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Opinion

The long way from Kyoto to Marrakesh: Implications of the Kyoto Protocol negotiations for global ecology

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Abstract

The Sixth and Seventh Conference of the Parties (COP 6 and 7) at The Hague, Bonn and Marrakesh came to a final Agreement on the Kyoto Protocol, which is thus ready for ratification by the individual nations. The Agreement was only achieved by allowing countries to offset their fossil fuel emission targets (on average 95% of the 1990 emissions) by increasing biological carbon sequestration, and by trading carbon credits. Activities that would count as increasing biological carbon sequestration include afforestation and reforestation, and changes in management of agriculture and forestry. According to the Agreement reached in Marrakesh, biological carbon sequestration may reach an offset of up to 80% of the required reduction in fossil fuel emissions (4% of the 5% reduction commitment). We explain why the allowable offset rose as high during the course of the negotiations. It is highlighted that major unintended consequences may be a result of the policy as it stands in the Marrakesh Accord. Major losses of biodiversity and primary forest are expected. We present scientific concerns regarding verification, which lead to scientific doubts that the practices encouraged by the Agreement can actually increase sequestration under a full carbon accounting scheme. We explain that there is a 'win-win' option that would protect high carbon pools and biodiversity in an economically efficient way. But, this is not supported by the Agreement. Despite the very positive signal that most nations of the United Nations will devote major efforts towards climate protection, there remains a most urgent need to develop additional rules to avoid unintended outcomes, and to promote the 'win-win' options that we explain.

Keywords: biodiversity, carbon accounting, carbon-cycle management, Kyoto protocol

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List of abbreviations

ARD	Afforestation, Reforestation, Deforestation
CBD	Convention on Biological Diversity of the United Nations
CDM	Clean Development Mechanism of the Kyoto Protocol
CDS	Country Data Submission of the Kyoto Protocol
COP	Conference of Parties of the conventions
FCCC	Framework Convention on Climate Change of the United Nations
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel of Climate Change of the United Nations
JI	Joint Implementation of the Kyoto Protocol
LU	Land-Use
LUC	Land-Use Change
NPP	Net Primary Productivity (Photosynthesis minus plant respiration)
NEP	Net Ecosystem Productivity (photosynthesis minus plant and soil respiration)
NBP	Net Biome Productivity (NEP minus non-respiratory losses)
QELRC	Quantified Emission Limitation or Reduction Commitment of the Kyoto Protocol

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SBSTA Subsidiary Body on Scientific and Technological Advice of the Conventions
WBGU Wissenschaftlicher Beirat der Bundesregierung für Globale Umweltfragen (German Advisory Council on Global Change)

Introduction

The warning of the Intergovernmental Panel of Climate Change that 'the balance of evidence suggests a discernible human influence on global climate' (IPCC, 1996) led directly to the negotiations of the Kyoto Protocol which is part of the UN Framework Convention on Climate Change (WBGU, 1998; WBGU, 2001; Benedick, 2001). The Kyoto Protocol aims at reducing fossil fuel emissions, which were identified as the main source of greenhouse gases – especially CO_2. The focus on CO_2 immediately opened a debate on energy use in the industrialised world, and it initiated major efforts, especially in the EU, to invest into research and development in the field of alternative and renewable energy sources. Although the conclusions of the IPCC (1996), namely that climate will change due to anthropogenic causes, were reinforced by the Third Assessment Report of IPCC (2001), this did generally not further increase the efforts to reduce fossil fuel emissions but rather increased the desire to use biological sinks as balance.

Inspecting global carbon stores and fluxes (Prentice *et al*., 2001) shows that the emission of fossil carbon (C) is part of a much larger, predominantly natural cycle of C assimilation (photosynthesis) and respiration. However, this natural cycle has been disturbed not only by fossil fuel emission, but also by land-use changes (mainly deforestation and harvest of primary forest). It became apparent that the carbon cycle links biology with industrial and agricultural production with the consequence that practically no group in society is unaffected by changes in the carbon cycle or its management. This is presumably why it has proved so difficult to turn an apparently simple request idea – namely, to begin to adjust fossil fuel emissions downwards towards a rate that can be reabsorbed by natural processes – into action.

Here we summarise the aims of the Kyoto Protocol, and the negotiations in The Hague, October 2000, and Bonn, June 2001, as well as in Marrakesh, November 2001. This summary is based on personal impressions of the three authors all of whom participated in the negotiations. The Agreement reached in Bonn and Marrakesh could potentially have an enormous impact on global ecology. Our objective is to show that this Agreement, as it stands, could lead to a form of management of the terrestrial biosphere and the global carbon cycle that could have unintended and counterproductive consequences for natural ecosystems as well as for atmospheric CO_2.

The Kyoto Protocol[1]

The Kyoto Protocol is an international treaty agreed upon in 1997 to achieve the worldwide reduction of greenhouse gas (GHG) emissions, which are responsible for the current global warming (IPCC, 2001). The Protocol tries to achieve a balance between technically and economically feasible ways to reduce the anthropogenic emissions, and possible increases in the re-assimilation of CO_2 by terrestrial ecosystems. The final aim is to reduce the concentration of CO_2, and other GHGs, in the atmosphere.

In the following we will refer to a 'carbon sink' wherever the land surface assimilates more carbon than it respires, and to a 'carbon source' if respiration exceeds assimilation. Management of terrestrial ecosystems provides various ways to increase the uptake of CO_2 by the land surface, i.e. to reduce C sources and increase C sinks.

The core elements of the Kyoto Protocol are as follows:

1. The industrialised nations and those with economics in transition (the 45 'Annex B' countries[2]) commit themselves to a reduction in fossil fuel emissions in the first commitment period (2008–2012) as compared to the emissions in the base year 1990 (Article 3.1). The reduction should be at least 5% when averaged across all Annex B nations in order 'to minimise … adverse effects of climate change' (Art. 2.3). The specific commitment however, varies among countries, and this results in country specific 'assigned amounts' for fossil fuel emissions in 2010. Some countries are allowed to increase emissions, such as Australia (+8%). Others will then have to make larger reductions. The EU pledged to reduce emissions −8%. Within the EU, a 'burden sharing' Agreement (the EU 'emission reduction bubble') requires −21% reductions for Denmark and Germany and −22% for Luxembourg (see Table 3), while some other EU countries are allowed to increase emissions (e.g. +30% for Greece).

