RETHINKING EQUITY AND EFFICIENCY IN MITIGATING CLIMATE CHANGE

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Abstract

The Kyoto Protocol represents the prevailing international consensus on climate control. However, the Kyoto Protocol fails to provide adequate incentives for forest preservation and carbon sequestration in the developing world. Any approach that focuses solely on emissions reductions to the exclusion of forest conservation generates unacceptable efficiency losses while foreclosing more equitable ways to combat global warming. Future climate treaties should provide incentives to all countries to reduce emissions and to preserve and enhance forest carbon sinks. Forests in tropical countries currently provide climate stabilization services valued between $36-$395 billion per year. An alternative approach to climate control that would facilitate payment for these services, either directly through carbon subsidies, or indirectly through the sale of emissions credits for verifiable changes in land use, could transfer substantial income to the developing world. In which case, fairness for developing countries could be achieved explicitly, rather than implicitly by temporary exclusion from emissions quotas. It is time to rethink equity and efficiency in mitigating climate change.

Introduction

The Debate

In 1997 in Kyoto Japan more than 150 countries completed negotiations on the Kyoto Protocol, the prevailing international treaty on climate change that requires industrialized countries to reduce emissions of carbon dioxide (CO2) and other greenhouse gases (GHG) contributing to global warming. Implementation of the now four-year-old treaty has been

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stalled by debate over how countries can and will reduce emissions. Specifically, the controversy surrounds the inclusion of carbon sequestering forest sinks as means to mitigate global warming and the exclusion of the developing countries from obligations to reduce greenhouse gas emissions.

Reducing greenhouse gas emissions from energy, transportation, and industry in the industrialized countries is critical to preventing future climate change. However, a successful climate change treaty must also provide incentives to developing countries to mitigate emissions, primarily by slowing deforestation and increasing carbon sequestration by forests. Implementation of the Kyoto Protocol, given its present emphasis on emissions reductions in the industrialized countries could generate unacceptable efficiency losses while foreclosing more efficient and equitable means to combat global warming. Indeed, the best approach for combating climate change would require all countries to cap emissions, but distribute the costs more equitably to correct for historical imbalance in greenhouse gas production. Subsidizing developing countries for carbon sequestration and forest conservation is key to this approach. Rethinking the potential efficiency gains and distributional effects of this strategy is necessary to inform future climate control efforts and avoid the predictable breakdowns in negotiations that have thwarted progress thus far.

Climate Change

Climate change refers to a change in the earth's climate in excess of natural climate variability that is attributed directly or indirectly to human induced changes to the atmosphere's composition (1). Atmospheric concentrations of carbon dioxide and other greenhouse gases warm the Earth's surface by trapping a portion of the sun's outgoing energy reflected by the Earth. Global warming is the result of the intensification of this "greenhouse effect" due to increasing anthropogenic emissions of greenhouse gases, most notably carbon emissions from fossil fuel burning and deforestation.

As carbon sinks, forests play a key role in stabilizing global climate. Forests sequester carbon emissions from the atmosphere and store carbon long-term in vegetation and soils. Currently, terrestrial ecosystems and the oceans absorb roughly ½ of the anthropogenic emissions of carbon (IPCC, 2001). However, economic activity that gives rise to land use change, especially deforestation, can disrupt the global carbon cycle, releasing carbon back into the atmosphere and preventing new sequestration. Emissions from land use change accounted for 25% (33 billion tons) of total carbon emissions during the past 20 years (IPCC, 2001).

During the 20th century alone, average surface temperatures have increased .6° C. The 1990's were the warmest decade and 1998 the warmest year on record (IPCC, 2001). In January 2001, the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was released (2). It predicts an increase in average surface temperatures over the next century of 1.4-5.8°C . The potential consequences of this warming trend are severe. As glaciers melt sea levels will rise, potentially displacing millions of people in low-lying areas and island states. In Africa and Latin America, regions already suffering from acute food shortages, agricultural productivity will decline. As precipitation patterns change, the frequency of droughts in arid and semi-arid regions such as Southern Africa, the Middle East, Southern Europe, and Australia will increase. The probability of weather related catastrophes such as monsoons will rise. The incidence of tropical diseases like malaria and dengue will multiply. Ecological systems such as forests and coral reefs will exhibit diminished capacity to provide critical ecosystem services (IPCC, 2001).

