Land **use**

& Global **climate change**

Forests, Land Management, and the Kyoto Protocol

Prepared for the Pew Center on Global Climate Change

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Foreword *Eileen Claussen, President, Pew Center on Global Climate Change*

Allowing nations to receive credit under the Kyoto Protocol for using lands and forests to store carbon has been, and will continue to be, controversial until key issues are settled. The Protocol sets forth a partial system for including land-use change and forestry, and negotiators are left with the difficult task of closing potentially important gaps in the rules. Without specific crediting rules, countries can posture for interpretations that could allow them to weaken commitments made under the Protocol. With this situation in mind, the Pew Center commissioned this report to identify key issues in the debate regarding terrestrial carbon.

Report authors Bernhard Schlamadinger and Gregg Marland examine how forests and other lands can be managed to slow the rate of increase in atmospheric carbon dioxide levels, review how the Kyoto Protocol deals with forests and other land uses, and identify outstanding issues that must be resolved if the Protocol is to be implemented.

The report finds the following:

- Forests and the way we manage them provide significant opportunities to assist in climate control efforts.
- The Kyoto Protocol includes land use, land-use change, and forestry, but it does so selectively: sometimes awarding credits for increasing carbon stored through forest and land management, and sometimes not; sometimes charging decreases in carbon stocks (e.g., as a result of deforestation) against national commitments, and sometimes not. As currently crafted, the system is only a partial one and requires further clarification and practical, effective implementation methodologies if potential benefits from land management are to be realized.
- A climate control effort that includes forests needs to account for carbon dioxide both released and absorbed, and it needs to do so in a balanced manner that only rewards activities that contribute to slowing the rate of increase of atmospheric carbon dioxide.

While not a panacea, storing carbon could be an important part of a menu of options aimed at slowing the build-up of atmospheric carbon dioxide levels.

The authors have been part of the writing team for the Intergovernmental Panel on Climate Change's Special Report on Land Use, Land-Use Change, and Forestry, and acknowledge the importance of discussions and interactions with other experts during that process in helping shape this report. Discussions within IEA (International Energy Agency) Bioenergy, Task 25 (Greenhouse Gas Balances of Bioenergy Systems) were also an important source of ideas and feedback. The Pew Center and authors are grateful to Don Goldberg, Mark Trexler, Kristiina Vogt, and Murray Ward, who reviewed the manuscript in draft form, and to Sandra Brown for her guidance as an expert consultant on this report.

Executive Summary

There is increasing concern that the Earth's climate is changing because of the rising concentration of greenhouse gases in the atmosphere. The United Nations Framework Convention on Climate Change (UNFCCC), drafted in 1992, expresses this concern, and the Kyoto Protocol, negotiated in 1997, sets forth binding targets for emissions of greenhouse gases from developed countries. The Kyoto Protocol represents considerable progress in building a global consensus on how to confront the growth of greenhouse gas concentrations in the atmosphere, but it also contains many ambiguities and leaves many issues that need to be resolved before it can be implemented.

The Kyoto Protocol sets quantitative targets for countries to reduce their emissions of greenhouse gases to the atmosphere, but it recognizes that the same goal can be achieved by removing greenhouse gases from the atmosphere. There are opportunities to reduce the rate of build-up of atmospheric carbon dioxide (CO_2) through land management activities, referred to as Land Use, Land-Use Change, and Forestry (LULUCF) activities. These opportunities include slowing the loss of carbon from plants and soils — e.g., through reduced rates of deforestation — and encouraging the return of carbon from the atmosphere to plants and soils — e.g., by planting trees (afforestation and reforestation) or improving management of forests or agricultural soils.

This paper explores whether LULUCF activities provide the same long-term benefit for the climate system as does reducing emissions from fossil-fuel combustion; sketches the development of international negotiations on LULUCF issues; looks at the consensus negotiated so far on this issue; and examines the ambiguities of the Kyoto Protocol, the issues yet to be resolved, and the decisions yet to be made before the Protocol can serve as an effective international instrument. An effective instrument would encourage countries to manage the terrestrial biosphere in a way that minimizes net emissions of greenhouse gases while serving other goals such as sustainable development.

Important issues when designing incentives for land-based climate-change mitigation are whether net carbon sequestration can be considered permanent; whether there will be excessive leakage — a phenomenon where, for example, efforts to protect or increase forests in one place hastens their loss elsewhere; whether the potential for LULUCF activities is sufficiently large to offer real opportunity for reductions in atmospheric CO_2; and whether analytical techniques permit an accurate measure of carbon gained or retained (or lost) in terrestrial ecosystems.

LULUCF activities differ from emission reductions from fossil fuels because their overall potential is limited by the lands available and the amount of carbon that can be stored per unit of land ("saturation"); and because carbon offsets in the biosphere are at risk of being lost at a later time, whereas emission reductions from fossil fuels not burned in one year do not generally trigger greater emissions in a subsequent year ("permanence"). Saturation is relevant especially in the long term (several decades). Options for addressing the lack of permanence of terrestrial carbon stocks exist and are discussed in this paper.

Several articles of the Kyoto Protocol address land management issues. Article 3.3 provides that some LULUCF activities — afforestation, reforestation, and deforestation (ARD) — will be accounted for in determining compliance with national commitments to reduce greenhouse gas emissions. Many negotiators did not want to sanction credits without actions. Consequently, credits in the LULUCF sector are restricted not just to ARD, but to those ARD activities that are directly human-induced, and then only to activities that are initiated after January 1, 1990. Article 3.4 outlines the procedure for including additional LULUCF activities in commitment periods after the first (i.e., after 2012), and in the first commitment period provided that activities have taken place since 1990.

Implementation of these articles is confounded by a lack of definitions for words like "reforestation" and "forest," and the implications of choosing among commonly used definitions are very large. The precise definitions of terms and the rules for taking account of carbon emissions and removals due to LULUCF activities will have different impacts on different countries depending on: 1) the nature of their forests, 2) whether or not the LULUCF sector is currently a source (net emitter) or sink (net remover) for atmospheric CO_2, and 3) the expected emissions balance of the LULUCF sector over the coming decades. The LULUCF provisions in the Kyoto Protocol can only be implemented once the accounting rules have been determined. Inevitably there is a problem when the commitments have already been agreed to, but agreement on the opportunities and rules for meeting those commitments has not yet been fully reached.

Implementation of the LULUCF provisions of the Protocol raises at least six principal issues for domestic LULUCF activities:

- What is meant by a "direct human-induced" activity?
- What is a forest and what is reforestation?
- How will uncertainty and verifiability be dealt with?
- How will accounts deal with the issues of (non)permanence (sequestration reversed by emissions at a later date, e.g. if a new forest is destroyed by a catastrophic event) and leakage?
- Which activities beyond ARD, if any, will be included, and what accounting rules should apply?
- Which carbon pools and which greenhouse gases should be considered?

The last point includes the issue of whether and how to consider that harvested materials from forests can result in an increasing stock of carbon in long-lived wood products and landfills. The Kyoto Protocol does recognize that greenhouse gas emissions will be reduced when sustainably-produced biomass products are used in place of fossil fuels or energy-intensive materials. Biomass fuels, for example, can be used in place of fossil fuels, and construction wood can be used in place of other, often more energy-intensive, materials such as steel or concrete.

In addition to encouraging certain domestic LULUCF activities, the Protocol, through Articles 6 and 12, provides for mitigation projects in other countries and trading of emission credits. When projects involve only developed countries (Article 6), emission reductions or enhancement of sinks that are credited to one country are subtracted from the assigned amount of the other, and there is no change in the global total of assigned amounts. Projects involving both developed and developing countries (Article 12), referred to as clean development mechanism (CDM) projects, result in an increase in the global total of assigned amounts because credits are added to the assigned amounts of developed countries whereas, in the absence of emission limits in developing countries, no subtraction takes place elsewhere. It is therefore critical that the credits result from real emission reductions, or sink enhancements, that go beyond what would have happened without the project. Herein arises the concept of "additionality."

Article 12 of the Kyoto Protocol does not specifically include or exclude LULUCF projects. At least two important, project-level issues for LULUCF remain to be addressed:

- Will LULUCF activities in developing countries be accepted in the CDM and, if so, which activities?
- What accounting mechanisms are appropriate if LULUCF projects in developing countries can generate emission credits but there is no responsibility for debits if the carbon is subsequently lost?

The potential for increasing carbon stocks in the terrestrial biosphere might be limited compared to total greenhouse gas emissions, but their impact could be considerable in relation to the reductions necessary for compliance in the first commitment period (2008-2012). However, not all changes in carbon stocks in the biosphere are treated equally in the Protocol, some yield credits or debits and some do not. It is inevitable that a system cannot be optimized by treating only a portion of that system, and the definitions and rules for LULUCF will have to be carefully crafted to provide incentives for increasing carbon stocks while recognizing the other important roles played by the terrestrial biosphere and its products. It is, however, important that the transaction costs associated with these rules are not so high that they discourage participation toward the ultimate objective of stabilizing atmospheric CO_2. If all of this can be achieved, improved management of the terrestrial biosphere can provide an important contribution toward meeting climate-change objectives, and the Kyoto Protocol can provide incentives for improved management of the terrestrial biosphere.

I. Introduction

Carbon dioxide (CO_2) is a greenhouse gas. Greenhouse gases are those that absorb infrared radiation in the wavelengths at which the Earth radiates energy to space. Carbon dioxide is a naturally occurring component of the Earth's atmosphere, but its concentration is increasing because humans have been burning fossil fuels and clearing forests. The prevailing view of scientists, as summarized in the publications of the Intergovernmental Panel on Climate Change (IPCC, 1996a), is that CO_2 is the most important of the greenhouse gases and that the increasing concentration of CO_2 in the atmosphere will cause changes in the Earth's climate system.

Representatives of most of the countries on Earth met in Rio de Janeiro in June of 1992 and adopted the United Nations Framework Convention on Climate Change, a framework for beginning to address the increasing concentrations of greenhouse gases in the atmosphere. In December 1997, the countries met again, in Kyoto, Japan, to supplement the Framework Convention with a binding, quantitative agreement for reducing emissions of greenhouse gases. The Kyoto Protocol requires developed countries to reduce their emissions on average to 5.2% below the amount they emitted in 1990. The Framework Convention on Climate Change has been ratified by 182 countries and entered into force in March 1994. The Kyoto Protocol has been signed by 84 countries and ratified by 22, as of January 13, 2000. Entry into force of the Kyoto Protocol requires ratification by at least 55 countries, representing 55% or more of 1990 CO_2 emissions in developed countries. The Protocol represents the beginning of a negotiated, international consensus on what might be done to reduce emissions and how this might be implemented.

The Kyoto Protocol recognizes that reducing net emissions of CO_2 can be accomplished by either reducing the rate at which CO_2 is added to the atmosphere (e.g., from burning fossil fuels and from clearing and burning forests) or increasing the rate at which CO_2 is removed from the atmosphere (e.g., by storing additional carbon in the terrestrial biosphere[1]). Storing carbon in the terrestrial biosphere was contentious in negotiation of the Protocol, and it is likely to be contentious in implementation of the Protocol.

The question posed here, and by the Parties who participated in drafting the Kyoto Protocol, is whether it is possible to change the way in which land is managed so as to slow the rate of build-up of CO_2 in the atmosphere. Is it possible to protect existing forests, to plant forests where there are not now forests, to protect or increase the carbon in agricultural soils?

There appear to be many opportunities for managing carbon in what is loosely characterized as the land use, land-use change, and forestry (LULUCF) sector. Increasing carbon in the terrestrial biosphere appears to be a low-cost way to help mitigate the increasing concentration of atmospheric CO_2 while providing ancillary benefits in terms of protecting forests, biodiversity, water quality, and soil fertility. Many LULUCF activities are attractive because they can be pursued now, without technological innovation. Increasing carbon storage cannot by itself solve the problem of increasing atmospheric CO_2, but it can help, especially in the short term.

The purpose of this paper is threefold: 1) to examine how possibilities for increasing carbon in the terrestrial biosphere might be treated alongside possibilities for reducing greenhouse gas emissions from fossil-fuel burning, 2) to review how the Kyoto Protocol deals with storing carbon in the terrestrial biosphere, and 3) to summarize the issues that remain to be resolved if the Kyoto Protocol is to be implemented and to provide appropriate incentives for managing carbon in the biosphere.

Section II and Box 1 describe the global biogeochemical cycling of carbon and how this might be managed to mitigate the increase in atmospheric CO_2. Section III describes the evolution and the details of the Kyoto Protocol that pertain to the terrestrial biosphere, discusses what the Protocol says about carbon sequestration[2] in the terrestrial biosphere, and provides some background on the reasoning that led to the final text. Section IV is a discussion of some of the critical LULUCF issues that need yet to be resolved if the Kyoto Protocol is to become a functioning and useful international agreement. These issues are also critical if LULUCF activities are to be accepted as part of a strategy to mitigate increasing atmospheric carbon dioxide under some other international accord. Whereas Section IV focuses on issues of national concern, Section V focuses on issues of concern at the project level. Section VI discusses country positions on LULUCF issues since the 1997 agreements in Kyoto. Conclusions are presented in Section VII.

Box 1

The Terrestrial Biosphere and the Global Carbon Cycle

Carbon is the essential element on which all life on Earth is based. It is a small but critical component of the Earth's atmosphere. It exists dissolved in the oceans and as a major component of many soils, sediments, and rocks.

Photosynthesis extracts carbon, in the form of carbon dioxide, from the atmosphere and uses energy from the sun to convert the carbon into the basic building blocks of life. Most living organisms rely on the stored chemical energy of these carbon compounds to power their life processes, and then respire the carbon back to the atmosphere as carbon dioxide. Industrial society also relies on the stored chemical energy of these carbon compounds — accumulated by green plants and converted by time, heat, and pressure into fossil fuels — to power cars, homes, and factories. Machines take carbon that has been stored for millennia in geologic materials and return it to the atmosphere as carbon dioxide.

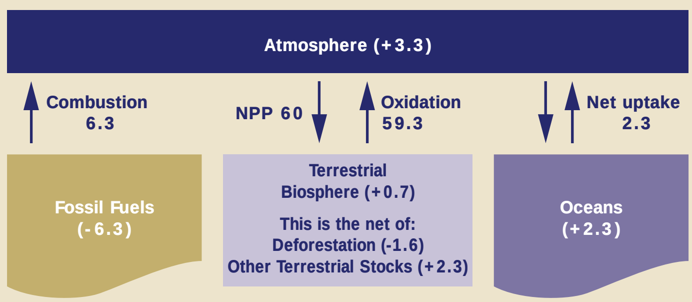
Carbon cycles continuously through the biosphere, the atmosphere, and the oceans as a result of natural processes. Human activities are altering some of the flows of carbon and are changing the balance of the global cycling of carbon. Carbon exists in the atmosphere primarily as carbon dioxide but also as carbon monoxide, methane, and other trace species. Carbon exists in the oceans as a variety of dissolved and particulate, organic and inorganic species. Carbon exists in living and dead plants and in soils in a plethora of organic compounds. For discussion, it is easiest to follow the stocks and flows of carbon without always detailing how, and with what elements, it is combined.

Figure 1 provides a summary of the major stocks[3], stock changes, and flows of carbon in the global carbon cycle. The diagram shows that humans are now releasing about 6.3 billion tons[4] of carbon to the atmosphere each year from fossil-fuel burning. This is not a large number in terms of some of the other components of the global carbon cycle, but it is a flow that did not exist before humans began using fossil fuels, a flow that is increasing rapidly with time. The stocks and flows of the rest of the carbon cycle are adjusting to this additional, human factor.