[1]Readers who are interested in more details about the official documents of the negotiations are recommended to look at www.UNFCCC.de, where all official documents of this paper are listed under COP or SBSTA. The legal text of the Kyoto Protocol is found at this address under COP3 as FCCC/CP/1997/Add.1, Decision 1/CP.3, Annex 7. Direct internet access to the text of the Kyoto Protocol is www.unfccc.org/resource/docs/cop3/01a01.pdf.

[2]Annex B parties are the 45 countries that signed the Kyoto Protocol, i.e. the Annex II parties plus countries of central and eastern Europe with economics in transition. Annex II parties are the 24 countries, plus the European Union, listed in annex II to the United Nations Framework Convention on Climate Change (UNFCCC), i.e. this are the high per capita income countries.

The accounting will take place according to specific rules in the 'First commitment period' between 2008 and 2012. The year 1990 will be the base line year for several definitions and actions.

2. Nations are allowed to create carbon sinks in order to offset emissions. This can be done by planting new forests (afforestation and reforestation) instead of practicing deforestation (Article 3.3: ARD), or by applying new management approaches (Art. 3.4: Additional activities) which can create new carbon pools or enhance existing pools. These new C-pools can become a tradable resource in their own right.
3. The Protocol can be interpreted in ways that allow nations, and the private sector, to trade CO_2 equivalent units from technological developments (e.g. improving power station efficiency) and from additional activities in forestry and agriculture. Carbon units can be achieved and then traded between Annex B nations (Art. 6: Joint implementations, JI) as well as between industrialised Annex B nations and developing non-Annex B nations (Art. 12: Clean development mechanism, CDM).

Possible ramifications and implications of the treaty were not fully considered at that time (1997). Only after the Kyoto Protocol was cast into legal text it did become apparent that many terms in the text were not clearly defined, and that the language was sometimes ambiguous, allowing counterproductive interpretations (i.e. under-accounting of sources). These 'unwanted' effects might, at worst, reverse the intention of the Protocol (see IGBP, 1998; WBGU, 1998).

The Subsidiary Body on Scientific and Technological Advice (SBSTA, a committee that gives advice to the member states) therefore asked the Intergovernmental Panel of Climate Change (IPCC) to clarify and define the terminology and to make suggestions with respect to procedural issues. This advice was compiled in the Land Use, Land Use Change and Forestry Report (LULUCF-report) of the IPCC (2000). The IPCC was asked to be politically relevant, but not prescriptive. Decisions are to be made by policy makers on the basis of options to be provided by the IPCC on scientific grounds. Thus, the IPCC report only described a range of options for achieving a certain goal and possible consequences. At the political level, however, each nation chose that option which suited best the national demands. This situation led to confusion in later negotiations, when possible scenarios were discussed. Even basic data, such as national reports (CDS: country data submission) on forest growth and management, turned out to have been compiled on the basis of different assumptions and interpretations. The weak data-basis made political decisions independent of science necessary.

Based on this IPCC report, and driven by the timing by the Kyoto Protocol itself, the Sixth Conference of the Parties (COP 6) met in The Hague in year 2000 in order to settle the unresolved issues and to prepare a legal document as a basis for ratification of the Protocol by the signatory nations.

The ecological implications

There are major ecological concerns associated with the Kyoto Protocol and the following negotiations, some of which are addressed in the following:

- *Definitions:* There are several distinct terms called 'productivity', and their distinction is fundamental for the global carbon cycle, yet has not always been consistently used in the discussions around the Kyoto Protocol. Briefly, Gross Primary Productivity (GPP) is the key physiological term, being the rate of photosynthetic carbon fixation by leaves. Net Primary Productivity (NPP), however, accounts for plant respiration (R_a; NPP = GPP − Ra), and it is the actual input to ecosystems. Forest managers and agriculturalists are concerned with a fraction of NPP, namely the harvestable wood or grain yield. Net Ecosystem Productivity (NEP = NPP − Rh; Rh being heterotrophic respiration) is a more appropriate measure of sink strength. There are additional C-losses from ecosystems which are not associated with respiration, most importantly, losses from fire, harvest, and biological volatile organic compounds or leakage of dissolved organic carbon to groundwater. The so-called Net Biome Productivity (NBP, Schulze & Heimann, 1998; Schulze *et al.*, 2000) takes account of these losses as well. Net Biome Productivity is the sink or source that is actually 'seen' by the atmosphere. Net Biome Productivity is much smaller than NPP or NEP.

  Even defining a 'forest' is a problem because of different national circumstances. During the negotiations it was agreed for the first commitment period that forests have a minimum area of 0.05 ha (i.e. 500 m^2), >10% crown cover and >2 m height. The small minimum size reflects the extremely patchy forest structure in highly cultivated regions such as Europe. There are also countries where forests reach only modest height (e.g. Mediterranean oak woodlands). It follows from this definition that fruit plantations and city parks are forests, unless an activity-based definition were to be added. The status of areas practising agroforestry is also not clear.

  More importantly, any deforestation may (according to the Kyoto definitions) be preceded by degradation (with associated emissions) until 10% of the initial cover and the equivalent amount of C is reached. If

the area is then deforested (i.e. land-use changes take place) only 10% of the initial C pool in biomass would be accounted as emission. Similarly, a partial forest harvest prior to deforestation would reduce the accountable loss. In contrast to those activities that create a sink (afforestation, reforestation, re-vegetation), many land-use activities that cause emissions remained undefined (degradation, conversion of forest types, harvest) or neglected by the Protocol (e.g. deforestation between 1990 and 2008). The inclusion of the harvest cycle still remains a matter of discussion. Any change in C stocks is supposed to appear in national reports.

There are many definitional issues which need further discussion, such as defining afforestation. These are tree plantations that take place on land that did not carry forest for at least 50 years. This includes natural wetlands, bogs, heath- and grasslands. Many of these habitats are major sites with respect to biodiversity, and the priority of activities does not recognise this fact.

- *'Additional human induced activities since 1990' in reference to Art. 3.4*: The wording of this article opens two issues: What is additional, and what is meant by 'human induced since 1990'?

  The basic idea of the Kyoto Protocol was to stimulate additional activities in natural carbon sequestration which exceed the pre 1990 activities. But the wording can be interpreted in many other ways, and has led to major discrepancies in the subsequent negotiations.

  One view is that all activities in most part of this world are in some way 'human-induced' – even nature protection and biodiversity conservation. Thus, it is the full carbon balance ('full carbon accounting') and the change in total carbon sequestration since 1990 that count, and if this carbon balance indicates increased storage of C, this would be regarded as an additional activity for which credit can be claimed.

