# Rates and Processes of Amazon Deforestation

by

Michael H. Glantz
Amara Tandy Brook
Patricia Parisi

July 1997

Environmental & Societal Impacts Group
National Center for Atmospheric Research*
P.O. Box 3000, Boulder, Colorado 80307-3000

*The National Center for Atmospheric Research is sponsored by the National Science Foundation.

Photo on front: Deforestation in Rondonia, Brazil
(Photo by M.H. Glantz, January, 1992)

# Rates and Processes of Amazon Deforestation

by

Michael H. Glantz

Amara Tandy Brook

Patricia Parisi

July 1997

Environmental and Societal Impacts Group
National Center for Atmospheric Research*
P.O. Box 3000, Boulder, Colorado 80307-3000
Phone: (303) 497-8119
Fax: (303) 497-8125
E-mail: glantz@ucar.edu

http://yabae.cptec.inpe.br/lba/rates.html

---

*The National Center for Atmospheric Research is sponsored by the National Science Foundation.

# Contents

# Rates and Processes of Amazon Deforestation

Michael H. Glantz, Amara Tandy Brook and Patricia Parisi 17 July 1997
*Environmental and Societal Impacts Group/National Center for Atmospheric Research*, Boulder, Colorado, USA*
**National Center for Atmospheric Research is sponsored by the National Science Foundation*

## Introduction

Amazon deforestation has been a hot political issue for the last two decades. Many scientific and popular articles have focused on this issue, but despite all the scientific and media attention, a wide range of rates of Amazon deforestation exist in the literature.

Why is this wide range of rates a problem? Rates of environmental change are often more influential than actual magnitude of the change, in determining policy responses. The problem with having a wide range of rates in the literature, is that policymakers can find rates to justify whatever position they would like to take on an issue. Those opposed to taking action to combat deforestation can find low rates to support a status quo position. Conversely, those who want drastic action taken to combat deforestation can choose high rates from the scientific literature to support their position. In addition, improved, reliable rates of deforestation are important to climate modelers, such those at NCAR's Climate Modeling, Analysis, and Prediction Project (CMAP), seeking to identify, for example, the influence of drastic land use changes on regional and local atmospheric processes. Improved understanding of rate estimates will help modelers better understand deforestation processes.

Until now, the various rate estimates in the literature have not been comprehensively catalogued in an easy-to-compare fashion. The anthropogenic processes driving the destruction are as important for policy responses as the estimates of rates of Amazon deforestation. In order to formulate policies to combat deforestation, policymakers need an understanding of what human processes are responsible for this problem. With such

information, policymakers can at the least slow down the rates of deforestation and arrest its underlying political, social and economic causes providing more time for scientists to investigate the science of deforestation.

Since 1991, ESIG researchers have conducted a review of both the scientific and the popular literature (in English) on Amazon deforestation, in order to identify rate estimates and deforestation processes. This Amazon deforestation research is the largest case study in a larger project investigating the rates and processes of global environmental change. This project was undertaken in an attempt to reduce the confusion surrounding the various estimates of the rates of global environmental change, and the anthropogenic processes driving those rates. The central product of this Amazon deforestation research is this set of two charts, 1) *Amazon Deforestation Rates* and 2) *Amazon Deforestation Processes and Policies.* Since rate estimates are continually being produced, the rate chart has been updated through June 1997. The process/policy chart was last updated in 1993. It is our experience that the rate estimates change more over time than do processes.

During the course of this project, a magazine and journal article were produced (Parisi and Glantz, 1992; Downton, 1995). The magazine article, entitled "Deforestation and Public Policy" (Parisi and Glantz, 1992), presents the rationale behind our Amazon deforestation rates and processes work. It reviews the variation that exists in rate estimates in the literature, and explains why this is a problem in the policy arena: policymakers can find rates to support any position they want to take, and the public ends up generally confused. This article identifies the key problems in rate estimates in the literature: different definitions, different geographical reference areas, different techniques used to estimate deforestation,

inadequacy/expense of available remote sensing data and different analogies/units used.

The journal article (Downton, 1995), entitled "Measuring Tropical Deforestation: Development of the Methods", goes into much more detail about why rate estimates vary so much. It gives more details of specific limitations of specific studies, and limitations of available technologies. Both the magazine article and journal article are excellent complements to these charts.

Producing the charts has always been viewed as the heart of this project and we are making them available for use by other researchers. We feel that in their complete form, the charts are a more useful resource than a cursory synopsis. Below are some comments on the rate data contained in the attached charts. The process/policy data is self-explanatory.

One interesting observation is the impact of the Earth Summit in Rio de Janeiro in June, 1992 on estimates of rates of deforestation. In response to the onset of the Earth Summit, researchers became more focused on producing the most reliable estimates of Amazon deforestation possible for the Earth Summit deliberations. Thus, there is a notable improvement and convergence of rate estimates after 1992.

**Organization of the Rate Chart**

The rate chart is organized in several "layers". First, rates are listed separately for each geographical reference area. For example, all the estimates for the Brazilian Amazon are listed together, as are the references for the Legal Amazon, as are the references for Rondonia. Second, within each geographical section, the estimates of cumulative deforestation are listed after the estimates of annual deforestation. Third, within each of these

categories, estimates are organized in order of increasing year of reference. For example, within the category of annual deforestation rate in the Legal Amazon, an estimate of the rate in 1978 is listed before an estimate of the rate for the year 1980. The "Country/Region" column of the chart also details the reference year. In the cases where the year of reference was not explicitly stated in the source article, we have made the best guess based on the information in the article and put a question mark by the assumed reference year.

In the first column of the chart, if a rate was given in, or could be converted to, square kilometers per year, then there is no unit given within the individual cell. However, if the rate could not be converted to square kilometers per year, the appropriate unit is given in the individual cell.

The rate chart reference list is divided into a section for the primary source cited and a second section for sources cited by the primary sources. Since the literature review includes both scientific and popular literature, the degree of precision in citations within the articles reviewed varies dramatically. In the cases where the primary source article gave a full citation, the citation is included in the secondary source reference list. If only a cryptic, incomplete reference was given in the primary article, then the secondary reference is given only within the rate chart itself and not in the full reference list.

The "Comments" column of the rate chart gives relevant comment made by the author of the article, or information given in the article about the derivation of the rate estimate. Usually only scientific sources, not popular ones, gave information on the derivation of their rate estimates.

**Observations on the Rate Data**

*Currentness of Data*

Many articles cite the same original sources, many of which are several years old. For example, Mantovani and Setzer (1997) cite INPE (1992) and Skole and Tucker (1993). Saatchi *et al* (1997) cite INPE (1992) and Skole and Tucker (1993) as well! On the other hand, some older sources cite more recent data than do newer sources, so the most recent source is not necessarily providing the most current data available. To evaluate the currentness of data in an article, it is critical to check the sources cited by the article. These secondary citations are provided right next to the primary citation on the rate chart.

*Geographical References*

Sources refer to several different countries/regions, some of which may actually be the same geographical area with different names. For example, sources refer to deforestation of the Brazilian Amazon, Brazil, Brazil's Legal Amazon and Amazonia. In most cases, it is impossible to tell from the source if, for example, the deforestation estimate for the Brazilian Amazon really refers to the Legal Amazon. Thus references have been organized in the chart according to geographical reference.

*Incomparability*

Some sources cite rates for specific study areas which are hard to compare with rates from other sources. For example, sources may refer to specific study areas in Ecuador or specific parts of Amazonia along certain highways. These are almost impossible to compare

meaningfully to other estimates, and have been placed together at the very end of the rate chart.

*Units*

Another problem is that sources use many different units to describe an area deforested, most of which the general public can not relate to very well. These units include hectares, square kilometers and square miles. Others references use analogies such as the size of a U.S. football field or "the size of [the U.S. state of] Rhode Island" in an attempt to make the areas more understandable by analogy to the reader. The problem is that it is hard to compare such analogies. The estimates in the rate chart have been converted to square kilometers whenever possible. Sources also often give percentages for deforested areas, but often do not specify what figure was used for the denominator. For example, if an article claims Rondonia is x% deforested, is this the percent of the area of the state, or the area of the original forest or the area of the remaining forest? Percentages from sources used in the chart have been converted to square kilometers wherever possible. If a percentage of a political geographic state is given, we used the area of that state (e.g., Rondonia) as the reference to convert the percentage to square kilometers.

*General Data Trends*

Despite the large discrepancies in deforestation rates which appear in the literature, the degree of variation seems to have decreased over time (Downton, 1995). This is largely due to the increasing reliance on objective remote sensing technologies in deforestation surveys

rather than reliance on "expert opinions." Grainger (1993) identifies subjectivity and lack of adequate reliance on remote sensing as key causal factors in the huge discrepancies in rates of deforestation given in the literature. Indeed, a consensus has emerged over time that any reliable evaluations of deforestation must be based on non-subjective, remote sensing methodology. Thus, older studies using "expert opinion" methodology are rapidly becoming obsolete. Where the information is available, the rate chart indicated what methodology was used to produce the quoted estimate.

Remote sensing observation and interpretation technology has also increased dramatically in the last decade, and will continue to do so in the future. This has also helped narrow the range of rates of deforestation found in the literature. However, remote sensing technologies are still far from perfect, and a general rule applies that the higher the resolution of satellite images used in a study, the higher the cost of the images. Using the highest available resolution images, such as 10 meter x 10 meter French SPOT images for as vast an area as the Amazon is far too expensive. Usually, lower resolution images are used for the bulk of the Amazon, and the resulting deforestation maps are spot checked using higher resolution images.

As remote sensing technology improves over time, estimates of Amazon deforestation should also become more accurate.

**Final Notes**

It is our hope that these charts will help to reduce some of the unnecessary confusion surrounding the wide-ranging estimates of the rates of Amazon deforestation, and the processes and policies behind these rates.

**Source List**


Downton, Mary W. 1995. "Measuring Tropical Deforestation: Development of the Methods." *Environmental Conservation.* Vol. 22, No. 3. Autumn. pp. 229-240.

Grainger, Alan. 1993. "Rates of deforestation in the humid tropics: estimates and measurements." *The Geographical Journal.* Vol. 159, No. 1. March. pp. 33-44.

Instituto Nacional de Pesquisas Espacias (INPE). 1992. *Deforestation in Brazilian Amazonia, Folheto.* INPE: Sao Jose dos Campos, Brazil.

Mantovani, A.C. Di Maio and A.W. Setzer. 1997. "Deforestation detection in the Amazon with an AVHRR-based system." *International Journal of Remote Sensing.* Vol. 18, No. 2. pp. 273-286.

Parisi, P. and M.H. Glantz. 1992. "Deforestation and Public Policy." *The World and I.* November. pp. 270-277.

Saatchi, Sasan S., Joao Vianei Soares and Diogenes Salas Alves. 1997. "Mapping Deforestation and Land Use in the Amazon Rainforest by Using SIR-C Imagery." *Remote Sensing of the Environment.* Vol. 59, No. 2. pp. 191-202.

Skole, David and Compton Tucker. 1993. "Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988." *Science.* Vol. 260. June 25. pp.1905-1910.

# Rates and Processes of Amazon Deforestation

## *Rates*

Michael H. Glantz, Amara Tandy Brook and Patricia Parisi

*Environmental and Societal Impacts Group/National Center for Atmospheric Research*, Boulder Colorado, USA*

