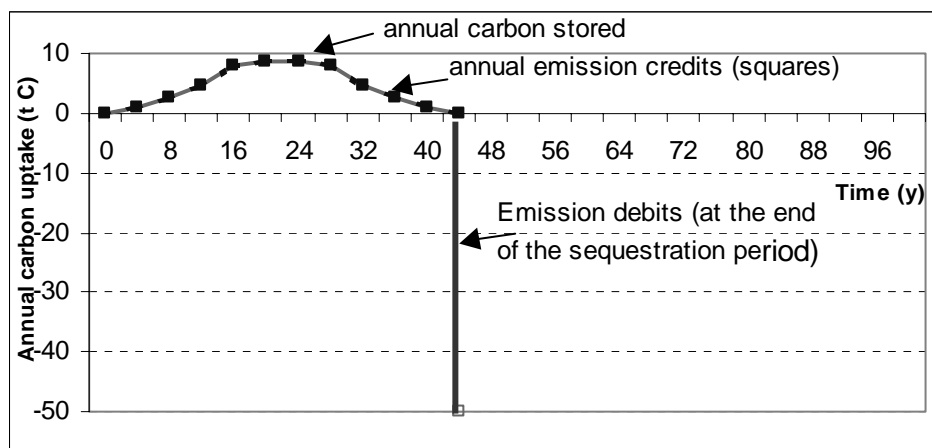
period could be extended (and the credits renewed) if the sequestration remained in place. These two possible regimes are explored below.

An advantage of both regimes is that they would provide flexibility on the possibilities for land-use change on an individual project site. This shorter term commitment to a particular land use may be more acceptable to the local population than crediting regimes which would require the use of a particular plot of land to remain constant for a century or more.

4.3.1 Temporary and expiring credits

Emission credits generated by forestry-related CDM projects could be set as valid for a limited period only, e.g. X number of years or until a project's sequestration ends. If at the end of the project the emission credits obtained by the sequestration project would be "repaid" (Figure 8), more than one TCER²¹ would be required to offset one ton of emissions during the lifetime of those emissions in the atmosphere.

Figure 8: Temporary, expiring emission credits



A crediting system set up using temporary, expiring credits could have a positive effect on GHG concentrations, if the sequestration in projects generating T-CERs was permanent, as temporary credits would have to be replaced even if sequestration was permanent. However, in order to generate a certain number of credits from A/R projects, a greater land area would often be needed for a system that allocates temporary and expiring credits than a crediting system that allocates "permanent" credits. If this occurs, it could have detrimental effects in other ways. For example, there could be negative impacts on biodiversity (e.g. if plantations are used for A/R projects and if increased plantation area diminishes areas of contiguous natural forests).

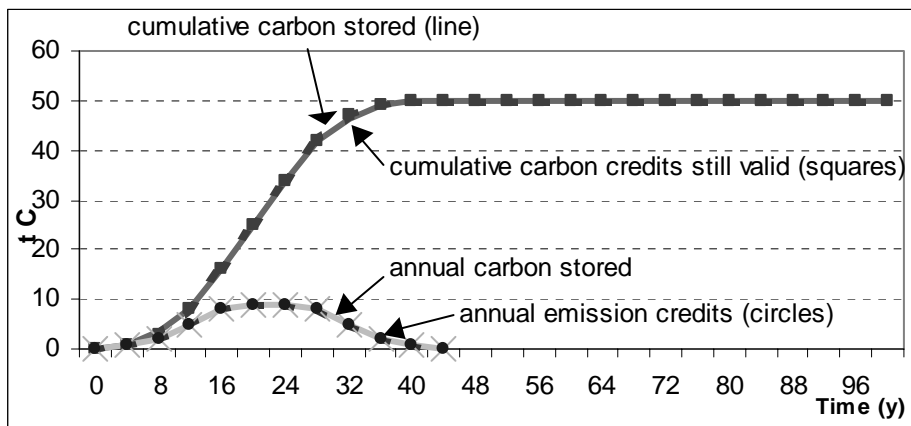
4.3.2 Renewable temporary crediting

Renewable temporary crediting (described e.g. in ONF 2001) recognises that the carbon sequestered in forestry projects could remain sequestered for a longer or shorter period of time, and allocates credits accordingly. Under this scheme, forestry activities that resulted in permanent sequestration would generate credits that were effectively also permanent, while forestry activities that were only short-lived would