  A different view considers only specific projects that entail a change from 1990 management practices as being accountable. All practices that went on before 1990 are considered to represent the pre 1990 activities, and thus are not accountable. In contrast to 'full carbon accounting', such 'partial carbon accounting' (restricted to specific activities) can create loopholes that conceal emissions.

  Unless the accounting protocol is very clear, the outcome may strongly depend on the assumptions made about 'additionality since 1990'. For example, in the case of forest management, the harvest of forest followed by regeneration would be considered as carbon-neutral 'business as usual' because this is an inherent part of managing forests even if a change of the dominant species is involved which could create net emissions during conversion (e.g. conversion of *Eucalyptus* forest into a plantation of *Pinus radiata*; replacing deciduous forest by coniferous plantations; and so on). Also, the initial exploitation of primary forests, in the boreal and tropical regions, which initially possess very large carbon pools, would not be accounted for as emission and would not be considered as a carbon source but as part of normal forest practice.

  Normal forest management is excluded from the Kyoto Protocol, although it is by no means always carbon-neutral. Management can result in additional sinks or sources for CO_2. Also the afforestation of Art. 3.3 contains the ambiguity of being accountable only since 1990. Afforestations took place before 1990 both in industrial and non-industrial nations (e.g. with Official Development Assistance, ODA, support). Thus the afforestation rate in 1990 – not the establishment of new plots since 1990 – should more fairly be the base line to measure additionality. Following the same argument, forests that were harvested few decades ago (and not bare land) should be the baseline for accounting of reforestation or afforestation projects.

- *Role of old forest and plantations*: Odum (1969) building on the climax concept of Clements (1936), defined the hypothesis of ecological equilibrium, in which it is assumed that ecosystems tend toward a stage where assimilation and respiration are balanced. However, there are indications that this hypothesis is false (e.g. Carey *et al*., 2001). Although the harvestable stem biomass may become constant, old-growth forests have been shown to be carbon sinks by ecosystem studies (Schulze, 2000), by canopy flux measurements (Valentini *et al*., 2000a), and by modelling C-sinks based on CO_2 concentrations in the atmosphere. The observed spatial patterns of changes in CO_2 concentration in the troposphere point at a major carbon sink in Siberia, which possesses the largest area of primary forest on the globe (Bousquet *et al*., 2000; Schimel *et al*., 2001). One possible reason for primary forests to be sinks is that the turnover of leaves and roots contribute to the carbon balance at the ecosystem scale by formation of recalcitrant humus, or to lose carbon as dissolved organic C to groundwaters. This turnover reaches a maximum in unmanaged forests. Also, old-growth forests (like other forests) may be able to respond to increasing CO_2 concentrations by increasing turnover, then allowing recalcitrant soil C to be formed at a greater rate.

  The hypothesis of ecological equilibrium in natural communities is the basis for an assumption that old-growth forests are carbon-neutral and therefore of 'no use' in removing anthropogenic CO_2 from the atmosphere. Following the ecological equilibrium hypothesis it could be (and has been) claimed that old-growth

forests should be replaced by actively growing plantations. Unfortunately, this would be entirely counterproductive. Exploitation of primary forest results in large C losses, due to the harvesting of a very large C-pool which will never again be reached in a future plantation. Thus, this is a permanent loss of C to the atmosphere. The average lifetime of wood products, currently estimated as 15–20 years (Nabuurs & Sikkema, 2001), is much shorter than the lifetime of wood in living trees. If only 'human induced' plantations can be accounted, and if natural forests are assumed to be C-neutral, it becomes attractive in the context of the Kyoto Protocol to convert non-human-induced, unaccountable old-growth forest into plantations (the harvest may remain unaccounted as normal forest practice), and claim credit for stem growth of these plantations – even though the real effect of such action is to increase the amount of CO_2 released to the atmosphere. New plantations with high NPP can be carbon neutral or even sources due to soil disturbance (Valentini *et al*., 2000b). In this context, primary forests are at the maximum risk, and the Kyoto Protocol offers a mandate to accelerate their demise. The problem will be addressed in future by a joint task force representing the climate convention and the convention of biodiversity.

Negotiations at The Hague

The negotiations started at a conference of the parties at The Hague (COP6), and continued in Bonn (COP6-second part), and where carried on at Marrakesh (COP7).

Starting condition

In negotiating a complicated issue among more than 100 nations it is inevitable that the partners will form groups to more effectively articulate their demands and requests. The main groups in the Kyoto negotiations were: (1) the Umbrella group consisting of the USA, Canada, Japan, Australia, Norway, New Zealand and the Russian Federation; (2) the EU group, comprising its 15 member-states; (3) the G77 with China, which contain the developing countries, including Saudi Arabia; (4) AOSIS, the Association of Small Island States, which run the risk of being drowned by sea level rise; (5) G11, i.e. the European countries with transition economies, and (6) the Environmental Integrity Group, led by Switzerland.

The position of the *Umbrella group* was that biological sinks should be credited to balance fossil fuel emissions, and that land management is an important tool to produce or enhance sinks. It was proposed that a national full carbon balance (full carbon accounting) should be used as basis for negotiations, because virtually all land in industrialised nations is in fact being managed; even national parks are set aside by human actions. The US delegation made clear in the general assembly that they would use statistical sampling and models in order to integrate the biological sinks of North America and determine from this the C storage of the nation. The USA is at present accumulating carbon in forests that have regrown on former agricultural land that was cleared a century ago (Houghton *et al*., 1999). Thus, the US position of promoting full carbon accounting is beneficial for the USA in the Kyoto Protocol with respect to Art. 3.4. Full carbon accounting would include not only forestry and agriculture but also other activities such as waste management that are small but potentially significant components of the carbon cycle. The umbrella group emphasised that from a scientific point of view, a full carbon balance is the only measure that can be quantified and verified by independent observations.

The position of the *EU group* was in sharp contrast to the view of the Umbrella group. The EU wished to restrict the accountability of sinks, and to encourage technological changes that reduce fossil fuel emission (increased efficiency of energy use, and of alternative energies sources). The only area where the EU proposed to allow accounting of biological sinks was afforestation and reforestation (i.e. Part of Art. 3.3). As an initial negotiation position, the EU did not want to open the negotiation towards the accounting of sinks created by management (forest, agriculture and grazing management) or projects proposed under the CDM.

In order to make accounting of management under Art. 3.4 impracticable (see FCCC/SBSTA/2000/CRP.11), forest management was defined by the EU very qualitatively as 'the stewardship and use of forests in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and potential to fulfil, now and in future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems'. Since it will be very difficult to measure this stewardship, an owner of afforested land should presumably establish (a) control plots, (b) collect data from research plots, and (c) place the actions in relation to existing forest survey and planting data for the last 10 years. This cannot seriously be accomplished on a 0.05 ha basis.