**National Center for Atmospheric Research is sponsored by the National Science Foundation*

17 July 1997

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 8,000 - 10,000 | Brazilian Amazon, 1970s | Moran *et al*, 1994 | Mahar, 1988 | | approximate figures |
| 125,000 | Brazilian Amazonia, 1980 | Moran, 1993 | Mahar, 1988 | 12,500,000 hectares/yr | Says rate increased steadily from 1975-1987. "Houghton [1992] has suggested that up to 40% of this amount were land already deforested." |
| 177.25 | Brazil's Amazon | Filho, 1985 | | 5 acres/hr | |
| minimum 23,000 | Brazilian Amazon now | Salati *et al*, 1986 | Anon., PMCFB, 1982 | minimum 2.3 million ha/yr | says rate and extent likely greater than officialy recognized. Need to distinguish btwn. primary and replacement forest. Need to realize that Legal Amazonia is only 1/2 rf, so if % is taken against forest area, it would be double that given against L.A. |
| 21,130 | Brazilian Amazon, 1978-1989 | Mantovani and Setzer, 1997 | INPE, 1992b | | INPE used 30m Thematic Mapper (TM), high resolution Landsat images |
| 22,000 | Brazilian Amazon, 1978-1988 | Saatchi *et al*, 1997 | INPE, 1992b; Skole and Tucker, 1993 | | |
| 15,000 | Brazilian Amazon, 1978-1988 | Kenitzer, 1993 | Skole and Tucker, 1993 | 6,000 $mi^2$/yr | |
| about 20,000 | Brazilian Amazon, 1978-1988 (avg.) | Faminow, 1997 | INPE | | Faminow says these are, "...the best data and the only ones that ought to be used now..." Based on "hi-res Landsat" images. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 21,130 | Brazilian Amazon?, average annual rate 1978-88 | Miranda, 1992 | INPE | 0.54%/year | |
| 35,000 | Brazilian Amazon, 1980s | Moran *et al*, 1994 | Fearnside, 1989b | | average for the 1980s |
| 29,992 | Brazil's Amazon, 1985 | Brooke, 1992 | INPE statistics | 11,580 $mi^2$/yr | Based on INPE's, "...analysis of photographs taken by Landsat 5 satellites over the Amazon." |
| 21,000 | Brazilian Amazon, 1978-86 | Brazil's Report to UNCED, 1992 | reviewed published data, + satellite photography | | |
| Up to 80,000 | Brazilian Amazonia, 1987 | Moran, 1993 | Booth, 1989; Setzer and Pereira, 1991 | 8 million hectares/yr | "...possibly the peak rate to date..." |
| 80,000-200,000 $km^2$ | Brazil's Amazon 1987 | Setzer and Pereira, 1991 | | hectares, biomass burnings, 5 times size of Switzerland | |
| | Brazil Amazon, 1987 | Myers, 1988 | | 2.5% of biome/yr | burning primary forest = 80,000 $km^2$ in 1987 |
| 100,000 $km^2$ of primary forest | Brazil's Amazon 1987-88 | Hildyard, 1989 | | 10% already gone | "at least 10% of Brazil's Amazon has been laid to waste"? don't know what forest types he's referring to. Devl. projects-highways, dams, plantations, pastures, industry, mining. |
| 17,860 | Brazilian Amazon?, annual rate 1988-89 | Miranda, 1992 | INPE | 0.48%/yr | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 17,860 | Brazilian Amazon, 1988-1989 | Alves | INPE | | Based on Landsat Thematic Mapper (TM) imagery |
| | (Brazilian?) Amazon | Worcman, 1990 | Mesquita, former IBAMA President | down 30% between 1988-1989 | Fernando Cesar Mesquita is former president of the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), and says this is how much the "Our Nature" Program reduced deforestation in it's first year. |
| 18,000 | Brazilian Amazonia, 1989 | Moran, 1993 | Houghton, 1992 | 1,800,000 hectares/yr | |
| 30,000 | Brazilian Amazon | Leopoldo, 1989 | | | cleared for "new areas of colonization" |
| 35,000 | Brazil's Amazon now | Fearnside, 1989b | himself | | 35,000 $km^2$/yr lost to cattle production; other causes: land speculation, agric., gov't subsidies. Says Legal Amazon region=5 million $km^2$, covering all or part of 9 states; depending on definitions of forest, about 70-80% of region is forest, remainder |
| | | Fearnside, 1989b (continued) | | | is savanna. Says a problem is using the area of pilitical units as basis for %, since savanna lands are not considered. Suggests use of extractive reserves |
| 81,000 | Brazil's Amazon | Waters, 1989 | INPE, Setzer | 20,000,000 acres | burned |
| 18,000 | Brazilian Amazon, 1989 | Brazil's Report to UNCED, 1992 | | | |
| 19,000 | Brazilian Amazonia, 1989 | Brazil's Report to UNCED, 1992 | | | |
| 14,000 | Brazilian Amazon, 1990 | Brazil's Report to UNCED, 1992 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 23,957 | (Brazilian?) Amazon, average rate for 1980s and rate between Jan. 1989 and July 1990 | Worcman, 1990 | INPE satellite data, no citation | 9,250 $mi^2$/year | |
| 13,810 | Brazilian Amazon?, 1989-90 | Miranda, 1992 | INPE | 0.37% | |
| 13,810 | Brazilian Amazon, 1989-1990 | Alves | INPE | | Figure is based on Landsat Thematic Mapper (TM) imagery. |
| 14,000 | Brazilian Amazon, 1989-1990 | Saatchi *et al*, 1997 | INPE, 1992b; Skole and Tucker, 1993 | | |
| 50,000-80,000 | Brazilian Amazon, late 1980s | Kenitzer, 1993 | "estimates" (high) | 20,000-32,000 $mi^2$/yr | |
| 17,000-80,000 | Brazilian [Amazon] Rainforest, 1990? | Maxwell, 1991 | WRI, 1990-91 | 1.7-8 million hectares | |
| 13,800 | Brazilian Amazonia, 1990 | Moran, 1993 | Houghton, 1992 | 1,380,000 hectares/yr | |
| 25,000-50,000 | Brazil's Amazonia | Shukla *et al*, 1990 | Fearnside, 1987; Myers, 1982; Mahar, 1989; INPE, 1989a | will disappear in 50-100 yrs | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| ? | Brazilian Amazon, 1990-1991 | Alves | INPE | | Figure is based on Landsat Thematic Mapper (TM) imagery. |
| 19,000 | Brazilian Amazon, 1990-1991 | Saatchi *et al*, 1997 | INPE, 1992b; Skole and Tucker, 1993 | | |
| 11,130 | Brazilian Amazon (?), 1990 1991 | Miranda, 1992 | INPE | 0.30% | |
| 11,134 | Brazil's Amazon, Yr preceeding August 1991 | Brooke, 1992 | INPE statistics | 4,299 $mi^2$/yr | Figure is based on INPE's, "...analysis of photographs taken by Landsat 5 satellites over the Amazon." Filho, INPE program director, notes that it would take 330 years to deforest the entire Amazon at this rate (4,299 $mi^2$/year). |
| 11,100 | Brazilian Amazonia, 1991 | Moran, 1993 | Houghton, 1992 | 1,110,000 hectares/yr | |
| 20,000 | Brazilian Amazon?, 1991 | *Latin American Regional Reports - Brazil*, 1995 | Kirchoff, acting director of INPE | area of forest burned | Estimate based on available data, final report with more satellite data due in 1996. |
| 11,132 | (Brazilian) Amazon region, 1991 | Rainforest Relief Portland Chapter, 1996 | Brazil Ministry of Science and Technology | 4298 $mi^2$ | |
| 11,137 | (Brazilian) Amazon, 1991 | EnviroNews Service, 1996 | "govt figures" (Brazilian) | 4300 $mi^2$ | Annual rose 26% from 1991-1994. |
| 11,137 | Brazilian Amazon, 1991 | Associated Press, 1996 | "government figures" | 4300 $mi^2$ | |
| 10,000 | Brazil's Amazon, 1992 | Park, 1992 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 15,000 | Brazilian Amazon, 1994 | McConahay, 1997 | "experts" | | Author says 1995 and 1996 rates are probably higher. |
| 14,892 | Brazil Amazon, 1994 | Associated Press, 1996 | "government figures" | 5750 $mi^2$ | |
| 10,000 | Brazilian Amazon?, 1994 | *Latin American Regional Reports - Brazil*, 1995 | Kirchoff, acting director of INPE | area of forest burned | Estimate based on available data, final report with more satellite data due in 1996. |
| 14,893 | (Brazilian) Amazon region, 1994 | Rainforest Relief Portland Chapter, 1996 | Brazil Ministry of Science and Technology | 5750 $mi^2$ | |
| 14,893 | (Brazilian) Amazon, 1994 | EnviroNews Service, 1996 | "govt figures" (Brazilian) | 5750 $mi^2$ | Annual rose 26% from 1991-1994. |
| 10,000 | Brazilian Amazon?, 1995 | *Latin American Regional Reports - Brazil*, 1995 | Kirchoff, acting director of INPE | area of forest burned | Estimate based on available data. Final report with more satellite data due in 1996. |
| 20,000 | Brazilian Amazon, Amazonia (1995?) | "Demography and Environment...", 1992-1995 | INPE | "1 to 1.5 percent of the total forested area in the Amazon Basin." | |
| > 20,234 | "Amazon region in Brazil", updated 1996 | Raytheon Electronic Systems, updated 1996 | | >5,000,000 acres/year | |
| 80,000 | Brazilian Amazon? | Miranda, 1992 | says this is an often cited figure | | Dr. Miranda says that INPE analysis shows that annual deforestation never reached this rate. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Brazil's Amazon | Brooke, 1992 | INPE statistics | "63 percent drop in annual deforestation rates... since 1985." 1985 - 11,580 $mi^2$. Yr preceeding August 1991 - 4,299 $mi^2$ | Based on INPE's, "...analysis of photographs taken by Landsat 5 satellites over the Amazon." Filho, INPE program director, notes that it would take 330 years to deforest the entire Amazon at the previous year's rate (4,299 $mi^2$/year). |
| 11,131 | Brazil's Amazon, 1991 | Reuter, 1996 | | | |
| 14,892 | Brazil's Amazon, 1994 | Reuter, 1996 | | | |
| | Brazil's Amazon, by 1996? | Reuter, 1996 | | 11% | "... percent of Brazil's Western Europe-sized chunk of the forest..." |
| | (Brazilian) Amazon | WWF web site | | rate up 34% since 1992 | |
| 50,000 - 80,000 | Brazilian Amazon | Faminow, 1997 | "has been reported" | | "...derived from low resolution weather satellites, which are not very precise and known to badly exaggerate the extent of deforestation." |
| 30,000 $km^2$ | Brazilian Amazonia, total by 1975 | Moran, 1993 | Mahar, 1988 | 3,000,000 hectares, 0.06% | |
| | Brazil's Amazon 1975-1978 | Buschbacher 1986 | INPE Landsat (1980) | 4% deforested as of 1985; 0.33% cleared/yr | |
| 78,000 $km^2$ | Brazilian Amazon Basin, total by 1978 | Skole and Tucker, 1993 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 208,000 $km^2$ | Brazilian Amazon Basin, total forest habitat affected by 1978 | Skole and Tucker, 1993 | | | This is the area, "...severely affected with respect to biological diversity...", due to edge effects |
| 260,000 $km^2$ | Brazilian Amazonia, "recent past" (defines as the last two decades) | Myers, 1980 | INPA (Warwick Kerr). At least 1/10 (260,000 $km^2$) of the original forest cover has been eliminated | "ostensibly reputable opinion seems to suggest that as much as 260,000 $km^2$..." | forest conversion in Brazil: smallholder colonization and cattle raising, both entail complete elimination of the original forest. Says much variation among figures of forest eliminated/yr. Diff. to comment on validity of figures. Says though bioclimatic |
| | | Myers, 1980 (continued) | | | data suggest that the orig. spread of Amazonian forest was far greater than w/in recent past, still cannot state w/assurance how much forest in fact existed at turn of century. Nor can one ascertain how much forest now remains in all the areas in question |
| | | Myers, 1980 (continued) | | | (fringe territories). |
| 148,000 $km^2$ | Brazil's Amazon, total by 1983 | Park, 1992 | | | |
| | Brazil's Amazon rf, 1975-85 | Barbier, 1991 | | 11% cleared | cattle ranching, settlement, timber, lg. dev. projects, gov't subsidy, high population growth rate |
| | Brazil's Amazon ("recent"?) | Buschbacher 1986 | | 1.55% def. | government subsidies, pasture development, road networks, timber extraction, charcoal manufacturing |
| 230,000 $km^2$ | Brazilian Amazon Basin,total by 1988 | Skole and Tucker, 1993 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 230,000 $km^2$ | Brazilian Amazon, total 1978-88 | Moran *et al*, 1994 | Skole and Tucker, 1993 | | "...the most recent estimates, based on detailed examination of satellite data." |
| | Brazil's Amazon 1987-88 | Hildyard, 1989 | World Bank | 12 % already gone | |
| 377,600 $km^2$ | Brazilian Amazon, total by 1988 | Alves | INPE | | This figure is based on Landsat Thematic Mapper (TM) imagery. |
| 300,000 - 400,000 $km^2$ | Brazilian Amazon, in (total by?) 1988 | Faminow, 1997 | "believable estimates" | 6 - 9.4% | Total forested area is greater than 4,000,000 $km^2$. |
| | Brazilian Amazon, total deforestation by (1988) | Faminow, 1997 | INPE | 9.40% | Area is included in 9.4% "...even if secondary growth has returned." |
| 400,000 $km^2$ | Brazilian Amazonia, total by 1988 | Myers, 1989 | Fearnside, 1989c, Fearnside, 1990b, Mahar, 1988 | remote sensing data | =11% of originally forested Amazonia. IINPE, 1989 says figure is 251,000 $km^2$, though. Of the 400,000 $km^2$ cleared, about 69% has occurred since 1980. |
| | | Myers, 1989 (continued) | | | projected problems/causes: settlement/immigration, road building, mining, dam construction, commercial logging, fossil fuel devl.: all of these planned activities will deforest btwn 750,000-1,366,000 $km^2$ of Brazilian amazonia. Incidental def.: |
| | | Myers, 1989 (continued) | | | farmers/ranchers, shifting cult., spontaneous migrants. Underlying causes: skewed land distribution, inadeq. land tenure systems, shaky Brazilian economy, debt burden, pop. growth; int'l devl. banks, aid agencies. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 588,000 $km^2$ | Brazilian Amazon Basin, total forest habitat affected by 1988 | Skole and Tucker, 1993 | | | |
| 590,000 $km^2$ | Brazilian Amazon, total "alteration" in terms of biodiversity by 1988 | Mantovani and Setzer, 1997 | Skole and Tucker, 1993 | | Skole and Tucker used black and white Landsat TM images |
| 588,000 $km^2$ | Brazilian Amazon, area affected through edge effects, 1978-1988 | Moran *et al*, 1994 | Skole and Tucker, 1993 | | These are, "...the most recent estimates, based on detailed examination of satellite data" |
| 396,689 $km^2$ | Brazilian Amazon, total by August 1989 | Moran, 1993 | | 90% still intact | Area in "Legal Amazonia" = 4,906,787 $km^2$; Original (approx.) forest area = 3,964,000 $km^2$ |
| | Brazilian Amazon, total by 1989? | Maxwell, 1991 | Mahar, 1989 | "as high as 12%" | "...estimates on the basis of Landsat images." |
| 415,000 $km^2$ | Brazilian Amazonia, total by 1990 | Brazil's report to UNCED, 1992 | | | |
| | Brazilian [Amazon] Rainforest, by 1990? | Maxwell, 1991 | WRI, 1990-91; "experts" | "7% of... forested area has already been lost." | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | considering (Brazilian) Amazon rf alone | Neto, 1990 | INPE | 10.9% destroyed | Used Landsat. |
| 426,000 $km^2$ | Brazilian Amazon, total by 1991 | Saatchi *et al*, 1997 | INPE, 1992b; Skole and Tucker, 1993 | 10.5% of Brazil's land which was originally in forest | Figures are based on Landsat data. |
| | Brazil's Amazon | Brooke, 1992 | Fearnside | 10% deforested already | |
| 426,000 $km^2$ | Brazilian Amazonia, total deforestation | Miranda, 1992 | INPE | 10-11%, "a very large area, larger than the area of Germany." | Includes all deforestation in last 200 years, but most has occurred "occurred in the last 20 years." |
| 397,000 $km^2$ | Brazilian Amazon, "total area altered" | Moran *et al*, 1994 | Molion, 1991 | 10.80% | |
| | Brazilian Amazon, by 1994 | WCMC, 1997a | WCMC, 1994 | "10%... has been cleared" | |
| | (Brazilian) Amazon Rainforest, (by 1996?) | EnviroNews Service, 1996 | | 12% already deforested | |
| | Brazilian Amazon 1991 | Acharya, 1996 | INPE Satellite | 17,800 fires in July | "... relationship between the number of fires and the rate of deforestation is uncertain...." Def. rate directly monitored by INPE b/w 1989-1991. Halted in 1991 for lack of funding. INPE now using hi-res satellite data to assess def. for 1994 and 1995. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Brazilian Amazon, June-October dry season, 1991 | *Latin American Regional Reports - Brazil*, 1995 | Brazil environment minister Gustavo Krause | 312,000 fires | Based on satellite data other than what the *Veja* satellite used |
| | Brazilian Amazon 1992 | Acharya, 1996 | INPE Satellite | 13,100 fires in July | "... relationship between the number of fires and the rate of deforestation is uncertain...." Def. rate directly monitored by INPE b/w 1989-1991. Halted in 1991 for lack of funding. INPE now using hi-res satellite data to assess def. for 1994 and 1995. |
| | Brazilian Amazon 1993 | Acharya, 1996 | INPE Satellite | 19,800 fires in July | "... relationship between the number of fires and the rate of deforestation is uncertain...." Def. rate directly monitored by INPE b/w 1989-1991. Halted in 1991 for lack of funding. INPE now using hi-res satellite data to assess def. for 1994 and 1995. |
| | Brazilian Amazon 1994 | Acharya, 1996 | INPE Satellite | 8,500 fires in July | "... relationship between the number of fires and the rate of deforestation is uncertain...." Def. rate directly monitored by INPE b/w 1989-1991. Halted in 1991 for lack of funding. INPE now using hi-res satellite data to assess def. for 1994 and 1995. |
| | Brazilian Amazon, June-October dry season, 1994 | *Latin American Regional Reports - Brazil*, 1995 | Brazil environment minister Gustavo Krause | 69,683 fires | Figure is based on satellite data other than what the *Veja* satellite used. |
| | Brazilian Amazon 1995 | Acharya, 1996 | NASA photos | 40,000 fires in July | "... relationship between the number of fires and the rate of deforestation is uncertain...." Def. rate directly monitored by INPE b/w 1989-1991. Halted in 1991 for lack of funding. INPE now using hi-res satellite data to assess def. for 1994 and 1995. |
| | Brazilian Amazon, June-October dry season, 1995 | *Latin American Regional Reports - Brazil*, 1995 | Brazil environment minister Gustavo Krause | 75,423 fires | "Krause admitted that about 10,600 hot spots recorded in mid-July had been excluded because of technical problems with the satellite." |
| | | | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 13,600 | Brazil, 1970s | Skole and Tucker, 1993 | FAO, 1981 | | |
| 14,000 | Brazil | Monastersky, 1990 | UN, 1980 | 1.4 million hectares/yr | |
| | Brazil, 1976-80 | Grainger, 1993 | Grainger, 1983 | 1,360,000 ha/yr | |
| 13,600 | Brazil | Jackson, 1983 | | 0.38%/yr deforested | |
| 80,000 | Brazil, 1987 | Monastersky, 1990 | INPE; WRI | 8 million hectares | "... based on IR satellite images that reveal smoke from fires" |
| 80,000 | Brazil in 1987 | Booth, 1989 | Setzer | hectares | "converted," "burned;" suggests use of NOAA 1km res. satellites and Landsat w/30m res. and random ground checks to provide info on forces driving def. causes: colonists leaving overcrowded cities, newly paved roads. Measured fires using satellite. |
| | Brazil, late 1980s | Grainger, 1993 | Myers, 1989 | 5,000,000 ha/yr | |
| 80,000 | Brazil, late 1980s | Grainger, 1993 | WRI, 1990 | | |
| 15,000 - 20,000 | Brazil | Skole *et al*, 1994 | FAO, 1993c; Myers, 1991; Skole and Tucker, 1993 | $1.5x10^6$ - $2.0x10^6$ ha/yr | |
| 21,000 | Brazil | Miranda, 1992 | INPE | 2.1 million hectares/yr | Dr. Miranda says FAO conceded to this rate at Earth Summit "...when pressed." He says that, "This is an admission that they were inflating the deforestation rate by nearly 300 percent." INPE figures are based on Landsat 5 satellite data. |
| 80,000 | Brazil | Miranda, 1992 | FAO "report released at the Earth Summit." | 8 million hectares/yr | Dr. Miranda says FAO still uses this number, though it is a discredited figure. |
| 36,710 | Brazil | WCMC, 1997a | WWF/WCMC, 1996; FAO, 1995 | 0.65%/yr, 3,671,000 ha/yr | "Annual change" in forest cover |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 21,500 | Brazil, 1978-1988 | Brazilian Embassy, UK "Deforestation" | | | "...average annual rate..." |
| 48,000 | Brazil, 1988 | Downton, 1995 | WRI, 1990 | | "...estimate of... primary forest cleared...", based on AVHRR data projections. Downton says this estimate is wrong. |
| 50,000 | Brazil | Myers, 1989 | various sources listed in biblio | 2.3%/yr of remaining forest | 2,860,000 $km^2$ orig. extent of forest cover; 2,200,000 $km^2$ present extent of forest cover; 1,800,000 $km^2$ present extent of primary forests. |
| 18,842 | Brazil, 1988-1989 | "Deforestation", Brazilian Embassy, UK | | | |
| 13,813 | Brazil, 1989-1990 | "Deforestation", Brazilian Embassy, UK | | | This is a 27% decrease from the 1988-1989 rate. |
| 28,000 | Brazil, now (1990) | Comm. on Devl. & Env. for Amazonia, 1992 | INPE, 1990 | | |
| 36,710 | Brazil | FAO, 1993a, Table 4c | | 3,671,000 ha/yr = 0.6%/yr | Time period 1980-1990 (decadal average?) |
| 17,000 | Brazil, average for 1980s | Monastersky, 1990 | INPE | 1.7 million hectares/yr | |
| 23,230 | Brazil in 1980s | Speth, 1990 | FAO, World Bank | hectares | |
| 21,853 | Brazil | "The Rate of Rainforest Destruction: In Brazil." | (obviously from Rainforest Action NW website) though no reference is given) | 5,400,000 acres/yr | average 1979-1990 |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 21,853 | Brazil | Rainforest Action Network | Myers, 1989 | 5,400,000 acres/yr | average 1979-1990 |
| 50,000 | Brazil | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 2.3% | |
| 25,000-80,000 | Brazil now | Repetto, 1990 | | hectares, square miles | land speculation, road building, cattle ranches, government subsidies |
| 80,000 | Brazil | Wood, 1990 | Repetto, 1990 | def. rate: 2.2% | |
| 100,000 $km^2$ | Brazil, "until 1970" | "Deforestation", Brazilian Embassy, UK | | | Deforestation was concentrated in Para and Maranhao. |
| 367,000 $km^2$ | Brazil, 1975-88 | Comm. on Devl. & Env. for Amazonia, 1992 | INPE, 1990 | | |
| 415,215 $km^2$ | Brazil, by Feb. 1991 | "Deforestation", Brazilian Embassy, UK | | | |
| | Brazil | Park, 1992 | | | landless peasants driven out of crowded cities and poverty to search for land; gov't resettlement schemes; gov't concessions to commercial operators; and unequal land distribution causes landless situation. In Brazil 4.5% of the pop. controls 81% of the |
| | | Park, 1992 (continued) | | | land; 3/4 of the rural pop. own no land at all |
| | Brazil, 1994 | *Latin American Regional Reports - Brazil*, 1995 | *Veja*, 1995 | 8,000 fires in July; # of fires in July 1995 is 5 times that of previous yr | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Brazil, 1995 | *Latin American Regional Reports - Brazil*, 1995 | *Veja*, 1995 | 72,219 in "first half of August" | |
| | Brazil, 1995 | *Latin American Regional Reports - Brazil*, 1995 | *Veja*, 1995 | 40,000 fires in July | #s in *Veja* report are based on US NOAA-14 satellite pictures. INPE supplied #s to *Veja*. Later, INPE "switched to the NOAA-12 satellite after it was discovered that the other one could not distinguish between fires and reflections from rivers and lakes." |
| | Brazil | Park, 1992 | World Wide Fund for Nature, 1988 | 1/3 lost by year 2000 | based on proportion of remaining forest |
| 775,249 $km^2$ | Brazil | McCloskey and Spalding, 1989 | | 17.8% loss; sqaure miles; has 42% total terr. in tf | used Smithsonian Inst. maps, some use of Landsat, showing existence of undisturbed primary closed canopy moist trf; say original world total of trf was 14.3 million $km^2$; current total of trf is 9.64 million $km^2$ (world); do not say what time period "origin |
| | | McCloskey and Spalding, 1989 (continued) | | | refers to, nor when or how losses occurred. |
| | Brazil | Lewis, 1990 | Myers | 60% of original forest cover remaining: | |
| | Brazil | Park, 1992 | | | accounts for 3/4 of total world rainforest clearance. Amazon rainforest in Brazil covers 3.37 million $km^2$. |
| | | | | | |
| 40,000 | entire Amazon | Salati *et al*, 1986 | | 4 million ha/yr | says actual current deforestation for the entire Amazon could be 4 million ha/yr, based on observations by researchers indicate that great pressure on the forest exists; large areas replaced by agriculture and pasture. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 80,000 $km^2$ | Amazon Basin | Moran *et al*, 1994 | Booth, 1989 | 8 million hectares | |
| 100,000 | Amazonia? | Lutzenberger, 1987 | | 2%/yr | area not defined<br>"cleared" "felled" |
| 20,000-30,000 | Amazon Basin | Bunyard, 1987 | | hectares | 100,000 $km^2$ cleared for cattle from 1966-83; crops, pastures area not defined |
| 80,000 | virgin forest, Amazon Basin, 1987 | Park, 1992 | INPE, 1987 | remote sensing | says 1987 was the peak; most deforestation occurred by roads. 1987 was the last year that land/tax credits were available. 40% drop in def. rate in 1988. Rate fell by 1/2 again in 1989. |
| nearly 213,097 $km^2$ | Amazon, 1987 (burned) | Schwartzman, 1989 | "recent satellite evidence" | "an area nearly the size of Kansas." (1987) | "The forest is being destroyed at an increasingly rapid rate: the cleared area expanded five times between 1980 and 1988." |
| 21,000 | virgin forest Amazon area, 1989 | Editors, *New Scientist*, 1991 | Ibama | | area not defined |
| 13,818 | area of Amazon rf, 1990 | Homewood, 1991 | UN | | "destroyed" says rate is declining |
| 17,871 | area of Amazon rf, 1989 | Homewood, 1991 | UN | | "destroyed" |
| 18,000 | virgin forest in Amazon area, 1990 | Editors, *New Scientist*, 1991 | Ibama | | area not defined |
| | Amazon forests now | Josephson, 1991 | | 1-2%/yr | area not defined |
| 10,588 $km^2$ | Amazon forest | Brooke, 1992 | | "area twice the size of Delaware" | This is the area "...going up in smoke last year" (1991) |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 11,000 | Amazon, 1992-1993 | "Deforestation", Brazilian Embassy, UK | Tucker and Skole, 1993 | 0.3%/yr | Author says Tucker and Skole consider "...Brazilian estimates of deforestation in Brazil's Amazon... scientifically accurate." (quote from Tucker and Skole) |
| 80,000 | Amazon | Miranda, 1992 | World Bank, 1988 report | 8 million hectares/year | Dr. Miranda says this is much higher than INPE's figures. |
| about 30,513 | Amazon Basin | "The Rate of Rainforest Destruction: In Brazil." | | " about the size of Belgium" | |
| 170,000 $km^2$ | Amazon Basin, total '78-88 | Park, 1992 | INPE | remote sensing/ (satellite imagery) | says some imagery (VHRR) can only detect smoke over an area, can't detect deforestation without fire; and overestimates deforestation with fire. Only broad classes of vegetation can be distinguished. |
| 600,000 $km^2$ | Amazon Region, by 1988 | "Deforestation", Brazilian Embassy, UK | Tucker and Skole/NASA, 1994 (who cited World Bank, 1988) | 12% | |
| 280,000 $km^2$ | Amazon Region, by 1988 | "Deforestation", Brazilian Embassy, UK | Tucker and Skole/NASA, 1994 (who cited INPE) | 5% | Author says Tucker and Skole's "...estimates are even lower" |
| | Amazon | Earthworks, 1989 | | 80% since 1980 | |
| 6879.66 $km^2$ | Amazon, total since early 1970s | Brooke, 1989 | Marc J. Dourojeanni, Peruvian forest engineer, 1987 study | 1.7 million acres since early 1970s | This is the amount of deforestation "...directly or indirectly..." caused by coca production since "...coca boom began in the early 1970s." |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 800,000 $km^2$ have been deforested | entire Amazon region | Comm. on Devl. & Env. for Amazonia 1992 | | | >50% of that loss in Brazil alone |
| | Amazon, past decade | Pearce, 1992 | | 12 % destroyed | road building, tax concessions, push to migrate, World Bank-financed Polonoroeste project in the '80s |
| | | | | | |
| 114,697 $km^2$ eliminated; = 10,427 $km^2$/yr | Amazonia 1966-77 | Myers, 1980 | IBDF (gov't forestry agency) officials, 1979 | | |
| 115,000 $km^2$ = 12,777 $km^2$/yr | Amazonia 1966-75 | Myers, 1980 | SUDAM | | 45,000 $km^2$ from cattle raising, 35,000 $km^2$ thru smallholder settlement, agric. colonization, 30,000 $km^2$ thru highway construction, and 5,000 $km^2$ thru timber harvesting |
| | | Myers, 1980 (continued) | | | says this survey/book does not attempt to produce a best judgment figure for the total amount of forest cleared in Amazonia or of the current clearing rate 'cuz a comprehensive remote sensing assessment made by INPE in the future will overtake such a |
| | | Myers, 1980 (continued) | | | semi-arbitrary reckoning. |
| | Amazonia up to 1983 | Park, 1992 | Friends of the Earth, 1989 | | 1/10 of all forest clearance in Amazon up to 1983 caused by small farmers practicing shifting cultivation |
