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Human solidarity in a divided world

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Climate Mitigation, Deforestation and Human Development in Brazil

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CLIMATE MITIGATION, DEFORESTATION AND HUMAN DEVELOPMENT IN BRAZIL

Human Development Report 2007 – Thematic Paper
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CONTENT

1. EXECUTIVE SUMMARY

Climate change mitigation in developing countries is a growing priority for many governments. Much of the current research into this area concentrates on emissions from industry and households. However, in many countries changing land use patterns drives carbon flows into the atmosphere. This Thematic Paper for the UNDP Human Development Report 2007 focuses on tropical deforestation as a major source of rising carbon emissions and wider human development problems in the Brazilian Amazon–the largest area of tropical forests in the world. Consistently with the Terms of Reference, this paper cover five broad themes: (i) the scale, pace and location of deforestation; (ii) an analysis of the factors driving deforestation, including public policies; (iii) how deforestation is contributing to carbon emissions; (iv) the human development effects of deforestation, and; (v) what can be done to address the problem.

More of the Brazilian Amazonian forest has been destroyed since 1970 than in the previous 450 years since European colonisation. By 2005, deforestation had exceeded 690,000 Km2 – an area larger than France and Portugal, generating 200 million tons of carbon emissions per year or even higher, and making Brazil the 4^{th} world larger emitter of greenhouse gases. Extensive cattle ranching represents the predominant cause of deforestation in the Amazon – accounting for about 70-80% of the clearing activity– followed by burn-and-slash farming and, over the last few years, rapid expansion of soybean plantations. Other drivers include illegal logging, infrastructure projects, and forest fires. Public policies including weak law enforcement, unsecured land tenure, tax incentives and subsidised credits for cattle ranching and soybean cultivation are all elements promoting forest conversion. Deforestation in the Brazilian Amazon carries significant direct and indirect consequences on human development, including violence and life threat to local communities and indigenous people. Deforestation affects negatively natural resources such as rainfall and freshwater, soil productivity, clean air, and forestry and biodiversity resources–all fundamental for local livelihoods. This massive transformation results in severe socio-economic impacts not only on Amazonians –which are robbed of a potentially sustainable future– but also on areas far beyond the region.

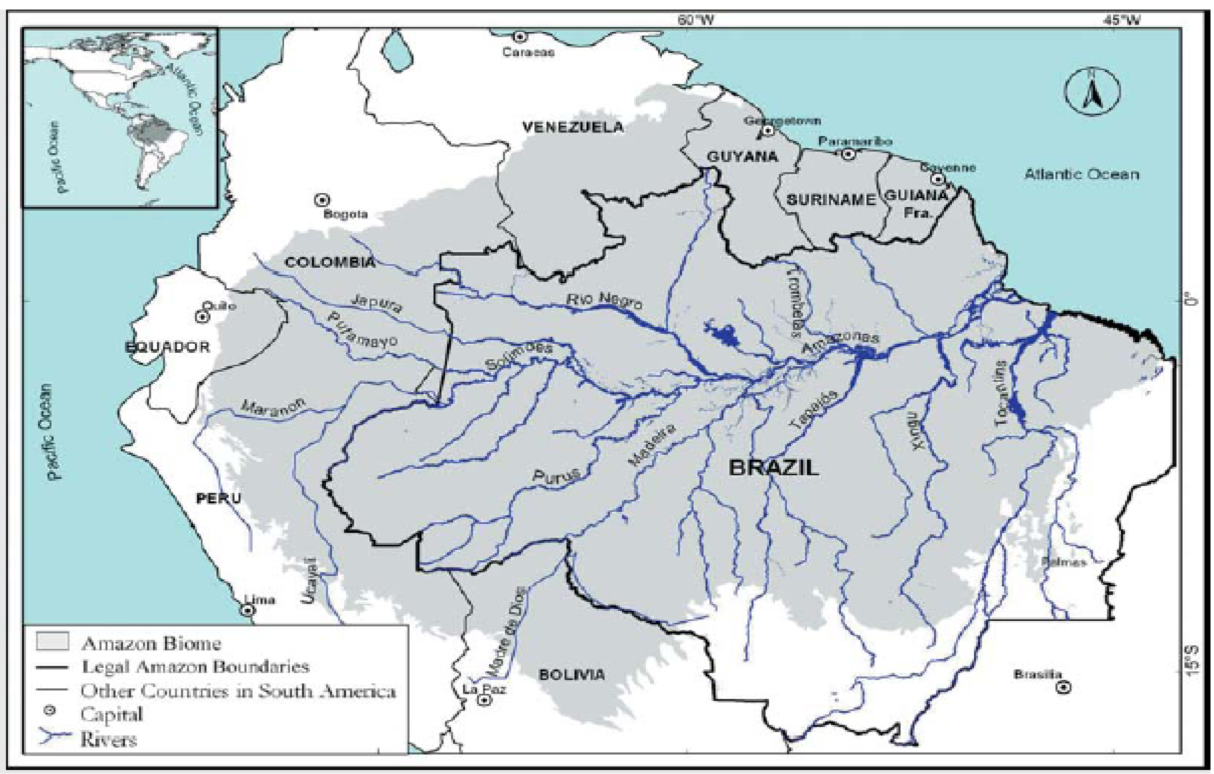
Strategies for reducing and, eventually reverting, deforestation will have to make the cutting of forest more expensive than the potential economic benefits related to it, while creating opportunities for sustainable development of the Amazon. This will require first and foremost a “governance revolution”, whereby existing environmental laws are effectively enforced and land tenure regimes clearly established. Existing tax incentives, credit and subsidies for cattle ranching and agriculture expansion need to be reformed and re-directed to support sustainable forestry and encourage cattle ranching and farming on the area the size of Suriname that has already been cleared and then abandoned. National and international financial institutions can play a key role in this “governance revolution” by conditioning their loans/funding to compliance with minimum socio-environmental criteria aimed at encouraging farmers to obey the forest law and adopt good land stewardship practices. Finally, additional financial resources to enhance the value of standing forests will have to be leveraged through the implementation of schemes for payment of environmental services, including through the international climate regime. This will require the international community to provide incentives to reduce emissions from tropical deforestation under the UN Climate Change Convention and/or the Kyoto Protocol, while Brazil must urgently establish a national quantifiable emissions reduction programme.

2. THE SCALE, PACE AND LOCATION OF DEFORESTATION IN BRAZIL

BRAZIL'S TROPICAL FORESTS

Brazil holds about one-third of the world's remaining rainforests, including a majority of the Amazon Basin – a mosaic of ecosystems and vegetation types including rainforests (the vast majority), seasonal forests, deciduous forests, flooded forests, and savannahs, and comprises the largest and most species-rich tract of tropical rainforest in the world. For this, Brazil is also overwhelmingly the most biodiverse country on Earth, with more than 56,000 described species of plants, 1,700 species of birds, 695 amphibians, 578 mammals, and 651 reptiles (Capobianco et al. 2001). The Brazilian Amazon overlaps with two other geographic areas: the Amazon Basin and the Legal Amazon (see Figure 1). The Amazon Basin includes 25,000 km of navigable rivers and extends over 6.9 million km2 – roughly the size of the forty-eight contiguous United States – through Venezuela, Colombia, Ecuador, Peru, Bolivia, Brazil, French Guiana, Guyana, and Suriname (Barreto et al. 2006). Sixty percent of the Amazon Basin lies within Brazil's boundaries, and this portion is known as the Brazilian Amazon, which covers about 4 million km²–roughly the size of the European Union. The Legal Amazon contains approximately 5 million km² or 50 % of Brazil's territory and is an administrative unit –defined by law in 1966 – that encompasses the states of Acre, Amazonas, Roraima, Amapá, Pará, Rondônia, Mato Grosso, Tocantins, and Maranhão. Portions of the states of Maranhão, Tocantins, and Mato Grosso are outside of the Amazon Basin. Most of the existing official statistics available are for the Legal Amazon.

Figure 1: Amazon, Brazilian Amazon, and Legal Amazon. *Source: Barreto et al. 2006..*



Outside the Amazon, Brazil does have other tropical forests. To the south of the Amazon is an expanse of forest that lies in the Tocantins River system. A small area of forest, greatly reduced by urbanisation and agriculture to less than 7% of its original cover, is found along the Atlantic seaboard in Brazil. Known as the *Mata Atlântica* (Atlantic Forest), this ecosystem is home to the world-famous golden lion tamarin. Other important Brazilian ecosystems are the Pantanal biome, an inland wetland that borders Paraguay and Bolivia and covers an area of 154,884 km², and the *cerrado* biomes, a tropical grassland that covers 1,890,278 km², or approximately 22 percent of the country. Considered that the Brazilian Amazon is home to the largest rainforest on the Earth, this paper will focus on this region to study the causes and dynamics of tropical deforestation and its impacts on climate change and human development.

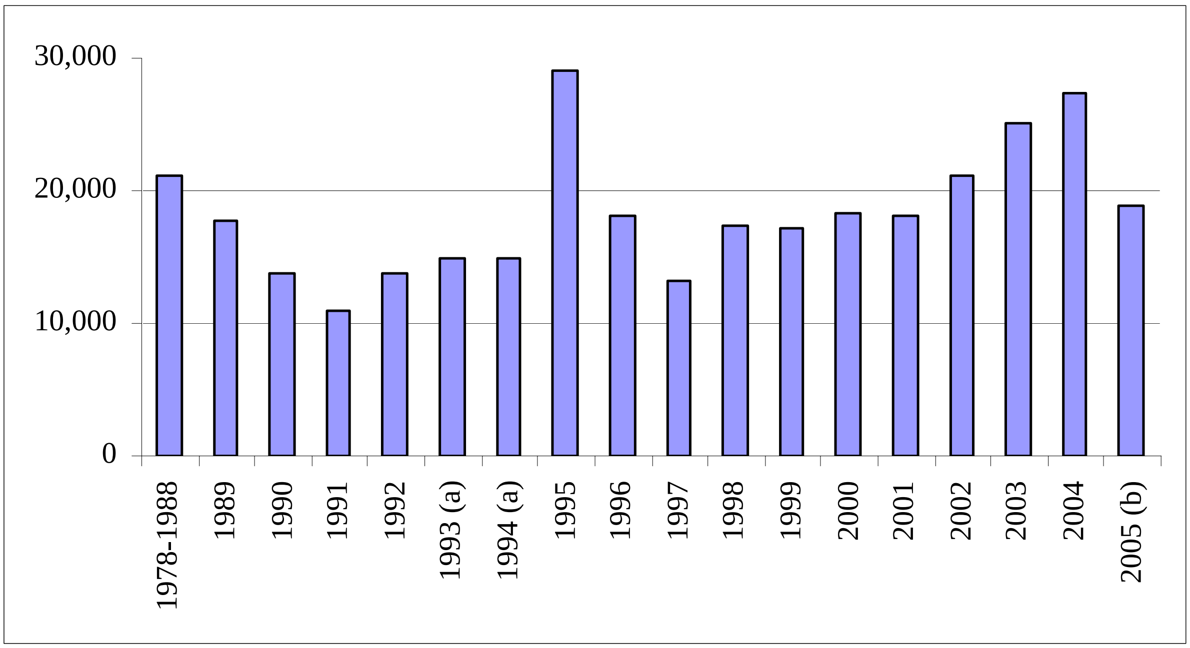
HISTORY OF DEFORESTATION

Prior to the early 1960's, the Brazilian Amazon has been protected from threats due to its isolation – access was difficult, there were limited settlements, and resource extraction was confined to immediate margins of navigable rivers. This pattern began to change in the 1960s due to three factors: a major infrastructure build up (new roads such as the Trans-Amazonian Highway, establishment of planned rural settlements, airports, and hydroelectric dams); the concession of subsidised credit channelled primarily to large scale ranching; and the establishment of a free port in the city of Manaus. As a result, more of the Brazilian Amazon's forest has been destroyed since 1970 than in the previous 450 years since European colonisation (Lovejoy 1999). By 2005, forest cleared had exceeded 690,000 km² (~268,000 square miles) – larger than the size of France and Portugal combined– (~17 % of the 4 million km² originally forested portion of Brazil's 5 million Km² Legal Amazon Region, including approximately 100,000 km² of "old" (pre-1970) deforestation in Pará and Maranhão (Fearnside 2005) (see Figure 2).

One of the worst period of destruction occurred from 1978 to 1988, when about 21,000 Km² of forest were destroyed a year (see Figure 1). From 1988 to 1991, there was slowdown in the rate of deforestation due to Brazil's unravelling economy (1991 was an exceptionally low year because Brazilian bank accounts were frozen) and in 1992, 13,786 Km² of forest was cleared. In 1993 and 1994, rainforest deforestation increased to an average of 14,896 Km² per year. In 1995 deforestation reached previously unrecorded levels. 29,059 km², or about 3.4 km² every hour, of Amazonian forest were cleared as a reflection of the economic recovery under the 'Plano Real'. The reforms increased the availability of capital (used for forest clearing) and municipal elections in 1994 also resulted in an increase in agricultural credit that spurred deforestation (Fearnside 2005). In 1996, deforestation slowed to 18, 161 km² while 1997 figures show that 13,383 km² disappeared. The 1996-1997 decline in deforestation rates accompanied a drop in land prices by over 50% over the same period –a price decrease that is best explained as the result of the greatly reduced rate of inflation having eliminated the role of land as an inflation hedge. The association of falling land prices with reduced deforestation rates suggests that a significant part of the deforestation that was taking place in prior years was motivated by speculation (Fearnside 2002). During the 1998 El Niño episode, forest loss was accelerated through the downward spiral of land use, drought and fire. 40,000 km² of dried out forest burned during that year. In these areas half of the adult trees were killed, wildlife was devastated, and the likelihood of recurrent fire increased (Nepstad 2005). As a result deforestation increased by 30% to 17,383 km² of forest in 1998.

In the first few years of the millennium, deforestation rates climbed substantially to 27,400 km² in 2004, 50% above the long-term average. This can be partly attributed to growing demand for soy in Europe and China, and soaring prices for beef which coincided with the weakness of the Real (Nepstad et al. 2006). Conversely, with the decline of soy and beef prices in 2005 and 2006, the strengthening of the Real against the dollar, but possibly also to enhanced law enforcement, deforestation rates slowed to 18,800 and 13,100 km² respectively (INPE 2006). However, this decrease was not uniform. In some regions, like Roraima, deforestation dropped by 51%, but in the Maranhão it increased by 22% and in Tocatins by 72% due to the expansion of soybean cultivation (INPE 2006). There is little evidence for a sustained declining trend. Currently soy prices are climbing again as the demand for corn to make ethanol grows in the US, as sugar cane production expands in Brazil, and as the demand for soy oil as a diesel substitute increases. In the absence of policy reforms and large-scale economic incentives for sustainable development of the region, deforestation rates are likely to increase again with a rebound of international soybean and beef prices.