Climate Control Policy

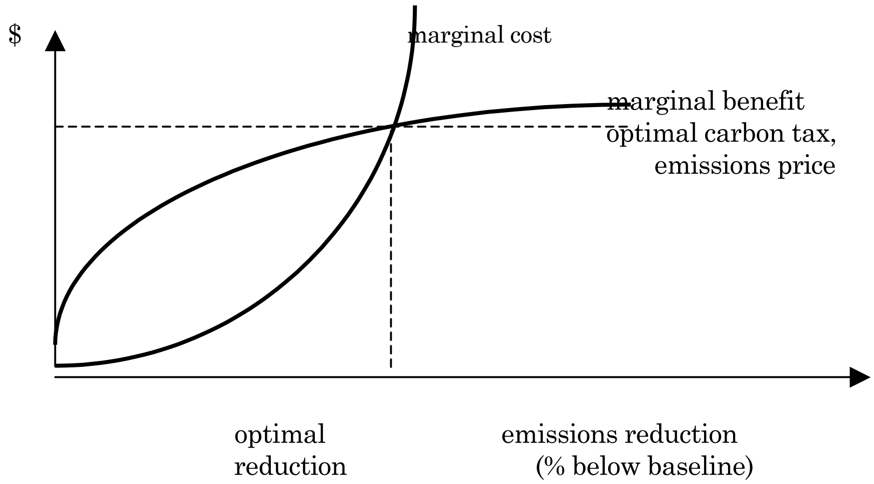
Reducing Carbon Emissions

In economic terms, the crisis of global warming can be attributed to market failures that engendered a dependency upon burning fossil fuels for energy, transportation, and industry. As market prices for fossil fuels historically have not accounted for the long-run effects of carbon emissions on global climate, the market system has provided little incentive to reduce their use or develop alternatives. Consequently, carbon dioxide levels have increased 31% since 1750, the beginning of the industrial age (IPCC, 2001).

Carbon dioxide emissions are examples of public "bads", the negative unintended effects of economic activity whose costs are external to and thus not mediated by markets through the price mechanism. Public bads signal a divergence between the private and social costs of an activity that subsequently gives rise to market failures. Markets "fail" when they produce goods in excess of the socially efficient level of output at prices too low to reflect the full social costs of their production or consumption. Markets fail because the producers and consumers of goods that generate public bads consider in their decision making only the private costs and benefits of their actions. To generate the socially efficient outcome, decision-making must weigh the full costs and benefits of economic activity, including any and all external costs and benefits. At the socially efficient level of economic activity, marginal social cost equals marginal social benefit. This level is considered socially optimal because it maximizes social welfare, the difference between benefits and costs to all affected parties (3).

Correcting for inefficiencies stemming from public bads such as carbon emissions requires increasing the private costs of using fossil fuels in line with the social costs. Either carbon taxes or permits can be used to force users to "internalize" the external damages of burning fossil fuels thereby providing incentives to reduce emissions to their socially efficient level. At the socially efficient level of emissions reduction, the marginal social cost of reducing emissions should equal the marginal social benefit, or equivalently, the marginal damage of carbon emissions. A carbon tax is a tax levied on fossil fuels in proportion to their carbon content. Therefore, the optimal carbon tax should equal the marginal damage of carbon emissions (figure 1). Under a carbon permit system, polluters are required to purchase permits for the amount of carbon they emit. A permit system caps total carbon emissions by the number of permits issued, while the supply and demand for permits determines their price. The efficient number of permits to issue is the number that yields the same overall reduction in emissions that would have resulted from a tax equal to the marginal damage of emissions (figure 1). Such a permit program is equivalent to the optimal tax program in the sense that it yields the same (optimal) overall reduction in emissions at the same (minimum) social cost (4).

Figure 1. Optimal Carbon Dioxide Reduction



The Kyoto Protocol

The Kyoto Protocol established legally binding quotas for greenhouse gas emissions for the industrialized countries. Although individual country commitments vary, the industrialized countries, on average, are required to reduce emissions by 5% below 1990 levels during the commitment period, 2008-2012. Emissions quotas indirectly increase the cost of burning fossil fuels, imposing an implicit "price" on carbon emissions similar to a carbon tax or permit program. The Kyoto Protocol should have assigned caps to each country to reduce global emissions to the socially efficient level. At this level the international price of carbon emissions would reflect the marginal external damage of carbon emissions.