Terrestrial plants remove approximately a net of 60 billion tons of carbon from the atmosphere each year. This is what is called Net Primary Productivity (NPP) and is the difference between what plants actually produce each year by photosynthesis and what they use to provide for their own energy requirements. Much of this carbon removed from the atmosphere each year by plants is returned to the atmosphere as a result of the respiration of other organisms (including humans), fire, harvest, etc. In essence, it seems that, globally, the terrestrial biosphere (including living and dead plants and soils) is increasing in mass, enhancing its carbon stock by some 0.7 billion tons of carbon per year. With losses from deforestation currently at about 1.6 billion tons per year, the remaining biosphere must be accumulating 2.3 billion tons of carbon per year. This accumulation, or sink, is a result of forests returning or recovering from earlier disturbance or from clearing by humans, the later particularly in the mid-latitudes of the Northern Hemisphere. It is also, probably, a consequence of forests being fertilized by the enhanced CO_2 in the atmosphere and by other human activities that increase the availability of essential plant nutrients. Some of this increase may be carbon stored in soils. There is considerable uncertainty about where much of this accumulation is occurring.

Figure 1

The Global Carbon Cycle: Carbon Stock Changes and Flows



Note: Brown colored pool is decreasing in size. Blue colored pools are increasing. Intensity of blue indicates magnitude of stock change. Numbers are in billions of metric tons carbon per year and are approximate average annual values over the last decade. NPP is net primary productivity.

Source: Bolin et al. in IPCC, 2000.

The oceans too are currently taking up more carbon from the atmosphere each year, on average, than they release back to the atmosphere — about 2.3 billion tons of carbon per year more. The remaining 3.3 billion tons of excess carbon discharged to the atmosphere each year is building up in the atmosphere as carbon dioxide (CO_2). Measurements taken at Mauna Loa Observatory in Hawaii since 1958, and at many other sites over shorter monitoring periods, show that the atmospheric concentration of CO_2 has increased from 316 parts per million (ppm) (by volume) in 1959 to 367 ppm in 1998 (Keeling and Whorf, 1999), an increase of 109 billion tons of carbon. The concentration in the atmosphere before the beginning of the industrial era is believed to have been near 285 ppm.

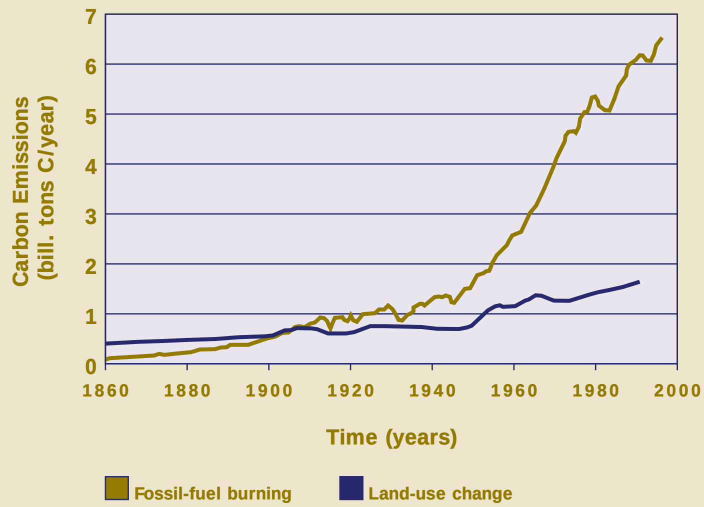
Box 1 cont'd

Figure 2 shows the magnitude of carbon releases to the atmosphere from burning fossil fuels and from land-use change (largely the clearing of forests and the accompanying release of the carbon contained in plants and soils). Since the beginning of the industrial era, humans have released to the atmosphere 270 billion tons of carbon from fossil-fuel burning and another 136 billion tons from clearing of natural vegetation (Bolin et al. in IPCC, 2000).

Some of the numbers summarized in this box are difficult to estimate, and their uncertainty is rather large. Scientists can measure the increase in atmospheric CO_2 very accurately, and the rate of CO_2 release from fossil fuel burning is accurate within +/-10% or less. On the other hand, the IPCC reports the net increase of carbon in the biosphere as 0.7 +/-1.0 billion tons per year (Bolin et al. in IPCC, 2000). Scientists understand the basic functioning of the global carbon cycle and can demonstrate the cause-and-effect relationship between fossil-fuel burning and the atmospheric increase in CO_2, but there is much yet to be learned about the details of the full system and how it will respond into the future.

Figure 2

Annual Carbon Emissions from Fossil Fuels and from Land-Use Change (Deforestation)



Source: Houghton, R.A., 1996; Marland et al., 1999.

II. Mitigating Climate Change by Managing the Terrestrial Biosphere

The scientific literature (reviewed by Brown et al. in IPCC, 1996b) and ongoing projects on the land (Brown et al. in IPCC, 2000) show that the terrestrial biosphere can be used to slow the CO_2 increase in the atmosphere. There are several ways that this can be done. Some activities increase the carbon stock in the biosphere (or slow its decrease), some activities reduce emissions from the combustion of fossil fuels, and some activities do both.

Any scheme that gives value to reducing emissions of CO_2 is going to confront the extent to which tons of carbon conserved or sequestered in the biosphere are equivalent to tons of carbon in emissions from fossil-fuel combustion. This section first discusses the relative merits of LULUCF activities (carbon sequestration or carbon emissions avoidance in the biosphere) and activities aimed at substituting biomass fuels for fossil fuels or substituting wood products for energy-intensive materials such as steel or concrete. The section then compares LULUCF activities with mitigation activities in the energy sector in general. There are three key aspects in which LULUCF activities may differ from activities in the energy sector, and these can have implications for the design of an appropriate system of credits and debits:

- Permanence: Are carbon benefits long-term once they have been realized?
- Saturation: Are there limits to the amount of carbon benefits that can be achieved?
- Verifiability: Can the carbon benefits be accurately measured and verified?

This section does not dwell on the ancillary environmental, cultural, and economic effects that will accompany mitigation activities, although these often make LULUCF activities more attractive and will certainly play a major role in determining when and where these activities will be pursued. The focus is more on addressing the problems raised in trying to include LULUCF activities in international accords to address global climate change.

A. Options for Managing Terrestrial Carbon: Avoidance, Sequestration, Fossil-Fuel Substitution

There are several mechanisms through which land management can influence the global carbon cycle. Each mechanism suggests opportunities to affect stocks and flows of carbon and thus the CO_2 concentration of the atmosphere (Brown et al. in IPCC, 1996b). The three basic mechanisms are:

- Avoid emissions through the conservation of existing carbon stocks in forests and other ecosystems, including in soils (i.e., reducing LULUCF emissions). An example is reducing the rate of deforestation.
- Sequester additional carbon in forests and other ecosystems (including in soils), in forest products, and in landfills (i.e., enhancing LULUCF removals). An example is planting trees where there have not been trees in the past (afforestation).
- Substitute renewable biomass fuels for fossil fuels (i.e., fuel substitution), or use biomass products to replace products from other materials such as steel or concrete, that have different, often greater, fossil-fuel requirements in their production and use (i.e., materials substitution).

The net impact of forest and land management decisions and the use of biomass products on the atmospheric concentration of CO_2 is the sum of the effects of all of these mechanisms. This suggests a fundamental question. Given a parcel of land, is a greater carbon benefit to be gained by using the land to sequester carbon or by using the land to produce products that displace fossil-fuel use? Initial inquiries suggest that the answer is very specific for a particular location or for a particular set of circumstances. There is not a global answer: the local circumstances must be evaluated. In simplest terms, there seem to be four principal, physical factors that influence the balance: the initial carbon stock in plants, litter, and soils; the productivity of the site (e.g., the growth rate of plants); the efficiency with which biomass is harvested and used; and the time period under consideration. A strategy that relies on sequestering or protecting carbon on the site is likely to have the largest potential carbon benefit when the initial carbon stocks are at a high level, the biomass growth rate is low, the efficiency of biomass use is low, and the time period of consideration is short. The opposite set of conditions (low biomass at the beginning, high growth rates, efficient use, and longer times of consideration) will favor fuel or materials substitution (Hall et al., 1991; Marland and Marland, 1992; Marland and Schlamadinger, 1997). In some circumstances, carbon sequestration and biomass use for fossil-fuel substitution will be synergetic, e.g., energy-crop plantations can serve to increase the terrestrial carbon stocks while at the same time providing for a continuing reduction of CO_2 emissions from fossil fuels. For individual projects, social and economic conditions and the market for products will clearly have a large impact on net carbon benefits.

B. How LULUCF Activities Differ from Energy Sector Activities

If land management strategies are proposed to mitigate the accumulation of CO_2 in the atmosphere, it is important for us to understand if options for sequestering carbon in the terrestrial biosphere are different from options for reducing emissions from burning fossil fuels. Although the atmosphere does not distinguish between a decrease in emissions and an increase in removals, there appear to be some important differences between LULUCF options and energy-based options. The basic question is whether it is true in practice that removing one ton of carbon from the atmosphere and storing it in the terrestrial biosphere will have the same benefit for the climate as reducing emissions from fossil fuels by one ton. Is it appropriate to carry these two quantities in the same account and to treat them identically when the goal is to stabilize the concentration of greenhouse gases in the atmosphere? There are three fundamental issues for consideration:

- If activities succeed in increasing the carbon in the biosphere, will it stay there (the permanence issue)?
- If activities succeed in increasing the rate of carbon accumulation in the biosphere, how long will it be possible to continue at this increased rate (the saturation issue)?
- If activities succeed in increasing carbon stocks in the biosphere, is it possible to accurately and precisely measure and affirm that it has been done (the verifiability issue)?

A fourth issue often raised is whether success in protecting or increasing carbon in the biosphere in one place might simply hasten release of carbon from the biosphere elsewhere (the leakage issue). The leakage issue, however, does not seem to be fundamentally different in the LULUCF sector than in the energy sector. Saving fossil-fuel use in one place may similarly result in increased use of fossil fuels elsewhere.

Permanence

Emission reductions in the energy sector can be regarded as permanent. For LULUCF activities, on the other hand, there is a possibility that any carbon accumulated or protected in the biosphere might be released at a later time.

To suggest that reductions in the energy sector are permanent is not to say that an activity will continue forever or that reductions achieved in one year will be achieved again the following year. It is not to say that the same molecule of carbon that has been kept out of the atmosphere in one year will be kept out of the atmosphere in the next year. However, achieving lower emissions in one year will seldom lead to higher emissions in later years. If less automotive fuel is used in one year, emissions will not increase in the next as a result. The total, cumulative emissions up to any given time will be smaller. This is true so long as the potential supply of fossil fuels is very large and the question is not simply how soon the fuel supply is fully converted to CO_2. The potential supply of fossil fuels is indeed very large, and will not be exhausted within the time frame of concern in current discussions of climate change (Nakicenovic et al. in IPCC, 1996b).

For LULUCF activities, on the other hand, changes in land ownership, public policy, commitment by the landowner, climate, or natural disturbances such as fire or pests could cause accumulated carbon to be released back to the atmosphere. In fact, increased carbon stocks in the biosphere could increase their vulnerability to subsequent release to the atmosphere by, e.g., accumulating combustible material in fire-prone areas.

Figure 3 shows four simple scenarios that illustrate the difference between cumulative carbon saved by avoiding use of fossil fuels and by sequestering carbon in the biosphere:

1. A power plant fired with coal for a time span of 40 years;

2. A power plant with no net release of carbon dioxide for 20 years (perhaps because it uses sustainably-produced biomass) but that is fired with coal for the following 20 years;

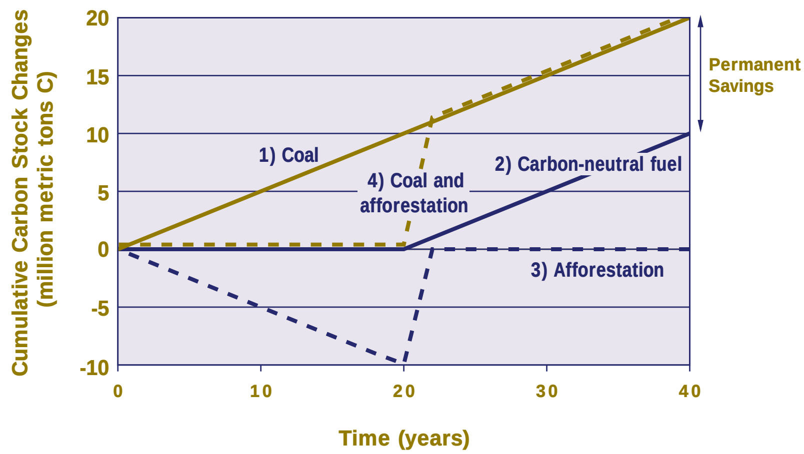
3. An afforestation project, where a loss of the forest after 20 years is assumed, and the trees are not replanted;

4. A combination of scenarios 1 and 3 in which a power plant's emissions are balanced by an afforestation project for 20 years, but where the forest is lost in the 20th year.

It can be seen that converting the power plant back from a carbon-neutral fuel to coal (scenario 2, solid blue line) does not lead to a loss of the carbon emissions saved during the first 20 years. Permanent savings are achieved, as indicated by the difference between lines 1 and 2. However, when carbon is accumulated in trees as an offset for emissions from the coal plant, and then lost (scenario 4, dashed brown line), the cumulative path of emissions leads back to that of the coal plant without afforestation (i.e., there is no difference between lines 1 and 4 after year 20).

Figure 3

Fossil-Fuel Emission Reductions versus Land-Use Activities: The Question of Permanence



Note: The diagram shows the cumulative carbon stock changes in the atmosphere in four hypothetical scenarios: a coal-fired power plant (line 1), a power plant that uses a carbon-neutral fuel in years 1-20 and switches to coal in years 20-40 (line 2), an afforestation project with a loss of its accumulated carbon in year 20 (line 3), and a combination of scenarios 1 and 3 (line 4).

The conclusion is that savings of carbon emissions achieved by using sustainable biomass (or other low-carbon fuel) to substitute for fossil fuel or for energy-intensive non-wood products can be considered permanent savings in carbon emissions. Carbon stocks in terrestrial systems and in wood products are subject to a risk of future release to the atmosphere, and are not necessarily permanent. Lack of permanence does not create problems for LULUCF options so long as the accounting system deals similarly with credits and debits: when carbon stocks increase they create emission credits, and if carbon stocks are lost later, their emissions to the atmosphere will yield debits. Those who are engaged in increasing the carbon storage in the biosphere will be at risk of losing credits later. Having said this, there may be value in the temporary storage of carbon away from the atmosphere, even if the carbon is released at a later time, because the growth in atmospheric CO_2 would be delayed.

Saturation

The potential of the terrestrial biosphere to take up additional carbon is limited by the total land area available and by the amount of additional carbon that can be stored by the plants and soils per unit area. This means that at some point in time any net removals of carbon will, of necessity, diminish. The point at which this saturation will occur will vary for different places and will depend on the history of land management. It will sometimes be true that places with the greatest loss of forest and soil carbon in the past will have the largest opportunities for uptake of carbon in the future.

