The Scale of Land Use, Land-Use Change and Forestry (LULUCF) in Developing Countries for Climate Mitigation

By Christiaan Vrolijk and John O. Niles

Prepared for the Nature Conservancy

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PREFACE

Forests have a unique, three-fold relationship to global climate change: They are simultaneously at risk from the effects of climate change, while being part of the cause and part of the solution. Diverse climate models indicate that many forest ecosystems will face future changes in temperature and rainfall regimes, increases in the extent and severity of forest fires and other factors that may result in broad shifts in forest distribution and composition. At the same time, forests are a source of greenhouse gases. Some 20-25% of global CO2 emissions are the result of deforestation and land-use change, primarily in the tropics – home to a majority of the world's biodiversity. Finally, conserving and restoring forests can make a significant contribution to reducing or mitigating greenhouse gas emissions. Well-designed and implemented projects that reduce the rate of deforestation or increase the rate of CO2 uptake in new vegetation, can yield real, measurable, long-term climate benefits. While no substitute for needed reductions in fossil-fuel consumption, these projects can also provide additional benefits to local community development and bio-diversity conservation.

The compromises reached in the latest rounds of climate-change negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol recognize these important roles that forests can play. In the first commitment period under the Kyoto Protocol (2008-2012) some land use, land-use change and forestry (LULUCF) activities may be counted towards part of industrialized countries' obligations to reduce their net greenhouse gas emissions, both within their borders and internationally through Joint Implementation and the Clean Development Mechanism. Although the current United States administration has distanced itself from the Kyoto Protocol, LULUCF projects have been explored since at least the early 1990s by private companies, federal agencies and non-governmental organizations as a useful tool for addressing climate change. Though the shape of future US responses to climate change is as yet to be defined, it is likely that LULUCF activities will play an important role.

LULUCF activities have been accepted as legitimate elements in the tool kit that policy makers and project developers have at hand to deal with climate change. If these are to generate the sorts of real results that are an environmental necessity in the face of climate change, then they must be based on solid rules, rigorous accounting and transparent monitoring. This is particularly important because if LULUCF projects result in mere additional emissions rather than real reductions, as some fear, the result will be a relative increase in the severity of global climate change, and increased pressure on the world's forest resources.

The Nature Conservancy, in both its international and domestic programs, has been engaged for over a decade in exploring options on the ground for using forest conservation and forest restoration to simultaneously achieve climate change mitigation and biodiversity conservation goals. TNC, working with local partners in Belize, Bolivia, Paraguay, Guatemala, Dominican Republic, Brazil and Peru has developed and/or implemented a series of pilot projects. These projects have served to generate a wealth of practical experience, highlighting the special challenges that these sorts of projects imply as well as demonstrating, in practice, that with rigorous monitoring and careful design, effective responses can be put in place.

TNC has been particularly active in Latin America, a region with a priceless natural heritage of biodiversity as well as alarming rates of forest loss. In seeking to reconcile the often apparently contradictory pressures of human needs and biodiversity conservation, of economic development and environmental quality, many governments, organizations and communities have seen international investment in climate change mitigation projects as one possible solution. Policy makers, analysts, NGOs and project developers throughout Latin America are working through the devilish details of making LULUCF projects work and work well.

Much of the fine print that still needs to be spelled out involves often inter-related issues such as permanence, leakage, scale, baselines, additionality, and sustainable development criteria. In 2001, TNC commissioned this series of papers by leading experts in their fields as part of an effort to build capacity on climate change in Latin America sponsored by the United States Agency for International Development (USAID). The purpose was to shed light and provide additional information about these issues to policy makers as they strive to hammer out agreements that will allow for workable projects with measurable, positive consequences for the global atmosphere. During workshops with Latin American and other experts in climate policy and science, three issues were identified as particularly worthy of further exploration since they are key factors in determining the environmental integrity as well as the viability of projects: **permanence, leakage and scale.**

In this paper on scale, Christiaan Vrolijk and John O. Niles explore the possible trajectories of supply, demand and price under different scenarios for the global emissions market—and in particular what impact inclusion of different LULUCF activities might have. In a market still plagued by uncertainties as policies and rules evolve, they seek to describe how LULUCF activities might affect the supply of GHG offsets, the demand for projects from other sectors and the consequences for the market price of offsets.

Two other papers, in this series, address the issues of leakage and permanence.

The paper on permanence, by Pedro Moura Costa describes some of the innovative accounting frameworks that have been proposed to address the possibility that carbon in forests may not be permanently stored. Decisions by project developers or national authorities, or circumstances beyond the project developer's control (both natural events such as fire and hurricane, as well as human activity such as illegal logging) may result in the future release to the atmosphere of carbon held in forest biomass. A variety of methods might be adopted by policy makers to account for real climate benefits, even where projects are non-permanent. (Available at www.nature.org/aboutus/projects/climate/docs).

In their paper Reimund Schwarze, John O. Niles and Jacob Olander provide an overview of leakage, the risk that emissions may be displaced in time or space outside LULUCF project boundaries, resulting in diminished greenhouse gas benefits. They also summarize some of the approaches used by project developers and proposed by analysts for effectively managing or accounting for leakage, to ensure that projects produce real, measurable greenhouse gas benefits. (Available at www.nature.org/aboutus/projects/climate/docs).

It should be noted that TNC commissioned these papers by independent experts to provide cutting-edge perspectives on these critical issues. The results should not be construed as institutional positions of TNC, but will ideally contribute to the lively and important policy debate around these issues in Latin America and globally.

Jacob Olander

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Executive Summary

Continuing talks on the Kyoto Protocol increase the probability of an emerging market for carbon abatement. Many specific details about this possible carbon market remain speculative and highly uncertain. One of many uncertainties pertaining to the carbon market is how land use, land-use change and forestry (LULUCF) activities in developing countries will impact fossil fuel abatement. This paper addresses this concern to see if LULUCF projects in developing countries could "swamp the market" and lead to negligible fossil fuel mitigation. This work demonstrates possible impacts on the price, distribution, and quantity of the carbon market by LULUCF projects from developing countries.

In this paper, a global carbon market model called CERT (the Carbon Emission Reduction Trade) is used. The CERT model combines parameters such as cost functions and emission trajectories from other sources in a simple-to-use spreadsheet model. The CERT model is used in part because it can be rapidly updated to reflect changing political and legal developments. CERT is also accessible to a wide range of users; it is only as complicated as a sophisticated spreadsheet file. To specifically evaluate how developing country LULUCF (DC LULUCF[1]) could influence the global carbon market, assumptions about parameters for other aspects of the carbon market are kept relatively constant. (Readers should note these assumptions carefully, as any model is only as valid as its inputs.)

The carbon market before DC LULUCF

The first part of the paper defines likely ranges of supply and demand estimates for carbon offset credits before considering DC LULUCF projects. Some key findings, or, "initial conditions" from this part of the paper include:

1) Mean demand for carbon offsets varies (very approximately) from between 300 and 700 MtC per year, depending on whether or not the United States (US) engages in the Kyoto Protocol's carbon market.
2) The treatment of "hot air" will have a substantial impact on the market (more so than DC LULUCF influences).
3) Appendix Z allowances for Annex B LULUCF activities are significant, but relatively modest compared to "hot air".

