TROPICAL FOREST AND THE EMERGING CO_2 MARKET

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SUMMARY

Since the Earth Summit gathered in Rio Janeiro in 1992, more than 180 countries of the world have been negotiating the United Nations Framework Convention on Climate Change including a strategy to reduce the emissions of gases that are thought to contribute to global warming. The Kyoto Protocol (1997) –that was announced recently will be ratified– includes provisions to allow countries where emissions reductions are very costly to meet their reduction targets by buying credits from countries where emissions reductions are cheaper. This strategy is still being debated; moreover, the sixth conference of the parties (COP VI) reached only a partial agreement.

Costa Rica has been a pioneer in developing and selling emission reduction credits. Costa Rica's carbon credits came primarily from two sources. First, converting cultivated fields and pastures into forests and second, from reducing deforestation. In 1996, in an unprecedented transaction, Costa Rica sold its first 200,000 tons of carbon emission reduction credits to Norway for $10 per ton of carbon. In early 1998, however, Costa Rica received no bids when it tried to auction an additional 1,000,000 tons of carbon credits with a floor price of $20 per ton. During the year 2001, other 8 Latin American countries offered credits to the World Bank's Prototype Carbon Fund at prices between $2.9 and $20 per ton. Carbon trade final results will depend on the ultimate rules, regulations, and carbon prices.

KEY WORDS: Tropical forest
Climate Change
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Protected areas

INTRODUCTION

During the previous decade, a vast majority of scientists and policy makers had become convinced that increased emissions of carbon dioxide and other so-called greenhouse gases (methane, nitrous oxide, and related synthetic compounds) were contributing to change the global climate and warming the planet. Emissions of greenhouse gases had grown with industrialization, and particularly from the burning of fossil fuels, such as coal and petroleum to power industry; to heat, cool, and light homes and offices; and to

transport goods and passengers. After fossil fuel combustion, deforestation is the second largest source of carbon dioxide emissions to the atmosphere [1].

Recently a new report of the Intergovernmental Panel on Climate Change (IPCC, 2001a) over the 20th century highlights that global average surface temperature increased by 0.6-0.2 C, a value about 0.15 C larger than that estimated by the Second Assessment Report (SAR) up to 1994. It also indicates that globally it is very likely [2] that 1990 was the warmest decade and 1998 the warmest year since 1861, the period for which instrument-taken records exist.

The new report concludes: «there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities», going beyond the SAR conclusion that «the balance of evidence suggests a discernible human influence on global climate». Moreover, the report stresses that «human influence will continue to change atmospheric composition throughout the 21st century» and «anthropogenic climate change will persist for many centuries». It also indicates that «emissions of CO_2 due to fossil fuel burning are virtually certain to be the dominant influence on the trend in atmospheric CO_2 concentration during this century [3].

The IPCC estimates global average surface temperature to increase between 1.4 C and 5.8 C over the period 1990 to 2100, based on its Special Report on Emission Scenarios (IPCC, 2000). This represents a projected rate of warming much larger than the observed changes during the 20th century. Global average water vapor concentration and precipitation are also projected to continue increasing during the 21st century, as well as sea level (IPCC, 2001a).

Several factors had made it difficult to reach an agreement on a strategy to cope with the threat of global warming. In the first place, there is still substantial scientific uncertainty about the link between the rising levels of greenhouse gasses and global warming. To many, it seems obvious that the planet is warming. For example, the polar ice caps are receding, and the 14 warmest years since 1866 —when world temperatures were first recorded— had all occurred after 1979. However, it is still unclear whether the warming is a long-term trend and how much the build up of greenhouse gases is contributing to it. The scientific models of climate change are so complex and sensitive that small and plausible differences in assumptions could significantly change predictions about future temperatures.

Second, the benefits of preventing global warming are also in dispute. Concerned scientists forecast that rising temperatures would lead to massive coastal flooding, dramatic changes in crop yields, more violent storms, the extinction of species due to habitat loss, and other terrible results. On the contrary, some models indicate that global warming would help many parts of the world by increasing rainfall and extending growing seasons, and others argue that the world could adapt to rising temperatures without enormous suffering or cost, particularly if the temperature increase is not too extreme.

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[1] Estimates of annual global emissions from deforestation range from 0.6 to 2.8 billion tons, compared with close to 6.0 billion tons from fossil fuel combustion (Houghton, 1991; Smith *et al.* 1993).

[2] Judgemental estimates of confidence used by the IPCC (2001a) in the TAR are the following: very high (95 % or higher); high (67-95 %); medium (33-67 %); low (5-33 %) and very low (5 % or less).

[3] The report of Working Group II, *Climate Change 2001: Impacts, Adaptation and Vulnerability* (IPCC, 2001b) assesses the potential consequences of projected climate change, as well as the sensitivity, adaptive capacity, and vulnerability of natural and human systems to such phenomenon.

Third, there is disagreement about how the burden of reducing greenhouse gas emissions should be shared among the countries of the world. Historically, the industrialized countries had contributed the lion's share of emissions, the United States alone accounted for nearly 25 percent. But «business-as-usual» forecasts show that the developing countries' share of greenhouse emissions would rise rapidly as they industrialize (see Table 1). The developing countries argue that they should not have to reduce their emissions below their current modest levels, instead they should be allowed some margin for growth. But the industrialized nations are reluctant to bear the burden alone or to make sacrifices that might just encourage profligate emissions by others.

Table 1

Total Carbon Emissions by Region, 1995 and 2020
(In millions of metric tons)

	Actual 1995	Projected 2020	Annual % change 1995-2020
Regions			
North America	1,629	3,313	1.4 %
Western Europe	925	1,239	1.2 %
Industrialized Asia	379	415	1.2 %
Eastern Europe and former Soviet Union	866	1,223	1.4 %
Developing Asia	1,427	3,835	4.0 %
Middle East	229	409	2.3 %
Africa	192	341	2.3 %
Central and South America	194	574	4.4 %
World total	5,841	10,447	2.4 %
Selected countries			
United States	1,411	1,956	1.3 %
Canada	135	198	1.5 %
Japan	82	159	2.7 %
Mexico	281	385	1.3 %
China	792	2,340	4.4 %
India	222	523	3.5 %
Brazil	64	208	4.9 %

Source: Energy Information Administration, *International Energy Outlook, 1998.*

The debate has been further complicated by uncertainty about the cost of reducing emissions. Pessimists point out that sources of energy with low or no greenhouse gas emissions tend to be either fairly expensive (such as solar or wind power) or to cause other environmental risks (such as nuclear power). Optimists claim that the costs of alternative energy sources and cleaner technologies would decline rapidly once businesses and households are given incentives to reduce greenhouse gas emissions.