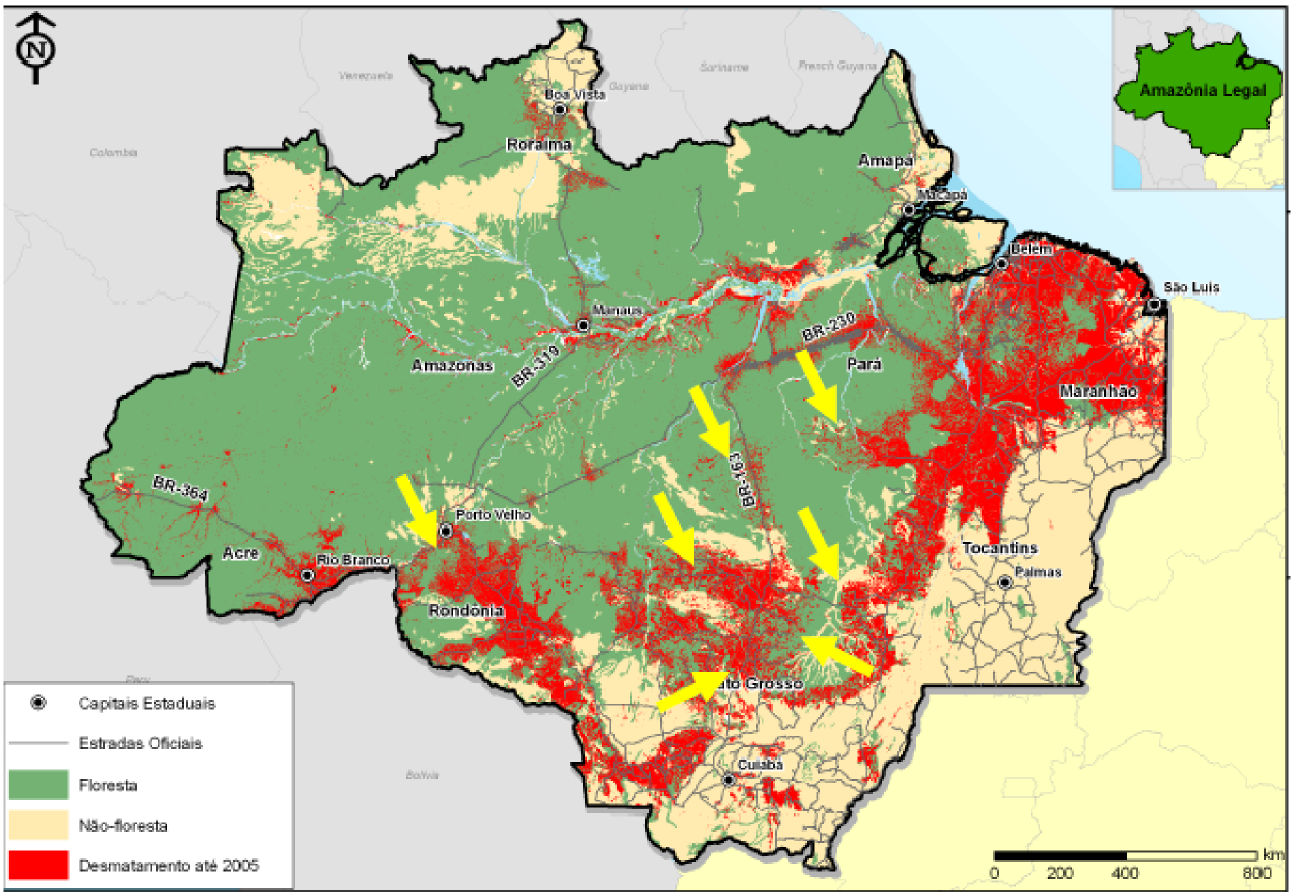
Figure 2: Deforestation rate in the Amazon (Km²). *Source: INPE 2006*



LOCATION OF DEFORESTATION

The majority of deforestation is concentrated along a so-called 'Arc of deforestation', including the following states: the south-east of Maranhão, the north of Tocantins, the south of Parana, the north of Mato Grosso, Rondonia, the south of Amazônas and the Southeast of Acre (see Figure 3). In absolute terms, Mato Grosso and Para are the 'champions' of deforestation in the Brazilian Amazon (see Figure 4), with the majority of the forest clearing between 2000 and 2005 occurred in these two states. However, the former increased significantly its share of total deforestation, from 35% in 2003 to 48.1% in 2004, while the latter decreased its participation, going 36% in 2003 to 15% in 2004 (Alencar et al. 2004). In 2005, Mato Grosso was responsible for 40% of deforestation in the whole Brazilian Amazon. In this region, deforestation focuses located along the federal roads BR-364, BR-163 e MT-158, driven primarily by commercial agriculture and cattle ranching and secondly by illegal gold mining (IBGE 2006). In Para, most deforestation is concentrated along federal roads such as the Transamazônica and the BR-163, in addition to the state road PA-150. In the west part of the state, a clandestine gold mine is affecting the National Forest of Altamira. Until 2003, iron-pig industries around the Carajás region were also a driver for deforestation. In relative terms, Rondônia is the state with the highest rate of deforested area, which is 28.50% of its surface in 2005 compared to only 1.76% in 1978 (IBGE 2006). Concerning municipalities with the highest increase in deforestation, the municipality of Aripuanã, ranked first in 2004, followed by Novo Progresso. In São Félix do Xingu, historically the most deforesting municipality, forest clearing has decreased by 40% in 2004 because increase in monitoring and law enforcement.

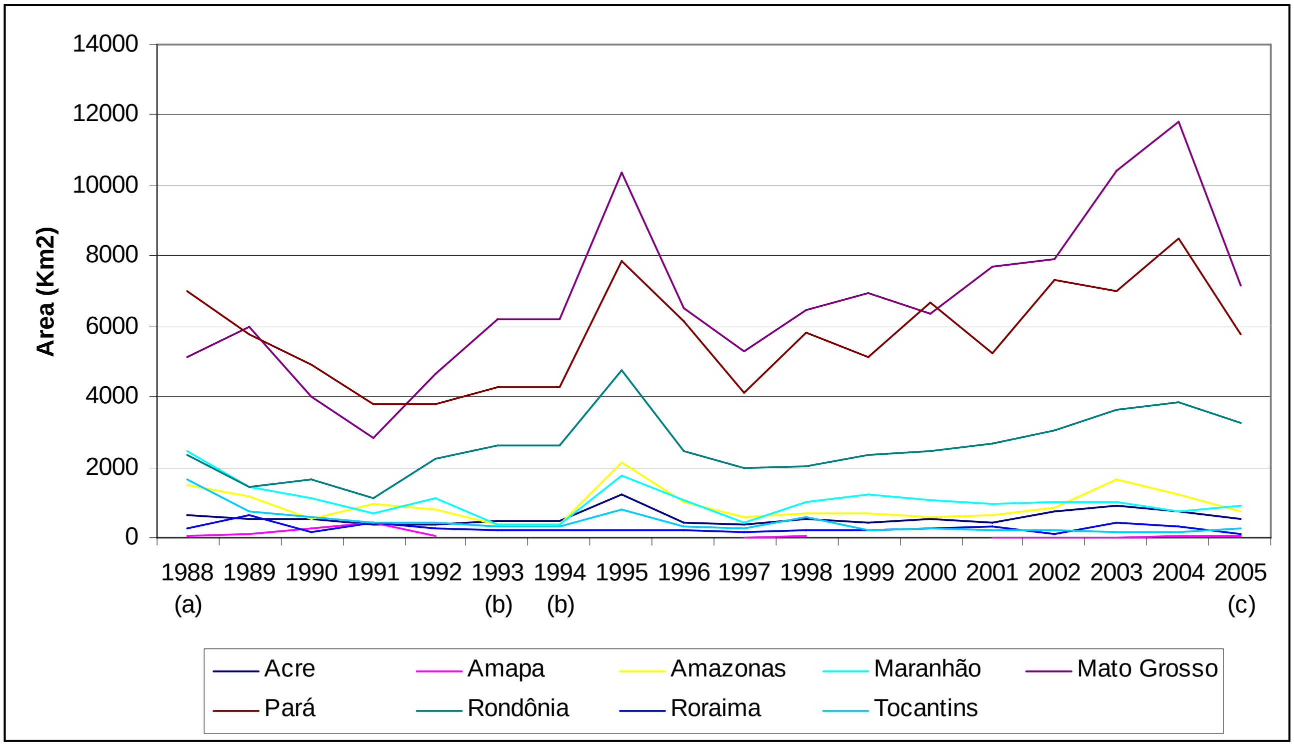
Figure 3: The so-called 'deforestation arc' in 2005; *Green = forests vegetation; White = No forest area; Red = deforested areas in 2005. Source: INPE 2006.*



RESPONSIBILITY OF DEFORESTATION

Understanding whom is to blame for deforestation is crucial for any public policy attempting to reduce it. In many tropical countries, the majority of deforestation is due to actions from poor subsistence cultivators. In Brazil, however, poor people are believed responsible for 18-25% of deforestation in the Brazilian Amazonia (Chomitz et al. 2006, Alencar et al. 2004). On the contrary, most of deforestation is undertaken by large-scale well-capitalised landowners because forest clearing is expensive and, at large scale, it requires mechanical equipment. Surveys carried out in 1998 indicates that slightly over half of the clearing done over the 1997-1998 period in the Brazilian Amazonia was in the form of continuous patches at least 100 hectares in area (Nepstad et al. 1999), a scale of activity that exceeds by at least 20 times what a small farmer can clear in a single year using family labour. Another quarter of deforestation occurred on clearing larger than 200 hectares.

Figure 4: Deforestation rate in the Brazilian Amazon by state (1988-2005, Km²). *Source: INPE 2006.*



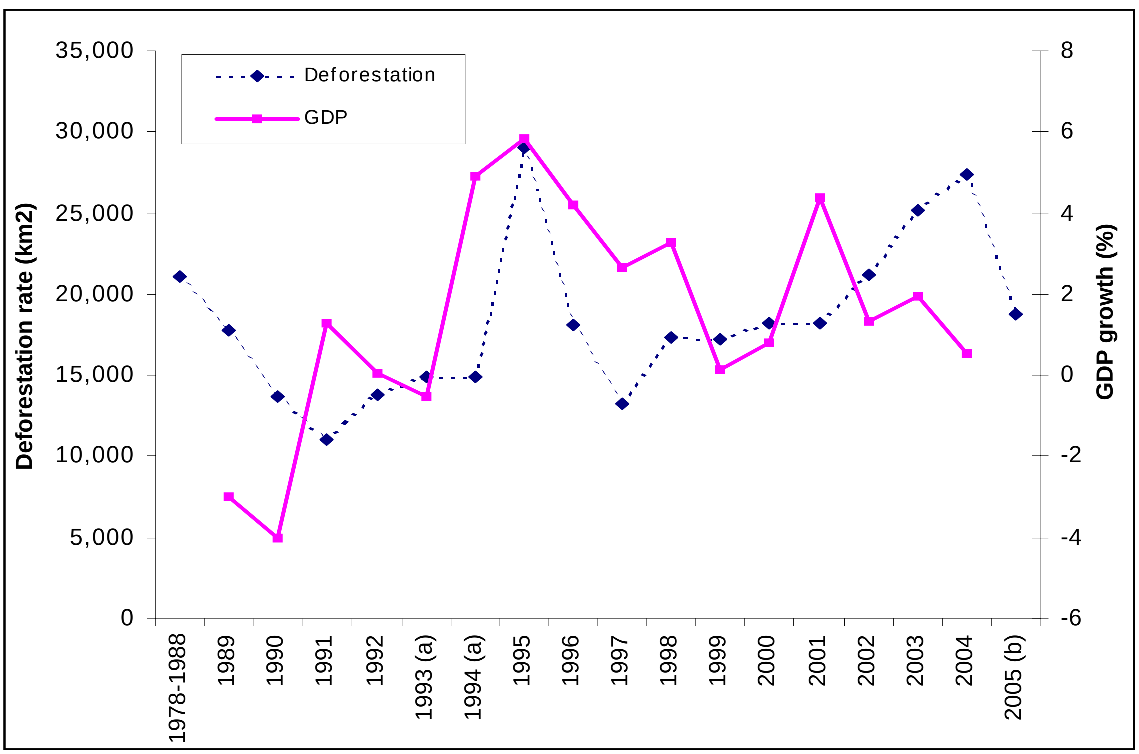
3. DRIVERS OF DEFORESTATION

Various studies have analysed deforestation in the Brazilian Amazon and identified both direct and indirect drivers (Alencar et al. 2004, Fearnside 2005). These include cattle ranching, subsistence agriculture, soybean production, illegal logging, infrastructure projects, and forest fires. These activities are driven indirectly by factors like weak enforcement of environmental regulations, unclear land tenure, national tax incentives and subsidised credits, and growing international demand for beef and soy.

DOMESTIC VS INTERNATIONAL DRIVERS

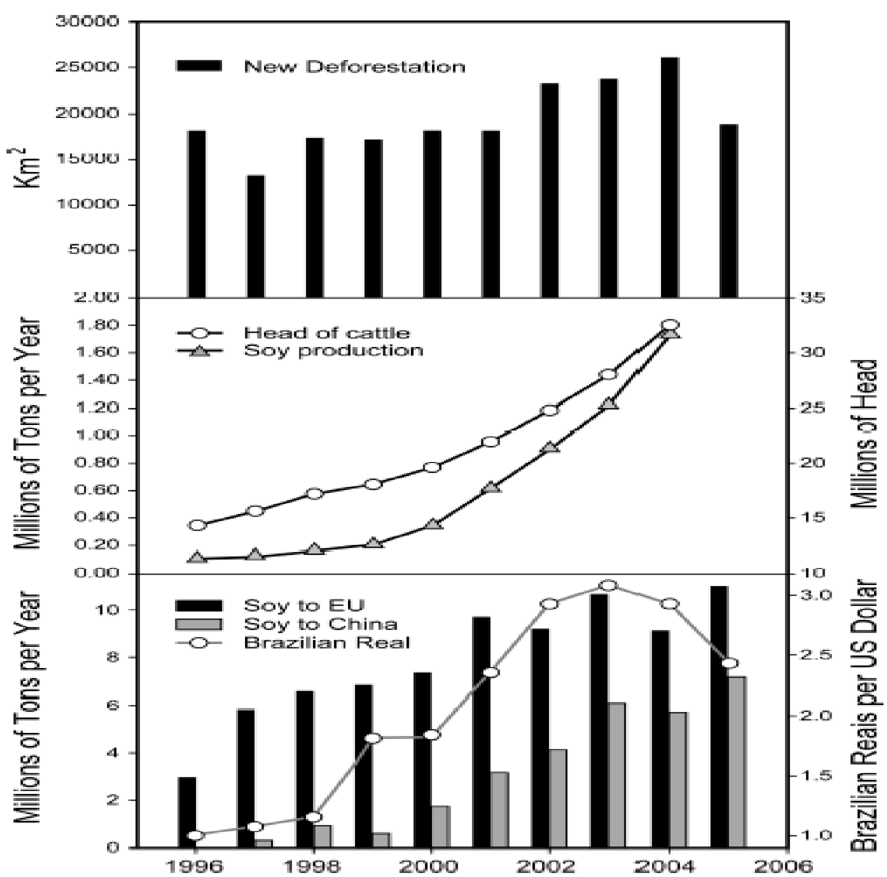
For many years, federal governmental policies promoting the integration of the Amazon region with the Brazilian national economy were the primary drivers for deforestation. This includes federal road cuts into the rainforest, accompanied by public colonisation programmes in the 1970s and generous tax incentives and subsidised credits for large-scale cattle ranching in the 1970s and 1980s. Figure 5 shows the historical correlation between deforestation trends and the economic health of the country. Brazil's economic recession best explains the decline in deforestation rates from 1987 through 1991, while the rocketing rate of deforestation from 1993-1998 paralleled Brazil's period of rapid economic growth (Alencar et al. 2004). This is because during times of economic slowdown, developers and ranchers do not have the financial resources to rapidly expand their pasturelands and operations, while government lacks funds to support infrastructure projects and colonisation programs and grant tax breaks and subsidies to forest exploiters.