²¹ Or a mixture of T-CERs and additional emission reductions.

generate temporary credits. Credits from certified sequestration activities would be valid for a certain period of time, e.g. five years. If after that time certification indicates that the carbon remains sequestered, the validity of the credits would be renewed for another time period²². This process would continue, and mean that this regime would allocate credits in the same manner as the carbon-year storage regime if sequestration was permanent (Figure 9).

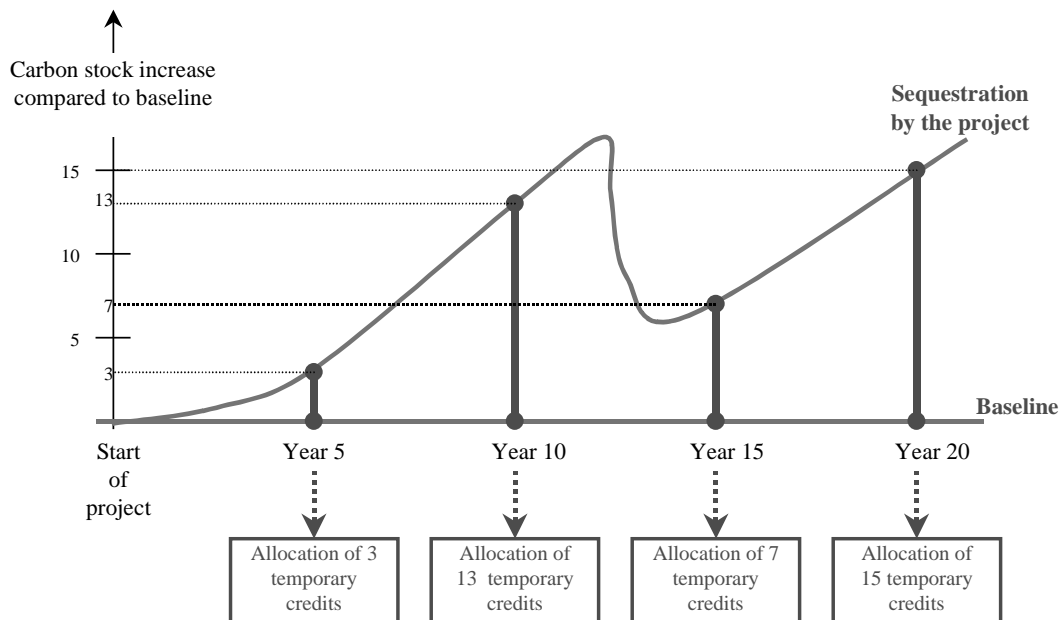
Figure 9: **Renewable temporary crediting (if carbon sequestered permanently)**



However, if sequestration was not permanent for part of the project, the validity period of the number of credits corresponding to that partial reduction in carbon stocks would not be renewed. Some of the temporary credits initially assigned would then need to be withdrawn from the holder's assigned amount (Figure 10). If the validity period of credits is short (e.g. 5y) it would mean that credits for carbon sequestration that has been reversed would soon cease to be valid. Longer validity periods for renewable temporary credits (e.g. 30y) would provide more crediting certainty to investors. However, it may not enable a carbon stock reduction to be accounted for promptly.

²² Alternatively, the first batch of temporary credits could be retired but replaced by new temporary credits.

Figure 10: Renewable temporary crediting (if some sequestration not permanent)



Source: ONF 2001

5. Effect of different crediting regimes/discounting on project value

Different possible crediting regimes and associated project lifetimes can have substantial impacts on the economic attractiveness of a project, and on the economic impacts of carbon stock reduction²³. This section explores the effect of the different crediting regimes discussed above on the value of credits obtained from an afforestation project currently underway in Scotland (Ancient Woodlands Project, AWP, Tipper et al. 2001). For the AWP project, these different regimes would lead to crediting lifetimes varying from 60 to 160 years²⁴.