However, estimating the socially efficient level of emissions reduction is difficult as studies thus far of the economic impacts of global warming provide total, rather than marginal damages from carbon emissions. Moreover, these studies focus primarily on high-income countries where the impacts of global warming are expected to be relatively less costly than in the developing world. For example, Nordhaus (1994) and Cline (1992) estimate the annual costs to the U.S. of a 3°C warming to be $70 and $75 billion respectively, or roughly 1% of total U.S. GDP (5). However, global damages may approximate 2-3% of global output with higher losses as a percentage of GDP experienced by the developing countries (IPCC, 1995).

Without estimates of the marginal damage of carbon emissions, the Kyoto Protocol could not impose the efficient price for carbon emissions through emissions targets. Politics determined target levels, not efficiency. Since preventing climate change is a global public good, each country had an incentive to free ride off other countries' reductions and negotiate a higher emissions cap for itself (6). Therefore, the quotas established by the Kyoto Protocol likely exceed the limits recommended by science or economics. If so, efficiency would be greater served by further emissions reductions. This is important to keep in mind as countries continue to spend time, money, and political capital debating implementation of the Kyoto Protocol.

Assuming the optimal level of global reductions was known, the issue still remains of how to distribute the cost equitably across countries. Requiring all countries to reduce emissions by an equivalent amount is neither fair nor efficient. If some countries can decrease emissions at relatively lower costs, it is more efficient for those countries to engage in more reductions. Alternatively, emissions trading would allow countries to buy "credits" for reducing emissions in areas where abatement costs are lower to offset their own quotas. Countries that buy emissions credits still pay a price for emitting carbon, however, the price they pay to purchase credits is presumably lower than their domestic reduction costs.

The extent to which countries can engage in emissions trading under the Kyoto Protocol is still debated. Although emissions trading can decrease the total cost of reducing emissions worldwide, some countries could benefit more than others. For example, the U.S. could potentially meet its target by purchasing emissions credits from Russia where an economic slowdown throughout the 1990's led to an unexpected decrease in industrial emissions. U.S. demand could drive up the price of emissions credits, precluding many smaller countries from the market. Similarly, the initial distribution of emissions caps to countries will affect which countries become net buyers and sellers of emissions credits and therefore, the distribution of income.

To be fair, the designation of emissions caps to individual countries should account for the fact that some countries share greater culpability for global warming than others. The industrialized countries account for 2/3 of global carbon emissions. The United States alone, representing less than 5% of the global population, produces 25% of global emissions (Heil, 1997). The Kyoto Protocol exempted developing countries from emissions quotas to compensate for historical imbalance in emissions production and to afford them more time to invest in costly abatement technologies. However, the exemption has provided a convenient excuse to already reluctant industrial countries, such as the U.S., not to sign and implement the treaty. Critics claim that unless the developing countries are similarly required to reduce emissions, the Kyoto Protocol will hinder the competitiveness of U.S. businesses.

Also at stake is the long-run effectiveness of a global warming treaty that would allow emissions to increase at the alarming rates predicted for many developing countries. Inevitably, a successful climate change treaty must cap the rate of emissions increase in these countries. But this shifts the cost of averting global warming onto those countries that are least responsible and least able to afford it. The challenge is to minimize the cost to developing countries while limiting future emissions to rates commensurate with their immediate development needs. Distributing emissions caps worldwide in such a way as to allow developing countries to become net exporters of emissions credits is one approach; for example, setting quotas for developing countries in excess of their current emissions levels. Selling excess emissions credits abroad would provide a compensating windfall gain to developing countries. Yet, because a country that chooses to increase emissions forgoes the sale of emissions credits, the quota still imposes a price for carbon emissions, thereby providing efficient incentives to reduce their production.

Similarly, crediting developing countries for carbon sequestration and conservation within their borders can reduce the cost of meeting emissions quotas and potentially generate a surplus of emissions credits for sale. A climate change treaty that would facilitate payment for the preservation and enhancement of forest carbon sinks could transfer substantial income to the developing world. Therefore, any approach to mitigating climate change that focuses solely on emissions reduction to the exclusion of forest carbon sinks will generate unacceptable efficiency losses while foreclosing an effective means to generate sustainable development.

Preserving Forests as Carbon Sinks

Global warming is the consequence of rising atmospheric concentrations of greenhouse gases, notably carbon dioxide, from burning fossil fuels and deforestation. Accordingly, there are two ways to avoid climate change: 1) reduce the flow of carbon emissions into the atmosphere; 2) increase the rate at which carbon emissions are removed from the atmosphere. Slowing deforestation and increasing carbon sequestration by forests achieve these objectives. Therefore, a climate change treaty should provide incentives to preserve and manage forests for their role in climate stabilization. To discourage deforestation, countries should pay for the external social costs of carbon emissions through carbon taxes, permits, or quotas. To encourage reforestation, afforestation, or conservation, countries should be subsidized for the external social benefits of carbon sequestration (7).