The cumulative amount of carbon released from the biosphere as a result of land-use change, over the time interval 1850 to 1998, has been estimated at 136 billion tons of carbon (Bolin et al. in IPCC, 2000); and considerable land-use change occured in places like Europe and China before 1850. The IPCC (Brown et al. in IPCC, 1996b) has suggested that the terrestrial biosphere could be managed over the next 50 years to conserve or sequester 60-87 billion tons of carbon in forests and another 23-44 billion tons of carbon in agricultural soils. This is carbon that has already been released to the atmosphere or is likely to be released. Brown et al. suggest that the annual carbon gain in forests could reach 2.2 billion tons by 2050 (Brown et al. in IPCC, 1996b). These are substantial and important numbers. However, the increasing concentration of atmospheric CO_2 cannot be solved solely by sequestering carbon in the terrestrial biosphere. Sequestration can be part of a strategy to mitigate the long-term increase in atmospheric CO_2 but it cannot fully offset emissions from fossil-fuel burning. And, inevitably, the contribution of sequestration will diminish with time. What then should be the interplay between opportunities to sequester carbon in the biosphere and the long-term need to confront emissions from fossil fuels?

Opportunities to reduce emissions in the energy sector will not be limited by saturation effects. Assuming that the resource of carbon-based fuels is not constraining CO_2 emissions, there will be continuous benefits from limiting use of fossil fuels through energy efficiency or the use of renewable energy. An activity that conserves use of fossil fuels this year can do the same next year and in succeeding years. An activity that increases the carbon in the biosphere this year may or may not be able to do so again next year.

Some nations with large areas of forests find that whereas their forests and other lands are currently providing an annual net uptake of carbon (referred to as a carbon sink), this is something that they cannot easily sustain for very long. As noted in Box 1, indications are that the biosphere is currently accumulating some 2.3 billion tons of carbon per year in places recovering from earlier losses of carbon or benefiting from the increase in atmospheric CO_2 or the deposition of atmospheric nitrogen.[5] The strength of this carbon sink is expected to ultimately approach zero as the biosphere approaches its carbon carrying capacity and the annual uptake of carbon is balanced by the annual loss of carbon.

As pointed out by the IPCC, although saturation of carbon sinks places a limit on the amount of additional carbon that might ultimately be sequestered in the biosphere, the terrestrial biosphere is currently well below its carrying capacity for carbon, and could continue to accumulate carbon for decades to centuries (Bolin et al. in IPCC, 2000; Brown et al. in IPCC, 1996b).

Verifiability

If carbon emissions to the atmosphere are to be offset by increasing the amount of carbon in the terrestrial biosphere, is it possible to accurately measure what has been accomplished? Can measurements affirm that one ton of carbon emissions has been offset by one ton of carbon sequestered in the biosphere?[6] Estimating changes in carbon stocks in the biosphere is not as simple and straightforward as estimating carbon emissions from fossil-fuel combustion. One reason for the difference in uncertainty of the estimates is that fossil fuels are a traded commodity whereas, except for timber, most biospheric carbon is not traded in commercial markets. In the case of fossil fuels, there is an economic incentive for accurately measuring energy flows, and hence the related carbon flows. For carbon in the biosphere, however, there are trade-offs among the economic incentive for measuring changes, the cost of measuring changes in carbon stocks, and the uncertainty in the measurement.

The CO_2 discharged from fossil-fuel burning can be estimated with an uncertainty of perhaps +/-10% on a global basis (Marland and Rotty, 1984), and the uncertainty is much less for countries or projects with good statistical data on energy consumption. If energy consumption is reduced with more energy-efficient devices or there is a shift toward fuels with less carbon content, it is straightforward to estimate the amount by which CO_2 emissions have been reduced. Brown et al. suggest that similar uncertainty (+/-10%) can be achieved for LULUCF activities at the project level (Brown et al. in IPCC, 2000). However, many groups believe that accounting for changes in carbon stocks in the biosphere is inherently more difficult than accounting for carbon emitted by burning fossil fuels. Two significant problems are resolution (recognizing small changes in large numbers) and maintaining the infrastructure needed for regular measurement of changes in carbon stocks. Temporal and spatial variability contribute to high variability in estimates of soil carbon at all scales. Uncertainty can be reduced at the cost of more intense sampling and analysis.

For carbon stored in tree stems, it is estimated that changes in carbon stocks over a ten-year interval can be approximated within +/-10% for a specific project (Brown et al. and Apps et al. in IPCC, 2000). Uncertainty will usually be larger for the below-ground carbon in roots and soils, although for some projects a precision level of +/-10% has been achieved (Brown et al. in IPCC, 2000). Because changes in soil carbon are likely to involve small changes in large numbers, accurate estimates of the change in soil carbon may require longer time intervals (to achieve a more readily distinguishable change) and extensive and/or expensive sampling. Current methods are effective for evaluating changes in soil organic carbon at relatively low precision (20-50% error) and at widely spaced time intervals (minimum three to five years) with levels of effort that are reasonably affordable (Post et al., 1999). If more sampling is required to improve the quality of estimates, the trade-off between the uncertainty and the cost of the estimate is likely to be encountered.

There are differences in monitoring costs and uncertainties between different types of projects, e.g., carbon stock changes associated with establishing new plantations are likely to have smaller uncertainty, at the same level of cost, than would stock changes associated with avoiding deforestation. In addition, as the cost and/or difficulty of making measurements increases, it becomes increasingly expensive and/or difficult for an impartial second party to verify sequestration estimates. The concern of negotiators in Kyoto is reflected in the fact that the LULUCF-related articles of the Protocol (Articles 3.3, 3.4, 6, 12, and 17) all contain some form of the word "verify."

III. Development of the Kyoto Protocol

The Kyoto Protocol was drafted in December 1997 to provide binding, quantitative commitments for reducing national emissions of greenhouse gases to the atmosphere. Thirty-eight countries (plus the European Union), listed in Annex B of the Protocol, agreed to reduce annual emissions for the period 2008 to 2012 by an average of 5.2% below emissions in 1990. The United States agreed to a reduction of 7%. The rules regarding which emissions are to be counted and how they are to be counted were not clearly defined in Kyoto. This section focuses on the agreements regarding emissions by sources and removals by sinks in the terrestrial biosphere, and how they evolved during negotiation of the Kyoto Protocol. In particular, the section examines the evolution of decisions on:

- How emissions in 2008-2012 would be compared to emissions in 1990,
- What LULUCF activities could be included in the accounting,
- What restrictions and accounting rules would be applied.

Box 2 explains the national commitments that were made in Kyoto and the context in which sources and sinks in the biosphere would be used to help meet these commitments.

A. The UNFCCC and the Berlin Mandate

The United Nations Framework Convention on Climate Change (UNFCCC) emerged from the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro – the Earth Summit. This global conference brought together 178 governments to address environment and development in a common agenda, a recognition of the central role of the environment in economic development. The UNFCCC succeeded in expressing global concern about climate change and in calling for "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, Article 2, 1992). However, the UNFCCC required little of signatories beyond

Box 2

Some Key Terms in the Kyoto Protocol Related to National Commitments

Base year: Targets for reducing greenhouse gas emissions are defined in relation to emissions in a base year. In the Kyoto Protocol, 1990 is used as the base year for most countries and most greenhouse gas emissions. Countries with economies in transition would be permitted to select an alternate base year and all countries would be permitted to use 1995 as the base year for some of the minor greenhouse gases.

Commitment period: A time period in the future for which countries negotiated greenhouse gas emission targets (commitments). Emissions during the commitment period would be compared with these targets. The first commitment period is the five-year period from 1 January 2008 to 31 December 2012.

QELRO (QELRC): "Quantified emission limitation and reduction objective (commitment)." The quantified commitment for greenhouse gas emissions negotiated in Kyoto and listed in Annex B of the Protocol. The word "objective" was widely used in the negotiations leading up to Kyoto, but "commitment" is the word used in the Kyoto Protocol. The QELRC for each country is a percentage (93% for the United States) that defines the average annual emissions during the commitment period when compared with emissions during the base year.

Commitment: The QELRC of an individual country, established in Annex B of the Kyoto Protocol.

Assigned amount: The emissions of greenhouse gases, measured as the carbon dioxide equivalent emissions, that are permitted during the commitment period. This is calculated using the negotiated QELRC along with other provisions that define the rules for what is to be counted, specify how it is to be counted, and allow trading of emission credits between countries.

Carbon dioxide equivalent emissions: A measurement that allows summing the different greenhouse gases according to an estimate of their relative effect, over time, on the climate. The amount of emissions of each gas is multiplied by a "global warming potential" (GWP) factor.

Annex I countries: Annex I to the UNFCCC lists 35 developed countries and countries with economies in transition that agreed to try to limit their emissions of greenhouse gases.

Annex B: Annex B to the Kyoto Protocol lists 38 developed countries and countries with economies in transition that agreed to QELRCs. The list is nearly identical to the list in Annex I of the UNFCCC except that it adds Croatia, Slovakia, Slovenia, Liechtenstein, and Monaco while dropping Turkey and Belarus.

Entry into force: The Kyoto Protocol will enter into force on the ninetieth day after ratification by at least 55 Parties to the Framework Convention, including Annex I Parties that accounted for at least 55% of the total Annex I carbon dioxide emissions in 1990.

reporting national greenhouse gas emissions. It included a non-binding call for holding emissions in developed countries in 2000 to the same level as those in 1990, and the principles of "common but differentiated responsibilities" and "specific national and regional development priorities" were enunciated. The UNFCCC entered into force on 21 March 1994, 90 days after ratification by 50 countries. It has now been ratified by 182 countries. The United States was one of the first to ratify the convention, on 15 October 1992.

The Framework Convention provided that a review of the adequacy of the commitments be included at the first Conference of the Parties (COP-1). By 1995, when the First Conference of the Parties to the UNFCCC was held in Berlin, there was wide recognition that most countries would not be able to meet the goals agreed to in Rio and that these goals would not be sufficient to stabilize the atmospheric concentrations of greenhouse gases. The countries at COP-1 thus agreed to the Berlin Mandate: to "begin a process to enable it (the UNFCCC) to take appropriate action for the period beyond 2000, including strengthening of the commitments of the Parties included in Annex I of the Convention…through the adoption of a Protocol or other legal instrument." The Berlin Mandate also affirmed that the process would not introduce new commitments for Parties not already included in Annex I.

The Ad Hoc Group on the Berlin Mandate (AGBM) met eight times before bringing a draft Protocol before delegates to the Third Conference of the Parties (COP-3) meeting in Kyoto, Japan, in December 1997. Over 10,000 participants attended COP-3, an intense conference that filled ten days and continued through the night into an eleventh day before adjourning with an adopted Protocol text.

B. Key Aspects of the "Sinks" Negotiations Leading to the Kyoto Protocol

The entire issue of whether, and how, sequestration of carbon in the terrestrial biosphere would be accepted for meeting commitments had been debated since before the Kyoto negotiations began. In the weeks before convening in Kyoto, it appeared that sinks were likely to be omitted from consideration entirely. Topics of concern included permanence, saturation, and verifiability, and the ability of accounting systems to be equitable and to encourage desired objectives such as sustainable development. Parties did not understand the implications for emission reduction targets (their own and others') of including carbon sinks in the biosphere, in part because of the lack of reporting of national data on LULUCF. Consensus on inclusion of sinks was not resolved until the late stages of the Kyoto negotiations. A sense of the intense, late negotiations leading to the final version of the Kyoto Protocol (UNFCCC, 1997b) can be gained by noting that three key sentences relative to LULUCF that are found in the final, 10 December, version of the Protocol, were not in the 9 December draft.[7] The text was in flux right to the very end of the negotiations.

Land use and land-use change are, and have historically been, a source of anthropogenic emissions of carbon dioxide to the atmosphere, primarily through deforestation (Dixon et al., 1994; Houghton, 1996) (see Figure 2). They also present opportunities to reduce net CO_2 emissions to the atmosphere or to increase the net uptake of carbon from the atmosphere (Brown et al. in IPCC, 1996b). For one or both of these reasons, many observers felt that it was desirable to include LULUCF activities in a binding treaty limiting greenhouse gas emissions (Trexler and Associates, 1997). The potential for ancillary benefits in terms of forest protection, biodiversity, water quality, and soil quality further encouraged inclusion.

Another argument for including LULUCF options was that they provide a cost-effective means of reducing net emissions to the atmosphere, especially in the short term. This is particularly relevant if the decision is made to limit the atmospheric CO_2 level to a value not too much larger than the current value. Model calculations show, for example, that if the atmospheric CO_2 concentration is to be limited to 450 ppm, and if cumulative fossil-fuel emissions between 1990 and 2100 are limited to 600 billion tons carbon (i.e., slightly below current levels for the next 100 years), carbon stocks in the terrestrial biosphere would have to increase by 120 billion tons carbon (Lashof and Hare, 1999). However, when the Ad Hoc Group on the Berlin Mandate (AGBM) invited Parties to submit views on the inclusion of sinks in meeting emission commitments, many Parties expressed fears that carbon sequestration would result in reduced commitments to limiting emissions from energy use, that there were important problems in measuring and verifying carbon sinks, and that accounting methods for sinks could create perverse incentives in forest management (UNFCCC, 1997a). Questions about permanence and leakage (discussed in Sections II.B. and IV.D, respectively) were also raised.

To anticipate how the Kyoto Protocol would ultimately deal with the issue of sinks for greenhouse gases, it is instructive to look at its predecessor documents. The UNFCCC refers repeatedly, in reference to both inventories of emissions and mitigation approaches, to "emissions by sources and removals by sinks." Similarly, the Berlin Mandate provides guiding principles for Kyoto, one of which is "coverage of all greenhouse gases, their emissions by sources and removals by sinks, and all relevant sectors." Nonetheless, there was considerable concern leading into Kyoto that some countries would try to meet much of their obligation by increasing carbon stocks in the terrestrial biosphere and would thus avoid having to confront the primary cause of increasing atmospheric CO_2: the emissions of CO_2 from combustion of fossil fuels. It was argued that the largest contribution to increasing atmospheric CO_2, especially in the future, is the use of fossil fuels, and that any solution must concentrate on fossil-fuel emissions. Inexpensive compliance achieved by using the terrestrial biosphere in the initial phase might not lead toward the long-term goals of the UNFCCC — stabilization of the greenhouse gas concentrations in the atmosphere. The use of cost-effective LULUCF measures now might increase the cost of mitigation in the medium to long term if sufficient motivation for developing the innovative technologies needed for deeper reductions is not provided early enough (Michaelowa and Schmidt, 1997). Others have argued conversely, that lower compliance costs in the first commitment period may lead to countries negotiating deeper cuts for future commitment periods, thus providing greater impetus toward the long-term goals of the UNFCCC.

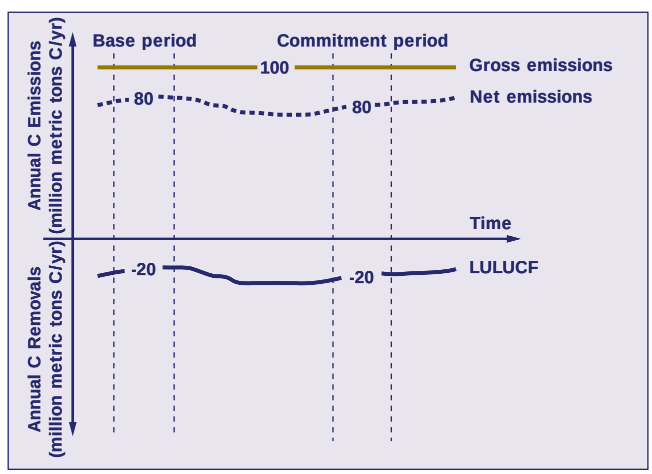
Net-Net and Gross-Net Accounting

Land use, land-use change and forestry are unique in that they can either be a source of CO_2 emissions to the atmosphere or serve to remove CO_2 from the atmosphere. The total effect of land-use change and forestry may be to offset some of the emissions from other sources (as in the United States) or to add to the total of emissions from other sources (as in Australia). In either case, the jargon that has evolved is that gross emissions of greenhouse gases are taken to be the total of emissions from all other sources and do not include emissions or removals from LULUCF, while net emissions do include the sources or sinks from LULUCF activities. This is shown with an example in Figure 4. The gross emissions from this hypothetical country in 1990 and in 2010 are 100 million metric tons carbon (MMTC), the LULUCF removals are 20 MMTC, and consequently net emissions in 1990 and 2010 are 80 MMTC.

