Human Pressure in the Brazilian Amazon[1]

Paulo Barreto,* Carlos Souza Jr., Anthony Anderson, Rodney Salomão, Janice Wiles & Ruth Noguerón

In 2002, approximately 47% of the Brazilian Amazon was under human pressure (Figure 1). Areas under settlement – including deforested sites, urban centers and agrarian reform settlements – covered 19% of the region. Areas subjected to incipient human pressure – comprised principally of zones surrounding forest fires (detected by satellite as hotspots) – covered 28% of the region. By revealing the dimension and location of various forms of human pressure, this study provides a tool for enforcing against illegal land settlement and resource use, establishing protected areas, and planning future settlement in the region.

Human Pressure beyond Deforestation

Deforestation is the most widely disseminated indicator of human pressure in the Brazilian Amazon. In 2004, 26,130 km^2 of forests were cleared in the region[2] – the second highest annual rate ever recorded. While the annual rate of deforestation is an important indicator, it fails to capture the full range of human pressures operating in the Brazilian Amazon. For example, current monitoring of deforestation by Brazil's space agency (Inpe) does not detect areas under 6.25 hectares, thereby disregarding forest clearings of 1-2 hectares made each year by numerous small-scale producers. Likewise, Inpe's monitoring program is not designed to map unofficial roads or logging that could indicate zones of future deforestation[3]. Finally, current monitoring does not take into account areas designated for agrarian reform settlements or mineral exploration, which also are potential targets for increasing human pressure.

To produce a more complete map of human pressures, we superimposed several data layers on a map of native vegetation: deforestation, urban centers, agrarian reform settlements, hotspots indicating forest fires, areas licensed for mining and mineral reserves, and positions of authorized logging operations. We refer to the area mapped as the Brazilian Amazon Biome, which covers approximately 4.1 million km^2 and corresponds to the original vegetation in the Brazilian portion of the Amazon basin. For monitoring human pressure on Amazon forest ecosystems, this unit is more meaningful than the so-called Legal Amazon. The latter is a political-administrative entity that covers 5.1 million km^2, extends outside of the Amazon basin and contains a much greater proportion of native non-forest vegetation such as woodlands and savannas (*cerrado*).