Future revenue flows are worth less (given discounting) than current revenue flows. This variation in when credits are allocated to projects and over how long leads to wide variations in the net present value of the credits generated by an individual project (Figure 11). This figure was calculated on the assumption that the price of CO₂ remains constant over the crediting lifetime of a project²⁵.

Even with the same assumptions for discount rates and price of carbon, the “value” of credits can vary by more than a factor of 30 (at a 5% discount rate), depending on when the credits accrue to a developer²⁶. For example, at an assumed price of USD 5/t CO₂ over the crediting life of a project and a discount rate of 5%, the NPVs of credits generated by an individual project can vary from approximately USD 3,000 to more than USD 100,000.

The most economically attractive regime is the average crediting regime over the growing period of the forest. Both the ton-year and delayed full crediting regimes result in a much lower NPV of the project because of the relatively high number of credits generated more than 50y after the project starts. Interestingly, the Colombian proposal (where credits essentially have to be repaid at the end of the project) is still more economically attractive than some of the crediting schemes where an investor permanently obtains all emission credits generated by a project.

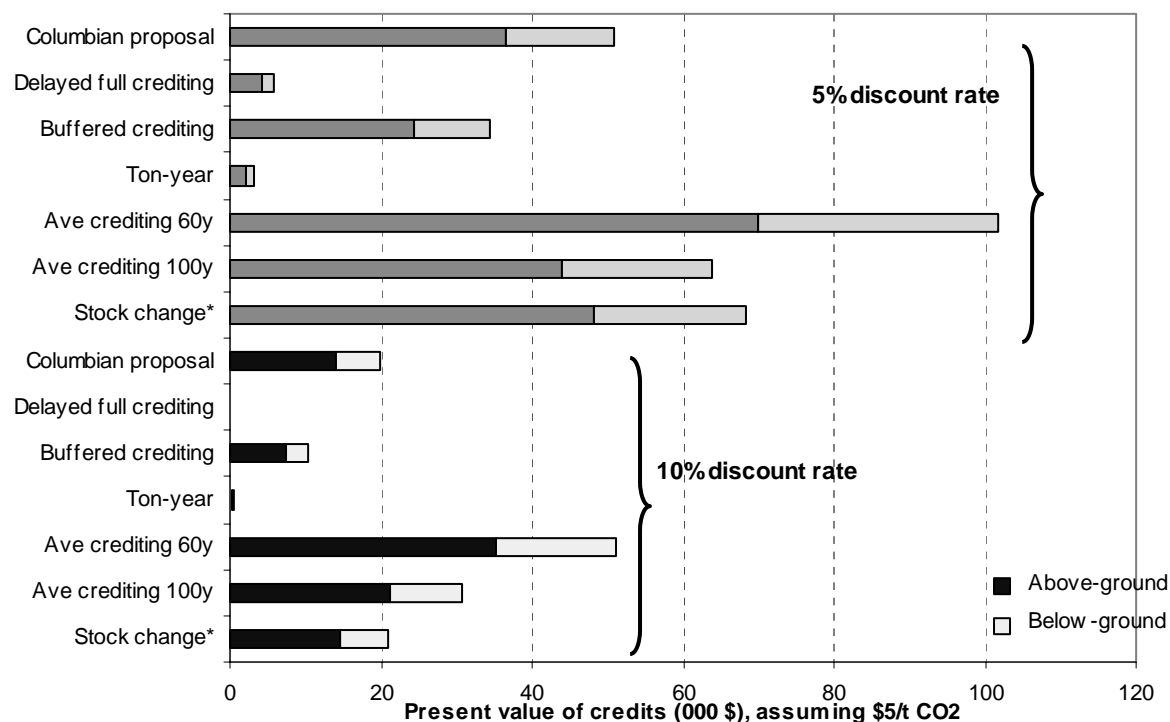
²³ At a project level, the value of a project is affected by whether or not any carbon stock reduction has occurred. This can obviously also have a significant effect on the value of an individual project.

