

Forestry and the ultimate objective of the Climate Convention

Michael Dutschke

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Hamburg Climate Change Cluster **climate+**
c/o Hamburgisches Welt-Wirtschafts-Archiv (HWWA)
Hamburg Institute of International Economics
Neuer Jungfernstieg 21 – 20347 Hamburg, Germany
Phone: 040/428 34 309
Fax: 040/428 34 451
e-mail: hwwa@climateplus.net
Internet: <http://www.climateplus.net>

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c/o Hamburgisches Welt-Wirtschafts-Archiv (HWWA)
Hamburg Institute of International Economics
Neuer Jungfernstieg 21 – 20347 Hamburg, Germany
e-mail: hwwa@climateplus.net

Edited by HWWA Programme International Climate Policy
Head: Dr. Axel Michaelowa

* Hamburg Institute of International Economics, Programme International Climate Policy

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Abstract

In its Article 2, the U.N. Framework Convention on Climate Change gives policymakers a long-term dynamic mandate under uncertainty. Taking the example of forestry activities in developing countries, the present article discusses whether land-based climate change mitigation measures are covered under the UNFCCC's ultimate objective. Both the problem of climate change and human intervention act over long, but not infinite timeframes. The article argues for taking a dynamic 100-year timeframe as a reference for present activities. It concludes that increasing biotic carbon storage is legitimate for measures that contribute to biodiversity conservation, as long as it does not serve as a pretext for neglecting technological change. Among all forestry options, the list of priorities should be avoiding deforestation and devegetation, sustainable forest management, and afforestation. The problem of saturation can be encountered by the combination of forestry with the increased use of wood products and bioenergy. Concluding, the article gathers criteria for post-Kyoto forestry incentive mechanisms.

Keywords: LULUCF; CDM; Climate Change; Biodiversity; Permanence; Saturation

JEL Classification: Q23, Q54; Q57; Q58

Michael Dutschke
Hamburg Institute of International Economics (HWWA)
Neuer Jungfernstieg 21
20347 Hamburg
Phone: +49 40 42834 434
E-mail: michael.dutschke@hwwa.de

1 Introduction

Forestry as a means of climate change mitigation has often been criticised, on the grounds that, compared to all other carbon reservoirs, terrestrial carbon stocks are very dynamic, and they are directly influenced by climate change itself. A lot of criticism against land-use activities under the CDM has been based on the argument that the use of terrestrial carbon “sinks” for compliance was not covered by the long-term objective expressed in Article 2 of the UN Framework Convention on Climate Change, arguing that non-Annex B countries were unable to guarantee the permanence of land use mitigation projects (Meinshausen & Hare 2000), and that any duration shorter than permanence would not comply with the ultimate objective of the Climate Convention.

Anthropogenic climate change is a problem that has a time horizon of decades to centuries. Land use is an important source of the greenhouse gases CO₂, CH₄ and N₂O. On the positive side, the land-use sector has the potential to remove important amounts of CO₂ from the atmosphere and to avoid future net emissions from this reservoir. While the role of forests as a source is uncontested, CO₂ removal by sinks as a means to mitigate climate change is contentious. The UN Framework Convention on Climate Change (UNFCCC) mentions the enhancement of sinks as a commitment in its Article 4 (b) and (d). The Kyoto Protocol to the UNFCCC recognises the role of sinks in Art. 3.3 and 3.4, related to the industrialized country Parties enumerated in its Annex B that have taken over emission limitation and reduction targets. For the first commitment period, under the Clean Development Mechanism (CDM) only afforestation and reforestation activities are eligible for generating certificates that can be accounted against Annex B targets. Actually, the CDM is the only instrument that allows accounting for climate change mitigation in developing nations. Its intention is “[...] to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention [...]”. What this means for project activities is that these shall neither be in conflict with the elements included in the objective, nor with its timeframe. In this article, project permanence will not be understood in the sense of *infinity*, but related to the timeframe indirectly defined in the Convention.

This article will concentrate on forests in developing countries and assess the role of time in carbon storage, and which criteria land-use activities need to fulfill in order to serve the ultimate objective of the Climate Convention.

2 The ultimate objective and its elements

UNFCCC Article 2 is complex, because it touches on a number of interrelated issues that shall be disentangled in the following paragraphs.

“The ultimate objective of this Convention and any related legal instruments (...) is to achieve (...) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”

The following elements can be distinguished:

- I The overall objective is to prevent dangerous anthropogenic interference with the climate system.
- II This is to be achieved by stabilizing GHG concentrations in the atmosphere. The timeframe of stabilization should be large enough,
 - (a) To allow ecosystems to adapt naturally to climate change;
 - (b) To ensure food production;
 - (c) To enable sustainable economic development.

All these elements require interpretation. There is no common sense, what level of interference can be considered “dangerous”. A timeframe is defined by natural adaptation, food production and sustainable development, every single of which underlie a variety of factors and interpretations. The 2002 World Summit on Sustainable Development defined an umbrella concept of essentials called *WEHAB* – Water, Health, Agriculture and Biodiversity, adding coastal areas. *WEHAB* comprises the three areas identified in UNFCCC Article 2 and is intended to help operationalize the concept of dangerous interference (Patwardhan, Schneider et al. 2003). We will examine Article 2 sub-objective by sub-objective, and assess which role forestry could assume in developing countries, with a focus on timing and duration issues.

2.1 Preventing dangerous interference with the climate system

The majority of scientists agree that dangerous anthropogenic interference with the climate system is caused by GHG emissions. No definition has yet been agreed, at what point anthropogenic interference with the climate system shall be considered *dangerous*. Climate change will affect different countries, regions and sectors in different ways. Some sectors in specific countries may even benefit from higher temperatures or increased rainfalls, while an increased sea level will threaten the existence of whole island states. Both will support different concepts of “dangerous human interference”. Ultimately, any risk definition on a global level will be a political one (Ott, Klepper et al. 2004). A stabilization target limits absolute total atmospheric loads to the rate of natural CO₂ absorption by biosphere and oceans, plus the uptake by persistent geological sinks, which are estimated at 0.2 Gt per year (Graßl, Kokott et al. 2003). It has been questioned, whether a concentration target can be the ultimate objective, rather than a tolerable limit of human-induced temperature increase above pre-industrial levels (ibid.). On the other hand, trace gas concentrations can be measured and attributed to a higher degree of confidentiality than global temperature variations. Additionally, GHG concentrations can be measured immediately, while temperature change or even sea-level rise lag behind by several decades or even centuries. Stabilization is a monstrous task, as a concentration goal implies a fixed ceiling on cumulative emissions from fossil fuels over all time” (Herzog, Caldeira et al. 2002), and emission rights need to be allocated over an infinite timeframe.

Unless there are certain absolute temperature values that trigger major catastrophic events, the rate of temperature change seems to be more important than the ultimate temperature level after stabilization is reached. The German Advisory Council on Global Change suggests that the global mean temperature should not stabilize at a level higher than 2 degrees above pre-industrial levels, given that it has already increased in 1.4 degrees since the beginning of industrialization. The rate of change acceptable is estimated at 0.2 degrees per decade (Graßl, Kokott et al. 1995).

2.1.1 Impact of forestry on GHG emissions

Presently, around 23 percent of all CO₂ emissions emanate from worldwide deforestation and devegetation. Most prominently, Brazil and Indonesia contribute to the destruction of natural

forests. There are even opinions that the global warming effect of deforestation is understated, on the grounds that the IPCC calculation of relative global warming potentials (GWP) underestimates CH₄ and Kyoto does not account for CO emissions, which acts indirectly towards global warming, by hindering the decay of CH₄ in the atmosphere (Fearnside 2002a).

On the other hand, there are doubts whether industrial emissions can really be compared to land-use related ones, considering that forests are living ecosystems. Much destruction is followed by spontaneous regeneration, leading to increased carbon uptake. This effect depends on the cause of destruction and its mid-term effects (Chazdon 2003).

Bushfires like in Australia are natural phenomena to which ecosystems are adapted. As long as they are not human-induced, they lead to stable multi-year circles of carbon emission and fixation. In many cases however, anthropogenic interference and natural causes are difficult to separate. Additionally, fire produces 'black carbon' and thereby increases soil carbon over time while instantaneously depleting carbon from vegetation pools (Schulze, Wirth et al. 2000). Preventing natural emissions as part of a climate change mitigation strategy may lead to unforeseeable effects and to an increase of emissions on the long run. These cases could occur, if weeds that are controlled by natural fire cycles come up due to fire protection and lead to a dieback of fire-adapted species, and, in consequence, to a reduction of biodiversity. Once new future bushfire would occur, vegetation could take much longer to regenerate.

Forests that suffer from collateral damages caused by the exploitation of precious woods may recover, depending on the climatic zone, water and soil conditions, and if human interference is restricted to single events. Enrichment planting and non-destructive forest management may stabilize the forest cover, and can increase the carbon stocks. This effect is however very site-dependant. Natural succession in the tropics has the potential to recover carbon stocks on deforested areas within 15 – 30 years, while from biodiversity and soil indicators human intervention can be traced back over several centenaries (Chazdon 2003).

If the area deforested is used for reforestation with fast-growing commercial species, the ability for natural rehabilitation and adaptation to climate change is disrupted, even though short-term carbon stocks may not vary considerably before and after human intervention. The long-term effect depends on the size of the plantation and the proximity of natural biodiversity reservoirs. Examples for this type of deforestation with the purpose of establishing plantations can be found in Indonesia, where the remaining natural forests are seriously threatened in many regions.

Long-term destruction occurs, if after deforestation the land is used for cattle grazing, or, even worse, in consequence of mining activities that drain water resources and contaminate soils and water with heavy metal residues. These activities may lead to irreversible damage on large areas.