Heading into Kyoto there were a number of distinctly different proposals for how sinks could be accommodated, including proposals that would have deferred inclusion of sinks until a later time, when the methods and accounting rules could be better established. Another possibility was the early U. S. proposal that both the targets and the means to meet them should be based on net emissions, the so-called "net-net" approach. Using the example in Figure 4, this approach would have compared net emissions of 80 MMTC in 2010 with net emissions of 80 MMTC in 1990, which is a stabilization of net emissions. Other parties recognized that the net-net approach would make it difficult for countries with a large sink in the base year, as it might be difficult for them to maintain the strength of the sink into the commitment period (the saturation effect). If the carbon sink is shrinking with time, the net-net approach would have the same effect on a country's calculated net emissions as would an increase in fossil-fuel burning.

Figure 4

Gross vs. Net Emissions



Note: For a hypothetical country with 100 MMTC of gross emissions of greenhouse gases and 20 MMTC of carbon removal from the atmosphere by LULUCF activities, net emissions are 80 MMTC. In net-net accounting, net emissions during the commitment period are compared with net emissions during the base period (80 in both cases). In gross-net accounting, gross emissions in the base period (100) are compared to net emissions in the commitment period (80).

The alternative proposed was the so-called "gross-net" approach. Under the "gross-net" approach, targets would be based on gross emissions in 1990 but countries could get the benefit of sinks in meeting their targets — i.e., emissions would be measured on a net basis in the first commitment period. In Figure 4, gross emissions in 1990 are 100 MMTC and net emissions in 2010 are 80 MMTC. The gross-net approach would count sinks only during the commitment period and give an apparent reduction of emissions by 20 MMTC, i.e., opening the possibility of increasing emissions by 20 MMTC in another sector while still reporting stabilization of emissions.

Parties were concerned that under a gross-net approach the accounted sinks during the first commitment period could turn out to be very large, especially if much of the 2.3 billion tons of apparent net annual sequestration in the biosphere (see Box 1) were identified to be in Annex I countries. This concern led to proposals to accept sinks to meet some of the commitments but to limit the extent to which sinks could be used — a "limited gross-net" approach.

The gross-net (and net-net) accounting approaches could be limited by adopting spatial, temporal, or activity limits. If all lands and all activities in a country are included, these might be referred to as "full gross-net" (or "full net-net") approaches. If accounting is limited to specific areas or specific LULUCF activities within a country, the approaches could be defined as "limited gross-net" (or "limited net-net") approaches. With the additional restriction to activities carried out since 1990, one could speak of a "limited gross-net" (or "limited net-net") approach with a "since 1990" requirement. The approach ultimately accepted in the Kyoto Protocol, for most countries, is a "limited gross-net" approach with a "since 1990" requirement. "Limited" refers to the fact that only a limited list of activities is included, and "since 1990" refers to the time limitation.

Country Positions on the LULUCF Options, and the Final Negotiations

The various countries involved in the negotiations in Kyoto represented widely divergent views on inclusion of LULUCF activities (UNFCCC, 1997a). In addition to the United States, it was Norway, New Zealand, and Australia that consistently supported comprehensive inclusion of sinks for meeting commitments under the Kyoto Protocol. All are countries with substantial forest resources. Canada sought full carbon accounting and inclusion of carbon sinks in soils, but also envisioned that credits might be adjusted in accordance with the uncertainty in their measurement. Peru, Iceland, and the Russian Federation also wrote in support of inclusion of sinks; while Japan, the Marshall Islands, and Nauru suggested they should be included, but only later when methodological problems were resolved (UNFCCC, 1997a).

During negotiations leading up to the Protocol, the European Union position was that sinks should not be included in the initial Protocol but might be added later, after the implications were clear and appropriate methods and accounting rules had been worked out. The EU was concerned about methodological difficulties in measuring and verifying sinks, about the long-term fate of carbon taken up in sinks, and was uncertain about the effects on national commitments if sinks were included. Once the inclusion of sinks was recognized as inevitable, the European Union preferred to put a limit on the extent to which sinks could be used to meet commitments. Brazil and the G77 (a group of now over 130 developing countries) sought to constrain credits to a limited list of direct, human-induced activities. The United States preferred more comprehensive accounting and wanted to add additional activities if a limited list was adopted.

Sweden, Finland, and Austria, with New Zealand, recognized that the net-net approach was not acceptable. If countries were unable to maintain their sink into the commitment period, the reduction in fossil-fuel emissions required to meet commitments would have to escalate to compensate for the reduced size of the sink. Many negotiators were concerned that a full gross-net approach would allow some countries to claim credit for sinks that were already occurring — termed “windfall credits” because they would accrue without efforts to reduce net emissions.

Others were also active in the negotiations. For example, environmental non-governmental organizations expressed a variety of views on inclusion of sinks and played a pivotal role in their evolution in the Kyoto text. They served to identify and advise on loopholes and potentially adverse outcomes that could arise from the inclusion of sinks. The forest products industry in the United States advocated for crediting of carbon sequestered in forests and in forest products.

By the fourth day of negotiations in Kyoto, draft text still offered options ranging from complete omission of sinks, to a full net-net approach, to a gross-net option in which activities limited to afforestation, reforestation, deforestation, and harvesting, since 1990, could be used to meet commitments. Attention focused ultimately on this limited gross-net approach. Forest management, forest conservation, and restoration of degraded land were considered for addition to the limited list, but discarded. By December 9th the concept of a limited list of activities had survived, but harvesting had been deleted from the list. The words "direct human-induced" had been inserted to insure that Parties could not claim credit for increases in the terrestrial biosphere pool that were occurring regardless of greenhouse gas mitigation efforts and that might be due to circumstances like CO_2 or nitrogen fertilization. What is found in Article 3.3 of the final Kyoto Protocol is a limited list of activities (direct human-induced afforestation, reforestation and deforestation) undertaken since 1990, avoiding some of the problems of other approaches while still allowing some sinks to be used toward compliance. The text of Article 3.4 allows additional activities to be added at some later time, thus accommodating the demands of some Parties for a more inclusive accounting of LULUCF.

In summary, several issues entered the discussion in Kyoto regarding the suitability of allowing terrestrial carbon sinks for meeting commitments and of the accounting approaches that might be adopted for inclusion of such sinks. These issues included the short and long-term objectives of the Protocol, the possibility of windfall credits or emission loopholes, and fairness to countries that began the process with different levels of ongoing sinks or sources in LULUCF. Negotiators were confronted with questions about which lands, which activities, and which carbon pools to include in establishing base-period emissions and in meeting commitments. There were concerns about what could be accurately measured and how to encourage the desired objectives. All of these fed into an attempt to provide incentives for activities that pursue the goal of slowing the increase of atmospheric CO_2 and that can be verified.

The Rules for LULUCF are Interrelated with Commitments

Although the magnitude of commitments for the first commitment period has now been agreed to in the Kyoto Protocol, some of the opportunities and rules for meeting these commitments are still quite unclear. Grubb et al. (1999), in summarizing the Kyoto negotiations, noted that "while the Protocol made an important structural decision regarding sinks and LULUCF, Kyoto was just a staging post in long-running and convoluted debates about the details of qualifying activities." The debates continue because there is a critical relationship between the rules regarding sinks and the commitments made by Parties to the Convention. In essence the rules regarding sinks present opportunities for meeting commitments and hence have an impact on the stringency of the commitments made by each Party. The more sink activities are allowed for generating credits, the easier it will be for Parties to achieve their reduction goal. This is a point recognized early by Parties like the United States and the European Union. When negotiating the stringency of its commitments, the United States was guided by the opportunities it saw for meeting those commitments.

In its 12 November 1997 submission to the Ad Hoc Group on the Berlin Mandate, the United States stated clearly that the framework for accounting for sinks should be definitely set before commitments were agreed to because "any change in this framework would change the nature and stringency of the obligation" (UNFCCC, 1997a). The United States wanted to know which sinks would be included and how they would be accounted for before making a commitment on the magnitude of reductions. At the same time the European Union recognized "the desirability of eventually taking into account sinks...once the modalities for doing so can be agreed." However, these rules were not clearly agreed upon before the commitments were negotiated and doing things in the opposite order has, as could only be expected, made it more difficult to agree on the choice of activities and how to account for them now that commitments have been established. Predictably, debate on implementation of the Protocol now includes concern that allowing credits for additional carbon sinks in the biosphere will ease the stringency of the negotiated commitments of Annex I countries.

C. How the Kyoto Protocol Incorporates LULUCF

Land-use change and forestry activities were ultimately included in the Kyoto Protocol. The extent to which carbon changes in the terrestrial biosphere can be used for meeting commitments is limited to specific activities: "...direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation, since 1990" (Article 3.3). Land-use change and forestry are, however, not included among the sectors/source categories listed in Annex A of the Protocol for calculating the "aggregate anthropogenic carbon dioxide equivalent emissions" (Article 3.1). Simply stated, for most countries a limited gross-net accounting system is prescribed for LULUCF. Emissions and removals in LULUCF are not included in the 1990 emissions baseline, from which commitments are calculated, but specified terrestrial emissions and removals can be used to meet the commitments in the first commitment period (2008-2012) (Schlamadinger and Marland, 1999). Article 3.3 has the effect of severely limiting the activities that can be included when meeting commitments under the Protocol.

Article 3.7 of the Kyoto Protocol provides special accounting rules, that is, a "limited net-net approach," for those countries for which land-use change and forestry was a net source of emissions in the 1990 base year. Article 3.7 recognizes that a country with net emissions from land-use change and forestry in 1990 is likely to still have a net source of emissions continuing into the first commitment period. This rule was brought into the negotiations by Australia and applies primarily to Australia. A net-net accounting approach makes it possible to get some credit for improvements: that is, reductions in emissions from the terrestrial biosphere. Such an accounting approach could be a viable option for some developing countries if at some time they were to accept commitments, because many of them have significant emissions from LULUCF.

Article 3.3 of the Kyoto Protocol calls for assessing the changes in carbon stocks as a measure of carbon sources and sinks in the biosphere. This approach to measuring emissions was reaffirmed by the Fourth Conference of the Parties (UNFCCC, 1998a). Further, Article 3.4 of the Kyoto Protocol requires each Party to "...establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years." Box 3 provides a discussion of accounting approaches that report changes in carbon stocks versus approaches that report carbon flows.

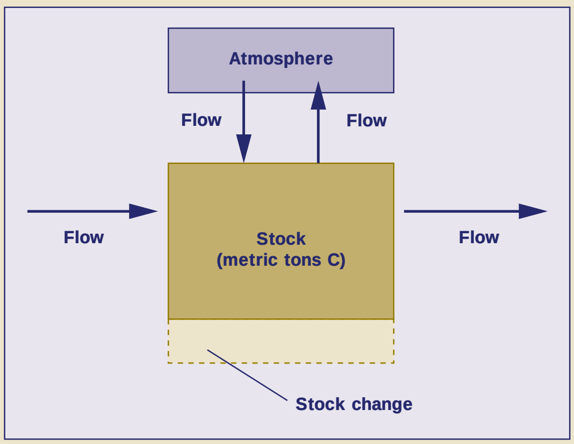
Box 3

Carbon Accounting: Stocks and Flows

The various components of the global carbon cycle — e.g., ocean, atmosphere, plants, soils — that contain carbon are often referred to as carbon pools or carbon reservoirs. The mass of carbon in any reservoir is the carbon stock (Figure 5). Carbon moving between pools is described as a flow. The net of all flows into and out of a pool over a specified time period will be equal to the change in the stock. Increases in terrestrial carbon stocks are sometimes referred to as "removals by sinks" and decreases as "emissions by sources." Sequestration in a carbon pool represents an increase in its carbon stock.

Figure 5

Carbon **Stocks and Flows**



Note: The sum of all of the flows of carbon into and out of the pool is equal to the change of carbon stocks in the pool. The horizontal lines represent flows between terrestrial carbon pools, for example from trees to soils or from wood products to landfills.

Ultimately the focus here is on the net change of carbon in the atmosphere. In an accounting system that focuses on the national carbon budgets, there are two important questions to deal with: 1) what is it that is reported? and 2) how are the reported numbers derived?

Regarding the first question, one can report either stock changes or the flows of carbon to and from the atmosphere (vertical arrows in the figure) over a certain period of time. For most sources of greenhouse gases, including CO_2 emissions from fossil-fuel combustion, the IPCC has prepared guidelines to enable countries to estimate the flow of greenhouse gases to the atmosphere (Houghton et al., 1997). If, for example, oil is produced by Country A, exported to Country B, and burned in year M, CO_2 will be reported to have been emitted by Country B in year M. The flows of greenhouse gases from each country to the atmosphere are reported.

The nature of carbon emissions and removals in the terrestrial biosphere is fundamentally different. For example, in a forest where regrowth matches harvest (sustainable yield forestry), carbon can be removed from the atmosphere by photosynthesis, stored in trees, harvested to make wood products, exported to another country, and decayed or burned as fuel. If one ignores, for the time being, the fuel used to harvest and transport the materials, the end of this sequence looks no different than the beginning from the viewpoint of the atmosphere. This suggests that for carbon discharged from the terrestrial biosphere an estimate of flows to and from the atmosphere might not be the most efficient or most accurate option. An alternative would be to simply estimate the changes in each of the carbon stocks.

The IPCC considered these alternatives for accounting of biomass carbon (i.e., an estimate of emissions based on carbon flows to and from the atmosphere versus an estimate based on changes in carbon stocks) at length and reported on the merits and drawbacks of each alternative (Brown et al., 1998). The authors of this report were among those who argued that it is simpler, more accurate, and more in keeping with the potentially cyclic nature of the carbon in the biosphere to estimate the changes in stocks rather than to keep track of the flows in and the flows out of the atmosphere (Apps et al., 1997).

If a tree is grown in a sustainably managed forest in Country A, exported to Country B, and burned in year M, an estimate of the change in stocks will show no change in either country during year M. An estimate of carbon flows would show a sink of carbon in Country A (due to tree growth) and a source of carbon emissions in Country B (due to oxidation of imported wood). The measure of stock changes will show a decrease of carbon stocks in Country A if the forest is not managed in a sustainable way and harvest exceeds regrowth.

Regarding the second question, there are two ways of deriving a stock change (once it has been determined to focus on stock changes, as in Article 3.3): either by measuring the stock at two different times, or by measuring all of the flows in and out of the pool between these two times (Figure 5).

Although Article 3.3 strictly limits the LULUCF activities that can be used to meet commitments, the Protocol does have provisions that allow these limits to be modified. Article 3.4 of the Kyoto Protocol states that the meeting of the Parties, i.e. a meeting of all countries that have ratified the Protocol, shall decide how, and which, additional human-induced activities might be used to meet commitments. Any such decision will apply in commitment periods after the first, i.e., after 2012, except that a Party can choose, with restrictions, to apply that decision in the first commitment period.

In Article 6 the Kyoto Protocol provides that projects carried out by one Annex I country within another Annex I country can be used to meet the commitments of the former. Both carbon emissions by sources and removals by sinks are specifically mentioned in Article 6, so LULUCF projects seem eligible to create “emission reduction units.” Credits that enter the account of one Party are subtracted from the account of the other Party. Similarly, Article 17 provides that two Annex B parties can trade emissions to meet their commitments. Article 17 differs from Article 6 in that this trading of credits can occur independently of any specific emission mitigation project.