| | Amazonia now | Hecht, 1989 | | 85% still forested | 85% of what was there 100 years ago is still there |
| | Amazonia | *Latin American Regional Reports - Brazil*, 1995 | US Rainforest Action Network | 130,000 mahogany trees cut per year | |
| | | | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 80,000 $km^2$ | Brazilian Legal Amazon, "dense forest", 1987; "new deforestation" | Fearnside, 1989a; Fearnside, 1990a | Setzer *et al*, 1988 | | Area burned, ID with NOAA satellite. Fearnside says this estimate is too high because it overestimates burning area and there is a "..lack of an objective method for estimating the % of burning that represents new deforestation." (Fearnside, 1990, p.214) |
| 35,000 $km^2$ | Brazilian Legal Amazon, 1987 | Fearnside, 1989a | | | Fearnside refers to "...our calculations...." |
| 15,000 - 20,000 | Brazilian Legal Amazon | Skole *et al*, 1994 | | | Authors used Landsat Thematic Mapper (TM) images for 1988, converted into a digital map from which area of deforestation was calculated. Compared this to areas reported by Tardin et al, 1980. Deforestation rate estimate is close to INPE, 1992 figures. |
| 225,300 | Brazilian Legal Amazon, total Jan 1978-Apr 1988 | INPE, 1996 | | | |
| 22,000 | Brazilian Legal Amazon, 1978-88 annual average | Brazil's Report to UNCED, 1992 | | | |
| ~ 15,000 | Brazilian Legal Amazon, average 1978-88 | Skole and Tucker, 1993 | | | Authors used Landsat TM, 1:500,000 with visual interpretation. |
| 15,200 | Brazilian Legal Amazon, avg. annual 1978-88 | Downton, 1995 | Skole and Tucker, 1993 | | This figures is based on 1:500,000 black and white Landsat TM images. |
| 22,000 | Brazilian Legal Amazon, 1978-88 | Downton, 1995 | Fearnside, 1993 | | "Covers a slightly larger area (229 Landsat TM images), improves treatment of cloud-covered areas, and corrects errors in earlier analyses... including flooding by hydroelectric dams." |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 22,000 | Brazilian Legal Amazon, avg. annual rate 1978-88 | Downton, 1995 | INPE, 1992b | | Figure is based on 1:500,000 black and white Landsat MSS images. |
| 21,000 | Brazilian [Legal] Amazonia, average 1978-88 | Skole and Tucker, 1993 | Fearnside *et al*, 1990; INPE, 1992b; Tardin *et al*, 1979; Tardin *et al*, 1980; Tardin and Cunha, 1990 | | |
| 20,298 | Brazilian Legal Amazon, 1988 | Fearnside, 1990a | | | |
| 20,000 | Brazilian Legal Amazon, 1988 | Fearnside, 1990a | | | This number represents forest loss, not including cerrado clearing. |
| 48,000 $km^2$ | Brazilian Legal Amazon, 1988 | Fearnside, 1990a | INPE (Setzer *et al* in prep); Tuffani, 1989 | 40% of 1988 burning area is new deforestation | This is an "...AVHRR infrared estimate...." It is not a very reliable estimate because of poor methodology using correction factors. |
| 50,000 | Brazilian Legal Amazon, 1988 | Fearnside *et al*, 1990 | Myers, 1989 | | says Myers and WRI methods used NOAA satellites which detect fires and cannot estimate size of the deforested area accurately. Used 222 Landsat TM images. |
| 19,000 | Brazilian Legal Amazon, 1988-89 | Brazil's Report to UNCED, 1992 | | | |
| 19,000 | Brazilian Legal Amazon, 1988-89 | Downton, 1995 | Fearnside, 1993 | | "Covers a slightly larger area (229 Landsat TM images), improves treatment of cloud-covered areas, and corrects errors in earlier analyses... including flooding by hydroelectric dams." |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 50,000 | Brazilian [Legal] Amazonia, 1989? | Fearnside, 1990a | Myers, 1989 | | "..current rate of forest loss (both primary and secondary)..." "based on INPE... AVHRR estimate of 48,000 $km^2$ for primary forest... clearance in 1988." Fearnside says this estimate's basis is invalid because of problems interpreting AVHRR burning data. |
| 23,900 $km^2$ | Brazilian Legal Amazon, total Apr 1988 - Aug 1989 | INPE, 1996 | | | |
| 21,130 | Legal Amazon, 1978-89 | INPE, 1992a | | as % of remaining forest: 0.54% | INPE, uses LANDSAT; measures dense tropical forest and thick savannah (cerrado) |
| 17,860 | Legal Amazon, 1987/88-1989 | INPE, 1992a | | 0.48% | |
| 21,800 | Legal Amazon 1979-90 | WRI, 1992 | INPE | 2.18 million ha/yr | |
| 21,400 | Legal Amazon 1985-90 | WRI, 1992 | FAO | 2.14 million ha/yr | |
| 13,800 | Brazilian Legal Amazon, 1989-90 | Brazil's Report to UNCED, 1992 | | | |
| 13,800 | Brazilian Legal Amazon, 1989-90 | Downton, 1995 | Fearnside, 1993 | | "Covers a slightly larger area (229 Landsat TM images), improves treatment of cloud-covered areas, and corrects errors in earlier analyses... including flooding by hydroelectric dams." |
| 13,800 | Brazilian Legal Amazon, total Aug 1989 - Aug 1990 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 80,000 | Brazilian Legal Amazon, 1980s average | Fearnside *et al*, 1990 | WRI, 1990 | | says Myers and WRI methods used NOAA satellites which detect fires and cannot estimate size of the deforested area accurately. Used 222 Landsat TM images. |
| 13,810 | Legal Amazon, 1989-90 | INPE, 1992a | | 0.37% | |
| 20,000 | Brazil's Legal Amazon now | Fearnside, 1990a | | | says problems are definitions of def. and veg. types; scale of images; cost of Landsat; inconsistent classification expresses loss in %, but do not know original extent of forest cover. Problem: use of "vegetation cover" (rate of loss) when actually |
| | | Fearnside, 1990a (continued) | | | referring to "forest cover." Need to have ino. on areas of forest & cerrado present originally. Difficult, tho, to disting. btwn. forest & cerrado 'cuz of continuous gradations btwn. veg. types is broken into many finer categories--which makes assigning |
| | | Fearnside, 1990a (continued) | | | intermediate categories to 'forest' or 'cerrado' groups somewhat arbitrary. Used Landsat 80m res. and 30m res. 1972-82. |
| 11,130 | Legal Amazon, 1990-91 | INPE, 1992a | | 0.30% | shows rate is decreasing over time. Extent of gross deforestation in L.A.:1978:54,600 $km^2$ + old def.=152,200 $km^2$;1988:280,000 $km^2$ + old def.=377,600 $km^2$;1989:303,800 $km^2$ + old def.=401,400;1990:317,600 $km^2$ + old def.=415,200 $km^2$;1991:328,700 $km^2$ + |
| | | INPE, 1992a (continued) | | | old def.=426,400 $km^2$=total extent of deforestation. |
| 11,100 | Brazilian Legal Amazon, 1990-91 | Downton, 1995 | Fearnside, 1993 | | "Covers a slightly larger area (229 Landsat TM images), improves treatment of cloud-covered areas, and corrects errors in earlier analyses... including flooding by hydroelectric dams." |
| 11,200 | Brazilian Legal Amazon, total Aug 1990 - Aug 1991 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 13,786 | Brazilian Legal Amazon, total Aug 1991 - Aug 1992 | INPE, 1996 | | | |
| 29,792 $km^2$ | Brazilian Legal Amazon, total Aug 1992 - Aug 1994 | INPE, 1996 | | | |
| 28,595 $km^2$ | Legal Amazonia, total by 1975 | Mahar, 1989 | Fearnside, 1986b, World Bank | | L.A.=Acre+Amapa+Amazonas+Goias+Maranhao+Mato Grosso+Para+Rondonia+Roraima. L.A.="Amazonia" in Mahar's book. 2.5-2.8 million $km^2$ upland areas in which the orig. veg. was trf. Another 500,000 $km^2$ consists of transitional forest. Also savanna (cerrado) in |
| | | Mahar, 1989 (continued) | | | southern Amazonia (Mato Grosso, Goias) def. by 1975=0.6% of Legal Amazonia. Used LANDSAT. |
| | legal Amazonia, by 1975 | Hurrell, JLAS | | 0.60% | Figure is based on Landsat surveys. |
| 77,172 $km^2$ | Legal Amazonia, total by 1978 | Mahar, 1989 | Fearnside, 1986b, World Bank | | def. by 1978=1.5% of Legal Amazonia. Used LANDSAT. |
| 152,200 km2 | Brazilian Legal Amazon, total by January 1978 | Brazil's Report to UNCED, 1992 | | 3.6% "of original forest area" | |
| 78,268 $km^2$ | Brazilian Legal Amazon, total by 1978 | Skole and Tucker, 1993 | | | |
| 54,600 $km^2$ | Brazilian Legal Amazon, total by Jan 1978 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 152,200 $km^2$ | Brazilian Legal Amazon, total by January 1978 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| 125,108 $km^2$ | Legal Amazonia, total by 1980 | Mahar, 1989 | Fearnside, 1986b, World Bank | | def. by 1980=2.5% of Legal Amazonia. Used LANDSAT. |
| 2.50% | legal Amazonia, by 1980 | Hurrell, JLAS | | 2.50% | Figure is based on Landsat surveys. |
| 155,168 $km^2$ | Brazil, Legal Amazon, total by 1985 | Hankins | Prof John Browder and "official estimates" | 3.1% of Legal Amazon by 1985 | Hankins says area may actually be 2-5 times this, citing Prof. John Browder of Virginia Polytechnic Institute. |
| | Brazilian Legal Amazon, total by 1988 | Fearnside, 1990a | | 8.2% of orig forest cleared | |
| 598,000 $km^2$ | Legal Amazonia, total by 1988 | Mahar, 1989 | Fearnside, 1986b, World Bank | | def. by 1988=12% of Legal Amazonia. Used LANDSAT. |
| | | Mahar, 1989, (continued) | | | says main proximate causes of def. in Amazonia are small-scale agriculture, cattle ranching, logging, road building, hydroelectric devl., mining, urban growth. Says rel. contribution of each cannot be determined w/precision. Most imp. single factor, |
| | | Mahar, 1989, (continued) | | | though, is rapid expansion of agric. Gov't policies to encourage economic activity play key role in def. process. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 280,000 $km^2$ | Brazilian [Legal] Amazonia, total by 1988 | Skole and Tucker, 1993 | Fearnside *et al*, 1990; INPE, 1992b; Tardin *et al*, 1979; Tardin *et al*, 1980; Tardin and Cunha, 1990 | | |
| 230,324 $km^2$ | Brazilian Legal Amazon, total by 1988 | Skole and Tucker, 1993 | | | |
| 376,700 km2 | Brazilian Legal Amazon, total by April 1988 | Brazil's Report to UNCED, 1992 | | 8.8% "of original forest area" | |
| 279,900 $km^2$ | Brazilian Legal Amazon, total by April 1988 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 279,000 $km^2$ | Brazilian Legal Amazon, toal by April 1988 | Downton, 1995 | INPE, 1992b | | This is based on color Landsat TM, not "...including pre-1960..." deforestation. |
| 377,500 $km^2$ | Brazilian Legal Amazon, total by April 1988 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| 376,700 $km^2$ | Brazilian Legal Amazon, total by April 1988 | Downton, 1995 | INPE, 1992b | | This is based on color Landsat TM, "...including pre-1960..." deforestation. |
| | Brazilian Legal Amazon, 1960-1988 | Downton, 1995 | Fearnside 1990a | 6.80% | For percent calculation, author uses "...approximate rainforest area..." rather than total area of the Legal Amazon in the denominator. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 191,765 $km^2$ | Brazilian Legal Amazon, 1960-88 | Fearnside, 1990a | | "9.6% of forest" | |
| 267,969 (~268,000) $km^2$ | [Brazilian] Legal Amazon, 1960-1988 | Fearnside, 1990a | | "6.4% of the forest" | Based on "...INPE Landsat study data." Does not include pre-1960 deforestation. According to INPE, pre-1960 deforestation was "...31,822 $km^2$ in Para and 60,724 $km^2$ in Maranhao." (p.218) |
| 251,429 $km^2$ | Brazilian Legal Amazon, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | | Forest only, not cerrado clearing. |
| 295,432 $km^2$ | Brazilian Legal Amazon, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 7.0% of the area of the Brazilian Legal Amazon | Forest only, not cerrado clearing. |
| 267,969 $km^2$ | Brazilian Legal Amazon, 1960-88 | Fearnside, 1990a | | 6.4% of the area of the Brazilian Legal Amazon cut since 1960 | "Current best estimate." Forest only, not cerrado clearing. |
| | legal Amazonia, by 1988 | Hurrell, JLAS | | 12% | Figure is based on Landsat surveys. |
| 345,274 $km^2$ | Brazilian Legal Amazon, total by 1988 | Fearnside, 1990a | | 8.2% of "original primary forest cut" | Forest only, not cerrado clearing. |
| 598,922 $km^2$ | "Brazilian Amazonia" (obviously refers to Brazil's Legal Amazon), total by 1988 | Fearnside, 1989a; Fearnside, 1990a | Mahar, 1988; Mahar, 1989 | 12% | Figure is based on exponential projections from Fearnside, 1986 data (summarizing studies to 1980). Fearnside says this estimate is too high. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | "Brazilian Amazonia" (obviously refers to Brazil's Legal Amazon), total by 1988 | Fearnside, 1989a | himself | 8% | "The deforested area of Brazil's Legal Amazon is still relatively small, but it is expanding explosively." |
| 345,000 $km^2$ | [Brazilian] Legal Amazon, total by 1988? | Fearnside, 1990a | | "8.2% of the original forest area," "an area the size of Finland" | This is the"...area that has lost its original forest cover, including the old secondary-forest area." |
| 459,734 $km^2$ | Brazilian Legal Amazon, total by 1988 | Fearnside, 1990a | | | |
| 600,000 $km^2$ | Legal Amazonia, total by 1988 | Mahar, 1989 | | 12% of Amazonia =>France | small scale agric., commercial logging, fuelwood gathering, #1 cause is cattle raising;road building, urban growth, mining, hydroelectric devel. UNDERLYING causes:poverty, inequal land dist., low agric. prod., rapid pop. growth, misguided public policies |
| | Legal Amazonia | Neto, 1989 | INPE | 5.12% destroyed | related to total area of Legal Amazon; "INPE related the area destroyed (250,429 $km^2$) to the total area of the Brazilian Amazon region, rather than to total area of rf, which is smaller" |
| | Legal Amazonia | Neto, 1989 | World Bank | 12% destroyed | related to area of rf "Total area of rf (3,700,000 $km^2$) suggests that 6.8% of the rf has been destroyed." Used Landsat data from Fearnside. |
| | Legal Amazonia | Neto, 1989 | Fearnside | 8% destroyed | |
| 404,000 $km^2$ | Legal Amazon, total by 1989 | Neto, 1990 | INPE | | Legal Amazon=adminstrative definition. Used 1989 Landsat images |
| 396,689 $km^2$ | Brazil's Legal Amazon as of 1989 | Fearnside *et al*, 1990 | | | says Myers and WRI methods used NOAA satellites which detect fires and cannot estimate size of the deforested area accurately. Used 222 Landsat TM images. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 303,800 $km^2$ | Brazilian Legal Amazon, total by August 1989 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 401,400 km2 | Brazilian Legal Amazon, total by August 1989 | Brazil's Report to UNCED, 1992 | | 9.4% "of original forest area" | |
| 401,400 $km^2$ | Brazilian Legal Amazon, total by August 1989 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| | if Legal Amazon=the Amazon | Neto, 1990 | INPE | 8.2% destroyed since 16th century; 0.8%/yr now | Brazilian Amazon legally defined as consisting of the whole of 6 states: Acre, Amazonas, Rondonia, Roraima, Para, Amapa;and parts of 3 others:Mato Grosso, Maranhao, Tocantus. 3/4 of its 4,906,784 $km^2$ contain rf. about 1/4 consists of savanna. Used Landsat |
| 415,000 | Legal Amazon, total by 1990 | WRI, 1992 | INPE, 1991 | 41.5 million ha total cum. def. | says FAO hopes to use a new, more scientific methodology for est. the amount and rate of def.: compare satellite data from 2 time periods in statistically selected sites. By comparing satellite images taken at comparable time of year and confirming the |
| | | WRI, 1992 (continued) | | | data w/field obs., can produce more accurate def. estimates. FAO wants to monitor trop. def. continuously rather than every 10 years. |
| 415,200 $km^2$ | Brazilian Legal Amazon, total by August 1990 | Brazil's Report to UNCED, 1992 | | 9.7% "of original forest area" | |
| 317,600 $km^2$ | Brazilian Legal Amazon, total by August 1990 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 415,200 $km^2$ | Brazilian Legal Amazon, total by August 1990 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 426,400 $km^2$ | Brazilian Legal Amazon, total by August 1991 | Downton, 1995 | INPE | 10.7% of original forested area | |
| 328,800 $km^2$ | Brazilian Legal Amazon, total by August 1991 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 426,400 $km^2$ | Brazilian Legal Amazon, total by August 1991 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| 342,586 $km^2$ | Brazilian Legal Amazon, total by August 1992 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 440,186 $km^2$ | Brazilian Legal Amazon, total by August 1992 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| 372,378 $km^2$ | Brazilian Legal Amazon, total by August 1994 | INPE, 1996 | | | This does not include "ancient" deforestation (97,600 $km^2$). |
| 469,978 $km^2$ | Brazilian Legal Amazon, total by August 1994 | INPE, 1996 | | | This includes "ancient" deforestation (97,600 $km^2$). |
| 230,324 $km^2$ | Brazilian Legal Amazon | Skole *et al*, 1994 | | 6% of closed forests | This is the "...total area deforested in 1988." |
| | | | | | |
| 270 | Rondonia, 1976-78 | Woodwell *et al*, 1986 | | 27,000 ha/yr; | 54,000 ha total; LANDSAT |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Rondonia | Fearnside, 1986a | | From 0.9% cleared in 1975 to 4% in 1980; Rondonia= 3,067,920 $km^2$ | says figures are conservative; used 1980 Landsat images |
| 550 | Rondonia, 1978-81 | Woodwell *et al*, 1986 | | 55,000 ha/yr | 165,000 ha total; LANDSAT |
| 440 | Rondonia, 1976-81 | Woodwell *et al*, 1986 | | 44,000 ha/yr | 220,000 ha total; says 5-year interval was sufficient to determine total area of clearing, but not rates of clearing. LANDSAT |
| 2,187 | Rondonia, 1978-1989 | Saatchi *et al*, 1997 | Alves and Skole, 1996; Skole and Tucker, 1993; INPE, 1992b | 0.9%/yr | This is derived from analysis of Landsat data. |
| 25,800 $km^2$ | Rondonia, Jan 1978-April 1988 | INPE, 1996 | | | |
| 32,282 $km^2$ | Rondonia, 1987 | Fearnside, 1990a | | 13.30% | This is "...a corrected AVHRR clearing estimate." |
| | Rondonia, 1987? | Fearnside, 1990a | Setzer *et al*, 1988 | 18.70% | Estimate is based on AVHRR data. This percentage represents the "...area registered as burning... equivalent to approximately 40% deforestation as each hectare is burned once every 2-3 years." |
| 22,913 $km^2$ | Rondonia, 1987 | Fearnside, 1990a | IBDF, 1989 | 9.40% | This figure is based on a Landsat study. |
| 41.2 of "primary forest"; 19.7 of "secondary vegetation" | Rondonia, 1986-1988 | Skole *et al*, 1994, p.316 | | | Statistics represent areas cleared for agriculture only. Authors used high-resolution Spot satellite data for 1986, 1988 and 1989 Skole, 1992) with "...extensive field verification." |
| 41,521 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 17.1% of the area of Rondonia | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 30,046 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 12.6% of the area of Rondonia | |
| 31,623 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 13.0% of the area of Rondonia | |
| 58,000 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 23.7% of the area of Rondonia | |
| 31,623 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | | 13.0% of the area of Rondonia; 13.0% of forest and cerrado cut since 1960 | "Current best estimate." |
| 30,634 $km^2$ | Rondonia, total by 1988 (1960-1988) | Fearnside, 1990a | INPE, 1989b | 14.2% of "original primary forest cut" | |
| 3,916 | Rondonia, 1988 | Fearnside, 1990a | Malingreau and Tucker, 1988 (modified with Skole calculations) | | This is calculated from "...the trend from the 1985-87 period shown by AVHRR." |
| 1,800 $km^2$ | Rondonia, April 1988-Aug 1989 | INPE, 1996 | | | |
| 86.3 of "primary forest"; 62.1 of "secondary vegetation" | Rondonia, 1988-1989 | Skole *et al*, 1994 | | | Statistics are areas cleared for agriculture only. Authors used high-resolution Spot satellite data for 1986, 1988 and 1989 Skole, 1992) with "extensive field verification". |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 680 | Rondonia | FAO, 1993a, Table 16 | FAO, FORIS database | 1.1% of remaining forest 68,000 ha/yr | Time period 1980-1990 (decadal average?) |
| 1,458 | Rondonia, 1988-1991 | Saatchi *et al*, 1997 | Alves and Skole, 1996; Skole and Tucker, 1993; INPE, 1992b | 0.6%/yr | Figure is derived from analysis of Landsat data. |
| 1,700 | Rondonia, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 972 | Rondonia, 1990-1991 | Saatchi *et al*, 1997 | Alves and Skole, 1996; Skole and Tucker, 1993; INPE, 1992b | 0.4%/yr | Figure is derived from analysis of Landsat data. |
| 1,100 | Rondonia, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 2,265 | Rondonia, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 5,190 $km^2$ | Rondonia, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| | Rondonia in 1970s | Filho, 1985 | | 37% def. increase | new roads, colonies, ranches, expanding towns, growing pop., poor utilization of natural resources, poor use of soils, real estate speculation, indiscriminate growth of ranches |
| 4,200 | Rondonia, total by Jan 1978 | INPE, 1996 | | | |
| 6,281 $km^2$ | Rondonia, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at a 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 22,913 $km^2$ | Rondonia, total by 1987 | Fearnside, 1990a | IBDF, 1989 | | |
| | Rondonia, total by 1987? | Fearnside, 1990a | Malingreau, 1988 | 15.10% | |
| 23,998 $km^2$ | Rondonia, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| | Rondonia | Moran, 1993 | Mahar, 1988 | 24% | "The average area deforested each year in Rondonia in the 1980s was equal to the total area deforested before 1980." |
| 31,623 $km^2$ | Rondonia, total by 1988 | Fearnside, 1990a | INPE (with Fearnside adjustments) | "13% of the area of the state" | Large discrepancies exist for data on Rondonia. |
| 42,000 $km^2$ | Rondonia, total by 1988 | Millikan, 1992 | Tardin *et al*, 1980; Fearnside, 1982; Woodwell *et al*, 1987; Malingreau and Tucker, 1988 | 4.2 million hectares, 17.1% of Rondonia's surface area | |
| 30,634 $km^2$ | Rondonia, 1960-88 | Fearnside, 1990a | INPE, 1989b | "14.2% of forest" | Figures are corrected "for State areas and *cerrado*-clearing." |
| 30,000 $km^2$ | Rondonia, total by April 1988 | INPE, 1996 | | | |
| 29,600 $km^2$ | Rondonia, total by April 1988 | Downton, 1995 | INPE, 1992b | | |
| | Rondonia | Ellis, 1988 | "experts" | as much as 20% destroyed; sq mi | says "man's misuse denudes 64,720 $km^2$ of earth's surface/yr" |
| | Rondonia in a decade | Hecht, 1989 | | 17% deforested | land spec., failed colonization, timber exploitation, dam projects, cattle ranching, subsidies, land concessions |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Rondonia and Mato Grosso, "mostly since 1980" | Schwartzman, 1989 | | "Nearly 2.5%" of forests lost | |
| 31,476 $km^2$ | Rondonia, total by August 1989 | Moran, 1993 | | 85% still intact | Area in "Legal Amazonia" = 238,379 $km^2$; Original (approx.) forest area = 214,000 $km^2$. |
| 31,800 $km^2$ | Rondonia, total by Aug 1989 | INPE, 1996 | | | |
| 24,281 $km^2$ | Rondonia 1985-89 | Waters, 1989 | | acres; =Vermont | |
| < 30,624 $km^2$ | Rondonia, total by 1990 | "Deforestation", Brazilian Embassy, UK | | < 12.6% | Figure is based on "satellite imagery." Rondonia is the most heavily deforested state. |
| 33,500 $km^2$ | Rondonia, total by Aug 1990 | INPE, 1996 | | | |
| 34,000 $km^2$ | Rondonia, total by August 1991 | Saatchi et al, 1997 | Alves and Skole, 1996; Skole and Tucker, 1993; | | Figure is derived from analysis of Landsat data. |
| 34,600 $km^2$ | Rondonia, total by Aug 1991 | INPE, 1996 | | | |
| 36,865 $km^2$ | Rondonia, total by Aug 1992 | INPE, 1996 | | | |
| 42,055 $km^2$ | Rondonia, total by Aug 1994 | INPE, 1996 | | | |
| | Rondonia | Skole *et al*, 1994 | | 11.50% | This are was mostly cleared since 1970. |
| | | | | | |
| 6,400 $km^2$ | Acre, Jan 1978-April 1988 | INPE, 1996 | | | |
| 501 | Acre, 1988 | Fearnside, 1990a | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 900 $km^2$ | Acre, April 1988-Aug 1989 | INPE, 1996 | | | |
| 500 | Acre, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 2,310 | Acre | FAO, 1993a, Table 16 | FAO, FORIS database | 0.5% of remaining forest 231,000 ha/yr | Time period 1980-1990 (decadal average?) |
| 400 | Acre, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 400 | Acre, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 964 $km^2$ | Acre, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 2,500 $km^2$ | Acre, total by Jan 1978 | INPE, 1996 | | | |
| 2,612 $km^2$ | Acre, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 8,133 $km^2$ | Acre, total by 1987 | Fearnside, 1990a | IBDF, 1988 | 5.30% | |
| 8,634 $km^2$ | Acre, 1960-88 (total by 1988) | Fearnside, 1990a | Fearnside, 1990b | "5.7% of forest" | |
| 8,634 $km^2$ | Acre, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 5.7% of the area of Acre | |
| 5,510 $km^2$ | Acre, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 3.6% of the area of Acre | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 5,510 $km^2$ | Acre, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 3.6% of the area of Acre | |
| 19,500 $km^2$ | Acre, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 12.8% of the area of Acre | |
| 8,634 $km^2$ | Acre, 1960-88 | Fearnside, 1990a | "Current best estimate." | 5.7% of the area of acre; 5.7% of forest and cerrado cut since 1960 | |
| 8,634 $km^2$ | Acre, total by 1988 | Fearnside, 1990a | | 5.7% of "original primary forest cut" | |
| 5,509 $km^2$ | Acre, total by 1988 | Fearnside, 1990a | INPE | 3.60% | This figure is inconsistent with the 1987 IBDF estimate of 8,133 $km^2$, due to differences in the scale of images used and interpretation differences. |
| 6,369 $km^2$ | Acre, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 8,900 $km^2$ | Acre, total by April 1988 | INPE, 1996 | | | |
| 9,800 $km^2$ | Acre, total by August 1989 | INPE, 1996 | | | |
| 8,836 $km^2$ | Acre, by August 1989 | Moran, 1993 | | 94% still intact | Area in "Legal Amazonia" = 153,698 $km^2$; Original (approx.) forest area = 153,000 $km^2$. |
| | Acre now | Hecht, 1989 | | 5% deforested | |
| 10,300 $km^2$ | Acre, total by August 1990 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 10,700 $km^2$ | Acre, total by August 1991 | INPE, 1996 | | | |
| 11,100 $km^2$ | Acre, total by August 1992 | INPE, 1996 | | | |
| 12,064 $km^2$ | Acre, total by August 1994 | INPE, 1996 | | | |
| | | | | | |
| 600 $km^2$ | Amapa, Jan 1978 April 1988 | INPE, 1996 | | | |
| 67 | Amapa, 1988 | Fearnside, 1990a | | | |
| 200 $km^2$ | Amapa, April 1988-Aug 1989 | INPE, 1996 | | | |
| 300 | Amapa, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 400 | Amapa, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 36 | Amapa, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 0 $km^2$ | Amapa, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 171 $km^2$ | Amapa, total by 1978 | Fearnside, 1990a | Tardin *et al*, 1980 | | |
| 200 $km^2$ | Amapa, total by Jan 1978 | INPE, 1996 | | | |
| 182 $km^2$ | Amapa, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 842 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | INPE, 1989b | "0.8% of forest" | Figures are corrected for "State areas and *cerrado*-clearing." |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 231 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 0.2% of the area of Amapa | |
| 842 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 0.6% of the area of Amapa | |
| 842 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 0.6% of the area of Amapa | |
| 572 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 0.4% of the area of Amapa | |
| 842 $km^2$ | Amapa, 1960-88 | Fearnside, 1990a | | 0.6% of the area of Amapa; 0.8% of forest and cerrado cut since 1960 | "Current best estimate." |
| 842 $km^2$ | Amapa, total by 1988 | Fearnside, 1990a | | 0.8% of "original primary forest cut" | |
| 842 $km^2$ | Amapa, total by 1988 | Fearnside, 1990a | INPE, 1989b | 0.60% | This estimate "...represents the best data available for Amapa." |
| 210 $km^2$ | Amapa, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 800 $km^2$ | Amapa, total by April 1988 | INPE, 1996 | | | |
| 1,000 $km^2$ | Amapa, total by Aug 1989 | INPE, 1996 | | | |