The Bonn 1% Cap

This paper notes that even if current plantation rates in the tropics are doubled, the "1% Bonn cap" negotiated on DC LULUCF projects would not be met. (This conclusion includes the fact that projects may start early and accrue credits to be used during the first commitment period.) However, the establishment of an effective price signal could spark additional investment that would create emission reductions beyond the 1% cap. Depending on the

[1] We use the acronym 'DC LULUCF' in this summary for brevity. It represents any possible land use, land-use change or forestry carbon credits from developing countries. We choose this term and not a Kyoto Protocol term since current US opposition to the Kyoto Protocol may lead it to engage in activities not 'sanctioned' by the Kyoto Protocol.

position of the US in the carbon market, within or outside the Kyoto–Bonn–Marrakesh rules, this could thus effectively limit DC LULUCF development.

Supply of DC LULUCF carbon credits

The magnitude of possible DC LULUCF supply of carbon credits for the global carbon market is then explored. Estimating the potential scale of DC LULUCF projects is confounded by uncertainty concerning projects types that will be eligible for trading. Two key issues are: 1) whether plantations will be eligible and 2) if the US joins the carbon market, will it pursue avoided deforestation projects. This second question complicates the analysis since negotiations of the Kyoto Protocol have excluded avoided deforestation from the carbon market while the US has indicated it will pursue this mitigation.

In addition to uncertainties regarding plantations and the US/avoided deforestation question, the *cost* of DC LULUCF and the *potential amount* of credits remain speculative. This paper uses two scenarios for these parameters. An "optimistic" scenario estimates 400 MtC per year of DC LULUCF credits could enter the market at prices ranging from almost nothing to $20/ton of C (tC). A "realistic" scenario uses a supply of 200 MtC, with costs rising from almost nothing to $40/tC. The latter scenario represents the fact that historically, almost half of the development projects in various countries have failed to be sustainable over long periods of time. Both of these supply estimates account for some DC LULUCF activities starting before the first commitment period and being 'banked'.

The impact of DC LULUCF on the carbon market

The authors chose three main scenarios to examine how DC LULUCF carbon supplies could affect the global carbon market. Results from these scenarios suggest that the DC LULUCF impact will be modest.

In terms of the latest negotiations (referred to as the "Marrakesh scenario" in the paper), the impact of DC LULUCF within the Kyoto market will likely be negligible if the US remains outside the Kyoto Process. If the US engages in carbon trading *on its own*, it is estimated that the US would buy a much more substantial 33% of its 415 MtC/year from DC LULUCF. This figure could encompass such activities as avoided deforestation credits, which are otherwise not allowed in the first commitment period. From this model, the market price the US would pay for carbon credits would be around $11/tC.

If the US joins other Parties in the "Marrakesh scenario" and *uses the 28 MtC pursuant to Appendix Z*, total demand for carbon at the market price would be 779 MtC per year. Inclusion of the DC LULUCF carbon credits reduces the price of carbon (from approximately $17/tC to $11/tC) and thus leads to an increase of the net demand at the market price (only by about 20 MtC). Of the total 801 MtC demanded per year, an estimated 136 MtC (17% of the total demand) would come from LULUCF projects, replacing emission reductions from other sources.

A final scenario was run to see how US re-engagement in the Kyoto Protocol process and carbon market would change things. Under this scenario, the US is granted 5 times its preliminary Appendix Z allowance. This scenario also reflects the situation where the US would develop a market (based on a stabilization from 1990 levels target) parallel to Kyoto – consequently the US and Kyoto markets would compete for DC LULUCF credits on the international market. In this case, inclusion of DC LULUCF raises net annual global carbon demand by reducing the market price from 686 MtC to 701 MtC. Under this scenario, DC LULUC carbon credits would account for 15% of the total (105 MtC/year) and would lower the price from $12/tC to $8/tC.

Including DC LULUCF would subtract from carbon credits demanded from other flexibility measures. For instance, assuming the current Appendix Z allowances, JI and economies-in-transition would lose about 20 MtC/year net.

Conclusion

There are many uncertainties in terms of a global carbon market should one emerge in conjunction with the Kyoto Protocol. Using the CERT model with the assumptions given, in scenarios where the US engages the Kyoto Protocol process, DC LULUCF credits are estimated to make up around 15%–17% of the total. Given that approximately 20% of worldwide greenhouse gas emissions emanate from land use change in developing countries, this does not seem to be a disproportionate amount of abatement via DC LULUCF. The cost of carbon would also decline with inclusion of DC LULUCF by $4/tC to $6/tC. This represents a substantial savings of several billion dollars per year. These impacts must be evaluated in the broader context of the LULUCF debate and on the utility and risks of flexibility mechanisms in general.

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1. Background - the Kyoto Protocol and global carbon markets

Historically, countries and companies had no limit on the amount of greenhouse gases they could emit. The Kyoto Protocol essentially seeks to change this by restricting the amount of carbon and other greenhouse gas emissions that a subset of countries can release. The countries that took on quantified emission limitation and reduction commitments, primarily the more developed nations of the world, are labelled Annex B Parties to the Protocol (and in this paper). Rules for allocating emission limits within any individual Annex B country have been left up to each nation to decide. Countries that did not agree to limit their emissions are referred to as non-Annex B Parties.

By restricting Annex B nations' emissions, the Kyoto Protocol implies a cost to these emissions. A basic tenant of economics is that restricting the supply of a good or service (in this case, the ability to emit greenhouse gases) increases the price for that good or service. Since carbon emissions are associated with most facets of the global economy, the Kyoto Protocol adopted a market-based approach to lower the price tag of addressing climate change. Instead of mandating that each nation meet its target individually, the Kyoto Protocol allows countries to make the required carbon reductions wherever they are cheapest.

2. Land use, land-use change and forestry in the Kyoto Protocol

In the parlance of negotiators, changes in land use, vegetation, soil carbon or other similar processes that alter carbon fluxes (as distinct from fossil fuel activities) are referred to as land use, land-use change and forestry, or LULUCF activities. This paper will use the term LULUCF to describe carbon fluxes from changes on soils and vegetation. "Sinks" is often used as a catchword for any LULUCF activity. The word "sink" is not accurate since a sink refers only to sequestration of carbon and does not adequately distinguish between carbon sources and carbon sinks. The Kyoto Protocol allows countries a limited amount of carbon mitigation to be achieved via processes associated with LULUCF actions to meet their goals. This can either be accomplished domestically within an Annex B country, or can be purchased on the global carbon market.