In Article 12 a clean development mechanism (CDM) is described. The CDM provides a way for developed (Annex I) countries to obtain “certified emission reductions” credits for emission reduction projects carried out in developing countries. These credits can be used by Annex I countries to meet commitments. Article 12 mentions emission reductions, but removals by sinks are neither specifically included nor specifically excluded. It is therefore unclear which forest activities, if any, would qualify under the CDM. Article 12 also prescribes that the CDM is to assist non-Annex I countries in achieving sustainable development. Both Articles 6 and 12 require that projects result in emission reductions that are additional to those that would otherwise occur.

The clean development mechanism was originally presented by Brazil (in July, 1997) as the clean development fund, a way to impose penalties for non-compliance with Kyoto commitments and with the idea that proceeds would be used to finance projects in non-Annex I countries. The idea evolved into a mechanism for Annex I countries to invest in projects to help in meeting their commitments, essentially a replacement for the earlier, much maligned, concept of joint implementation. Much of the negotiations on the CDM took place in informal bilateral and group discussions led by the United States and Brazil and the first public debate was late in the Kyoto process (IISD, 1997). The fact that Article 12 does not specifically include LULUCF sinks “illustrates the difficulties that the AGBM had in getting a consensus on how to deal with sinks. The Group of 77 (G-77) and China was unable, throughout the negotiations on sinks, to come up with a consensus. A significant section of the Group views developed country interest in sinks as the creation of another big loophole in the implementation of the Kyoto Protocol” (Mwandosya, 1999).

The text of the Kyoto Protocol is complex, sometimes convoluted, often inadequately prescribed, seldom clear, and not always unambiguous. It leaves numerous opportunities for multiple interpretations. To become a functional document, the Kyoto Protocol needs to be supplemented with definitions and clarifications. The remainder of this report focuses on some of the major LULUCF issues opened or left open by the text of the Protocol.

IV. Critical Issues for National Land-Use Change and Forestry

The text of the Kyoto Protocol leaves open many issues that need to be defined or clarified. It sets some broad boundaries and principles without resolving all of the details. For example, the Protocol limits qualifying activities to afforestation, reforestation, and deforestation. However, it would have been almost impossible to take into account that some 130 definitions of forest are used around the world (Lund, 1999). Reflection by many analysts, including the UNFCCC Secretariat (UNFCCC, 1998) and the authors of the IPCC Special Report on LULUCF (IPCC, 2000), have bounded some issues and raised others. The definitions, accounting rules, and methods eventually adopted for the treatment of sinks in the terrestrial biosphere will be regarded as successful if they provide incentives for activities that result in a lower CO_2 concentration in the atmosphere.

Some issues have technical solutions but many will require political resolution. In many cases interaction between political decision-making and complex technical analyses will be required to ensure that the objectives are met and the appropriate incentives are in place. Sections IV and V address what are believed to be the most critical issues remaining. Section IV focuses on issues relevant to national accounts, while Section V considers issues that arise from individual mitigation projects. The most critical issues that need to be resolved for national accounting are:

- What constitutes "direct human-induced?"
- What constitutes a forest? What constitutes reforestation?
- What will count as a verifiable stock change?
- How should the possible impermanence and leakage of terrestrial carbon gains and losses be incorporated?
- What constitutes an "additional activity," and how are resultant impacts on greenhouse gases to be accounted?
- Which biotic carbon pools and which greenhouse gases can or must be counted?

A. Human-Induced Activities

In the negotiations leading up to the Kyoto Protocol, there was clearly a concern that some carbon emissions or removals, such as increased biotic growth resulting from CO_2 fertilization, be excluded from the accounting toward commitments. Countries were aware that some 2.3 billion tons of carbon were apparently being sequestered annually in the terrestrial biosphere (see Box 1 and Figure 1), but they were not sure where this was occurring and whether some Annex I countries might receive credit for parts of it. These concerns have been incorporated into the Protocol by limiting the activities that can be used to meet commitments to afforestation, reforestation, and deforestation and by specifying, within this limited set of activities, inclusion of only those activities that are "direct human-induced." Planting trees on agricultural land would clearly meet both criteria and thus be admissible. There are, however, examples that are less clear. In the case of abandonment of agricultural land followed by natural growth of forest, it could be argued that the forest was not a result of human inducement or, conversely, it could be argued that the abandonment is a human decision, and thus the forest is a result of direct human inducement. Another unclear case might be land where fire destroys a large forest. Would the failure of humans to regenerate the burned forest make this into a direct human-induced land-use change? If the fire were followed by conversion to an agricultural or urban land use, would the loss of carbon then be considered to be direct human-induced?

With land management ranging from intense plantation forestry to fire suppression to designation as wilderness areas, both narrow and broadly inclusive interpretations have been suggested for "human-induced activity." An IPCC expert workshop did not resolve the question of what should be embraced under "human activities" (IPCC, 1997). The sentiments emerging in the IPCC special report on LULUCF (IPCC, 2000) suggest that the distinction of what constitutes a direct human-induced activity cannot be made on scientific or technical grounds: policy-makers will have to define this term. Taking any definition of "human induced" and making it operational will create additional challenges.

Once an activity has been judged to be direct human-induced, there are still influences on the subsequent changes in carbon stocks that are beyond direct human control. For example, a newly established forest stand might be growing slower or faster than anticipated due to changes in climate, fertilization by CO_2, or nitrogen deposition. Does including the full stock change in an accounting system create windfall credits or unfair debits? In the cases of afforestation or reforestation, the "natural" and indirect human-induced enhancement (or reduction) of the stock change would not be possible without the human activity of establishing a tree cover in the first place. In addition, it may be difficult to separate the effect of CO_2 or nitrogen fertilization from direct human impacts on changes in carbon stocks.

Articles 3.3 and 3.4 differ in their use of “human-induced” to limit activities. Article 3.3 limits activities to those that are “direct human-induced,” while Article 3.4 refers simply to “human-induced” activities. Was this distinction deliberate or just the incidental omission of a word? Policy-makers will have to confront this issue as they discuss the additional activities under Article 3.4 and what constitutes “human-induced.”

B. What is a Forest? What is Reforestation?

The Kyoto Protocol permits consideration of changes in carbon stocks resulting from “afforestation, reforestation and deforestation” without providing definitions for these three words, or even of the word “forest.” The words “afforestation” and “deforestation” do not create severe problems and the intent of the Protocol seems consistent with conventional definitions, i.e., conversion from non-forest to forest and vice versa. The definition of reforestation is more problematic. In some definitions (e.g., Glossary of IPCC Guidelines, Houghton et al., 1997) the word “reforestation” is restricted to indicate a land-use change from non-forest to forest, similar to afforestation with the distinction that reforestation implies that the land was forested at some point in the past. In this definition, reforestation is the mirror process of deforestation. In other definitions (e.g., FAO, 1997), reforestation includes the establishment of new tree cover soon after a forest has been harvested, with the land remaining forest land, i.e., without a change in land use. In this definition, reforestation is the mirror process of harvesting. Discussion with delegates from Kyoto suggests that some assumed the IPCC definition was being applied while others were not aware that the IPCC Guidelines included a definition and assumed a definition akin to the Food and Agriculture Organization (FAO) version.

Before considering deforestation or reforestation, however, it is necessary to define a forest. Lund (1999) completed a broad search of the literature and found 130 different definitions of the term “forest.” Some of these are based on administrative or legal criteria, some are based on land-cover characteristics, and some are based on land-use. Definitions differ among countries and among agencies within a single country. They reflect different applications and different geographic settings. The IPCC special report on LULUCF discusses several definitions of forest, afforestation, reforestation, and deforestation, and constructs consistent sets of compatible definitions of all four terms that are intended to reflect the range of possible combinations of definitions (IPCC, 2000). These definitional scenarios differ not only in the way forest and reforestation are defined, but also in the degree of flexibility for individual countries to choose definitions appropriate to their own needs, within certain bounds.

Discussion of the definition of forest can become very esoteric, but one example can serve to illustrate the potential importance of definitions when accounting for changes in carbon stocks under the Kyoto Protocol. Suppose that a forest is defined as an area in which 30% of the ground is covered by tree canopy. For an area in which 100% of the ground is now covered by tree canopy, 69% of the trees could be removed without triggering the classification of "deforestation." Conversely, if forest is defined as land with 70% covered by tree canopy, a treeless area could be planted to 69% tree cover without yielding credit for afforestation. One possible solution would be to define forest so that the threshold for the fraction of land covered by trees is different for different geographic settings. This would result in a much more complex definition of "forest" but would allow the regional differences in tree canopy cover, e.g., densely-stocked temperate forests versus open tropical woodlands and savannas, to be taken into account.

Once a definition for the word "forest" has been agreed on, the core of the discussion on defining "reforestation" comes down to the question: does replanting forest after a harvest constitute reforestation, or is reforestation restricted to a change in land-use from non-forest to forest? Harvest is not an activity that is reported under Article 3.3. The IPCC (2000) shows that the interaction of the FAO definition of reforestation with the "since 1990" phrase in Article 3.3 could lead to a circumstance where many countries would end up with a net debit from reforestation activities during the first commitment period. The Protocol states that emissions are to be measured as the change in carbon stocks in the period 2008-2012. If a forest is harvested and replanted during this commitment period, there will be smaller carbon stocks at the end of 2012 than at the beginning of 2008 (before the harvest), even though the area was "reforested." If a country manages its forests so that each year's harvest is balanced by the regrowth of other stands (i.e., sustainable-yield forestry), this would lead to no net change in carbon stocks for the forests as a whole. However, the "since 1990" phrase dictates that, although all lands harvested and "reforested" between 2008 and 2012 would enter the calculation, the regrowth credited would not be the regrowth in the entire forest, but only on those lands "reforested" since 1990.

The accounting approach discussed so far in this section would measure the change in carbon stocks on land parcels on which an Article 3.3 or 3.4 activity has taken place, and would measure the stock changes on these lands over the whole commitment period — a land-based accounting framework. An alternative would be an activity-based accounting framework. For any activity that starts in 1990 or later, the change in carbon stocks would be counted from the onset of the activity, or from the beginning of the commitment period if the activity starts before the commitment period. Only changes due to the activity would be counted. The reported stock change in reforestation following a harvest would then start no earlier than the time of reforestation. Credits would accumulate as trees grow, but no debits would accrue as the trees would have been harvested prior to the reforestation activity. This approach would set the starting point of the accounting at the minimum of carbon stocks in trees over a harvest-regeneration cycle. The essence of this approach is that forests existing prior to harvest and reforestation would be treated as if they had not existed. Carbon credits would be gained even though carbon stocks in the full landscape were not increased. Such an approach would result in unbalanced accounting of carbon sources and sinks. Simulation results (Schlamadinger et al. in IPCC, 2000) demonstrate that reported stock changes from afforestation, reforestation and deforestation (ARD) activities better resemble the actual stock changes on lands subject to ARD activities if reforestation is defined as a land-use change from non-forest to forest.

In the aftermath of Kyoto some Parties have argued that reforestation was meant to be defined broadly, to encompass the harvest-regeneration cycle and a definition similar to that of the FAO, perhaps perceiving this as a way to maximize credits under the Protocol. Others have indicated a desire for symmetry in carbon credits and debits, i.e., if credits are awarded for an activity, debits must accrue for the converse or mirror activity. This latter view leads to the conclusion that it makes more sense to define reforestation narrowly (as in the IPCC definition) and to leave forest management, including the harvest-regeneration cycle, for Article 3.4.

C. Dealing with Uncertainty and Verifiability

There is continuing concern about the large uncertainty surrounding estimates of sources and sinks of greenhouse gases. For example, the total LULUCF carbon sink in Annex I countries, as reported by these countries in their emissions inventories for 1990, is 0.5 billion tons of carbon, whereas the total inferred from top-down methods by the IPCC is 1.8 billion tons of carbon (Lashof and Hare, 1999). This uncertainty about the LULUCF budget of Annex I countries was one of the reasons that the Kyoto Protocol ended up permitting credits for only a limited list of activities. Article 3.3 activities are to be measured as "*verifiable* changes in carbon stocks," and uncertainties and verifiability are to be taken into account if the list of permitted activities is to be enlarged via Article 3.4.

A clear definition of the term "verifiable" will be required to implement the Kyoto Protocol. Does the term imply second-party confirmation of a reported change in carbon stocks using the same, or different, means than used in the original measurement? Or does it imply only that the process through which the stock change was established be openly verifiable by a second party so that no additional measurements will be required?

It will sometimes be difficult, and likely expensive, to accurately determine changes of carbon stocks over a time period as short as a five-year commitment period, especially if the stocks are large and the stock changes are small by comparison. The United States currently undertakes a forest inventory every ten years, with plans to reduce the interval to five years in the near future. But uncertainties will always remain, and will likely depend on the carbon pools that are measured (see Section II.B). It has been suggested that credits or debits for carbon sequestration in the biosphere might be limited by the uncertainty in their measurement. In one suggestion, for example, if the change in carbon stocks can be measured within +/-40% (at the 90% confidence level), then credits might be not for the mean of the estimate but for the mean less 40% — the value in which there is 90% confidence (UNFCCC, 1998b). To be consistent, debits could be for the mean plus 40%. With this sort of approach, there would be a trade-off in the credits available and the uncertainty in measurement. One could gain more credits by investing more in measurements to decrease the uncertainty in the estimates.[8]

D. Other Times and Other Places: Permanence and Leakage

Sequestering carbon at one time and place raises the question whether this carbon will be lost at a later time (permanence) or result in offsetting losses elsewhere (leakage). Reducing emissions from fossil-fuel burning raises fewer concerns about permanence (see Section II.B) but similar concerns about leakage.

Article 3.3 of the Kyoto Protocol provides that “changes in carbon stocks in *each* commitment period *shall* be used to meet the commitments.” As long as commitment periods are contiguous, a condition not specified in the Kyoto Protocol, the succession of gains and losses of carbon in Annex I countries should be captured over time, and a Party that gains credits for carbon accumulating during one commitment period should receive debits if that carbon is lost at some later time. If negotiators should arrive at a future where there is a gap between commitment periods, they would create the possibility for unaccounted losses (or gains) in Annex I countries. A similar possibility of unaccounted losses arises if countries listed in Annex I get credits for sequestering carbon in non-Annex I countries but eventual losses remain unaccounted for, a topic which is further elaborated in Section V.

If human activities succeed in increasing the carbon stock in the biosphere in one place, this might lead to losses from the biosphere in other places. As an example, avoiding deforestation in one place might lead to an acceleration in deforestation in some other place. This phenomenon is often referred to as leakage. Leakage is the unexpected loss of anticipated benefits when the displacement of activities or market effects leads to losses elsewhere (adapted from Brown, 1999). Leakage can occur in both energy and LULUCF activities and it is not clear that one is more prone to leakage than the other. Just as increasing the availability of wood can lower prices and alter the markets for wood, more efficient energy production can lower prices and alter the markets for energy. Just as decreasing deforestation in one country can lead to increased deforestation elsewhere, restricting energy-intensive industries in one country can foster energy-intensive industries elsewhere. This latter kind of leakage is of particular concern in the current situation, where Annex I countries have commitments to reduce emissions but non-Annex I countries have no such commitments.