| 1,016 $km^2$ | Amapa, total by August 1989 | Moran, 1993 | | 99% still intact | Area in "Legal Amazonia" = 142,359 $km^2$; Original (approx.) forest area = 112,000 $km^2$. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 1,300 $km^2$ | Amapa, total by Aug 1990 | INPE, 1996 | | | |
| 1,700 $km^2$ | Amapa, total by Aug 1991 | INPE, 1996 | | | |
| 1,736 $km^2$ | Amapa, total by Aug 1992 | INPE, 1996 | | | |
| 1,736 $km^2$ | Amapa, total by Aug 1994 | INPE, 1996 | | | |
| | | | | | |
| 18,000 $km^2$ | Amazonas, Jan 1978-April 1988 | INPE, 1996 | | | |
| 1,105 | Amazonas, 1988 | Fearnside, 1990a | | | |
| 2,000 $km^2$ | Amazonas, April 1988-Aug 1989 | INPE, 1996 | | | |
| 500 | Amazonas, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| | Amazonas, Mato Grosso, Para, Rondonia | Setzer and Pereira, 1991 | | Deforestation increases 20-30%/yr | |
| 1,000 | Amazonas, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 799 | Amazonas, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 740 $km^2$ | Amazonas, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 1,700 $km^2$ | Amazonas, total by Jan 1978 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 2,300 $km^2$ | Amazonas, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 1,791 $km^2$ | Amazonas, total by 1978 | Fearnside, 1990a | Tardin *et al*, 1980 | | |
| | Amazonas, total by 1988 | Fearnside, 1990a | Mahar, 1989 | 6.80% | |
| 12,837 $km^2$ | Amazonas, total by 1988 (1960-1988) | Fearnside, 1990a | INPE, 1989b | 0.80% | |
| 5,150 $km^2$ | Amazonas, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 0.3% of the area of Amazonas | |
| 12,837 $km^2$ | Amazonas, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 0.8% of the area of Amazonas | |
| 12,837 $km^2$ | Amazonas, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 0.8% of the area of Amazonas | |
| 105,790 $km^2$ | Amazonas, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 6.8% of the area of Amazonas | |
| 12,837 $km^2$ | Amazonas, 1960-88 | Fearnside, 1990a | | 0.8% of the area of Amazonas; 0.8% of forest and cerrado cut since 1960 | "Current best estimate." |
| 12,837 $km^2$ | Amazonas, total by 1988 | Fearnside, 1990a | | 0.8% of "original primary forest cut" | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 11,813 $km^2$ | Amazonas, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 19,700 $km^2$ | Amazonas, total by April 1988 | INPE, 1996 | | | |
| 17,300 $km^2$ | Amazonas, total by April 1988 | Downton, 1995 | INPE, 1992b | | Figure is based on color Landsat TM images. |
| 21,700 $km^2$ | Amazonas, total by Aug 1989 | INPE, 1996 | | | |
| 21,551 $km^2$ | Amazonas, total by August 1989 | Moran, 1993 | | 99% still intact | Area in "Legal Amazonia" = 1,567,954 $km^2$; Original (approx.) forest area = 1,540,000 $km^2$. |
| 22,200 $km^2$ | Amazonas, total by Aug 1990 | INPE, 1996 | | | |
| 23,200 $km^2$ | Amazonas, total by Aug 1991 | INPE, 1996 | | | |
| 23,999 $km^2$ | Amazonas, total by Aug 1992 | INPE, 1996 | | | |
| 24,739 $km^2$ | Amazonas, total by Aug 1994 | INPE, 1996 | | | |
| | | | | | |
| 26,900 $km^2$ | Maranhao, Jan 1978-April 1988 | INPE, 1996 | | | |
| 3,437 | Maranhao, 1988 | Fearnside, 1990a | | | Figure includes "...reclearing in the area of old (pre-1960) secondary forest." |
| 1,500 $km^2$ | Maranhao, April 1988-Aug 1989 | INPE, 1996 | | | |
| 1,100 | Maranhao, Aug 1989-Aug 1990 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 700 | Maranhao, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 1,135 | Maranhao, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 744 $km^2$ | Maranhao, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 6,100 $km^2$ | Maranhao, total by Jan 1978 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$) |
| 63,900 $km^2$ | Maranhao, total by Jan 1978 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$) |
| 9,426 $km^2$ | Maranhao, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 10,671 $km^2$ | Maranhao, total by 1980 | Fearnside, 1990a | IBDF, 1983a | | |
| 84,495 $km^2$ | Maranhao, total by 1988? | Fearnside, 1990a | | 60.7% of original forest | 60,724 $km^2$ = "old" deforestation; 23,771 $km^2$ = "recent loss" |
| 34,140 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | INPE, 1989b | "24.5% of forest" | Figures are corrected "...for State areas and *cerrado*-clearing." |
| 24,019 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 9.3% of the area of Maranhao | |
| 23,771 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 9.1% of the area of Maranhao | |
| 54,803 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 21.1% of the area of Maranhao | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 50,670 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 19.7% of the area of Maranhao | |
| 54,803 $km^2$ | Maranhao, 1960-88 | Fearnside, 1990a | | 21.1% of the area of Maranhao; 21.1% of forest and cerrado cut since 1960 | "Current best estimate." |
| 84,495 $km^2$ | Maranhao, total by 1988 | Fearnside, 1990a | | 60.7% of "original primary forest cut" | |
| 54,803 $km^2$ | Maranhao, total by 1988 | Fearnside, 1990a | | | |
| 31,952 $km^2$ | Maranhao, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 33,000 $km^2$ | Maranhao, total by April 1988 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |
| 90,800 $km^2$ | Maranhao, total by April 1988 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| 34,500 $km^2$ | Maranhao, total by Aug 1989 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |
| 92,300 $km^2$ | Maranhao, total by Aug 1989 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| 88,664 $km^2$ | Maranhao, total by August 1989 | Moran, 1993 | | 46% still intact | Area in "Legal Amazonia" = 260,233 $km^2$; Original (approx.) forest area = 163,000 $km^2$. |
| 35,600 $km^2$ | Maranhao, total by Aug 1990 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 93,400 $km^2$ | Maranhao, total by Aug 1990 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| 36,300 $km^2$ | Maranhao, total by Aug 1991 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |
| 94,100 $km^2$ | Maranhao, total by Aug 1991 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| 37,435 $km^2$ | Maranhao, total by Aug 1992 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |
| 95,235 $km^2$ | Maranhao, total by Aug 1992 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| 38,179 $km^2$ | Maranhao, total by Aug 1994 | INPE, 1996 | | | Figure does not include "ancient" deforestation (57,800 $km^2$). |
| 95,979 $km^2$ | Maranhao, total by Aug 1994 | INPE, 1996 | | | Figure includes "ancient" deforestation (57,800 $km^2$). |
| | Maranhao | Skole *et al*, 1994 | | 27% of forest "converted" | |
| | | | | | |
| 51,500 $km^2$ | Mato Grosso, Jan 1978-April 1988 | INPE, 1996 | | | |
| 5,580 | Mato Grosso, 1988 | Fearnside, 1990a | | | |
| 8,100 $km^2$ | Mato Grosso, April 1988-Aug 1989 | INPE, 1996 | | | |
| 4,000 | Mato Grosso, Aug 1989-Aug 1990 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 2,900 | Mato Grosso, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 4,674 | Mato Grosso, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 12,440 $km^2$ | Mato Grosso, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 20,000 $km^2$ | Mato Grosso, total by Jan 1978 | INPE, 1996 | | | |
| 21,134 $km^2$ | Mato Grosso, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| | Mato Grosso 1978-80 | Salati *et al*, 1986 | Fearnside, 1982 | 3% has been deforested | |
| 52,786 $km^2$ | Mato Grosso, total by 1980 | Fearnside, 1990a | IBDF, 1982 | | |
| 67,216 $km^2$ | Mato Grosso, total by 1988 (1960-88) | Fearnside, 1990a | INPE, 1989b | "11.7% of the original forest" | "...The value used for deforestation in this State is highly uncertain." (p.222) Value is corrected "...for State areas and *cerrado*-clearing." |
| 151,766 $km^2$ | Mato Grosso, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 17.2% of the area of Mato Grosso | |
| 67,216 $km^2$ | Mato Grosso, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 8.4% of the area of Mato Grosso | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 201,493 $km^2$ | Mato Grosso, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 22.9% of the area of Mato Grosso | |
| 208,000 $km^2$ | Mato Grosso, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 23.6% of the area of Mato Grosso | |
| 201,493 $km^2$ | Mato Grosso, 1960-88 | Fearnside, 1990a | | 22.9% of the area of Mato Grosso; 24.9% of forest and cerrado cut since 1960 | "Current best estimate." |
| 67,216 $km^2$ | Mato Grosso, total by 1988 | Fearnside, 1990a | | 11.7% of "original primary forest cut" | |
| 201,493 $km^2$ | Mato Grosso, total by 1988 | Fearnside, 1990a | | | |
| 47,568 $km^2$ | Mato Grosso, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 71,500 $km^2$ | Mato Grosso, total by April 1988 | INPE, 1996 | | | |
| 79,600 $km^2$ | Mato Grosso, total by Aug 1989 | INPE, 1996 | | | |
| 79,594 $km^2$ | Mato Grosso, total by August 1989 | Moran, 1993 | | 81% still intact | Area in "Legal Amazonia" = 802,403 $km^2$; Original (approx.) forest area = 417,000 $km^2$. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 83,600 $km^2$ | Mato Grosso, total by Aug 1990 | INPE, 1996 | | | |
| 86,500 $km^2$ | Mato Grosso, total by Aug 1991 | INPE, 1996 | | | |
| 91,174 $km^2$ | Mato Grosso, total by Aug 1992 | INPE, 1996 | | | |
| 103,614 $km^2$ | Mato Grosso, total by Aug 1994 | INPE, 1996 | | | |
| | | | | | |
| 75,100 $km^2$ | Para, Jan 1978-April 1988 | INPE, 1996 | | | |
| 3,788 | Para, 1988 | Fearnside, 1990a | | | |
| 7,800 $km^2$ | Para, April 1988-Aug 1989 | INPE, 1996 | | | |
| 4,900 | Para, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 3,800 | Para, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 3,787 | Para, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 8,568 $km^2$ | Para, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 16,500 $km^2$ | Para, total by Jan 1978 | Downton, 1995 | INPE, 1992b | | Figure is based on Landsat MSS images. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 16,600 $km^2$ | Para, total by Jan 1978 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 56,400 $km^2$ | Para, total by Jan 1978 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 30,449 $km^2$ | Para, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 85,203 $km^2$ | Para, total by 1986 | Fearnside, 1990a | SUDAM/IBDF, 1988 | | |
| 91,200 $km^2$ | Para, 1960-88 | Fearnside, 1990a | INPE, 1989b | "7.7% of forest" | Figures are corrected "for State areas and *cerrado*-clearing." |
| 148,111 $km^2$ | Para, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 12.1% of the area of Para | |
| 88,741 $km^2$ | Para, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 7.1% of the area of Para | |
| 92,922 $km^2$ | Para, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 7.5% of the area of Para | |
| 120,000 $km^2$ | Para, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 9.6% of the area of Para | |
| 92,922 $km^2$ | Para, 1960-88 | Fearnside, 1990a | | 7.5% of the area of Para; 7.7% of forest and cerrado cut since 1960 | "Current best estimate." |
| 118,150 $km^2$ | Para, total by 1988 | Fearnside, 1990a | | 10.0% of "original primary forest cut" | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 124,744 $km^2$ | Para, total by 1988 | Fearnside, 1990a | | | Deforestation from 1960-88 = 92,922 $km^2$; "Old" deforestation = 31,822 $km^2$. |
| 92,922 $km^2$ | Para, total by 1988 | Fearnside, 1990a | | | |
| 95,075 $km^2$ | Para, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 89,700 $km^2$ | Para, total by April 1988 | Downton, 1995 | INPE, 1992b | | Figure is based on color Landsat TM images. |
| 91,700 $km^2$ | Para, total by April 1988 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 131,500 $km^2$ | Para, total by April 1988 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 99,500 $km^2$ | Para, total by Aug 1989 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 139,300 $km^2$ | Para, total by Aug 1989 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 139,604 $km^2$ | Para, total by August 1989 | Moran, 1993 | | 88% still intact | Area in "Legal Amazonia" = 1,246,833 $km^2$; Original (approx.) forest area = 1,140,000 $km^2$. |
| 104,400 $km^2$ | Para, total by Aug 1990 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 144,200 $km^2$ | Para, total by Aug 1990 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 108,200 $km^2$ | Para, total by Aug 1991 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 148,000 $km^2$ | Para, total by Aug 1991 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 111,987 $km^2$ | Para, total by Aug 1992 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 151,787 $km^2$ | Para, total by Aug 1992 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| 120,555 $km^2$ | Para, total by Aug 1994 | INPE, 1996 | | | Figure does not include "ancient" deforestation (39,800 $km^2$). |
| 160,355 $km^2$ | Para, total by Aug 1994 | INPE, 1996 | | | Figure includes "ancient" deforestation (39,800 $km^2$). |
| | | | | | |
| 2,600 $km^2$ | Roraima, Jan 1978-April 1988 | INPE, 1996 | | | |
| 145 | Roraima, 1988 | Fearnside, 1990a | | | |
| 900 $km^2$ | Roraima, April 1988-Aug 1989 | INPE, 1996 | | | |
| 200 | Roraima, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 400 | Roraima, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 281 | Roraima, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 480 $km^2$ | Roraima, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 100 $km^2$ | Roraima, total by Jan 1978 | INPE, 1996 | | | |
| 196 $km^2$ | Roraima, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 1,170 $km^2$ | Roraima, total by 1981 | Fearnside, 1990a | IBDF, 1983b | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 2,187 $km^2$ | Roraima, total by 1988 (1960-88) | Fearnside, 1990a | INPE, 1989b | "1.0% of the State's area", "1.3% of forest" | Figures are corrected "...for State areas and *cerrado*-clearing." |
| 3,565 $km^2$ | Roraima, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 1.6% of the area of Roraima | |
| 2,187 $km^2$ | Roraima, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 1.0% of the area of Roraima | |
| 2,187 $km^2$ | Roraima, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 1.0% of the area of Roraima | |
| 3,270 $km^2$ | Roraima, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 1.4% of the area of Roraima | |
| 2,187 $km^2$ | Roraima, 1960-88 | Fearnside, 1990a | | 1.0% of the area of Roraima; 1.3% of forest and cerrado cut since 1960 | "Current best estimate." |
| 2,187 $km^2$ | Roraima, total by 1988 | Fearnside, 1990a | | 1.3% of "original primary forest cut" | |
| 1,908 $km^2$ | Roraima, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 2,700 $km^2$ | Roraima, total by April 1988 | INPE, 1996 | | | |
| 3,600 $km^2$ | Roraima, total by Aug 1989 | INPE, 1996 | | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 3,621 $km^2$ | Roraima, by August 1989 | Moran, 1993 | | 98% still intact | Area in "Legal Amazonia" = 225,017 $km^2$; Original (approx.) forest area = 185,000 $km^2$. |
| 3,800 $km^2$ | Roraima, total by Aug 1990 | INPE, 1996 | | | |
| 4,200 $km^2$ | Roraima, total by Aug 1991 | INPE, 1996 | | | |
| 4,481 $km^2$ | Roraima, total by Aug 1992 | INPE, 1996 | | | |
| 4,961 $km^2$ | Roraima, total by Aug 1994 | INPE, 1996 | | | |
| | | | | | |
| 18,400 $km^2$ | Tocantins, Jan 1978-April 1988 | INPE, 1996 | | | |
| 1,759 | Tocantins, 1988 | Fearnside, 1990a | | | |
| 700 $km^2$ | Tocantins, April 1988-Aug 1989 | INPE, 1996 | | | |
| 600 | Tocantins, Aug 1989-Aug 1990 | INPE, 1996 | | | |
| 500 | Tocantins, Aug 1990-Aug 1991 | INPE, 1996 | | | |
| 409 | Tocantins, Aug 1991-Aug 1992 | INPE, 1996 | | | |
| 666 $km^2$ | Tocantins, Aug 1992-Aug 1994 | INPE, 1996 | | | |
| 3,200 $km^2$ | Tocantins, total by Jan 1978 | INPE, 1996 | | | |
| 5,688 $km^2$ | Tocantins, total by 1978 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 9,120 $km^2$ | Tocantins/Goias, total by 1980 | Fearnside, 1990a | IBDF, 1983a | | |
| 20,279 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | INPE, 1989b | "20.2% of forest" | Figures are corrected "...for State areas and *cerrado*-clearing." |
| 16,768 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | Fearnside, 1990b | 5.9% of the area of Tocantins/ Goias | |
| 20,279 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989a, as reported" | 7.5% of the area of Tocantins/ Goias | |
| 170,700 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | "Brazil, INPE, 1989b with corrections" | 63.2% of the area of Tocantins/ Goias | |
| 33,120 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | Mahar, 1989 | 11.6% of the area of Tocantins/ Goias | |
| 54,393 $km^2$ | Tocantins/Goias, 1960-88 | Fearnside, 1990a | | 20.2% of the area of Tocantins/ Goias; 20.2% of forest and cerrado cut since 1960 | "Current best estimate." |
| 20,279 $km^2$ | Tocantins/Goias, total by 1988 | Fearnside, 1990a | | 20.2% of "original primary forest cut" | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 54,393 $km^2$ | Tocantins, total by 1988 | Fearnside, 1990a | | | |
| 11,431 $km^2$ | Tocantins, total by 1988 | Skole and Tucker, 1993 | | | Skole and Tucker used 210 Channel 5 Landsat TM images at 1:500,000 scale. Images are primarily from 1988, and were digitized visually and with GIS. |
| 21,600 $km^2$ | Tocantins, total by April 1988 | INPE, 1996 | | | |
| 22,300 $km^2$ | Tocantins, total by Aug 1989 | INPE, 1996 | | | |
| 269,911 $km^2$ | Tocantins, total by August 1989 | Moran, 1993 | | 44% still intact | Area in "Legal Amazonia" = 269,911 $km^2$; Original (approx.) forest area = 40,000 $km^2$. |
| 22,900 $km^2$ | Tocantins, total by Aug 1990 | INPE, 1996 | | | |
| 23,400 $km^2$ | Tocantins, total by Aug 1991 | INPE, 1996 | | | |
| 23,809 $km^2$ | Tocantins, total by Aug 1992 | INPE, 1996 | | | |
| 24,475 $km^2$ | Tocantins, total by Aug 1994 | INPE, 1996 | | | |
| | | | | | |
| 650 | Bolivia, 1970s | Skole and Tucker, 1993 | FAO, 1981 | | |
| 650 | Bolivia, 1976-80 | Grainger, 1993 | Grainger, 1983 | 65,000 ha/yr | |
| 6,250 | Bolivia | FAO, 1993a, Table 4c | | 625,000 ha/yr = 1.2%/yr | Time period 1980-1990 (decadal average?) |
| 1,500 | Bolivia, late 1980s | Grainger, 1993 | Myers, 1989 | 150,000 ha/yr | |
| 870 | Bolivia, late 1980s | Skole and Tucker, 1993 | WRI, 1990 | | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 1,500 | Bolivia | Myers, 1989 | various sources listed in biblio | 2.1%/yr | 90,000 $km^2$ orig. extent of forest cover; 70,000 $km^2$ present extent; 45,000 $km^2$ pres. extent of primary forests. |
| 531 $km^2$ lost | Bolivia | McCloskey and Spalding, 1989 | | 0.2% loss | |
| | Bolivia | Lewis, 1990 | Myers | 50% of original forest cover remaining: | |
| 8,000 | Colombia, 1970s | Skole and Tucker, 1993 | FAO, 1981 | | |
| 8,000 | Colombia, 1976-80 | Grainger, 1993 | Grainger 1983 | 800,000 ha/yr | |
| 3,670 | Colombia | FAO, 1993a, Table 4c | | 367,000 ha/yr = 0.7%/yr | Time period 1980-1990 (decadal average?) |
| 6,500 | Colombia, late 1980s | Grainger, 1993 | Myers, 1989 | 650,000 ha/yr | |
| 6,500 | Colombia | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 2.30% | |
| 8,200 | Colombia, late 1980s | Skole and Tucker, 1993 | WRI, 1990 | | |
| 9,000 | Colombia | Wood, 1990 | Repetto, 1990 | def. rate: 2.00% | |
| 20,000 | Colombia | Comm. on Devl. & Env. for Amazonia, 1992 | | ha | another 20,000 $km^2$ in process of being "opened;" interpreted satellite images; representing 10% of total area (of Colombia or of Colombia's forests?) |
| 238,277 $km^2$ | Colombia | McCloskey and Spalding, 1989 | | 28.7% loss, has 52% total territory in forest | other Amazon countries: Ecuador has lost 34.8%; 49,249 $km^2$=area lost; Venezuela has lost 8.2%; 38,096 $km^2$=area lost; has 47% total territory in tf; Peru has lost 2.9%; 20,262 $km^2$=area lost; has 54% total terr. in tf; Fr. Guiana, Guyana, Surinam have lost |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | | McCloskey and Spalding, 1989 (continued) | | | 0%; Fr. Guiana has 100%, Guyana has 63%, Surinam has 59.5% total territory in tf |
| | Colombia | Lewis, 1990 | Myers | 30% of original forest cover remaining: | |
| 3,000 | Ecuador, 1976-80 | Grainger, 1993 | Grainger, 1983 | 300,000 ha/yr | |
| | Ecuador | Jackson, 1983 | | 2.38%/yr | |
| 2,380 | Ecuador | WCMC, 1997b | WWF/WCMC, 1996; FAO, 1995 | 1.99%/yr, 238,000 ha/yr | This is the "...annual change" in forest cover. |
| 2,380 | Ecuador | FAO, 1993a, Table 4c | | 238,000 ha/yr = 1.8%/yr | Time period 1980-1990 (decadal average?) |
| 3,000 | Ecuador, late 1980s | Grainger, 1993 | Myers, 1989 | 300,000 ha/yr | |
| 3,000 | Ecuador | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 4.00% | |
| 5,104 | Ecuador | Thapa *et al*, 1996 | FAO, 1993b | 1.8% per year | Second highest rate of def. in S. America. Includes all of Ecuador, not just Amzn. More acres of def. occuring in the the Ec. Amzn than in rest of country, but little cutting means high def. rates in non Amzn. pts b/c most already deforested. |
| 4,000 | Ecuador | Wood, 1990 | Repetto, 1990 | def. rate: 2.50% | |
| | Ecuador | Lewis, 1990 | Myers | 30% of original forest cover remaining: | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | Napo and Sucumbios provinces in NE Ecuadorian Amazon, 1965-1984 | Thapa *et al*, 1996 | Southgate and Whitaker, 1992 | 1.4% per year | |
| | Upano-Palora region of the Ecuadorian Amazon | Rudel, 1995 | | 70-90% of forest still standing in late 1980s | |
| 640 | Fr. Guyana, 1976 80 | Grainger, 1993 | Grainger, 1983 | 64,000 ha/yr | |
| 0 | Fr. Guyana | FAO, 1993a, Table 4c | | 0,000 ha/yr very small % | Time period 1980-1990 (decadal average?) |
| 500 | Fr. Guyana, Guyana and Surinam combined, late 1980s | Grainger, 1993 | Myers, 1989 | 50,000 ha/yr | |
| 500 | Guyana, Fr. Guiana, Surinam | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 0.10% | |
| | Guyanas | Lewis, 1990 | Myers | 70% of original forest cover remaining: | |
| 30 | Guyana, 1976-80 | Grainger, 1993 | Grainger, 1983 | 3,000 ha/yr | |
| 180 | Guyana | FAO, 1993a, Table 4c | | 18,000 ha/yr = 0.1%/yr | Time period 1980-1990 (decadal average?) |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 4,030 | Paraguay | FAO, 1993a, Table 4c | | 403,000 ha/yr = 2.7%/yr | Time period 1980-1990 (decadal average?) |
| 2,450 | Peru, 1970s | Skole and Tucker, 1993 | FAO, 1981 | | |
| 1,600 | Peru, 1976-80 | Grainger, 1993 | Grainger, 1983 | 160,000 ha/yr | |
| 2,800 | Peru, 1975-86 | Comm. on Devl. & Env. for Amazonia, 1992 | gov't stats | | |
| 2,710 | Peru | FAO, 1993a, Table 4c | | 271,000 ha/yr = 0.4%/yr | Time period 1980-1990 (decadal average?) |
| 3,500 | Peru, late 1980s | Grainger, 1993 | Myers, 1989 | 350,000 ha/yr | |
| 2,700 | Peru, late 1980s | Skole and Tucker, 1993 | WRI, 1990 | | |
| 3,500 | Peru | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 0.70% | |
| 21,700 $km^2$ | Peru, 1975-86 | Comm. on Devl. & Env. for Amazonia, 1992 | gov't stats | | says estimates of Peru's area deforested range from 51,220 $km^2$ to 85,000 $km^2$ (Webb & Fernandez Baca, 1991) |
| roughly 6278 $km^2$ | Peru | Brooke, 1989 | | "area... roughly twice the size of Rhode Island" | This is, "...the area of direct and indirect damage from coca production in Peru...." |
| well over 202.34 $km^2$ | Peruvian Amazon | Brooke, 1989 | | "well over 50,000 acres" | This is the area destroyed by coca growers. |
| | Peru | Lewis, 1990 | Myers | 60% of original forest cover remaining: | |
| 30 | Surinam, 1976-80 | Grainger, 1993 | Grainger, 1983 | 3,000 ha/yr | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 130 | Suriname | FAO, 1993a, Table 4c | | 13,000 ha/yr = 0.1%/yr | Time period 1980-1990 (decadal average?) |
| 1,250 | Venezuela, 1970s | Skole and Tucker, 1993 | FAO, 1981 | | |
| 1,250 | Venezuela, 1976-80 | Grainger, 1993 | Grainger, 1983 | 125,000 ha/yr | |
| 1,500 | Venezuela, late 1980s | Grainger, 1993 | Myers, 1989 | 150,000 ha/yr | |
| 1,250 | Venezuela, late 1980s | Skole and Tucker, 1993 | WRI, 1990 | | |
| 1,500 | Venezuela | Bundestag, 1991 | Myers, 1989 | as % of remaining forest cover: 0.40% | |
| 5,990 | Venezuela | WCMC, 1997c | WWF/WCMC, 1996; FAO, 1995 | 1.31%/yr, 599,000 ha/yr | This is the "...annual change" in forest cover. |
| 5,990 | Venezuela | FAO, 1993a, Table 4c | | 599,000 ha/yr = 1.2%/yr | Time period 1980-1990 (decadal average?) |
| | Venezuela | Lewis, 1990 | Myers | 70% of original forest cover remaining: | |
| | | | | | |
| 192.3 $km^2$ | Eastern Altamira, Amazonia, 1985-1991 | Moran *et al*, 1994 | | 11.19% lost | The absolute figure is calculated from the beginninng and ending hectares of forest cover given in the paper. |
| 95.01$km^2$ | Western Altamira, Amazonia, 1985-1991 | Moran *et al*, 1994 | | 5.46% lost | The absolute figure is calculated from the beginninng and ending hectares of forest cover given in paper |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| 2.62 $km^2$ | Altamira subsite km 46 | Moran *et al*, 1994 | | 3.77% lost | absolute figure calculated from beginninng and ending hectares of forest cover given in paper |
| 300 $km^2$ | "an area of 4,700,000 hectares along the PA-150 highway", by 1972 | Moran, 1993 | Mahar, 1988 | 30,000 hectares | |
| 1,700 $km^2$ | "an area of 4,700,000 hectares along the PA-150 highway", by 1977 | Moran, 1993 | Mahar, 1988 | 170,000 hectares | |
| 8,200 $km^2$ by 1985 | "an area of 4,700,000 hectares along the PA-150 highway" | Moran, 1993 | Mahar, 1988 | 820,000 hectares | |
| 190 $km^2$ | Altamira area of Brazil | Moran, 1993 | | 7% mature forest cut | In same period of time, "...secondary growth increased... by 32,000 hectares." (320 $km^2$) |
| 69,000 | "all of South America" | Miranda, 1992 | FAO | 6.9 million hectares/year | Dr. Miranda says that this is much too large a number to be credible, if you accept 2.1 million hectares/year as the rate for Brazil, which contains 70% of S. Amer. trop. forests. |
| 15,000 | "[mostly] Brazil and Central America", "early nineties" | Gillis, 1996 | | | This figure represents "...forest clearing for cattle ranching." |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | other Amazon countries listed also | Myers, 1989 | | | says def. in Brazilian Amazonia is highly diferrentiated; some parts are losing forest rapidly, others hardly at all. Brazil still has 27.5% of all tropical forests, totalling 8 million $km^2$. |
| | | Myers, 1980 | | | says there's no standard and objective classification of "tropical moist forests" that can be applied uniformly from region to region across the biome. Defines TMF as "evergreen or partly evergreen forests, in areas receiving not less than 100mm of |
| | | Myers, 1980 (continued) | | | precipitation in any month for 2 out of 3 years, w/mean annual temp. of 24+deg C; some trees may be decid; the forests usually occur at altitudes below 1300m (Amazonia up to 1800m, SE Asia around 750m); distinctive strata in mature forests. Human |
| | | Myers, 1980 (continued) | | | disruption also comes in multiple forms w/differing degrees of intensity. Calls rainforest syn. w/tmf. Also defines primary/climax forests & secondary forests (p.18-20). |
| | | Myers, 1986 | | | Myers' chapter: says there are 2 forms of depletion; says confusion about discrepancies btwn. estimates of rates is because of misunderstanding. "Conversion:" catch-all term that stands for all types of forest depletion. "Major disturbance:" qualitative |
| | | Myers, 1986 | | | depletion, leading to pronounced, as apposed to marginal, impoversihment of forest ecosystems. "Deforestation:" complete and permanent removal of all forest cover. |
| | | Myers, 1986 | | | Myers' chapter: says figures represent no more than informed estimates. Problems w/tf surveys: diverse definitions and classifications of the biome, inaccuracy of data, and political compulsion to fudge the figures. |
| | | | | | |
| | Latin Amer. | Park, 1992 | FAO, 1982 | 37% lost | |

