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AVOIDED DEFORESTATION IN AMAZONIA AS A GLOBAL WARMING MITIGATION MEASURE: THE CASE OF MATO GROSSO

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Deforestation in Brazil's Amazon region has long resisted government efforts to control the process. Now, a licensing and enforcement program in the state of Mato Grosso appears to have a significant effect. Clearing rates of Amazonian forest and of the "transition" between forest and cerrado (central Brazilian savanna) have declined since the program began in 1999, while deforestation in the rest of Brazil's nine-state "Legal Amazon" region has continued to increase. Examination of trends at the county (*município*) level help separate the effects of frontier aging and repression. In new frontiers, clearing rates were increasing before the enforcement program, but decline sharply after 1999. Clearing rates declined more sharply where enforcement is concentrated. The assumption that deforestation in Amazonia is uncontrollable is at the root of Brazil's traditional resistance to international monetary flows to reward avoided deforestation, as through the Kyoto Protocol. The recent events in Mato Grosso indicate that this assumption is flawed, and that deforestation can be controlled. Assuming 1999 as the baseline, reduced deforestation in Mato Grosso over the 2000-2001 period avoided 36 million tons of carbon emission annually, equivalent to about half of Brazil's current emissions from fossil fuels.

I.) Introduction

From 1999 to 2003 a program to license and control deforestation in the state of Mato Grosso, was carried out by the state government's environmental agency (State Foundation for the Environment-Mato Grosso: FEMA-MT) (Mato Grosso, FEMA, 2001). Although Mato Grosso has traditionally been one of the Amazonian states with the highest rates of deforestation (Brazil, INPE, 2001), several indicators suggest that the program had a significant effect on deforestation (Fearnside, 2003). Because the resources and know-how of the FEMA team were more limited in 1999 and 2000 than in 2001, the impact of the program in future years can be expected to be greater than those observable in the 2001 satellite data available at present. In addition, a natural lag exists between the inspection, notification and punishment of landowners who clear illegally and the behavior changes as these landowners and their neighbors are convinced to adapt to the new regulatory environment.

In Brazil's October 2002 elections, Blairo Maggi, the largest soybean entrepreneur in Brazil (and probably in the world), was elected governor of Mato Grosso for the 2003-2006 period. While this change resulted in an abrupt loss of political commitment to the environmental licensing program at the state level in Mato Grosso, federal authorities and the judicial system continue to have responsibility for enforcement of environmental laws throughout Brazil, including Mato Grosso. Regardless of the fate of the licensing system in Mato Grosso, its demonstration of the ability of government to limit deforestation has important implications for all of Amazonia.

II.) Avoided Carbon Emissions

A rough calculation of the carbon emissions from avoided deforestation can be made based on the areas cleared in each of the three major categories of original vegetation in Mato Grosso: forest, transition and *cerrado*. "Forest" is considered to include the 1:250,000-scale

RADAMBRASIL mapping (Brazil, Projeto RADAMBRASIL, 1973-1983) in Mato Grosso corresponding to the following IBAMA vegetation map codes (Brazil, IBGE and IBDF, 1989; see Fearnside and Ferraz, 1995): Da, Ds, Aa, As, Cs, Fa, Fb and Fs. "Transition" is considered to include ON, SN, SO, TN, Sd, Pa and Pf. "*Cerrado*" is considered to include Sa, Sg, Sp, Tg, Tp, Ph, and ST. Some vegetation types, especially Sd, Pa, Pf and Ph, do not fit well in any of the three categories, these were allocated to the most similar group. The vegetation types are defined in Table 1, and their per-hectare biomass, areas and biomass stocks are given in Table 2, including the steps in the conversion of RADAMBRASIL volume data to biomass for forest vegetation types. The area and biomass estimates are given in Table 3 for the three broad groups of vegetation: forest, transition and cerrado