Table 1. Carbon Emission Prices

Author/Model (year)	*Reduction Scenario*	*Emission Price $/ton*
Nordhaus (1994)	Optimal reduction[a]	$20
Nordhaus (1994)	20% decrease from 1990 levels	$140
Nordhaus (1994)	Stabilize climate	$280
Cline (1992)	Various scenarios	$140-$300
MIT (2000)[b]	7% decrease from 1990 levels (U.S.)	$266
Energy Information Administration (2000)[b]	7% decrease from 1990 levels (U.S.)	$348
Pacific Northwest Laboratory (2000)[b]	7% decrease from 1990 levels (U.S.)	$220

All figures in 1996 U.S. $
a. Assumes marginal damage from carbon emissions equal to $20/ton.
b. Reported by the Energy Information Administration, *Comparing Cost Estimates for the Kyoto Protocol*, report # SR/OIAF/98-03

Since the net atmospheric concentration of carbon dioxide is the critical variable driving climate change, the same incentives offered for preventing emissions should be offered for activities that remove carbon emissions from the atmosphere. In theory, the value of a ton of carbon emitted should equal the value of a ton of carbon removed from the atmosphere. Therefore, the price imposed on carbon emissions through taxes, permits, or quotas should equal the price paid for emissions stored or sequestered by forests. Accordingly, the price of carbon emissions can be estimated as the marginal cost of reducing emissions. Estimates of the marginal costs in the U.S. of a 7% reduction below 1990 levels as required by the Kyoto Protocol range from $220 to $348 per ton (table 1). Cline (1992) and Nordhaus (1994) report carbon emission prices ranging from $20 to $300 per ton for various levels of emissions reduction (table 1) (8).

During the past twenty years, emissions from land use change accounted for 25%, or 33 billion tons, of total carbon emissions (IPCC, 2001). Assuming a conservative range for carbon emission prices between $20-$220/ton, the value of the carbon lost from deforestation approximated $660 billion to $7.3 trillion dollars (9). Unless countries are paid for the climate stabilization services they provide for the global community, forest areas will continue to decline. This is especially true for developing countries in the tropics where deforestation rates are highest. Table 2 details the actual and projected average annual deforestation rates by decade and subsequent carbon loss in Africa, Latin America, and Asia between 1995-2045. Throughout the 1990's, an average of 15.6 million hectares of tropical forest were lost each year, 7.8 million hectares in Latin America alone. Assuming emission prices of $20-$220/ton, the resulting loss in carbon storage was equivalent to $35-$389 billion dollars annually.

Table 2. Average Annual Deforestation and Carbon Loss By Region

Africa	**1995**	**2005**	**2015**	**2025**	**2035**	**2045**	**Total**
Carbon Loss	461	390	334	307	282	283	2057
Deforestation	4575	3860	3260	2900	2535	2485	19615
Lat. Am.							
Carbon Loss	873	689	598	501	454	453	3568
Deforestation	7757	6275	5135	4160	3570	3550	30447
Asia							
Carbon Loss	436	406	363	314	268	254	2041
Deforestation	3283	3035	2665	2170	1850	1760	14763
All Tropics							
Carbon Loss	1770	1485	1295	1122	1004	990	7666
Deforestation	15615	13170	11060	9230	7955	7795	64825

Source: Trexler and Haugen, World Resources Institute 1995.
Average annual deforestation by decade (1000 ha) and carbon emissions (million tons)

However, deforestation not only releases carbon emissions, it decreases carbon sequestration. On average, old-growth forest can sequester 1.5 tons of carbon per hectare per year (10). Table three details the average annual value of carbon sequestration and storage for the

1990's for Asia, Africa, and Latin America. Tropical forests provided climate stabilization services, both carbon sequestration and storage, equal to $36-$395 billion dollars per year (table 3).