Figure 5: Annual increase of national GDP (%) vs annual deforestation rate, 1998 -2005
Source: Deforestation data from INPE (2006) and economic data from IBGE (2006)



Since the end of the 1990s, the Amazon is undergoing a second phase of colonisation where the factors driving deforestation have become to shift away from Brazil's domestic policies and economy to the international market (Nepstad et al. 2006). Governmental subsidies and tax incentives play less of a role and the profitability of extractive activities (logging) and commercial agriculture/cattle-raising are driving the expansion of the agriculture frontier and, consequently, deforestation rates (Margulis 2003). On the margins of this process are the small farmers that depend on their own labour and produce to satisfy their basic needs and therefore contribute to the base deforestation rate to a much lesser degree. As shown in Figure 6, two of the largest deforestation rates on record took place in 2003 (~24,000 km²) and 2004 (~25,000 km²) were triggered by booming world demand for beef and soy, coupled with a substantial devaluation of the Brazilian currency (REAL) at the beginning if 1999 (Nepstad et al. 2006). A strong correlation between deforestation and the average annual price of soybeans has been found (Douglas Morton et al. 2006). As soybean prices rose from US$ 184 to 277 in 2004, the conversion from forest to cropland increased, while the amount of land converted to pasture declined. In 2005, soybean prices fell by more than 25% and some areas of Mato Grosso showed a decrease in large deforestation events, although the central agricultural zone continued to clear forests. Deforestation rates could return to the high levels seen in 2003-2004 as soybean and other crop prices begin to rebound in international markets.

Figure 6: Trends in Amazon deforestation, cattle herd and soy production and exports, and the value of the Brazilian real. Cattle heard and soy production were calculated from IBGE (2005) data, excluding those *municipios* in which the original vegetation is primarily *cerrado* woodland. *Reproduced from Nepstad et al. 2006a.*



CATTLE RANCHING

Extensive and low-yield cattle ranching, typically by relatively wealthy land-owners, represents the predominant cause of deforestation in the Amazon. Around 70-80% of the area deforested was cattle pasture by 1995 (Fearnside 2005; Arima et al. 2005). This area could be even larger considering that parts of pastureland have been abandoned and are classified as unused land. Lower land prices and slightly higher productivity make mid- and large-scale pastures more lucrative in the Amazon than in other regions of Brazil (Margulis 2003). Furthermore, low-density ranching (i.e., less than one head per hectare) offers a lower financial risk than soybean, rice, or corn production (Schneider et al. 2002).

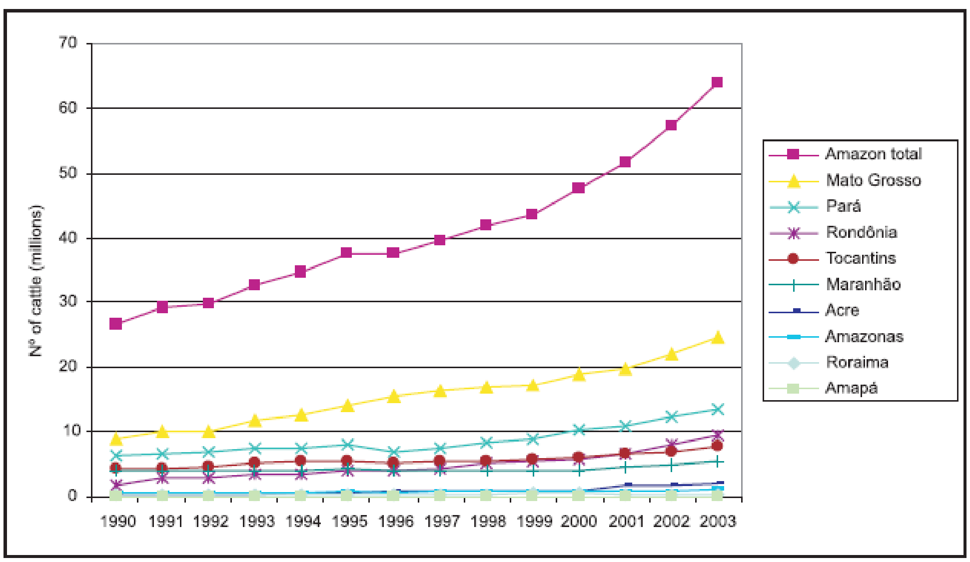
Historically extensive cattle ranching have been encouraged by generous governmental subsidies, land tenure rules, and fiscal policies (Fearnside 1993). In the 70s and 80s, various federal subsidies schemes promoted deforestation. For example, the Superintendency for Development of Amazonia (SUDAM) programme offered certain corporations a tax credit scheme that promoted live stock ranches in the legal Amazon. Designed to improve economic development in the region, it resulted in rapid deforestation, modest afforestation, and enormous fiscal costs (exceeding $1 billion US dollars in the time period between 1975 and 1986) (Binswanger, 1991). Although the SUDAM was closed in 2001, other rural development programs continue to promote the development of cattle ranching in the region (Margulis 2003). For instance, between 1989 and 2002, the *Banco da Amazônia* (Amazon Bank) lent around U$ 5.8 billion from Federal development funds, of which at least US$ 2.36 billion (40%) was for cattle ranching (Barreto et al. 2006). Low-productivity cattle ranching continues to expand also due to land tenure rules and land speculation. As land titling in Brazil depends on demonstration of “productive uses” of the land, replacing the forest with pasture is the cheapest way to occupy an area and protect it from take-over by squatters, neighbouring ranchers, or governmental agrarian reform programmes. Pasture also counts as an “improvement” (*benfeitoria*) to justify the granting of a definitive title (Fearnside 2000). Additionally during the 70s-80s, land value in Amazonia steadily increased at a rate higher than Brazilian rampant inflation, so ranching served a role as a store of value. Furthermore, the tax system incentives deforestation. Uncleared forest-land is considered unused, resulting in higher taxes. If that land were simply cleared for no reason, taxes would fall (Binswanger 1991).

In recent years, rising deforestation has been fuelled by the dramatic growth of cattle ranching in the Amazon (see Figure 7), driven by growing international demand, mainly from Europe (see Figure 8). Between 1990 and 2003 the cattle herd of the Brazilian Amazon grew from 27 million to 64 million head, more than in France (Kaimowitz et al. 2004). Accordingly, the Legal Amazon increased its participation in the national herd from 22% to 33%. In this period, Mato Grosso and Para were the principal producers, accounting for almost 60% of the region’s herd in 2003 (IBGE 2007). This growth is largely export driven. For the first time domestic beef consumption –for decades responsible for the sector's expansion– developed slower than exports, which increased more than seven-fold from approximately 250 million tons in 1996 to over 1800 million tons in 2006 (US$A 2006) (See figure 8). Between 1990 and 2001 the percentage of Europe's processed meat imports that came from Brazil rose from 40 to 74%. Since 2004 Brazil has been the world’s largest beef exporter, with 38% of its exports destined to the EU, 12% to Middle East, and 10% to Russia (IBGE 2006). There are several reasons for this increase in Amazon beef exports, including:

- *Improvements in beef production*. The southern Amazon cattle industry has modernised. Ranchers are now using artificial insemination, tracking of animal origins and sojourns, and improved pasture management techniques (Arima et al. 2005).
- *Eradication of Foot and Mouth Diseases (FMD)*. Foot and mouth disease (FMD) has been eradicated in a large region (1.5 million km²) of southern Amazonia including the states of Mato Grosso, Acre, and the southern half of the State of Pará (Kaimowitz et al. 2004). This has granted access to outside markets. Despite a new outbreak of FMD in 2005 that led several countries to ban meat imports from regions affected by the disease, Brazil will remain a significant player in world meat markets (Valdes 2006).
- *Outbreaks of Bovine Spongiform Encephalopathy (BSE)*. The outbreaks of BSE –or mad-cow disease– in Europe resulted in growing demand for open-range, grass-fed cattle, because of health concerns associated with ration-fed systems of cattle production (Economist 2006).
- *Currency devaluation*. The devaluation of the Brazilian currency (the real) has increased the competitiveness of Brazilian beef on world markets. From 1997 to 2003, the exchange rate of a real for a dollar increased nearly threefold, from 1.04 to 3.05, lowering the price of Brazilian commodities, including beef, in the international marketplace.

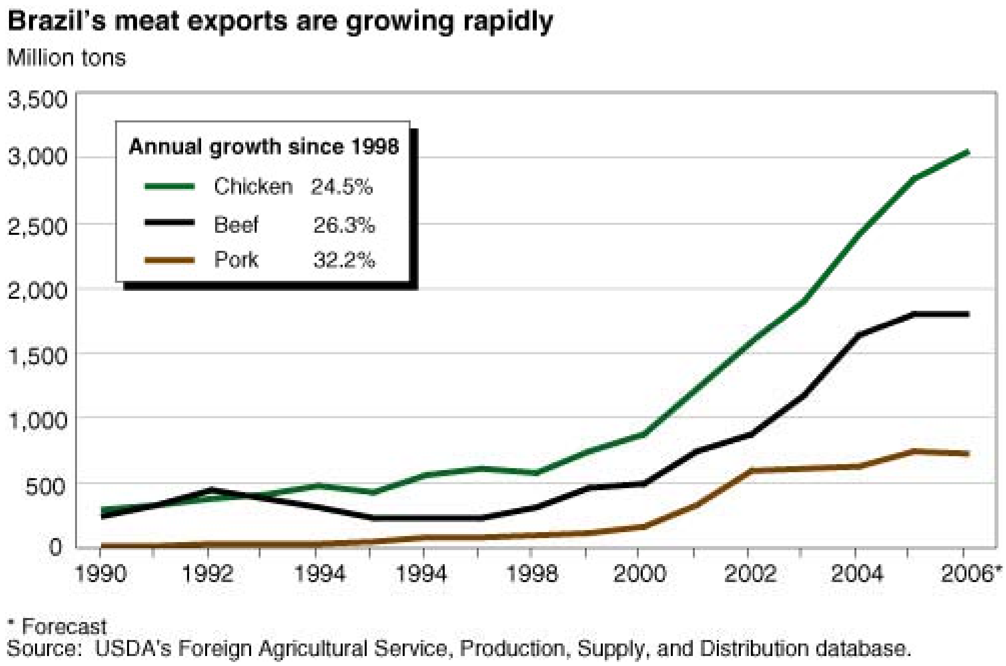
In addition to exports demand, reduction of pasture in the Centre-South of Brazil is also like to drive cattle ranching further into the Amazon. The substitution of pasture by intensive agriculture would continue because its profitability tends to be greater than that of pasture, and there are projections of a significant increase in grain production in Brazil in the next decade. Finally, infrastructure investments planned for the Amazon –such as the asphalting of the Highway BR-163 (Cuiaba-Santarem), of one stretch of the BR-364 in Acre and of the BR-319 (Manaus - Porto Velho)– will make cattle ranching in the region even more competitive (Barreto et al. 2006).

Figure 7: Cattle heard growth in the Brazilian Amazon states (1990-2003). *Source: IBGE*



2006.

Figure 8: Growth of Brazilian meat export (1990-2006). *Source USDA/FSA 2006.*

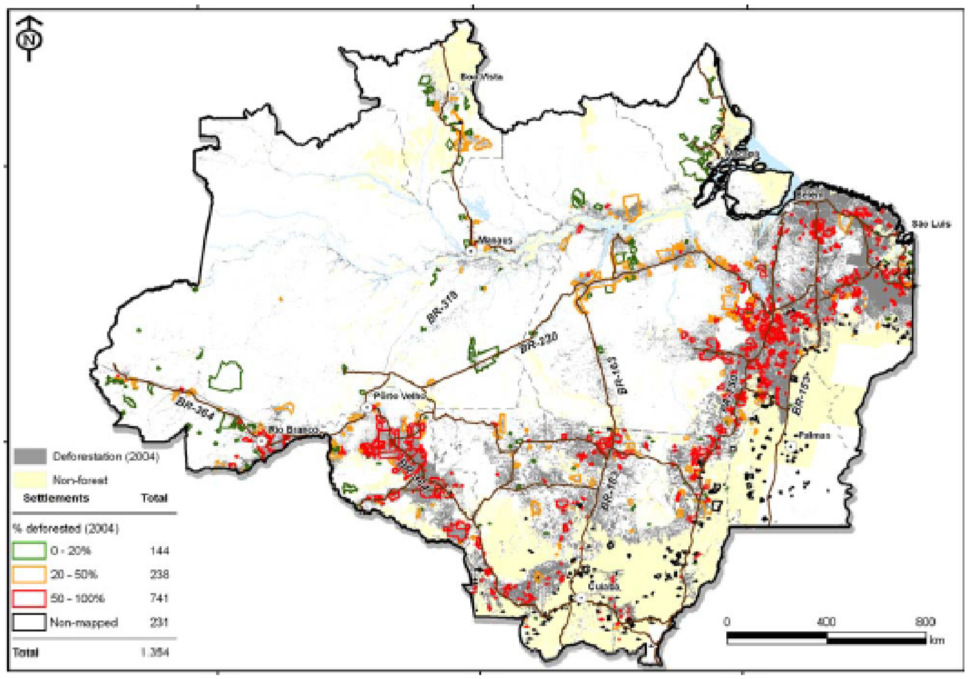


SUBSISTENCE AGRICULTURE

The second factor contributing to Amazon deforestation is slash-and-burn farming, estimated to be responsible for 18% -30% of the felled area (Alencar et al. 2004, Fearnside 2005) (See Figure 9). Typically subsistence agriculture is conducted by small landowners who clear 1-2 hectares of forest each year (Laurance et al. 2004). The forest's shrubbery is cleared and then forest trees are cut. The area is left to dry for a few months and then burned during the dry season. The ash from the burned vegetation provides a brief pulse of plant nutrients. Crops like bananas, palms, manioc, maize, or rice are planted for a few years before the area is left to fallow and the farmer is forced to clear more forest. Slash-and-burn farming can occur both opportunistically (often illegally) or as a result of government-sponsored colonisation programme. The former occurs because squatters acquire the right to continue using a piece of land by living on a plot of unclaimed public land and "using" it for at least one year and a day. After five years, the squatter acquires the ownership and hence the right to sell the land. Up until at least the mid-90s, governmental policy also allowed each claimant to gain title for an amount of land up to three times the amount of forest cleared (Binswanger 1991).

Tracts of primary forest have also been distributed to poor farmers as a result of governmental colonisation programs. Between 1994 and 2002, the number of families receiving land from the government grew from 161,500 to 528,571, reaching over 750,000 in 2003 (Fearnside 2005). The federal government provides subsidies to agrarian reform settlers in the form of food allowances, money for housing and credit at reduced interest rates. Combined with the adjudication of legal rights, this makes agrarian reform settlers more prone to deforest than small-scale settlers elsewhere. Given that household income tends to be relatively low, many families abandon or (illegally) sell their lots to seek new settlement areas or migrate to urban centres. Consequently, an estimated 50-60% of land in agrarian reform plots in southern Pará has been illegally sold (Agência Estado 2004). Some of this land becomes consolidated in larger land holdings, which tend to be more economically efficient and profitable. Overall, the federal government acknowledges that land reform has led to “environmental and social losses, deforestation, and abandonment and subsequent concentration of land ownership” (PDR 2004).