TABLE 1: VEGETATION TYPES IN MATO GROSSO

Cate-gory	Sub-category	Code	Group	Subgroup	Class
Forest					
	Dense	Da	Ombrophyllous forest	dense forest	aluvial Amazonian
		Ds	Ombrophyllous forest	dense forest	submontane Amazonian
	Open	Aa	Ombrophyllous forest	open	alluvial
		As	Ombrophyllous forest	open	submontane
	Seasonal	Cs	Seasonal forest	deciduous	submontane
		Fa	Seasonal forest	semideciduous	alluvial
		Fb	Seasonal forest	semideciduous	lowlands
		Fs	Seasonal forest	semideciduous	submontane
	Contact	ON	Areas of ecological tension and contact		ombrophyllous forest--seasonal forest
		SN	Areas of ecological tension and contact		savanna--seasonal forest
		SO	Areas of ecological tension and contact		savanna--ombrophyllous forest
		TN	Areas of ecological tension and contact		
	Cerradão	Sd	Savanna	cerrado	dense arboreal
	Pioneer	Pa	Areas of pioneer formations		fluvial influence
		Pf	Areas of pioneer formations		fluvio-marine influence[(a)]
Non-forest					
	Contact	ST	Areas of ecological tension and contact		savanna--steppe-like savanna
	Savannas	Sa	Savanna	cerrado	open arboreal
		Sg	Savanna	cerrado	grassy-woody
		Sp	Savanna	cerrado	parkland
		Tg	Steppe-like savanna		grassy-woody
		Tp	Steppe-like savanna		parkland
	Pioneer	Ph			

(a) The original RADAMBRASIL classification is maintained here; Pf areas in Mato Grosso should probably be reclassified as Pa because no areas of marine influence exist in Mato Grosso.

TABLE 2: BIOMASS STOCKS OF VEGETATION TYPES IN MATO GROSSO

Category	Sub-category	Vegetation type (IBAMA map code)[(a)]	Live above-ground volume (m^3/ha)[(b)]	Density of live above-ground biomass (Mg/m^3)[(c)]	Biomass expansion factor (BEF)[(d)]	Stand biomass (Mg/ha)[(d)]	Live above-ground biomass (Mg/ha)[(e)]	Dead above-ground biomass (Mg/ha)[(f)]	Below-ground biomass (Mg/ha)[(g)]	Total biomass (Mg/ha)	Area (km^2)	Total biomass stock (10^6 Mg)
FOREST												
	Dense	Da	*52.1*	0.66	3.705	43.0	193.6	16.7	56.4	268.0	2,943	78.87
		Ds	103.2	0.67	2.603	86.4	273.3	23.5	79.6	378.3	22,919	867.13
	Open	Aa	*99.0*	0.60	2.811	74.3	253.6	21.8	73.9	351.0	91	3.20
		As	*98.2*	0.65	2.710	79.8	262.7	22.6	76.6	363.7	131,723	4,790.71
	Seasonal	Cs	*71.9*	0.66	3.149	59.3	226.9	19.5	66.1	314.1	1,907	59.91
		Fa	58.5	0.66	3.496	48.2	204.9	17.6	59.7	283.7	10,145	287.78
		Fb	**72.0**	0.66	3.148	59.4	227.0	19.5	66.2	314.3	7,339	230.65
		Fs	*52.5*	0.66	3.694	43.3	194.2	16.7	56.6	268.9	31,250	840.16
	Contact	ON	75.3	0.65	3.101	61.1	230.4	19.8	67.1	318.9	178,563	5,694.44
		SN	96.4	0.63	3.811	40.7	188.4	16.2	54.9	260.8	156,817	4,089.16
		SO	55.5	0.71	3.460	49.2	207.0	17.8	60.3	286.6	25,314	725.40
		TN	**94.3**	0.66	2.746	77.8	259.4	22.3	75.6	359.1	236	8.49
	Cerradão	Sd		0.66			58.1	13.2	55.0	126.3	26,083	329.47
	Pioneer	Pa		0.66			202.4	17.4	59.0	280.2	7,189	201.45
		Pf		0.66			176.6	15.2	51.5	243.3	217	5.29
NON-FOREST												
	Contact	ST		0.66			22.3	7.1	41.7	71.2	7,347	52.31
	Savannas	Sa		0.66			26.8	8.4	46.0	81.2	216,920	1,762.36
		Sg		0.39			7.4	0.6	16.3	24.4	12,659	30.83
		Sp		0.39			7.3	3.3	30.1	40.6	51,941	210.94
		Tg		0.39			8.4	1.5	19.8	29.7	25	0.07
		Tp		0.41			6.9	2.7	27.6	37.2	59	0.22
	Pioneer	Ph					5.6	0.5	12.4	18.5	1,830	3.39
Total											893,519	20,272.23