LULUCF activities have caused long debates and disagreement in the international negotiations. In principle, the text of the UN Framework Convention on Climate Change (FCCC) supports a comprehensive approach to achieve the goal of stabilisation of greenhouse gas concentrations and calls for programmes 'addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases'.[2]

LULUCF activities have remained controversial for several reasons.[3] The first set of reasons

[2] FCCC Article 4.1b.
[3] For a review of this debate, see for example Schlamadinger and Marland, 2000 and Niles, 2002.

why some Parties contest the inclusion of LULUCF in the Kyoto Protocol are technical and ecological in nature. Some groups argue that there are not well-established monitoring systems for LULUCF carbon fluxes. These groups fear changes in carbon storage cannot be measured with sufficient accuracy, possibly distorting compliance requirements and threatening the validity of trading in carbon credits. However, others argue that LULUCF activities can be, and are being, monitored and verified adequately.

Another related concern is that carbon stored in terrestrial pools may be impermanent and unstable. Opponents of a broad inclusion of LULUCF into the Kyoto Protocol point out that human activities may lead to the release of land-based carbon at any time. Proponents of a LULUCF inclusive treaty point out the numerous co-benefits of managing carbon wisely in the terrestrial ecosystems (biodiversity protection, watershed maintenance, sustainable forestry and stabilized land surface conditions). These proponents argue that because of these co-benefits, LULUCF should be a key part of efforts to mitigate global climate change. Still others point out that comprehensive monitoring by all countries would eliminate problems with tracking LULUCF mitigation.

A further reason why LULUCF remains controversial is that some see LULUCF activities as a diversion from the main task, i.e. the reduction of fossil emissions. There is a concern that as the negotiations on details of the Protocol have proceeded, more and more LULUCF activities have been legitimised as a means of meeting the Kyoto Protocol's targets. Opponents of this trend fear that negotiators are "diluting" the treaty of necessary fossil fuel curbs. Proponents of more LULUCF in the treaty argue that, since land based emissions (primarily from tropical deforestation) are a significant portion of GHG emissions, they should be part of the solution. Rather than being a diversion, proponents argue that LULUCF activities are essential policy tools that lower the cost of climate change mitigation and can help transition economies away from fossil use.[4]

This paper addresses the second broad concern; the impacts LULUCF might have on the broader market for greenhouse gas offsets. This paper specifically seeks to quantify the probable scale and effect of LULUCF activities in developing countries on the global carbon market.

3. THE GLOBAL MARKET FOR CARBON REDUCTIONS

The following is some basic information on the global market for greenhouse gas offsets. The demand for carbon offsets internationally will be determined largely by the total emission reductions required of Annex B nations from their business as usual emission trajectory and the cost of making these reductions. As a general rule, the higher the cost of domestic (within-Annex B) carbon mitigation, the higher the demand will be for purchased carbon offsets on a global market. Additional LULUCF allowances for meeting some of the Annex B emission reductions have been agreed upon in negotiations. These allowances will lower the total potential demand for international and other carbon offsets. Finally, LULUCF carbon offsets from non-Annex B nations will compete against other supplies, such as from emission trading, joint implementation and non LULUCF projects in the Clean Development Mechanism. Several models of the aggregated market for reducing or sequestering carbon are available. In this analysis, the CERT model is used.

[4] Noble 2000.

3.1 The CERT model

The carbon market model employed in this paper is the CERT (Carbon Emission Reduction Trade) model.[5] CERT is not a general equilibrium model but a spreadsheet-based "meta-model" using inputs from other models, such as marginal abatement cost (MAC) curves and business-as-usual (BAU) emissions.[6] By using MACs and BAUs from other models, CERT closely represents the outcomes of other models, yet is easier to adjust and simpler to use. Given the fast pace of negotiations, CERT's adaptability allows users to run scenarios that respond to the latest outcomes of negotiations, political developments and new information about mitigation costs and demand functions. The easy-to-use nature of CERT is also critical for climate change analyses, given the complex subject matter and the need for models that are widely accessible.

In the CERT model, the global carbon market is broken down according to the division of nations specified in the Kyoto Protocol. Annex B nations will potentially supply and demand carbon offsets, whereas non-Annex B nations will only supply carbon credits. The demand for carbon offsets will be a function of the commitments Parties made to reduce emissions at the Kyoto negotiations, projected emissions in the first commitment period, and other allowances (primarily within Annex B LULUCF allowances). In terms of the potential impact the LULUCF projects in developing countries may have, this will be largely determined by the relative costs of supplying reliable carbon offsets as compared to other flexibility measures.

3.2 Annex B countries and the demand for carbon offsets

In 1997, at the Third Conference of Parties (COP-3) in Kyoto, Japan, Parties agreed on quantified emission limitation and reduction commitments (QUELRCs). These QUELRCs, averaging a 5.2 % reduction for Annex B from 1990 levels, compared with BAU emissions during the first commitment period (2008-2012) establish the upper limit of global carbon demand.

Table 1, below, gives a range of estimates for BAU emission projections, as compiled by the FCCC. This compilation shows a wide variation in projections, ranging from an Annex I wide emission reduction of 2% to an increase of nearly 15% from 1990 levels by 2010. In our analyses to estimate demand for carbon offsets, we use marginal abatement costs that the developers of CERT derived from ABARE-GTEM, and emission projections from the low and reference growth scenario of the International Energy Outlook (IEO) of the US Energy Information Administration (2001 update). Table 1 shows that these two scenarios are close to the average of the dozen-odd studies summarised in the FCCC technical paper on emission projections, as well as having full details easily accessible on the internet.

Table 1. Emission projections according to some studies, 2010 (% from 1990)

[5] CERT was developed by Jürg Grütter (Grütter Consulting), Rolf Kappel, and Peter Staub (ETH Zurich), Switzerland, for the World Bank National Strategies Studies. See Grütter, Kappel and Staub, 2000; now available on www.ghgmarket.info, and from j.gruetter@bluewin.ch. The model was used in the "Quantifying Kyoto" workshop organised by the Royal Institute of International Affairs, in association with other international institutes, 30–31 August 2000, London; see Vrolijk and Grubb, 2000.

[6] For this analysis, we use marginal abatement cost curves derived from ABARE-GTEM as collected by the developers of the CERT model (pers.comm., Cain Polidano ABARE, Oct 2000); and BAU from the International Energy Outlook, 2001.

Source	Annex II	EIT	Annex I
Minimum	*+13.0*	*-40.5*	*-2.0*
EIA IEO (low growth)	+19.9	-29.1	+5.5
Average	*+20.5*	*-29.0*	*+6.0*
EIA IEO (reference growth)	+24.4	-26.1	+9.5
Maximum	*+29.0*	*-17.7*	*+14.6*

Source: FCCC/TP/2001/1, 10 July 2001, see http://www.unfccc.int.

In addition to establishing QUELRCs, COP-3 agreed on certain LULUCF activities for the Annex B Parties. Afforestation, reforestation and deforestation (ARD) were included in Article 3.3 of the Protocol. The door was also left open for the inclusion of additional LULUCF actions through Article 3.4.[7] Many of the subsequent negotiations, leading up to the Bonn Agreement and the subsequent COP-7, revolved around LULUCF both in Annex B nations and with respect to non-Annex B nations.[8] Some Parties argued for stringent caps on LULUCF mitigation so as to not diminish fossil fuel emission reductions. Other Parties argued for maximum flexibility through the use of LULUCF to be able to reach their targets.