International Conventions on Climate Change

The countries of the world took a key step toward a global agreement on climate change in 1988, when they established the Intergovernmental Panel on Climate Change (IPCC) to assess the scientific, technical, and socio-economic research on climate change. The IPCC's work helped convince many in the world community that the risk of global warming was serious enough to warrant action. Responding to the concern that human activities are increasing concentrations of «greenhouse gases» (such as carbon dioxide and methane) in the atmosphere, most nations of the world joined together in 1992 to sign the United Nations Framework Convention on Climate Change (UNFCCC). It included a legally non-binding, voluntary pledge that the major industrialized/developed nations would reduce their greenhouse gas emissions to 1990 levels by the year 2000, and that all nations would undertake voluntary actions to measure, report, and limit greenhouse gas emissions. It was decided by the Parties that this round of negotiations would establish limitations only for the developed countries (those listed in Annex I to the UNFCCC, including the former Communist countries, and referred to as «Annex I countries». Developing countries are referred to as «non-Annex I countries»).

Soon after, 165 countries ratified this convention. However, since the convention had no specific targets for individual countries, its effect was more symbolic than practical. A subsequent summit in Berlin in 1994 produced only limited progress. Scientific consensus grew that human activities were having a discernible impact on global climate systems. Furthermore, it became apparent that major nations such as the United States and Japan would not meet the voluntary stabilization target by 2000.

By 1997, concern about global warming had increased to the point that a third world conference, at Kyoto, approved more specific measures. In Annex I of the Kyoto Protocol, the industrialized nations and many of the transition-economy countries of Eastern Europe committed to specific emissions reduction targets that averaged a 5.2 percent rollback from 1990 emissions levels. These targets were to be achieved by the year 2008 and sustained through the year 2012.

The developing countries did not commit to specific reduction targets at Kyoto because they were reluctant to incur expenses and they wanted to see whether technological progress would reduce the costs of cleaner technologies and development. The process of ratification among the Annex I countries is proceeding slowly [4].

The United States had taken a firm position that «meaningful participation» of developing countries in commitments made in the Protocol is critical both to achieving the goals of the treaty and to its approval by the U.S. Senate. This reflects the requirement articulated by the U.S. Senate, that the United States should not become a party to the Kyoto Protocol until developing countries were subject to binding emissions targets. The U.S. government also argued that success in dealing with the issue of climate change and global warming would require such participation. The developing country bloc argued that the Berlin Mandate –the terms of reference of the Kyoto negotiations established at COP I in 1995– clearly excluded them from new commitments in this Protocol, and they continued to oppose emissions limitation commitments by non-Annex I countries.

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[4] By July 2001, at the so called COP VI *bis,* held in Bonn Germany, only 39 countries have ratified the Kyoto Protocol, among them only Romania belong to Annex I.

In late March, the Bush Administration made a determination to consider the Kyoto Protocol «dead» in terms of U.S. policy, and instead announced a cabinet-level review of climate policy. This initiated a high-level effort by the European nations to re-engage the United States in the Kyoto process. This effort was reported as having been «rebuffed» by the United States, in favor of an effort to find new approaches, centered on market-based incentives, to international cooperation to address climate change concerns.

Initially, the U.S. withdrawal from the Kyoto Protocol was considered its death knell. The agreement can only enter into force internationally if it is ratified by at least 55 nations that, together, accounted for at least 55 % of the total carbon dioxide emissions in 1990. Given that the U.S. alone was responsible for about 25 % of the 1990 carbon dioxide emissions, experts predicted that without the participation of the U.S., the Kyoto Protocol would never be implemented.

However, in July 2001, the European Union, Japan, Canada, Russia, Australia, and 170 other nations reached an agreement to proceed with the treaty. In order to secure the support of highly industrialized nations, the European Union was forced to make substantial concessions. It is highly probable that the Kyoto Protocol will become into force by 2002.

The Potential for Global Emissions Trading [5]

The Kyoto Protocol allows countries with binding targets to lower the cost of meeting their targets by participating in international emissions trading. In emissions trading, one country transfers part of its assigned amount to another. The basic idea is that every country would agree to reduce its emissions by a certain amount. If countries that could reduce emissions at a relatively low cost exceed their reduction commitments, they would be allow to sell the credits for the excess to countries where emissions reduction is more expensive. It includes three specific provisions for trading emissions credits. Two could be used for trading only among Annex I countries, but the third, called the Clean Development Mechanism (CDM), could be used for trading between Annex I countries and developing countries [6]. To qualify for a CDM trade, the developing country has to demonstrate that the emissions credits that it is selling are «additional» to those emission reductions that it might be expected to achieve under a business-as-usual scenario.

The United States has successfully established a market for emissions credits to help reduce sulfur dioxide emissions from power plants in the 1990s. The hope is that a similar market for greenhouse gas emission credits could reduce the cost of slowing global warming.

Because the cost of controlling greenhouse gases differs by many times from country to country, emissions trading will allow enormous savings in meeting the Kyoto targets.

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[5] The information and tables in this section are drawn from Richard Baron, «The Kyoto Mechanisms: How Much Flexibility do they Provide?» in Richard Baron, Maratina Bosi, and Alessandro Lanza, *Emissions Trading and the Clean Development Mechanism: Resource Transfers, Project Costs and Investment Incentives,* report by the International Energy Agency for the Fifth Conference of the Parties, Bonn, October-November 1999.

[6] The two that could be used among Annex 1 countries are «international permit trading» (under article 17) and «joint implementation» (under article 6). The clean development mechanism is described in article 12.