Regardless of the very different positions of the Umbrella group and the EU, it remained clear and agreed that carbon sinks would only become accountable when they are attributable to land-use change (even if, as the Umbrella group suggested, this could include land-use changes that took place some decades or centuries ago). Primary forest, as an unmanaged system remained

officially 'useless', and harvesting primary forest was not considered as land-use change but as part of normal forestry practice. Forests must be managed (i.e. by wood extraction, which is the main objective of forestry) in order to make them accountable asset. This principle unfortunately favours the eradication of primary forest. Their productivity existed before 1990; they are not 'additional'; and they are not 'human induced' according to the EU interpretation. The possibility that protection to preserve biodiversity could be considered in some way accountable was discussed, but rejected because very large credits could then be claimed by the few countries hosting primary forest (Canada and Russia). Also, there was the concern, that a 'non-use' obligation would create additional complications. Thus, for economic reasons the primary forests remained unaccountable and unprotected.

The national reports on the national carbon sinks that were submitted by 1 August 2000 (CDS: country data submission) differed radically because each nation started with a different accounting principle (Table 1).

Striking features of this table are as follows

- Most EU countries did not report data for agriculture. The FAO numbers for forestry are generally higher than the CDS numbers, e.g. for Germany CDS is 8.6 but FAO is 14.5 TgC yr^{-1}. This may indicate that country data were submitted with strategic considerations. During negotiations it turned out that nations with incomplete national reports had a beneficial starting condition, because in this cases FAO data were inserted (see Tables 1 and 3). In other cases, such as Italy, a wrong number was submitted (the true number is 9.1 TgC yr^{-1} or 6.7 TgC yr^{-1} according to FAO). In these cases no correction was applied, such as to use the FAO data.
- The numbers provided by the Umbrella group and the EU were different by factors 10 to 100 even when corrected for area. This presumably reflects the differences in the accounting approach.
- Many umbrella and EU states have a negative Afforestation, Reforestation, Deforestation (ARD) balance (Art. 3.3)
- The large numbers given by the Umbrella group for forest management (i.e. the Art. 3.4 column) resulted from inclusion of fire protection at present frequency in areas where fire is a natural environmental factor, and from the specifics of land-use history in the case of the USA.
- The large numbers assigned to agricultural management by the USA and Russia are due to considering changes in ploughing (low tillage).

The EU wanted to prevent the accounting of the large sinks attributed to forest management and agriculture because if the numbers cited by the Umbrella group were accepted, this would provide no incentive to reduce fossil fuel emissions by some industrialised nations. Yet the low numbers attributed to forest management for the EU resulted from the qualitative definition of management in Europe, and from the exclusion of agriculture for most of the countries.

Table 1 Summary of national reports from year 2000 (CDS: country data submission) and FAO data on Art. 3.3 and 3.4 (all numbers are TgC yr^{-1} being equal to 10^6 t C yr^{-1}nation^{-1}). The sign convention is opposite to that used for atmospheric measurements: i.e. here positive numbers refer to a sink and negative numbers to a source (see FCCC/SBSTA/2000/9/add.1 for internet access see footnote 1). These data were produced by each country by different methodologies. For forest areas and for countries that did not submit data, the Table shows data from FAO (2000)

		Art. 3.4	
Country	Art. 3.3	Forestry	Agriculture
European Union			
Austria	−0.2	5.1/FAO	no report
Belgium	no report	0.2/FAO	no report
Denmark	0.1	0.3/FAO	no report
Finland	−1.1	2.2/CDS	no report
France	0.9	2.7/CDS	no report
Germany	−0.2	8.6/CDS	no report
Greece	no report	0.6/FAO	no report
Ireland	0.9	0.4/FAO	no report
Italy	0.5	1.1/CDS	no report
Luxembourg	no report	0.1/FAO	no report
Netherlands	0.0	0.1/CDS	−0.73
Portugal	no report	1.4/FAO	no report
Spain	no report	4.5/FAO	no report
Sweden	−0.1	4.6/CDS	no report
United Kingdom	0.6	2.5/CDS	−0.25
Total EU	**3.0/−1.6**	**24.4**	**−0.98**
Umbrella group			
United States	−7.2	288.4/CDS	24.0
Australia[1]	no report	42.6/FAO	2.2
Canada	−4.4	9.1/CDS	4.08
Japan[2]	−0.7	11.4/CDS	0.7
Norway	+0.02	+0.04/CDS	no report
New Zealand	7.7	4.7/FAO	no report
Total Umbrella	**7.7/−53.0**	**357.1**	**58.2**
Russia[3]	−34.0	428.8/FAO	27.2

[1]Australia submitted data in 3.4 but not for forest management.
[2]Japan CDS refers to all forests.
[3]The FAO data for Russia appear very high. IIASA has estimated 117.5 TgC yr^{-1} (Nilsson *et al*., 2000).

The course of the negotiation

Table 1 shows the weak point in the EU position. Some EU countries (particularly Finland) showed a negative ARD balance under Art. 3.3. This problem could have been solved prior to The Hague, e.g. by creating a European 'ARD-bubble', similar to the 'emission reduction bubble' (see above). However, some countries that were faced with a negative ARD balance insisted that they in reality have an overall carbon stock increase in the forest sector, and that this increase should be taken into account to balance the deforestation. This view was supported by the G77 nations, of which many have extensive primary forest.

The diverse views on handling debits under Art. 3.3, undermined the European position and opened the door for negotiations to include Art. 3.4.

To limit accounting under Art. 3.4, Norway proposed limiting the maximum amount by which a negative ARD balance could be compensated by Art. 3.4 to 30 $TgCO_2\,yr^{-1}$ (8, 2 $TgC\,yr^{-1}$). The idea of defining a 'cap', i.e. the maximum amount allowed, was then pursued in order to limit other large claims by some nations of the Umbrella group for carbon sinks that were based on full carbon accounting.

There was one additional conceptual problem: the increasing carbon uptake by forests since 1990 is not only a success of land-managers, but in part it is the result of the rise in CO_2 concentration and/or N deposition (Schimel *et al*., 2001). There was agreement, however, that increasing sinks due to N-deposition and CO_2 cannot be claimed by any country. Since it is impossible to separate effects of management from growth responses to CO_2 and N (Mund *et al*., 2002), it was decided to discount the total amount that was claimed for management by a certain fraction, which remained to be negotiated.