A General Vision of Human Pressure

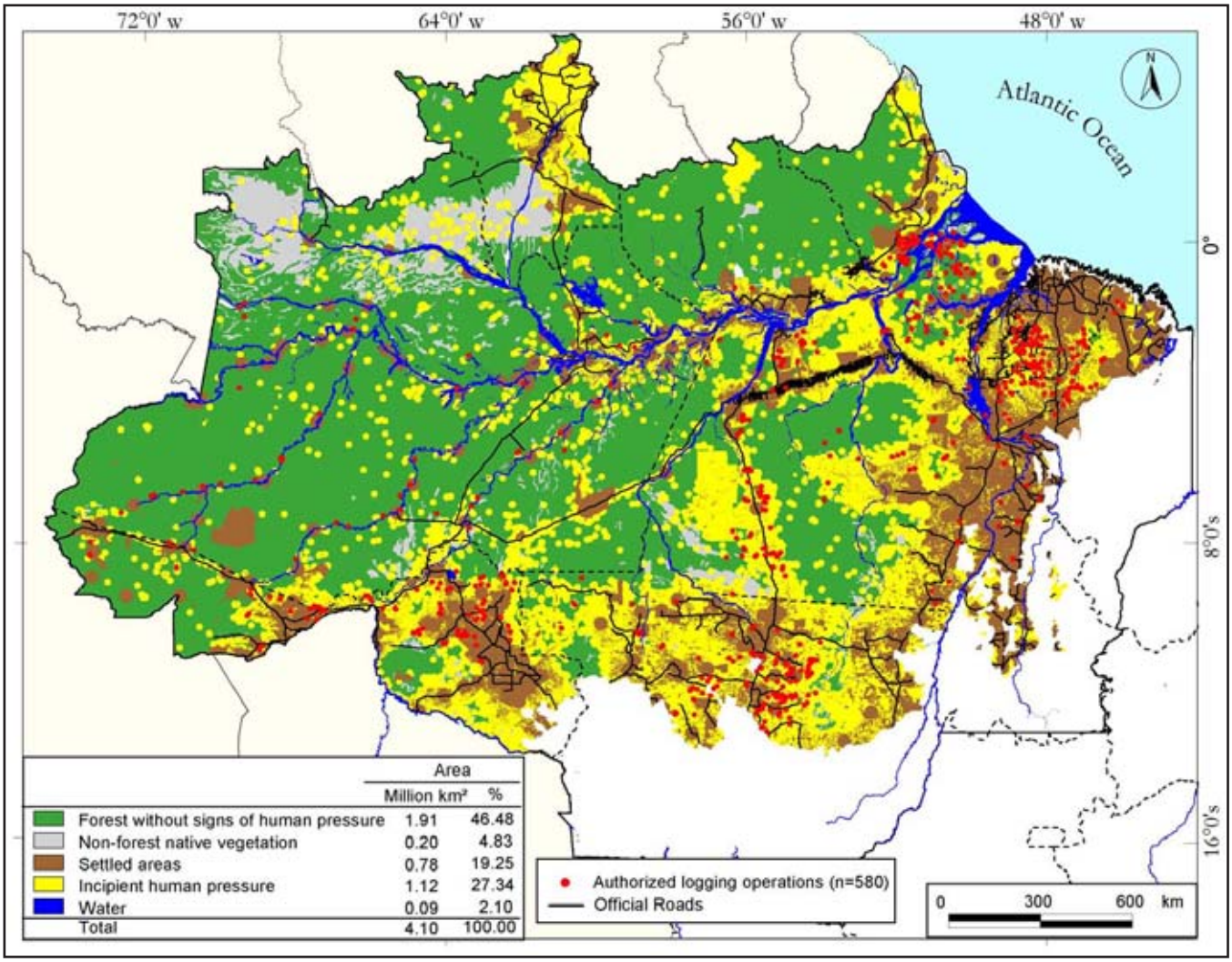
In 2002, areas under pressure by human settlements – including deforested sites, urban centers and agrarian reform settlements – covered 19% of the Brazilian Amazon (0.78 million km^2). This form of pressure occurs primarily along official roads located in the so-called arc of deforestation, which stretches from eastern and southern Pará state through northern Tocantins and Mato Grosso, cutting through Rondônia and reaching into eastern Acre. Other major areas of pressure due to settlements occur along the Transamazon highway in Pará state, the Amazon River between Manaus and Belém, the Cuiabá-Santarém highway near the city of Santarém, and around the main urban centers in Roraima and Amapá (Figure 1).

Areas subjected to incipient human pressure – which are mainly comprised of zones surrounding hotspots indicating forest fires (see text below) – covered 28% of the Brazilian Amazon (1.12 million km^2). These areas are generally clustered and adjacent to settled areas, probably representing zones of frontier expansion. Evidence of such clustered areas of incipient pressure occurs primarily in the states where deforestation is greatest – especially Pará, Mato Grosso e Rondônia. Additional research by Imazon has revealed an extensive network of unofficial roads within these areas in northern Mato Grosso and southern Pará.[4] Furthermore, half of the approved forest management plans are located in areas subjected to incipient human pressure.

Isolated areas showing incipient human pressure occur along navigable rivers throughout the Brazilian Amazon. Such areas appear to be associated, respectively, with traditional *mestizo* communities and Amerindian populations.

A more detailed discussion of the various forms of human pressure operating in the Brazilian Amazon (Figure 2) is presented below.

Figure 1. Areas under settlement and areas subjected to incipient human pressure in the Brazilian Amazon.



Deforestation

In 2002 deforested areas covered 11% of the Brazilian Amazon (Figure 2) and are most prevalent in the arc of deforestation mentioned above. In 1995, cattle pastures were estimated to cover about three-quarters of the area deforested in the Legal Amazon.[5] More recent observations show that, while cattle pastures continue to predominate, degraded pastures have been converted to annual crops such as rice, maize and soy in some areas, particularly in eastern Pará, Rondônia and Mato Grosso. On the other hand, the expansion of such crops is limited by excessive humidity or uneven topography, as is the case in the municipality of Paragominas in Pará. The 2005 agricultural census will provide more current information on the distribution of land uses associated with deforestation in the region.