Countries that have relatively inexpensive ways to control greenhouse gases have incentives to reduce emissions by more than their targets require, because they can sell to others tradable allowances that they will not need. Since greenhouse gases are global pollutants, the environmental impact of reducing them is the same no matter where the reductions take place. The same overall reduction is achieved, total costs are reduced, and both buyers and sellers gain from the savings allowed by trading.

While countries can benefit by engaging in emissions trading at the government-to-government level, far more savings are possible if countries also authorize their legal entities (companies, individuals, NGOs, etc.) to trade. The cost of controlling greenhouse gas emissions varies dramatically between companies both within the same country and across borders. The private sector can be much more effective than governments in finding the lowest-cost emission reduction opportunities. The greatest savings can come if private sector companies with the ability to reduce emissions are allowed to buy and sell allowances with other companies in the same country and with companies in other countries.

Emissions trading rules could be structured to give countries strong incentives to comply with basic requirements of the Protocol. For example, a country that came out of compliance with the Article 5 and 7 measurement and reporting rules, or that failed to maintain its national registry, could lose its eligibility to trade. The prospect of losing the savings available from trading could be a strong inducement to keep buyer countries in compliance. Likewise, the prospect of losing investment revenue could be a strong encouragement for seller countries to remain in compliance.

The main issue in emissions trading is «supplementarity», the position of the United States is that there should not be quantitative limits to the amount of emissions reductions that are allowed toward a country's obligations through emissions trading or joint implementation [7]. The EU and others argue that there should be such limitations, in order to force nations to take more extensive domestic action to reduce emissions. This issue is related to the commitment outlined in the Kyoto Protocol that emissions trading should be «supplemental» to domestic action. Another related issue is whether carbon sinks can be included in the Clean Development Mechanism (CDM) in which a contributing developed country can claim credit for actions to reduce emissions in developing countries. There are significant divisions on this issue not only among developed countries, but also among developing countries, as well.

DISCUSSION

Research suggests that, at least in theory, emissions trading could substantially reduce the cost of rolling back greenhouse gas emissions. Table 2 summarizes estimates of the costs of achieving the Kyoto Protocol commitments from eight economic models produced by researchers from a variety of different countries selected by the International Energy Agency. The results vary somewhat because of differing model assumptions about, for example, the rates at which the costs of cleaner technologies will decline. Nevertheless, the eight models are fairly consistent in predicting that trading can significantly

[7] The United States is supported by the «umbrella group» in which it is joined by New Zealand, Japan, Canada, Australia, Russia, Ukraine, Norway and Iceland.

Table 2

Estimates of the Marginal Cost of Abatement with and without Trading (In 1995 dollars per ton of carbon)

Name of Model	No trading			Trading	
	United States	Europe	Japan	Annex I countries	Global
SGM	163			76	27
MEREGE	274			114	80
G-cubed	63	167	252	37	13
POLES	82	130-140	249	112	33
GTEM	375	773	751	123	
WorldScan	38	78	87	20	
GREEN	149	196	77	67	25
AIM	166	214	253	65	43
Average	***164***	***260***	***277***	***80***	***28***

Source: Richard Baron, «The Kyoto Mechanisms: How Much Flexibility do they Provide?», in Richard Baron, Maratina Bosi, and Alessandro Lanza, *Emissions Trading and the Clean Development Mechanism: Resource Transfers, Project Costs and Investment Incentives,* report by the International Energy Agency for the Fifth Conference of the Parties, Bonn, October-November 1999.

reduce costs. For example, using the average results from the eight models, without trading, the marginal cost of a ton of carbon emissions reductions would be $164 in the United States, $260 in Europe, and $277 in Japan. If trading were allowed among the Annex I countries, the marginal cost could drop to $80 per ton. Furthermore, if trading were allowed with the developing countries as well, the marginal cost would drop even more, to $28 per ton (Baron *et al.*, 1999) [8].

Table 3 translates the results into effects on Gross National Product (GNP). The majority of global studies show reductions in projected GDP of about 0.2 % to 2 % in 2010 for different Annex II regions in the absence of emissions trading between Annex B countries. With full emissions trading between Annex B countries, the estimated reductions in 2010 are between 0.1 % and 1.1 % of projected GDP. These studies encompass a wide range of assumptions. For example, models whose results are reported in this paragraph assume full use of emissions trading without transaction cost. Results for cases that do not allow Annex B trading assume full domestic trading within each region. Models do not include sinks or non- CO_2 greenhouse gases. They do not include the CDM, negative cost options, ancillary benefits, or targeted revenue recycling (Baron *et al.*, 1999).

But some researchers suspect that the models' cost estimates are likely to be optimistic, for two reasons. First, the models all assume that each country would choose the most cost-effective domestic emissions control strategy. If policy makers chose to protect politi-

[8] The simulations assumed that developing countries would be able to sell credits for any emissions reduction below their business-as-usual forecast.

Table 3

Aggregate Economic Cost of Kyoto Commitments with and without Trading (In 2010 as a percentage reduction in Gross National or Domestic Product)

Model or researcher	Country	No trading	Trading among Annex I countries	Global trading
SGM	U.S.	0.4 %	0.28 %	0.12 %
MERGE	U.S.	1 %		0.25 %
G-cubed	U.S.	0.3 %	0.2 %	
	Japan	0.8 %	0.2 %	
	Other OECD	1.4 %	0.5 %	
GTEM	All industrialized	1.2 %	0.3 %	
GREEN	All industrialized	0.5 %	0.1 %	
AIM	U.S.	0.45 %	0.3 %	0.2 %
	Japan	0.25 %	0.15 %	0 %
	European Union	0.3 %	0.17 %	0.07 %

Source: Richard Baron, «The Kyoto Mechanisms: How Much Flexibility do they Provide?», in Richard Baron, Maratina Bosi, and Alessandro Lanza, *Emissions Trading and the Clean Development Mechanism: Resource Transfers, Project Costs and Investment Incentives,* report by the International Energy Agency for the Fifth Conference of the Parties, Bonn, October-November 1999.

cally sensitive domestic industries and regions from adopting even low-cost measures, however, then the costs of abatement without trading might be much higher than estimated.