# Rates and Processes of Amazon Deforestation

## *Rates*

| RATE ($km^2$/year) | COUNTRY/ REGION | SOURCE/ YEAR | Refers to other source(s) | ANALOGY/ units | COMMENTS (problems w/rates,causes of deforestation,technology used) |
|---|---|---|---|---|---|
| | C. Amer | Park, 1992 | FAO, 1982 | 66% lost | says reliable estimates are difficult to secure: disagreement over methodologies used and estimates produced. No universal method, different time scales, lack of baseline surveys, varying definitions: degradation/depletion, tropical forests/rainforests. |
| | | | | | Some countries do not make all of their def. records available. Says satellite imagery has often established that gov't figures are unreliable. |
| >6000 $km^2$ cleared for pasture | Brazilian state of Paragominas by 1983 | Nepstad, 1991 | | 23% cleared for pasture | in Brazilian state of Para from 1975-88, area of cleared forest increased from 8700 (0.7%) to 120,000 $km^2$ (9.6%) of the state's territory. Mostly cleared for pasture. |
| 100,000 $km^2$ "cleared" | S&C America | Salati & Vose, 1983 | | | slash/burn, fuelwood, logging, cattle grazing, gov't policies, land reform, road building. Says validity of data uncertain; some local data most reliable;data out of date says global data result of FAO stats which are supplied by gov'ts may not be correct |
| | S. America, % loss of orig. tropical rain forest | McCloskey & Spalding, 1989 | 16% | loss in Brazil> size of France and=to size of Texas; S. Amer.= 1.13 million $km^2$ | |
| 68,000 | Tropical South America | WRI, 1992 | FAO 1980s estimate | 6,800,000 ha/yr; annual rate of change 1981-1990: -0.8% | |
| | parts of Brazil | Editors, *Ecologist,* 1987 | | 33%/yr | what "parts"? |

# Rates and Processes of Amazon Deforestation

## *Rate Chart Sources*

Michael H. Glantz, Amara Tandy Brook and Patricia Parisi 17 July 1997
*Environmental and Societal Impacts Group/National Center for Atmospheric Research*, Boulder, Colorado, USA*
**National Center for Atmospheric Research is sponsored by the National Science Foundation*

Acharya, Anjali. 1996. "More Fires in the Amazon." *World Watch.* Vol. 9, No. 4. July/August. pp.6-7.

Alves, Diogenes. "Brazil Monitors Amazon Forests." Retrieved 5/97 from <http://amazon.unh.edu/pathfinder/information/papers/gisworld2/index.html>

Associated Press. 1996. "Brazil suspends cutting of rare woods." *The Milwaukee Journal Sentinel.* July 28. News.

Barbier, Edward B., Joanne C. Burgess, and Anil Markandya. 1991. "The Economics of Tropical Deforestation." *Ambio.* Vol. 20, No. 2. April. pp. 55-58.

Booth, William. 1989. "Monitoring the Fate of the Forests from Space." *Science.* Vol. 243, March 17. pp.1428-1429.

Brazil's report to UNCED. 1992. *The Challenge of Sustainable Development.* The Brazilian Report for the United Nations Conference on Environment and Development. Interministerial Commission for the Preparation of the United Nations Conference on Environment and Development (CIMA). Press Secretary of the Presidency of the Republic

Brooke, James. 1992. "Homesteaders Gnaw at Brazil Rain Forest." *New York Times.* May 22.

Brooke, James. 1989. "Peruvian Farmers Razing Rain Forest to Sow Drug Crops." *New York Times.* August 13.

Bundestag. 1991. *Protecting the Tropical Forests.* German Enquente Commission Report.

Bunyard, Peter. 1987. "The Significance of the Amazon Basin for Global Climatic Equilibrium." *The Ecologist.* Vol. 17, No. 4/5. pp.139-141.

Buschbacher, Robert J. 1986. "Tropical Deforestation and Pasture Development." *Bioscience,* Vol.36, No. 1. January. pp.22-28.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Commission on Development and Environment for Amazonia. 1992. *Amazonia Without Myths.* Inter-American Development Bank, United Nations Development Programme, Amazon Cooperation Treaty: Washington, DC.

"Deforestation." Link from Brazilian Embassy in London website. Retrieved 5/97 from <http://www.demon.co.uk/Itamaraty/rain4.html>

"Demography and the Environment: Professor Takes New Approach to Deforestation in the Amazon." *ILAS Newsletter.* University of Texas at Austin, 1992-1995. Retrieved 5/97 from <http://www.lanic.utexas.edu/ilas/news/demography.html>

Downton, Mary W. 1995. "Measuring Tropical Deforestation: Development of the Methods." *Environmental Conservation.* Vol. 22, No. 3. Autumn. pp. 229-240.

Earthworks. 1989. *Fifty Simple Things You Can Do To Save The Earth.*

Editors. 1987. "Tropical Forests: A Plan for Action." *Ecologist.* Vol. 17, No. 4/5. pp.129-133.

Editors. 1991. "Rainforests Saved by Satellite." *New Scientist.* April 13. p.15.

Ellis, William S. 1988. "Rondonia's Settlers Invade Brazil's Imperiled Rain Forest," *National Geographic.* December. pp.772-799.

EnviroNews Service. 1996. "E-Link: Brazil Suspends ALL Logging Contracts." July 26. Retrieved 5/97 from <http://www.envirolink.org/archives/enews/0153.html>

Faminow, Merle D. 1997 (updated). "The Disappearing Amazon Rainforest Problem." *Canadian Newsletter.* International Association of Agricultural Economists Canadian Council. Retrieved 5/97 from <http://www.unb.ca/web/enviro/iaae/iaae2.html>

Fearnside, Philip M. 1986. "Spatial Concentration of Deforestation in the Brazilian Amazon." *Ambio.* Vol. 15, No. 2. pp. 74-81.

Fearnside, Philip M. 1989a. "Deforestation in Brazilian Amazonia: The Rates and Causes of Forest Destruction." *The Ecologist.* Vol. 19, No. 6. November/December. pp. 214-218.

Fearnside, Philip M. 1989b. "A Prescription for Slowing Deforestation in Amazonia." *Environment.* Vol. 31, No. 4, May. pp.16-20, 39-40.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Fearnside, Philip M. 1990a. "The Rate and Extent of Deforestation in Brazilian Amazonia." *Environmental Conservation.* Vol. 17, No. 3. Autumn. pp. 213-226.

Fearnside, Philip M., A.T. Tardin and L.G.M. Filho. 1990. "Deforestation Rate in Brazilian Amazonia." National Institute for Research in Amazonia (INPA) and Institute for Space Research (INPE) report. August.

Filho, Joao Meirelles. 1985. "The Perils of Deforestation." *World Press Review.* May. p.33.

Food and Agriculture Organization of the United Nations (FAO). 1993a. *1990 Forest resources assessment: Tropical countries.* Rome: Food and Agriculture Organization of the United Nations. Retrieved 5/20/97 from CIESIN web site <http://www.ciesin.org/docs/002-471/002-471.html>

Gillis, Malcolm. 1996. "Tropical Deforestation, Poverty, Population and Public Policy." 1996 Rice Environmental Conference. Retrieved 4/18/97 from <http://riceinfo.rice.edu/projects/reno/speeches/19960202_Gillis-Envconf.html>

Grainger, Alan. 1993. "Rates of deforestation in the humid tropics: estimates and measurements." *The Geographical Journal.* Vol. 159, No. 1. March. pp. 33-44.

Hankins, Mark. "Editorial: Agriculture and Tropical Forest: Where do we go from here?" Retrieved 5/97 from<http://www.envirolink.org/pubs/rodale/ag-sieve/vol1no3/art2.html>

Hecht, Susanna and Alexander Cockburn. 1989. "Defenders of the Amazon." *The Nation.* May 22. p.695.

Hildyard, Nicholas. 1989. "Amazonia: The Future in the Balance." *The Ecologist.* Vol. 19, No. 6, Nov/Dec. pp.207-210.

Homewood, Brian. 1991. "Dirty Cities Head Brazil's Environmental Ills." *New Scientist,* September 7. p.21.

Hurrell, Andrew. 1991. "The Politics of Amazon Deforestation." *Journal of Latin American Studies.* Vol. 23, Part 1. February. pp.197-215.

INPE brochure from UNCED. 1992a. (Table of Brazilian Amazon's rate and extent of deforestation).

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Instituto Nacional de Pesquisas Espacias (INPE). 1996. "Inpe divulga resultado das areas desflorestadas na Amazonia entre 92 e 94." *INPE Noticias.* Year 2, No. 7. July/August.

Jackson, Peter. 1983. 'The Tragedy of our Tropical Rainforests." *Ambio.* Vol. 12, No. 5. pp.252-254.

Josephson, Julian. 1991. "Tropical Forests: Effects of Destruction vs. Preservation." *Environmental Science and Technology.* Vol. 25, No. 7.

Kenitzer, Allen. 1993. "NASA Study Refines Estimates of Amazon Deforestation." *The Earth Observer.* July/August. Reprint from *Goddard News.* July. Vol. 40, No. 7. Retrieved 5/21/97 from <http://eospso.gsfc.nasa.gov/eos_observ/7_8_93/p32.html>

*Latin American Regional Reports - Brazil.* 1995. "Burning Issue in the Amazon: Row Over Satellite Deforestation Data." RB-95-10. November 30. pp.6-7.