At COP-6bis in Bonn, Germany, the Conference of Parties agreed to include ‘forest management’, ‘cropland management’, ‘grazing land management’ and ‘re-vegetation’ under Article 3.4 for Annex B nations within certain limits or “caps”.[9] However, mainly due to further lobbying by Russia to increase its allowances under Article 3.4 at COP-7, the caps were adjusted again in the Marrakesh Accords.[10] The following LULUCF activities are allowed as of now, subject to caps in three tiers.

First, any debits (emissions) under Article 3.3 may be compensated by forest management under Article 3.4, up to 9.0MtC per year.
Secondly, net-net accounting[11] for agricultural activities, without further discounting was allowed.
Thirdly, any further credits from forest management (including through joint implementation) can be used up to the cap given in ‘Appendix Z’. The caps are a “political fix” – for some Parties the cap given is very high, reflecting political needs of the Party, in particular for Canada and Japan, 12MtC and 13MtC respectively. The Russian Federation lobbied hard at COP-7 and nearly doubled its cap from 17.6MtC to 33MtC.

The US did not take part in these negotiations because it had already withdrawn from the Protocol. The Bonn Agreement, however, does give an estimated cap for the US of 28MtC if at some point the US re-engages in the Kyoto Protocol process. Together, the above “Bonn/Marrakesh rules” determine to what extent Annex B countries can use domestic land-use practices and accounting to meet their targets.

[7] Kyoto Protocol Article 3.4 says ‘The Conference of Parties serving as meeting of the Parties to this Protocol shall … decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities … [will be counted. This] decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period’.
[8] For an explanation of the sinks issue in the COP-6 (part I and II) negotiations, see Sikkema, 2001.
[9] A Party *may* choose to apply any or all of these activities during the first commitment period; however, Parties shall fix their choice of eligible activities prior to the start of the first commitment period.
[10] For more information see Vrolijk, 2002.
[11] Net-net accounting takes into account only the increased (or decreased) absorption in the commitment period compared to the absorption that took place in the 1990 base year.

Table 2 quantifies the LULUCF caps of the Bonn Agreement and Marrakesh Accords. The total amounts of Article 3.3 credits are small compared to the overall allowances for the 'additional' activities. In total, LULUCF activities from the Annex B countries could satisfy a large part of the emission reduction demand, adding up to over 100MtC.

Table 2. The Bonn Agreement and LULUCF activities (MtC/y of allowed mitigation)

Category (tier)	Annex B (with US)	Without the US
Article 3.3 (projections)	*10 credit 24 deficit*[^]	*n.a.*
Article 3.4 (tier 1): compensate debits	24	n.a.
Article 3.4 (tier 2): further forest management, Appendix Z	98[#]	70
Article 3.4 (tier 3): net-net accounting of agricultural activities	45	n.a.
Article 12 (tier 4): LULUCF activities up to 1% of base year emissions	49	33

Source: Richard Sikkema (2001), the Marrakesh Accords, and FCCC emissions database.
Notes: n.a. Not available.
[^] *Parties with a credit add up to 10MtC/y, Parties with a deficit add up to 24MtC/y.*
[#] *This estimate is based on the amounts in the Marrakesh Accords and the estimate for the US, 28MtC, in 'Appendix Z' of the Bonn Agreement.*

Using the CERT model, a net global demand schedule (quantity demanded as a function of cost) can be estimated for carbon offsets. This "net" demand schedule takes into account the original commitments, projected emissions in the first commitment period and the three tiers of LULUCF Annex B allowances.

Figure 1. Global demand schedule for carbon credits, annually

Source: Authors using CERT model and IEO (2001) emission scenarios.
Note: The low and reference ("ref") scenarios are close to the average forecasts from a series of models as studied by the FCCC.

Figure 1 shows two main sets of demand schedules. As for all types of economic demand curves, these show that as the cost for carbon credits increase, the demand for credits will decline. The two sets of demand curves show demand with (lines on right of graph) and without (lines on left of graph) the US participating in the carbon markets established under the Kyoto Protocol.

On the right-hand half of Figure 1 are annual demand schedules, if: 1) the US joins the carbon market, but is allocated five times more "Appendix Z allowances " than the Bonn Agreement tentatively allowed as a hypothetical condition for US re-engagment in the Kyoto process (heavy-dashed line)[12] – this is also very close to a stabilisation target from 1990 emission levels, 2) the demand curve given the current Appendix Z allowance (heavy continuous line), 3) the reference estimate of the worldwide demand without Appendix Z allowances (thin line), and 4) the low estimate of worldwide demand (thin dashed line), giving a range of likely demand from low to reference before Appendix Z allowances were made (for comparison). These scenarios suggest that if the market for carbon credits equilibrates at a cost $25/tC to $50/tC the market demand for credits would be 775 MtC and 700 MtC per year respectively. (The $25/tC and $50/tC are used only as benchmark – to demonstrate how these scenarios can be interpreted.)

The schedules on the left represent demand for carbon offsets without US participation in the carbon market. The heavy line is the reference scenario demand without US participation. The thin line shows the reference demand before the Appendix Z allowances were negotiated. The lower end of the demand range (without Appendix Z) is given by the thin dashed line. Figure 1 shows that non-participation by the US would decrease overall demand significantly, so that a clearing price of $25–$50/tC, global demand would drop to somewhere at or below 300 MtC/year.

3.3. Non-Annex B nations as potential suppliers of LULUCF carbon offsets

The Bonn Agreement also clarified the scope of LULUCF mitigation outside of the Annex B countries. As mentioned previously, developing countries do not have emission reduction targets under the Kyoto Protocol but can supply carbon offset credits though a variety of projects. The Clean Development Mechanism (CDM) of the Kyoto Protocol engages developing countries in the carbon market. The CDM allows Annex B countries to sponsor climate change mitigation projects in amenable developing (non-Annex B) countries. These projects can reduce emissions or increase carbon uptake. If the particular type of project is allowed, and certain criteria can be satisfied, then the Annex B country can use these carbon credits to meet their targets. Doing so diminishes the need for "domestic" action by Annex B nations.

Under the Bonn Agreement, afforestation and reforestation are the only eligible LULUCF activities under the CDM. There is remaining uncertainty as to what will constitute legitimate afforestation and reforestation. Some analysts assume plantations will not be eligible, since it can be difficult to prove additionality for plantations or how they contribute to sustainable development. Others assume that only plantations will be allowed, and smaller scale forest restoration projects will not be allowed since these may be classified as "forest management" (a category which is not allowed). Ultimately, this question will significantly influence the carbon market. Until future decisions are made, viewpoints on this question remain speculative. This Bonn decision to certify only afforestation and reforestation CDM projects precluded projects that stop deforestation (and prevent emissions) from being used in the Kyoto carbon market.