Second, the models assume fully fluid-markets for emission credits with no significant barriers or transaction costs. In practice, however, the fact that the developing countries have not committed to specific emissions targets is a source of concern among Annex I countries. In particular, there are concern about the idea of leakage and slippage. The Convention uses these terms to refer to the possibility that the net benefits of a carbon sequestration project will be reduced if a landowner takes the money earmarked for forest conservation and uses it to convert a forest to cropland in another area (leakage). Or otherwise he might increase his CO_2 emissions by, for example, buying more vehicles (slippage). This situation might prove a major impediment to carbon reduction trading and at the very least it would mean that some neutral party would have to be sure that the additionality requirement was met —that is, that the emissions reduction would not have occurred anyway under business as usual. Germany had emerged as the spokesperson for a number of industrialized countries that were opposed to allowing significant trading with developing countries until the countries committed to emission targets. Germany argued that without emissions commitments, additionality would be hard to determine and easily evaded.

Even if the developing countries do commit to specific emissions targets, some observers wonder whether the trade flows involved are realistic. Trading among the Annex I countries would involve payments of roughly $42 billion per year from Europe, Japan and North America to the transition countries of Eastern Europe. If global trading is allowed, the industrialized countries would be paying the developing countries roughly $9 billion per year for emissions credits. The amounts involved would be substantially larger than the foreign aid payments that many developing and transition-economy countries currently receive. Understandably, some developing and transition countries want assurances that the industrialized countries would not simply cut their foreign aid budgets to compen-

sate. Skeptics also wonder whether or not the emissions reductions implied in the transition and developing countries are realistic. If trade goes on at the scale predicted by the models, the transition economies would be emitting roughly 50 percent less than under the business-as-usual scenario while the developing countries would be emitting only 20 to 30 percent less.

Despite these concerns, trading in emissions credits with developing countries is proceeding on a limited basis. The 1992 Rio convention had encouraged experimental trading to determine how such a system might work. The 1997 Kyoto convention had approved the Clean Development Mechanism (CDM). Despite the ambiguous legal status of the credits, some countries and large multinational businesses with high emissions control costs were interested in buying them. British Petroleum a major international energy company had recently set up an experimental system to trade emissions credits among its plants in industrialized and developing countries, and discovered that even with inter-plant trading its marginal costs of abatement were likely to be close to $70 per ton. Buying some low-cost credits from other sources might be worthwhile as a method for hedging its bets. And it didn't hurt that purchasing credits generated favorable corporate publicity.

Most of the proposed emission credit trades are for electric power generating projects. For example, a credit might be issued for to install wind turbines that generate electricity with no greenhouse gas emissions, or to convert a coal-fired generating station to use cleaner-burning natural gas. But there is also a growing interest in credits for other types of emission reduction measures, including reforestation. Reforestation credits typically are offered for a limited period of time, say 20 years, with the idea that at the end the forest might be logged and replanted. This causes some environmental groups to oppose reforestation credits since they would have to be replaced if the forest is logged. The international environmental group, Greenpeace, labeled credits for reforestation «a time bomb» that would cause serious problems when they expire. But advocates of reforestation pointed out that other credits are for only a limited period as well —for example, a wind turbine could be expected to last only 20 years. Hopefully, in 20 years technological progress would have reduced the costs of emissions abatement.

Many models have been used to estimate an order of magnitude of the sequestration and mitigation potential of the forest. Early models calculated that around 500 million hectares were necessary (Sedjo and Solomon, 1989) or available (Nordhaus, 1991b) for carbon sequestration at the global level. All Latin American and African early models consistently showed that these countries could provide at least 50 % of the required amount of land, with a low preparation cost and a high forest-growing rate. These combined factors offered, especially to tropical countries, a highly competitive position in any carbon market that includes forest projects. More recent studies such as the Harvard University study for Central America and the UNAM University study for Mexico [9] compared carbon and fossil fuel options. The first calculated the carbon reduction coming from forest (conservation, forest management, and reforestation) in 54 million tons per year compared with 6 million coming from the potential of fossil fuel emission reduction

[9] The first study was financed by the Central American Bank and is forthcoming; the second was partially financed by the Inter-American Development Bank and was presented at its annual governor's meeting in March 2000.

in Central America. The second calculates that forest represents 87 % of the 40 million tons eventually available in Mexico for the year 2000.

In economic terms, carbon sequestration through forest or reduced deforestation may be a cost-effective approach to contribute to reduced global atmospheric concentrations of CO_2 [10]. However, the countries participating in the UNFCCC are still debating whether reducing carbon emission through projects that reduce deforestation will be acceptable as an option for emissions reduction and trade under the treaty. This unresolved legal situation is likely to affect the carbon trade more than any scientific concerns because if the UNFCCC excludes the preservation of natural forests as an option, it would encourage forest plantations that do not constitute very rich ecosystems. A second effect is a bias for options in countries that use CO_2 intensive energy sources. For example, big developing countries using mainly fossil fuels –liquid or solid– like China and India, will benefit because they will be able to provide cheaper and larger volumes of carbon emission reductions as a result of fuel switching or using cleaner energy sources. On the other hand, countries like Costa Rica and Brazil that are currently using mainly renewable energy sources will highly reduce their participation in the emerging carbon market.

Costa Rica's Forest and Climate Change Pioneer Experience

Costa Rica is a country of 3.8 million people with a landmass of 5.2 million hectares in Central America. It is one of the most stable democracies in Latin America, and has not suffered from the civil wars or unrest that had plagued many of its neighbors in recent decades. Perhaps as a result, Costa Rica has the highest per capita income in Central America and one of the highest in Latin America.