²⁴ This project is situated in Scotland. Although growth in total carbon has not stopped after 100 years, more than 96% of above-ground biomass accumulation has occurred by year 60. This timeframe was therefore chosen as the shortest time over which crediting would take place. However, for projects involving the establishment of a sustainably managed forest, i.e. one involving some harvesting, or for projects involving fast-growing species in tropical areas, the time taken to reach maximum carbon stocks will be quicker and so shorter crediting lifetimes may be appropriate.

²⁵ The price of carbon will be influenced by many factors, including the level and timing of future emission commitments; the extent of technological change; changes in industrial structure; level of economic growth; and which activities can be used to offset emissions. Estimating different carbon price scenarios over 100 years or more is beyond the scope of this paper.

²⁶ Of course, these results would be different if the price of carbon varies over time. If the price increases gradually over time (e.g. 1-2% p.a.), the differences in NPV between different crediting regimes would be reduced. If the price grows more rapidly than the assumed discount rate (a nominal rate of 5 or 10% in this paper), the relative values of different crediting regimes could change.

Figure 11: Influence of carbon pools, changing crediting patterns and discount rates on the value of credits from an afforestation project (assuming USD 5/t CO₂ over the crediting lifetime of the project)



* Renewable temporary crediting would have the same value as stock change, assuming that sequestration was permanent, and that the price for temporary and permanent credits were the same²⁷.

The differences between the NPV of project credits under different crediting regimes for a given discount rate and carbon price would be different when examining results for fast-growing species, e.g. those with a maturity period of 25 years or less. The difference in NPVs of credits between the most and least economically attractive regime would be increased for projects involving fast-growing species, reflecting an increased variation in crediting lifetime²⁸. However, the difference in NPV of credits between those regimes with shorter crediting lifetimes (e.g. actual stock change and average storage over the growth period of the forest) may be reduced. While it will take 50 years to achieve 85% of total carbon sequestration for the project examined in this paper, other species planted in other locations will mature much more quickly. A shorter crediting lifetime could be judged appropriate for projects where fast-

²⁷ This is unlikely to be the case, but an assessment of the relative prices of temporary and permanent credits (which may depend on project specific factors) is beyond the scope of this paper.

²⁸ For example, the shortest crediting period for a project establishing a non-harvested forest may reflect the time taken to reach maturity. The longest crediting period may reflect a delayed crediting or ton-year approach (with the delay period or the equivalence factor respectively being set at 100 years). For a project that reaches maturity in 25 years, the regimes would lead to crediting lifetimes of 25 and 125 years respectively, whereas a project that reaches maturity in 60 years would lead to crediting lifetimes of 60 and 160 years respectively. The relative difference between the crediting lifetimes is thus larger for fast-growing species.

growing species are planted (or for forests or plantations in tropical areas, where growth is quicker than in temperate areas).

The majority of the mitigation effect of the AWP project is on the above-ground carbon stocks. However, the relative importance of above and below-ground carbon to the value of a project will vary according to the land-use before the project, and to the forest type. Moreover, because the rate of accumulation of above and below-ground carbon is different, the relative importance of the value of above-ground carbon “credits” varies slightly according to which crediting approach is used and over which timescale.

The net present costs of the AWP were estimated at kUSD 133.7 at a 5% discount rate (BFT 2000), but did not include costs of land purchase as it was not required for this project. However, land purchase may be needed for other afforestation/reforestation projects and could significantly raise the cost of GHG mitigation associated with such projects. The AWP project was estimated to mitigate 67.7 kt CO₂ (Tipper et. al. 2001), making the cost of carbon reduction USD 1.97/t CO₂. This low cost of carbon mitigation is further reduced (to a greater or lesser extent, see Figure 11) by offsetting the value of credits received over the project lifetime.