Figure 9: Deforestation up to 2004 (%) in the settlements created in the Brazilian Amazon from 1970 to 2002. *Source: Brandão 2005 et al.*



SOYBEAN PLANTATIONS

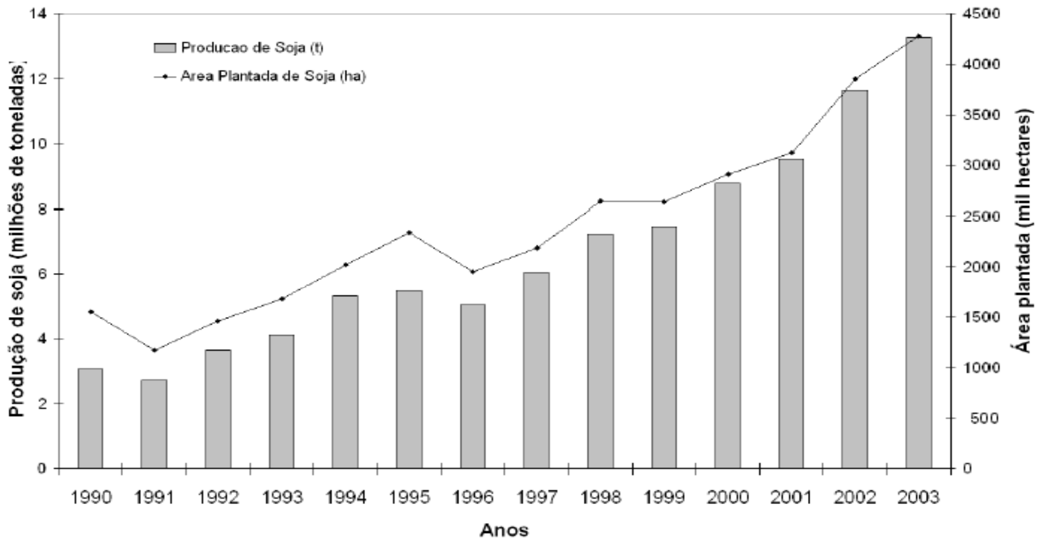
Soybeans have become one of the main economic forces behind the expansion of the agricultural frontier in the Brazilian Amazon, contributing both directly and indirectly to explosive deforestation rates in recent years (Fearnside 2005, Nepstad et al. 2006). Until 1980s, soybean production in the region was almost non-existent due to the lack of varieties adapted to Amazon soils and climate. Soy expansion began in 1997 when new soy varieties were developed that tolerated the humid, hot Amazon climate. Between 1998 and 2002 soybean production in the Brazilian Amazon states grew approximately 60%, making Brazil the second largest soybean exporter (USDA 2006). While soybeans’ economic returns are high, the expansion of the crop is geographically much more limited than cattle ranching. Growth has been concentrated in relatively flat and dry zones along the eastern and southern margins of the Brazilian Amazon, usually on already deforested pastures or in areas originally covered by shrub savannah vegetation (*cerrado*) in the states of Mato Grosso and Maranhão. Figure 10 shows the booming growth of soy plantations in Mato Grosso.

By occupying pasture areas, soybeans displace cattle ranching from the margins to the core of the Amazon region, causing an indirect impact on deforestation. This process promotes intense land speculation –in Mato Grosso the price of fields in local currency quadrupled between mid 1999 and the end of 2004 (Chomitz et al. 2006). As a result, cattle ranching and other land uses are pushed onto cheaper and more distant lands, stimulating expansion within the forest. In 2003, more than 20 percent of the forests in the state of Mato Grosso were converted to cropland, suggesting that the recent expansion of mechanised cropland in the region is contributing significantly to deforestation (Fearnside 2005). Soybeans have also begun to be raised directly in some forest areas due to the building of ports and highways in the core of Amazon which reduced transportation costs (Alencar et al. 2004). For instance, only five years ago, much of the land around Santarem was heavily forested. But when the soy company Cargill announced plans to build two grain silos, a US$ 20 million terminal and its own port to make possible soy export through the Amazon River, land prices rocketed and soy took off as farmers from all over Brazil arrived to take advantage of guaranteed markets. Satellite images show that in two years, deforestation rates doubled to 28,000 hectares (69,000 acres) a year (Chomitz et al. 2005, Greenpeace 2006).

The development of soybean varieties suited to the Amazonian climate, improvements in transport and storage infrastructure, devaluation of the Brazilian Real, and growth in international demand for soybeans, particularly from Europe and China are the drivers behind these increases (Vera-Diaz and Schwartzman, 2005). The European Union has become the most important market for soybeans grown in the Amazon, since mad cow disease outbreaks increased demand for soybeans as a source of protein in cattle rations. Europe's soy imports from Brazil have grown by 15% between 1999 and 2003. Currently, one half of the EU's soy imports –about 6 million tons– is from Brazil. China represents another important market as its growing middle class consumes more soy-fed port and poultry. Brazilian soy exports to China increased from one million tons to four million tons between 1999 and 2003. In 2003, the country imported 21 million tons, 83% more than it imported in 2002. 29% percent of this soy came from Brazil (Nepstand et al. 2006).

World trade in and processing of soy is currently concentrated in the hand of a small number of global commodity traders, including ADM, Bunge and Cargill. In Brazil, this cartel provides farmers with seeds, fertilisers, and chemicals in return of soy at harvest. Together these three companies are responsible for about 60% of the total financing of soy production in Brazil and control almost 80% of the EU's soy crushing capacity for meal and oil (Carneiro 2006). Along with these multinationals, soy expansion is promoted by big Brazilian players like the Grupo André Maggi, a major international soy trader headed by Blario Maggi, current governor of the state of Mato Grosso, well known for as 'O rey da soja'- the soy king. The Grupo André Maggi exports over two million tonnes of soy annually (GAM 2006).

Figure 10: Soy production and planted area in Mato Grosso (1990-2003). *Source: Alencar et al. 2004 based on data from IBGE.*

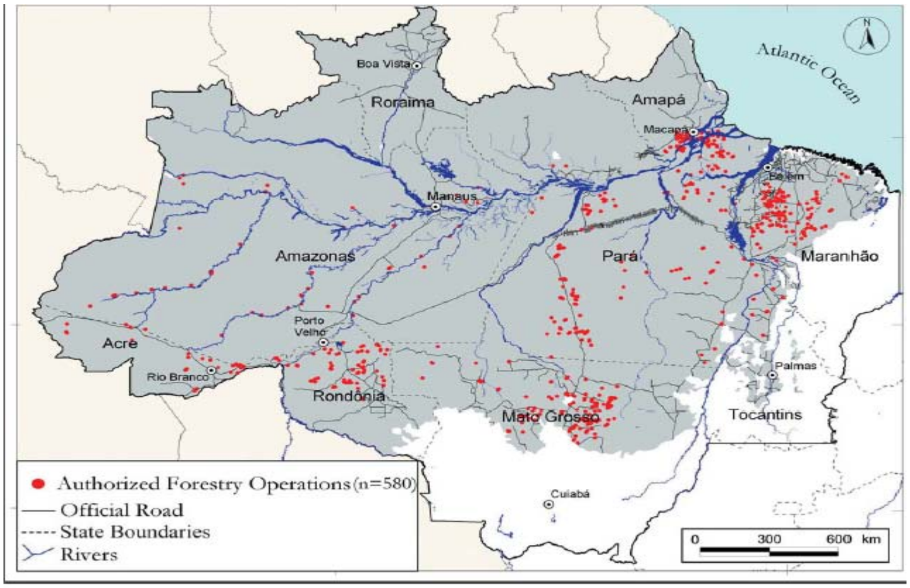


ILLEGAL LOGGING

Unsustainable logging has been a major catalyst of Amazon deforestation. In theory, logging is controlled by strict licensing which allows timber to be harvested only in designated areas. However research concluded that 80% of Amazonian logging was illegal, and recent raids have netted massive stocks of stolen timber (Abramovitz 1998). Typically, the opening of access roads (official or clandestine) allows for the selective extraction of the most valuable tropical hardwoods, such as mahogany. Log sales can help finance the costs of clearing remaining trees and preparing the land for planting of crops or pasture. The Brazilian Amazon is the world's second largest producers of timber, producing 24.5 million cubic meters of logs (around 6.2 million trees or 16,000 km² of forest) and generating US$ 943 million in export incomes in 2004 (Lentini et al. 2005). 36 % of this timber is exported to other countries and the remainder consumed in Brazil.

Illegal logging can severely damage forests. Research using new remote sensing techniques has found that the area degraded by logging (~10,000-15,000 km²) can exceed the clear-cut area in five Brazilian states (Nepstad et al. 1999). The logging process results in the damage of almost twice the volume of the trees being harvested (Veríssimo et al. 1992). Gaps in the forest canopy allow sun and wind to reach the forest. floor, resulting in drier microclimates and making forests more susceptible to fires (Veríssimo et al. 1995). The number of rainless days needed for the understorey to reach flammable condition is much less for a forest that has been logged than for one that has not (Nepstad et al. 2004). Aside from widespread illegal cutting, most legal operations from the hundreds of domestic timber companies in the Amazon are poorly managed (see figure 11 for their location). As a result, in a effort to gain better control over logging operations, in 1997 Brazil opened 39 of its National Forests (totalling 14 million ha) to logging, arguing that logging concessions would not be granted to companies with poor environmental records (Anon 1997). Much larger areas of the Brazilian Amazon are to be designated as logging reserves in the future following the approval of a public forest concession law in 2006.

Figure 11: **Logging permits for forest management plans in 2000**. *Source: Greenpeace 2001*.

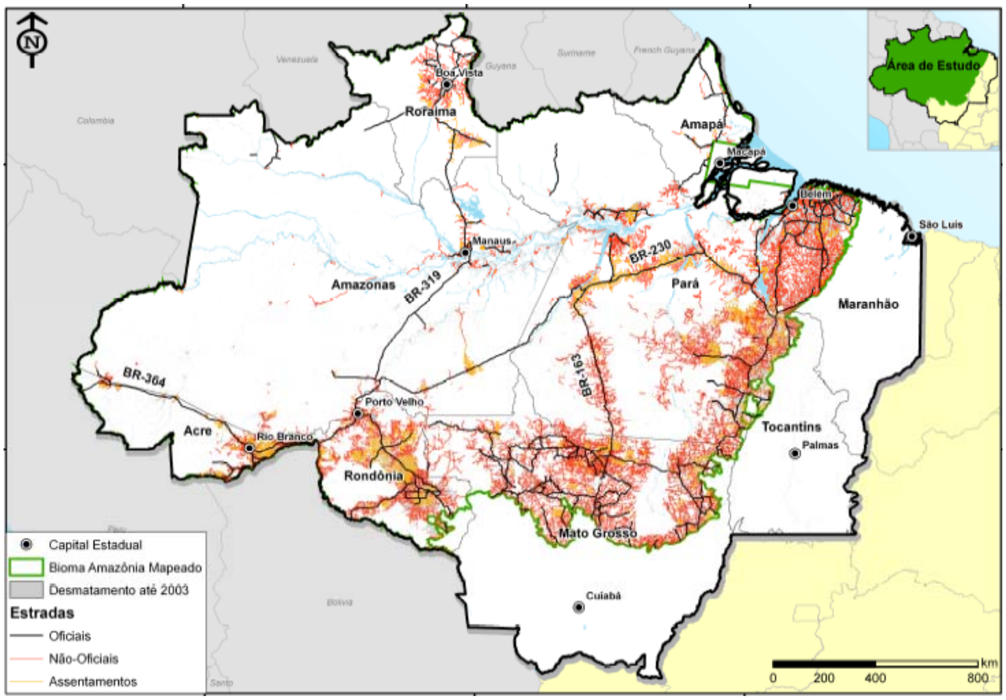


Source: Greenpeace 2000. Logging permits for forest management plans. Timber harvest from clear cut (deforestation) is not included.

INFRASTRUCTURE DEVELOPMENT

Infrastructure development, including paved highways, hydropower and mining projects, is another catalyst of deforestation, accelerating migration to remote areas and increasing the clearing of already-established properties. Data suggests that between 1978 and 1994, about 75% of deforestation occurred within a 100 km band along major paved highway –the arteries of deforestation (PDR 2004) (see Figure 12). Typically, roads provide access to logging and mining sites while opening forest frontier land to exploitation by poor landless farmers. For instance, satellite data from 2004 shows a marked increase in deforestation along the BR-163 road, a highway the government has been partially paving in an effort to help soy farmers from Mato Grosso get their crops to export markets (Nepstand et al. 2004). Timber companies, settlers, and local governments have also constructed feeder roads along the Trans-Amazon Highway in Pará, north-eastern Mato Grosso, and southern Amazon, which could explain the high concentration of forest fires in these areas (Rodgers 2003). The paved roads can also make it easier for farmers and loggers to encroach upon indigenous reserves and national parks. Of special concern are unofficial roads –being built without the planning and authorisation required by law. In some cases, unofficial roads serve only for one-shot extraction of high-value resources, such as mahogany and gold, in areas isolated from official infrastructure. In others, loggers, ranchers and miners have opened a vast and growing array of unofficial roads, enabling temporary or permanent human occupation over extensive areas of the region (Barreto et al. 2006). The Brazilian NGO Imazon identified and mapped about 21,000 km of unofficial roads in the Central-West region of the State of Pará (the Midlands, or *Terra do Meio*), an area that represents about half of the State (Brandão and Souza 2005).

Figure 12: Roads and deforestation. Grey lines = official road. Red lines = non-official roads. *Source: Souza 2006.*



Historically, hydroelectric projects have flooded vast areas of Amazon rainforest. The Balbina dam flooded some 2,400 km2 of rainforest when it was completed. It has been calculated that in the first three years of its existence, the Balbina Reservoir emitted 23.7 million tons of carbon dioxide and 140,000 tons of methane, both potent greenhouse gases that contribute to global climate change (Fearnside 1995). Over the next 10-20 years, at least 19 major (100-13,000 megawatt) dams are planned in the Brazilian Amazon, nearly all in forested areas. These new dams will vastly increase the 600,000 ha of forest that is currently inundated by reservoirs (because the region is quite flat, Amazonian hydroelectric reservoirs are often very large). In addition to destroying forests and degrading aquatic systems, hydroelectric dams require networks of access roads and power-line clearings, which promote further forest loss and fragmentation.

In the early 1990s there were about 1 million gold miners (*garimpeiros*) in more than two thousand mining camps in the Amazon region (Bezerra et al. 1996). Typically, gold mining exerts direct environmental impacts from forest clearing for the mine and the adjacent mining camp, and indirect impacts such as soil erosion and mercury pollution. Construction of infrastructure and accumulation of capital provide also a basis for other land-use activities and additional frontier expansion. This phenomenon occurred in the Tapajós River basin of western Pará, where around 245 gold mining camps used to employ roughly 30,000 people in the early 1990s (Bezerra et al.1996). The gross value of the gold extracted reached US$110 million per year, which helped to finance land conversion to non-forest uses such as cattle ranches. When gold resources have been depleted, unsuccessful miners frequently seek agrarian reform settlements or move to urban centres. Planned infrastructure projects in Brazilian Amazonia could further speed deforestation, logging and other forms of degradation in the coming decades. One modeling of the impacts of Avança Brasil[1] –a US$20 billion infrastructure development package for the period 2000–2007– and other planned projects indicate an additional 269,000 to 506,000 ha/year of deforestation by 2020, plus conversion of 1.53-2.37 million ha/year of forest from the two least degraded categories ("pristine" or lightly degraded) to the two most degraded categories (moderately or heavily degraded). The deforestation alone would result in increased carbon emissions of 52.2-98.2 million t C/year (Laurance et al. 2001).