One way in which leakage might occur in LULUCF activities is through the impact of a large-scale reforestation program on timber prices. Greater availability of timber could lead to lower prices. This could, in turn, cause reduced rates of planting in other places. The reduced prices for timber might also cause conversion of existing forests to agricultural uses (Adams et al., 1993). The International Energy Agency Greenhouse Gas R&D Programme used a global timber market model to estimate that between 2% and 16% of the carbon benefits from a global reforestation program might be lost due to leakage over a 100-year simulation period (IEA, 1998). These losses would occur mainly through a loss of other, existing, industrial plantations. However, the increased timber supplies from widespread implementation of Article 3.3 might permit increased use of wood as a fuel or reduce pressure on native forests. The kinds of leakage described above will presumably be captured in national accounting under the Kyoto Protocol, as long as the leakage occurs within Annex I countries.

Leakage creates a different kind of problem when it occurs at the project level or between countries, and especially if one of the countries is a country without emission commitments. Also, leakage need not necessarily be negative. Leakage can result in a positive reinforcement of the initial objective if, for example, an innovation or practice (such as reduced-impact logging) that is created for an explicit purpose is adopted more widely.

E. Additional Human-Induced Activities

A key point for post-Kyoto negotiations is whether, which, and how additional human-induced LULUCF activities will be used to meet commitments to reduce net greenhouse gas emissions. During the negotiations in Kyoto a limited list of LULUCF activities was accepted for inclusion in meeting national commitments: afforestation, reforestation and deforestation since 1990. Other activities will now be considered for inclusion under Article 3.4.

Article 3.4 specifies that additional human-induced activities in the agricultural soils and the land-use change and forestry categories might yet be used for meeting commitments in the second and subsequent commitment periods. Which activities, if any, will be accepted under Article 3.4 will be determined by the meeting of the Parties to the Protocol (i.e., after the Protocol has entered into force), although it appears that many of the relevant agreements will be negotiated before the Protocol is ratified. If additional activities are agreed to, they could be used in the first commitment period, provided a country so wishes and the activities have taken place since 1990. The accounting rules for how these activities are to be included must also be determined. The range of activities and the accounting rules might be chosen to be different in the first than in subsequent commitment periods.

The first challenge is to define the word “activity.” The Parties may choose to define “activity” narrowly, so that it specifies practices like forest thinning, reduced-impact logging, and fire suppression — practices that generally maintain higher average levels of carbon in managed forests. They could also choose to define “activity” broadly so that categories like forest management and range-land management are considered for inclusion. The former choice has the advantage of being able to limit activities to a prescribed list of well-defined activities that can be described and monitored. The latter choice has the advantage that it avoids having to consider an infinite list of current and future practices and that it can accommodate all lands and land-uses within a small number of categories. The IPCC offers a matrix in which, for example, conversion of forest to range-land is defined as deforestation, conversion of range-land to forest is defined as reforestation, maintenance of forest land is defined as forest management, maintenance of range-land is defined as range-land management, and all activities can be simply defined in terms of a small number of land-use categories (Sampson et al. in IPCC, 2000).

It is instructive to compare the increase in carbon stocks from LULUCF in a group of developed countries with the total greenhouse gas emissions from these countries (Grubb et al., 1999). Twenty Annex I countries — including the United States, Russia, Ukraine, New Zealand, and many European countries — reported emissions inventories in 1990 with offsets due to LULUCF activities greater than 5% of gross emissions. Australia, on the other hand, reported that 14% of total emissions were from LULUCF activities. On average, the LULUCF sector was able to offset over 15% of total greenhouse gas emissions in these 21 countries. This net LULUCF sink in 1990 was not due to policies directed specifically towards enhancing domestic sinks, but was largely the result of other factors, including CO2 and nitrogen fertilization, the changing age-class structure of forests, increases in forest area, etc. In short, the sink was due largely to the history of land management and recent changes in the global and regional environment.

A broad inclusion of activities under Article 3.4 could potentially bring much of this large carbon sink into the accounting in the first commitment period. Some would say that this inclusion, coupled with gross-net accounting, would create a large number of windfall credits.[9] Whether or not these are "windfall" credits depends on what the individual Parties envisioned as the opportunities when they negotiated their commitments in Kyoto. It might be a windfall for some, but it might be in keeping with the expectations of others. In either case, a broad inclusion of activities under 3.4 would make it easier for most countries to meet their commitments in the first commitment period than would be the case without the inclusion of these additional carbon sinks. The problem arises because the commitments have been set for the first commitment period but the opportunities in the LULUCF sector for meeting these commitments are still to be defined. For the second and subsequent commitment periods this issue can be addressed if the rules and limits for activities under Article 3.4 are established before the commitments are negotiated. The question facing Parties now is how to deal with these "additional human-induced activities" during the first commitment period. There are several options that could be considered for bringing in additional activities without admitting large numbers of credits for meeting previously negotiated commitments.

Three possibilities are:

- Accept a limited number of narrowly defined activities that account for only a limited amount of carbon removals.

- Accept a broad definition of activity (or a long list of narrowly defined activities), but permit credits only to the extent that increases in carbon stocks are greater than under some baseline scenario. The baseline might be business-as-usual, no change from existing practice, extent of penetration of a preferred technology, or some other variant of these.

- Inclusion of activities on a "project-by-project" basis, following the example of Article 6.

A baseline may be needed in these options and could be used to provide credits (or debits) only when there has been a change in practice or land-use category, or more widespread adoption of a practice, after some reference time (perhaps 1990).[10] A baseline could also serve to provide credits when activities such as reducing deforestation rates result in a decreasing source of emissions. Note that Article 3.7 has the effect of bringing a baseline (i.e., emissions in 1990 from land-use change) into the accounting for countries with a net source of emissions from land-use change and forestry in 1990. If Article 3.4 is used to add activities that are a significant source of CO_2 emissions from some countries, it may be appropriate to ensure that some similar baseline is provided. Baselines and the accrual of credits (or debits) when there is a change from a baseline are also discussed in Section V.C.

In most of these possibilities it is probably appropriate to think of the activity list in such a way that both carbon gains and carbon losses from the biosphere are captured in a symmetric way, i.e., that both activities and their mirror-activities are included (such as harvesting and the regeneration that follows).

In summary, Article 3.4 will be key in the continuing negotiations on how to implement the Kyoto Protocol. It could make it easier for some countries to meet their commitments during the first commitment period, it could be used to build a bridge to full carbon accounting (i.e., coverage of all lands and activities) in the future, it could open new opportunities for meeting more stringent post-2012 commitments, and it could provide a new set of incentives for improved management of the terrestrial biosphere.

F. Which Pools and Which Gases?

LULUCF activities can affect carbon pools other than standing trees, and they can affect greenhouse gases other than CO_2. Management of forests can affect the carbon stocks both in the forest and in forest products. Furthermore, a forest includes not only the living trees but also the dead organic matter in the forest and the forest soils. LULUCF activities can cause carbon in some pools to increase and in others to decrease. An accounting system for carbon could be designed to include all pools, or it could be designed so that all pools with a decrease in carbon must be reported, but only a subset of pools that increase need to be reported. A Party might decide to claim credits only for carbon accumulating in stemwood, for example, although other carbon pools are increasing as well. Which pools to include, among those with an increase in carbon stocks, could depend on how much a Party decides to spend on measuring and monitoring changes in carbon stocks.

Article 3.3 says nothing of forest products. The harvest and removal of material from a forest does not necessarily result in the release of all of the carbon to the atmosphere; some may remain in forest products or accumulate in landfills. Evidence from several studies suggests that the mass of carbon in forest products is increasing, i.e., the rate of production of forest products was greater than the rate of oxidation of forest products by some 140 million tons of carbon per year in 1990 (Winjum et al., 1998). Accumulation of carbon in forest products may be important to some countries or some projects. A decision will be needed regarding whether and how to account for carbon stored in long-lived products and landfills. Inclusion of carbon in wood products in Article 3.3 would limit the accounting to products that result from afforestation, reforestation or deforestation. More complete coverage of wood products seems possible under Article 3.4.

The Kyoto Protocol is not very clear regarding greenhouse gases other than CO_2 from LULUCF activities. With the exception of methane and nitrous oxide from agriculture, Annex A of the Protocol[11] does not include land-use change and forestry. The limited inclusion of LULUCF is as specified in Articles 3.3 and 3.4. In some places (notably Article 3.3) the Protocol stipulates that emissions be measured as verifiable changes in stocks, but this is not meaningful for non-CO_2 greenhouse gases. In other places the Protocol language that applies to LULUCF is broadly inclusive of "greenhouse gases." Omitting consideration of non-CO_2 greenhouse gases when accounting for impacts of LULUCF activities could lead to omission of changes in some important sources of methane and nitrous oxide, two potent greenhouse gases.

G. An Efficient National Accounting System

The definitions and carbon accounting rules adopted for implementing the Kyoto Protocol should provide incentives for activities that increase carbon stocks and disincentives for activities that diminish carbon stocks over the long-term. The design and operation of such a system is not a simple task. The efficiency and cost of meeting these objectives in the LULUCF sector are important considerations that should not be forgotten. The costs and efficiency of the accounting system will depend on:

- The methods used to identify and monitor qualifying activities,
- The similarity of accounting rules under Articles 3.3 and 3.4, and
- The spatial and temporal scales for which stock changes are reported.

One factor that will determine the efficiency and cost of accounting for changes in carbon stocks is the degree to which statistical sampling will be admissible for determining areas and changes in carbon stocks. Will a full assessment of all lands that fall under Articles 3.3 and 3.4 be required or will statistical samples be sufficient? The IPCC suggests that if LULUCF activities are to be tracked accurately, they need to be tied to a specific area (IPCC, 2000). This means that reporting needs to be georeferenced, i.e., that the spatial coordinates of a piece of land on which an activity has occurred need to be specified. Without georeferencing, it would be difficult to go back to the same land and to monitor changes in carbon stocks into the future. Is it really necessary, however, to know where all of the afforested lands in a country are and to visit each of them to measure the carbon? Is it sufficient to know where all of them are but to visit only a sampled subset to measure the carbon? Is it sufficient to know a statistical, georeferenced subset of all areas (so that the total area concerned can be inferred) and to measure the carbon stocks within this subset? Such progressive simplifications would be easier and less expensive to implement, they would be reflected in estimates of the change in carbon stocks that have progressively greater uncertainty, and yet they should each capture the long-term trends in land use and carbon stocks. It is likely that a system that is excessively complex and/or excessively expensive would discourage participation, and hence fail to achieve the objective of encouraging increases in carbon stocks in the biosphere.

The rise and fall over time of carbon stocks on managed lands is largely a consequence of the growth and harvest of biological materials, natural disturbances, and the variability in climate. The magnitude of these changes can be very much a matter of scale and might be evened out by averaging the carbon stocks over longer times or over larger spaces. Averaging over the full harvest cycle, or some other pattern of change, rather than over short time periods, and over a full forest rather than for each forest stand, could simplify measurement and reporting. Implementation of the Kyoto Protocol will require coming to grips with these matters of scale. Box 4 provides an example.

Box 4

The Scale Issue: Spatial or Temporal Averaging for Simplified Carbon Accounting

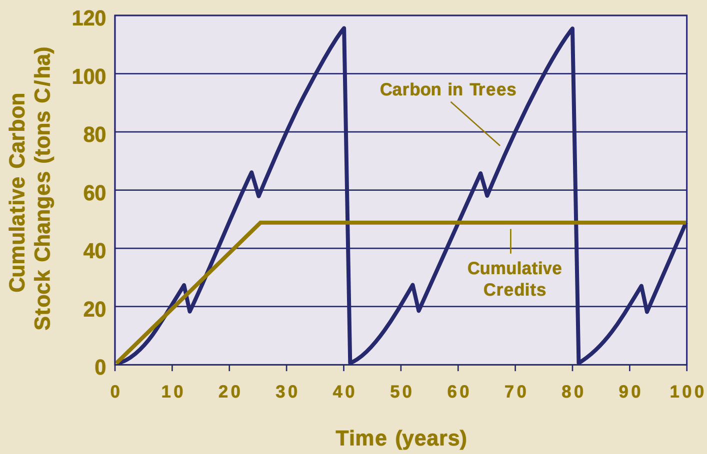
If the carbon stock in a forest stand is monitored, it will, ideally, rise year after year to a maximum, and then fall sharply if the forest stand is harvested. If the carbon stock in a large forest that is managed for a sustainable flow of forest products is monitored, there should be little change over time in the carbon stock, since some stands are harvested each year but the harvest is compensated by continuing growth of other stands. The variability seen at the stand level is a matter of scale; as averaging takes place over a larger area, the variability diminishes. Averaging over the large area should still reveal long term trends, e.g., if each year's harvest is not replanted, the carbon in the total forest will decrease over time. Averaging over time will yield similar results. Measuring carbon stocks yearly may show large year-to-year variability whereas taking the mean over ten years would show less variability, and the variability would again shrink as the averaging time increased.

To what extent is it appropriate to use this principle of spatial and/or temporal averaging to minimize the requirements for measuring and monitoring activities under the Kyoto Protocol? Is it possible to derive a set of regionally appropriate values that describe the average carbon stocks before and after a given activity or land-use conversion? If so, one could establish the long-term change in carbon stocks as the difference between the two numbers and the annual change in carbon stocks would be simply the difference between the two values divided by the number of years expected for the transformation. With regionally appropriate "default values" it would be possible to estimate net annual changes in carbon stocks by knowing only the area over which an activity has been adopted.

Figure 6 illustrates how this temporal averaging might be applied to a forest stand that is planted where there was no previous forest, but where it is expected that the stand will be harvested periodically. The blue line shows the exact path of carbon stocks in trees over time, with some periodic thinning and a clear-cut harvest every 40 years. The brown line represents averaged carbon stocks and could be used as the basis for crediting.

Figure 6

Possible Accounting Method for Cumulative Carbon Stock Changes in a Hypothetical, Managed, Forest Stand



Note: The stand is assumed to be established at time zero and harvested and replanted every 40 years. The stand is also subject to thinning 12 and 25 years after each new planting. The brown line represents a possible carbon-credit curve to approximate the long-term change of carbon stocks on the site. A constant annual amount of credits would be accounted for about 25 years with no further credits after 25 years. An exact accounting of the stock changes represented by the blue line would require extensive measurement and monitoring and would yield a sequence of credits and debits, depending on the stock changes during each commitment period.

V. Critical Issues Surrounding Project-Based Activities

Critical issues concerning project-level activities include whether LULUCF projects will be accepted under the CDM, how to deal with the issue of permanence in non-Annex I countries, and how the concept of additionality will affect project-level accounting. LULUCF projects could be developed under Article 6 of the Kyoto Protocol (projects in Annex I countries using investments from other Annex I countries) and possibly under Article 12 (projects in non-Annex I countries using investments from Annex I countries). LULUCF projects could also be carried out in pursuit of domestic implementation of Articles 3.3 or 3.4 in Annex I countries.

A. Carbon Sinks and the Clean Development Mechanism

In defining the CDM, Article 12 of the Kyoto Protocol permits Annex I countries to conduct emission reduction projects within non-Annex I countries. Certified emission reductions from these projects can be used by the Annex I countries to meet their commitments under the Protocol. Article 12 refers to reductions in emissions but does not mention removals by sinks. Negotiators in Kyoto were simply unable to develop a consensus for the specific inclusion of sinks under the CDM.

A literal reading of the Protocol suggests that reducing emissions by avoiding deforestation might create certified emission reductions, whereas carbon removals from the atmosphere through an afforestation project might not. The Parties to the Protocol will have to decide whether certified emission reductions are defined to be only reductions in gross emissions, gross emissions plus emissions from LULUCF (such as from deforestation or forest degradation), or whether they can be more broadly interpreted to refer to the net emissions, and hence to include removals by sinks. The decision on LULUCF in the CDM will be an important one. Many of the experimental projects in developing countries have involved LULUCF projects. For example, many projects undertaken under the U.S. Initiative on Joint Implementation and the Activities

Implemented Jointly Pilot Phase of the UNFCCC have been land-use projects in developing countries. To date, these projects involve an area of just under 4 million hectares (Brown et al. in IPCC, 2000).