[12] A cap of the size would be roughly half what the US has stated it believes the amount of carbon sequestration it projects it will be sequestering. (FCC/SBSTA/2000/MISC.6/Add.1)

Box 1. Definitions of afforestation and reforestation in the Marrakesh Accords

Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.
Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

Source: The Marrakesh Accords, Decision 11/CP.7, FCCC/CP/2001/13/Add.1.

A cap on afforestation and reforestation was set in Bonn equal to 1% of the Annex B Party's base-year emissions. In reality, because flexibility within the Kyoto Protocol, this formulation caps the amount of CDM LULUCF[13] credits to 1% of 1990 emissions of all Annex B Parties that ratify and engage in trading. This quota holds for each of the five years of the first accounting period. The Bonn Agreement thus clarified some of the "boundaries" of the potential carbon market regarding LULUCF. LULUCF activities will thus not be ale to flood the market and eliminate any need for fossil fuel-based reductions, as was feared by some green NGOs. Still, the total amount of well over 100MtC annually can have a significant impact on the market.

4. Land-use change and the United States

The eventual role of the US in the Kyoto Protocol will have a tremendous impact on the Kyoto Protocol's subsequent carbon market. The spring 2001 decision by the Bush administration to abandon the Kyoto Protocol has created substantial uncertainty surrounding carbon trading in general and with respect to LULUCF activities specifically. It appears the US will likely not re-engage with the Protocol during the current Bush administration, despite continued pressure from other countries. The US and many Parties to the Kyoto Protocol also are at odds over what constitutes effective climate change projects. d pressure from other countries

However, even if the United States remains outside of the Kyoto Protocol treaty process, it may still engage in the Kyoto carbon market, albeit on its own terms. This complicates the ability to precisely model the impact of LULUCF mitigation in developing countries on the broader carbon market. For example, even though avoided deforestation and forest management were not allowed in the Kyoto Protocol per the Bonn agreement, comments by the US administration suggest it will include stopping deforestation in some Latin American countries as a key component of its overall strategy.[14] The US may also decide to pursue some mitigation via forest plantations or forest restoration activities, activities that appear more eligible. This would result in the US activities being in competition with Kyoto projects in the market.

[13] While the acronyms may become a bit confusing, the combined term "CDM LULUCF" refers to projects in developing countries that involve afforestation and reforestation, the LULUCF activities allowed under the terms of the Bonn Agreement.
[14] Watson, H. 2001.

The eventual role of the United State is an extremely important variable on the larger market for carbon. This is complicated by the fact that the US and other Kyoto Protocol Parties seem to be headed in different directions on certain LULUCF activities in developing countries. In order to understand the impact of developing country LULUCF projects on the carbon market, it is essential to understand the possible scope of various activities, even though some may be outside the current negotiated agreement on what is, and is not, allowed.

5. THE MARKET FOR EMISSION REDUCTIONS

As the largest emitter of greenhouse gases and the country with the largest reduction requirements in the Protocol, the market size and price of carbon is strongly dependent on US participation. While US participation currently has the greatest impact on the Kyoto markets[15], accounting for half of demand for emission reductions, various other determinants are important. The other key parameters are the business-as-usual emission projections; marginal costs of abatement for various mechanisms (ET, JI, the CDM); the inclusion and cost of LULUCF measures; and the domestic policies that will take place independently of the market. Many of the EU countries, for example, are planning to meet the targets without using the Kyoto mechanisms.

Figure 2 represents the supply side on the Kyoto market, with different cost curves for the various mechanisms. In this figure ET stands for trade in the likely surplus of some of the Economies in Transition (EITs) which has a marginal costs equal to zero to supply (a range of likely hot air supply is given), and JI represents all emission reductions in EITs below the BAU baseline. Projects in developing countries (CDM) does not include LULUCF activities in this figure. The figure clearly shows that the use of more of the mechanisms lowers the marginal cost of supply.

Figure 2. Supply on the carbon market without LULUCF from developing countries

To be inserted (figure 2)

Source: Authors using CERT model and IEO (2001) emission scenarios.
Notes: "ET" stands for the trade in the EITs' hot air; "JI" stands for supply from the economies in transition that comes from reductions of emissions below business as usual; "CDM" represents emission reduction projects in developing countries. Appendix Z adds to the "hot air", shifting the supply curves further to the right, but does not diminish the range of hot air estimate (also given)s. In none of these scenarios LULUCF in developing countries is included The full definitions of JI, ET and CDM can be found in the Kyoto Protocol — Articles 6, 17 and 12 respectively.

[15] Den Elzen and De Moor, 2001. On page two these authors note 'The US withdrawal has by far the greatest impact in reducing the environmental effectiveness … demand is substantially reduced and permit prices will drop dramatically'.

These supply curves show carbon credits from JI have relatively “steep” functions (relatively few “cheap” carbon credits) compared to CDM credits. Figure 2 also shows the various supply curves starting at 0 MtC demanded and then adjusted to the right (starting at around 400 MtC) to take into account the impact of hot air on the market.

6. THE MARKET FOR LULUCF CARBON OFFSETS FROM DEVELOPING COUNTRIES

The potential for LULUCF projects to mitigate climate change and enter the carbon market is highly uncertain. It is impossible to know *a priori* which countries will be able to implement cost-effective and long-term carbon mitigation. There are also numerous social and political trade-offs with either avoided deforestation or forest restoration for any given country. Also since the global carbon market is still mostly speculative, this could delay investments in LULUCF projects. Since long (several year) lead times will be required from the inception of a project to the crediting of carbon offsets, the supply of carbon credits under LULUCF in developing countries remains speculative. The following estimates should serve only as benchmarks.

6.1 Cost of LULUCF in developing countries

It appears that the cost of developing country LULUCF offsets will be modest, possibly even cheap when compared to other alternatives. Estimates are wide-ranging, anywhere from less than $1 to $25 per tonne of carbon, and higher for some specific projects.[16]

There are several limitations to these estimates. First of all, there are no examples of the cost for LULUCF credits that have faced verification procedures mandated by the Protocol. Transaction costs of complying with the CDM may be high. Prior cost estimates have been for projects that were essentially self-reported and self-policed. Additionally, these estimates do not take into account the (at least) decade-long time period that projects will need to be sustained.

Finally, most estimates do not take into account real risks projects face. Evidence from World Bank and other international agencies show that substantial portions of its “development and/or conservation” projects do not succeed over long time periods. Roughly only 65% of World Bank sponsored development projects have succeeded over reasonable time frames.[17] Like any enterprise, there are often high attrition rates for sustainable development schemes. If half of the proposed projects to secure carbon offsets fail, that effectively doubles the price of verifiable carbon offsets. Notwithstanding these concerns, there is a general belief that CDM LULUCF projects will be at least competitive on a per ton basis with other forms of climate change mitigation.[18]

6.2 Optimistic estimates

[16] See for example Missfeldt and Haites, 2001 and Greenpeace,2001.
[17] World Bank, 2001.
[18] See for example the IPCC’s Second and Third Assessment Reports.