FOREST FIRES

Forest fires are a growing threat to the conservation of the Brazilian Amazon, being both a result and a further cause of deforestation (Cochrane 1999). Between 2000 and 2002 the number of fires nearly doubled from 22,000 per year to almost 43,000 per year, indicating the acceleration of human occupation (Barreto et al. 2006). Fire is the principal tool used to clear land for planting soon after deforestation, and thereafter to maintain pasture. They accidentally escapes from agricultural lands to forested areas, mostly to logged areas that become more susceptible to burning, especially during droughts. It has been calculated that half of the forest fires in the region are accidental (Nepstad et al. 1999). Under natural conditions, large-scale fires are very rare in Amazonian rainforests, however human land-uses have dramatically increased the incidence of forest fire. Logging leads to higher forest desiccation and woody debris, and greatly facilitates access by slash-and-burn farmers and ranchers, which are the main sources of ignition. Fragmented forests are also vulnerable to fire. This is because fragment edges are prone to desiccation (Kapos 1989) and because forest remnants are juxtaposed with fire-prone pastures, farmlands, and regrowth forests. Ground fires originating in nearby pastures can penetrate hundreds to thousands of meters into fragmented forests. During the 1997/98 El Niño drought, wildfires lit by farmers and ranchers burned ~ 13,000 km^2 of primary tropical forest in the northern Amazonian state of Roraima (Barbosa and Fearnside 1999). Fires in the "arc of deforestation" were estimated to have totalled a further 15,000 km2–half of the size of Belgium (Cochrane 2003).

Burned forests are greatly susceptible to recurrent fires, which in turn can be more severe in intensity and impact. Fires set in motion a vicious cycle of tree mortality, increasing fuel loads, and re-entry of fire, until the forest is completely destroyed (Nepstad et al. 1999). Research suggests that there might be a "deforestation threshold", above which landscapes become far more prone to fires. This could potentially occur as a result of a vicious cycle combining the impacts of deforestation, regional drying, smoke, and fire (Cochrane et al. 1999, Laurance and Williamson 2001). Amazonian forests recycle at least half of all rainfall back into the atmosphere, helping to maintain frequent rains, lower surface temperatures, and moderate dry seasons (Salati and Vose 1984). Regional deforestation can reduce rainfall (IPCC 1996), making forests more fire prone and, in turn promoting additional deforestation and fires. Smoke particles from fires further reduce rainfall by trapping microdroplets of water in the atmosphere, precluding the formation of raindrops (Rosenfeld 1999). Such process is most likely in the drier eastern, southern, and north-central areas of the Amazon, where rainforests are already near their physiological limits (Nepstad et al. 1998).

[1] *Avança Brasil's* successors, the "Pluriannual Plan" (PPA) and the Programme for Accelerating Growth (PAC) respectively for the 2004-2007 and the recently announced 2007-2011 periods, are virtually identical to *Avança Brasil*

4. HOW DEFORESTATION IS CONTRIBUTING TO CLIMATE CHANGE

Forest plants and soils drive the global carbon cycle by sequestering carbon dioxide through photosynthesis and releasing it back into the atmosphere through respiration and decomposition of organic matter. One of the consequences of deforestation is that the carbon, which makes up about half of the dry weight of wood, is converted to carbon dioxide (CO_2), either immediately when the trees are burned, or more slowly by decomposition of unburned wood. Only a small fraction of the biomass initially held in a forest ends up stored in houses or other long-lasting structures (Houghton 2006). Most of the carbon is released to the atmosphere as carbon dioxide, but small amounts of methane and carbon monoxide may also be released with decomposition or burning. A further release of CO_2 results from oxidation of part of the organic matter stock in the soil–a consequence of higher soil temperature under pasture or cultivation than under forest. Carbon emissions originating from tropical deforestation can be calculated by multiplying the area deforested (estimates from satellite images) by forest biomass. For calculations of net emissions, deduct from the previous calculation the quantity of carbon sequestered by vegetation growth (Houghton 2006).

TROPICAL DEFORESTATION AND CARBON EMISSIONS

Tropical forests play a critical role in the global carbon cycle and in the Earth's climate because they contain about as much carbon in their vegetation and soils as temperate-zone and boreal forests combined. Per unit are, tropical forests store on average about 50% more carbon than forest outside the tropics. Some 200 billion tons of carbon are locked up in the tropical vegetation that covers the planet (IPCC 2001). Amazon trees, alone, contain 70 billion tons of carbon – amounting to between 10 and 15% of global terrestrial biomass (Houghton et al. 2001). Tropical deforestation and degradation caused by high impact logging, shifting cultivation, forest fires, and forest fragmentation accounted for about 20-25% of the total anthropogenic emissions of GHGs (Houghton 2005)[2], higher than the annual emissions from the Unites States (see Figure 13) and from the transport sector (see Figure 14). Without prompt action, emissions from deforestation between 2008 and 2012 are expected to total 400 billion tons of CO2, which alone would raise atmospheric levels of CO2 by ~2ppm, greater than the cumulative total of aviation emissions from the invention of the flying machine until at least 2025 (Stern 2006). The felling of forests in the tropical portion of Latin America alone produced a net carbon flow into the atmosphere on the order of 0.3 billion C/year during the 1980s. This amount rose to 0.4 billion C/year throughout the 1990s, as a result of deforestation of over 40,000 km² /year (Defries et al. 2002).

Forest fires and tree mortality can double carbon emissions from tropical forests during dry years (Mendonça et al. 2004). For instance, in 1998, when El Niño triggered severe droughts in the Amazon and in South East Asia, 0.8 to 2.6 billion extra tons of carbon were released to the atmosphere through accidental fire in South East Asia peat forests (Page et al. 2002), while Amazon fires resulted in an additional 0.1 to 0.3 billion tons (Alencar et al. 2006). Climate change is expected to increase the frequency of El Niño events (IPCC 2001). Experimental evidence from the Amazon indicates that severe drought like those experienced in 1998 or in 2005 kill large canopy trees more than small understory ones (Nepstad et al. 2002). This is

[2] For a discussion of uncertainties of estimates of carbon emissions from deforestation and degradation see Brown et al. 2006.

important because canopy trees protect the forest interior from sunlight, thus increasing forest resistance to fires. If droughts become more severe in the future through more frequent and severe El Niño episodes (Timmermann et al. 1999), or the dry season becomes lengthier due to deforestation-induced rainfall inhibition (Silva-Dias et al. 2002) or there are rainfall reductions due to global warming (Cox et al. 2000), then substantial portions of the 200 billion of carbon stored globally in tropical forest trees could be transferred to the atmosphere in the coming decades.

Figure 13: Fossil fuel emissions from selected countries and mean annual deforestation emissions (1989-1995). *Source: Santilli 2004 based on data from IPCC.*

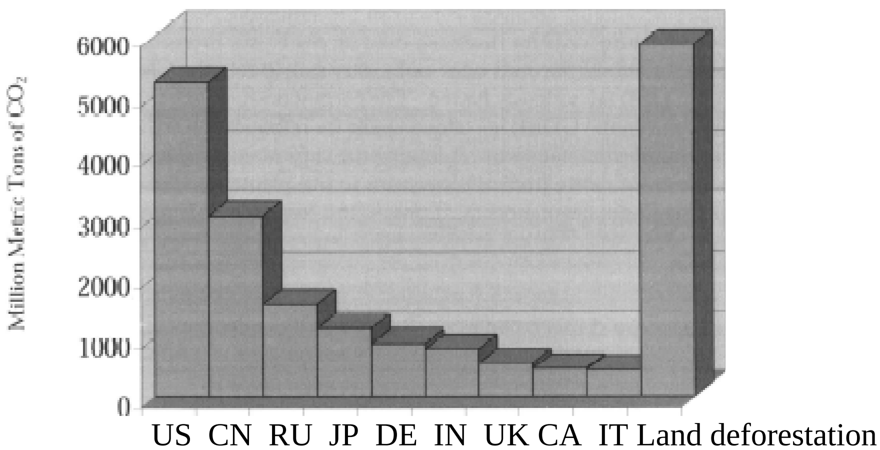
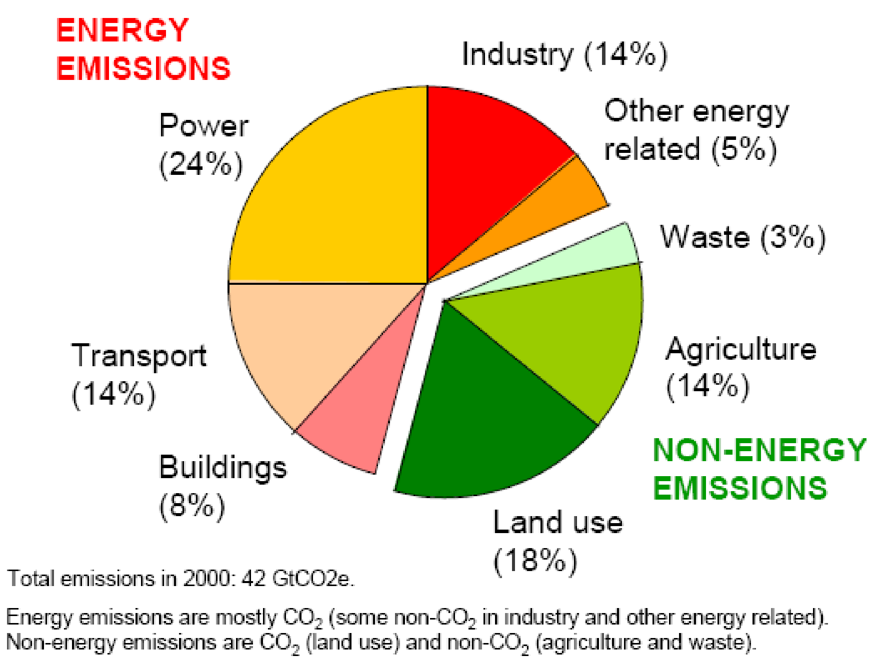


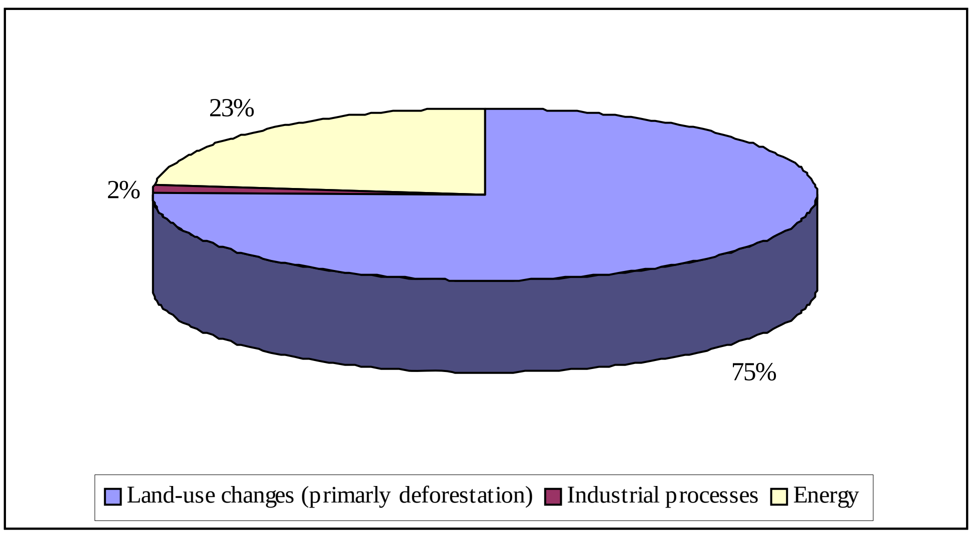
Figure 14: World's greenhouse gas emissions by source, 2000. *Source: Stern 2006 based on WRI/CAIT data.*



AMAZON'S DEFORESTATION AND CARBON EMISSIONS

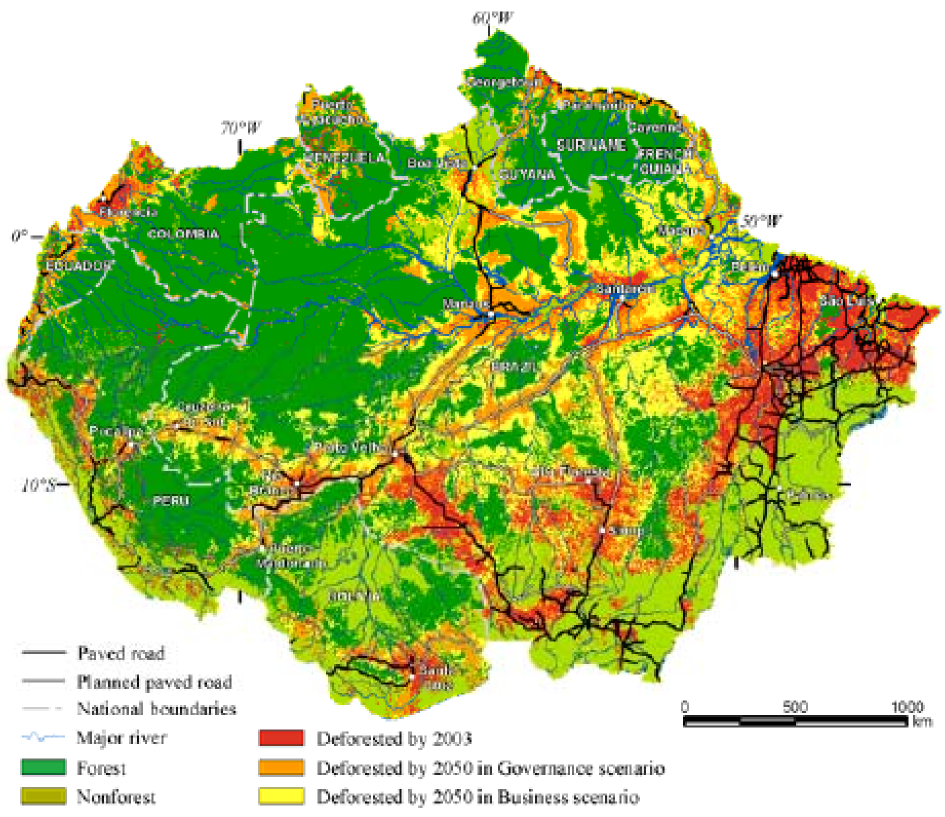
In 2000, Brazil was the world's fourth largest emitter of climate-changing greenhouse gases, ahead of industrialised countries such as Germany and the UK (WRI/CAIT 2006). The profile of emissions in Brazil is rather different from that of developed countries, where emissions from fossil fuel combustion represents the greatest share of emissions. Deforestation is responsible for 75% of the total GHGs emissions and generates approximately 200 million tons carbon per year, with about 60% coming from Amazon deforestation (MCT 2004).). Selective logging could add another 5-10%, equal to 10-20 million tons carbon year (Vera Diaz 2006), although there is still no clear idea of carbon volumes absorbed by regeneration of vegetation after selective logging. Combustion of fossil fuels responsible for the remaining 25%, or about 90 million tons/year of carbon (see Figure 15). Figures on emissions in other tropical countries are similar. In Indonesia, 17,000 km²/year of forests were cut down between 1987 and 1997 and 21,000 km² in 2003 and another 200 million tons C/year was emitted (Houghton et al. 2003). Recent estimates put the net mean annual carbon flux from deforestation and forest re-growth on abandoned land in Brazil 150 million tons C/year in the 1980s and 280 million tons C/year in the 1990s (DeFries et al. 2002). These figures represent 8-14% of global land-use change emissions. These estimates do not include emissions from tropical forest fires caused by accidental fires in prolonged drought periods.