Through most of the 1980s, Costa Rica's economy depended largely on exports of coffee, bananas, and cattle and its domestic industry and farmers were protected by high tariffs. However, these policies led to a slow economic growth, however, and the government began to run fiscal deficits in an effort to meet the popular desire for an improved standard of living. By 1988, the financial situation had become so precarious that the government had to appeal to the International Monetary Fund (IMF) for loans. As a condition for the loans, the IMF required that Costa Rica reduced its import barriers and opened its economy to foreign investment. These reforms helped to transform the Costa Rican economy over the next decade. Tourism to Costa Rica's beautiful beaches and tropical forests increased, and soon overtook agriculture as the leading foreign exchange earner. Foreign companies invested so much in local assembly plants that in 1998 electronics overtook tourism as the number one foreign exchange earner. With the opening of a new Intel computer chip plant, electronics is expected to be the first foreign exchange source for the next decade.

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[10] This is the conclusion for Costa Rica in the Costa Rican Dilemma (Castro and Cordero, 1999). It was also concluded as so for Mexico by Omar Masera in his presentation at the Inter-American Development Bank meeting, held in New Orleans, March 2000. A similar conclusion was reached for the USA in an article called «Climate Change and Forest Sinks: Factors Affecting the Costs of Carbon Sequestration» (Harvard University, November 1998) prepared by Professors Robert Stavins and Richard Newell. In this article they stated: «even for highly industrialized countries such as the United States, carbon sequestration through land-use changes could arguably be part of a cost-effective portfolio of short term strategies» (p. 24).

The 1990s also brought increased efforts by Costa Rica to protect its forests and wildlife (see Table 4). In the decades when agriculture was the primary export earner, thousands of hectares of forest had been chopped down for plantations and ranches. The destruction prompted the government to expand its system of national parks and to create a national network of Wildlife Conservation Areas (WCAs) that covered 15 percent of the country's land area. The WCAs were intended to preserve the habitats of sensitive forest species and consisted of either publicly owned lands or private lands where, for a fee, the owner had agreed to limit logging to levels that would not harm the wildlife. The national parks and WCAs had helped to establish Costa Rica as one of the premier destinations for eco-tourism in the 1980s and 1990s.

Table 4

Land Use in Costa Rica, 1998

	Hectares (millions)	Percentage
Agriculture and forestry	3.5	68
Coffee, banana and other export crops	0.2	4
Beef cattle	1.0	19
Dairy and mixed use	1.0	20
Private forest	0.8	15
Abandoned cropland	0.5	10
Parks and Wildlife Conservation Areas	1.3	25
Others	0,4	7
Urban	0.3	5
Miscellaneous others	0.1	2
Total	***5.2***	***100***

Source: René Castro Salazar, «Valuing the Environmental Service of Permanent Forest Stands to the Global Climate: The Case of Costa Rica», unpublished doctoral dissertation, Harvard University, June 1999.

In 1994, however, ecologists from various government and non-governmental conservation agencies determined that the WCAs should be expanded to cover an additional 10 % of the country's land area in order to adequately protect Costa Rica's wildlife [11]. Costa Rica had several different types of tropical forest and, as a result, was the home to an unusually large number of species. Some of these species were rare and endangered [12], including many that were thought unique to its forests and as yet unknown to science. Costa Rican environmentalists stressed that the nation had an obligation to the world to

[11] The expanded area is called the Protected Areas Project. For simplicity's sake we refer to it as the WCAs expansion.

[12] The Costa Rican Government published a decree on January 16, 1997 protecting 18 endangered tree species, based on several studies. One of them by Dr. Quírico Jiménez was the most influential one.

preserve this biodiversity. Moreover, many of these species had potential economic value as the source of new medicines, food, and cosmetics. In the early 1990s, for example, Costa Rica had signed contracts with two international pharmaceutical companies to share in the profits from medicines that might have been developed from rare Costa Rican species. The expanded WCAs would also protect the quality of Costa Rica's drinking water.

The desire to expand the WCAs stimulated Costa Rica's effort to develop carbon emissions reduction credits. Without the revenue from selling credits, the government would be hard pressed to find the funds either to purchase land outright or to pay landowners not to develop all the additional hectares that it wanted to add to the WCAs. Reforesting neighboring plantations and cattle ranches would absorb carbon dioxide from the atmosphere, however, and thus offset greenhouse gas emissions. If the government could sell the credits for sequestering the carbon to Annex I countries, it could use the proceeds to buy or protect the hectares it wanted. For example, Table 5 shows that if carbon prices reach $10 only 10 % of the proposed WCAs expansion will be financially feasible, at $30 an average of 82 % will be acquired and at unlikely prices of $100 per ton 98 % of the proposed expansion will be feasible (Castro, 1999).

Table 5

Estimated Expansion of Costa Rica's Protected Areas at Different Carbon Prices

Proposed Protected Area Expansion	Price Scenarios						Maximum land
	$10	$20	$30	$50	$100	$200	
	Percentage of the Total Area						ha
La Amistad	18	88	100	100	100	100	186,201
Rincón de la Vieja	0	10	26	76	94	95	12,421
Palo Verde	0	33	70	98	98	100	9,302
Piedras Blancas	4	4	8	25	65	89	11,537
Barra Honda	0	45	45	66	88	100	2,019
Guanacaste	1	18	61	91	100	100	32,895
Carara	0	11	90	94	95	100	5,349
Barbilla	0	18	61	100	100	100	2,604
All Areas	***10***	***56***	***82***	***93***	***98***	***99***	***262,000***

Note: Each protected area has a different opportunity cost and carbon productivity level. All land costs are based on historical acquisitions. All protected area figures are rounded to the unit, the proposed expansion of the protected areas.
Source: Castro, 1999.

Additionally a reforestation scheme was also politically advantageous as well because it helped rural residents. The rural areas felt left out of the country's growing prosperity because most of the plants and other new economic activities were located around San Jose, the capital city. Traditional rural agriculture was declining because world prices for coffee, bananas, and beef remained low and because young people could now find better jobs in San Jose. Expanding the WCAs would provide new sources of income for rural communities.

Impact of the emerging CO_2 market on forested and agricultural areas

A study conducted by Castro (1999) during 1998 and 1999, focused on Costa Rica's forested areas. The results obtained strongly suggest that including forest from tropical countries like Costa Rica, in the options considered in the Kyoto Protocol to reduce and mitigate CO_2 emissions, would further reduce its cost.