How much carbon that originates from forestry and land use projects in developing countries will enter the carbon market? There are several ways to estimate this potential, ranging from global models to specific project-based proposals.

Many studies project a substantial amount of LULUCF carbon credit could enter the carbon market (Table 3). Simplistic calculations support this as well; tens of millions of acres can be planted with trees and tens of millions of hectares of forests are destroyed each year. Stopping a fraction of deforestation or planting trees on a fraction of potentially available land would yield massive amounts of credits over time. Houghton et al (1996) estimated that up to 165 GtC (165,000MtC) could be sequestered or conserved in a worldwide program over a long time period. Trexler and Haughn (1995) looked at developing nations and estimated that, over 60 years, 55 GtC of carbon could be conserved or sequestered. These estimates would almost certainly "flood" the market for carbon offsets, compared to the Protocol's modest targets.

Table 3. Top-down estimates of potential worldwide LULUCF supply

Study	**Quantity (GtC/timeframe)**	**Comments**
Hougthon et al (1996)	160	Developing and developed nations, time frame not specified. Mostly a biophyscial potential.
Trexler and Haughn (1995)	55 GtC over 60 year timeframe	Developing countries only. Includes plantations, forest restoration and forest conservation.
Sedjo and Solomon (1989)	2.9 GtC/year	Sequestration only

These scenarios are highly unlikely. The collective worldwide efforts required to achieve these changes would entail a massive reorganization of land use. These scenarios would also entail reversing or changing trends that have been relatively consistent and show no appreciable sign of changing. Thus far, all estimates of what could be done have seriously over-estimated what has been done – often by orders of magnitude (although, of course, no markets yet exist).

6.3 More conservative estimates

Other models show it will not be so easy for LULUCF CDM credits to "swamp" the carbon market. There are often limited technical, institutional and human resources in most developing countries to operate large-scale forest projects. Studies put out by the World Bank demonstrate real limits on how much mitigation can realistically be expected from countries.[19] Furthermore, as already discussed, many projects initiated may not succeed, or investors may not be forthcoming.

One recent study (Niles et al, 2001) estimated the size of LULUCF carbon credits from developing countries given "real world" constraints. The methods in this study involved estimating country-specific area potentials for reforestation (through natural and assisted regeneration, excluding commercial plantations), adoption of sustainable agricultural

[19] Details on World Bank national strategy studies can be found at: http://lnweb18.worldbank.org/ESSD/essdext.nsf/46ByDocName/InstrumentsNationalStrategyStudies

practices, and avoided deforestation from a variety of sources. These "area-potentials" were then multiplied by estimates of the change in carbon stocks that various land management options produce in individual countries. Conservative to central estimates of carbon stock changes were used since a reasonable burden of proof for crediting LULUCF projects is likely to restrain reported carbon mitigation to conservative values (Sathaye et al., 1997).

Table 4. Potential carbon credits from non-plantation LULUCF projects in developing countries (MtC/commitment-period year)*

Regions	Forest restoration	Avoided deforestation (forest conservation)	Sustainable agriculture	*Total*
Latin America	36	219	15	*270*
Africa	8	34	11	*53*
Asia	19	60	32	*111*
TOTALS	**63**	**313**	**58**	***434***

Source: Niles, J., S. Brown, J. Pretty, A. Ball and J. Fay. 2001.
*Note: * These figures have been normalized from a ten-year period (2003-2012) to the five-year accounting period of the Protocol's first commitment period. This is done since mitigation can begin prior to the start of the first commitment period and be banked. In effect, figures represented here are approximately two times the actual annual carbon mitigation likely for the activities shown since the period evaluated was ten years.*

This analysis concluded that if a market for LULUCF carbon offsets were started rapidly, a maximum of 2,170MtC could enter the market in aggregate over the five years of the first commitment period. Since credits can be banked between the present and the beginning of the commitment period, this leads to a potential infusion of carbon credits of 434 MtC per year during the commitment period (2,170 MtC/5 years).

Importantly, the bulk of credits from LULUCF activities in developing countries are categories of projects that the Bonn Agreement has disallowed. Avoided deforestation and sustainable agriculture constitute 371 MtC/year of the total 434 MtC/year offsets in LULUCF activities in developing countries. These offsets, were they to be realized, would only be available to the United States operating outside Kyoto Protocol's rules. Only 63MtC per year would be from forest restoration activities, potentially eligible under the Bonn Agreement.

Equally importantly, the above analysis does not include plantations. Plantations may or may not pass various litmus tests (including additionality, biodiversity, sustainable development. etc.) for LULUCF CDM projects. Were massive plantations allowed in the CDM, these would almost certainly influence global carbon markets. The volume of carbon generated by these sorts of projects could be significant and their relative costs would likely be low or even negative.

Last, even this more "realistic" study is probably too high an estimate for realistic LULUCF carbon offsets from developing countries. The study did not consider technical, financial or political constraints that may limit these potential carbon supply streams . The three countries with the highest rates of deforestation are either not in favour of carbon-based forest conservation (e.g., Brazil) or may not be stable enough to support long-term land management projects (e.g., Indonesia and the Democratic Republic of Congo). Investors may also be reluctant to invest in countries that lack political stability or strong legal and market structures. These "real world" factors will likely restrict the actual supply of carbon credits from LULUCF in developing countries to levels below those reported in Table 4.

6.4 The Bonn Agreement's 1% cap on LULUCF in the CDM [20]

Negotiators in Bonn limited credits developed countries may gain via CDM forestry projects. During the first commitment period, developed countries may only use CDM forestry projects to meet 1% of their respective 1990 emissions per year, for each of the five years in the first commitment period. The carbon equivalent of the 1% cap is in the range of 33 MtC/year, or 165 MtC during the first commitment period (2008-2012).[21] The US was not included in this estimate.

Figure 3 compares the amounts of *accumulated, or cumulative,* carbon credits for two different future plantations scenarios (10 and 50 Mill. ha over a 30-year period)[22] with the carbon ceiling introduced in the Bonn accord (Art. 12, Para. VII). For comparison, 50 million hectares of new plantations over the next 30 years is essentially a doubling of the current plantation rate.[23] For this analysis, annual carbon yields for carbon plantations were estimated to be 2 tons of carbon per year per hectare, including soil carbon.[24] It was also assumed plantations would generate carbon credits as early as 2004 that would be banked until the first commitment period. Figure 3 shows that even if the current worldwide plantation establishment rates were doubled, total carbon accumulated in these plantations will not "hit" the Bonn ceiling on LULUCF activities in developing countries.

Figure 3. The Bonn 1%–ceiling on CDM LULUCF, excluding the US, for two plantation rates

To be inserted (figure 3).

Source: Reimund Schwarze, unpublished.

6.5 Incorporating CDM LULUCF into the CERT model

In the CERT model used for this analysis, we evaluated two potential LULUCF supply functions from developing countries. In an "optimistic" scenario, we assumed 400MtC per

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[20] This analysis is from unpublished work of Reimund Schwarze.
[21] The Annex I countries' emissions of the six Kyoto gases (CO_2, CH_4, N_20 and three industrial gases) totalled 4.776 GtCe in 1990. Roughly one third or 1.582GtC equivalents of this emission originated from United States, according to FCCC/CP/1998/11/Add.2, Table C.6.