If LULUCF activities are accepted as part of the CDM, Parties may have to decide which activities would be included and which definitions and carbon accounting rules would be used. One option would be to limit LULUCF activities under the CDM just as they are limited in Annex I countries, i.e., to activities specifically included under Articles 3.3 and/or 3.4. This would allow the use of definitions and rules developed for Articles 3.3 and 3.4. Another option would be to have a more inclusive approach based on the ability to develop acceptable baselines, determine additionality, and verify the reductions in emissions or enhancements of sinks that occur.

B. Permanence in Annex I versus Non-Annex I Countries

Changes in carbon stocks in Annex I countries can be accounted for "in each commitment period." Carbon will appear as a credit when it is accumulated in the biosphere and as a debit if it is subsequently lost back to the atmosphere. However, the situation is more complex for projects in developing countries. In developing countries there are currently no means for the losses to appear as debits in a national account, especially if they occur after the end of a project. How then does one deal with certified emission reductions that may not be permanent; where the carbon may be lost back to the atmosphere; where there is no long-term commitment from the host, developing country to report losses? Suggestions to date have included the requirement that the Annex I country partner retain responsibility in perpetuity, that a system of insurance be created to cover such losses, that a reserve of carbon credits be required to cover losses, or that emission reductions be rented rather than purchased from developing countries. The latter idea has not yet been well developed, but it includes the concept that the market might determine the value of retaining one ton of carbon from the atmosphere for one year.

Another possible avenue for involving developing countries, and at the same time addressing the permanence issue in the CDM, might be through emission commitments that are limited to the LULUCF sector. If developing countries adopted commitments that were limited to one sector, rather than full national commitments, this could reduce net greenhouse gas emissions without restraining growth and development in other areas of the economy. A single-sector commitment could both address emissions from LULUCF — an important source of atmospheric CO_2 in some non-Annex I countries — and address the permanence issue for LULUCF projects in non-Annex I countries.

In general, the concept of symmetry in accounting for sources and sinks of carbon in the biosphere will be a challenge when the accounting rules for carbon are different in different places. If projects in developing countries increase carbon stocks in the biosphere (or reduce the rate of decrease of stocks), those increased or saved carbon stocks might be sold as emission reduction credits. There is, at the moment, however, no motivation to account for subsequent losses of that carbon from the biosphere. How to treat the permanence issue for carbon sequestered in a country without an emissions commitment has to be resolved if LULUCF projects are to be included under the CDM.

C. Additionality and Baselines

Articles 6 and 12 of the Kyoto Protocol refer to emission reductions that are "additional." Article 12 stipulates that certified emission reductions would be for "reductions in emissions that are additional to any that would occur in the absence of the certified project activity." Article 6 of the Kyoto Protocol provides that any Annex I country can transfer to, or acquire from, another Annex I country emission reduction units resulting from projects, provided that "any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur."

The objective in both cases is that when projects create carbon credits that can be used toward meeting national commitments, they result in real, measurable improvements for the atmosphere. This requires measuring improvements in relation to something: some reference, some baseline. It is then necessary to measure not only the real changes in carbon stocks but also to estimate the changes in carbon stocks that would have taken place in the absence of the project. "In the absence of the...project" could be taken, for example, to mean business-as-usual, no change in current practice, or some other reference scenario. Insofar as establishing a baseline requires estimating emissions along the path not traveled, it is fraught with difficulty. Once another path is chosen, it is no longer possible to know the rate at which innovation, such as improved forest management techniques, would have occurred or the rate at which forest would have been cleared.

Currently there are no standard methods or guidelines for developing baselines and defining additionality. Several approaches have been proposed. These include case-by-case, project-specific approaches and generic, "top-down" approaches (Brown et al. in IPCC, 2000). The former have the advantage that they focus on the specific areas and activities relating to the project, and project developers may have a better knowledge of local conditions. However, it may also be argued that giving project developers the task of developing baselines introduces the risk that they may choose baselines that maximize their perceived benefits. Generic, or top-down, approaches include possibilities such as benchmarks, possibilities that are also being assessed for the industrial and energy sectors (e.g., Baumert et al., in press). As an example, certain practices could be considered "standard management practices," and baselines might be set to reflect the level of carbon sequestration or emission avoidance that would occur if these practices were universally applied. Credit would then be available to the extent that a project improved on the results that would be obtained by applying these standard practices.

Aside from the uncertainties in measurement discussed in section II.B, difficulties of establishing baselines are not unique to projects in the terrestrial biosphere but apply to projects in the energy and other sectors as well.

Although seemingly parallel, the repercussions of "additionality" are different under Articles 6 and 12. In an Article 6 project, both the country in which the project is carried out and the country receiving credits would be Annex I countries; they would both be subject to emissions limits. In this situation, the concept of additionality may be important to the project participants but it is not important to the atmosphere. If Country A carries out a project in Country B, the project would create credits in Country B. However, the credits would be subtracted from the assigned amount of Country B and added to the assigned amount of Country A (as prescribed in Articles 3.10 and 3.11 of the Kyoto Protocol). The total commitments from all countries would not be changed.

In an Article 12 project, the concept of additionality is important to the atmosphere. Under Article 12, emission credits generated in Country B, where Country B is a non-Annex I country, would be added to the assigned amount of country A, an Annex I country. However, the non-Annex I project host would have no emission restriction and hence would not subtract the emission credits; i.e., the total emissions allowed from all countries would be increased by the amount of credits generated by the project. This is acceptable as long as these credits are based on real, measurable benefits for the atmosphere — benefits that would otherwise not have occurred. Especially under Article 12 there are incentives for both investor and host to exaggerate the benefits of mitigation projects — the investor would receive more credits toward its national commitment and the project host would sell more certified emission reductions. Thus, under Article 12, third-party verification of projects is essential, especially for evaluating additionality and baseline assumptions. There is no difference between LULUCF and energy sector projects in this regard.

D. An Accounting System for Projects

Annex I countries can pursue LULUCF projects domestically, in other Annex I countries (Article 6) or possibly in non-Annex I countries (Article 12). The manner in which the accounting for domestic projects is accomplished will depend on how an individual country chooses to implement and document projects. On the other hand, projects that involve cooperation among countries (under Article 6 or Article 12), would require a more standardized project-level accounting system. Such a system would facilitate transfer of credits between countries, would be accessible to international verification, would be compatible with national level accounting, and would also document the changes in carbon stocks that are additional to a baseline.

The accounting system emerging for project-based activities is different from national-level carbon accounting because project-level accounting does not need to be as spatially comprehensive. Lack of spatially comprehensive accounting for projects will, however, make it more difficult to recognize and compensate for project leakage. While leakage might be captured in a spatially comprehensive national accounting, this is not as easily achieved for individual projects. Lack of current and historical data, infrastructure, political stability, and commitment to long-term preservation of carbon stocks may all make accounting more difficult for projects in developing countries. Differences in risks and in cost of monitoring might, however, be counteracted by lower costs of projects in developing countries.

VI. Country Positions on LULUCF Post-Kyoto

Now that sinks are embodied in the Kyoto Protocol, there are three basic levels of concern about the detailed rules for their inclusion and for the calculation of credits and debits. First, of course, is concern about the environment. The justification for the Kyoto Protocol is to reduce anthropogenic emissions of greenhouse gases to the atmosphere, and the UNFCCC and the Kyoto Protocol both express the need to promote sustainable development and sustainable forest management. Second is concern about how countries will meet national commitments. This includes countries concerned about meeting their own commitments and other parties concerned about the ease with which they can do so. Third is concern about business opportunities in carbon sequestration. If carbon emissions are to be capped, those who are able to sequester carbon or avoid carbon emissions will find a market for emission reduction units. This will include both entrepreneurs seeking business opportunities and developing countries seeking ways to finance projects or development opportunities. While these three concerns are not mutually exclusive, they do represent a variety of motivations and interests in the continuing negotiations. The interests span different spatial and temporal scales, are sometimes — but not always — compatible, and all feed into the country negotiating positions.

A. The Effect of LULUCF Activities on the United States Target

The position of the United States going into Kyoto was to reduce emissions of greenhouse gases to 1990 levels by 2008-2012. Given projections of U.S. emissions, this would be the equivalent of reducing emissions to 33% below projected levels for 2008-2012 (US DOE, 1998). The final U.S. commitment agreed to in Kyoto was to lower average emissions for the 2008-2012 commitment period to 7% below 1990 emissions. A fact sheet issued by the State Department on 15 January 1998 explained that the 7% reduction was in fact "at most" a 3% real reduction below President Clinton's initial proposal. The additional 4% would be achieved by "certain changes in the way gases and sinks are calculated." Of these four percentage points, three percentage points were, according to the State Department, a result of changing the 1990 base emissions for LULUCF from those that were anticipated in the initial U.S. calculations.

The United States had originally supported a full net-net accounting system (see Section III.B) and had assumed that the full LULUCF carbon sink would be included both in the 1990 base period and in the first commitment period. This turned out not to be the final outcome from Kyoto. The implication of the State Department's explanation is that U.S. negotiators calculated that some fraction of U.S. gross emissions in 1990 were actually offset by sinks in the terrestrial biosphere and that this offset would be smaller in the commitment period. However, once it was agreed that the full LULUCF sink was not to be counted, a 3% gain toward commitments was implied. A U.S. submission to the Ad Hoc Group on the Berlin Mandate (UNFCCC, 1997a) explained this numerically. In 1990, 17% of U.S. gross greenhouse gas emissions were offset by net CO_2 removals in LULUCF. This sink was expected to decline and would be smaller by about 40 million tons of carbon by 2010. Forty million tons of carbon is about 2.5% of 1990 gross emissions.

The first essential point is that the accounting system for LULUCF was changing throughout the Kyoto negotiations, heading in ways different than used by the United States in establishing its initial goals and its position going into Kyoto; and this evolution during Kyoto was forcing the United States (and other Parties) to continually rethink how the accounting rules affected their negotiating targets and potential commitments. The second essential point is that very little of the carbon sinks in the biosphere will be creditable under the Kyoto Protocol unless the limits imposed under Article 3.3 are accompanied by more inclusive rules under Article 3.4 (depending somewhat on the exact definitions of terms and the temporal and spatial accounting rules chosen for implementing Article 3.3).

The latest U.S. inventory of greenhouse gas emissions and sinks (EPA, 1999) shows gross emissions of all greenhouse gases in 1990 of 1632.1 million metric tons of carbon equivalent (MMTCE), with a sink from LULUCF (not including non-forest soils) of 311.5 MMTCE (19%). A White House analysis confirms that U.S. negotiators in Kyoto envisioned that omission of sinks from the base period and from the commitment period would change the U.S. target by (a slightly revised) about 50 MMTCE (about 3%), a slight revision from the earlier estimate (Council of Economic Advisers, 1998). Simply stated, given a net-net accounting method, the United States expected to have a carbon sink of about 311 million tons of carbon in 1990 but only about 261 million tons in 2010. Given the limited gross-net accounting system that emerged from Kyoto, the United States is expected to show no carbon sink in 1990 and a small sink in 2010 (depending on the definition of reforestation, and the choice of Article 3.4 activities).

If the Kyoto Protocol comes into force, it specifies a national commitment for the United States but it does not stipulate the internal mechanisms that the United States would implement in order to meet that commitment. Many are interested in the details of which carbon sinks will be included: large emitters (e.g., electric power companies and petroleum companies) who might want to invest in carbon emission offsets either domestically or internationally, land owners (e.g., forestry companies and farmers) who might have credits to sell, and entrepreneurs who might broker or manage such transactions. Interest also resides with governments and non-governmental organizations concerned that the rules and incentives are compatible with other environmental and social objectives.

B. Present Positions on LULUCF

For most participants and observers to the Kyoto negotiations, the general attitude toward sinks in the terrestrial biosphere expressed pre-Kyoto remains in place post-Kyoto. Carbon sinks are now part of the Protocol, however, and the focus of concern has shifted: how much will countries be able to use sinks to meet commitments, what are the definitions and accounting rules for their inclusion, and will sinks be permitted under the CDM?

The issues raised by developing countries have varied between concerns about sovereignty — that sink projects in their countries would create long-term land commitments for carbon sequestration, thus restricting development opportunities — to visions of opportunities for outside aid aimed at economic development and preserving ecological resources. With respect to the CDM, one consideration is that sinks would compete with other options for reducing greenhouse gas emissions, such as energy efficiency improvements or renewable energy, thus reducing technology transfer to developing countries. Developing countries have also expressed concern that sinks would provide a loophole through which the developed countries would escape greater commitment to reducing emissions from fossil-fuel combustion. On the other hand, sinks projects are likely to provide host countries with co-benefits such as enhanced biodiversity, reduced soil erosion, or increased local employment.

At the fifth Conference of Parties (COP-5) meeting in Bonn in October/November 1999, most Latin American countries, except Brazil and Peru, advocated that forestry projects be included under the CDM. This would include forest conservation and sustainable forest management. Several African countries joined in supporting inclusion of credits for avoiding deforestation, seeing LULUCF projects as providing their main possibility for participating in the CDM. While Brazil would not support this position, it left open a decision on whether to support eligibility of forestry projects (Goetze, 1999). Not surprisingly, the oil exporting countries have long supported the inclusion of carbon sinks as a way to offset emissions from burning fossil fuels.

Canada has reiterated its desire to include replanting after forest harvest as a part of reforestation in Article 3.3, and to add improved management of agricultural soils as an activity under Article 3.4. Other forest nations, including the United States, favor inclusion of a broad range of land-use and forest-management activities under the auspices of Article 3.4. Inclusion of forest management activities largely under Article 3.4 may require reforestation in Article 3.3 to be restricted to land-use changes. Australia has voiced support for such a narrow definition of reforestation. Some European countries have proposed a ceiling on the magnitude of credits that can be received from LULUCF activities as a way of limiting the impact of LULUCF activities on national commitments.

There is a range of views from environmental groups (Goetze, 1999). Some oppose inclusion of land-use projects under the CDM and some oppose inclusion of Article 3.4 activities during the first commitment period. Some environmental groups, including the Union of Concerned Scientists and The Nature Conservancy, advocate that, with strong rules, inclusion of LULUCF activities can bring environmental and socio-economic benefits to developed and developing countries (Goetze, 1999; Hardner et al., in press). The Union of Concerned Scientists has written specifically, "The Kyoto Protocol's Clean Development Mechanism creates an opportunity to motivate investments in projects that reduce greenhouse gas emissions by helping developing countries conserve and restore their forests." (Frumhoff et al., 1998).

A 17 September 1999 statement by Finland, on behalf of the European Community and its member states captures much of the post-Kyoto concern (Finland, 1999). Finland calls for country-specific data on how the rules for inclusion of sinks would affect the ability of Parties to meet national commitments. This group believes that the incentive for emission reductions should be maintained and they do not want to agree to LULUCF rules without knowing how they will impact the ability of others to meet commitments. They appear ready to consider a comprehensive approach to dealing with carbon stocks in the biosphere in the second and subsequent commitment periods, but are concerned about the implications for already-negotiated commitments in the first commitment period.

VII. Conclusions

The Kyoto Protocol represents a remarkable achievement in arriving at a global consensus that the increase in greenhouse gases in the Earth's atmosphere is a serious problem that needs to be addressed. Land use, land-use change, and forestry are included in the Kyoto Protocol. Increasing carbon stocks in the terrestrial biosphere is sometimes rewarded with credits toward meeting national commitments to reduce anthropogenic emissions of carbon dioxide to the atmosphere, and decreasing carbon stocks in the terrestrial biosphere is sometimes charged against national commitments. However, all increases or decreases in carbon stocks are not treated equally. Some yield credits or debits and some do not. It is inevitable that a system cannot be optimized by treating only a portion of that system. The interests and concerns of negotiators have created a framework for carbon sinks but with many issues still to be decided.