Figure 15: Brazil CO2 emissions by sectors in 1994. *Source: MCT 2004.*



Potential trends in the rates of deforestation and resulting greenhouse gas emissions have been illustrated by a simulation study of the Amazon rainforest under "business-as-usual" and "governance" scenarios (Soares-Filho et al. 2006) (see Figure 16). If current trends in agriculture expansion are extended into the future, with the most likely road-paving projects completed over the next two decades, by 2050 the Amazon rainforest is expected to reduce from its current area of 5.3 million km2 to 3.2 million km2, with over two million km2 –equal to the area of Mexico– to be deforested. This would release about 33 billion tons of carbon to the atmosphere, equivalent to about four years of human-induced emissions. On the contrary, under the "governance scenario", deforestation would be cut by 40%, leaving 4.5 million km2 of forest standing by 2050, and reducing carbon emissions by 17 billion tons. Under the governance scenario, the deforestation rate, although raising initially because of road paving, declines over time, simulating the effect of growing market pressure in favour of land management, incentives for landholders who conserve the forest standing and emerging markets for carbon retained in native forests. In addition, the governance scenario assumes the full planned expansion of the network of Protected Areas in the Brazilian Amazon (ARPA), from 32% to 41% of the total forest area (MMA 2006). The negative regional economic impact of this reduction in carbon emissions from the Amazon could be rather small since much of the deforestation that is to be avoided should be on marginal lands that are unsuitable for agriculture (Houghton et al. 2000). The findings of these scenarios are conservative because the simulation study does not consider forest degradation through logging and fire, and the potential impacts of global warming on the Amazon forest itself, which will be discussed in the following section.

Figure 16: **Amazon deforestation under "business-as-usual" and "governance" scenarios.** *Source: Soares Filho et al. 2006.*



PROJECTED CLIMATE CHANGE IMPACTS ON BRAZIL

Like other developing countries, Brazil is highly vulnerable to climate change: the pressures of poverty make it harder for its population to recover from natural disasters. And these are predicted to be on the rise, as new climate change regional models are projecting that global warming will increase the frequency of extreme climatic events such as floods and drought and is most likely to affect agriculture, and natural ecosystems such as the Amazon rainforest and Pantanal wetlands (Marengo 2006, Case 2005). Under a business as usual scenario, climate models forecast the temperature in most of the country rising 4-6 °C by 2100. Major increases would occur in a small area of north Amazon, where a 8 °C rise is predicted. Under a Kyoto Protocol scenario, between 2070 and 2100 there will be an increase in the annual average temperature of 2-3 °C around nearly the entire Brazilian coast and a substantial portion of the rest of the country. An area of the Amazonas state the size of the United Kingdom may see increases of up to 6 °C. The climate in the Amazon region has already changed over the last 40 years, with average monthly air temperature records have increased by 1 to 3°C in heavy deforested areas (LBA 2004).

Climate models suggest that rain will decrease in the Amazon and the Pantanal, as well as in Brazil's Northeast, a good part of which is already semi-arid. In the Amazon rainforest, climate change will result in warming as well as delays in the rainy season's arrival. The region would become 5–15 % drier at best, and 15–20 % drier in the worst-case scenario. This would affect water flow, not only in the Amazon river but in all other rivers in the region, and would have a major impact on river transport and hydroelectric energy generation. The risk of forest fires would increase. It would also have an impact on public health, as dry weather increases the incidence of respiratory diseases. Such changes would result in significant shifts in ecosystem types –from tropical forest to dry savannah– and loss of species in many parts of the Amazon. In the absence of effective measures to reduce emissions globally, climate change could convert from 15 up to 30 % of the Amazon rain forest into a type of dry savannah by 2050-2100, according to research carried out under the auspices of Brazil's National Space Research Institute (Nobre 2006).

On the contrary, rains are predicted to growth by five per cent in Brazil's southern and southeast regions and in parts of Argentina, brought by winds from the Atlantic Ocean. These rains, however, will be intense and concentrated into a few days, and so won't be copious enough to fill water reservoirs at hydroelectric power stations. This will be problematic, as the higher temperatures bring increased energy demands for air-conditioning. Climate changes will have a massive impact on agriculture, and may make growing crops such as soybeans, corn and coffee –some of Brazil's most important exports– unfeasible in some areas. Building on these findings, EMBRAPA, Brazil's Agricultural Research Corporation (EBRAPA), found that some of the plantations will have to move south as the heat rises. Farmers will have to adapt, either by creating seeds that can survive in a warmer climate, or by cultivating species that resist heat and dry weather. Furthermore, projected warmer temperatures and changes in precipitation will undoubtedly impact the agricultural sector (including plantation forestry) in the Amazon. Particularly hard hit will be subsistence farming. Climatic change would subsequently require larger areas of land to meet the current levels of demand. In fact, Fearnside (1999) predicts that the total plantation area will have to increase up to 4.5 times the 1991 area by 2050.

5. DEFORESTATION IMPACTS ON HUMAN DEVELOPMENT

Deforestation in the Brazilian Amazon carries significant direct and indirect consequences on human development, including violence and life threat to local communities and indigenous people. Deforestation affects negatively natural resources such as rainfall and freshwater, soil productivity, clean air, and forestry and biodiversity resources–all fundamental for local livelihoods. This massive transformation results in severe socio-economic impacts not only on Amazonians –which are robbed of a potentially sustainable future– but also on areas far beyond the region.

IMPACTS ON FOREST'S PEOPLE

Forest people's lives are dramatically threatened by deforestation. The latter is frequently associated with violence and threats against local communities and indigenous people, which are expelled from their lands. Slavery and degrading work are also usually linked with forest destruction in many countries. The Pastoral Land Commission, a non-governmental group linked to the Catholic Church, found that land battles in the nation's countryside reached the highest level in at least 20 years in 2004 (CPT 2004). For instance, documented conflicts over land among peasants, farmers, and land speculators rose to 1,801 in 2004 from 1,690 conflicts in 2003 and 925 recorded in 2002 (CPT 2004). The state of Pará has the largest numbers of murders resulting from land conflicts in Brazil. Between 1985 and 2001, almost 40% of the 1,237 rural workers killed took place in Pará. Of the 53 deaths registered in land conflicts between January and November 2004 across the whole of Brazil, 19 took place in the state of Pará. (CPT 2005). Tensions reached their peak earlier in 2005 with the high profile slaying of Dorothy Stang, an American nun who worked with rural poor, by gunmen associated with plantation owners (see Box 1). In response to the murder, the Brazilian government sent in the army to quell violence in the region and promised to step up environmental monitoring efforts.

For Amazonians indigenous tribes, forest destruction means either death or loss of cultural identity when acculturation transforms the survivors into the lowest stratum of the dominant society (CIMI 2006). Brazil's Legal Amazon has over 350 indigenous areas in various stages of documentation, ranging from "unidentified" areas where no measurements of aerial extent have been made to "regularised" areas where full legal protection applies (Fearnside 2005). Most of the land area and tribal population do not have legal protection beyond the little provided by the "identification" stage that begins the long process of reserve creation but carries little guarantee that the land will not be subsequently usurped by other groups. Of the 60 known isolated indigenous peoples in Amazon region, at least 17 are under the serious risk of extermination due to "genocide practices", carried out by extermination groups hired by illegal landowners, wood logging companies and large farmers. The strategy is to finish with the presence of indigenous peoples, so that demarcation of the lands by the indigenous people will be impossible, and the land can serve for illegal logging, cattle ranching, and commercial agriculture. Deforestation is also related to slavery practices in the Amazon. While Brazil officially abolished slavery in 1888, the government acknowledges that at least 25,000 Brazilians work under "conditions analogous to slavery," clearing land and working for cattle ranches, soy farms, and other labour-intensive industries In 2005, 4,133 slaves were freed after Brazilian Swat-style teams raided 183 farms.

Box 1: Sister Dorothy Stang

Sister Dorothy Stang, known as Sister Dorothy, American naturalised Brazilian citizen and member of the 'Notre Dame de Namur' Order, worked in the state of Pará since 1966 as a defender of environmental issues and landless agrarian workers against large landowners and timber companies. On 12 February 2005, at the age of 73, Sister Dorothy was ambushed and murdered while walking to a meeting at the *Assentamento Esperança* (Hope Settlement) near the town of Anapu, state of Pará.

Sister Dorothy had faced death threats from large landowners in the Anapu region since 1997 when she started working with rural workers seeking to implement Sustainable Development Project (*Projeto de Desenvolvimento Sustentável*, or PDS) and other types of settlements that are not destructive of the Amazon forest. On many occasions her denunciations became public. In a February 2004 letter addressed to the Secretary for Social Defense in Pará, Sister Dorothy recounted the death threats received by rural workers from large landowners and timber companies in the region. She described the tension in the region as warlike. In a testimony before Brazil's Federal Senate, she reported *grileiros'* actions and the deforestation of 12 to 13 thousand hectares. According to the Pastoral Land Commission, 40 people, including rural leaders, trade unionists, religious leaders, and politicians, are facing death threats in three regions of Pará: Altamira, Marabá, and São Felix do Xingu.

After Sister Dorothy´s murder, the federal government announced that it would increase from six to ten its outposts in the Amazon, and that more than ninety INCRA inspectors would be sent to the region. Additionally, the federal police would send seven teams to the region, each made up of one police chief, one assistant, and two agents. Two thousand army soldiers were sent to Pará, with the task of monitoring and fighting public land grabbing (*grilagem)* and deforestation through the seizure of landowners' weapons. In December 2005, the material authors of Sister Dorothy's murder were tried and convicted in prison. However, Mr Bastos de Moura and Mr Pereira Galvão, accused of being the intellectual authors, have not been tried thus far.

Source: Galo et al. 2005.

IMPACTS ON RAINFALL AND FRESHWATER

Widespread deforestation impacts the water cycle, which in turn can have serious effects on forest survival and on agriculture production both in the region and in the Rio de la Plata basin, where 2/3 of South America GDP is produced. Rainfall in Amazonia is closely tied to the presence of forest. The latter contributes significantly to the stock of water vapour present in the atmosphere over Amazonia and neighbouring regions, through evapotranspiration. This is the process by which plants release water through their leaves. In the water cycle, moisture is transpired and evaporated into the atmosphere, forming rain clouds before being precipitated as rain back onto the forest. About half of the rainfall in the Amazon returns to the atmosphere through evapotranspiration (Salati and Vose 1984), thus deforestation can reduce rainfall. Rainfall is also affected when forest-clearing fires create air pollution and release tiny particles–known as aerosols–into the atmosphere, which increase cloud formation but decrease rainfall. In areas with lots of smoke, cloud droplets form around the aerosol particles, but may never grow large enough to fall as rain. Research estimates that more than 70% of the forest cover of

Amazon landscapes may be necessary to maintain the forest-dependent rainfall regime (Silva Dias et al. 2002).

In addition to maintenance of basin-wide precipitation, the Amazon rainforest has a crucial role in long-range water transport through South America (Fearnside 2005). In fact, a substantial amount of water vapour (25%) is transported to south and south central Brazil, Paraguay, Uruguay and Argentina, and some continues across the Atlantic to southern Africa. During the dry-to-wet transition period (September-October) in South-West Amazonia, water vapour supply is particularly important to avoid a lengthening of the dry season in São Paulo, critical as Brazil's most productive agricultural region. Hydroelectric generation capacity, on the other hand, is particularly dependent on rain in the austral summer (December), corresponding to the rainy season in south-west Amazonia when the difference between the hydrological behaviour of forested and deforested areas is least. This is critical to Brazil's energy security, as shown by the repeated blackouts and electricity rationing in 2001 caused by low water level in hydropower reservoirs in the non-Amazonian portion of the country (Rosa 2001). As a result, Amazonian deforestation has a level of impact on freshwater resources and human development which goes far beyond the Amazon region.

IMPACTS ON SOIL PRODUCTIVITY

Soil erosion, nutrient depletion, and soil compaction are among other impacts of deforestation. When the forest is removed, the soil becomes compacted upon simple exposure to sun and rain. Increased soil temperature shifts the equilibrium between oxidation and formation of organic matter such that less of this essential material is present to maintain a good soil structure. The trampling of cattle further speeds the process of soil compaction. Research found that infiltration of the rainwater into the soil is decreased by an order of magnitude in Amazonia pastures as compared to adjacent forest (Dantas 1979). As a result, rainwater runs off over the surface rather than sinking into the soil. Direct measurements of erosion under various land uses confirm the rapid loss of soil also under annual crops and pasture (Fearnside 1979). Soil erosion results in loss of nutrient capital and agriculture productive potential that is permanent on the scale of human planning. Although erosion losses can be compensated through use of fertilisers, Amazonia's vastness and lack of deposits of key elements such as phosphates makes this impractical on any significant scale (Fearnside 1997a). Because of increased runoff, rivers in the region expected to have reduced water flows at the end of the dry season and higher and more irregular floods in the rain season. These changes can be particularly damaging to agriculture in the *várzea* (floodplain), where farming depends on precise timing of agriculture activities in accord with the river's annual cycle. Hydropower schemes can also be affected, as runoff from deforested areas also contain silt from soil erosion, which can greatly speed the sedimentation of the reservoirs.

IMPACTS ON FOREST AND BIODIVERSITY RESOURCES

Deforestation removes options for sustainable forest management for both timber and, presently little-valued, genetic and pharmacological resources. Deforestation destroys many of the most socially and environmentally attractive options for development in Amazonia. Loss of natural ecosystems directly eliminates economically-valuable species such as trees for hardwood timber, trees now producing about a score of extractive products including Brazilian nuts and rubber, and the many medicinal plants whose economic exploitation is growing. The potential for obtaining valuable genetic material from the forest is another opportunity that is jeopardised by deforestation. Like medicinal plants, genetic resources are irreplaceable –they cannot be bough back with the money earned through deforestation. Germplasm can valuable both in supplying new crops to agriculture and in providing a number of varieties of already-cultivated species (Fearnside 1990). Destruction of the forest cancels the opportunity for sustainable management of this resource. Once the forest ecosystem has been clear-cut to be replaced by pastureland, re-establishing any kind of forest is costly and difficult, and regaining the original ecosystem can be considered impossible.