As there are chances for recovery in the destruction of forests as depicted above, a comparison between the emissions due to burning of fossil fuels and the ones related to forest destruction is inconsistent. It would be interesting to quantify anthropogenic deforestation and devegetation damages compared to the actual recovery induced by them. The affirmation by Schulze et al. (2000) that “[i]n contradiction to the ecological equilibrium paradigm, the total carbon pool continues to increase even in old stands” indicates that old forests are part of the ‘missing sink’, as their litter increases the pool of long-lived, non-active soil carbon.

The overall dynamic effect of deforestation on carbon fluxes F_{total} is thus

$$F_{total} = -V - D + R_{nat} + R_{anth}$$

where V is the carbon embodied in the part of the aboveground vegetation destroyed, D is the soil carbon deposition deferred by human disturbance. On the positive side, R_{nat} is the increased natural re-growth induced by removal, and R_{anth} the carbon embodied in the anthropogenic use of the area, if any.

Deforestation can be explained by the low value of unused land. In developing countries, there is a high social discount rate. Thus, incentives for forest protection need to be more profitable for the landowner on the short hand than alternative uses for cash crops or pastures.

Deforestation avoidance has its highest benefits if started at the earliest point in time possible. It is due to the state of the climate negotiation process in summer 2001 that it was not included as an emissions reduction activity type under the CDM. Environmental NGOs and European negotiators felt that the enormous reduction potential could dwarf domestic compliance by Annex-I Parties. Its permanence can however only be granted, if sub-objective II a (“to allow ecosystems to adapt naturally to climate change”) is achieved. In case combined efforts of energy, transport and land use mitigation fail to achieve this target, the effect will be aggravated by GHG emissions from a part of the earth’s natural forests and

other fragile ecosystems. On the other hand, failing to protect natural forests will result in an emissions increase earlier. The issue that deforestation avoidance is an active contribution to climate change mitigation is separate from questions over accounting.

There is a benefit in terms of the ultimate objective of the Climate Convention even in temporarily reducing GHG emissions from deforestation.

1. Some observers argue that deforestation does not matter, because today's sinks will turn to sources anyway during this century (Hadley-Centre 2000; Cramer, Bondeau et al. 2001). However, areas that are today most threatened by deforestation will not necessarily be the ones most threatened by future climate change, and vice-versa.
2. The more biodiversity is protected, the higher the chances for ecosystems to adapt to climate change, the lower the carbon losses that can be expected as a result of climate change.
3. Along the lines of deforestation, there is an increased breakout of diseases like Malaria, Dengue or Typhus (Saphores & Bakshi 2001). The jump-over of HIV from primates to humans has been related to deforestation of areas untouched by mankind before (McMichael 2003). The spread of diseases is a complex process; it is closely linked to water pollution. Trees contribute to the supply of clean water by stabilizing water levels and filtering water (Nasi, Wunder et al. 2002). Protected forests thus have the ability to increase human health and resilience against the consequences of climate change.

2.2 Stabilizing GHG concentrations in the atmosphere

A stabilization target limits absolute total atmospheric loads to the rate of natural CO₂ absorption by biosphere and oceans, plus the uptake by persistent geological sinks. It has been questioned, whether a concentration target can be the ultimate objective, rather than a tolerable human-induced temperature limit above the pre-industrial level (Graßl, Kokott et al. 2003). On the other hand, trace gas concentrations can be measured and attributed to a higher degree of confidentiality than global temperature variations. This pragmatic approach however limits the imposition of possible refinements. Several more gases than mentioned in Annex A of the Kyoto Protocol can be subject to future regulation, most prominently water steam, which shows different levels of radiative forcing, depending on which level of the

atmosphere it occurs. Several anthropogenic precursor gases in the atmospheric chemistry can be identified and limited. What is not included in Annex 2 is the radiative forcing effect of land use, even though it may reach orders of magnitude comparable to the effects of afforestation on a specific area (Pielke Sr, Marland et al. 2002; Marland, Pielke Sr et al. 2003). It is interesting to observe that concerns about albedo effect (Hadley-Centre 2000), surface roughness (Marland, Pielke Sr et al. 2003) and surface heat fluxes only forestry land use is being considered, while any large-scale land use intervention may cause similar effects, like road infrastructure, airfields, water reservoirs, or large urbanizations.

Sub-objective II can be read in the way that mitigation of GHG concentrations may include reduction of sources or increases in sinks that are actually not interfered by human activities.

The “timeframe” issue merits special considerations, as it delimits the upper and lower temporal boundaries of any mitigation activities.¹ Sub-objective II (a) is derived from the adaptive capacity of the biosphere, and it is thus related to the rate of temperature change. This condition is better described with biodiversity conservation (Ott, Klepper et al. 2004). II (b) relates to the primary land use, namely food production, but implicitly also to population growth. II (c) includes all other economic activities. This last sub-objective is the limiting factor to the speed of mitigation, as its repercussions are short-term. There is a trade-off between mitigation and adaptation costs that determines an optimal time path under economic aspects (Graßl, Kokott et al. 2003). Article 2 does not explicitly define the timeframe within which “safe” concentration level should be reached. However, the word *stabilization* implies a stable state in the future. Under the worst-case scenario of completely burning up fossil resources, CO₂ concentrations are currently expected to peak between the years 2100 and 2300 (Hasselmann, Latif et al. 2003) and then slowly decline. This gives us an indication over what to understand by permanence. CO₂ removed by forests today should theoretically be kept out of the atmosphere until the CO₂ concentration increase comes to an end, which is 100 to 200 years from now. Therefore, we will discuss permanence of carbon stocks within this temporal range.

The timeframe derived from this worst-case scenario can only be a first approximation for our analysis. Under the assumption of CO₂ concentrations ranging between 1,200 and 4,000 ppm, it seems unlikely that much of the carbon sequestered in biotic systems will be present by that time, due to extreme climate change. Furthermore, the assumption that fossil resources are

¹ See section 3 of this article

burned up completely, leads to a permanence problem for energy-related mitigation. Fuel saved today under this hypothesis would be used in the future, resulting in temporal leakage, i.e. the same type of problem we are discussing for biotic carbon storage.

Land use options can thus only fulfil a complementary function within a strategy to halt GHG emissions from the use of fossil fuels. Biotic reservoirs are an indicator of nature's adaptive capacity. By increasing them, a global mitigation strategy can be supported. If this strategy fails however, they will lead to a feedback effect, as they turn (back) to important sources of CO₂, and CH₄ (Cramer, Bondeau et al. 2001). There is a difference in this respect between managed and unmanaged forests. Managed forests are replanted, be it in clear-cut cycles, be it in cohorts, leading to complete stock renewal within periods of 20 – 100 years. Economic interest will lead landowners to adapt to gradually changing climatic conditions, as long as no abrupt changes occur. Natural forests benefit from their degree of biodiversity when adapting to climate change, but this process does not include an element of provision. Thus, a temporal differentiation is likely to take place: Anthropogenic forest sinks will slowly be implemented, but may be more stable over a medium timeframe. Deforestation avoidance for existing natural forests on the other hand, will lead to large-scale emission reductions in the beginning, but these gains could be temporary, as stocks may decrease over time. There is a role to play for active resource management, like enrichment planting or other forest management measures to avoid the expected die-back of forests in the tropical zones (Cramer, Bondeau et al. 2001).

2.3 Allowing ecosystems to adapt naturally to climate change

Sub-objective II (a) is derived from the adaptive capacity of the biosphere, and it is thus related to the rate of temperature change. This condition is better described with biodiversity conservation (Ott, Klepper et al. 2004). Biodiversity is actually being massively threatened by human intervention, not only in climate. Besides a reduction of anthropogenic GHG emissions that helps reducing the rate of change, avoiding deforestation and devegetation directly contributes to the conservation of biodiversity. Between 50 and 90 percent of the approximately 10 million species on earth are believed to be hosted by tropical forests (Saphores & Bakshi 2001). Commercial logging tends to concentrate on biodiversity rich forests, as these host the most valuable trees (ibid.). Afforestation may under certain conditions contribute to biodiversity as well, but pure “carbon forestry” will most certainly

not achieve this goal . Biodiversity conservation in managed systems requires an inventory of the ecosystem as a precondition for adapted site management. Natural adaptation to climate change implies a high migratory capacity of species within their habitat. Pollination plays an prominent role in this respect (Nasi, Wunder et al. 2002). Species migration can be enabled or hindered by landscape management. Actually, the increasing habitat fragmentation by human activities reduces natural adaptive capacities for species migration.

2.4 Ensuring food production

In the actuality, famines occur in spite of food production being more than sufficient worldwide. What the world sees today are mostly distributional problems, being aggravated by regional climate variations. The generic sense of the sub-objective relates to the carrying capacity of the earth. Intuitively, the problem is rather population growth than climate change. Under perfect market conditions, short-rotational species like most food crops will be planted where the climate is most suitable for them. New species will be reared that are best adapted to climatic conditions in each zone. Farmers have high flexibility in adapting species and management techniques to climatic variations when they cultivate annual crops (Adams, Hurd et al. 1999). The limiting factors however are water and soils. When vegetation zones migrate (e.g. by permafrost soils becoming arable or dry soils that desertify under decreasing rainfalls), the newly arable soils may lack humus and quickly loose their water storage ability. The process of desertification leads to CO₂ emissions from soil erosion. The function of bushes and trees for soil and watershed management can thus not be overestimated.

The use of biotic sinks has been criticized from a moral point of view. Considerations over strong vs. weak sustainability lead Ott et al. to the conclusion that under strong sustainability criteria, a “structured heritage package” should be carried over to future generations. This implied that the sink capacity of natural systems should not be over-used (Ott, Klepper et al. 2004). How could this over-use be defined?