Castro's study suggests that considering carbon sequestration benefits will lead to larger areas of forest being protected than if only the need to protect biodiversity or fragile ecosystems is considered. For example, at prices between $50 and $100 per ton the Costa Rican protected areas of La Amistad, Barbilla and Palo Verde might expand further than proposed. Moreover, with prices closer to $100 the objective of consolidating and expanding protected areas up to 25 % of the national territory seems feasible.

In addition, if Costa Rican landowners were paid for carbon sequestration, many of them might switch from crops to planting forests. The forest projects would probably first replace traditional activities such as raising cattle and rice, which require considerable land extensions. Forests would less likely replace the more profitable export-oriented crops such as coffee, bananas, and pineapples. For example, Castro found that if the carbon price is at least $83 per ton, a farmer producing –or with potential to produce– the average agricultural mix for Costa Rica might switch to a pine plantation *(Pinus patula).*

Finally, carbon sequestration payments would also induce landowners to protect their natural forests outside the protected areas. For example, if a hypothetical private owner of natural forest were considering whether to preserve the natural forest or to use it to raise beef cattle or rice, he would find that preserving the natural forest is a more profitable option if the price is set at $20 per ton (see Table 6). On the other hand, if that same owner had natural forestland that was suitable for growing export-oriented crops, he or she might well use it for those crops unless the carbon price were to exceed $100 per ton.

Costa Rica's Emissions Credit Program and Global CO_2 Markets

Costa Rica's emissions credit program has gone through three stages. In the first stage, which lasted from 1994 to 1995, the government tried to facilitate trades between individual Costa Rican landowners and businesses and foreign governments or corporations. Although one trade was almost consummated, the government soon realized that individual emissions reduction projects would have to be consolidated if trading was to be viable. Negotiating a deal for a small reforestation project was almost as costly –in translators, lawyers, air tickets and the like– as negotiating a deal for a large one.

In the second stage, from 1995 to 1997, the Ministry of Environment and Energy assumed the responsibility for consolidating small projects and offering them for sale. This effort resulted in the first-ever sale of an emission credit based on reforestation. Two hundred and thirty eight individual reforestation projects, many bordering the existing WCAs, were consolidated to provide a credit for 200,000 tons of carbon for 20 years. This credit was sold to the Norwegian government in 1996 for $10 per ton, a price the Ministry had set to recover the payments that it expected to have to make to cattle ranchers to induce them to convert their ranches into plantation forests. Despite its success, however, the Ministry was soon criticized by the Inspector General, a government watchdog agency, for having sold the credits at cost. The Inspector General argued that the Ministry could have gotten a much higher price.

Table 6

Carbon Indifference Price between Private Natural Forest Protection and Competing Agricultural Activities

Crops or Activity	Region or Private Natural Forest (cost estimates ($/ton)							
	La Amistad	Rincón de la Vieja	Palo Verde	Piedras Blancas	Barra Honda	Guanacaste	Carara	Barbilla
Coffee	386	219	275	168	228	226	211	227
Pineapples	372	458	522	524	502	469	549	487
Watermelons	309	378	432	431	415	389	455	403
Yams	251	305	350	346	335	314	368	327
Avocados	245	298	342	338	327	307	360	320
Plantains	244	297	341	337	326	306	359	319
Tiquisque*	198	240	277	270	263	248	291	258
Passion Fruit	189	228	263	256	250	235	276	245
Tomatoes	170	204	236	228	224	211	248	221
Forest plantations	124	35	71	14	51	50	54	62
Bananas	102	118	140	129	130	124	147	131
Palm hearts	98	114	135	124	125	119	142	126
Yucca*	91	106	126	114	116	111	132	118
Coconuts	73	82	99	87	91	87	104	93
Dairy cattle	66	74	90	77	81	79	94	84
African palms	63	70	85	72	77	74	89	80
Oranges	63	71	86	74	78	76	90	81
Sugar cane	61	68	83	70	75	73	87	78
Beef/dairy cattle	51	55	68	55	61	59	71	64
Lemons	35	35	46	32	39	39	48	44
Beans	27	25	35	20	28	29	36	33
Melons	23	20	30	15	23	24	31	28
Potatoes	22	19	29	14	22	23	30	27
Rice	12	6	14	<0	8	10	14	14
Beef cattle	11	6	13	<0	7	9	13	13
Mangoes	3	<0	1	<0	<0	<0	<0	1
Managed forestry	3	<0	2	<0	<0	<0	1	2

* Tiquisque and yucca are roots similar to cassava.

Source: René Castro Salazar, «Valuing the Environment Service of Permanent Forest Stands to the Global Climate: The Case of Costa Rica», unpublished doctoral dissertation, Harvard University, June 1999.

In the third stage, from 1997 to 1998, the Ministry decided to address the Inspector General's concerns by auctioning credits to the highest bidder. This time it assembled enough projects to sequester 1,000,000 tons of carbon and offered them at a floor price of $20 per ton. Although a number of governments and multi-national firms expressed interest in the auction, in the end there were no bidders. The Ministry was told privately by some bidders that the floor price was too high. The Ministry also suspected that uncertainty about the new additionality requirements that had just been established under the Kyoto protocol might have been a factor. To help address the additionality question, in March 1998 the Ministry hired a world-famous French technical certification firm to audit

the project and attest that the reforestation would take place as promised [13]. But the Ministry delayed offering the credits for auction again until after national elections that were scheduled for later that year.

On the pricing question the Costa Rican Ministry of the Environment had new estimates of how much it would have to pay farmers to switch to forests. The new figures confirmed that the cost was about $10 per ton for the first five million tons but rose steadily thereafter (see Figure 1) due to increasing marginal cost when more expensive land is planted. Bolivia was rumored to have potential buyers at $15 to $20 per ton for its new credits. New studies also suggested that the forestation projects might be feasible in the United States at prices of $20 per ton, only slightly more than the cost of emissions abatement from some U.S. power-generating projects (see Figure 2). In July 1999, the World Bank Prototype Carbon Fund announced a price range of $20 to $30 per ton.