6. Conclusions

The environmental benefits of land use change and forestry projects can be significant. However, such projects risk being degraded through natural and/or human-induced events such as fire, deforestation or attacks from pests. For Joint Implementation or Clean Development Mechanism projects, this means that – unlike emission reductions generated through JI/CDM projects in the energy or industry sectors – the greenhouse gas benefits of re/afforestation projects can be reversed. Establishing guidance on project siting and rules on how to allocate credits from forestry projects could help to reduce the economic and/or environmental risks associated with carbon stock reduction in forestry mitigation projects.

Certain project types (e.g. monoculture plantations) or locations (e.g. in areas with a high risk of being affected by encroachment or a natural catastrophe) run a greater risk of carbon stock reduction than others. However, through environmental management approaches, the physical risk of carbon stock reduction can be reduced or avoided. Assessing these different risks and planning (or changing) the project site accordingly is particularly important for the project developer in this respect.

However, the likely sources of risk and hence the appropriate risk management strategies vary by project location, climate and species planted. As a result, it is difficult to generalise physical risk-management strategies for re/afforestation projects.

Reduction in carbon stocks of a re/afforested area can have economic as well as environmental impacts. For project investors, carbon stock reduction may result in lower than expected carbon credits and revenue associated with a project. There are certain measures that project developers can take in order to manage these economic risks. These include through insurance provisions or diversifying the location and types of sequestration projects undertaken. Both the economic and environmental impact of carbon stock reduction can also be influenced through rules about how forestry projects generate credits. Such decisions may be most appropriately made by the international community.

There are many different ways in which the benefits of forestry projects can be credited to investors. These crediting regimes vary in the incentives they provide to investors to encourage long-term sequestration. A crediting regime could be set up to encourage very long-term (or permanent) sequestration, e.g. by ensuring that:

- credits accrue over a long period of time - perhaps substantially longer than the growing period of the forest. This could lead to a crediting lifetime of several decades (e.g. for fast-growing species) or more than 100y (for slower growing species).
- a significant proportion of credits accrue or are allocated towards the end of the crediting life of a project. This would help encourage investors to maintain risk avoidance strategies over the long term (although it would not necessarily reduce the likelihood of certain natural catastrophes nor attenuate the environmental impact of any carbon stock reduction).

If CERs issued for forestry projects are “permanent”, they would remain valid even if the sequestration activity that generated the CERs was reversed. In other words, issuing permanent CERs for CDM forestry projects would mean that the environment (rather than the “buyer” or “seller” of credits) would lose in the event of a carbon stock reduction. However, the crediting regime could be set up to mitigate the environmental effect of any carbon stock reduction. This could be done by attaching some form of liability to credits generated from A/R projects, or by accounting carbon credits for forestry CDM projects on a ton-year basis.

The different crediting regimes explored in this paper allocate credits from forestry projects based on carbon stock changes, ton-years, or temporary credits. The characteristics of these regimes are summarised in Table 3.

Many of the crediting options examined require a potentially arbitrary choice of crediting lifetime to be made. These choices mean that a particular project would generate credits over a significantly different period of time depending on which crediting regime, using which assumptions, were used. This variation in crediting lifetime can be of the order of several decades, and influences both the absolute and relative economic attractiveness of a project. Thus, a shorter crediting lifetime - such as that used in the average storage crediting regime - results in a higher “front end loading” (and NPV) of credits.

This paper examined the different crediting regimes and their impact on the value of potential credits generated by an afforestation project currently underway. The net present cost of the project was kUSD 133.7 and mitigated 67.7 kt CO₂, leading to a cost of carbon mitigation of USD 1.97/t CO₂. If this project were to generate emission credits, these costs could be significantly offset from revenues generated by the project’s emission credits, which varied between 3.1 and 101 kUSD (assuming a constant USD 5/t CO₂ over the crediting lifetime at a discount rate of 5%) under different crediting regimes.