It could be considered such an over-use of the biosphere for its sink capacity, if areas occupied by forests were needed for food production. The underlying assumption is that forests and food production are in opposition, which is vividly contested by the Director General of the Food and Agriculture Organization, Jacques Diouf: "First, trees and forests produce food directly. In some areas, they are a primary source of food; almost everywhere,

they provide a regular supplement to the diet. Foods from the forest are consumed when cultivated supplies are in short supply, such as between harvest seasons, or during emergencies, such as famines and wars" (FAO 1996). Additionally, firewood plays a role in food preparation and conservation; mangroves even provide fishing grounds. There are thus strong indications that the existence of forestry activities is positively correlated to food production.

Food production is seriously threatened in the People's Republic of China, which has been opposing the inclusion of land use activities under the CDM since the beginning. Over 40 percent of China's total land area is affected by wind and water erosion, loss of grazing, deforestation and salinization (Berry 2003), so that the country is now renting agrarian lands abroad (in Mexico, Cuba, Laos and Kazakhstan) for food production (Gärtner 2004).

Food production however is not a mere function of heads of population. Annex I nutritional habits require so much energy, land and water resources that an adoption of them by the majority of world population would already lead to serious scarcity without climate change. Much of the deforestation in developing countries is related to meat production. Agricultural subsidies in industrialized countries are externalizing the environmental cost incurred for food production. The higher this subsidy level, the less world economy will be able to adapt to global change.

2.5 Enabling sustainable economic development

Sub-objective II (c) includes all other economic activities, besides food production. The formulation "to enable economic development to proceed in a sustainable manner" tends to suggest the global economy was already sustainable, which is at best expresses wishful thinking. Economic considerations limit the speed of transition to low-carbon production, and its repercussions are short-term. There is a trade-off between mitigation and adaptation costs that determines an optimal time path under economic aspects (Graßl, Kokott et al. 2003). What could be a potential over-use of biotic sinks with respect to economic development? The dilemma is already being faced on a regional scale, when considering environmental costs and economic benefits of road building, e.g. in the context of the national program *Avança Brasil*, which aims at improving infrastructure. Environmentalists fear for important parts of the Amazon forest to be deforested alongside newly paved roads, like the BR-163

between Cuiabá and Santarem (Carvalho, Moutinho et al. 2004). Brazil is facing this dilemma mostly because there is practically no economic benefit attached to the mere existence of its natural forests. In case today's generations decided to afforest vast areas of the world, this dilemma might under this line of argumentation, become more common. This is however only true for unproductive protected areas. As managed forests usually bring economic benefits to local populations, a CO₂ sink orientated policy will create income sources and resources for future use. As every single investor will have to weigh opportunity costs of alternative investment, under market conditions there will be a saturation point where afforestation is no longer a profitable activity, compared to agricultural production or sale for industrial or housing expansion. Today, the problem in developing countries is the opposite: As interest rates are burdened with a high risk premium, long-term investment is not undertaken in most developing countries. In the case of Brazil, this leads to the situation that the country may become a net importer of wood in the near future, as the (planted) resource is over-exploited. Under these conditions, short-term crops are more profitable, even though they in many cases deplete the soils, leading to a direct loss of carbon and, indirectly, further slash-and-burn deforestation.

Under climatic and biodiversity aspects, the first choice is to protect all standing natural forests. This would be conditioned by important North-South transfers to allow economy to proceed in a sustainable manner. The amount of transfers needed depends on the opportunity costs of the lands otherwise deforested over time (Saphores & Bakshi 2001). On the other hand, the subsistence of between 1 and 1.5 billion poor directly depends on forest and its products (Scherr, White et al. 2003).

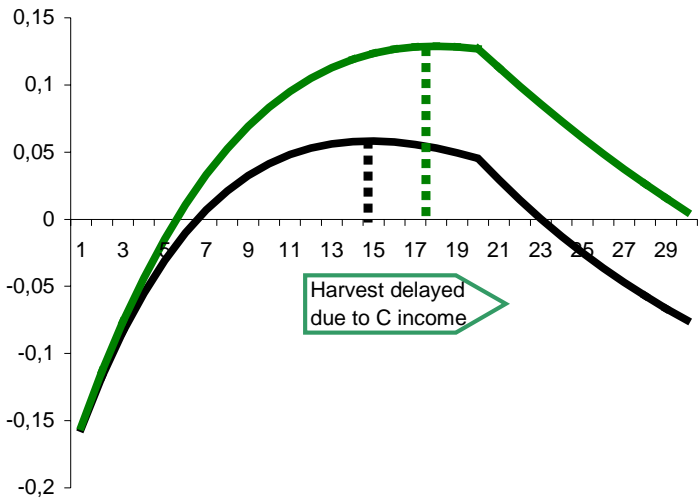
On the remaining today non-forested areas, the most carbon-effective way of afforestation are fast-growing fuel wood plantations combined with energy production and geological sequestration (Read 1999; Obersteiner, Azar et al. 2002), which would be the first choice, if a critical threshold was to be avoided within few years. This would however not necessarily benefit biodiversity and might conflict with soil and water protection.

The second choice for climate would be to build up carbon-rich forests and leave them as protected areas forever. This solution is likely to be economically unsustainable. The alternative is to develop a forestry sector, which keeps large areas under forest use. Depending on the situation of the area, this can be profitable in the future, once a financial mechanism provided seed capital. Harvesting will lead to a dynamic system in which carbon stocks stay below the biological maximum. In many cases, it will as well remain below the

macro-economic maximum, as the landowner's discount rate is so high that the marginal ton of wood would lower economic benefits. There is a role to play for forest management measures.

Figure 1 shows how an instrument valuing carbon benefits can work. It presents a case for a hypothetical single-stand plantation with constant growth leveling out at year 20, where C content is set at 100 percent, of which the price is one. Assuming a zero interest rate, it would be rational for the landowner to wait until year 20 before harvesting (lower dotted line). Adding C benefits valued according to their lifetime to the salvage value would make it profitable to defer harvesting. Under a 6-percent interest rate, the landowner would not wait until maturity for, but would be forced to harvest at year 15. Combined timber and C benefits would continue to increase until year 18.²

Figure 1: Present value of a plantation's income streams of timber and combined timber and C plantation at 6% interest rate



The annually granted carbon incentive is calculated based on the pro-rata carbon stock. There is a relationship between growth rate, interest rate, and the carbon incentive needed. A subsidy granted annually based on C stocks and their lifetimes could thus lead to an optimal carbon content of a given area. The amount of additional funding needed for sustaining a forest until the point of saturation is determined by the moment when the marginal stock

² For this example, the market risk was neglected, and the following assumptions were met: Constant carbon increase of 5% annually until year 20. Annual value per tC at 3 percent of the timber salvage value, plantation costs of 20 percent of the C stocks at year 20, harvesting costs at 10 percent of each tC harvested.

value increase minus harvesting costs falls below the interest rate. In our example, this occurs in year 16. Carbon returns need to be higher than the opportunity costs of delaying the harvest.

Let's assume, due to an international subsidy, an over-use of mitigation options really took place. Would it have to be considered a mitigation measure that led to an increase in future emissions, as the amounts of forests planted today would lead to land scarcities in the future? Under market conditions, land scarcity provoked by massive afforestation would lead to clearance of the remaining natural forests. In this case, the subsidy would have perverse effects related to biodiversity, but would compensate the "over-use of sinks" from an atmospheric point of view.

Forestry includes adaptation elements related to sustainable development, as for instance:

- The proximity of natural forests increases the pest resistance of agriculture and plantation forests (Nasi, Wunder et al. 2002).
- Natural forests provide a genetic pool, which represents an option value for drug development and other commercial uses (Saphores & Bakshi 2001).
- Shade trees in many cases increase agricultural harvests, or protect cattle.
- Forests have the potential to protect watersheds and increase soil carbon in the long term.
- Windbreak plantations reduce soil erosion.
- Urban forests and trees in residential areas decrease people's exposure to direct sunlight, heat and dust and improve the micro-climate through their evapotranspiration, thereby contributing to public health.
- Forests act as a filter and improve water quality (Nasi, Wunder et al. 2002).
- "Living fences" are able to protect productive lands or natural forests against intruders.
- Firewood plantations improve livelihoods, where unsustainable biomass use leads to deforestation and devegetation.

- Timber as a raw material can in many cases replace energy-intensive materials such as plastic, aluminum, steel and concrete. .
- Forestry creates local income, thereby avoiding migration.
- Mangroves shield low-lying areas against the worst consequences of sea-level rise, while at the same time providing a shelter for marine biodiversity and creating income from fishery.

Most of these features are externalities to the forest owner. Under business as usual, cases exist where forestry operations worldwide that do not contribute to sustainable development, be it for biodiversity, food production or economic aspects. The choice of non-adapted species may lead to an over-use of water supplies. Indigenous peoples are being displaced from their lands, and customary rights not respected (Andersson 1997). Some of these cases may even aspire to be registered as CDM projects (Lohmann 1999; Kill 2001). Due to a lack of control, logging companies in many tropical countries over-use their concessions, or harvest in a way that brings about important collateral damage. Much of the potential harm from large-scale forestry comes from the vast areas covered and the fact that the scarcity of fertile soils is in many cases not reflected in land prices. Land use activities under the Climate Convention thus require higher social and environmental standards than regular forestry operations.