Leopoldo, Paulo Rodolfo. 1989. "Deforestation in the Amazon Region." *Interciencia,* Vol. 14, No. 6, Nov/Dec. p.283.

Lewis. 1990. "You Can't See the Wood for the Trees." *Geographical Magazine.* Vol. LXII, No. 7. July. pp.22-27.

Lutzenberger, Jose A. 1987. "Who is Destroying the Amazon Rainforest?" *The Ecologist.* Vol. 17, No. 4/5. pp.155-160.

Mahar, Dennis J. 1989. *Government Policies and Deforestation in Brazil's Amazon Region.* World Bank Publication: Washington, D.C.

Mantovani, A.C. Di Maio and A.W. Setzer. 1997. "Deforestation detection in the Amazon with an AVHRR-based system." *International Journal of Remote Sensing.* Vol. 18, No. 2. pp.273-286.

Maxwell, Kenneth. 1991. "The Tragedy of the Amazon." *The New York Review of Books.* Vol. 38, No. 5. March 7. pp.24-27.

McCloskey, Michael and Heather Spalding. 1989. "Measuring the Destruction of Tropical Rainforests." Draft report, Sierra Club: Washington, D.C. June 30.

McConahay, Mary Jo. 1997. "Amazonian Futures." *Choices.* Vol. 6, No. 2. April. United Nations Development Programme. pp. 19-25.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Millikan, Brent H. 1992. "Tropical Deforestation, Land Degradation, and Society: Lessons from Rondonia, Brazil." *Latin American Perspectives.* Issue 52, Vol. 19, No. 1. Winter p.45-72

Miranda, Dr. Evaristo Eduardo de. 1992. "The Amazing Amazon." Interview in *The New American.* Vol. 8, No. 16. August 10. pp.16-17.

Monsatersky, Richard. 1990. "The Fall of the Forest: Tropical tree losses go from bad to worse." *Science News,* Vol. 138, July 21. pp.40-41.

Moran, Emilio F., Eduardo Brondizio, Paul Mausel and You Wu. 1994. "Integrating Amazonian Vegetation, Land-use, and Satellite Data." *BioScience.* Vol. 44, No. 5. May. pp.329-338.

Moran, Emilio F. 1993. "Deforestation and Land Use in the Brazilian Amazon." *Human Ecology.* Vol. 21, No. 1. pp.1-21.

Myers, Norman. 1989. *Deforestation Rates in Tropical Forests and Their Climatic Implications.* Friends of the Earth report. December. London.

Myers, Norman. 1988. "Tropical Deforestation and Climatic Change." *Environmental Conservation,* Vol. 15, No. 4, Winter. pp.293-298.

Myers, Norman. 1986. "Tropical Forests: Patterns of Depletion." pp. 9-22 in Prance, Ghillean T. *Tropical Rain Forests and the World Atmosphere.* AAAS Selected Symposium 101.

Myers, Norman. 1980. *Conversion of Tropical Moist Forests.* National Research Council, National Academy of Sciences: Washington, D.C.

Nepstad, Daniel; Uhl, Christopher; and Emanuel A.S. Serrao. 1991. "Recuperation of a Degraded Amazonian Landscape: Forest Recovery and Agricultural Restoration." *Ambio.* Vol. 20, No. 6, September. p.248-255.

Neto, Ricardo Bonalume. 1989. "Disputes about Destruction." *Nature.* Vol. 338, April 13. p.531.

Neto, Ricardo Bonalume. 1990. "Latest deforestation figures." *Nature.* Vol. 345, June 28. p.754.

Park, Chris C. 1992. *Tropical Rainforests.* Routledge: London.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Pearce, Fred. 1992. "First Aid for the Amazon." *New Scientist.* March 28. pp.43-46.

Rainforest Action Network. "Rates of Rainforest Loss: In Brazil." Retrieved 5/97 from <http://www.ran.org/ran/ran/info_center/rates.html>

Rainforest Relief - Portland Chapter. 1996. "Brazil Steps up Preservation Measures." *Raindrops West.* Vol. 1, No. 3. October/November. Retrieved 5/97 from <http://www.envirolink.org/envlib/orgs/rainrelief/rainwestv1n3.html>

"The Rate of Rainforest Destruction: In Brazil." Retrieved 5/97 from <http://somerset.qld.edu.au/student/IO_CE/CARRIGAN%20Sara/Rate.html>

Raytheon Electronic Systems. "SIVAM." 1996 (updated). Retrieved 5/97 from <http://www.raytheon.com/sivam/>

Repetto, Robert. 1990. "Deforestation in the Tropics." *Scientific American.* Vol. 262, No. 4. April. pp.36-42.

Reuter, William Schomberg. 1996. "Asian Loggers Target Brazil: Three multinational companies have moved into the Amazon prompting the government to toughen enforcement." *The Financial Post.* Vol. 40. September 19. Section 1, News.

Rudel, Thomas K. 1995. "When Do Property Rights Matter? Open Access, Informal Social Controls, and Deforestation in the Ecuadorian Amazon." *Human Organization.* Vol. 54, No. 2. pp. 187-194.

Saatchi, Sasan S., Joao Vianei Soares and Diogenes Salas Alves. 1997. "Mapping Deforestation and Land Use in the Amazon Rainforest by Using SIR-C Imagery." *Remote Sensing of the Environment.* Vol. 59, No. 2. pp.191-202.

Salati, Eneas and Peter B. Vose. 1983. "Depletion of Tropical Rainforests." *Ambio.* Vol. 12, No. 2.. pp. 67-71.

Salati, Eneas, Peter B. Vose and Thomas E. Lovejoy. 1986. "Amazon Rainfall, Potential Effects of Deforestation, and Plans for Future Research." pp. 61-74 in Prance, Ghillean T., (ed.) *Tropical Rain Forests and the World Atmosphere.* AAAS Selected Symposium 101. Westview Press: Boulder, Colorado.

Schwartzman, Dr. Stephan. 1989. "Protecting the Amazon Rainforest, A Global Resource." *EDF Letter.* Vol. XX, No. 1. February. Retrieved 5/97 from <http://www.edf.org/pubs/EDF-Letter/1989/Feb/o_amazon.html>

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Setzer, A. and M. Pereira. 1991. "Amazonia Biomass Burnings in 1987 and an Estimate of Their Tropospheric Emissions." *Ambio,* Vol. 20, No. 1. February. pp.19-22.

Shukla, J.; C. Nobre; P. Sellers. 1990. "Amazon Deforestation and Climate Change." *Science,* Vol. 247. March 16. pp. 1322-1325.

Skole, D.L. and C.J. Tucker. 1993. "Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988." *Science.* Vol. 260. June 25. pp.1905-1910.

Skole, D.L., W.H. Chomentowski, W.A. Salas and A.D. Nobre. 1994. "Physical and Human Dimensions of Deforestation in Amazonia." *BioScience.* Vol. 44, No. 5. May. pp.314-322.

Speth, James Gustave. 1990. "Coming to Terms: Toward a North-South Compact for the Environment." *Environment,* Vol. 32, No. 5, June. p.20.

Thapa, Keshari K., Richard E. Bilsborrow and Laura Murphy. 1996. "Deforestation, Land Use, and Women's Agricultural Activities in the Ecuadorian Amazon." *World Development.* Vol. 24, No. 8. pp. 1317-1332.

Waters, Tom. 1989. "Fall of the Rain Forest." *Discover,* January. p.40.

Wood, William B. 1990. "Tropical Deforestation: Balancing regional development demands and global environmental concerns." *Global Environmental Change.* December. pp.23-41.

Woodwell, George M., Richard A. Houghton and Thomas A. Stone. 1986. "Deforestation in the Brazilian Amazon Basin Measured by Satellite Imagery." pp. 23-32 in Prance, Ghillean T., (ed.) *Tropical Rain Forests and the World Atmosphere.* AAAS Selected Symposium 101. Westview Press: Boulder, Colorado.

Worcman, Nira Broner. 1990. "Brazil's Thriving Environmental Movement." *Technology Review.* Vol. 93, No. 7. October p.42-51

World Conservation Monitoring Centre (WCMC). 1997a. "Brazil: Forest statistics." Retrieved 5/20/97 from <http://www.wcmc.org.uk:80/cgi-bin/fp_countryquery.p>

World Conservation Monitoring Centre (WCMC). 1997b. "Ecuador: Forest statistics." Retrieved 5/20/97 from <http://www.wcmc.org.uk:80/cgi-bin/fp_countryquery.p>

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***

World Conservation Monitoring Centre (WCMC). 1997c. "Venezuela: Forest statistics." Retrieved 5/20/97 from <http://www.wcmc.org.uk:80/cgi-bin/fp_countryquery.p>

World Resources Institute (WRI). 1992. *World Resources, 1992-93: A Guide to the Global Environment.* Oxford University Press: New York/ Oxford.

World Wildlife Fund (WWF). "Forests for Life Campaign Action Alert: Help Pass Measures to Save Brazilian Rain Forests." Retrieved 5/97 from <http://www.panda.org/action/act.htm>

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***

**Rate Chart Secondary Sources (Cited by Primary Sources)**


Alves, D.S. and D.L. Skole. 1996. "Characterizing land cover dynamics using multi-temporal imagery." *International Journal of Remote Sensing.* Vol. 17. pp.835-839.

Booth, W. 1989. "Monitoring the fate of the forests from space." *Science* Vol. 243. March 17. pp. 1428-1429.

Fearnside, P.M. 1982. "Deforestation in the Brazilian Amazon: How fast is it occurring?" *Interciencia.* Vol. 7. pp.82-88.

Fearnside, Philip M. 1986b. *Human Carrying Capacity of the Brazilian Rainforest.* Columbia University Press: New York.

Fearnside, Philip M. 1987. pp. 37-61 in *The Geophysiology of Amazonia.* R.E. Dickinson, (ed.) Wiley: New York.

Fearnside, P. 1989b. "A prescription for slowing deforestation in Amazonia." *Environment.* Vol. 31, No. 4. pp.17-20, 39-40.

Fearnside, Philip M. 1989c. Forest Management in Amazonia: The Need for New Criteria in Evaluating Economic Development Options. *Forest Ecology and Management.*

Fearnside, P.M. 1990b. "Deforestation in Brazilian Amazonia." in *The Earth in Transition: Patterns and Processes of Biotic Impoverishment.* Ed: G.M. Woodwell. Cambridge University Press: New York, NY.

Fearnside, P.M. 1990a. "The rate and extent of deforestation in Brazilian Amazonia." *Environmental Conservation.* Vol. 17. pp. 213-226.

Fearnside, Philip M., A.T. Tardin and L.G.M. Filho. 1990. "Deforestation Rate in Brazilian Amazonia." National Institute for Research in Amazonia (INPA) and Institute for Space Research (INPE) Report. August.

Fearnside, P.M. 1993. "Deforestation in Brazilian Amazonia: the effect of population and land tenure." *Ambio.* Vol. 22, No. 8. pp.537-45.

Food and Agriculture Organization (FAO) of the United Nations. 1981. "Los Recursos Forestales de la America Tropical." *Tech. Rep. No. 1.* 32/6.1301-78-04. Food and Agriculture Organization of the United Nations: Rome.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Food and Agriculture Organisation (FAO). 1982. *Tropical Forest Resources.* FAO Forestry Paper No. 30. FAO: Rome.

Food and Agriculture Organization, Forest Resources Division. 1993b. *Forest Resources Assessment 1990: Non-tropical Developing Countries.* No. FO:MISC/94/3. Food and Agriculture Organization of the United Nations: Rome.

Food and Agriculture Organization. 1995. *Forest resources assessment 1990 - Global Synthesis.* FAO Forestry Paper 124.

Food and Agricultural Organization of the United Nations (FAO). 1993c. *Forest resources assessment.* FAO Forestry Paper 112. FAO: Rome.

Food and Agriculture Organization of the United Nations. Forest Resources Information System (FORIS) Database.

Friends of the Earth. 1989. *Damming the Rainforest: Indian Peoples' Summit of Altamira.* Friends of the Earth: London.

Grainger, A. 1983. "Improving the monitoring of deforestation in the humid tropics." In Sutton, S.L., Whitmore, T.C. and Chadwick, A.C. (eds) *Tropical rain forest-ecology and management.* pp.387-395. Blackwell Scientific Publications: Oxford.

Houghton, R.A. 1992. "The Extent of Land Use Change, Worldwide." Paper presented at 1992 Meeting of the Ecological Society of America. Honolulu, Hawaii.

Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1982. *Alteracao da Cobertura Vegetal Natural do Estado de Mato Grosso: Relatorio Tecnico.* Brasilia, Brazil.

Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1983a. *Desenvolvimento Florestal no Brasil.* PNUD/FAO/BRA-82-008. Folha Informativa No. 5. Brasilia, Brazil.

Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1983b. *Alteracao da Cobertura Vegetal Natural do Territorio de Roraima: Anexo Relatorio Tecnico.* Brasilia, Brazil.

Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1988. *Alteracao da Cobertura Vegetal do Estado de Acre: Relatorio Tecnico.* Brasilia, Brazil.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1989. *Alteracao da Cobertura Vegetal Natural do Estado de Rondonia: Relatorio Tecnico.* Brasilia, Brazil.

Instituto Nacional de Pesquisas Espacias (INPE). 1989a. *Avaliacao da Cobertura Florestal na Amazonia Legal Utilizando Sensoriamento Remoto Orbital.* Sao Jose dos Campos, Sao Paulo, Brazil.

Instituto Nacional de Pesquisas Espacias (INPE). 1989b. *Avaliacao da Cobertura Florestal na Amazonia Legal Utilizando Sensoriamento Remoto Orbital, 2a edicao.* Sao Jose dos Campos, Sao Paulo, Brazil.

Instituto Nacional de Pesquisas Espacias (INPE). 1992b. *Deforestation in Brazilian Amazonia, Folheto.* INPE: Sao Jose dos Campos, Brazil.

Mahar, D. 1988. *Government Policies and Deforestation in Brazil's Amazon Region.* Environment Department Working Paper No. 7. World Bank: Washington, D.C.

Mahar, D. 1989. *Government Policies and Deforestation in Brazil's Amazon Region.* World Bank: Washington, D.C.

Malingreau, J.P. and C.J. Tucker. 1988. "Large-scale deforestation in the southwestern Amazon Basin of Brazil." *Ambio.* Vol. 17. pp.49-55.

Molion, L.C.B. 1991. "Amazonia: burning and global climate impacts." pp.457-462 in J.S. Levine, ed. *Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications.* MIT Press: Cambridge, MA.

Myers, Norman. 1982. *Acta Amazonica.* Vol. 12. p.785.

Myers, N. 1989. *Deforestation rates in tropical forests and their climatic implications.* Friends of the Earth: London.

Myers, N. 1991. "Tropical forests: present status and future outlook." *Climatic Change.* Vol. 19. pp. 3-32.

Repetto, Robert. 1990. "Deforestation in the Tropics." *Scientific American*, Vol. 262, No. 4, April. pp.36-42.

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***


Setzer, A.W., M.C. Pereira, A.C. Jun and S.A.O. Almeida. 1988. *Relatorio de Atividades do Projeto IBDF-INPE 'SEQE' - Ano 1987.* Publication No. INPE-4534-RPE/565. Instituto de Pesquisas Espaciais (INPE): Sao Jose dos Campos, Sao Paulo, Brazil.

Setzer, A. and M. Pereira. 1991. "Amazonian biomass burnings in 1987 and an estimate of their tropospheric emissions." *Ambio.* Vol. 20, No. 1. February. pp.19-22.

Skole, D.L. and C.J. Tucker. 1993. "Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988." *Science.* Vol. 260. June 25. pp. 1905-1910.

Southgate, D.D. and M. Whitaker with F. Ortiz-Crespo. 1992. *Development and the Environment: Ecuador's Policy Crisis.* Instituto de Estrategias Agropecuarias: Quito, Ecuador.

Superintendencia do Desenvolvimento da Amazonia (SUDAM), Ministerio do Interior/Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Ministerio da Agricultura. 1988. *Alteracao da Cobertura Vegetal Natural do Estado do Para: Relatorio Tecnico.* Brasilia, Brazil.

Tardin, A.T. et al. 1979. *Rep. 411-NTE/142.* Instituto Nacional de Pesquisas Espaciais (INPE): Sao Jose dos Campos, Sao Paulo, Brazil.

Tardin, A.T., D.C.L. Lee, R.J.R. Santos, O.R. de Assis, M.P dos Santos de Barbosa, M. de Lourdes Moreira, M.T. Pereira, D. Silva and C.P. dos Santos Filho. 1980. *Subprojeto Desmatamento, Convênio IBDF/CNPq-INPE 1979.* (Relatório INPE-1649-RPE/103.) Instituto Nacional de Pesquisas Espaciais: Sao Jose dos Campos, Sao Paulo, Brazil.

Tardin, A.T. and R.P. da Cunha. 1990. *Report INPE-5015-RPE/609.* Instituto Nacional de Pesquisas Espaciais (INPE): Sao Jose dos Campos, Sao Paulo, Brazil.

Tucker, Compton and David Skole. 1994. Presentation of the results of an independent NASA-commissioned study to the United States Congressional Subcommittee on Western Hemisphere Affairs. May 11.

Tuffani, M. 1989. "Desmatamento de 87 e 88 superam a metade de toda devastacao Amazonica." *A Folha de Sao Paulo.* Brazil. June 18. p.C-3.

*Veja.* November, 1995. (no more details given)

**Rates and Processes of Amazon Deforestation**
***Rate Chart Sources***

Webb, R. and G. Fernandez Baca. 1991. *Peru en numeros 1991.* Lima, Peru.

Woodwell, G.M. et al. 1987. "Deforestation in the tropics: new measurements in the Amazon Basin using LANDSAT and NOAA advanced very high resolution radiometer imagery." *Journal of Geophysical Research.* Vol. 92, No. D2. pp.2157-2163.

World Conservation Monitoring Centre (WCMC). 1994. *Biodiversity Source Book.*

World Resources Institute (WRI). 1990. *World Resources, 1990-1991: A Guide to the Global Environment.* Oxford University Press: New York.

World Wide Fund for Nature. 1988. *Conservation of Tropical Forests.* Special Report 1. WWF: Gland, Switzerland.

World Wildlife Fund/World Conservation Monitoring Centre (WWF/WCMC). 1996. "Forests for Life Campaign."

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

Michael H. Glantz, Amara Tandy Brook and Patricia Parisi
*Environmental and Societal Impacts Group/National Center for Atmospheric Research*, Boulder, Colorado, USA*
**National Center for Atmospheric Research is sponsored by the National Science Foundation*