Urban Centers

The area subjected to pressure from urban centers was found to cover 5.6% of the Brazilian Amazon (Figure 2). This area was determined by defining a 20-km radius around each of the region's 450 municipal seats. Only municipal seats and not other small urban settlements were included in this estimate. A 20-km radius was believed to capture the area under greatest pressure around urban centers. Such pressures include small-scale clearings (under 6.25 hectares) for peri-urban agriculture and spontaneous settlement, extraction of forest products (timber and non-timber), waste deposits, and release of untreated sewage. Urbanization is spreading rapidly throughout the region. For example, between 1980 and 2000, the Legal Amazon's urban population almost tripled, from 4.7 million (45% of the region's population) to 13.7 million (69%). Urbanization has been especially notable around the major cities, duty-free zones (Manaus and Macapá), and zones dedicated to wood processing and mining.

Agrarian Reform Settlements

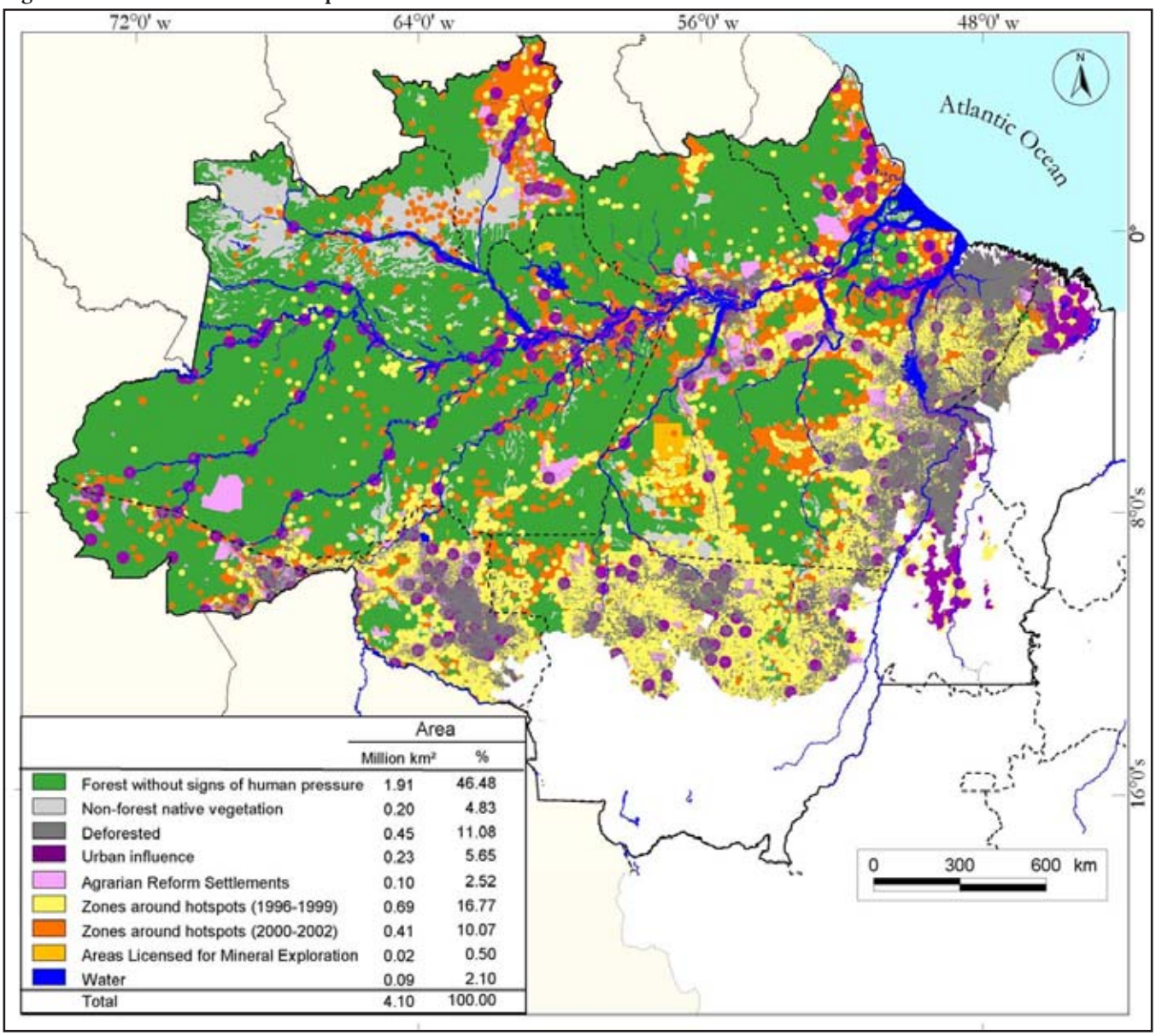
Agrarian reform settlements cover 4.9% of the Brazilian Amazon, of which about half is in forested areas without other signs of human pressure such as deforestation or urban zones. According to Brazil's Institute for Agrarian Reform (Incra), the number of families in agrarian reform settlements in the Legal Amazon more than tripled between 1994 and 2002, from 161,500 to 528,571. Agrarian reform settlements are found in forestlands in all Amazonian states, but they are especially abundant in Pará – particularly the southern and eastern parts of the state (Figure 2).