(a) Brazil, IBGE and IBDF (1989).

(b) Italics=Weighted mean with adjustments for values in neighboring states; bold=No RADAMBRASIL data for Mato Grosso: value used from nearest state with data.

(c) Fearnside (1997a) for forest vegetation types; Barbosa and Fearnside (in preparation) for non-forest types.

(d) Biomass expansion factor (BEF) and stand biomass (SB) as defined by Brown and Lugo (1992).

(e) Forest vegetation types (except Sd) include adjustment of above-ground live biomass by 22.11%, based on multipliers derived for use with RADAMBRASIL data (Fearnside, 1992,1994): Trees with diameter at 1.3 m (DBH) 30-31.8 cm: 1.036; trees with DBH < 10 cm: 1.12; Palms: 1.035; vines 1.0425; other non-tree components: 1.0021; bark=0.9856; sapwood=0.9948.

(f) Dead above-ground biomass 8.6% of live above-ground biomass (Fearnside, 1994)

(g) Below-ground for forest types (except Sd): 29.14% of live above-ground biomass (Fearnside, 1994); for non-forest vegetation types and Sd below-ground biomass is calculated from regression (Barbosa and Fearnside, in preparation): $y=1/(a + b x^c)$, where y=below-ground biomass, x=above-ground live woody biomass, a=0.06269, b=-0.0323, c=0.08076.

TABLE 3: AREAS AND BIOMASSES OF VEGETATION CATEGORIES AND REDUCTION OF ANI

	Area (km^2)
"Forest"	208,316
"Transition"	394,421
"Cerrado"	291,782
Total	893,519

(a) This is the weighted mean biomass in the areas where clearing is considered avoided. The weighted mean for all vegetation originally present in the state is 227 Mg/ha.

Considering biomass estimates for each type and for replacement vegetation (areas and biomasses updated from Fearnside, 1997b), the emission corresponding to these clearing rates can be calculated (Table 4). This assumes that all of the decline in deforestation between the 1998-1999 biennium and the 2000-2001 biennium can be attributed to the program. Values are presented on an annual basis (*i.e.*, half of the biennium values). Since part of the decline resulted from other processes, the 36 million tons of carbon indicated would decline accordingly. Despite uncertainty regarding the portion of the decline that can be attributed to the licensing program, several lines of evidence discussed above indicate that there has been an effect on deforestation rates, and the corresponding amounts of carbon are therefore substantial.

Table 4 also includes a monetary value for these avoided emissions if calculated assuming US$20/ton (Mg) of carbon. These values provide a useful illustration, indicating a value US$722 million/year if all reduction in deforestation were to result in carbon credit. A variety of considerations restrict the amount of credit that could be claimed for avoided deforestation, depending on future decisions regarding accounting for such factors as certainty, permanence (the time carbon remains out of the atmosphere) and "leakage" (potential movement of emissions sources, such as deforestation, to areas outside of a given project area, as by movement to another state) (see Watson *et al*., 2000). While the US$20/ton value continues to be the most commonly used one in discussions of carbon, even after the March 2001 withdrawal of the United States from the Kyoto Protocol's first commitment period (2008-2012) makes this value unlikely on the short term, it should be remembered that it is purely illustrative. The US$20/ton price originated from budget calculations in the United States under the Clinton administration. Prices on carbon markets are expected to vary freely in response to supply and demand; on the long term, the price of carbon can be expected to rise greatly when industrial countries reach agreements requiring greater reductions in their greenhouse gas emissions.