17 July 1997

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Aldous, 1993 | | | def. worse in SE Asia (1.6%/yr); threat to biodiversity |
| Allem, 1991 | says migratory agriculture accounts for 35, 70, and 40% of def. in trop. zones of America, Africa, Asia. Birth control program essential to mitigate grip on natural resources. Says people are materialistic anyway, tho, and will always look for a profit (man's exploitative attitude toward nature dictated by subsistence needs and economic interests). | legislation demands proof that plots of land donated to migrants do not remain idle. 1st thing new owners do is bulldoze the virgin forest to guarantee legal possession. | quotes a Brazilian politician: "power is orgasm"; indicates that prestige is real target; environmental issues end in stalemate.<br>says it is assumed that rationality will find its way as long as technical info becomes available thru scientific knowledge. But, he says critical scrutiny of social sciences will contribute more to understanding what went wrong in man's dealing w/the environment. |
| Allen & Barnes, 1985 | rapid pop. growth, cropland expansion, fuelwood harvesting, wood exports, cattle ranching all contribute to def. in diff. areas. | subsidized cattle ranching in Amazon | compares def. rates from diff. sources; and statistical analysis of def. variables |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Barbier, et al., 1991 | cattle ranching, colonial settlement, timber production, major devl. projects. Says the land-tax system provides incentive to owners of large farms to convert their forests, so then they will be exempt from the tax. Agric. income is virtually exempt from Brazil's income tax laws, so land is acquired and converted for speculation and as a hedge against inflation and risky financial markets. | cattle ranching assisted by generous gov't subsidies greatest single factor in Brazil (38-73% contribution to "altered forest area") Small farmer settlement 2nd major cause (by 1983, responsible for 11% of Br Am def.) | deliberate policy measures to promote corporate forestry, agric & mining interests have accounted for 35% of all forest area altered in Br Am by 1980: i. private capital investment in Amazon thru tax incentives, ii. agric production thru rural credits, & road investments, iii. small farmer settlement thru directed & semi-directed colonization, iv. exports of products thru subsidies. |
| Binswanger, 1991 | tax policies, tax incentives, land allocation rules, agric. credit system all accelerate def. in the Amazon. The policies increase the size of land holdings and reduce chances of the poor to become farmers. | income tax laws exempt agric & convert it into a tax shelter, which adds demand for land. (80-90% agric profits exempt from taxable income). People claim land by squatting, can get land title by "effectively" using the land, ie, converting to agric. Forest land is considered "unused" and taxed at higher rates than one w/ pasture or cropland, providing incentives for deforestation. | says the SUDAM's tax credit scheme for corporate livestock ranches in the legal Amazon has the largest effect on deforestation. And, the ranches are inefficient, and overgrazing is practiced. |
| Bird, 1991 | | | impacts: loss of plants/medicines; since early 1990s, Europeans have destroyed more than 90 indigenous tribes in Brazil. According to the WWF, 1/2 of the world's rf has been destroyed and 25-30 million ha are lost each year. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Booth, 1989 | colonists who leave overcrowded cities slash/burn the rainforest of Rondonia, following newly paved roads. | | says estimates of def. vary wildly; Setzer reports as many as 8 million ha burned in Brazil in 1987. Landsat resolution of 30m; costs $3600 per scene; would take 200 scenes to survey the Amazon Basin. NOAA's satellites have 1 km resolution, pass over every day. |
| Braga, 1992 | says direct causes of loss of trf are conversion to agric.,cattle ranching, commercial logging, demand for fuelwood. Estimates of the contribution of each are more precarious than the available estimates for def. rates.<br>Since 1969, Brazil has imposed an export log ban for tropical wood. Most logging incentives in the Amazon have been phased out in the past few years. | in Brazil, poverty, official devl. projects, rapid migration, logging and cattle ranching are backed by gov't policies. Subsistence agric and cattle ranching are the main factors (and geared toward domestic market). Brazil's rf mainly in northern part of country, covers about 39% of Brazil's territory. | depletion: encompasses both significant qualitative disruption of the ecosystem and outright deforestation--the clearing of forests and the conversion of land to nonforest uses. |
| Bundestag, 1991 | causes worldwide: settlement programs and absence of land reforms, lack of technology & foreign reserves, taxation systems, corruption, military interests, displacement of small farmers (population growth, poverty, debt problems, economic framework); expansion of agric land, large-scale projects, overexploitation of wood | | effects: climatic, economic, social, ecological |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Bunyard, 1987 | | | says about 2-3 million ha per year are cleared in the Amazon Basin for annual crops and pasture; over 100,000 sq km have been cleared there for cattle 1966-1983. |
| Buschbacher, 1986 | says the impetus for converting Central American forest to pasture comes from demand for low-grade beef in US; Brazilian beef not permitted entry to the US. | in Paragominas, Para state in Brazil, development began in late '60s and reached height in mid '70s when big financial incentives subsidized forest clearing. Subsidies reduced when gov't faced monetary crisis ($ going to development projects) in late '70s. But, 100 sawmills still operate there, harvesting timber from remaining forest. | greatest cost of Amazonian def are cultural extinction and loss of biodiversity. Consequences of def.: conversion to savanna, species extinction, CO2, altered water cycling–increased runoff., loss of soil fertility/less potential for agriculture. Pastures in Amazon are not justified by the short-term yields. |
| Connor, 1992 | says reason for drop in def. in Brazil is not from gov't policy but from its hurting economy. Inflation is 22% per month which has stopped corporations from expanding into the forest, and the gov't has had to curtail its development projects. | says biggest problem in Brazil is urbanization; people flood into coastal cities, swelling the favelas. The Mata Atlantica (east coast forest) is down to 10% of its original size. | says when economy turns around, def. will start up again. Says gov't continues to funnel people into the Amazon thru road building and frontier settlement. Low commodity prices last winter forced indebted sharecroppers who gather nuts to cut their trees to pay off loans and turn to ranching and cash crops. Growers will have to clear larger areas to support selves since their sustainable crop is gone. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Editors, *Ecologist*, 1987 | In Brazil, colonization schemes are held directly responsible for 17% of forest destruction btwn. 1966-1975. Says cannot blame peasants for deforestation when they are forced into these schemes. The problem is landlessness. In Latin America, 93% of the arable lands are held by 7% of land owners–much of that land is used for plantation agric or ranching, thus denied to poor farmers who have been disposed of their own lands often by point of a gun. In absence of land reforms they have no choice but to invade the forests. | says in Brazil, gov't statistics reveal that 60% of forest destruction btwn. 1966-1975 was caused by large ranching schemes (3.87 million ha) and road building (3 million ha). Dams cause def. too. Tucurui project flooded 216,000 ha virgin forest. In Manaus in NW Amazonia, the Balbina dam will flood 2346 sq km. The dams planned for Amazonia are expected to flood an area the size of Montana, much of it forest. | impacts: cultural death of tribal people; extinction of animal/plant species; erosion; loss of drinking water as springs and streams dry up; flooding. Forest dwellers are resettled, usually forcibly, under govt' schemes to incorporate them into mainstream society. They end up in burgeoning slums of cities where they live in poverty and fall prey to prostitution & alcoholism. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Editors, *Economist*, 1988 | a recent study found that in Brazil 80,000 sq km of virgin forest were burnt in '87.<br><br>in Rondonia, the pop of 10,000 (mostly Indians) in 1960 became > 1m in 1985. Forest loss accelerated from 1200 sq km in 1975 to > 1600 sq km in 1985. Few of the newly established settlements have proven successful. | In Brazil, (which has nearly 1/3 of the world's remaining tfs), main cause of def. is a moving frontier of shifting cultivators who have been attracted into the Amazon by colonization schemes that are heavily subsidized by the gov't. Brazil's gov't promote internal migration by investing in TransAmaz hwys. Settlers flee landlessness/poverty into Amazon. Gov't calls it land reform, but it's not; 70% of rural pop lacks land titles and 0.7% of farms occupy 43% of the land area. (Concentration of land in hands of a few landlords–often absentee). Rather than redistribute the non-forest lands, gov't opts to colonize the rf. | biologists estimate that 10,000 plant & animal species are lost every year (world tropical forests). 1/4 of prescription drugs used in US are derived from trf plants. Acc to World Bank, 200m people make their livelihoods directly from tfs, more than 1/4 are traditional inhabitants, the rest moved in from political pressure, pop incr, and env degradation in neighboring areas. Loss of forests=poverty, dismal future. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Editors, *Economist*, 1989 | forests still cover 3.5x as much of the earth's surface as cropland, but they are shrinking: since pre-industrial times, earth has lost 1/5 of its forests, most from temperate areas of Europe and N.Amer. Now, threat is in tfs.<br><br>*Brazil's system of exempting tax on agric land adds demand for land and drives up its price, making it hard for poor to buy, driving the landlessness north into Amazon. In Amazon, clearing land is way to get a title. In some parts, tax credits for livestock biggest factor in def. | altho pop. pressure, land hunger an dneed for fuel wood have all helped to cause def, it has been hugely encouraged by bad economics. A tf is far more productive than the scrubland that succeeds it. Gov'ts allow heavy logging but exaggerate the economic gains, & collect little royalties from timber; less revenue for gov't means bigger gains for loggers, but logging creates fewer jobs than harvesting forests; almost all tropical wood exporting countries have fewer than 1% of their workforce in the timber industry. | impacts: global warming; biodiversity; tropical plants, medicines.<br>1/3 of world's rf is in Brazil.<br><br>World Bank has changed its old view that tfs can be easily cleared and farmed, but not before it financed Brazil's Polonoroeste project–to colonize its tfs w/small farmers.<br><br>*mixture of subsidies & tax allowances encourage def. Brazil's tax system exempts agric & turns it into a tax shelter. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Editors, *Science*, March 22, 1991 | def slowed in Brazilian Amazon, attributed to elimination of gov't subsidies to cattle ranchers. | | 1. Jose Lutzenberger said the amount of cleared forest land may have dropped more than 90%, from 90,000 sq km in 1987 to 5,000-10,000 sq km in 1990.<br>2. Brazilian sec of state for sci & tech said def had slowed by 30% over past 2 years.<br>3. INPE (Brazil's space agency) estimated that 19,000 sq km of land were cleared in 1989, a big decline over 1989 figures.<br><br>good figures hard to come by. WRI says most figures probably on high side 'cuz they were calculated from activities not specifically designed to measure def rates. INPE's estimates based on Landsat images more precise but has only compiled data since 1988. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Fearnside, 1989a | def. process will continue unless changes occur in the legal and economic structure underlying forest clearance. Def. strongly influenced by gov't decisions, such as construction of Belem-Brasilia highway in 1960, and its paving in 1974. In 1967, const. of Cuiaba-Porto Velho hwy, paved in 1984, w/$ from World Bank allowed colonization into western Amazonia. In 1986, paving of BR-364 from Rondonia to Acre, funded by InterAmerican Devl Bank. Oil/gas discovery in Jurua & Urucu River valleys has added road constr. in western Amazonas which may be destination for migrants next. | def. stimulated by gov't thru programs to attract migrants from other parts of country, thru new roads to settlements in Amazon. Pasture plays central role in accelerating def, both for small colonists and for large land owners and speculators. Real estate speculation is major force driving def. in Brazil's Amazon, and pasture has central role: it increases value of lots, planting pasture after def. is method used by posseiros (squatters) and by grileiros (land grabbers) who are attracted by speculative opportunities. The granting of the right of possession to whoever deforests a piece of land is a centuries-old practice. These rights are eventually transformed into full ownership rights. Pasture is easiest way to occupy an extensive area, incr. impact of a small pop. on def. | Says def. for subsistence productin is not a major cause of def, but may become more significant w/incr. population. Says the groups and indiv profiting from def are not the same ones who pay the resulting env, social and financial costs; profits channeled outside Amazon region. Says the social problems motivating the rush of migrants to the region must be solved in the source areas. Land tenure system in Amazonia founded on deforestation, should be modified to make forest use possible w/out clearing it. Commercial logging is rapidly becoming big source of disturbance, as forests in SE Asia are quickly being lost (homogenous forests there, less so in Amazon). Industry causes: charcoal making, pig iron, mining gold, construction of military bases, hydroelectric devl. Root causes: govt' activities: granting of land titles w/criteria of improvement thru def., special loans & tax incentives for agric and cattle ranching; govt' builds hwys, leads to pop migration, def. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Fearnside, 1989b | Cattle pasture dominates land use in def areas of Brazil's Amazon, greatly magnifying the impact of a small human pop. on the forest. Generous financial incentives given to large ranchers by gov't thru SUDAM projects that exempt income tax on ranching. Loans are granted w/interest rates below the rate of Brazil's inflation (so the interest is actually negative). Gov't subsidies account for up to 75% of the investment in the ranches. | Subsidizing ranches grew rapidly in '70s but have ceased to expand since. In 1979 SUDAM announced no new incentives in forest of Legal Amazon but kept over 300 projects that were already approved. So, the subsidized ranches are still an imp factor in def., but Brazil's economic crisis has reduced the amount of $ for this. Expects $ to flow back to ranchers when economy picks up.<br><br>Most cleared area in Brazil's Amazon converted to non-sustainable uses like cattle pasture. Underlying processes driving def need to be addressed: the expulsion of pop. from S & NE Brazil since there the land is concentrated in large holdings; the substitution of labor intensive crops by ranching and mechanized agric; the use of pasture as effective & cheap means of protecting land claim against invasion by squatters or loss to other ranchers/speculators; road building & land spec; policy of recognizing land tenure claims based on pasture as an improvement; frontier expansion: hwys, settlements for mining, hydroelectric devl; military bases. | agribusiness accounts for small portion of cleared area relative to pasture, but could expand. Timber exploitation becoming larger factor as forests in SE Asia and Africa are depleted. Small sawmills are rapidly proliferating in Amazon. Wood chips for use as fuel for thermoelectric plants contributes to def also. If oil price is high as petroleum is depleted wood chips used more (causing depleted forests). Says shifting cultivation is a minor factor of def. in Brazil. But "pioneer agric" is a growing force: they cut and burn the forest but do not allow enough time to let it regenerate, depleting nutrients; or they plant the area w/pasture. This is a big factor in Peru & Ecuador parts of Amazon too. Shift cultivation as practiced by indigenous is not damaging, but not sustainable for large pop's. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Fearnside, 1989c | annual loss of 35,000 sq km of forest in Brazil's Amazon to unproductive cattle pasture. Land speculation is principal force driving def; forest is free for anyone who can claim it. By clearcutting forest for cattle pasture, settlers can gain title to a tract of land and keep other squatters or ranchers from invading the area. Land tenure is established by planting pasture, an "benfeitoria" (improvement). | Def. encouraged by special gov't subsidies for agric and pig-iron projects; and ranching projects and sawmills approved by SUDAM. Incentives for def. include income tax exemptions, arrangements that forgive half the taxes owed on profits from undertakings elsewhere in Brazil provided the $ is invested in Amazonian devl, and loans granted at interest rates lower than Brazil's inflation rate. | Legal Amazonia covers 5 million sq km, of mostly lowland rainforest. SUDAM stopped new incentives in LA in 1979, but still grants incentives in transition forest areas; and old projects are free of the 1979 rule in LA.<br>Says road building is key component of def.; encourages clear cutting by fueling land spec, pasture planting, colonist turnover and new immigration. Says road building should be restricted to areas suitable for agric. Often projects start before a RIMA (Report on Impact on the Env) is completed. |
| Fearnside, 1986 | large cattle ranches are esp. powerful agents of def. in northern Mato Grosso & southern Para. | | diff rates and trend of def in diff states/territories of Brazil. Incr in cleared areas dominated by immigration to colonized areas such as Rondonia. Also, thru expansion of cattle ranching for speculation. |
| Filho, 1985 | new roads, colonies, ranches, expanding towns, growing pop, poor use of natural resources & soils, real estate speculation. Major cause is indiscriminate growth of ranching. 5 acres/hour of virgin forest gone. | | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Hecht, 1990 | gradual mechanization of countryside in '60s created unemployment among peasant masses, who opted for migration to the cities in search of better life. This aggravated crime and unempl in already crowded cities. Gov't chose Amazonia to transform Brazil's economy into LAmer's "powerhouse" and as a political "escape valve"–dumped Brazilians there. | "expansion of ranching did not come as a result of world demand for beef as in CAmer, it reflected Brazil's economic inequality and unusual economic climate that triggered & has maintained a fierce speculative boom in land." SUDAM started the program of tax incentives, road building, grants to corporations, subsidized credits in '60s. | |
| Hecht, 1989 | majority of def. by pasture devl. Livestock have been means to claiming land & tax breaks & are vehicles to other financial benefits, subsidies and immense speculative gains. SUDAM (Superintendency of Amazonia) ranches take up 8763 sq km of Amazonia; in s. Para and n. Mato Gross, SUDAM responsible for 30% of the clearing, acc to INPE. | "underlying the devastation is a combination of local processes, regional policies and national economics in which cattle & their pastures have a flexibility unmatched by other more ecologically appropriate land uses and an ability to serve a myriad of eocnomic purposes" | fiscal incentives: SUDAM ranches received grants of up to 75% of devl. costs to encourage corporate groups to invest. Incentives have totalled $600m. Tax holidays: up to 100% of corporation's tax bill forgiven if the $ were invested in holdings in Amazon or NE. No import taxes: imported equip exempt from duty. Subsidized credits: credits available at essentially negative interest rates. Land concessions: free land or at nominal cost. That ranching was not sustainable, economical or appropriate didn't matter under these circumstances. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Hildyard, 1989 | says "at least 10% of Brazilian Amazon has been laid to rest"; btwn 1987-88, 100,000 sq km primary forest lost. Causes of def. in Amazonia: highways, dams, plantations, pastures, industry, mining–projects which are intended to open up the region to resource intensive, export-led development. Grande Carajas program intended to open up e. Amazonia to industry & industrialized agric.; project occupies 900,000 sq km (size of France & Britain combined). In NW, Yanomami & other tribal groups deprived of their lands under Calha Norte Programme (which provides access to mineral reserves). | policies themselves–rather than their implementation–that are at fault. The belief that better mgm't will avert ecological disaster in Amazonia assumes that the root cause of destruction lies in poor mgm't. Yet, this is only partially true. In the case of pasture devl., the driving force behind clearance is not from economic gains to be made from rearing cattle but from land speculation. | destruction of Amazonia increases local poverty, malnutrition, alienation, unrest; loss of culture of tribal groups. Degraded & impoverished existence, w/little prospect for improvement. Incr. erosion, local climatic change & disruption of drought-flood cycles. Social impact of soil erosion & land degradation is severe. Colonists who have moved into forests are forced to move on every other year to find new forest land to cultivate. Many are "devl refugees" whose own land has been taken over by plantations, cattle ranches, dams, mining projects. Social effects of soil erosion go beyond enforced migration & translate into malnutrition & starvation. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Houghton, 1990 | in 1980, area of tf (world) cleared annually (largely for agric uses) was size of Pennsy. or Louisiana (11.3m ha). in 1989, area nearly 2x as large, =size of Florida & Maine combined. | says policies to stabilize the concentration of $CO_2$ in the atmosphere must include a reduction of fossil fuel use, cease deforestation, expand area of forests thru reforestation.<br><br>says despite emphasis on the tropics, these measures are at least as important & appropriate in the industrialized countries where about 75% of the greenhouse gas emissions occur. | effects of def.: loss of food, shelter for inhabitants; erosion of soil, reduced rainfall, reduced capacity of soils to hold water, incr. frequency & severity of floods, siltation of dams, warmer temperatures; loss of species, alteration of potentially productive land into land w/less capacity to support crops, forests, people; change in water cycle, heat balance, climate of earth; emissions of chemically or radiatively active trace gases such as carbon dioxide, methane, $N_2O$ and carbon monoxide. |
| Houghton, 1991 | over last 200 yrs, concentration of $CO_2$ in the atmosphere has incr. by more than 25%, from about 275 ppm in 18th century, to more than 350ppm in 1989; most from combustion of fossil fuels, 1/3 from deforestation. Expansion of croplands in Europe, N America, Russia major cause of def in last century; since first 1/4 of 20th century, def in those regions has slowed, while accelerating in tropical regions, esp. since 1945. | says fate of def lands or land use contributes to the range of estimated carbon fluxes. Is def. permanent or temporary? Major discrepancies btwn estimates of def. are found in assessing role of shifting cultivation in def. | net flux of carbon is calculated from 3 types of data: rates of def., stocks of carbon per unit area, and fate of deforested lands. Emissions of carbon cannot be measured for the earth as a whole nor for an area as large as the tropics: spatial & temporal variability is too great. Says forests hold more carbon per unit area in trees and soils than the ecosystems that replace them. Carbon released to the atmosphere thru burning when def., and thru decay in the yrs following. Cleared lands may hold 20-50 times less carbon per unit area than forests. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Jackson, 1983 | says nearly half of the original forests are gone in Malaysia, esp. in the last 20 yrs as the country has become a leading exporter of processed tropical hardwoods. And for agric., agro-industries (rubber and oil-palm). FAO estimates that world has less than 2/3 of the orig area covered by tfs. FAO estimates rate at 7m ha/yr or 0.6%/yr. Says 1/2 of def. caused by shifting cultivators ("forest farmers"). 150m sc's, many who are poor, landless who have nowhere else to go except the forest. | says def. started in 17th Century, cleared for plantations, esp. sugar, (in NE Brazil, Barbados, Jamaica, Haiti, Cuba). Plantation development is major factor still in def., continues to supply the affluent countries. Best forestlands of C & S America, n/e/w Africa, and parts of Asia turned into producing strawberries, carnations, peppers, eggplants, pineapples, bananas, cucumbers, tea, coffee, sugar, groundnuts, palm kernels, cotton, rubber (mostly all for foreign markets). Cattle ranches esp. in Brazil and C Amer. Def. compounded as people displaced from land converted to plantations and ranches are forced onto poor hill soils, where removal of veg leads to soil erosion and loss of fertility. | Brazil has tried to solve problem of poverty and landlessness in the NE by moving people to Amazonia.<br><br>Logging: acc to FAO, 153,762,000 ha or 13.25% of tmf have been logged, and each year a further 4.4 million ha are affected, mainly in SE Asia and some African countries. Settlers come on the heels of loggers. Many logging companies are under obligation to replant but this is seldom done. Demand for tropical timbers in Europe, Japan, US quintupled btwn 1960-80. Projected that the developed countries' imports will rise by 50% by year 2000.<br><br>Impacts: loss of plant & animal species; forest protect watersheds, soak up rains and prevent floods and soil erosion (which can destroy river and delta fisheries and clog reservoirs); they have a moderating effect on climate. Huge tf trees hold selves erect not by deep roots but by buttresses and widely spreading roots, which remain near surface and quickly absorb nutrients released by decaying matter. Once trees are removed, soil quickly loses fertility. Tfs contain many species w/in given area. Def. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Kiracofe, 1989 | 3.5m ha of Amazon in Brazil= Amazonia=1/4 of total rf remaining on earth. Amazonia contains 30m life forms. Area of forest cleared annually is very ambiguous figure, dep on source, from 5% to 12% of total land area of Amazonia. | Amazonian colonization growth most noticeable since 1940s– to collect rubber to aid in Allied War effort in Europe. Since late 50s, road building projects by gov't to integrate Amazon basin w/rest of Brazil. After roads brought migrants, came agric devl. Tax incentives to clear land. Until moratorium declared in '79, conversion for cattle ranching was largest land use in Amazon. Gov't subsidies for land clearing & cattle production made the activities econ viable for ranch owners/operators but not profitable in their own right.<br><br>Brazil is depending on Amazon's resources to leverage a monumental debt & to aid in financing other devls that it says will enhance the standard of living for the masses. Any devl. constraints placed on Brazil's gov't are unjustified in the eyes of Brazilians. Br gov't needs to realize that Amazonian devl impacts native peoples, and that def has impacts on global env. | several lg. agro-industrial devl. undertaken in Amazon. "Jari" (project) devl. w/intentions of providing pulpwood to world markets. Has not been a profitable project (sold for $280m after investing $1b). Under the 2010 Plan, 136 dams planned in Brazil, 68 in Amazon interior (for hydro- electric power) will cause def of vast tracts and displacement of native pop's. Def. in Amazon caused by a political & economic devl policy on the part of Brazilian gov't. Gov't sponsored projects touted as being agric in nature, but are non-economic due to inability of soils to sustain agric. While agric objectives were sought to sustain settlement, devl of Amazon also encouraged by military & political leaders to keep bordering nations from making territorial claims in Brazilian territory that contains minerals & other raw materials of economic & strategic importance. This "Calhe Norte" program led the Brazilian army to secure the 4000 km border w/Peru, Colombia, Venezuela, Guyana, Suriname. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Leopoldo, 1989 | 1970 colonization program, road construction. Amazon river basin contains about 60% of the surviving tropical forest. | In Brazilian Amazon alone about 3m ha of forest cleared annually for new areas of colonization. | |
| LeTacon & Harley, 1990 | forest areas in developing countries have declined by half during this century. 40% of closed tf has been cleared, logged or degraded already. Reasons for def. complex; due partially to overexploitation & export of timber for foreign $, for use of wood as energy (about 80% burnt for fuel), agric demands, exacerbated by rise in pop's. | export of forest products is responsible for less than 10% of def in Africa & S Amer. (resp. in SE Asia for 30-40% of def.) | |
| Lewis, 1990 (uses Norman Myers as source) | Brazil has 60% of original forest cover; Peru 60%, Bolivia 50%, Ecuador 30%, Colombia 30%, Guyanas 70%, Venezuela 70%; Costa Rica 10%, Mexico 30% | Ivory Coast has 10% original forest cover, Nigeria 10%, Cameroon 30%, Gabon 40%, Zaire 50%, Madagascar 20%, Congo 80% | India has 10% original forest cover, Burma 10%, Laos 20%, Vietnam 10%, Thailand 20%, Kampuchea 20%, Philippines 30%, Malaysia 30%, Indonesia 40%, PNG 40% |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Lugo, 1988 | 1/2 of world's forests located in tropics; largest area of mature forest located in tropics. Highest rates of land use change in tropics, where pop is growing rapidly. 10m ha/yr of mature tf cover are converted to other uses each year. Also, about 5m ha of secondary forest and 6m ha of deforested agric lands are created each year. | Difficult to understand the many temporal & spatial scales at which def occurs. May occur in areas as small as a few sq meters or as large as millions of ha. Changes can be instantaneous or occur over millions of years. | Impacts: incr in $CO_2$ content of the atmosphere, species extinctions, declining env quality, direct threats to human welfare, detrimental to long-term productivity of the land. Not all forest conversions are negative; some lead to sustainable land uses (agroecosystems). Difficult to separate changes induced by humans from those induced by natural phenomena. Hurricanes, fire, drought may be attributed to human causes; blame may fall on nature for human's poor land use (floods, droughts). |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Lutzenberger, 1987 | plantations, large dams, mining operations, colonization schemes are major causes of def in Amazon rf. Sioli estimates that 100,000 sq km forest felled/yr= 2%/yr for at least a decade. | Brazilian gov't (military dictatorship set up in 1964) set course for devl. at any cost. Its definition of devl is a technocratic one: economic model geared to fast industrializtion & cash crop agric, w/vast monocultures, to feed industry & export market. TNCs or Brazilian corporations or rich indiv go to Amazon to make $$$. Set up huge projects: cattle ranches, paper mills, monocultures for pulp, immense rice plantations, sugar cane for gasohol, timber mills, mining. These are financed w/state subsidies, tax rebates; that's why they are extremely wasteful and have scandalously low rates of productivity. | TNCs, big business, colonization schemes; (lg-scale destruction of forest by small settlers due to outside forces). Brazil's colonization agency, INCRA (Instituto Nacional de Colonizacao e Reforma Agraria) shows aerial photos of settlers clearing land in Amazon, w/slogan: Brazil is making the largest agrarian reform in the world." Schemes conceived to not have to face agrarian reform in other areas, tho! NE displaces people (landlords don't want peasant culture developing), South displaces people (soybean monoculture for cow feed drives people off their land), in C Brazil, gasahol program forces people away. People move onto land and INCRA accepts as improvements clearing of the forest. Settlers clear as much as possible, even more, to get a land title, then sell to bigger estates, then move on (make living w/land speculation) |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Lutzenberger, 1987 (continued) | INCRA colonization schemes have no regard for landscape and people. Divide land in checkerboard fashion, over steep slopes, rock outcroppings, rivers; forest cut down on a slope=>soil erosion. No agric extension agency worthy of the name exists. Cash crops are promoted, credit system geared to monoculture (coffee, cocoa, rubber & citrus trees). | Socially, the settlement schemes are very disruptive. 1. they prevent reforms in the regions where the migrants come from. 2. they destroy existing social fabric in settlement areas, 3. settlers run into trouble when their soils become degraded & there is no more virgin forest to move into. 4. local Indians are killed, liquidated; survivors driven deeper into jungle, until they meet colonists moving in from another direction; face lethal epidemics, cold, measles, VD.; end of their culture. | small loggers dependent on forest; big TNC logging companies use heavy machinery, destroying the whole ecosystem; required to reforest, but rarely do so, & if they do, they reforest w/commercial monocultures, & the area is smaller than the area destroyed. Local fishermen also suffer. Fish life mostly dependent on forest, esp. on the flood plains, feed on fruit or forest residues during high water season. Commercial overfishing causes extinctions & wasteful. Seringueiro (rubber tappers) derive most their food from forest & river, as do the caboclos who practice shifting agric, and h&g. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Mahar, 1989 | spread of small-scale agric most imp proximate cause of trop def. Acc to Myers '86, it causes 150,000 sq km depleted/yr worldwide. Other major proximate causes are commercial logging (45,000 sq km/yr), fuelwood gathering (25,000 sq km/yr), cattle raising (20,000 sq km/yr). These are not the underlying causes. Small farmer not responsible for trop def., real causes are poverty, unequal land distribution, low agric productivity w/rapid pop growth, misguided public policies that purposely or inadvertently encourage def. | first scientific estimates of def in Amazonia made in early '70s by Brazil's gov't Radar in Amazonia Project (RADAM) which used airborne slr to gather data, showed that little clearing had occurred. Few years later, Landsat satellite images indicated 30,000 sq km or 0.6% of Amazonia had been cleared as of 1975 (Fearnside, World Bank cited). | says "depletion" refers to both "deforestation" (complete & permanent removal of all forest cover), and "major disturbances" (any modification of the forest, such as selective logging, that leads to pronounced impoverishment of the forest ecosystem). Estimates 200,000 sq km of tf depleted/yr. 70,000- 90,000 sq km of tf deforested/yr worldwide. Amazonia has an area of >5m sq km, which is about 58% of Brazil's total land area. Legal Amazonia comprises Acre, Amapa, Amazonas, Mato Grosso, Para, Rondonia, Roraima, and parts of Goias, Maranhao. 1/2 of Amazonia comprises upland areas (terra firme) which original veg was trf. Another 500,000 sq km is transitional forests. Also large areas of savanna (cerrado) in Mato Grosso and Goias. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Mahar, 1989 (continued) | causes in Amazonia: small-scale agric, cattle ranching, logging, road building, hydroelectric devl, mining, urban growth. Relative contribution of each difficult to determine. Rapid expansion of agric frontier over past 20 yrs the most imp single factor. Acc to agric census data, farmland in Amazonia incr from 313,000 sq km in 1970 to >900,000 sq km in 1985. Conversion of forest to pasture at rate of 8-10,000 sq km/yr during '70s, most on large landholdings. Pasture is predominant form of agric land use, so cattle ranching appears to be leading proximate cause of def. Annual cropping, 2nd most imp form of ag land use incr by 2000 sq km/yr 1970-80. Small plots sold or abandoned after just a few years 'cuz of rapidly declining yields. Then converted to pasture by lg landowners or quickly invaded by secondary growth (capoeira). Some def attributed to ranching probably caused by spread of small-scale ag. | regional policies: massive road-building programs in '60s, '70s made large areas accessible by land for the first time, and gov't sponsored settlement schemes simultaneously attracted migrants from Brazil's NE and S regions. Special fiscal incentives, subsidized credit encouraged cattle ranching, which allowed a small pop to have lg impact on the rf.<br><br>Operation Amazonia: series of legislative acts and decrees enacted in '66, '67 when the gov't committed itself to the devl & occupation of the region, and eventual integration w/ rest of Brazil (road building to link Amazon w/ NE & S, ag colonization schemes, fiscal incentives to attract new industrial & ag enterprises. SUDAM created (Superintendency for Devl of Amazonia). Motives for Operation were geopolitical; Brazil's military leaders anxious to ensure national sovereignty by establishing self- sustaining settlements in frontier, and to claim natural resources hidden in the forest.<br><br>Belem-Brasilia Highway: (BR-010), in 1964, 1900-km long highway connecting capital city of Brasilia in | not clear how much def can be attributed to logging, as timber extraction in Amazonia is byproduct of land clearing for ag purposes. Says loggers selectively cut commercially valuable species in newly opened areas, and the trees represent a small proportion of the standing forest. Practically no replanting is done. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Mahar, 1989 (continued) | (policies con't):<br><br>Subsidized Credit: about 90% of all pasture formation in Amazonia has been carried out by firms or indiv who did not receive fiscal incentive funds. They received subsidized rural credit, which incr private rates of return to investment and so encourage deforestation, which would not be undertaken if credit were priced at market rates.<br><br>Subsidized credit skewed further the distribution of wealth in the region. Because possession of a land title is a prerequisite for obtaining investment credit in Brazil, Amazon's many sharecroppers, tenants and squatters were denied access to the subsidy. It reduced the chances of the landless to obtain titles, by raising land prices well above what could be earned thru farming or ranching. Since 1980 the volume of official rural credit has been reduced in attempt to restore internal balance to Brazil's economy. The subsidy element in the credit was eliminated completely in 1987. | (con't) Migrants searching for land and employment entered by BR-010, as did firms to establish cattle ranches to take advantage of cheap land and generous tax, credit incentives offered by gov't. Hwy generated demand for feeder roads, which attracted more pop., and more roadside def.<br><br>Incentives for livestock devl: investment tax credits; Brazilian corporations got up to a 50% credit against their federal income tax liabilities if resulting savings were invested in projects in Amazonia and approved by SUDAM. A 1963 legislation created the tax credit for industrial projects, in 1966 ag, livestock and service projects also included. Since 1979, approval of livestock projects in rf has been officially prohibited but it's difficult to enforce. By 1985, 631 livestock projects approved by SUDAM out of 950 projects. 3/4 of livestock projects in S Para and N Mato Grosso. The ranches in those areas average about 24,000 ha each, several are larger than 100,000 ha. | in areas of Amazonia w/peasant economies based on extractive activities, conversion of forest to pasture has negative employment effects; the def of Brazil nut trees in Para deprived peasant communities of employment & income. The former nut gatherers migrated to nearby towns where they now depend on temp employment on cattle ranches.<br><br>Cattle ranches typically employ one person for every 250-300 ha of pasture. |