Table 3. Annual Value of Climate Stabilization Services

	Annual Value Carbon Storage	Annual Value Carbon Sequestration	Total Annual Value of Services
All Tropics			
High[a]	$389	$5.2	$395
Low[b]	$35	$0.5	$36
Africa			
High	$101	$1.6	$103
Low	$9	$0.1	$9.1
Asia			
High	$96	$1.1	$97
Low	$8.7	$0.1	$8.8
Lat. Am.			
High	$192	$2.6	$195
Low	$18	$0.2	$18.2

Value in $ billion (1996 U.S. $)
a. Estimated at $220/ton carbon
b. Estimated at $20/ton carbon

Unless tropical countries can capture the full value of their forests' carbon sequestration and storage services, there is little incentive to protect, rather than clear-cut forests for fuel, timber, or agricultural use. Because these services benefit the global community, relying on developing countries to shoulder the entire cost of their provision means that conservation and sequestration will be sub-optimally supplied. Subsidizing developing countries for the value of these benefits will provide real incentives to engage in climate stabilizing land use change and conservation. Within the context of a global warming treaty, subsidization could take the form of saleable emissions credits for verifiable changes in land use that either prevent emissions and, or increase carbon sequestration.

However, this approach to mitigating global warming could transfer substantial income to the developing world. Payments of $20-$220 per ton of carbon stored or sequestered could transfer $36-$395 billion to tropical countries per year at the average deforestation and sequestration rates that prevailed in the 1990's (table 3). In contrast, private capital flows to the developing world in 1997 were $90 billion

(Heal, 2000). On a per capita annual basis, the subsidies would cost $6-$66 per person worldwide, or $144-$1580 per person in the U.S. alone. Considering the ancillary benefits of protecting tropical forests, such as biodiversity and watershed protection, it may prove a relatively small price to pay. Nevertheless, industrial countries should only be willing to pay for these benefits if carbon sequestration and storage in developing countries costs less than reducing emissions from other sources. The cost will be a function of the amount of carbon stored or sequestered per unit area of forestland and the value of the land's alternative uses. While costs will vary across countries and regions, preliminary studies indicate that they fall well within the range of carbon emission prices the industrialized countries should be willing to pay (Heal, 2000; Brown et al., 1997; Faeth et al., 1994).

Despite the seemingly win-win prospects of this approach, there are many who challenge the logic and efficacy of paying for public goods that may otherwise have been provided. Since forests naturally sequester and store carbon, opponents claim that countries should not be compensated for public goods their resources freely provide. Rather, payment should be limited to activities that store or sequester carbon in addition to what might have occurred absent such incentives. This concern for the "additionality" of emissions reduction is well founded to the extent that subsidizing the preservation or enhancement of forest carbon sinks to meet emissions targets could substitute for reductions from other sources. If countries are credited for carbon sequestration or storage that would have occurred otherwise and subsequently can avoid limiting emissions, net atmospheric carbon levels will not decline.

The additionality issue has forestalled any meaningful inclusion of land use change or forestry options for mitigating climate change in the Kyoto Protocol. To demonstrate compliance with their emissions targets, countries must submit verifiable inventories of their net greenhouse gas emissions, including all emissions from sources and removals by sinks. Countries can only account in their inventories for changes in carbon sinks resulting from direct human-induced land use change, limited to reforestation, afforestation, or deforestation activities within their own borders since 1990. What exactly constitutes "direct human-induced" activity has yet to be fully determined, leaving many important questions unanswered. For example, can the U.S. credit carbon sequestration from its expansive commercial tree plantations towards its emissions target? If so, it could substantially decrease the amount by which U.S. industries would have to reduce emissions. Can countries credit emissions sequestered by all forest areas, or only those forest areas slated for development? If the latter, countries might have an incentive to exaggerate development threats, or worse yet, destroy forest areas to be able to claim credits for reforesting the area.

With respect to land use change and forestry in the developing countries, the Kyoto Protocol is even more ambiguous. Because developing countries are exempt from quotas, the Kyoto Protocol provides no direct incentives to developing countries to mitigate emissions through land use change. However, the Kyoto Protocol's proposed Clean Development Mechanism (CDM) gives industrialized countries the option to offset their emissions quotas by paying for land use and forestry mitigation projects in developing countries (11). But unlike emissions trading between industrialized countries, where reductions credited to one country's target are subtracted from another's, there is no subtraction for CDM projects (Schlamadinger and Marland, 2000: pp.41-43). In this context, gauging the additionality of reductions and enhancements of carbon sinks is critical. It requires estimating baselines for carbon sequestration and storage in developing countries in the absence of projects and only crediting changes that take place at the margin.