Hotspots

Hotspots detected by satellite in forestlands correspond either to small-scale clearings (under 6.25 hectares) that are not registered by the federal government's monitoring program, or to forest fires. The latter are more common in forests subjected to logging, which by opening the canopy increases fuel loads in the understory[6]. Forest wildfires generally begin by burning adjacent agricultural lands. Hence hotspots in forestlands indicate zones subjected to incipient human pressure. Between 2000 and 2002, the number of hotspots in forested areas nearly tripled from 16,000 to almost 42,000 per year, indicating rapid expansion of land-use activities into new forest frontiers.

To estimate the area subjected to incipient pressure around hotspots, we delimited a 10-km wide radius around each hotspot. The radius of ten kilometers corresponds to the distance observed to be the maximum that a hunter searches for prey

Figure 2. Various forms of human pressure in the Brazilian Amazon.



	Area	
	Million km²	%
Forest without signs of human pressure	1.91	46.48
Non-forest native vegetation	0.20	4.83
Deforested	0.45	11.08
Urban influence	0.23	5.65
Agrarian Reform Settlements	0.10	2.52
Zones around hotspots (1996-1999)	0.69	16.77
Zones around hotspots (2000-2002)	0.41	10.07
Areas Licensed for Mineral Exploration	0.02	0.50
Water	0.09	2.10
Total	4.10	100.00

from a given point of access within the forest.[7] At a minimum, hence, the area within this radius is subjected to incipient pressure by hunting. However, additional signs of incipient human pressure have been detected in these areas. For example, more detailed mapping in southern Pará and northern Mato Grosso states showed that 76% of the 10-km wide areas surrounding hotspots were associated with unofficial roads (established initially for logging or goldmining), official roads and navigable rivers (Figure 3). Furthermore, half of the sites approved for logging operations are located within such areas. As a result, the 10-km wide areas surrounding hotspots are subjected to various forms of pressure, including establishment of roads, logging, goldmining, hunting, and small-scale agricultural activities (below the 6.25-hectare limit observable by Inpe).