3 Timing issues

As shown above, the timing of activities is an implicit part of Article 2. We need to differentiate between the establishment of new plantations on the one hand, and the avoidance of deforestation and devegetation on the other, bearing in mind that

“[...] permanence issues are not the same for all types of sequestration projects. Protecting existing old growth does not increase the risks to future generations in the same way as suppressing forest fires or planting monocultures of fast-growing species. Other sink enhancement projects, such as changes in tillage practices, are also less susceptible to natural disturbances, albeit more susceptible to changes in management practices.” (Anderson, Grant et al. 2001)

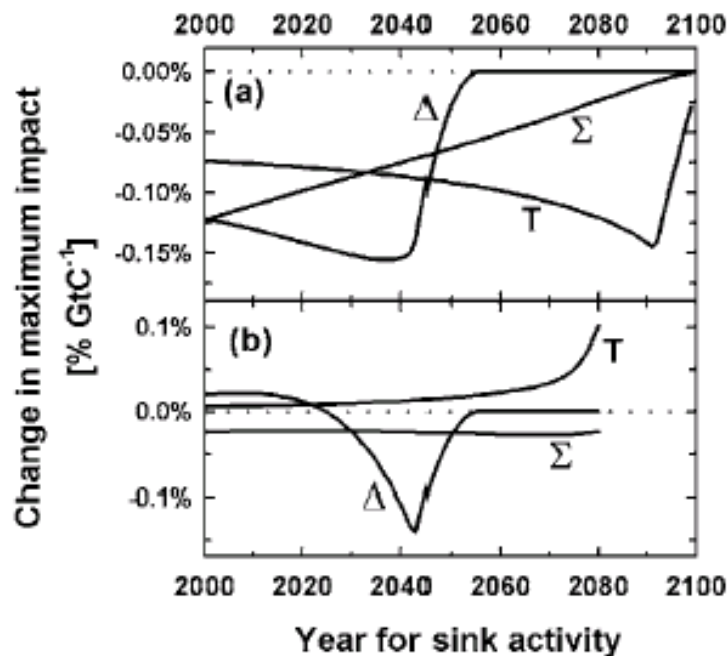
For new plantations, Kirschbaum (2003) identifies three effects of carbon storage in vegetation, which could be expressed by a delay of the related effects in days.

1. *the direct and instantaneous effect of CO₂ and its associated temperature;*

2. *the rate of change in CO₂ and its associated temperature;*
3. *the cumulative effect of CO₂ and its associated temperature.*

He runs his model based on the optimistic 1996 IPCC emissions scenario IS92, which departs from an effective GHG control until the end of this century. The rate of change under this scenario will have its turning point in 2040, while the absolute temperature increase is not completely halted within the century. As the potential for carbon sinks is limited, he distinguishes the three effects of afforestation. Within the 21st century, the instantaneous temperature increase could be diminished more the later sinks are established. Instantaneous consequences of temperature change (“T” in Figure 2) will be delayed by 25 days, if 1 Gt carbon is removed from the atmosphere at the time of highest concentrations, i.e. late in this century. The maximum effect of 1 Gt carbon reduced will be to delay the rate of change (“Δ”) by 70 days close to the year 2100, while the delay would be 45 days, in case the same option were implemented in 2000. Conversely, cumulative impacts (symbolized by “Σ”) would be mitigated most (a 20-day delay) if action were taken in 2000 already. *Temporary* sequestration in turn, may increase overall damages, in case releases occur during the phase of major rate of change. The same would be true for the situation of forest dieback due to climate change. The overall potential of biotic sinks is estimated at 87 Gt carbon until the year 2050 if aggressively pursued (Kirschbaum 2003). Under this assumption, 20 days per Gt carbon sequestered would translate into an overall delay of 5 years. In his model however, Kirschbaum disregards the lead-time for planning, land preparation, implementation and growth of a sink of this magnitude.

Figure 2: Effectiveness for the timing of permanent (a) and temporary sinks over 20 years (b)



(Source: Kirschbaum 2003)

Resuming, Kirschbaum advocates for establishing forests later this century on areas where other equally sustainable land uses exist. He explicitly excludes from this appeal opportunities for carbon sequestration that are not deferrable, like on areas under threat of salinization.

There is scientific uncertainty over the time horizon around the following issues:

1. Threshold values for total atmospheric CO₂ load or mean temperature that lead to abrupt and irreversible changes. In the presence of scientific uncertainty, the precautionary principle of environmental policy should prevail.
2. What is the limit of oceans and the terrestrial biosphere to take up CO₂? Most authors assume an unlimited increase in oceanic uptake capacity (Fearnside, Lashof et al. 2000; Moura-Costa & Wilson 2000; Fearnside 2002a; Kirschbaum 2003), while this is contested by others (Meinshausen & Hare 2000). A MIT Report expects the ocean uptake to peak by the middle of this century at 4.2 Gt of C and decline to 1.6 Gt C in 2300 (Sarofim, Forest et al. 2004).

The precautionary principle consists in avoiding risks that may occur in the future. Were the oceanic uptake unlimited over the next centuries, it would rather be the rate of change that

should concern us. Assuming limited oceanic uptake capacities would lead to a higher degree of urgency, including the immediate expansion of the biosphere's uptake capacity.

An economic equilibrium model serves to answer the question, whether deferring deforestation is economically attractive in order to “buy time” until the global economy has de-carbonized (Lecocq & Chomitz 2001). The authors assume permanence to be achieved in the moment when CO₂ concentrations return to today's levels, which may be in the 24th century. Until this time, payments are due to maintain natural forests protected. They agree that permanent sequestration is equivalent to fossil fuel abatement. Although single projects cannot be guaranteed to live up to this period, the overall portfolio of forestry projects will have a quantifiable survival chance. Key for sequestration dynamics is found to be the expected damage function, and not expectations about technological change. Temporary sequestration will, according to Lecocq & Chomitz only make sense if GHG concentrations are to be kept below critical thresholds. Hence, the use of LULUCF should start immediately, if these thresholds were near, and high damages expected at relatively low concentration levels. The shadow prices of carbon would rise at a faster rate than the economic discount rate. The optimum is reached, when the costs for temporary sequestering one ton CO₂e for a determined period plus abating the same amount, after this ton is released is equal to the actual abatement costs. Similarly, Herzog et al. find that “[t]here is little value to temporary storage if carbon prices rise at or near the discount rate” (Herzog, Caldeira et al. 2002). This finding points into the direction of expiring credits. These have the highest value, if mitigation prices are expected to decline, due to e.g. expectations over technological change, while an expected price increase above the investor's discount rate will invalidate them (McCarl, Murray et al. 2001; Dutschke, Schlamadinger et al. upcoming). As investors lack certainty, McCarl & Murray recommend a mixed mitigation strategy between emission reduction and carbon removal.

A somber picture on deforestation avoidance is drawn by a model calculation by Janssen & Mohr. Assuming a 5-year agricultural use of an area deforested, they calculate top-down opportunity costs per hectare for 13 tropical countries, based on real GNP for agriculture divided by the agriculturally used land area as given by FAO in 1999. Assuming that the willingness to pay by Annex-I countries solely depends on carbon content per hectare and is rising at an annual 10 percent, they calculate for which countries there is a window of opportunity for negotiating conservation transfers, which are the minimum strike prices per ton of carbon for each country. Until the moment of an agreement, deforestation is assumed to

proceed at the same level. Thus the carbon value per hectare would decrease, thereby determining the moment the window closes. The authors find that by the time the article was written, the cost of a ton of carbon preserved was between 9 US\$ (2.50 US\$ per ton of CO₂e) in Bolivia and 874 US\$ (238 US\$ per ton of CO₂e) in India. Even under the assumption of a carbon value of 100 US\$ (27 US\$ per ton of CO₂e), there would be no chance to survive for the natural forests of India, Indonesia and Malaysia (Janssen & Mohr 1998).

Like other top-down models, the Janssen & Mohr model can be criticized for its high degree of aggregation and the resulting low resolution. The main reason for its pessimistic undertone can be found in the high opportunity costs for foregone land use: First, the assumption that the main driver is agriculture is not legitimate in all cases. For instance, in S-E Asia, it is the timber market that drives deforestation. Second, the main contribution to the sectoral GNP does not usually come from areas under shifting cultivation, but rather from cash crops like banana, cotton, coffee or sugar that are intensively cultivated on areas cleared long before. Slash-and-burn practices contribute little to the creation of agricultural value added, and they are often realized by marginal farmers, whose products remain in the informal sector. Furthermore, exchange rates are varying (usually the value of the local currencies decreases over time). The erosion of the terms of trade for agricultural goods and the diminishing GDP contribution of the primary sector in developing economies (Sathaye, Chan et al. 2003) will over time lead to decreasing deforestation rates and contribute to the market chances for forest conservation. A functioning market for forest protection services would detect the least-cost options within the countries. Overall, the cited study shows that forest protection is not a low-cost option and it may come too late for important carbon reservoirs and biodiversity pools.

Fearnside, in defense of the ton-year approach for accounting of biotic sinks, argues for a non-linear discount to apply to damage occurring in the future. He ethically justifies his point of view relating to the cascading effect of lives lost or saved today for future generations (Fearnside 2002a). Which discount rate to apply, is an issue widely discussed in ecological economics (Tietenberg 2000), and Fearnside's approach is inspired by Generation Adjusted Discounting (Bayer 2000; Bayer 2003). Ecologists face a dilemma when proposing a discount rate (Pearson 2000). They use low discount rates for future damages, in order to prove urgency, because high rates would reduce the present value of damages and future costs for avoiding them. On the other hand, high discount rates tend to dissuade resource extraction projects with high upfront costs, like mining or hydroelectric dams. Risks associated to

climate change cannot be framed in present value considerations only, because they are uncertain, potential damages are high, and they will be borne by future generations (ibid.).