The July 2001 Bonn agreement rules out credit for avoided deforestation under the Protocol's "Clean Development Mechanism" during the first commitment period, but inclusion of such provisions could occur for 2013 onwards.

TABLE 4: MATO GROSSO: REDUCTION OF ANNUAL EMISSIONS FROM LAND-USE CHANGE IN 2000-2

	C la
"Forest"	
"Transition"	
"Cerrado"	
Total	

III.) Costs of the Program

The costs of the deforestation avoidance program in Mato Grosso are extremely modest, especially as compared to the magnitude of the environmental benefits. The program has cost about R$6 million/year (approximately US$3 million/year) from 1999 to 2002. The World Bank-financed PRODEAGRO program contributed R$ 0.6-1 million (approximately US$0.3-0.5 million), and the Pilot Program to Conserve the Brazilian Rainforest (PPG7) contributed about US$5 million. These values do not counting salaries, buildings and other infrastructure provided by FEMA.

IV.) Extension to Other States

On 26 February 2002, the minister of the environment announced that a "system of licensing of rural properties" would be extended to all of Amazonia based on the experience in the Mato Grosso. This is potentially very important in gaining control over the deforestation process. In the past, the annual announcements of deforestation estimates for Amazonia by Brazil's National Institute for Space Research (INPE) have often been accompanied by packages of control measures. In the succeeding year, deforestation appears to increase or decrease largely independent of these measures (Fearnside, 1997c). The experience in Mato Grosso provides an indication that this need not continue to be the case.

However, important differences are evident among the states as to official commitment to reducing deforestation. Acre and Amapá have a reputation for being the states that give greatest priority to the environment, while Maranhão, Rondônia and Roraima give the least. Within any state, this priority can change radically as different governors come and go. For example, Mato Grosso was a state with very little indication of concern over deforestation prior to 1999. In this case, the change even occurred during the same state administration: Dante de Oliveira (1995-2002).

One way to provide protection of the system against unfavorable state governments would be to have a federal center in Brasília, such as IBAMA other some other part of the Ministry of the Environment, process the deforestation data and/or maintain a mirror image of the data base from the state-level agencies. This would help to level some of the differences among states and among gubernatorial administrations within any given state in terms of the emphasis placed on the environment.

V.) Importance for Kyoto Negotiations

The experience in Mato Grosso takes on special importance in the context of Brazil's negotiating positions on the Kyoto Protocol. The Ministry of Foreign Affairs and the Ministry of Science and Technology, which represent Brazil in the climate negotiations, have opposed granting credit for avoided deforestation. This runs counter to the thinking of the great majority of Brazilian groups concerned with environmental problems in Amazonia (see Fearnside, 2001a; Manifestação da sociedade civil brasileira, 2000). The fundamental reason for the country's negotiating position is believed to be the fear among key individuals that accepting credit for avoided deforestation could expose Brazil to international pressures that would threaten the country's sovereignty over the region if Brazil were to take on commitments for emissions reductions that it subsequently was unable to meet (Fearnside, 2001b). The basic problem is a lack of confidence that deforestation can be controlled. Since 1997 deforestation rates in the Legal Amazon have continually crept upward. The events in Mato Grosso suggest that government measures are capable of influencing deforestation, and the process is not inherently uncontrollable. This is a potentially important development for negotiations to begin in 2005 regarding the future of the Protocol after its first commitment period ends in 2012.