The Central American Potential in the Carbon Market

The carbon market is expected to have a number of standards and regulations [14]. Nevertheless, as discussed for Costa Rica, some pioneering companies have carried out the first transactions without waiting for all the details, jumping ahead of full market regulation and operation. These pioneers are experimenting and learning, lowering costs and trying to position themselves in the emerging carbon market. Leading companies in the energy sector, such as British Petroleum, American Electric Power, Pacificorp and CSW (an electric power company based in Texas), have begun to invest in projects that reduce CO_2 emissions. The first projects have included renewable energy and forest conservation.

Analyses conducted for Central America estimate that a substantial part of the CERs could have production costs of less than $20/ton and suggest an annual CER production volume of no less than 10 million tons. For example, the Harvard-INCAE project estimated annual CER production capacity at 11.5 million tons for plantation and afforestation options and 44.5 million tons if natural forest conservation is included in the accounts, at a cost of less than $15/ton (HIID, CLADS, 2001). In other words, the region could generate between 1 % and 5 % of global CER needs. If these CERs were sold at an average price of $28/ton, they would generate at least $280 million a year for the region and up to five times that amount if the option of marketing forest conservation [15] is included.

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[13] The firm is Société Générale de Surveillance Group which had established a special Forestry Offset Carbon Verification Service.

[14] Since it is known that the Certified Emission Reductions (CERs) will have to be certified by independent and internally recognized firms, prestigious certifying companies, such as the Société General de Surveillance, have started defining their own standards and requirements, thereby expecting to influence the regulations that will be gradually developed in the Convention with concrete experiences and position themselves at an early date. It is expected that in the next two years the rules and regulation for the different trading regimes will be established at the conferences of the parties.

[15] The fifth Conference of the Parties to the Convention, held in Germany in November 1999, failed to resolve the question of which CO_2 emission reduction options in the forestry sector would be eligible to be certified and registered by the Convention. The sixth conference only accepted reforestation and afforestation. Other forest options are still in the limbo and this decision is crucial to the commercial viability of reductions from forest conservation.

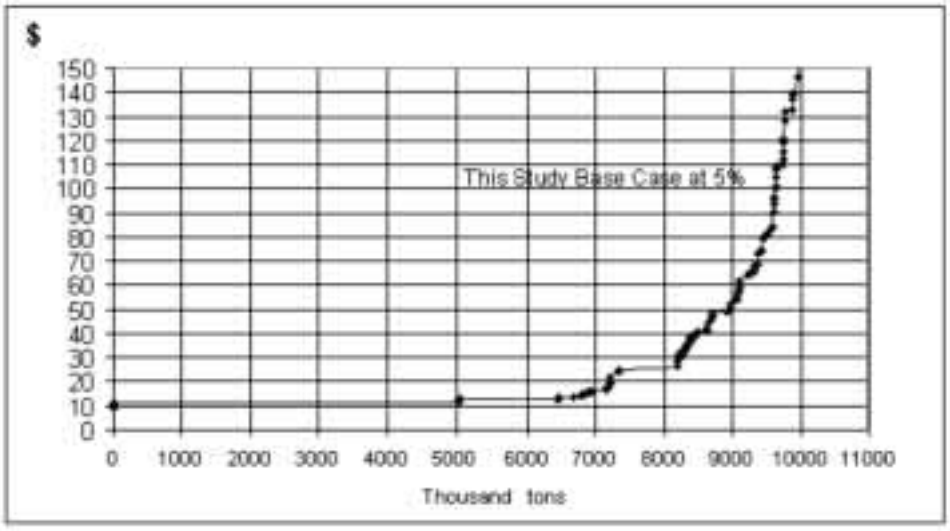

Fig. 1.–Estimates of the Marginal Cost of Forest Carbon Sequestration Projects in Costa Rica

Source: René Castro Salazar, «Valuing the Environment Service of Permanent Forest Stands to the Global Climate: The Case of Costa Rica», unpublished doctoral dissertation, Harvard University, June 1999.

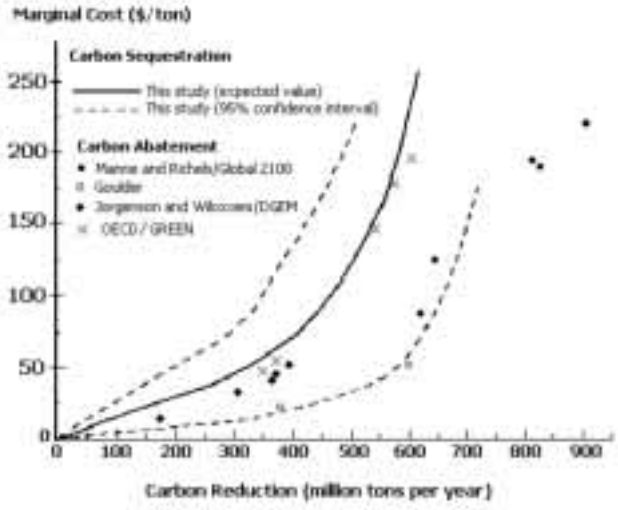

Fig. 2.–Estimates of the Marginal Cost of Forest Carbon Sequestration and Energy Carbon Emissions Reduction Projects in the United States

Note: The *carbon sequestration* lines are estimates of marginal costs for reforestation in the United States. The *carbon abatement* points are estimates of the marginal costs for emissions reductions from U.S. power plants.

Source: Robert N. Stavins, «The Costs of Carbon Sequestration: A Revealed Preference Approach», *American Economic Review,* vol. 89, no. 4 (September 1999), p. 1004.

More specifically, the results of the Harvard-INCAE project indicate that Central America has an annual emission reduction potential of 62.5 million metric tons of carbon (See Table 7). From this total, 71 % would come from activities to reduce deforestation [16], 19 % from plantations and afforestation and 10 % from reducing emissions produced by the use of fuel for energy purposes.

Table 7

Carbon Reduction Potential in Central America (In metric tons of carbon)

Country	Activity				
	Cleaner Fuels	Reduced Deforestation	Plantations	Afforestation	Total by country
Costa Rica	1,223,000	3,360,000	648,000	1,400,000	**6,631,000**
El Salvador	1,991,000	1,584,000	324,000	84,000	**3,983,000**
Guatemala	1,608,000	10,125,000	644,000	2,150,000	**14,527,000**
Honduras	964,000	16,218,000	227,000	2,826,000	**20,235,000**
Nicaragua	747,000	13,200,000	648,000	2,626,000	**17,221,000**
Total	**6,533,000**	**44,487,000**	**2,491,000**	**9,086,000**	**62,597,000**

Source: HIID, CLADS, 2001.