The “over-use” argument (Ott, Klepper et al. 2004) related to timing of land use measures is found in NGO criticism (Kill 2001): If in the future, developing countries were to agree to emissions targets, sinks opportunities would have already been tapped by the industrialized world. This could be the case if these opportunities were static, which however the same authors deny. Furthermore, as discount rates are high in developing countries, there is an undeniable advantage of receiving compensation for climate change mitigation activities today.

4 Discussion

Critiques of land use activities in the CDM have on many occasions pointed to other multilateral environmental agreements like the UN Convention on Biological Diversity, the UN Convention for Combating Desertification, or the UN Forum on Forests to provide the finance needed for sustainable forestry and insisted that the UNFCCC is all about carbon (Fearnside 2001). Like shown in the above paragraphs, natural or sustainably managed forests have their place in achieving the ultimate objective of the Climate Change convention. Their overall carbon removal or storage potential is limited however. The afforestation potential is estimated to remove 87 Gt carbon if aggressively pursued, and its use within this century could theoretically defer effects of climate change effects for a maximum of 12 years, applying the Kirschbaum model (Kirschbaum 2003). Carbon benefits from deforestation avoidance will be in the same range (Sathaye, Chan et al. 2003), depending on the baseline in each individual case. Permanent sinks enhancement is directly comparable to abatement options e.g. from energy conservation (Greenpeace 2002). The validity of this statement depends on how “permanence” is defined. If defined as an infinite period, conservation or enhancement of biotic pools will not at all contribute to climate change mitigation. Under this perspective however, climate change itself will be a temporary phenomenon, finding its solution in the end of fossil resources and the subsequent global temperature decline. On the long run, ecosystems will adapt naturally. It is thus not *per se* an ecological point of view to analyze an infinite timeframe. Considering a timeframe of e.g. 10,000 years, one may come to

the result that today's global warming problems are either insignificant, or, with a view to all the potential future damage, decision makers could end up paralyzed (Fearnside 2002b). We might include in our considerations a new ice age in 50,000 years, of which the effects could be delayed by some long-lasting trace gases left over in the atmosphere during the 20th and 21st century (Michaelowa 2003). A short timeframe should be expected to be similar in its effects to a high discount rate. The consequence on the choice of climate mitigation measures however depends on the underlying assumptions, rather than on timeframes. Michaelowa, concentrating on mitigating the rate of temperature *decrease* after GHG concentrations have peaked around the year 2200, advocates a bonus for mitigating short-lived gases like CH₄ and N₂O.³ The same result could be borne if a short timeframe was applied, like e.g. 20 years. The IPCC in its Second Assessment Report has opted for a 100-year timeframe for comparing different GHGs' warming potential, with a zero discount rate. This choice is not necessarily the ultimate truth, but rather an indicator for the willingness to pay of today's societies, and it may be subject to change for future commitment periods. Article 5.3 foresees a regular revision by the Conference of the Parties. The need for adopting the timeframe emerged when defining the "basket" of six GHGs not controlled by the Montreal Protocol in Annex A of the Kyoto Protocol. By capping the emission of each each single gas separately in the national inventories, the discussion around timeframes would have been avoided. In the context of biotic carbon sinks however, this issue is unavoidable. Every single sink is under constant threat to release the sequestered carbon again at any time. An incentive mechanism for the creation and conservation of sinks should assure that the release does not occur in parallel. Anyway, climate change is likely to lead to a conversion of some actual sinks to sources in the future (Schulze, Wirth et al. 2000; Read, Beerling et al. 2001). Fearnside et al. have referenced to the GWP timeframe: "Whether intended or not, the choice of a time horizon has created a value for time under the Protocol." (Fearnside, Lashof et al. 2000). Fearnside bases his argument on the perception of the individual within time, rather than on an economic cost-benefit analysis. His "unified index for time preference" is composed by the forward-looking valuation of the 40-year old decision maker, who may be inclined to attach decreasing values to his or her own life (40%), the children (35%), the one of grandchildren (15%), and finally the great-grandchildren (10%). These values were to be discussed in a societal discourse (Fearnside 2002a). This approach leads to a stepwise decreasing valuation function until year 110. This approach has been criticized as static. Applying it year after year, the discount factor would linearly fall, to reach zero after 150 years (Tol 2002).

³ It could be discussed whether Article 2 includes adaptation to global cooling. In the author's view, this issue is

After all, we may reduce our perspective to one of the following options:

1. A running hundred-year timeframe: 100 years is the horizon a single human is able to envisage. A mid-aged decision maker knows the persons who will live (and decide) in 100 years from now and is able to take the stewardship for them (Fearnside 2002b). The IPCC Relative Global Warming Potentials (GWPs) on the basis of 100-year damage seem to confirm the view that carbon sequestered needs to be kept out of the atmosphere for at least 100 years (Anderson, Grant et al. 2001). A dynamic element is needed, as most of our knowledge is recycled every 20 – 30 years. The precautionary principle should lead us to err on the conservative side, so that necessarily some of our apprehensions will turn out to be wrong.
2. The time necessary until GHG concentrations start to decline, which – according to the worst-case scenario of full fossil fuel use – will be between the years 2100 and 2200. The closer we get to this point, the higher our certainty. Once stabilization is reached, adaptation will still be necessary, because of the time lag of temperature and sea level changes, but the UNFCCC policy will come to an end. The ultimate objective will at best gradually be reached, and a future desirable temperature path will then need to be determined.
3. As an alternative, the return to today's GHG concentration levels is envisaged, which will be between the 23rd and the 24th century (Lecocq & Chomitz 2001). This point in time seems arbitrarily chosen. Circumstances will be different, when the atmospheric system crosses this line again.

Alternatives 1 and 2 do not necessarily exclude each other. Climate mitigation and adaptation activities can only be reached within our actual institutional framework. Institutions have limited lifetimes. The UN system has not accomplished 60 years of age. Taken together with its precursor, the League of Nations, it could be considered to exist for 86 years. The Geneva Convention, the first multilateral treaty in history (Madigan 2004), was signed by 12 nations in 1864. We should thus be cautious with respect to long-term activities, if we do not simultaneously build up the institutional support. The Kyoto Protocol as the first agreement on concrete action against climate change, signed in 1997, has to date not been ratified by the necessary quorum of Annex-I Parties. International law is developing slowly, and its institutions are weak. States act under a prisoner's dilemma when complying with

beyond the actual scope of the UNFCCC.

international treaties. As long as the Meeting of the Parties to the Kyoto Protocol has not confirmed the Marrakech Accords, the CDM Executive Board is working under provisional rules. Public law knows contracts of a maximum length of 99 years. In consequence individual climate mitigation and/or adaptation activities should be projected in a way that they to the best of today's knowledge do not conflict with the ultimate objective of the Climate Convention (as proposed in option 2), but it is arguable that their scope should be limited to a timeframe of 100 years, counted from their respective starting dates.

The value of forests for achieving the goals of biodiversity (ecosystems' adaptation), ensuring food production, and sustainable economic development is undeniable. If implemented in the right manner, they will contribute as much to climate change mitigation *and* adaptation. How can carbon and non-carbon effects of forests compare? If carbon-intensive land use can delay the incidence of global warming effects, its adaptation effect will gain time by allowing human and ecological systems to adapt to higher levels of GHG concentrations. Forestry projects that do not contribute to adaptation are hardly conceivable as mitigation activities. If they do not contribute to biodiversity, neither to sustainable economic development, their chances to serve as permanent carbon stocks are limited, to say the least. Nevertheless, there are climate adaptive land-use activities with a low carbon value. Adaptation is most cost-effective where it attends the needs of today's populations (Michaelowa 2001). As it tends to increase wealth, it will provide cascading benefits for future generations as well. It is therefore justifiable to apply a discount on benefits from adaptation. The adaptation value will even be achieved within a timeframe shorter than permanent.

For carbon benefits, discounting is being questioned because future generations will suffer from the release of CO₂ and other GHGs if an area is deforested again. It is arguable however, that the carbon sequestration time path is non-linear. Deforestation and devegetation avoidance are activities that cannot be delayed, as the resource is currently being overexploited and will most likely not recover within our 200-year timeframe. Another non-linearity is derived from the actual atmospheric GHG and temperature levels. The fertilization effect from higher CO₂ and N₂O levels in the atmosphere contributes to higher growth. There is an individual saturation level to this effect, depending on soil composition and solar exposition. It is rational to take advantage of the fertilization effect as long as it lasts. The opposite effect is the vegetation dieback under increased temperature levels, but it is yet impossible to tell, at which point in time this will occur on a worldwide level (Cox 2005).. Both effects may act in parallel, differentiated along regions, and counteract on a global scale.

Using the fertilization effect may contribute to delay the dieback. Under the aspect of the balance between the positive fertilization effect and the negative climate-change induced dieback, no discount should be applied to the earlier (Jackson 2002). In the meantime, forest research may be able to develop species adapted to changed climatic conditions. Would it be responsible towards future generations to refrain from any forestry activities? If the answer is no, it implies a discount on potential future damage. As deforestation and devegetation avoidance will not be CDM eligible in the first Kyoto commitment period, its acceptance after 2012 will already come too late for many of the Indonesian natural forests (Wietling 2004). It can be argued that a for the sake natural forests' adaptation services high time preference should be given to conservation, while afforestation can be delayed, as long as there are alternative sustainable uses of the area, eventually bringing about additional benefit in the future (Kirschbaum 2003).