Tropical deforestation and degradation of forests are a serious threat to many species of pants and animals in the Amazon. Because of the highly localised distribution of many species in the Amazon, these can be eliminated without deforesting large areas. Another characteristic of the forest that magnifies the impact on species of a relatively small amount of deforestation is the requirement of large areas of continuous forest for many species to maintain productively viable populations, together with the required sources of food, pollinators, dispersal agents and other ecosystem components. Climate change could make the areas needed to ensure survival even greater. Since climatic zones are expected to shift by hundreds of kilometres (and have already started to do so), the reserves that would need to be created to buffer against the forced migration of sensitive species may be much larger than currently implemented. Finally, the loss of major portions of Brazil's tropical forests is impoverishing, above all, the earth's biodiversity (Capobianco et al. 2001).

IMPACTS ON CLEAN AIR

Virtually all forest clearing, by small farmer and plantation owner alike, is done by fire. Though these fires are intended to burn only limited areas, they frequently escape agricultural plots and pastures and char pristine rainforest, especially in dry years like 2005. Many of the fires set for clearing forest are set during the three-month burning season and the smoke produced creates widespread problems across the region. Airports must be closed and hospitals report dramatic increases in the incidence of respiratory problems (Laurance 1998). These fires cover a vast area of forest. During the 1997/98 El Niño drought, wildfires lit by farmers and ranchers burned ~ 13,000 km² of primary tropical forest in the northern Amazonian state of Roraima (Barbosa and Fearnside 1999).

6. ADDRESSING DEFORESTATION

Any strategy for reducing and halting deforestation will have to make the felling of forest more expensive than the potential economic benefits related to it, while creating socially and environmentally attractive options for development in Amazonia. This will require first and foremost a “governance revolution”, whereby land tenure regimes are clearly defined and the rule of law effectively enforced. It will also need the various regulatory, economic and financial drivers of deforestation to be reformed so to encourage cattle ranching and farming on abandoned lands and support small-scale agriculture and sustainable forestry. Finally, the environmental services provided by standing forests, particularly the carbon-sink functions need to be rewarded, including through the international carbon regime.

IMPROVE LAW ENFORCEMENT AND REPRESSION

The first element of an effective strategy for reducing and, eventually, halting deforestation is to enforce the existing legislation to reduce illegal clearing in private properties, which represented 25% of the Amazon in 2005 (Diaz 2005). For instance, under the ‘Forest Code’ of the Unified Environmental Law in Brazil, property owners are required to retain a specified percentage of native vegetation (80% for forest areas, 50% for *cerrado*). They are also bound to preserve forest along rivers. An encouraging example that this is feasible is provided by a deforestation licensing and control program implemented the by Mato Grosso State Environmental Agency (FEMA), which showed strong indications of having a significant effect on clearing rates in the state over the 1999-2001 period (FEMA 2001, Fearnside 2003). If constant clearing at the 1999 rate is assumed as the baseline for comparison, the decrease in clearing in Mato Grosso over the 2000-2001 period avoided 43 million tons of carbon emission annually, equivalent to about half of Brazil’s current emissions from fossil fuels (Fearnside and Barbosa 2003). Unfortunately, in October 2002 the election as governor of Mato Grosso of Blairo Maggi, the world-largest soybean entrepreneur, lead to the discontinuation of the FEMA programme. Nevertheless, the reduction in deforestation rates is very important in demonstrating that deforestation is not beyond the control of government policies (Fearnside 2003). It also indicates that a pre-condition for effectively implementation of existing legislation is to strengthen enforcement capacity “on the ground”, that is, where deforestation, fires and logging take place (Alencar et al. 2004). Budget cutting policies of the federal government over the last decade progressively reduced funds for agencies responsible for surveillance and control of deforestation –such as Ibama, the national environmental agency– reducing their capacity to maintain inspectors effectively present in the field and in major urban centres. Currently, lack of qualified personnel, basic equipment and funds for field activities has limited the capacity of these institutions to perform their activities in a minimally adequate fashion (Eboli 2006).

The high degree of impunity in Brazil is a fundamental factor in the continuation of crimes, including environmental ones. Studying a sample of 55 forestry infractions in the largest timber producing state of Pará, researchers found that only 2% of the total amount of the fines levied had been effectively paid between 2001-2004, while only 2% of the offenders investigated had been criminally persecuted between 2001-2003 (Brito and Barreto 2005). To address this situation, it is urgent to provide enforcement agencies with the necessary financial and human resources, but also to overcome some regulatory and organisational barriers. For example, the approval of a new federal law will be necessary to ensure that offenders are not allowed to continue exercising economic activities (Brito and Barreto 2006). Currently, a company fined for transporting timber illegally, can obtain a transportation authorisation from Ibama even without having paid the fine and continue doing business as usual. It has been suggested that Ibama could increase its effectiveness by focusing its fine-collection efforts on the biggest offenders. For instance, in their sample Brito and Barreto (2006) found that 16% of environmental infractions accounted for 84% of the total value of fines, each of them with a value exceeding US$24,000. Besides increasing the return on investment in collection of fines, the effective punishment of the principal violators would give a strong signal against impunity, preventing future environmental crimes. Improving co-ordination among enforcing agencies is also key. Recent operations conducted jointly by the Federal Police, Public Prosecutor *(Ministério Público*) and Ibama have demonstrated the great potential for success in prosecuting illegal timber logging and trade. In 2005, two major operations of this type occurred. The first was called Operation Curupira and investigated criminal networks, leading to the arrest, in June 2005, of 148 persons, among them business people and employees of Ibama and the Mato Grosso State Environmental Agency, FEMA. The second was operation '*Ouro Verde'* (Green Gold), launched in October 2005, which found the chain of production and distribution of counterfeit authorisations for transporting forest products.

PREVENT LAND GRABBING, EXPAND PROTECTED AREAS AND REFORM SETTLEMENT PROGRAMMES

Law enforcement and repression are important but not sufficient to stop deforestation. Much forest clearing in the Brazilian Amazon is caused by illegal private appropriation of public lands, known as *Terras Devolutas*)–which represent nearly half of the region (Lentini et al. 2003). This happens in non-transparent and illegal and fraudulent ways which results in an award of title to land of uncertain status (Margulis 2004). Too often, the state and its enforcement capacity arrives too late, when the process of land-grabbing of public lands, deforestation, and conflict over ownership among different groups such indigenous people, large and small farmers, squatters, energy companies and the state itself is already installed. Therefore, in anticipation to this process, the state should arrive first, particularly in those areas to which access will be opened through road or other infrastructure projects, in order to designate land for the best uses, taking into account economic and environmental aspects. Lands rich in biodiversity and environmentally sensitive areas should be allocated to conservation. Protected areas, including parks, extractive reserves, and indigenous lands, have proven to be effective in slowing both deforestation and forest fires, especially along the Deforestation Arc. Satellite-based research found that deforestation was 1.7 to 20 times higher along the outside versus the inside perimeter of protected areas, while fires were 4 to 9 times higher (Nepstad et al. 2006b). The government needs to swiftly expand protected areas from the current 32% to the 41% of the total forest areas, as planned by the Amazon Region Protected Areas (ARPA) Programme.

In other areas, logging may be allowed subject to specific rights and duties, effectively enforced. Logging concessions can be granted with conditions such as permissible extraction levels and sustainability requirements. For instance, Brazil has recently granted such contracts to private companies. The concessions run for 40 years, operations are required to meet key criteria for sustainability. The revenues have been used to set up and run the Brazilian Forest Service, which manages these concessions (MMA 2006b). This measure is expected help combating the illegal occupation of public lands (*grilagem*). As mentioned earlier, in the Brazilian Amazon, deforestation for cattle pasture is considered to be an "improvement" (*benfeitoria*) for the purpose of establishing and maintaining land title. As long as this situation remains, one can expect landholders will clear-cut their forest despite prohibitions. A change in land-titling procedures to cease recognising pasture as an improvement has yet to take place.

As slash-and-burn agriculture is responsible of up to 30% of deforestation, using already cleared areas for agrarian reform, rather than following the politically easier path of distributing forestland is needed (Fearnside 2005). Since the mid-1990s the National Institute of Colonisation and Agrarian Reform (INCRA) has claimed that new settlements are only sited in areas already deforested so as to minimise their impact on deforestation. Despite numerous official statements that such a policy was in effect, however, new settlements continued to be placed in forested areas, such as the 1996 Rio Acarí and Rio Juma settlements in the state of Amazônas. Typically, the areas chosen by squatters for invasion are under primary tropical forest rather than pasture, agriculture or secondary forest. In fact, the timber provides capital for the squatters and the soils are considerably better than could be expected in a degraded cattle pasture. The fact that INCRA generally "legalises" these settlements creates an additional barrier to effective control of this form of deforestation. Colonist turnover is another driver for deforestation. There, effective restrictions are needed on selling of lots and on subsequently receiving lots under the agrarian reform program. This will require a national registry of settled migrants. Changing the terms of financing to tie loans to individuals rather than to plots of land would also help reducing colonist turnover. Furthermore, increased efforts are needed to achieve agrarian reform and viable family agriculture production in Amazon, but also in the source areas of migrants outside of the Amazon region in order to stem the flow of people to new areas in search of land. No program to deal with land-tenure and environmental problems in the Amazon can expect to be successful without ending the export of population from source areas (Fearnisde 2003).

REFORM TAXES, CREDITS AND SUBSIDIES, AND STRENGTH ENVIRONMENTAL IMPACT ASSESSMENTS

Perhaps the most important measure to combat deforestation is changing public and private economic incentives that lead to the conversion of forestland to agriculture and unsustainable logging. Tax credits for cattle ranches approved by the Superintendency for Development of Amazonia (SUDAM) were an important force motivating deforestation in the 1970s and 1980s (Binswanger 1991). The ending of approval of new subsidised projects in June 1991, however, did not revoke the projects for which tax subsidies had already been granted. SUDAM-approved projects not only gave tax-exemption on income they generated, but also allowed the owners to invest in their ranches part of the tax they owed on earnings from operations elsewhere. The exclusion of ranches in 1991 did not affect other damaging activities, such as sawmills and pig-iron smelters fuelled by charcoal. The remaining tax subsidies need to be removed. Another driver for deforestation, more prominent in the 1970s and 1980s than now, is land speculation. The capital gain from selling a property after holding it for a few years was a major source of profit for ranchers as long as land values increased faster than inflation. While average land values are no longer increasing at the rates prior to the abrupt slowing of inflation with the 1994 Real Plan, individual properties can still produce speculative profits, particularly when near a newly built or improved road. Heavy taxes should be applied to take the profit out of land speculation, both to remove the remaining speculative force in areas favoured by infrastructure and to provide protection should there someday be a return to the astronomical inflation rates prevailing in Brazil for most of the past century.

Deforestation also receives a strong impetus from subsidised agricultural credit. The government subsidy goes beyond low interest rates and generous grace periods. There are also frequent "amnesties", either forgiving debts or converting them to virtually token payments over long periods at low interest. Amnesties are granted when production is reduced by droughts or other "acts of God" (Fearnside 2003). While usually viewed as "one-time" interventions, in fact they are a regular feature and represent a large additional subsidy to deforestation. A variety of other subsidies also increase the profitability of agriculture and ranching. These include price supports for many agricultural products, with government guarantees of the price paid to the farmer irrespective of how distant from markets the farm may be. Many special programs supply inputs such as fertiliser or lime to specific crops, and the vast network of transportation infrastructure, at government expense. These subsidies need to be re-directed to encourage sustainable forestry and farming on the area of the size of Suriname that has been cleared and then abandoned (Economist 2006). In the majority of land in Amazon (especially in the humid zone) forest management could provide a more stable economy (income, employment and taxes) than that produced by agriculture (Schneider et al. 2000).

Along with public policies, market forces such as financiers and consumers bear an increasing amount of responsibility for driving deforestation in the Amazon, yet they can play a key role in preventing it. For instance, the leading Brazilian soy producing company André Maggi Goupo has had easy access to more than US$ 660 million of financing from public and private banks in Europe and Japan and from the International Finance Corporation (IFC) (Van Gelder 2006). These loans have helped the company finance advance payments to suppliers and infrastructure development for storage and transport of soy in the Amazon. A internal audit found that the IFC had not undertaken a sufficiently rigorous assessment of the environmental and social impacts associated to the project funding and that therefore its approval –classified as low-environmental risk by the international agency–could not be justified (Bickel 2003). In other words, through its loans the IFC had financed the conversion of the Amazon forest. To prevent such situation, private Brazilian and international banks need to re-examine their lending policies and practices by attaching socio-environmental criteria aimed at encouraging farmers to obey the forest law and adopt good land stewardship practices. Some private banks have begun to follow such approach. In May 2004, HSBC, which had previously financed Grupo André Maggi, introduced a policy that states that it will not longer finance projects located in and which significantly degrade or convert Critical Natural Habitats (HSBC 2004). Agriculture commodity traders need also to seek socially and environmentally begin suppliers. They have increasingly become important players in the development of international criteria for "responsible" soy production (WWF 2006). In one of the most powerful example of these trends, the companies that buy most of the soy produced in the Amazon recently declared a two-year moratorium on the purchase of soy grown on recently cleared Amazon rainforest soil. This came as a response to a public campaign launched by environmental groups targeting European McDonald's restaurants for their use of Amazon soy in the feed that fattens their chickens (Greenpeace 2006). Similarly, a Brazilian supermarket chain has expressed its interest in purchasing beef from ranches that meet a set of criteria developed under the "Registry of Socio-Environmental Responsibility" –an NGOs-backed initiative to promote law enforcement and sound forest stewardship (Nepstad et al. 2006).

The challenge presented by building of highways or hydropower plants in the Brazilian Amazon makes clear the need of further strengthening Brazil's environmental impact assessment (EIA) scheme through the implementation of strategic environmental assessment (SEA) for programme and plans (Fearnside 2002). Typically, the major impacts of infrastructure projects are caused by economic activities attracted to and facilitated by the projects. However, currently these impacts completely escape the environmental assessment process. The impacts of activities carried out by third parties, such as ranching and logging that accelerate when a access-road is built, the chains of events set in motion by inter-linked projects such as strings of hydroelectric dams, are not yet covered by the impact statement review process. Were the decision-making process to take full account of the costs of such impacts, including their global-warming effects, many projects would be seen as uneconomic and counterproductive and would not be undertaken. Progress has been minimal in incorporating such concerns into the planning process, despite frequent statements of intentions. The timing of environmental impact studies needs also to be changed so that they enter the decision-making process before the real decisions on infrastructure priorities have already been made and they provide input to the planning process, rather than merely legitimising projects after major decisions have already been made.

PROVIDE ECONOMIC INCENTIVES TO MAINTAIN LAND AS FOREST

The greatest challenge to effectively reducing deforestation in the Amazon, as well as in other tropical regions, is to make sure that conserving tropical forests becomes economically advantageous to landowners compared to the unsustainable land-uses described in section 2. This will require the establishment of a mechanism for attributing monetary value to the environmental services provided by standing forests, besides those conferred on it from its forest and non-forest resources (Fearnside 1997b). Key areas include: biodiversity conservation, tourism recreation, hydrological protection and carbon-sink functions. Perhaps the latter is the most important environmental service offered by forests, as keeping forest standing prevents significant quantities of carbon to be released into the atmosphere and to contribute to global warming. Following the proposals tabled by the Papua New Guinea (PNG) (see Box 2) and Brazil (see Box 3), the UN Climate Change Convention (UNFCCC) is currently providing a powerful forum to discuss the establishment of a mechanism for rewarding the carbon-related service of tropical forests and thus providing effective incentives for reducing of deforestation.