In assessing Central America's market potential, forest activities present greater uncertainty than activities in the energy sector, owing to the legal ambiguities concerning the concept of sinks in the Kyoto Protocol. Furthermore, if activities to stop the deforestation of primary forests are excluded, the Central American region's potential would be about 18.1 million metric tons of carbon a year. At the national level, the scenarios are as follows: if deforestation is included, the country with the greatest services potential in the region would be Honduras with 32 % of the market, followed by Nicaragua with 28 %, Guatemala with 23 %, Costa Rica with 11 % and El Salvador with 6 %. If deforestation is not included and only the energy sector, forest plantations and afforestation are taken into account, the market share would be led by Guatemala with 24 %, followed by Honduras and Nicaragua with 22 % each, Costa Rica with 18 % and El Salvador with 13 %. Table 1 shows the reduction potential by country and activity for each of the above-mentioned scenarios.

The Central American Bank is considering developing a Carbon Fund. Implicit in the Fund proposal is the conviction that the competitiveness and the attraction of environmental services in the Central American countries will show important synergies if they operate as a regional program. For example, economies of scale are important for market studies, certification of groups of projects, reduction of the implementation risks in each

[16] Reduced deforestation and forest conservation are two of the most controversial of the forest options discussed at the Conference of the Parties.

of the projects, and country risk reduction. Regional Funds will provide a more competitive position as compared to countries that can produce important volumes of CERs at competitive prices, such as Brazil, China, India and Indonesia. Consequently, the Central American countries are dedicated primarily to maximizing this synergies among the countries and companies in the region that decide to participate in the emerging carbon market.

In addition, the World Bank and the United Nations Development Program are financing the development of a network of protected areas called the Mesoamerican Corridor that will encompass 8 million hectares in Central America, and 2 million in southern Mexico. This project is based on the idea that these 7 countries share between 60 % and 80 % of the same living species, which will be more likely to survive within large interconnected protected areas. It is reasonable to expect that the figures calculated by Castro in his study, both in terms of carbon productivity and land opportunity cost, are relevant to the much larger Mesoamerican protected areas network, and his estimates of the marginal cost of carbon may apply to this larger region.

CONCLUSIONS

Most researchers and policy makers agree that the overall cost of mitigating CO_2 and other greenhouse gases could be reduced if the carbon trading options proposed in the Kyoto Protocol were implemented. For example, in the short run the cost of carbon abatement could easily exceed $100 per ton in energy projects in industrialized countries. However, if the forestry sector is included, the cost of reducing carbon emissions and sequestering carbon could be reduced to a range between $10 and $100 per ton of carbon. The Kyoto Protocol accepts in principle that a nation's forests-management practices, reforestation or afforestation, may be included in the accounting of net greenhouse gas emissions and their reduction.

These results are very important for two reasons. First, in countries from tropical Latin America and Africa, above 75 % of the projects with CO_2 mitigation potential are forest-based projects. Second, forest projects constitute the least cost option of the emerging 9 billion a year carbon market between industrialized and developing countries. Consequently, if the scientific and political communities could not reach an agreement in forthcoming conferences of the parties, clearly recommending to reduce legal barriers and other limits to forest projects, these projects are likely to produce a minuscule amount of carbon credits.

If forest projects are included, many tropical cattle growers in African countries that are currently making less than $50 per hectare per year will be better off switching to forest friendly activities if the carbon price were to reach at least $10 per ton, while the environment will be used in a more sustainable way. On the other hand, if forest projects are excluded, then fuel-switching projects in big developing countries like China and India will become the second best options, hence, capturing the bulk of the economic and technology transfers from North to South.

Even though this paper basically examines the Central American potential, Andean countries such as Bolivia, Ecuador, Venezuela, Peru, and Colombia with large extensions of land used for subsistence agriculture and extensive cattle ranching, may also have an

opportunity in forest projects that would provide an annual cash flow and a more sustainable alternative for the rural poor [17].

RESUMEN

Bosques tropicales y mercados emergentes de CO_2

Desde la Conferencia Mundial celebrada en Río de Janeiro en 1992, más de 180 países han estado negociando la Convención Marco de las Naciones Unidas para el Cambio Climático, incluyendo una estrategia para reducir las emisiones de gases que se piensa contribuyen al efecto invernadero. El Protocolo de Kioto (1997) –cuya ratificación se ha anunciado recientemente– incluye la posibilidad de permitir a los países con altos costes de reducción de emisiones de alcanzar sus compromisos de reducción a través de la compra de créditos a países en los que la reducción de emisiones es más barata. Esta estrategia está siendo aún debatida, de hecho, en la sexta conferencia de las partes (COP VI) se alcanzó únicamente un acuerdo parcial.

En este trabajo se hace un resumen de las medidas tomadas por Costa Rica, que ha sido pionera desde 1996 en el desarrollo y la venta de créditos de reducción de emisiones. Los créditos de carbono costarricenses provienen principalmente de dos fuentes. La primera, de la conversión de tierras de cultivo y pastizales en bosque, y la segunda a través de la reducción de la deforestación. Durante el año 2001, otros 8 países latinoamericanos ofrecieron créditos de carbono al Fondo Prototipo de Carbono del Banco Mundial. Se analiza en este trabajo cómo los resultados finales del comercio de emisiones dependerán en última instancia de las normas, regulaciones y precios de carbono.

PALABRAS CLAVE: Bosques tropicales
Cambio climático
Dióxido de carbono
Áreas protegidas

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[17] This assumption is based on regional models for land economic rent, that shows large regions in the Andean countries and in Africa with land rents lower than that of the $50 per hectare per year found for cattle growing areas in Costa Rica. We are also assuming that trees in these regions could fix similar amounts of CO_2 than those of Costa Rica (based on models published by FAO).

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