There is a fundamental error in the argument that the potential non-permanence of biotic carbon storage should not allow present generations to use it as a climate change mitigation option. Damages from future deforestation are not bound to occur automatically, but depend on the respective care of each generation. By inheriting forest resources to future generations, we entrust these to care for this heritage in a sustainable manner. Only the damage attributable to present GHG emissions can be considered our responsibility, thus we may decide not to discount all future damages. Assuming we expect 30 percent of the Amazon carbon content to be emitted over the next century only due to human-induced climatic changes, there is a share of 70 percent each generation whose protecting today may be discounted. The same applies to fossil resources: By refraining from their use today, we give future generations the option to use them, which could end up in temporal leakage of emissions (Herzog, Caldeira et al. 2002). The criterion of inter-generational equity implies that we must not be prescriptive in what we deem appropriate today. This is different for the question of nuclear waste or geologic CO₂ deposits bear only risks and no opportunities for future generations. An example for long-term decisions with intergenerational effects is the one of urban structures built up today. Suburbia will always imply a carbon-intensive transport infrastructure, and consequences of today's decisions will leap into the next century (Spence 2004).

As we saw above, carbon is an imperfect measure for the combined benefits of land use. While adaptation measures can stand for themselves, pure carbon forestry without a contribution to climate change adaptation is not compatible with the ultimate objective of the Climate Convention. From a pure carbon point of view, the overall contribution by biotic

sinks to long-term climate stabilization is rather insignificant on the secular timescale. Its adaptation effects can however increase the resilience of biotic and human systems against expected rates of temperature change. As we lack measures for the value of global ecosystem services (Andersson 1997; Saphores & Bakshi 2001), there is no quantitative manner to treat the issue. There are however priorities among the activities related to land use, land-use change and forestry:

1. Avoiding deforestation and devegetation is in many cases a cost-effective way to preserve big amounts of carbon from being emitted, while protecting soils, biodiversity and livelihoods needed for adaptation to climate change.
2. Forest management activities have the potential to increase carbon density in managed forests and avoid lasting damages from unsustainable harvesting practices. In most cases, forest management can only be profitable on the long run, as it increases site productivity and resource renewal (Ruzicka & Moura-Costa 1997). Therefore, the higher the country risks, the higher the carbon potential for forest management, given the right incentives.
3. Afforestation and reforestation according to the Marrakech definition⁴ can have a supplementary role in conservation and forest management. Contrarily to forest conservation, plantations will take up carbon slowly. There is a principal difference between restoration forestry destined to create secondary forests and production forests. The latter will be harvested regularly and will thus never achieve their biological growth equilibrium. As a minimum criterion, AR activities should not decrease carbon stocks in soils, even if properly accounted for. This can best be achieved, if only afforestation projects of a certain minimum length are eligible for credit.
4. Bioenergy is an important aspect of managed forestlands. Using wood from afforestation and forest management for energy production increases economic returns from forward linkages of the resource, adds another element of technology transfer, while at the same time addressing methodological problems like market leakage, permanence, and scale (Schlamadinger, Grubb et al. 2001).

⁴ For foresters, reforestation is the re-plantation of trees after harvesting. In Marrakech terms, it is the installation of forests on areas that were non-forested on 31st December 1989. Afforestation is understood to be the land-use change to forestry on areas that were non-forested at least for 50 years. Under the CDM, both categories are

Independently from their type, preference should be given to (combined) activities that achieve highest sustainability co-benefits at the lowest costs. This can be achieved by preserving or increasing biodiversity in carbon forestry and by creating community benefits. In the next paragraph, we ask, considering the above, which criteria a forestry incentive mechanism should fulfill in order to achieve long-term carbon and adaptation benefits.

Subject of the CDM are activities within states that do not belong to Annex I and have not (yet) agreed to a quantitative emission limitation obligation. For Annex I, there is unlimited liability for carbon removal once reported (Kyoto Protocol, Articles 3.3 and 3.4). It is likely that in the second or third Kyoto commitment period (or any other post-Kyoto climate regimes) more countries accept quantitative GHG emissions targets, be they voluntary or in the form of a full accession to Annex I. The CDM in their case is a temporary fix for a problem that will find a long-term solution. Permanence problems will vanish, as more countries get involved in target setting. The risk of gaming between the acceptance of liability for carbon stocks built up under the CDM and future targets needs to be minimized by transparent target allocation rules for future commitment periods. However, these are required anyway, in order to avoid free-riding effects like under the current commitment period.

There are two logical failures in the argument that potentials for developing country engagement were being taken by the CDM (besides the fact that it does not relate to the land-use mitigation option specifically). One is that mitigation opportunities are time-dependant and may not be present in the future, which is especially true for areas under deforestation and devegetation pressure. The other is that no country will take on future commitments, if CDM mitigation success is debited from its account.

Whereas the aim of any mitigation activity should be permanence (i.e. over 200 years), even temporary measures may be beneficial under the following conditions:

1. A slower pace in temperature increase would allow biotic systems to adapt, which would be impossible under very rapid global warming. The time needed for adaptation however depends on geological and biological conditions. Given the high uncertainty over the speeds of climate transition and adaptability of natural systems, thresholds will act on a regional rather than a global level.

treated in the same way, which is why we will refrain from further differentiation of the two categories in this article.

2. Future damage resulting from a potential release of the carbon removed may be discounted. Assuming a positive discount rate depends on one or more of the following assumptions that are closely related to each other:
 - a. Delaying global warming will increase the welfare of present generations and lead to a higher accumulation of wealth for future generations.
 - b. Increased wealth will help future generations coping with global warming problems.
3. Under the assumption of increasing greenhouse gas levels, the future emission of one ton of CO₂ sequestered today will cause a lower marginal damage than it does today (Chomitz 2000). This argument however is misleading, if the rate of change by the time these emissions occur is higher than the actual one.

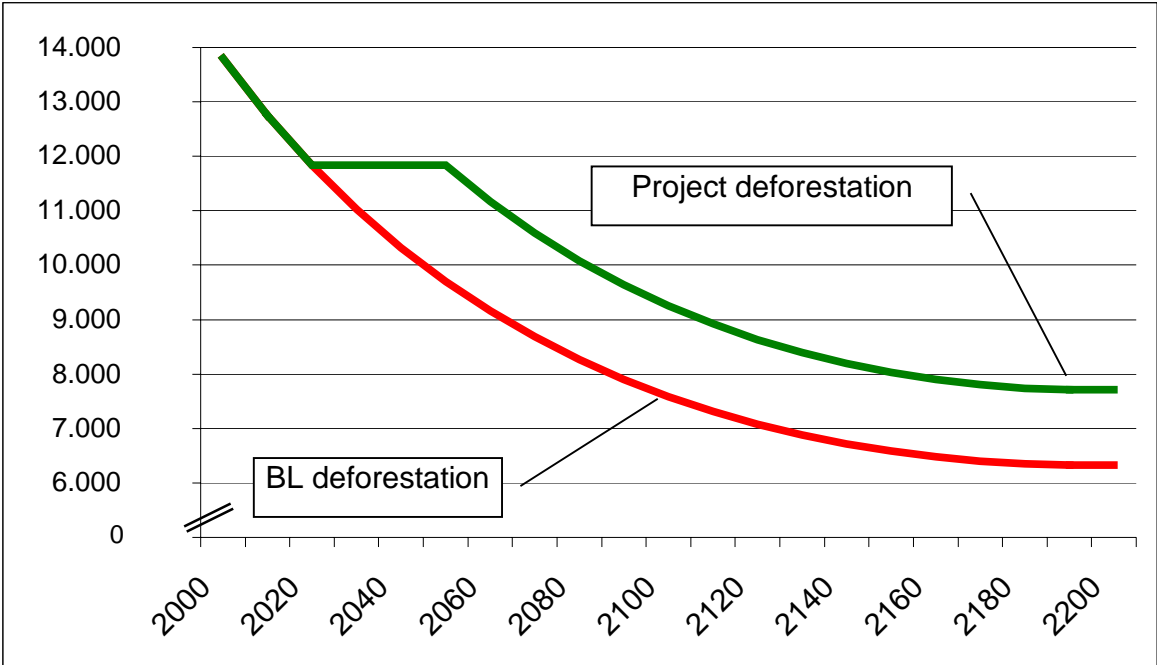
The permanence risk is further mitigated by two considerations. Overall, a higher percentage of land-use mitigation measures will remain permanent than without the carbon subsidy (Marland, Fruit et al. 2001). In developing countries, a future increase in wages and intensified agricultural technologies will lead to a reduction of marginal farming over time. In 30 years time, there will thus be less incentives for deforesting the areas protected or afforested today (Chomitz & Thomas 2001). It is expected that in consequence of the declining dependence on primary resources, deforestation rates will fall over this century. The peak for Africa will be reached in 2020, while in the other continents deforestation is already seen as decreasing (Sathaye, Chan et al. 2003). This leads us to a digression over baselines for deforestation and devegetation avoidance and their consequences on permanence.

4.1 Digression: Deforestation and devegetation avoidance – baselines and permanence

Deforestation avoidance bears more similarities with avoided fuel emissions. One ton of fossil fuel avoided for energy production may be used in the future and delay the end of oil drilling, which would be temporal leakage. The same could happen with the hectare of forest protected and chopped down in the future. However, on the assumption of the world economy to decarbonize, the resource will not be used up, and future energy demand will be covered by less fossil inputs. The same is true for deforestation: There are indications that due to a lower relative weight of the primary sector in developing economies, the pressure on land will

decrease. The benefit will thus be permanent, because one hectare of deforestation saved for one or two decades will be exposed to a lower deforestation rate in the future. In the example in Figure 3, an area of 15,000 ha was forested in 1990, with a 10-year deforestation of eight percent detected in the year 2000, a rate assumed to decline to zero until the end of this century. A conservation project protects the area against deforestation between the years 2020 and 2050. In our example, 7,710 ha will remain in 2100, as compared to the baseline case of 6,322. Temporary protection has led to a permanent carbon gain. In real life however, it may be difficult to clearly attribute this gain to the protection activity

Figure 3: Permanent gain of a 30 years forest conservation



There are two manners to determine a baseline for deforestation and devegetation; top-down or bottom-up. The top-down case is the easier way: a whole country commits to reduce deforestation below a threshold value. This threshold is best determined as an average over a base period. The baseline may be static, if deforestation values have been constant in absolute or relative numbers, or it is dynamic to mirror changes occurred in the past or factors independent from the project partners that will influence future compliance. If a country that does not belong to Annex I commits to reduce its deforestation rate, an inventory of the whole forest area and its variations is needed. This is different in the bottom-up case, as for every single activity area involved a scenario analysis is needed that it is indeed threatened from

deforestation. This has been done by The Nature Conservancy for the Brazilian Guaraquecaba project using the GEOMOD model (Brown, Burnham et al. 2000). It reacts to parameters like the proximity of roads, cities and other infrastructure and has been verified by identifying areas based on historical data that were effectively deforested. The problem of leakage has been tackled by contracts with logging companies to refrain from replacement deforestation outside the area. As long as these activities are legal or legally not prosecuted however, there is no long-term security of real project-related emission reductions.