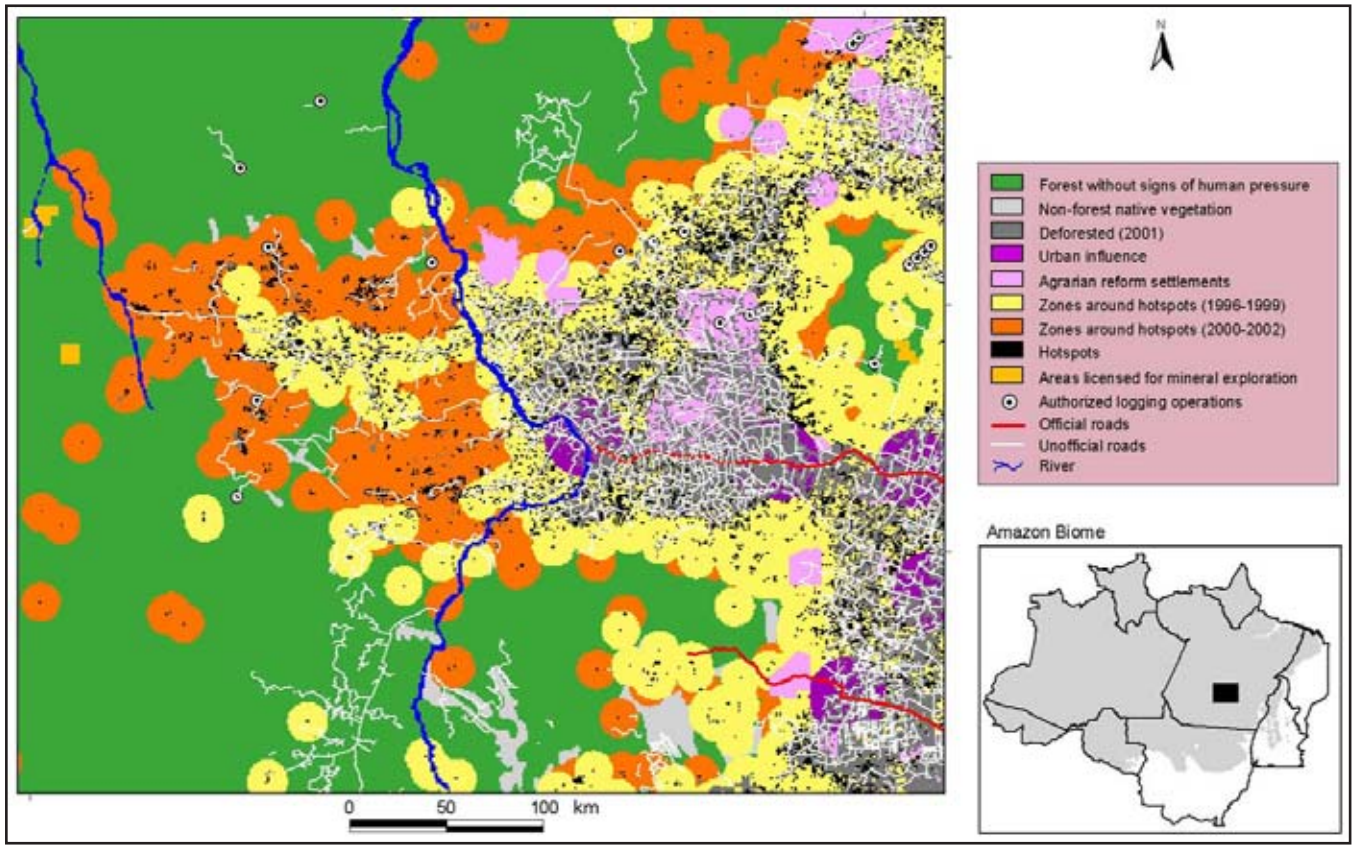
Using a 10-km wide radius, we found that the area of incipient human pressure corresponds to 27.5% of the Brazilian Amazon—or approximately 1 million km^2.

The degree of forest disturbance in the areas surrounding hotspots is highly variable. The geographic distribution of hotspots and infra-structure permits us to infer how such disturbance varies spatially. Most hotspots are concentrated near deforested zones or urban centers (see Figure 2). Two-thirds of the area surrounding hotspots were aggregated (with at least three areas connected), which indicates that the advance of occupation is associated with concentration of valuable resources such as timber, gold and suitable soils for farming.

The forests in such aggregated areas surrounding hotspots have been probably subjected to greatest disturbance, including logging and wildfires. Logging followed by wildfires can severely affect forests. While wildfires tend to be moderate when restricted to the forest understory, they can be catastrophic in forests subjected to more than one understory burn or in drier areas.[8] Wildfires can also spread over immense areas, as occurred in the state of Roraima during 1998 and 2003.[9] Such forests tend to be subsequently cleared for farming or ranching.

The forests within isolated areas surrounding hotspots – which generally originate due to shifting agriculture carried out by traditional mestizo communities or Amerindian populations – are subjected to less intensive pressures such as hunting, harvesting of non-timber forest products, and selective logging.

Figure 3. Human pressure surrounding hotspots in relation to unofficial and official roads in southern Pará.