Yet, much of delay over including forest carbon sinks, and CDM projects in particular, in the Kyoto Protocol stems from uncertainty over estimating baselines and predicting changes in carbon stocks over time. Identifying where and at what rate deforestation will proceed in the tropics is tenuous at best (Schlamadinger and Marland, 2000). There is always the risk that by slowing deforestation in one area of the world, the pressure for deforestation elsewhere will increase. Moreover, to the extent that CDM projects might promote economic growth in developing countries, the resultant rise in emissions could offset any initial sequestration or storage benefits. It is instructive to note that these issues could be avoided, almost entirely, if developing countries were also subject to emissions quotas and accounted for changes in carbon stocks themselves.

Finally, if the CDM allows industrialized countries to substitute carbon sequestration in developing countries for emissions reduction at home, it follows that the corresponding land use change must be permanent. That is, a country should not be credited for preventing deforestation or reforestation in one year, if subsequently the area is cleared. However, this suggests that the industrialized countries retain long-term interests over land management in project areas, a consequence antithetical to the sovereignty of developing countries. If ever emissions targets become binding for these countries, they may find that the industrialized countries have already exhausted the low-cost land use change and forestry options within their borders. Thus, while the CDM presents as a potential windfall gain for the developing countries, the primary beneficiaries may indeed be the industrialized countries in the long run. Equity and efficiency will be greater served by a climate control approach that encourages developing countries to enhance and preserve carbon sinks for themselves.

Conclusion

The Kyoto Protocol, as representative of the prevailing international consensus on mitigating climate change, raises serious equity and efficiency concerns. By focusing almost exclusively on reducing emissions in the industrialized countries, the Kyoto Protocol fails to provide the necessary incentives for preserving and enhancing forest carbon sinks in the developing world. Consequently, the Kyoto Protocol forecloses a valuable opportunity to promote sustainable development concurrent with emissions control. Kyoto Protocol's one exception, the Clean Development Mechanism, confronts seemingly insuperable difficulties related to uncertainty, permanence, and additionality while raising concerns for the sovereignty of developing countries.

Alternatively, future climate change treaties should provide incentives to all countries to mitigate emissions by all sources and sinks. The challenge will be to minimize the costs to developing countries while limiting emissions to rates commensurate with their development needs. Allocating emissions caps such that developing countries can become net exporters of emissions credits is one approach. Similarly, crediting developing countries for carbon sequestration and storage within their borders can minimize costs and potentially generate a surplus of emissions credits for sale. A climate change treaty that would facilitate payment for forest climate control services could transfer substantial income to the developing world. In which case, fairness for developing countries could be achieved explicitly, rather than implicitly by temporary exclusion from emissions quotas.

Notes

1. Definition of climate change used by the United Nation's Framework Convention on Climate Change.

2. The Intergovernmental Panel on Climate Change was jointly established by the World Meteorological Organization (WMO) and the United Nation's Environment Programme (UNEP) to assess the science, impacts, and economics of climate change. The Third Assessment Report incorporates results from the past five years of research. Hundreds of scientists worldwide contributed to this report.

3. If the marginal benefit of economic activity exceeds the marginal cost, welfare as defined as the difference between total benefits and costs increases. To maximize welfare, economic activity should continue until marginal benefits equal marginal costs.

4. Carbon taxes and permits are generally considered to be less costly than uniform regulatory approaches. By allowing polluters the option to either reduce emissions or pay the cost of a tax or permit, those who can reduce emissions at relatively low costs decrease emissions more than others, thereby minimizing the total cost of reducing emissions.

5. All figures reported in 1996 U.S. dollars.

6. A public good is one whose benefits accrue to all parties, not only to those who pay. Because outside parties cannot be excluded from the benefits of a public good, there is little incentive to provide it. Rather, every party has the incentive to "free-ride" off of the public goods provided by others.

7. Reforestation is the restoration of forests in previously forested areas. Afforestation is the introduction of forests to areas never before forested. Conservation is the protection of existing forest areas.

8. Nordhaus estimated the marginal damage of carbon emissions at $20/ton. Nordhaus' model has been criticized for underestimating both the extent and costs of global warming. See Cline 1992 for a discussion.

9. To be conservative, the minimum carbon price ($20/ton) and the minimum estimated marginal cost per ton of complying with the Kyoto Protocol ($220/ton) was used.

10. Rates of carbon sequestration vary according to region, climate, soil, forest type, and age. The rate of carbon uptake by old-growth forests is lowest, but on average even old-growth forests can sequester 1.5 tons of carbon per hectare per year (Villarin et al., 1999).

11. There are similar provisions in the Kyoto Protocol to allow industrialized countries to pay for emissions reductions in other industrialized countries and for industrialized countries to trade the resulting carbon offsets.

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