VI.) Conclusions

The experience with the deforestation licensing and control system in Mato Grosso offers strong indication of effect in reducing deforestation rates. They also have low cost relative to the environmental benefits. Together with programs to enhance the attractiveness of activities that maintain forest cover, including tapping the value of the environmental services of standing forest, licensing and control programs are an essential step in the government's ability to redirect development in the region along more sustainable and less environmentally damaging lines.

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VIII.) References

Brazil, Instituto Brasileiro de Geografia e Estatística (IBGE) and Instituto Brasileiro do Desenvolvimento Florestal (IBDF), *Mapa de Vegetação do Brasil*. Scale 1:5,000,000. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Brasília, DF, Brazil (1989).

Brazil, INPE (Instituto Nacional de Pesquisas Espaciais), *Monitoramento da Floresta Amazônica Brasileira por Satélite/Monitoring of the Brazilian Amazon Forest by Satellite: 1999-2000*, INPE, São José dos Campos, São Paulo, Brazil (http://www.inpe.br) (2001).

Brazil, Projeto RADAMBRASIL, *Levantamento de Recursos Naturais*, Vols. 1-31, Ministério das Minas e Energia, Departamento Nacional de Produção Mineral (DNPM), Rio de Janeiro, RJ, Brazil (1973-1983).

Brown, S. and A.E. Lugo, Aboveground biomass estimates for tropical moist forests of the Brazilian Amazon, *Interciencia,* **17**, 8-18 (1992).

Fearnside, P.M., Forest biomass in Brazilian Amazonia: comments on the estimate by Brown and Lugo, *Interciencia,* **17**, 19-27 (1992).

Fearnside, P.M., Biomassa das florestas Amazônicas brasileiras, pp. 95-124 in *Emissão × Seqüestro de* CO_2*: Uma Nova Oportunidade de Negócios para o Brasil*, Companhia Vale do Rio Doce (CVRD), Rio de Janeiro, Brazil (1994).

Fearnside, P.M., Wood density for estimating forest biomass in Brazilian Amazonia, *Forest Ecology and Management,* **90**, 59-89 (1997a).

Fearnside, P.M., Greenhouse gases from deforestation in Brazilian Amazonia: Net committed emissions, *Climatic Change,* **35**, 321-360 (1997b).

Fearnside, P.M., Monitoring needs to transform Amazonian forest maintenance into a global warming mitigation option, *Mitigation and Adaptation Strategies for Global Change,* **2**, 285-302 (1997c).

Fearnside, P.M., Saving tropical forests as a global warming countermeasure: An issue that divides the environmental movement, *Ecological Economics*, **39**, 167-184 (2001a).

Fearnside, P.M., The potential of Brazil's forest sector for mitigating global warming under the Kyoto Protocol, *Mitigation and Adaptation Strategies for Global Change*, **6**, 355-372 (2001b).

Fearnside, P.M., Deforestation control in Mato Grosso: A new model for slowing the loss of Brazil's Amazon forest, *Ambio,* **32**, 343-345 (2003).

Fearnside, P. M. and J. Ferraz, A conservation gap analysis of Brazil's Amazonian vegetation, *Conservation Biology,* **9,** 1134-1147 (1995).

"Manifestação da sociedade civil brasileira sobre as relações entre florestas e mudanças climáticas e as expectativas para a COP-6, Belém, 24 de outubro de 2000," Instituto de Pesquisa Ambiental da Amazônia (IPAM), Belém, Brazil (http://www.ipam.org.br/polamb/manbelem.htm.) (2000).

Mato Grosso, Fundação Estadual do Meio Ambiente (FEMA), *Environmental Control System on Rural Properties in Mato Grosso,* FEMA, Cuiabá, Mato Grosso, Brazil (2001).

Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken (editors.), *Land Use, Land-Use Change and Forestry: A Special Report of the Intergovernmental Panel on Climate Change (IPCC),* Cambridge University Press, Cambridge, U.K. (2000).