Areas Licensed for Mineral Exploration

The total area legally allocated for mineral exploration and reserves is approximately 1.5% of the Brazilian Amazon. Yet only 0.5% of this area is not under more intensive pressures such as those reported above. Should this remaining area become economically viable in the future, improved access and services could spark rapid in-migration and deforestation.

Areas Approved for Logging

A lack of precise logging maps made it impossible to estimate the area affected by this activity. Existing estimates indicate that logging affects an area comparable to that deforested each year.[10] Yet these estimates are subject to considerable error,[11] and as a result we used the location of logging permits as a crude indicator of human pressure. As mentioned above, about half of the logging permits occur within 10 km of hotspots. However, 15% are located in forests with no other sign of human pressure, suggesting that authorized logging operations may be contributing to frontier expansion.

The distribution of logging permits in 2000 corresponds to the geographic pattern of roundwood production in the region. Hence, 80% of such permits were located in Pará, Mato Grosso and Rondônia – states that concentrated 93% of roundwood production in 2001 and 2004.[12] Yet a substantial share of this production – estimated at 47% in 2001 and 37% in 2004[13] – was derived from illegal sources. In fact, illegal logging probably represents a greater share of the total, since numerous approved logging operations fail to apply appropriate interventions or take place on public lands illegally appropriated by private interests. However, at present there are no independent evaluations of approved logging operations in the region. As conventionally practiced, logging causes substantial damage to the forest, especially when associated with subsequent wildfires.

Human Pressure and Official Roads

There is a strong association between human pressure on the Amazon forest and roads. For example, about 80% of the total area deforested is located within 30 km of official roads, and about 80% of urban centers, agrarian reform settlements, and zones around hotspots are located within 70 km of such roads. On the other hand, the distance from official roads to agrarian reform settlements and urban centers can attain 210 km and 450 km, respectively. Human settlement in areas isolated from official roads is propitiated by navigable rivers and unofficial roads, which permit access to high-value resources such as mahogany (for example, in southern Pará) and gold (for example, in western Pará). Unofficial roads generally originate from official roads.

The Need for Additional Research

This diagnosis is an initial evaluation and needs to be improved because some of the data is currently limited, thereby preventing a full and precise analysis. For example, mapping of unofficial roads is only available for part of the Brazilian Amazon. Imazon is currently addressing this limitation by extending its map of such roads to include the entire region. Likewise, more accurate mapping of logging and forest degradation throughout the region is also possible, through application of existing remote sensing technologies and ground truthing at strategic sites.[14] Investments in such research would permit more precise evaluation of the type and intensity of pressure, especially in areas surrounding hotspots.

Policy Implications

The findings presented here have two main implications for public policies.

Tool for Enforcement. Vast areas of forest usually considered 'empty'–especially in the central and northern portions of the region– show increasing signs of human pressures, such as hotspots and unofficial roads. This information can help guide governmental authorities in taking preventative measures against degradation in such areas. These measures include establishing protected areas and enforcing current legislation against land grabbing and environmental degradation. Federal and state governments have been applying these measures, especially at the end of 2004 and early 2005. For example, in February of 2005, the federal government implemented a new legal mechanism that shows promise for reducing illegal occupation of frontier areas. Through a presidential decree, the government limited occupation of approximately 82,000 km^2 in western Pará until completion of studies required for establishing protected areas.

The Impacts of Infra-structure. Official roads are closely associated with major pressures such as deforestation, urban centers, agrarian reform settlements, and hotspots in forested areas. Yet the

map shows that some pressures also occur at surprisingly high distances from such roads – particularly when valuable resources such as mahogany and gold are available. This finding indicates a need for governmental agencies to incorporate extensive areas in the planning of major infrastructure projects planned or underway in the Brazilian Amazon – such paving of the Cuiabá-Santarém highway (BR-163).

Despite data limitations, the map presented here provides a more complete picture of the dimensions of human pressures in the Brazilian Amazon and the diverse forms that these pressures take. The map provides a useful tool for planning settlement, establishing protected areas, and enforcing laws against land grabbing and environmental degradation.