In order to generate CERs, the Kyoto Protocol indicates that CDM projects should result in real, measurable and long-term benefits and should also contribute to sustainable development. While the host country has a leading role in assessing whether the project contributes towards sustainable development, the international community can have a leading role in ensuring that credits from A/R projects lead to real, measurable and long-term benefits. Three of the crediting regimes examined in this paper could ensure this. Moreover, the Bonn Agreement stipulates that any reversal in carbon stocks should be able to be accounted for, and at an appropriate time. This can only be achieved, in the absence of any liability rules, by crediting regimes that allocate short-term, temporary credits (renewable or expiring). Two of the crediting regimes examined here fulfil these criteria (Table 3, overleaf).

If the credits generated by forestry mitigation projects under JI and the CDM are permanent (i.e. have an unlimited validity period and cannot be recalled in the event of a carbon stock reduction), using the buffered crediting regime to allocate credits may prove to be a good compromise between encouraging “real, measurable and long-term” environmental benefits, while providing investors some incentives to invest in re/afforestation projects. However, if credits generated by forestry mitigation projects can be temporary (i.e. different from the permanent credits that would be generated by JI/CDM projects in other sectors), the “renewable temporary crediting” option may be best. This option could be set up to generate credits that reflect real, measurable and long-term benefits, while also allowing any reversal in carbon sequestered to be accounted for appropriately.

Nevertheless, while the crediting regime used for forestry projects can be used to manage the risk of carbon stock reduction, the environmental risk associated with forestry mitigation projects could also be dealt with in other ways. These include allocating liability to credits from re/afforestation CDM projects in order to ensure that either “seller” or “buyer” has to make good any carbon stock reduction, or through rules relating to establishing the baseline for forestry mitigation activities. An examination of liability issues for forestry credits should be included in any analysis for SBSTA of how to develop definitions and modalities for including A/R project activities in CDM activities.

Table 3: Characteristics of different crediting regimes for a slow-growing CDM re/afforestation project¹

Crediting regime	Type of credits	Crediting lifetime	When credits are allocated	Consistent with provisions VII 1g in Bonn Agreement ² ?	Does this crediting regime ensure that credits allocated are			Relative economic attractiveness ³
					Real	Measurable	Long-term	
Actual stock change	Permanent	Growing period of forest (e.g. 60y)	As soon as stock change is certified	--, --	++	++	--	++
Average or simplified ⁴	Permanent	a) Growing period of forest or b) other (arbitrary) period, e.g. 100y	In accordance with a) average or simplified forest growth b) average growth over the time period chosen	--, --	a) -- or + b) - or +	- or + +	-- +	+++ ++
Delayed crediting	Permanent	Delay period + growing period of forest	After a delay period (e.g. 50 or 100y)	++, -	++	++	++	--
Buffered crediting	Permanent	Growing period of forest + a delay period	Some during growth period, some after delay	+, -	++	+	++	+
Ton-year	Permanent	Growing period + "equivalence factor" (e.g. 55 or 100y)	A small proportion of credits allocated during entire crediting lifetime	+, -	+	--	++	--
Expiring temporary crediting	Temporary	Can vary (e.g. all or part of growing period)	Forest growth period	++, +	+	+	-	+
Renewable temporary crediting	Temporary	Project lifetime	Forest growth period. The validity of credits is renewed for as long as sequestration continues.	++, ++	++	++	+	Could vary

¹ The relative economic attractiveness of these crediting regimes for fast-growing projects will be different.

² This indicates that reversal of sequestration from LULUCF projects a) be accounted for, and b) at an appropriate time.

³ The economic attractiveness was calculated at a 5% discount rate and assuming a constant price of carbon throughout the crediting life. Both the absolute and relative economic attractiveness of different crediting options vary with different assumptions on discount rates. If the price of carbon increased (but at a lower rate than the discount rate of 5%) the variation in economic attractiveness of different crediting regimes would be reduced.

⁴ If sequestration is permanent, credits allocated under the average crediting regime will represent "real" benefits over the crediting lifetime. However, if credits are permanent but sequestration is not, CERs allocated may not represent real emission benefits.