The note by the President of COP 6: The Pronk proposal

Near the end of COP6, the President of the conference (Mr J. Pronk, Netherlands) made a compromise proposal to settle all open issues (CP/2000/5/Add.2). There were open 'crunch' issues not only with respect to the accounting of sinks but also in all other fields of the negotiations, including Compliance, Supplementarity, Share of proceeds, Eligibility, and Funding. Here we will only comment on the sinks issue.

The following proposal was made for the first commitment period (2008–2012)

- Up to 8.2 $TgC\,yr^{-1}$ (30 $TgCO_2\,yr^{-1}$) of a negative ARD balance could be compensated by a positive management balance (Art. 3.3. debits compensation). This compensation was defined as the 'First tier' (i.e. fraction) for accounting under Art. 3.4.
- Parties may include grazing land management, cropland management or forest management, but accounting of these activities under Art. 3.4 would be limited to a maximum of 3% of the 1990 fossil fuel emissions.
- In forestry (second tier), after accounting of the first tier, changes in carbon pools during the commitment period would be discounted by 85% and in agriculture (third tier) changes in carbon sequestration in the commitment period as compared to 1990 would be discounted by 30%. These discounts were supposed to compensate for fertilisation by elevated CO_2 and nitrogen, and to account for activities that represent the pre 1990 activities and which are not 'additional' (in the European interpretation). For the sake of symmetry, the French EU presidency insisted that also debits must be discounted.

The Pronk proposal was not accepted by most countries. Some countries suggested closing the negotiation at this point.

COP6 ended with a proposal put forward by Germany which suggested (Table 2)

- allowing for credits under Art. 3.4 up to the level of debits under Art. 3.3;
- capping accounting under Art. 3.4 for some Umbrella states: 20 $TgC\,yr^{-1}$ for the US, 8 $TgC\,yr^{-1}$ for Canada and 12 $TgC\,yr^{-1}$ for Japan;
- disallowing accounting of sinks under CDM.

Table 2 Allowable sinks according to the Pronk and the German proposal ($TgC\,yr^{-1}$) including caps (upper accountable limits) and discounts of the two final proposals

	Accountable sinks (Art. 3.3 + 3.4)	
Country	Pronk proposal	German proposal
EU	7.1	7.1
United States	42.6	20.0
Australia	−2.9	−2.9
Canada	0.6	8.0
Japan	1.8	12.0
Russia	−9.1	−9.1
New Zealand	8.3	8.3
Total	46.0	42.0

During the final night the Umbrella group considered the proposal on Art. 3.4 but not the exclusion of CDM. In response, the EU did not agree to accepting only a part of the German proposal. At that time other groups (e.g. G77 and China) had not even been consulted, and many additional crunch issues, besides sinks, had remained unresolved. There was general agreement that time had been too short to find a fair compromise. Thus, COP6 ended with no agreement about the Pronk proposal. Instead agreement was reached to extend the negotiations into a second part, 'COP6bis', to be held in Bonn in June 2001.

Based on the negotiations in The Hague the accountable sinks would have been equivalent to 1.1% (Pronk proposal) or 1.0% (German proposal) of the base year emissions in 1990 averaged over all countries. Thus fossil fuel consumption would have to decrease about 4% below 1990 emissions in 2010, instead of the 5% as mandated in Kyoto.

The time between The Hague and Bonn

Prior to COP6bis many bilateral negotiations took place, yet the open questions remained unresolved.

The EU research cluster CarboEurope (http://www.bgc-jena.mpg.de/public/carboeur/index) summarised ideas that were discussed among various scientific groups and made the following proposal to the EU and to some of the member-states:

- There should be a list of total sink commitments (i.e. promises to create additional sinks beyond the level of 1990) by each nation.
- Combining all activities of Art. 3.3 and 3.4 would avoid all definitional issues, especially with respect to the 'additionality' of specific activities.
- Verification should be based on full carbon accounting, to be measured at the national scale by an independent method, preferably by measurements in the atmosphere. It was considered that there are too many loopholes apparent in the accounting scheme used at The Hague. Since it is the ultimate aim of the Kyoto Protocol to protect the real atmosphere verification should take place in that compartment.

This proposal was not considered by the EU at that time. The approach was considered as being too radical, and undermining the EU position on sinks.

During this interval, the US government changed and the new administration decided to withdraw from the Kyoto negotiations. In a now-famous speech, President W. Bush declared that climate change is real; but he observed that the US produces about 25% of the global industrial goods by using only 20% of the fossil fuel, while other nations use 80% of the fossil fuel with lower efficiency.

Prior to the negotiations at Bonn, Pronk summarised the status of the negotiation process in a 'consolidated negotiating text' (FCCC/CP/2001/2/Add.3 review as FCCC/CP/2001/2/Add.3/rev.1) which contained a clause (page 7, bullet 10c) that gave a special bonus to nations that have a population density of >300 people/km^2. However, this clause was not well received by these nations. An overall cap for second and third tier of Art. 3.4, Art. 6, and Art. 12 was set to be 50% of the QELRC (Quantified emission limitation or reduction commitment) for countries with a reduction commitment and 2.5% of the base year emissions for countries without a reduction commitment.

The Bonn agreement

In COP6 the experts met in the first week and the ministers in the second week. This partly explains why time ran out for a final compromise at The Hague. The COP6bis conference at Bonn was organised the other way around. The ministers gave the political direction, which was then to be put into legal language in the second week. COP6bis ended with the 'Bonn Agreement on the implementation of the Buenos Aires Plan of Action'. The parties accepted a final compromise, although some modifications were still required by the Russian Federation, and adoption of the final text remained open for COP7 in Marrakesh, November 2001 (FCCC/CP/2001/L.11/Rev.1). The main achievements concerning land-use, land use change and forestry were (draft decision: FCCC/CP/2000/L.11/Rev.1/CMP.1) as follows:

- General principles were affirmed concerning a scientific base, harmonisation of reporting and accounting, and conservation of biodiversity. Most importantly, 'the mere presence of carbon stocks be excluded from accounting' (Part 1d of draft decisions). This decision excludes primary forest from accounting. Nevertheless, the implementation of activities contributing to biodiversity and sustainable resource use are encouraged (Part 1e of draft decisions).
- With respect to Art. 3.3, afforestation is defined as an activity on land that has not been forested for a period of at least 50 years. This decision allows drainage of peatlands, and afforestation of natural shrub-, heath-, or grasslands. For the first commitment period, reforestation will be accountable on land that did not contain forest on December 31, 1989. This date may be moved forward in future commitment periods, which would make deforestations that take place after 1990, and which remained unaccounted because they did not occur in the commitment period, a valuable asset as accountable sink in future commitment periods.