The Protocol's lack of definition and clarity on LULUCF represent a lack of understanding, a lack of agreement, and a lack of time. If the Protocol is to come into force, negotiators must define the necessary terms and provide the necessary accounting rules so that they give incentives for increasing carbon storage in the terrestrial biosphere while recognizing the other important roles played by the terrestrial biosphere. It is also important that the rules do not reward practices that damage forests and other ecosystems. Rules need to be worked out so that high transaction costs do not discourage participation in the ultimate objective of stabilizing atmospheric CO_2. If all this can be done, LULUCF can provide an important contribution toward meeting climate-change objectives.

Although there were many contentious issues in development of the Protocol, and many places where consensus has yet to be achieved, there were also many places where consensus was achieved. Even if the Kyoto Protocol were not to enter into force but another future agreement were to be required, such an agreement could be negotiated from the groundwork laid in the Kyoto Protocol. There is much work to be done if the Kyoto Protocol is to come into force and to provide ratifying Parties with a reasonable chance of meeting their negotiated commitments for the first commitment period. Activities in the LULUCF sector might be implemented more quickly than many other types of mitigation strategies and could play a significant role in the early efforts toward compliance. The potential of sinks might be small and short term, compared to the total of greenhouse gas emissions, but the impact of sinks could be considerable in relation to the reductions necessary, and the time available, for compliance in the first commitment period. To make LULUCF an integral part of the national efforts for meeting commitments, methodological work will be required to devise a system to keep track of Article 3.3 and 3.4 activities.

In the very long term, it is recognized that carbon sinks in the terrestrial biosphere will approach saturation, a level where no more carbon can be accommodated. At that point the biosphere could continue to provide benefits for the global carbon cycle by providing a sustainable flow of renewable fuels and other products that displace the use of fossil fuels and energy-intensive materials.

This paper closes with a short list of the decisions that are thought to be necessary to implement the LULUCF provisions in the Kyoto Protocol. There are, of course, many other decisions related to leakage, baselines, uncertainty, compliance, monitoring, accounting, verification, etc. that will be necessary, but this list focuses on those that are unique to LULUCF.

- What is meant by a “direct human-induced” activity?
- What is a forest and what is reforestation?
- How will uncertainty and verifiability be dealt with?
- How will accounts deal with the issues of (non)permanence (sequestration reversed by emissions at a later date, e.g., when a new forest is destroyed by a catastrophic event) and leakage?
- Which activities beyond ARD, if any, will be included, and what accounting rules should apply?
- Which carbon pools and which greenhouse gases should be considered?
- Will LULUCF activities in developing countries be accepted in the CDM and, if so, which activities?
- What accounting mechanisms are appropriate if LULUCF projects in developing countries can generate emission credits, but there is no responsibility for debits if the carbon is subsequently lost?

It is now in the interest of each Party to arrive at a final understanding that is at least as accommodating to their interests as was their interpretation and expectation on 10 December, 1997, when they agreed to their targets. An accounting system that does not permit the credits that a country expected when it agreed to an emission target will increase the difficulty of reaching that target, of fulfilling that commitment. Similarly, an accounting system that permits additional credits would make it easier for a country to meet its negotiated commitments. In any event, the Kyoto Protocol has recognized that the terrestrial biosphere plays a significant role in the increase in atmospheric carbon dioxide and represents a consensus that managing the carbon content of the biosphere can help to restrain growth in atmospheric carbon dioxide.

Endnotes

1. The biosphere is that portion of the Earth inhabited by living organisms.

2. Carbon sequestration is the process by which carbon is removed from the atmosphere and stored in, for example, terrestrial ecosystems, thereby increasing the terrestrial stocks of carbon.

3. The carbon stock is the absolute quantity of carbon held in a pool at a specified time. A carbon pool is a system that has the capacity to accumulate or release carbon (IPCC, 2000).

4. A "ton" in this paper is a metric ton = 1000 kg. One metric ton equals 1.1023 short tons.

5. Water, light, CO_2, and other nutrients (e.g., nitrogen) are the basic ingredients required for plant growth. Increased availability of CO_2 or other nutrients is known to accelerate plant growth and hence to increase the rate of carbon uptake.

6. This discussion does not include consideration of leakage but confines itself to the accuracy with which the physical changes at hand can be measured.

7. These are the final two sentences of what is now Article 3.4 (concerning the application of Article 3.4 to the first and subsequent commitment periods) and the one final sentence of what is now Article 3.7 (establishing that some countries may apply a different accounting approach).

8. Other gases/sources with equal or greater uncertainty, e.g., methane from ruminants or nitrous oxide from agricultural soils, are included in the Protocol without provision for considering the uncertainty in their measurement.

9. Given that targets for the first commitment period are based on gross emissions in 1990 (without any adjustment for LULUCF), a very inclusive list of Article 3.4 activities could reintroduce the full gross-net approach for the first commitment period. The full gross-net approach and its repercussions are discussed in section III.B.

10. Activities under Article 3.4 that a Party wants to include in the accounting in the first commitment period have to be "since 1990." Since rules for subsequent commitment periods have not been set yet, it may be possible to allow more complete coverage of LULUCF activities for these periods.

11. Annex A of the Kyoto Protocol lists the greenhouse gases and the sectors/source categories that are generally covered by the provisions of the Protocol.

References

Adams, R.M., D.M. Adams, J.M. Callaway, C.C. Chang, B.A. McCarl. 1993. "Sequestering Carbon on Agricultural Land: Social Costs and Impacts on Timber Markets." Contemporary Policy Issues 11: 76-87.

Apps, M.J., and D.T. Price. 1996. Introduction. In Apps, M.J., and D.T. Price, eds. Forest Ecosystems, Forest Management and the Global Carbon Cycle. NATO ASI Series I, Vol. 40: 1-15.

Apps, M., T. Karjalainen, G. Marland, and B. Schlamadinger. 1997. Accounting System Considerations: CO_2 Emissions from Forests, Forest Products, and Land-Use Change. A Statement from Edmonton (www.joanneum.ac.at/iea-bioenergy-task25/publication).

Baumert, K.A., C. Figueras, and N. Kete. In press. CDM Design: How an "Open Architecture" Can Meet the Needs and Interests of a Broad Range of Interests. Climate Notes. World Resources Institute. Washington, D.C.

Bolin, B. 1998. "The Kyoto Negotiations on Climate Change: A Science Perspective." Science 279: 330-331.

Brown, P. 1998. Climate, Biodiversity, and Forests: Issues and Opportunities Emerging from the Kyoto Protocol. World Resources Institute (www.wri.org).

Brown, S., B. Lim, and B. Schlamadinger. 1998. Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide from Forest Harvesting and Wood Products. Meeting Report, Dakar/Senegal 5-7 May. Intergovernmental Panel on Climate Change, IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories. Paris, France.

Council of Economic Advisers, Executive Office of the President. 1998. The Kyoto Protocol and the President's Policies To Address Climate Change: Administration Economic Analysis. Washington, D.C. July.

Dixon, R.K., S. Brown, R.A. Houghton, A.M. Solomon, M.C. Trexler, and J. Wisniewski. 1994. "Carbon Pools and Flux of Global Forest Ecosystems." Science 263: 185-190.

FAO (Food and Agriculture Organization). 1997. State of the World's Forests. United Nations Food and Agriculture Organization. ISSN 1020-5705. Rome.

Finland. 1999. The Need for Country Specific Data and Information and its Relationship to a Decision-making Framework in the Context of the Requirements of the Kyoto Protocol. Submission by Finland to the UNFCCC Secretariat, 17 September.

Frumhoff, R.P.C., D.C. Goetze, and J.J. Hardner. 1998. Linking Solutions to Climate Change and Biodiversity Loss through the Kyoto Protocol's Clean Development Mechanism. Union of Concerned Scientists. Cambridge, MA. October.

Goetze, D. 1999. A Report on the Meeting of the 5th Meeting of the Conference of the Parties to the Climate Convention. Union of Concerned Scientists.

Grubb, M., C. Vrolijk, and D. Brack, 1999. The Kyoto Protocol: A Guide and Assessment. Royal Institute of International Affairs. London.

Hall, D.O., H.E. Mynick, and R.H. Williams. 1991. "Alternative Roles for Biomass in Coping with Greenhouse Warming." Science and Global Security 2, 113-151.

Hardner, J.J., P.C. Frumhoff, and D.G. Goetze. In press. Prospects for Mitigating Carbon, Conserving Biodiversity, and Promoting Socioeconomic Development Objectives through the Clean Development Mechanism. In S. Brown (ed)., Mitigation and Adaptation Strategies for Global Change.

Houghton, R.A. 1996. Land-Use Change and Terrestrial Carbon: the Temporal Record. In Apps, M.J., and D.T. Price (eds). Forest Ecosystems, Forest Management and the Global Carbon Cycle. NATO ASI Series I, Vol. 40: 117-134.

Houghton, J.T., L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs, and B.A. Callander, eds. 1997. Revised 1996 Guidelines for National Greenhouse Gas Inventories, 3 Volumes. Intergovernmental Panel on Climate Change. IPCC WGI Technical Support Unit. Hadley Center, Meterological Office, Bracknell, United Kingdom.

IEA (International Energy Agency) Greenhouse Gas R&D Programme. 1999. Carbon Sequestration by Forestry: Effects of Timber Markets. Report Number PH3/10. June.

IISD (International Institute for Sustainable Development). 1997. Report of the Third Conference of the Parties to the United Nations Framework Convention on Climate Change: 1-11 December 1997, Earth Negotiations Bulletin, Vol. 12, no. 76. (www.iisd.ca).

IPCC. 1996a. Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. NY: Cambridge University Press.

IPCC. 1996b. Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Chapter B: Energy Primer. N. Nakicenovic, A. Grubler, H. Ishitani, T. Johansson, G. Marland, J.R. Moreira, and H-H. Rogner. Chapter 24: Management of Forests for Mitigation of Greenhouse Gas Emissions. S. Brown, J. Sathaye, M. Cannell, and P. Kauppi. NY: Cambridge University Press.

IPCC. 1997. Intergovernmental Panel on Climate Change, IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories. Meeting Report of the Expert Group Meeting on Biomass Burning and Land-use Change and Forestry. Rockhampton, Australia. 15-18 September.

IPCC. 2000. Land Use, Land-use Change, and Forestry. Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken, eds. A Special Report of the IPCC. Cambridge University Press. Chapter 1: Global Perspective. B. Bolin, R. Sukumar, et al. Chapter 2: Implications of Different Definitions and Generic Issues. M. Apps, R. Houghton, D. Lashof, W. Makundi, D. Murdiyarso, B. Murray, I. Noble, W. Sombroek, R. Valentini, et al. Chapter 3: Afforestation, Reforestation, and Deforestation (ARD) Activities. B. Schlamadinger, T. Karjalainen, et al. Chapter 4: Additional Human-Induced Activities – Article 3.4. N. Sampson, R. Scholes, et al. Chapter 5: Project-Based Activities. S. Brown, O. Masera, J. Sathaye, et al. Chapter 6: Implications of the Kyoto Protocol for the Reporting Guidelines. B. Lim, G. Farquhar, N.H. Ravindranath, et al.

Keeling, C.D., and T.P. Whorf. 1999. “Atmospheric CO_2 Records from Sites in the SIO Air Sampling Network.” In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. Oak Ridge, TN.

Lashof, D., and B. Hare. 1999. “The Role of Biotic Carbon Stocks in Stabilizing Greenhouse Gas Concentrations at Safe Levels.” Environmental Science and Policy 2: 101-110.

Lund, G. 1999. “A ‘Forest’ By Any Other Name.” Environmental Science and Policy (Special Issue: Land Use, Land-use Change, and Forestry in the Kyoto Protocol) 2: 125-134.

Marland, G., and R.M. Rotty. 1984. “Carbon Dioxide Emissions from Fossil Fuels: a Procedure for Estimation and Results for 1950-1982.” Tellus 36B: 232-261.

Marland, G., and S. Marland. 1992. "Should We Store Carbon in Trees?" Water, Air, and Soil Pollution 64, 181-195.

Marland, G., and B. Schlamadinger. 1997. "Forests for Carbon Sequestration or Fossil Fuel Substitution? A Sensitivity Analysis." Biomass and Bioenergy 13: 389-397.

Marland, G., T.A. Boden, R.J. Andres, A.L. Brenkert, and C.A. Johnston. 1999. Global, Regional and National Fossil Fuel CO_2 Emissions. In Trends Online: A Compendium of Data on Global Change (www.cdiac.ornl.gov).

Marland G., and B. Schlamadinger. 1999. "The Kyoto Protocol Could Make a Difference for the Optimal Forest-based CO_2 Mitigation Strategy: Some Results from GORCAM." Environmental Science and Policy 2: 111-124.

Michaelowa, A., and H. Schmidt. 1997. "A Dynamic Crediting Regime for Joint Implementation To Foster Innovation in the Long Term." Mitigation and Adaptation Strategies for Global Change 2: 45-56.

Post, W.M., R.C. Izaurralde, L.K. Mann, and N. Bliss. 1999. Monitoring and Verifying Soil Organic Carbon Sequestration. In Rosenberg, N.J., R.C. Izaurralde, and E.L. Malone, eds. Carbon Sequestration in Soils: Science, Monitoring, and Beyond. Battelle Press: Columbus, OH.

Schlamadinger B. and G. Marland. 1998. "The Kyoto Protocol: Provisions and Unresolved Issues Relevant to Land-use Change and Forestry." Environmental Science and Policy 1: 313-327 .

Schlamadinger, B., and G. Marland. 1996. "The Role of Forest and Bioenergy Strategies in the Global Carbon Cycle." Biomass and Bioenergy 10: 275-300.

Trexler and Associates. 1998. Biotic Offsets Environment Workshop, Final Report of a Workshop in Baltimore, MD, 5-7 September.

UNFCCC. 1998a. COP4 Decision on Land-use Change and Forestry (www.unfccc.de/resource/docs/cop4/l05.pdf).

UNFCCC. 1997a. Response from Parties on Issues Related to Sinks, United Nations Framework Convention on Climate Change, Ad Hoc Group on the Berlin Mandate. FCCC/AGBM/1997/MISC.4 plus MISC.4/add.1 and MISC.4/Add.2 (www.unfccc.de/resource/docs/1997/agbm/misc04.pdf,misc04a1.pdf,misc04a2.pdf).

UNFCCC. 1997b. Kyoto Protocol to the Framework Convention on Climate Change (www.unfccc.de).

UNFCCC. 1998b. Methodological Issues. Issues Related to Land-use Change and Forestry. Note by the Secretariat. FCCC/SBSTA/1998/INF.1 (www.unfccc.de/resource/docs/1998/sbsta/info1.pdf).

US DOE. 1998. Impacts of the Kyoto Protocol on US Energy Markets and Economic Activity. SR/OIAF/98-03. Energy Information Administration. US Department of Energy, October.

US Executive Office of the President. 1998. The Kyoto Protocol and the President's Policies To Address Climate Change: Administration Economic Analysis. July.

US Environmental Protection Agency. 1999. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997. EEPA-R-99-003. April.

Winjum, J.K., S. Brown, and B. Schlamadinger. 1998. "Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide." Forest Science 44: 272-284.

World Resources Institute. 1998. World Resources 1998-99. Oxford University Press: Oxford.

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