7. References

- Borders Forest Trust (BFT), 2000, *Management Plan for the Restoration of Ancient Woodland Habitats in the Scottish Borders*, Ancrum, Scotland. (unpubl.)
- Centre for International Forest Research (CIFOR), 2000, *Capturing the value of forest carbon for local livelihoods: Opportunities Under the Clean Development Mechanism*, <http://www.cifor.org/news/carbon.htm#sum>
- Chomitz, K.M. 2000, *Evaluating carbon offsets from forestry and energy projects: how do they compare?* Development Research Group. The World Bank, Washington DC.
- ECE/FAO, 2000, *ECE/FAO Forest Products Annual Market Review 1999-2000*, <http://www.unece.org/unece/trade/timber/docs/rev-00/03.pdf>
- Face Foundation, 2001, <http://www.facefoundation.nl/Eng/frameset3dE.html>
- FAO, 1989, *Arid zone forestry: A guide for field technicians*, <http://www.fao.org/docrep/T0122E/t0122e00.htm#Contents>
- FAO, 1999a, *State of the World's Forests*, <http://www.fao.org/docrep/W9950E/w9950e03.htm>
- FAO, 1999, *Techniques de gestion des écosystèmes forestiers tropicaux: état de l'art*, <http://www.fao.org/DOCREP/003/X4110F/X4110F00.HTM>
- FAO/ECE, 1999, *Forest Fire Statistics*, <http://www.unene.org/trade/timb.pdf>
- Goldberg, Donald M, 2000, *Establishing permanent liability for LULUCF projects*, http://www.forest-trends.org/keytrends/pdf/durability/permanentliability_dmg.pdf
- Hadley Centre, 2000, *Climate effect on forestation*, <http://www.met-office.gov.uk/research/hadleycentre/pubs/brochures/B2000/forestation.html>
- Hogg, E. H., Brandt, J.P. and Kochtubajda, R, 2000, *Growth and Dieback of Aspen Forests in Northwestern Alberta in Relation to Climate and Insects*, http://nofc.cfs.nrcan.gc.ca/carbon/abstracts/toc_1.htm
- IFFN, 2000, *International Forest Fire News*, No. 23, December 2000, http://www.ruf.uni-freiburg.de/fireglobe/iffn/iffn_23/content.htm
- IGPO (International Greenhouse Partnerships Office), 2001, *Workbook on Land Use, Land Use Change and Forestry (LULUCF) Projects*, prepared by Jaakko Pöyry Consulting and Energy Strategies, Canberra
- IPCC 2000, *Special Report on Land Use, Land-Use Change, and Forestry*. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.
- Jaakko Pöyry Consulting Inc, 1992, *Forest Health*, <http://www.iic.state.mn.us/download/geis/health/forhealt.pdf>
- Koskela, Jarkko, Pekka Nygren, Frank Berniger, Olavi Luukkanen, 2000, *Implications of the Kyoto Protocol for tropical forest management and land use: prospects and pitfalls*, University of Helsinki, <http://honeybee.helsinki.fi/tropic/Kyoto.pdf>
- Landsberg, Johanna D, 1999, *Fire and forests: fire – a good servant or a bad master*, <http://www.unece.org/trade/timb.PDF>