- A table (Appendix to the Bonn Agreement, FCCC/CP/2001/L11(Rev.1)) was created which contained the allowable accountable sink attributable to forest management for each country (Table 3). This list is essentially the type of approach that was suggested by CarboEurope, but the table remained restricted to forest management activities under Art. 3.4. Thus, science had an important impact on this part of the negotiation, but only part of the accountable and promised sink activity was documented. ARD and other activities under Art. 3.4 remained un-quantified. Nevertheless, the Appendix documents for the first time the upper limit of what can be claimed as 'human induced activity since 1990' due to forest management.

The Appendix is based on a range of information that was available to the FCCC secretariat at that time: the country data submissions, FAO data, and others sources, such as the IIASA database on Russian forestry and some postsubmission modifications. National circumstances were considered for some Umbrella group countries and limits set (Japan: 13 $TgC\,yr^{-1}$; Canada: 12 $TgC\,yr^{-1}$) based on the outcome of political negotiations. This compromise was the basis for an Agreement by all the 101 nations present.

- The accounting remains based on 'human induced activities since 1990'. The word 'additional' of Art. 3.4 of the Kyoto Protocol was not used in the Bonn Agreement (see Annex to draft decision -/CMP.1 page 7 paragraph 8). A full carbon accounting scheme had been anticipated, but the G77 group insisted that the spirit of the Kyoto Protocol should be included in the Bonn Agreement. It remains unresolved how 'human induced activities since 1990' is to be interpreted. In a broad interpretation, there is no spot on this globe that is not affected by man. Interpreted narrowly, only specific projects are regarded as human-induced.
- Based on the Agreement at COP6, caps and discounts are to be applied to the national reports in order to account for effects of elevated CO_2 and N-deposition as well as to account for pre 1990 management activities. For crop- and grazing-land management and re-vegetation sinks will be accepted as full C-sinks on a so-called net-net basis (i.e. the C flux rate from 2008 until 2012 minus the flux at 1990 times five). In contrast, forest management sinks are defined based on the change in C-pools during the commitment period (2008 to 2012), discounted by 85% in order to account for the effects of elevated CO_2, N-deposition and forest age structure resulting from activities and practices before the reference year (paragraph 1 h and footnote 5 of the Bonn draft decision on land-use FCCC/CP/2001/L.11/Rev.1/CMP.1). It is assumed that pre 1990 activities are mirrored in the forest age structure. Thus, deforestation and harvest between 1990 and 2008 are not accounted. Also, the 85% rule does not fully cover the 'additionality' of human induced activities since 1990. The different treatment of forest vs. other land-use activities is not based on a clear scientific rationale, but is the result of political decisions during negotiations.
- For CDM, only afforestation and reforestation activities are allowed. It remained undecided if the same rules as in Art. 3.3 apply or if new rules and definitions need to be developed.

One major issue remained unresolved in Bonn: The new sink allowance remains without control of compliance. The rules for compliance were established, but the Umbrella group could not agree to these rules in a legally binding form. An Agreement in which the Umbrella nations would have to verify the sinks listed in the Appendix of the Bonn Agreement as 'human induced activity since 1990' was not acceptable to these nations. Verification and control of compliance remained therefore a major issue to be negotiated at COP7 in Marrakesh.

The last column in Table 3 indicate sinks that can be accounted for as fraction of the measured change in woody biomass. At this moment it is unclear how these numbers can be verified in view of the request of the G77 group that 'such activities have occurred since 1990 and are human-induced'. Large differences emerge between CDS and FAO data, which cannot be explained on scientific grounds. Also, some of the accountable sinks will be difficult to reach. Using the 85% discount rule, Japan should increase its carbon sequestration by forest management about five fold within the commitment period. Russia did not agree to the cap of balancing Art. 3.3 vs. Art. 3.4 and to the numbers referring to Russia in the Appendix (17.63 $Tg\,yr^{-1}$). The number was corrected at Marrakesh to be 33 $Tg\,yr^{-1}$ after discounting by 85%, which means that total increment of woody biomass from management is expected to be 220 $Tg\,yr^{-1}$, which is less than estimated by FAO but more than estimated by IIASA (see Table 1 and Shvidenko *et al.* 2001). In reality Russian carbon stocks currently may be constant or even be decreasing rather than increasing due to the continuing harvest of primary forest (Shvidenko & Nilsson, 1997). Neither Japan nor Russia could reach these numbers if the 'additionality' rule were applied in a narrow sense (see above). Thus, the Appendix of the Bonn Agreement caps the accounting of sinks under forest management and gives the impression of increased transparency in the accounting of biological sinks, but it remains essentially a mirage until the accounting scheme

Table 3 The accountable sinks in forests following Art. 3.3 and 3.4 of the The Hague and the Bonn Agreement (TgC yr^{-1}) based on country data submission (CDS: see **Table 1**), or on FAO data for countries that had not submitted data. The table also lists the emissions in the base year (1990) and the reduction commitment, as well as the estimated change in woody biomass according the FAO (2000), Appendix 3B.3, ninth column: annual change in total woody biomass, including roots and twigs of managed and unmanaged forest in each nation. The FAO data do not contain soils in contrast to many country submissions. Canada and Japan are negotiated numbers. (a) France suggested some update of their data after The Hague. (b) data for Russia are based on IIASA. (c) the Russian accountable contingent was increased to 33 Tg yr^{-1} at COP7. The agricultural data are not listed because of large gaps. For forestry the numbers refer to FCCC/SBSTA/(2000)/9/add.1