Box 2: Compensated reductions–proposal by the Papua New Guinea (PNG)

In the run up to the climate change conference in Montreal (COP11), Papua New Guinea (PNG) and Costa Rica, on behalf the Coalition of Rainforest Nations, led a move to reconsider approaches to “stimulate action to reduce emissions from deforestation” (PNG 2005). Their key proposal (commonly known as the PNG proposal) was to develop a mechanism to enable carbon saved through reduced deforestation in developing countries to be traded internationally.
Specifically, a country establishes a national baseline rate of deforestation (converted into carbon emissions) and negotiates a voluntary commitment (over a fixed commitment period) for reducing emissions below the baseline. Any reductions that are achieved below the baseline could then be sold under Kyoto or other carbon markets. No trading would be allowed if emissions were above the baseline in a commitment period. The proposal has focused attention on how deforestation might be included, either as part of future commitments under the Protocol or under the Climate Change Convention itself. The proposal is now being reviewed by the UNFCCC’s Subsidiary Body for Scientific and Technological Advice (SBSTA) to report back for COP13 in late 2007.
Source: Stern 2006.

Box 3: Brazil's proposal of a voluntary fund

At COP12 in Nairobi, Brazil has elaborated the PNG proposal into a mechanism of compensation for the reduction of deforestation emissions (Brazil 2006). This would be a voluntary arrangement in the context of UNFCCC, which does not generate future obligations, and would not count towards emission reduction commitments of Annex I countries of the Kyoto Protocol (industrialised countries).

There would be a reference emission rate based upon previous deforestation rates, which would be periodically updated. This would allow annual or periodical emissions from deforestation to be compared to the reference level with standard values of carbon per hectare. Countries could earn credit, or debits (deducted from future incentives), with incentives distributed, according to the ratio of emissions reductions achieved. This scheme has several elements in common with the PNG proposal–with the crucial difference that funding will be outside carbon markets.

Source: Stern 2006.

Box 4: Calculating the break even carbon price

At what carbon price would conservation compete with logging or ranching? To answer this question, Vera-Diaz and Schwartzman (2005) calculated the Break Even Carbon Prices (BEP), that is the price of carbon at which conservation of standing forests becomes financially attractive for loggers and ranchers. As the carbon content of tropical rainforest varies widely, they calculated BEP for high (397 tC/ha), medium (155 tC/ha), and low (121 tC/ha) values of biomass content found in the literature. They found that when deforestation benefits come from logging following cattle ranching, BEPs range from US$ 1/tC to US$ 14/tC. In the case of soybean plantation the BEP could go from US$ 6 tC to almost US$ 30 t/C.

Given an average price of Certified Emissions Reductions (CERs) in the EU emissions trading scheme from 2004-2005 was US$ 5.63 t/CO2 (or 20.64 t/C), they conclude that, in principle, conservation could compete with the most common land-use activities in the Amazon, including cattle ranching following logging. However, research suggests that it would be more difficult for conservation to compete with higher-return soybean plantations, although this could change as a result of expected future increases in carbon prices.

Source: Vera-Diaz and Schwartzman 2005.

In practice, potential steps to establish an international mechanism for compensating developing countries for reducing their deforestation rates and related carbon emissions would include (Joanneum Research et al. 2007, CAN 2007):

1. *Agreement to provide incentives to reduce emissions from deforestation.* Such incentives could be made available through both market and non-market mechanisms. Under the former approach, deeper developed countries emissions reductions than would be possible only considering fossil fuel emissions are essential in order to create the demand for deforestation emissions reduction credits. This would also ensure these new carbon units were not simply traded off against less reduction from fossil fuels. The non-market approach would consist in an international deforestation fund, based on direct donations, such as Official Development Assistance (ODA), or on surcharges on emission credit trading schemes, taxes on emissions from specific sectors (e.g. power generation or transportation) or a combination of these. As

reductions in deforestation would not be creditable and freely tradable on the global carbon market, it is still unclear whether developed countries would invest in such mechanism when the resulting emissions reductions could not be used to meet the current and future Kyoto targets. In any case, incentives should be commensurate to the full costs of reducing deforestation in developing countries. Research estimates the opportunity cost of forest protection in 8 countries responsible for 70% of emissions for land use could be around US$ 5 billion annually, initially, although this could rise over time (Stern 2006). Box 4 discusses the break even carbon price that would make conservation competitive with forest clearing for logging and cattle ranching.

2. *Development of national-level inventory and monitoring systems of land use changes*. Sufficient technical and data acquisition capacities exist at present to undertake a national-level inventory of land use change, including periodic monitoring and to detect inter-annual variability (GOFC 2006, Brown et al. 2006). A combination of remote sensing, ground/field surveys and/or forest inventories, as well as the use of the IPCC GHG inventory guidelines can be used to estimate GHG emissions from deforestation. More problematic is detecting and measuring forest degradation, where forest carbon stocks are decreased without complete land transformation. The IPCC is near completing a two-year process and report in which it has compiled methodologies on measuring emissions from deforestation and degradation. Countries with limited capacity to conduct an inventory of forestland and measure their deforestation or degradation rates should be supported through the building of capacity for the development of an inventory, including the necessary institutions and monitoring programmes to maintain such inventory.

3. *Establishment of historical emissions reference levels*. Those countries with the capacity to consistently and accurately monitor emissions from deforestation on a national scale could move forward to establish an historical emissions reference level, using information on historical deforestation rates and/or trends, thereby demonstrating its additionality to business-as-usual activities. Historical reference levels could be revised downwards in regular intervals in order to encourage reduction of deforestation rates. The procedure for selecting reference (or reduction goals) levels should take into account the different regional dynamics of deforestation in the tropics. Countries with substantial tropical forests, but with relatively low deforestation to date (for example Colombia and the Congo Basin) might adopt higher baselines than their recent deforestation rates as incentives to participate and to avoid future increases. For regions that have been heavily degraded (such as Sumatra and Sulawesi) a reference level could be expressed in terms of carbon stock changes.

4. *Establishment of national emissions reduction programmes*. Countries with sufficient national capacity and interest should have the option to establishing a national quantifiable emissions reduction programme, including historical emissions, trends, projections or reference levels, and management schemes to administer international/national funds earned for emissions reductions below an established amount. Such emissions reduction programmes should be linked with other ongoing efforts to reduce deforestation so as to leverage efforts as much as possible. These programmes would use the international incentive payments to fund deforestation reduction policies, programmes and activities on the ground. Countries with some capacity to assess deforestation/degradation but not yet at the national level could begin with regional emission reduction programmes aimed at addressing deforestation/degradation hotspots or specific deforestation/degradation activities such as illegal logging or fires. Leakage within this type of approach could be a major concern. A

sub-national mechanism should be thorough, effective and require a high standard for verification. Reported values of emissions reductions should factor in an estimate of leakage of emissions outside regional boundaries.

5. *Receipt of compensation based on annual reductions against a reference level*. Under a market approach, developing countries that choose to reduce their national deforestation rates against a reference level could receive compensation through trading in the global carbon market. Reductions below an agreed reference level would produce carbon credits post facto, which could be sold to Annex 1 countries. The potential scale of financing available through the carbon market makes it the most promising funding source for emissions reductions (Chomitz et al. 2006). For example, taking a weighted average of carbon market prices in 2004-2005 of U$5.63/t/CO2, if Brazil reduced its deforestation by 10% against a baseline of average annual deforestation for the 1980s, over five years, these reductions could earn U$495 million per year, or U$2.47 billion over five years (Moutinho et al. 2005). As comparison, governmental funds invested in the conservation of the Amazon amounted to U$52.5 million in 2005 (Geraque 2006). Under a non-market approach, developing countries would receive compensation for foregoing revenue from deforestation. As mentioned above, in any case bilateral or multilateral funding should be made available to help countries build technical capacity for addressing emissions from deforestation, including developing initial carbon inventories, and financing monitoring and enforcement needs. Under all options, international funding would be invested in public programmes and policies aimed at enforcing existing environmental legislation, strengthening institutional capacity particularly in the most remote regions, and providing financial support to economic alternatives to deforestation.

Any compensation mechanism –whether linked to the international carbon market or to bilateral/multilateral funds– would need to address the issues of leakage and permanence to maintain the environmental effectiveness, integrity and credibility of the global climate regime (Morgan et al. 2005, Joanneum Research et al. 2007):

- *Leakage*. The Kyoto Protocol rules rejected the inclusion of deforestation within CDM projects during the first commitment period primarily because of the concerns about the risk that protecting forests in one specific area, through a give project, would simply displace deforestation which would just take place elsewhere–an issue called 'leakage'. National deforestation reduction targets would go a long way into addressing potential leakage at national level. On the other hand, the participation of several countries from a given region (the Amazon basin for example) could help minimising the risk of international leakage from one country to another (e.g. Brazilian Amazon soy producers who move to Bolivia). Ultimately, addressing international leakage –in all emitting sectors including energy– requires all major emitters to participate into an international emissions reduction agreement.

- *Permanence*. While energy projects do have permanent effects in reducing carbon emissions, forests protected by reducing deforestation rates (i.e. protected carbon stocks) can be lost in the future due direct human action (e.g. new cattle ranching) or natural disturbance (e.g. drought caused by El Niño). Given these risks, the incentive mechanisms must discourage the removal of forest from land that has been subject of funding or involved in the generation of credits from reduced deforestation. A number of options exist to address the permanence issue. Countries that received compensation and subsequently exceeded their reference level deforestation rate would loose eligibility to incentives until net deforestation is reduced below the period of reference. A second option is to agree that participating countries that increase deforestation above their base periods will have to assume the surplus emitted as an obligatory reduction goal for the following commitment period. A third option would require other parties to purchase replacement credits to make up for the emissions in excess. Finally, an insurance system where a portion of the credits from reductions achieved in the first five-year commitment period can be available for emissions credits starting in 2013. Another part could be banked for use at sole later date.

Once established, such deforestation emissions reduction scheme could potentially serve as a strong political stimulus for establishing clear agenda to reduce deforestation while encouraging sustainable development, in the Brazilian Amazon region and elsewhere. Furthermore, it could provide additional financial resources to cover the costs of deforestation reduction measures. Of course, the mere existence of such a mechanism would not guarantee the final result and would be no substitute for sound national policies and effective governance for deforestation and land use. Decisions are being made now in Brazil and other developing countries regarding strategies for agriculture expansion, forestry activities and infrastructure development (see Box 5) which have profound implications for future greenhouse gas emissions, and such decisions should urgently and fully integrate the need to protect tropical forests and its peoples.

Box 5: Brazil's Action Plan to Prevent and Control Deforestation in the Legal Amazon

A recent attempt by the federal government to control deforestation was conducted with the launch of an "Action Plan to Prevent and Control Deforestation in the Legal Amazon" in March 2004 (PRD 2004). The US$135 million plan focuses on activities to reduce deforestation, including better greater enforcement of laws regarding deforestation and the illegal occupation of government lands, improved monitoring of deforestation, land use planning and "ecological-economic zoning", more detailed reviews of public infrastructure investments, greater support for indigenous territories and community forestry, increased support for sustainable agriculture, and greater control over credit for ranchers.

Differently from previous initiatives, which had been co-ordinated solely by the Ministry of the Environment, this plan involved 13 ministries, including those responsible for agriculture expansion and infrastructure development in the Amazon. However, the plan lacks quantified and time-bound targets for reducing deforestation, which makes monitoring its effectiveness difficult. Furthermore, it has been poorly implemented due to lack or disbursements of funding–a sign of low presidential priority. Involvement of key ministries (Ministry of Agriculture, for example) was practically non-existent. The Ministry of Transportation continues to announce large-scale road paving projects in the Amazon without any sort of prior planning, even though it lacks the investment capacity to carry them out. This also occurs with other kinds of infrastructure projects. Similarly, the Ministry of Agriculture keeps promoting agricultural expansion into the Amazon region through increased credits and incentives.

On the positive side, the Environment Ministry lead by Marina Silva was successful in advancing a number of key conservation measures. Between 2004 and 2005, 240,000 km^2 of new protected areas were created –an areas roughly equal to the size of the UK– and this mostly in the contested region of active deforestation. If enforced, these protected areas are expected to reduce deforestation by approximately 60,000 km2 over the next decade, preventing emissions of more than 0.6 billion tons of carbon to the atmosphere. The government made also progress in increasing the forest area under certification from 300,000 to 1.4 million hectares and the Congress recently approved new legislation creating a system of forestry concessions which should encourage sustainable forestry. The Ministry of Agrarian Development/INCRA reformed the process for legalising rural properties, making it more rigorous. Finally, the government sent the army into regions of illegal deforestation and logging and has jailed illegal loggers, illegal ranchers and corrupt government environmental personnel. Nevertheless, much more is needed to sustain the declining trend witness in 2005 and 2006. In the absence of policy reforms and large-scale economic incentives for sustainable development of the region, deforestation rates are likely to increase again.

Source: Mountinho 2006, Nepstad et al. 2006.

Policy recommendations

To sum up, to effectively reduce deforestation in the Brazilian Amazon the following six set of measures should be implemented by the Brazilian government and the international community:

1. *Improve law enforcement and repression.* The Government needs urgently to strengthen supervision, control and enforcement of environmental legislation, such as the Forest Code. Federal and State-level environmental agencies should to be provided with the necessary human and financial resources to effectively carry out its enforcement activities "on the ground". To fighting current status of impunity, environmental crime should be punished exemplarily and public credits should be assigned only to those rural landholders who follow environmental legislation.
2. *Prevent land grabbing.* The Government's Action Plan addressing land tenure is appropriate, but will require substantial political will, funding and proper mechanisms to stop ranchers illegally occupying government lands. A change in land-titling procedures to cease recognising pasture as an improvement has to take place.
3. *Expand protected areas*. Protected areas, including parks, extractive reserves, and indigenous lands, are effective in slowing both deforestation and forest fires, especially along areas of active deforestation. The ARPA Programme needs to be fully implemented, to cover 41% of the Brazilian Amazon and the required financial resources should be allocated.
4. *Reform tax credits and subsidies, and land reform programmes.* Existing tax incentives, credit and subsidies for cattle ranching and agriculture expansion need to be removed and re-directed to encourage cattle ranching and farming on abandoned lands and support sustainable forestry, while heavy taxes should be applied to take the profit out of land speculation. New land reform settlements need to be effectively sited in areas already deforested so as to minimise their impact on deforestation.
5. *Re-think infrastructure projects.* The plans for new road and energy projects in the Amazon must be revised to identify systematic impacts. Road paving should be conditioned to the land-use planning of the affected areas, so to prevent land-speculation and deforestation Financial institutions should condition their loans/funding to compliance with minimum socio-environmental criteria aimed at encouraging farmers to obey the forest law and adopt good land stewardship practices.
6. *Provide economic incentives to maintain forestland*. Brazil should consider direct payments for forest conservation. To effectively reduce deforestation will require more resources than the Brazilian government has so far been able to commit. Along with reformed national incentives, additional funding could come from an international mechanism for rewarding the carbon-related services of tropical forests. For this, the international community needs urgently to agree to provide incentives to reduce emissions from tropical deforestation under the UN Climate Change Convention and/or the Kyoto Protocol, while Brazil must establish a national quantifiable emissions reduction programme.

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NOTES

1 km2 = 100 ha = 0.621 square miles
1 ton carbon is equivalent to 3.67 tons CO2

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