15 YEARS
IMAZON
AMAZON INSTITUTE OF
PEOPLE AND THE ENVIROMENT

References and Notes

* Author for correspondence: pbarreto@imazon.org.br

[1] This policy brief summarizes the preliminary results of a GIS analysis carried out by the Institute of People and Environment in the Amazon(Imazon) in partnership with the World Resources Institute's Global Forest Watch Program. A peer-reviewed report is being prepared by the authors, and it is expected to be published this Fall. The project was funded with support from the Ford Foundation, the William and Flora Hewlett Foundation, the Gordon and Betty Moore Foundation, the Government of the Federal Republic of Germany through the Ministry of Economic Cooperation, the Dutch Government and the AbnAmro-Bank. Greenpeace Brazil kindly furnished a map of forest management pans used in the analysis.

[2] Source: Brazilian Ministry of Environment.

[3] Souza Jr., C., A. Brandão Jr., A. Anderson & A. Veríssimo. 2004. Avanço das estradas endógenas na Amazônia. *O Estado da Amazônia, n°1*. Imazon, Belém, Brazil. 2 p.

[4] See reference in footnote 3.

[5] Source: IBGE, 1996: http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=CA&z=t&o=11.

[6] Holdsworth, A. R. & Uhl, C. 1997. Fire in Amazonian selectively-logged rain forest and the potential for fire reduction. Ecological Applications 7 (2): 713-725.

[7] Peres, C. & J. Terborgh. 1995. Amazonian nature reserves: an analysis of the defensibility status of existing conservation units and design criteria for the future. *Conservation Biology* 1: 34-46.

[8] Cochrane, M. A. 2003. Fire Science for Rainforests. *Nature* 421: 913-919.

[9] Barbosa, R. I., M. R. Xaud, G. N. F. Silva & A. C. Cattâneo. 2004. Cinzas na Amazônia: incêndios florestais reencontram Roraima. *Ciência Hoje* 207:22-27.

[10] See Nepstad, D. A. , A. Veríssimo, C. Alencar, E. Nobre, P. Lima, P. Lefebvre, C. Schlesinger, C. Potter, M. A. Cochrane & V. Brooks. 1999. Large-scale impoverishment of Amazonian forest by logging and fire. *Nature* 398: 505-508. *In E. A. T.* Matricard, D. Skole, M. A. Chomentowski & M. A & Cochrane. 2001. Multi-temporal detection of selective logging in the Amazon using remote sensing. *BSRSI Research Advances* (RA03-01\w, Fall 2001). Available at: http://www.globalchange.msu.edu/publications/CGCEO%20RA%2003-01%20complete.pdf (3/10/05).

[11] For example, Matricardi *et al*. (2001) and Cochrane (2001) estimated that logging extended over area varying from 5,600 km^2 in 1992 to 23,400 km^2 in 1999. These estimates were based on mapping of patios where logs are stored, which may be detected over several years after such patios are no longer in use. Hence mapping of patios in any one year will detect patios from prior logging operations, thereby leading to an overestimate of areas subjected to logging (see Souza & Barreto, 2000, cited under footnote 14 below). This problem can be resolved through analysis of satellite imagery over shorter intervals. Matricard, E. A. T., D. Skole, M. A. Chomentowski & M. Cochrane. 2001. Multi-Temporal detection of selective logging in the Amazon using remote sensing. *BSRSI Research Advances* (RA03-01\w, Fall 2001; www.bsrsi.msu.edu/publications).

[12] Lentini, M., A. Veríssimo &. L. Sobral. 2003. *Fatos Florestais da Amazônia 2003*. Imazon, Belém, Brazil.108 p. Available at: http://www.imazon.org.br/upload/im_livros_002.pdf (3/10/05)

[13] Estimate from 2001 in Lentini *et al*., cited in footnote 12. Estimate from 2004 based on data of Imazon and Brazil's environmental agency, Ibama.

[14] See details on methodology in Souza Jr., C. & P. Barreto. 2000. An alternative approach for detecting and monitoring selectively logged forests in the Amazon. International Journal of Remote Sensing 21: 173-179; see also Souza, Jr., P. Barreto & A. Monteiro. 2003. Exploração madeireira na Amazônia: é possível monitorar por satélite? *Ciência Hoje* 197:62-65.