			Art. 3.3 reported (negative if source)			Forest Management (Art. 3.4)		
Country	Base year Emission All GHG TgC eqv yr^{-1}	Reduction commitment %	The Hague TgC yr^{-1}	Bonn TgC yr^{-1}	Change in wood FAO (TgC)	Country submission/FAO TgC yr^{-1}	After 15% discount TgC yr^{-1}	Appendix TgC yr^{-1}
Austria	21.0	−13.0	−0.20	−0.20	5.15	5.150	0.77	0.63
Belgium	37.3	−7.5			0.22	0.220	0.03	0.03
Denmark	19.1	−21.0	+0.10	+0.10	0.30	0.300	0.05	0.05
Finland	20.5	0.0	−1.09	−1.09	6.64	2.182	0.33	0.16
France (a)	150.9	0.0	+0.90	−1.74a	9.92	7.610	1.14	0.88
Germany	330.3	−21.0	−0.21	−0.21	14.02	8.455	1.27	1.24
Greece	29.3	+30.0			0.59	0.590	0.09	0.09
Ireland	14.6	+13.0	+0.91	+0.91	0.35	0.350	0.05	0.05
Italy	141.6	−6.5	+0.47	+0.47	6.95	1.230	0.18	0.18
Luxembourg	3.7	−22.0			0.09	0.090	0.01	0.01
Netherlands	59.7	−6.0	+0.04	+0.04	0.40	0.113	0.01	0.01
Portugal	17.4	+27.0			1.45	1.450	0.22	0.22
Spain	84.1	+15.0			4.49	4.490	0.67	0.67
Sweden	19.1	+4.0	−0.09	−0.09	10.85	4.555	0.68	0.58
UK	208.6	−12.5	+0.56	+0.56	1.79	2.455	0.37	0.37
Total EU	**1157.4**	**−8.0**	**+1.39**	**−1.25**	**63.21**	**39.240**	**5.87**	**5.17**
Australia	131.0	+8.0	0.00	0.00	42.62	0.000	0.00	0.00
Canada	163.4	−6.0	−4.40	−4.40	92.74	9.109	1.37	12.00
Japan	334.5	−6.0	−0.74	−0.74	13.67	11.368	1.71	13.00
New Zealand	19.9	0.0	+7.71	+7.71	4.75	4.750	0.71	0.20
Norway	14.2	+1.0	+0.02	+0.02	4.56	0.145	0.02	0.40
Russian Fed. (b)	828.4	0.0	−8.18	−8.18	428.79	117.450	17.62	17.63 (b)
Russian Fed.								33 (c)
Umbrella Rest	**1491.4**	**−3.0**	**−5.59**	**−5.59**	**587.13**	**142.822**	**21.43**	**43.23**
Including Correction for Russia (c)								**58.60**
Bulgaria	33.7	−8.0			2.65	2.650	0.40	0.37
Czech Repub.	51.8	−8.0			2.13	2.130	0.32	0.32
Estonia	11.1	−8.0			1.23	1.230	0.18	0.10
Hungary	23.6	−6.0			1.91	1.910	0.29	0.29
Iceland	0.7	+10.0	+0.02	+0.02	0.02	0.000	0.00	0.00
Latvia	9.7	−8.0			2.52	2.520	0.38	0.34
Liechtenstein	0.1	−8.0			0.00	0.000	0.00	0.01
Lithuania	14.1	−8.0			1.96	1.960	0.29	0.28
Monaco	0.0	−8.0			0.00	0.000	0.00	0.00
Poland	152.2	−6.0			5.49	5.490	0.82	0.82
Romania	62.5	−8.0			7.35	7.350	1.10	1.10
Slovakia	19.8	−8.0			3.43	3.430	0.51	0.50
Slovenia	5.2	−8.0			1.89	1.890	0.28	0.36
Switzerland	14.4	−8.0	−0.01	−0.01	0.71	0.290	0.04	0.50
Ukraine	250.5	0.0			7.36	7.360	1.10	1.11
USA	**1653.9**	**−7.0**	**−7.19**	**−7.19**	**166.46**	**288.000**	**43.20**	
Total Annex B	**4924.9**	**−5.0**	**−11.38**	**−14.02**	**855.42**	**508.267**	**75.21**	**54.50**
Including the correction for Russia (c)								**69.87**

for the national reports has been agreed on. In fact, any value listed in the Appendix could be reached, depending on the assumptions made in the national reports. An IPCC report on 'good practice', which is presently being assembled, may or may not be legally binding. The Bonn Agreement was taken as a compromise for the first Commitment period, and it will need further clarifications and modifications for the following commitment periods.

The compromise reached in Bonn can be understood only if one remembers that the Kyoto treaty comes into force when 55 countries have ratified, subject to the provision that their joint emissions make up at least 55% of the global emissions. This gives the Umbrella group strong leverage especially since the USA has declared that it will not ratify the Kyoto Protocol. Without Japan or Russia, the 55% rule cannot be met.

Although much of the discussion of the present report is centred around forest, the total accountable sink is much larger than listed in Table 3. Including agricultural sinks and CDM in addition to the forest management the total accountable biological sink is estimated to add up to 140 and 160 TgC yr^{-1} (Report of the German Delegation), amounting to 3.5% of the fossil fuel emissions in 1990. This number increased in Marrakesh following the technical correction of sinks in Russia to 4%. Thus a 1% reduction of fossil fuel emission below 1990 levels is anticipated by 2012. This is still 7 to 10% below the IPCC business-as-usual scenarios, with sinks contributing 23 to 6% of the overall emission reduction (De Elzen & de Moor, 2001).

The result of the COP7 at Marrakesh

The negotiations continued at Marrakesh mainly with the aim to find agreement on the compliance mechanism and to agree on the overall Bonn-package with following result:

Compliance

- An Enforcement- and Facilitation-Branch was formed that organises and controls compliance. This organisation consists of six non-Annex B and of four Annex B nations.
- In case of non-compliance, the assigned amount of a party will be reduced in the second commitment period by the excess emissions that took place in the first commitment period multiplied by the factor 1.3.
- COP 7 accepted the compliance mechanism, but it will be legally included into the Kyoto Protocol only after ratification at a meeting of all parties (COP/MOP1).

Flexible mechanisms

- Nations which participate in the trade of C-units will have to set-up an emission registry.
- Nations have to report annually their GHG emissions. Incorrect reports lead to a suspension of eligibility of the mechanisms for trade with units of CO_2 equivalents, which is important when other green house gases are part of the trade which have different effect on climate than CO_2 (CH_4, N_2O). However, only the correct reporting on sinks is the basis for eligibility but not its verification (see below). The Enforcement-Branch is responsible for control of the reports.

Trade of CO_2-equivalents is possible in the following units

AAU: Assigned amount units which contain the rights for emissions in 2008 to 2012.
RMU: Removal units for biological sinks.
ERU: Emission reduction units as part of joint implementation projects.
CER: Certified Emission Reduction which contain projects in CDM. Special definitions or including afforestation and reforestation under Art. 12 in the first commitment period have to be developed by SBSTA to be adopted by COP9.