Another problem arises when reviewing the deforestation baseline. In the top-down case, the difference between would-be and actual logging is being accounted for. When reviewing the baseline, the new deforestation rate will constitute the baseline. Consequently further deforestation reduction policies will become more costly per ton of carbon CO₂ equivalent reduced, the more area was conserved in the first term. If deforestation returns to previous heights, permanence of credits is threatened. In the bottom-up case, baseline deforestation will be monitored outside the protected area. If there is leakage not recognized as such, the future baseline will be higher as if there were none. Thus there is a double incentive for project participants to neglect leakage. If the area was preserved in the first crediting period, deforestation pressure will act on an area that would have been deforested already in the non-project case. By preserving areas that were preserved in earlier crediting periods, there seems to be no additional carbon benefit. Hadn't the project started, areas would be threatened that are out of reach after the first project phase. While early conservation activities are less costly in the beginning, on stabilization of the forest area, deforestation avoidance is accounted for only once, even though areas are out of reach for intended deforestation due to the existence of the project activity.

While for a first baseline validity term deforestation and devegetation avoidance seems feasible in principle, it may become methodologically cumbersome after some time of successful conservation. This is so, because either the baseline builds up on a double hypothetical state (had the project not existed before), or protection starts over with the risk of accounting twice for the same piece of land. In no case however, all of the carbon stored in natural vegetation in a given region can be accounted for, unless a business-as-usual devegetation of the complete project area is expected to occur within the first baseline validity period.

5 Conclusions: Criteria for forestry incentive mechanisms

The importance of “long-term benefits related to the mitigation of climate change” is stressed under the Kyoto Protocol Article 12 (b), in which the CDM is defined. Interpreting Article 2 on the ultimate objective of the Framework Convention on Climate Change, we have tried to define what is “long-term”. The result is a range of 100 to 200 years under future emission scenarios, but as well under ethical and institutional considerations. While planned activities should not run counter the stabilization goal of the Convention in a timeframe of 200 years, a span of 100 years is a timeframe the present generations can oversee and frame into legal and institutional structures. This latter timeframe should be dynamic, so that emissions resulting from today’s forestry activities are fully accounted for at the time they occur. Permanence of biotic carbon stocks is a problem for as long as host countries have not taken over proper emission targets. After that point in time, liability for emissions on their territory will be with them and need to be accounted for as appropriate. Any regulation needs to make accounting systems compatible to Annex B and to foresee a transition from CDM to domestic host country accounting, respectively Joint Implementation between Annex B Parties.

Sink conservation and enhancement is not at odds with the Climate Convention, but an integral part of it, as evidenced in Articles 3.3, 4.1 (d) and 7.1 (d), but it is no catch-all solution. Land use activities in carbon terms will in the long run only contribute a modest share to the solution of climate change. Their success critically depends on efforts in the field of industrial, commercial, transport and household emissions abatement. Clearly, climate forestry would run counter the ultimate objective of the Climate Convention, if land use activities resulted in a pretext for delaying emission reduction activities, because higher GHG concentration levels will most likely cause dieback of existing forests. GHG source reduction and biotic sink enhancement should be seen as complimentary. In the first Kyoto commitment period, a limitation of land use activities in compliance with climate targets has been agreed. For future commitment periods, emission targets should only be agreed *after* the activities eligible for compliance with these targets have been stipulated. An alternative could be to fix a separate target for credits from land use activities within the Parties’ country budgets. The aim should be to keep incentives for technological development high without disregarding the high mitigation, adaptation and sustainable development contribution of land use to the ultimate objective of the Climate Convention.

Land use activities comply with UNFCCC Article 2 inasmuch they contribute to adaptation against climate change (soil, watershed and biodiversity conservation, food and income production). In this respect, they acquire a double time value: Besides delaying climate change, they delay effects of vulnerability. Preference should be given to measures that avoid deforestation, devegetation and soil fertility. Minimum project duration for afforestation should ensure that initial losses of soil carbon if they occur are over-compensated in a later project stage. Beyond this minimum duration, there should be ways to account for temporary carbon storage.

Contrarily to the critiques, there is no conceivable over-use of sink potentials. Assuming growth conditions and soil quality to be constant over time, there may be benefits of eventually delaying afforestation and reforestation until late this century. Afforestation is most efficient as a complementary measure to conservation, and in situations where no alternative land use is able to protect soils or water resources. Competition with other land uses will lead to opportunity cost increases of sinks at the margin, so that market forces will limit unsustainable afforestation. Under an inter-generational equity point of view, forested lands constitute an exploitable renewable resource, as distinct from geological or marine CO₂ storage.

Compared to environmental services that act on a regional scale, such like watershed conservation, GHG removal or emission avoidance compensation is a relatively simple mechanism. The global benefit is uniform (CO₂ equivalent), verifiable and tradable, there is one central institution (the CDM Executive Board), a host country reference institution (the Designated National Entity), and there are private certification agencies (Designated Operational Entities). There is a need for a good storyline in the absence of the planned activity (the Baseline), and a reliable monitoring plan. For other positive project externalities, it is in many cases difficult to find appropriate beneficiaries (willing or able to pay) or to quantitatively define the service. In many cases, the consumers of these values are not even born today (Andersson 1997). There exist market mechanism on regional or national scales (Nasi, Wunder et al. 2002), but it is hard to imagine that rules for an international market based compensation scheme could be found, nonetheless because developing countries insist in defining sustainability for themselves. It seems thus rational to co-finance land use activities with high adaptation value from separate funding schemes, for which there should be an explicit exemption from the Marrakech rule over non-diversion of Official Development Assistance (Dutschke & Michaelowa 2004). Combined mitigation and

adaptation activities should be exempt from the adaptation levy. Carbon accounting should be differentiated according to the activity's contribution to adaptation, as expressed in the above ranking. Time preference can be expressed in a discount rate. As a practical example, a replacement for losses occurred on the area could be discounted for the time emissions were avoided.

For conservation, a supportive political environment is key, as there is a high leakage risk in the absence of administrative control. Logging companies bought out of one area will take up concessions in other places. Conservation should thus be carried out at least in a regional (Fearnside 2001), or better, a national framework. Costa Rica offers a living example how conservation can be integrated into a national regulatory structure (Dutschke & Michaelowa 2000; Vöhringer 2004). Government support is indispensable for conservation measures; in many cases it seems sensible for governments to seek for CDM funding to implement planned national parks. As the establishment of national parks by law increases chances for permanence, policies and measures for conservation should thus be eligible under the CDM. Conservation promises high carbon rewards in the beginning and long-term climatic benefits. The flipside of the coin is that conservation once achieved will become part of the baseline when the project baseline is reviewed, and not even temporary crediting will allow the trick to be repeated. This calls for the seller to take over long-term liability or an international financial mechanism that helps in securing protected forests.

References

- Adams, R., B. H. Hurd, et al. (1999). A review of impacts to U.S. agricultural resources. Washington D.C., PEW Center on Global Climate Change: 39.
- Anderson, D., R. Grant, et al. (2001). Taking credit: Canada and the role of sinks in international climate negotiations. Vancouver, David Suzuki Foundation: 86.
- Andersson, T. (1997). The Tropical Forests as a Global Resource: Impacts of Trade-Related Policy. Working Paper Series in Economics and Finance. Stockholm.
- Bayer, S. (2000). Intergenerationelle Diskontierung am Beispiel des Klimaschutzes. Marburg, Metropolis.
- Bayer, S. (2003). Generelle Nichtdiskontierung als Bedingung für eine nachhaltige Entwicklung? IAW-Diskussionspapiere. Tübingen: 24.
- Berry, L. (2003). Land Degradation in China: Its Extent and Impact, LADA - Land Degradation Assessment in Drylands, GEF / UNEP / UNCCD / FAO, Country Study
- Brown, S., M. Burnham, et al. (2000). "Issues and challenges for forest-based carbon-offset projects: a case study of the Noel Kempff Climate Action Project in Bolivia." Mitigation and Adaptation Strategies for Global Change(5): 99 - 121.
- Carvalho, G., P. Moutinho, et al. (2004). "An Amazon Perspective on the Forest-Climate Connection Opportunity for Climate Mitigation, Conservation and Development?" Environment, Development and Sustainability 6: 163-174.
- Chazdon, R. L. (2003). "Tropical forest recovery: legacies of human impact and natural disturbances." Perspectives in Plant Ecology, Evolution and Systematics 6(1,2): 51-71.
- Chomitz, K. M. (2000). Evaluating carbon offsets from forestry and energy projects : how do they compare? Washington, D.C, World Bank Development Research Group Infrastructure and Environment.
- Chomitz, K. M. and T. S. Thomas (2001). Geographic patterns of land use and intensity in the Brazilian Amazon. Washington, D.C., World Bank Development Research Group Infrastructure and Environment.
- Cox, P. (2005). Conditions for Positive Feedbacks from the Land Carbon Cycle. Avoiding Dangerous Climate Change, Exeter Feb. 1-3, 2005,
- Cramer, W., A. Bondeau, et al. (2001). "Global response of terrestrial ecosystem structure and function to CO₂ and climate change: results from six dynamic global vegetation models." Global Change Biol 7(4): 357-373.
- Dutschke, M. and A. Michaelowa (2000). Host country-driven implementation: the case of Costa Rica, in: Michaelowa & Dutschke (Ed.) 2000, pp. 133-179. Climate Policy and Development. A. Michaelowa and M. Dutschke. Cheltenham, Edward Elgar: 133-179.