- Lecocq, Franck, and Kenneth Chomitz, 2001, *Optimal use of carbon sequestration in a global climate mitigation strategy: is there a wooden bridge to a clean energy future?* (draft)
- Loisel, Cyril, 2001, personal communication (11.9.2001)
- Maclaren, Piers, 2000, *Carbon accounting methodologies – a comparison of real-time, tonne-years, and one-off stock change approaches*, presented at Land-Use, Land-Use Change and Forestry: the Road to COP6, Finland, September 2000, http://www.pik-potsdam.de/cp/chief/nima/macl_p.html
- Moura Costa, Pedro, and Charlie Wilson, 2000, *An equivalence factor between CO₂ avoided emissions and sequestration - description and applications in forestry*
- OECD/IEA, 1999, *Options for Project Emission Baselines*, OECD and IEA Information Paper, <http://www.oecd.org/env/cc/freedocs.htm>
- ONF (Office National des Forêts, France), 2001, *Forêt et Changement Climatique*, (unpublished working paper)
- Phillips, Gareth, Edwin Aalders, Irma Lubrecht, 2001, *Forestry Issues outstanding from COP 6*, SGS Climate change programme
- Pingoud, Kim, Riitta Korhonen, Ilkka Savolainen, Robert Matthews, 2000, *The ton-year index as a basis for carbon accounting of forestation projects under the Climate Convention*, presented at Land-Use, Land-Use Change and Forestry: the Road to COP6, Finland, September 2000
- Pronk, Jan, 2001, *New Proposals by the Chairman of COP6*, <http://www.unfccc.int>
- Schneider, J, 1999, *Preventive Measures*, <http://www.altnews.com.au/jetsunstudios/travelcam/mschneider/preventi.htm>
- SGS, 2000a, *Río Cónдор Forest Carbon Project, GHG Project Verification and Certification - Executive Summary*, <http://www.sgs.nl/nl/icm/agro/cov.html>
- SGS, 2000b, *Kilombero Forests Limited, GHG Project Verification and Certification - Executive Summary*, <http://www.sgs.nl/nl/icm/agro/cov.html>
- SGS, 2000c, *Profafor (Programa Face de Forestación), GHG Project Verification and Certification - Executive Summary*, <http://www.sgs.nl/nl/icm/agro/cov.html>
- STTFN (Southern Tablelands Farm Forestry Network Newsletter), 2000, *Australian Forest Growers Plantation Insurance Scheme*, <http://www.stffn.org.au/Newsletter/Newsletters/2000-01.htm#Australian Forest>
- Sumitomo Forestry Co. Ltd, 2001, *Forest Plantation Project in Indonesia*: presentation at the 11th Asia Pacific Seminar on Climate Change, Kitakyushu, August 28-31, Japan
- Tipper, Richard, William McGhee, Jane Ellis, Ben H. de Jong, Augustine Hellier, 2001, *An Initial View on Methodologies for Emission Baselines: Forestry Case Study* (unpublished - draft presented at March 2001 AIXG)
- UNFCCC, 2001, Decision 5/CP.6, *Implementing the Buenos Aires Plan of Action*, FCCC/CP/2001/L.7
- UNFCCC, 2001, *Consolidated Negotiating Text*, FCCC/CP/2001/2/Add.2 <http://www.unfccc.int/>
- UNFCCC, 2000, *Methodological Issues: Land Use, Land-Use Change and Forestry*, FCCC/SBSTA/2000/MISC.8 <http://www.unfccc.int/resource/docs/2000/sbsta/misc08.pdf>

WBGU (German Advisory Council on Global Change), 1998, *The Accounting of Biological Sinks and Sources under the Kyoto Protocol: a step forwards or backwards for global environmental protection? Special Report 1998*, http://www.awi-bremerhaven.de/WBGU/wbgu_sn1998_engl.html

8. Glossary

Anaerobic decomposition	Decomposition in the absence of oxygen. If organic matter decomposes anaerobically, the carbon contained in the organic material is emitted as CH ₄ rather than CO ₂ .
A/R	Afforestation/reforestation
Carbon stock reduction	A loss of carbon sequestered in trees. Carbon stock reduction can occur for natural or anthropogenic reasons.
CDM	Clean Development Mechanism (defined in Article 12 of the Kyoto Protocol)
CER	Certified emission reduction (emission credit generated by a CDM project)
CH ₄	methane
CNT	Consolidated Negotiating Text (UNFCCC 2001)
CO ₂	Carbon dioxide
COP	Conference of the Parties to the UNFCCC
ERU	Emission reduction unit (emission credit generated by a JI project)
GHG	Greenhouse gas
JI	Joint Implementation (defined in Article 6 of the Kyoto Protocol)
LULUCF	Land-use, land-use change and forestry
NPV	Net present value
UNFCCC	United Nations' Framework Convention on Climate Change