- Banking: No direct transfer of any of the RMUs into later commitment periods is possible, but RMUs must be converted into AAUs. Only then, and if biomass still exists, RMUs may be re-issued for the next commitment period. Since plantations have an exponential growth rate, the total amount of accountable C is expected to increase.
- Verification: Geo-referencing of sinks activities is not required. Reporting will be based for the boundaries of the region where these activities take place. Improvement of the inventories is a key issue for further commitment period negotiations.
- Russia: A technical correction was made to the Annex-table of Bonn with respect to the sink activity by forest management in Russia to increase the accountable sink activity from 17.6 to 33 TgC yr^{-1}, which is equivalent to 220 TgC yr^{-1} following the 85% discount rule (see Table 3).

Ecological concerns to the present Agreement

There is no doubt that the Bonn Agreement and the Marrakesh confirmation has been a major breakthrough in the international efforts concerning climate change. Nevertheless, major ecological issues which had emerged right from the beginning of the negotiations remained untouched. Here we list some of these issues:

- *Biodiversity:* The climate convention needs to be coordinated with the convention on Biological Diversity (CBD) because major hotspots of biological diversity are at risk under the mandate of FCCC. This is especially true with respect to primary forests (and wetlands), which are also carbon sinks. However, also natural grasslands, heathlands and scrublands are endangered under the present definition of land for afforestation. The use of primary forest will not only turn large areas of this globe into sources (e.g. Valentini *et al*., 2000b), but will have major impacts on global biodiversity. Although protection of primary forest is a major issue, the problems concerning biodiversity are much broader. Afforestations on land that never had forest, the introduction of alien species on plantations, the management of forest towards increased productivity, and the production of biofuel on set-aside land of agricultural land are some of the activities that are expected to reduce biodiversity in the forest and agricultural sector. Management of low tillage will probably require substantial use of herbicides and of herbicide resistant GM-cultivars, which again will affect biodiversity. A process to review of these problems has started, and specific submissions by the EU are under way, but it is uncertain if the Convention of Biological Diversity will be effective at this stage.
- It is interesting to see that the international community agreed to allow Russia to increase its accountable C sink in the forest sector to reach $33\,Tg\,yr^{-1}$. This large quantity can only be verified if the sink activity of primary forest is taken into account. This could in fact be an initiative to put a value on primary forest. Based on research in IGBP, Schimel *et al*. (2001) estimate that the Eurasian flux from the atmosphere to the land surface is $1.7\,Gt\,C\,yr^{-1}$. The largest fraction of this flux, probably in the order of $1.3\,Gt\,C\,yr^{-1}$ occurs in European and Asian Russia due to the activity of wetlands and primary forest. If one would harvest this forest, 32 Gt C would be released (Shvidenko *et al*., 2000) with a mean residence time of 15–20 years, and this region would turn into a carbon source or be carbon neutral for a period of at least 15 years (Valentini *et al*., 2000b). This could have dramatic effects on the atmosphere.
- *Accounting of sinks* remains an essential area of concern. From a scientific point of view, only 'full carbon accounting' can avoid unwanted loopholes (such as not accounting of deforestation and harvest between 1990 and 2008) and avoid problems concerning the 'additionality' of sinks. The role of forestry in harvesting the large C-pools of primary forest may remain unaccounted. Also, degradation of forests remains undefined. SBSTA has been asked to address this problem, and the IPCC report on Good Practice Guidance on sink reporting and accounting will address some of these issues. The national reports could be equivalent to full C-accounting including degradation, harvest and regeneration, and of projects, which contain tradable C-units, but the rules for producing these reports remain unclear. Non Annex B countries are not required to produce such reports unless the eligibility for CDM would require such report in future.
- *Verification:* The verification process becomes increasingly important because it is the pre requisite for the compliance scheme. Compliance remains weak until the reporting of sinks and emissions from the whole forest sector is clarified. Inventories are the basis for accounting and therefore the same numbers cannot be the basis for verification. An independent top-down approach of verification is needed (see above: CarboEurope Proposal), as without verification there is no compliance. The Marrakesh compromise on verification contains several areas of concern: For the first commitment period verification on the reporting of sinks is not anymore a mechanism for eligibility for emission trading. Thus it is sufficient to submit annual reports without controls to reach the eligibility requirements. Geo-referencing and hence a more stringent verification has become very weak. Only the regions subjected to sink activities have to be reported. This means that it is enough to report the administrative boundary of a region or of a country to fulfil this criteria. Furthermore, credits for forest management were increased beyond what can be possibly achieved in some countries. All these concessions were made to achieve a full status for emission trading, and these concessions endanger and not preserve pristine forest.

Verification of the Kyoto process must become independent of the national reports, which are based on country-specific accounting schemes. FCCC aimed at stabilising future greenhouse gas levels in the atmosphere 'in such a way as to minimise adverse effects…of climate change' (Art. 2.3 of the Kyoto Protocol). Therefore, we suggest that the verification must take place by measurements in the atmosphere. Atmospheric measurements above the continents must show that the Kyoto process had an effect. Continuous measurements of CO_2 concentrations on tall towers would be one possibility to achieve this (Hurst *et al*., 1997), and a new EU-project within the CarboEurope cluster will establish a tall tower system across Europe in order to observe the net effects of all actions in the atmosphere.

Meanwhile the economic consequences of the Bonn Agreement have been investigated (Missfeldt & Haites, 2001) using six scenarios, separating effects of Art. 3.3 and 3.4 in Annex B and non-Annex B countries. In addition an

option was chosen to investigate the effects of prevention of deforestation in non-Annex B countries. It is shown that the marginal cost and the market price for carbon is highest for afforestation/reforestation projects in Annex B countries. Price and marginal cost is lowest for the option of preventing deforestation. From an economic view, reduced deforestation in developing countries has a larger potential than all other categories of sinks combined. This result shows that preventing deforestation or harvest of primary forest would lead to a 'win-win' situation whereby emissions are avoided by protecting high carbon pools, biodiversity is maintained, and the economics of carbon sinks reach an optimum. It is a pity to see that this option is not supported neither by the Bonn nor the Marrakesh Agreement, and that non-Annex B countries are not required to report deforestation or harvest.

Despite all these concerns we wish to emphasise that without the willingness of the EU to make these compromises the Kyoto process would have died. In the end, 101 nations agreed to fight climate change. Many issues will hopefully be resolved in the second commitment period. It is quite clear (IPCC, 2001) that CO_2 stabilisation in the atmosphere, requires GHG emissions ultimately to be reduced far more drastically than anticipated in the Bonn Agreement. This might require additional tools that are not yet available in the tool-box of the Kyoto Protocol (see, e.g. WBGU, 2002). There remains a long way to even reach the modest goals at Kyoto.

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