- Dutschke, M. and A. Michaelowa (2004). "Development assistance and the CDM - how to interpret "financial additionality"." Environment and Development Economics(submitted).
- Dutschke, M., B. Schlamadinger, et al. (upcoming). "Value and risks of expiring carbon credits from afforestation and reforestation projects under the CDM." Climate Policy.
- FAO (1996). Press Release 97/43. Rome, Food and Agriculture Organisation,
- Fearnside, P. M. (2001). "Saving tropical forests as a global warming countermeasure: an issue that divides the environmental movement." Ecological Economics **39**(2): 167-184.
- Fearnside, P. M. (2002a). "Time preference in global warming calculations: a proposal for a unified index." Ecological Economics **41**(1): 21-31.
- Fearnside, P. M. (2002b). "Why a 100-year time horizon should be used for global warming mitigation calculations." Mitigation and Adaptation Strategies for Global Change **7**(1): 19-30.
- Fearnside, P. M., D. A. Lashof, et al. (2000). "Accounting for time in mitigating global warming through land-use change and forestry." Mitigation and Adaptation Strategies for Global Change **5**(3): 239-270.
- Gärtner, M. (2004). Engpässe in der Infrastruktur bremsen Chinas Wirtschaft: Computerfirmen denken über Produktionsverlagerung nach - Agrarland wird knapp. Handelsblatt, Düsseldorf 31.08.2004:8
- Graßl, H., J. Kokott, et al., Eds. (2003). Über Kioto hinaus denken - Klimaschutzstrategien für das 21. Jahrhundert. Berlin, WBGU - Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen.
- Graßl, H., J. Kokott, et al. (1995). Szenario zur Ableitung globaler CO₂-Reduktionsziele und Umsetzungsstrategien. Stellungnahme zur ersten Vertragsstaatenkonferenz der Klimakonvention in Berlin. Berlin - Heidelberg - New York, WBGU Wissenschaftlicher Beirat Globale Umweltveränderungen,
- Greenpeace (2002). Submission by Greenpeace on Issues related to modalities for including afforestation and reforestation under Article 12. Bonn, United Nations Framework Convention on Climate Change, UNFCCC/WEB/2002/12: 47-62.
- Hadley-Centre (2000). Climate Change. An update of recent research from the Hadley Centre. Bracknell Berkshire, UK.
- Hasselmann, K., M. Latif, et al. (2003). "The Challenge of Long-Term Climate Change." Science **302**: 1923-1925.
- Herzog, H., K. Caldeira, et al. (2002). An Issue of Permanence: Assessing the Effectiveness of Temporary Carbon Storage. Cambridge MA, MIT Joint Program on the Science and Policy of Global Change, Report 92: 19.
- Jackson, M. (2002). Subnational Entity Accounting for Carbon Sinks and Storage. Lyneham, Australia, The Carbon Store PTY LTD,
- Janssen, J. and E. Mohr (1998). "The Window of Opportunity for Rain Forest Protection: The Time Remaining in the Rio Process." International Environmental Affairs **10**(1): 40-63.

- Kill, J. (2001). Sinks in the Kyoto Protocol: A Dirty Deal for Forests, Forest Peoples and the Climate. FERN Briefing Note. Brussels.
- Kirschbaum, M. U. F. (2003). "Can Trees Buy Time? An Assessment of the Role of Vegetation Sinks as Part of the Global Carbon Cycle." Climatic Change **58**(1-2): 47-71.
- Lecocq, F. and K. M. Chomitz (2001). Optimal use of carbon sequestration in a global climate change strategy : is there a wooden bridge to a clean energy future? Washington, D.C., World Bank Development Research Group Infrastructure and Environment.
- Lohmann, L. (1999). The Carbon Shop: Planting New Problems. Montevideo, ISBN 9974-7587-7-7: 13.
- Madigan, J. H. (2004). Being human, being good: The source and summit of universal human rights. Faculty of the Graduate School. Maryland, University of Maryland: 356.
- Marland, G., K. Fruit, et al. (2001). Renting Carbon Offsets: The Question of Permanence. Washington D.C., Resources For the Future: 12.
- Marland, G., R. A. Pielke Sr, et al. (2003). "The climatic impacts of land surface change and carbon management, and the implications for climate-change mitigation policy." Climate Policy **3**: 149-157.
- McCarl, B. A., B. C. Murray, et al. (2001). Influences of Permanence on the Comparative Value of Biological Sequestration versus Emissions Offsets. Working Paper. I. S. U. Center for Agricultural and Rural Development. Ames, Iowa: 20.
- McMichael, A. J., Ed. (2003). Climate Change and Human Health - Risks and Responses / Summary. Geneva.
- Meinshausen, M. and B. Hare (2000). Temporary sinks do not cause permanent climatic benefits: Achieving short-term emission reduction targets at the future's expense, Greenpeace: 7.
- Michaelowa, A. (2001). Mitigation versus adaptation: the political economy of competition between climate policy strategies and the consequences for developing countries. HWWA Discussion Papers. Hamburg: 28.
- Michaelowa, A. (2003). "Limiting Global Cooling after Global Warming is Over. Differentiating Between Short- and Long-Lived Greenhouse Gases." OPEC Review **27**(4): 343-351.
- Moura-Costa, P. and C. Wilson (2000). "An equivalence factor between CO2 avoided emissions and sequestration - description and applications in forestry." Mitigation and Adaptation Strategies for Global Change **5**(1): 51 - 60.
- Nasi, R., S. Wunder, et al. (2002). Forest Ecosystem Services: Can they pay our way out of deforestation? Forestry Roundtable, New York
- Obersteiner, M., C. Azar, et al. (2002). Biomass Energy, Carbon Removal and Permanent Sequestration - A 'Real Option' for Managing Climate Risk. Laxenburg, AT, International Institute for Applied System Analysis IIASA, IR-02-042
- Ott, K., G. Klepper, et al. (2004). Konkretisierungsstrategien für Art. 2 der UN-Klimarahmenkonvention. Bad Neuenahr-Ahrweiler, Europäische Akademie GmbH.

- Patwardhan, A., S. H. Schneider, et al. (2003). Assessing the science to address UNFCCC Article 2. A concept paper relating to cross cutting theme number four, Intergovernmental Panel on Climate Change (IPCC),
- Pearson, C. S. (2000). Economics and the Global Environment. Cambridge, Cambridge University Press.
- Pielke Sr, R. A., G. Marland, et al. (2002). "The influence of land-use change and landscape dynamics on the climate system: relevance to climate-change policy beyond the radiative effect of greenhouse gases." Philosophical Transactions: Mathematical, Physical & Engineering Sciences **360**(1797): 1705-1719.
- Read, D., D. D. Beerling, et al. (2001). The role of land carbon sinks in mitigating global climate change. London, The Royal Society.
- Read, P. (1999). The role of biomass in meeting greenhouse gas reduction targets: Land allocation modeling of key market impacts. Discussion Paper. Massey.
- Ruzicka, I. and P. Moura-Costa (1997). Sustainable Forest Management: Allocation of resources and responsibilities. London, British Overseas Development Agency: 82.
- Saphores, J.-D. and B. Bakshi (2001). Forests, Biodiversity Conservation, and the Kyoto Protocol: Challenges and Opportunities. Irvine, CA, University of California,
- Sarofim, M. C., C. E. Forest, et al. (2004). Stabilization and Global Climate Policy. Cambridge MA, MIT Joint Program on the Science and Policy of Global Change, Report 110: 14.
- Sathaye, J., P. Chan, et al. (2003). A Summary Note. Estimating Global Forestry GHG Mitigation Potential and Costs: A Dynamic Partial Equilibrium Approach. Berkeley, CA.
- Scherr, S., A. White, et al. (2003). Current Status and Future Potential of Markets for Ecosystem Services of Tropical Forests: An Overview. ITTC 25th Session, Yokohama, JP
- Schlamadinger, B., M. Grubb, et al. (2001). Carbon sinks and energy production: A study of linkages, options and implications. London, UK, Climate Strategies: 84.
- Schulze, E.-D., C. Wirth, et al. (2000). "Managing forests after Kyoto." Science Magazine **289**(5487): 2058 - 2059.
- Spence, S. (2004). The Sustainable City and Climate Change. The Hague Conference on Environment, Security and Sustainable Development, The Hague
- Tietenberg, T. (2000). Environmental and Resource Economics. Reading, Massachusetts, Addison-Wesley.
- Tol, R. (2002). "Fearnside's unified index for time preference: a comment." Ecological Economics **41**: 33-34.
- Vöhringer, F. (2004). "Forest Conservation and the Clean Development Mechanism: The Case of the Costa Rican Protected Areas Project." Mitigation and Adaptation Strategies for Global Change **9**: 217-240.

Wietling, J. (2004). Totalschaden für den Regenwald / Papierfabriken beschleunigen die ökologische Verarmung Sumatras. Neue Zürcher Zeitung, Zurich 31.07.2004,