[22] Sohngen, B., R. Mendelsohn, and R. Sedjo, 1998.

[23] Using recent data from the FAO, 2001.
[24] Figures on average carbon yields are taken from Sohngen/Sedjo 2000, p. 13.

year (just less than the result from Table 4) would be available, with costs rising from almost $0 to about $20 per tonne of carbon. In a "realistic" scenario, the failure rate of CDM projects is 50%, effectively halving the potential credits and doubling the cost per tonne. Figures 4a and 4b show the marginal cost curves for both optimistic and realistic scenarios in the CERT model, and compares these to other supply curves, including the zero-cost supply from hot air and Appendix Z allowances for EITs.

Figure 4a. CDM LULUCF inclusion in CERT, and comparison with other carbon supplies.

To be inserted (figure 4a).

Figure 4b. CDM LULUCF addition to other carbon supplies.

To be inserted (figure 4b)

Source: Authors using CERT.
Notes: "DC LULUCF" indicates LULUCF projects taking place in developing countries.
The LULUCF optimistic case is indicated by the thin dashed line, LULUCF realistic is indicated by the heavy continuous line.

Results from these modelled supply curves of LULUCF activities in developing country are suggestive. The majority of these potential credits derive from activities that the Bonn Agreement has not allowed (avoided deforestation). So if the US remains outside of the Kyoto market, a large fraction of these carbon-offset credits will not be available to the Kyoto market. However, on the one hand these supply curves do not evaluate the possibility of widespread plantations in the CDM. On the other hand, US participation in some form other than Kyoto in a market for LULUCF credits from Developing countries will create demand for these activities.

7. The impact of LULUCF on the market

Figure 5. Supply and demand curves for the Marrakesh scenarios, excluding the US and excluding LULUCF from developing countries.

To be inserted (figure 5)

Source: Authors using CERT.

The range of demand estimates for Annex B nations, without US involvement in the Kyoto Protocol, is derived from the low and reference growth scenarios of the IEO. The available amount of hot air, according to the IEO scenarios is sufficient to satisfy non-US demand, only the inclusion of high growth scenario, substantially reducing the availability of "hot air", would require action through JI or CDM. Thus only in this case with less hot air available would a price higher than zero emerge. Figure 5 does *not* include LULUCF supplies from developing countries nor the US demand.

Figure 5 shows that full use of hot air would result in no effective demand for any offset credits. Furthermore, the price and quantity of demand for credits if hot air is excluded, will depend on the preference for supplies that are favoured by nations remaining in the market. If JI and CDM (not including LULUCF projects) were both extensively used, that would result in approximately 300 MtC of carbon demand internationally at a price of around $12/tC.

Figure 6. Supply (with and without LULUCF) and demand curves for the US alone.

To be inserted (figure 6).

Source: Authors using CERT.

Figure 6 shows the carbon market for the US outside of Kyoto. The range of demand estimates for the US are drawn from the low and reference growth scenarios of the IEO. The -7% range represents the US aiming for its Kyoto target without Appendix Z flexibility while outside Kyoto. The 0% range represents the US aiming for stabilisation of emissions at 1990 levels by 2010, without using further Appendix Z flexibility. Presumably, the US would use LULUCF projects in developing countries, but would not have access to "hot air" created under the Kyoto regime. These assumptions would lead to essentially two broad demand schedules, assuming stabilisation target.

- If the US does not engage in either JI or CDM, then theoretically this could produce a demand for LULUCF-alone (heavy line-"LULUCF realistic") from developing countries of around 350 MtC at a price of approximately $50/tC. With this price being substantially above the Kyoto-price, this scenario is highly unlikely. With the "optimistic" LULUCF supply function (thin dashed line), the US would on its own, seek around 450 MtC at a price of around $20/tC.

- However, it is more likely that the US would engage in full-fledged CDM, JI and CDM LULUCF projects (heavy line-"JI,CDM &LULUCF; gray line for optimistic LULUCF). Demand would then increase modestly to between 450 and 500 MtC, but the price would drop substantially to around $10-$15/tC.

Figure 7. Global supply and demand curves.

To be inserted (figure 7)

Source: Authors using CERT.

The two demand scenarios given in Figure 7 represent (1) the US' return to Kyoto (continuous line) as negotiated in the Marrakesh Accords, including the US' 28MtC/y Appendix Z allowance; and (2) the US either being outside of Kyoto taking on a stabilisation target, or the US re-engaging with Kyoto with substantial further concessions – in the form of a 5-fold increase of its Appendix Z allowance (dashed line) while retaining the –7% Kyoto target (with this additional Appendix Z allowance the US would only be required to reduce emissions to 1990 levels). In this second scenario, with the US outside Kyoto, it would be in competition on the international market with the Kyoto Parties for the cheapest emission reduction projects through JI, CDM and LULUCF, and therefore these two competing markets can be aggregated in the model.

These results show that the LULUCF influence on the global market for emission reductions would be real, but relatively modest as the LULUCF opportunities only add to the already existing flexibility of emissions trading, JI and CDM ("JI, ET and non-LULUCF"). With the US returning to Kyoto, the market price would be $17/tC without and $11/tC with the inclusion of (realistic) LULUCF ("All, including LULUCF"). (This price impact is much smaller than that of the inclusion of the CDM in general: with JI and ET only, the price would be around $50/tC depending on the US concessions.) However, the total reductions bough on the international market only increases slightly, from 779MtC to 801MtC. For instance, if the US decides to engage the Kyoto process, the difference between the "optimistic" scenario and the "realistic" scenario for LULUCF from developing countries is relatively minor. Even though the DC LULUCF supply function is halved with more realistic projections of supplies, the effective market-clearing price for credits remains more or less at a demand of 800 MtC at a price of approximately $12/tC. More quantitative results are shown in Table 5.

Table 5. The market for carbon credits

Scenario	**Marrakesh**	**US-only**	**Marrakesh***	**Marrakesh***	**Marrakesh**	**Marrakesh**
US participation	NO	YES, stabilisation	YES	YES	YES, extra concessions#	YES, extra concessions#
Inclusion of CDM	NO	YES	NO	YES	NO	YES

LULUCF[o]						
Market price ($/tC)	Political price max 12[@]	11	17	11	12	8
Quantity (MtC/y)	300[@]	415	779	801	686	701
— Of which	(MtC | %)	(MtC | %)	(MtC | %)	(MtC | %)	(MtC | %)	(MtC | %)
— Annex B excl US	300 | 100[@]	N/a	295 | 38	301 | 38	299 | 44	304 | 43
— US	N/a	415 | 100	484 | 62	500 | 62	387 | 56	397 | 57
— ET/"hot air"	N/a[@]	N/a	386 | 50	386 | 48	386 | 56	386 | 55
— JI/EIT reductions	111[@]	105 | 25	136 | 17	105 | 13	111 | 16	83 | 12
— CDM	189[@]	174 | 42	257 | 33	174 | 22	189 | 28	127 | 18
— CDM LULUCF	N/a	136 | 33	N/a	136 | 17	N/a	105 | 15

Source: Authors using the CERT.

[o] *Using a more realistic scenario (50% of the projects fail while 50% succeed).*
[@] *Using a scenario which completely excludes all 'hot air', otherwise the amount of hot air available would satisfy demand at zero price; this could only be agreed by a political decision stopping sales of hot air.*
* *US Appendix Z allowances as suggested in Bonn 28MtC/y.*
\# *US Appendix Z allowance extended 5-fold.*

8. CONCLUSION

Any modelling exercise must be viewed with serious restraint. This analysis after all uses just one model to simulate potential outcomes in an extremely complicated worldwide market that has not yet emerged. All models are fallible is several regards. We have only used one set of marginal cost curves in CERT, only few scenarios were reported, and assumptions were made about complex international economic and political interactions, including rules for CDM LULUCF and other matters.

The impact that LULUCF projects from developing countries can have on the global carbon market is complicated by many poorly understood factors. As one example, it is often assumed that LULUCF activities are cheap. Many cost-effective energy efficiency options could substantially reduce the overall global demand for carbon offsets and this possibility is not explored in the paper. Low cost energy options that are not properly considered could dramatically alter markets (in the CDM with or without LULUCF, in JI, etc.).

Given all these uncertainties, what conclusions can be drawn? The main conclusion is that LULUCF opportunities add another flexibility to the supply side, lowering the marginal costs of abatement. This is expected given that most LULUCF projects from developing countries are expected to be cost-competitive with other measures.

Another conclusion pertains to the issue of *proportionality*. Proportionality broadly refers to the notion that mitigation attempts should broadly mimic the source of the problem. In the case of GHG emissions, roughly 4/5 of the "problem" is from fossil fuel combustion and 1/5 from tropical deforestation. Some have argued that this is a reasonable target for where action should be focused. According to our analysis, the proportion of LULUCF mitigation from developing countries is between 15 and 17% if the US participates. This roughly equals the source of the problems emanating from land use decisions in developing countries. Were the US to go alone, the proportion of credits sought by the US from LULUCF would be roughly twice as high (in our results, 33% of the total mitigation it pursues).

8.1 Relative orders of magnitude of various factors

The CDM LULUCF cap (1% of Annex B emissions) will prevent developing country LULUCF supply from being the largest supply on the market. Hot air, for example, is several times larger than 1% CDM LULUCF cap. Appendix Z allowances also are approximately twice as much credit as could be gained under the 1% cap for LULUCF from the CDM. On the demand side, the US withdrawal from the Kyoto Protocol also has a substantially larger impact than LULUCF activities.

Second, if the US is not in the market for credits, 'hot air' supply will be sufficient to cover the market and the impact of CDM LULUCF will be nil. Were this the eventual case, probably a "political price" would emerge making room for some LULUCF projects to go ahead. Such a political compromise would comprise of a voluntary limitation of hot air sales, reducing the zero-cost supply to below the total demand; this would result in a price somewhere between free trade (price is zero) and complete exclusion of 'hot air', propping up the price, as indicated in the table (price up to $12/tC). The scale of the impact then of LULUCF on the market price of carbon would depend exclusively on the restriction (or the political price) negotiated.

8.2 The CDM LULUCF cap of 1% - can it be met?

The CDM cap of 1% is actually not very "tight" if applicable only to a small subset of LULUCF activities, such as plantations or forest restoration. Reaching the cap would require more-than-doubling the current rate of plantations. However, if LULUCF in developing countries is unlimited, both in size and category (for example including avoided deforestation and/or plantations), there is a risk that LULUCF from developing countries could be a very substantial source of supply on the market. Potentially, forestry programs in developing counties could theoretically supply hundreds of MtCs - up to the order of total world demand for reductions. Many "real world" constraints - such as willing investors, project success rates and the ability and/or willingness of non-Annex B countries - will likely keep LULUCF from developing countries below the cap. The political decision to exclude avoided deforestation was in part driven by fears regarding the greater potential scale of these offsets.

To reach the Bonn cap would necessitate a combination of extremely high rates of success for multi- or bi-lateral projects in developing countries; widespread use of plantations that effectively double (or more) current plantation rates; and/or the reversal of the decision to disallow avoided deforestation in the CDM. However, if the US is to play a role in the near future on the international carbon market, the role of LULUCF will be substantial – either through a unilateral US market for DC LULUCF reductions, or further concessions needed as a condition for US re-engagement with the Kyoto framework.

Indeed, our modelling shows that the US could rely for about one-third upon LULUCF credits to satisfy a possible stabilisation target. Much of these credits could be derived from activities that fall outside the scope of the Kyoto Protocol. This heavy reliance on LULUCF could help the US meet a stabilisation target at relatively modest costs, about $11/tC. However, US policy regarding climate change does not allow to accurately estimate targets or policies regarding such projects.

8.3 LULUCF in the CDM in the global market (with the US)

The inclusion of LULUCF credits does reduce the price of the credits, and is probably one of the concessions required for the US to rejoin Kyoto. Only with access to large amounts of cheap credits, more than the Bonn 1% cap, and with activities outside those allowed under the CDM would the US consider rejoining. If the US rejoins with its original Appendix Z allowance, the price would jump to $17/tC without LULUCF concessions. However, LULUCF from developing countries could account for approximately 136 MtC/year (17% of global demand), breaking the Bonn 1% cap, and leading to a drop in price to $11/tC. This LULUCF supply is in the same order of magnitude as the non-hot-air supply from the EITs and non-LULUCF CDM supply from the developing countries. The CDM LULUCF inclusion "eats away" from other CDM projects in particular, less so from JI, but the total of CDM + CDM LULUCF credits would increase. This, as well as the price drop, would lower the income from carbon markets for EIT. In our scenario, the income would go down from $2.3 billion dollars ($17 * 136MtC) to $1.2billion ($11 * 105MtC). The income in developing countries would also be reduced from $4.4bn ($17 * 257) to $3.4bn ($11 * 174+136).

8.4 Sinks after 2012

The impact of land use, land-use change and forestry on the carbon markets will almost certainly change for the second commitment period, which is likely to start in year 2013. The second commitment period could include fewer or more sources and/or sinks. Depending on the targets to be established as well as the success and credibility of LULUCF activities in the first commitment period, there may or may not be limits or restrictions on the amount of LULUCF mitigation. A footnote to Appendix Z explicitly states that the method used for capping LULUCF activities in the first period does not set a precedent for future commitment periods.

The Marrakesh Accords request further work on LULUCF activities, including on LULUCF in joint implementation and the CDM, management practices, uncertainty management, and methodologies for factoring out direct human-induced changes from indirect and natural land-use change. Much of this work of the IPCC could determine the level of application of LULUCF in future commitment periods.

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