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Mahar, 1989 (continued) | (policies, con't): in 1968, 1500-km Cuiaba-Porto Velho hwy (BR-364) opened up Rondonia for settlement. Migratory flow incr from 3000/yr in 1960s to 10x that in the 1970s, migrants, land grabbers and adventurers took land free for the asking. Most of def in the area for ag purposes in settlement projects along hwy. In 1981, gov't reconstructed/paved BR-364 as part of larger program of integrated regional devl, in hopes of curing incr. socioeconomic problems in the region. Program called Northwest Brazil Integrated Development Program (POLONOROESTE), purpose to reduce forest clearing on land w/little ag potential to to promote sustainable farming of tree crops. Did not work. Def area of Rondonia was 3% of state in 1980, 24% by 1988; rapid conversion of forest to pasture instead. INCRA's polcies encourage inappropriate land use: accepting def as evidence of land improvement. | National Integration Program (PIN): est in 1970, provided impetus to road-building boom (Transamazon hwy connecting Amazon w/NE, and the Cuiaba-Santarem hwy linking Amazon w/ S & SE). Rationale for PIN: E/W Transamazon hwy would provide solution to drought problem in NE by creating jobs for displaced NE families in short term; in long term, to alleviate pop and social pressures in NE and promote occupation of Amazon; and to uncover mineral deposits during road construction. Overriding motive: national security and fear of foreign domination in the region. INCRA (Nat'l Inst for Colonization & Agrarian Reform) established network of villlages, towns, cities along the hwy and demarcated 100-ha farm plots with goal to settle 70,000 families btwn 1970-2. Failure of hwy & settlement scheme to act as safety valve for social pressures in NE evident: total of 8000 families settled, 40% of which were from the NE. Neither were sizable mineral deposits discovered. | the directed settlement of the early to mid '70s failed to create self-sustaining ag communities: adverse env factors played lg role. Routing of Transam hwy & layour of colonization projects done hastily & w/little regard for soil fertility or topography; (very hilly, extremes of rough terrain). Cleared areas eroded quickly. Alteration of forest created favorable breeding conditions for Anopheles mosquito, the most common vector of malaria. Peak malaria transmission period coincides w/planting/harvesting periods–debilitating disease had effects on reduced ag yields. Also, crops were annual crops–upland rice, which is not env or econ sustainable in areas cleared from rf. Colonization projects far from major markets for ag commodities, putting settlers at another disadvantage. Lg. cost of transport so fertilizers, pesticides, herbicides sold at costs far beyond what they could afford. Crops succumbed to diseases, farmers cut/burn more forest to try to maintain average yields. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Malingreau & Tucker, 1988 | study area: SE Amazon Basin of Brazil (Mato Grosso, Rondonia, Acre). def associated w/new roads.<br><br>deforestation: conversion of a forest canopy into a barren area of into another vegetation community dominated by grass, shrub, tree or field crops. | "explosive" def in Rondonia made possible thru promoted frontier expansion scheme. BR-364 brought wave of migration and def. Estimates that 10,000 sq km of Rondonia was def in 1982, 17,000 sq km was def in 1984, incr to 27,000 sq km in 1985. | world's tfs once covered 24.5m sq km, now cover 10m sq km of earth's surface. 8m sq km trop land converted to ag, 3m sq km under shifting cultivation, 3.5m sq km have been converted to pasture. Majority of world's tfs are w/in Amazon Basin in Brazil. Legal Amazon covers 5m sqkm, of which 70% is terra firme (forest), rest is swamp forest, flooded grassland and cerrado (scrub savanna). |
| Manchete, 1989 | Amazon region comprises 45% of S. America; total area=7m sqkm; Brazilian area=5m sq km; 60% of Brazilian territory; 2/3 of world's trf of which 3.7m sq km in Brazilian territory; 25,000 km of navigable rivers, waterways; all of Europe except USSR fits w/in Amazon region. | Amazon river: longest river on earth, 7,200 km. | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| McCloskey & Spalding, 1989 draft | digitized Smithsonian maps of moist lowland evergreen and semi-evergreen (closed canopy rfs) in the tropics, also submontane forests. Gathered country by country estimates according to a common definition. Smithsonian maps depict the estimated original range of world's moist tfs and contrast it w/range of what is thought to remain. They excluded seriously degraded rfs from survey, but some inventoried areas had been impacted by shifting ag & logging. They generally tried to show where so-called undisturbed primary rfs can be still found. | Original total: 5.5m sq miles; current total: 3.7m sq miles; loss of 1.8m sq miles, which is = to US east of Rocky Mountains; 1/3 of world's trfs lost, 2/3 remain. Says there are considerable differences in the base figures for the range of original rf, so estimates of how much has been lost varies greatly (range from 6.4m sq miles to 11.8m sq miles originally). Puts more faith in #s relating to current size than in original rf size, since latter involves speculation and confusion over definitions, and varied assumptions about at what time one fixes the original rf's size. (original could mean millions of years, thousands of years, hundreds or decades ago). | measurements of Smithsonian data show remaining trfs distributed as: S Amer: 2.3m sq mi; Asia & Melanesia: 690,500 sq mi; Africa: 612,000 sq mi; C Amer & Carib: 92,000 sq mi. [1sq mi=2.59 sq km]<br><br>1/2 of remaining trf in 3 countries: Brazil (1.385m sq mi), Indonesia (360k sq mi), Zaire (318k sq mi).<br><br>5 countries account for >1/2 the losses of trfs: Brazil (300k sq mi), Indonesia (280k sq mi), Zaire (164k sq mi), Colombia (92k sq mi), Burma (86k sq mi). Loss in Brazil is area>France and = to Texas.<br><br>C Amer & Carib have lost 65%, Asia & Melanesia 53%, Africa 40%, S Amer 16%.<br><br>Brazil, most severe losses in east coast, in Rondonia, eastern Amazon. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Millikan, 1992 | says social causes of tf destruction are poorly understood. 1/3 of world's remaining tfs located in the 5.8m sq km Amazon Basin, over 1/2 which is included w/in Brazil's boundaries.<br><br>policy: in 1970, gov't launched the National Integration Program (PIN), which incl an unprecedented small-farmer colonization scheme for the Amazon Basin. Settlement would be concentrated along a new hwy, the Transamazonica (BR-230), an e/w road south of Amazon River that would link Recife on the Atlantic w/ Peruvian border. INCRA responsible for carrying out the project. INCRA (National Institute for Colonization & Agrarian Reform) was created in 1970. INCRA put in control of all "national security" lands, to review claims, define land-use categories, survey, transfer public lands to private ownership thru colonization projects or other land distribution. | turning point in Rondonia's region was construction of Cuiaba-Porto Velho hwy (BR-364), to link the nw frontier w/Brazil's more industrialized center-south region. Hwy completed in 1960. rationale to decentralize Brazil's pop away from coastal cities, open up markets for expanding consumer-goods industries based in the center-south, and gaining access to raw materials in the hinterland.<br><br>after military coup in '64, Brazil's new leaders initiated policies to integrate Amazon Basin into nat'l society: construction of roads, promotion of private enterprises thru generous subsidies & fiscal incentives in livestock & mining sectors. "Geopolitical concerns w/ nat'l security and the occupation of distant border regions were guiding principles in the military regime's planning. | soon after gov't initiated PIN, they lost interest in those colonization schemes--instead realized that huge profits could be made thru investments in Amazon, esp. thru speculative cattle ranching. Meanwhile Rondonia undergoing demographic boom--BR 364 hwy triggered migration & land occupation and state did not exercise direct control. During '70s, Rondonia's pop incr from 100,000 to 500,000, an average growth rate of 15.8% compared w/2.48% for entire country. The state's boom was a direct reflection of rural poverty & landlessness in the migrants' source regions. Most imp consequence of this was massive incr in rural-to-urban migration. Faced w/difficulties of survival as marginalized pop's in already overcrowded cities, thousands of poor opted for migration to frontier regions like Rondonia in a desperate attempt to regain access to land. Meanwhile, in '70s, agric modernization in rapidly industrializing center-south Brazil. |

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Millikan, 1992 (continued) | "given the magnitude of the migration, implementation of carefully planned colonization projects became an impossibility". w/the demand for land outstripping the rate of settlement by INCRA, frontier expansion in Rondonia was incr based on land invasion by migrants seeking to establish squatter's rights; the invasions frequently involved land of very limited ag potential. Rondonia's land boom attracted wealthier speculators (grileiros) seeking control over lg properties for cattle ranches or for resale. This also contributed to indiscriminate land occupation & a chaotic land-rights situation in which violence & lawlessness prevailed" INCRA exacerbated the situation by recognizing forest clearing as a means of legitimizing land claims. Large tracts of public lands were auctioned by INCRA at nominal prices, usually to speculative cattle ranchers; these lands contained Rondonia's more fertile soils, migrants still were settled on marginal soils. Other lg properties acquired thru bribery of INCRA & other gov't officials. | World Bank invested in 1980 in the Cuiaba-Porto Velho hwy reconstruction, as part of a larger devl project to include feeder roads, consolidation of small-farmer settlements, land-tenure services, creation of new settlements, public health services, env protection, and support for Amerindian communities. Initial budget of $1.5 billion US, the Northwest Brazil Integrated Development Program (POLONOROESTE) was created in 1981. Perennial crops promoted (coffee, cacao, rubber) as recipe for sustainable development (to replace forest clearing in areas occupied by colonists). Newly paved hwy opened in 1984. By 1988 cumulative forest clearing in Rondonia had reached 4.2m ha, 17% of the state's total area. Rate of migration far exceeded gov't projections. Immig due partially to newly paved hwy and fueled by deepening economic crisis (immig were displaced rural poor and city dwellers escaping poverty & underemployment). Demand for land outstripped gov't distribution (INCRA) of small plots. Migrants incr pressure on lands of marginal ag potential. Areas w/high | rapid frontier expansion infringed on areas occupied by indigenous people, rubber tappers (seringueiros) and other locals. INCRA's policies neglected the region's physical landscape and its preexisting cultural landscape. Frontier used as an escape valve for social tensions generated elsewhere in Brazilian society. Small-farmer settlement programs contributed to a widening of socioeconomic disparity at the national level.<br><br>land claims by recent immig often characterized by insecurity due to conflict w/grileiros, other posseiros, and hostile indigenous groups, and lack of definitive titles that would allow access to ag credit. Also faced malaria and other diseases.<br><br>disappointing performance of perennial crops in Rondonia was partly due to shortfalls in supply of ag credit (because of Brazil's foreign debt and economic recession and rising interest rates). Also, because many immig were squattors and did not have titles to their plots which they needed to receive long-term rural credit for crops. Migrants attempting to claim land thru squatters' rights |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Molion, 1989 | | | impacts: Amazon forests play critical role in regulating climate at regional and global levels. Massive quantities of carbon are locked up in forest biomass, which, if released, would add to global warming. The forests pump heat into atmosphere, cooling the tropics and distributing head to temperate zones. At local level, def incr temperatures, decrease rainfall, and disrupt hydrological cycles (floods, erosion from runoff, soil degradation) |
| Monastersky, 1993 | has a chart depicting forest loss, source is FAO: Forest remaining as of 1990:<br>Africa: 527,586,000 ha<br>East Sahel Africa: 65,450,000 ha<br>West Africa: 55,607,000 ha<br>Central Africa: 204,112,000 ha<br>Trop Southern Africa: 145,868,000 ha<br>Asia: 310,597,000 ha<br>Continental SE Asia: 75,240,000 ha<br>Insular SE Asia: 135,426,000 ha<br>Latin America: 918,115,000 ha<br>C Amer & Mexico: 68,096,000 ha<br>Trop South America: 802,904,000 ha<br>World Total: 1,756,297,000 ha | Annual deforestation 1981-1990 (FAO is source):<br>Africa: 4,100,000 ha<br>Asia: 3,904,000 ha<br>Latin America: 7,407,000 ha<br>World Total: 15,411,000 ha<br><br>Annual rate of def (percentage):<br>Africa: 0.7<br>Asia: 1.2<br>Latin America: 0.8<br><br>(Continental SE Asia: 1.6%<br>C Amer & Mexico: 1.5%<br>Trop S America: 0.7%) | cites June 25 Science study on problems w/estimates of rates of def. Quotes David Skole of Univ of NH in Durham: "all of the published global studies do not use a systematic approach. They use secondary & tertiary sources, anecdotal reports, diff time periods, diff methodologies, diff terminology. It's the state of affairs now in def monitoring." |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Myers, 1988 | amount of forest remaining in humid tropics is about 8m sq km, or roughly 1/2 of what once existed. By early '80s, about 100,000 sq km eliminated each year, mainly thru conversion to ag for lg-scale ranching, and small-scale cultivation; and another 100,000 sq km/yr disrupted thru heavy logging and intensive slash/burn farming. | in Brazilian Amazon in 1987, 80,000 sq km of primary forest was burnt. At least 2.5% of the entire biome (refers to world or Amazon?) is being eliminated each year in terms of forest cover w/its full biomass, biotic diversity, ecological complexity"<br><br>"Adopting a wait-and-see attitude, which is essentially what policymakers are implicitly doing now–presumes that we shall anticipate sufficiently the amount and rate of trop def, plus its impacts, and that we are confident we can accommodate all the possible climatic repercussions." | If Amazonia were to be widely deforested, there could be a pronounced decr in amount of moisture that is being evapotranspired from it into the atmosphere, leading to a significant decline in rainfall = > irreversible ecological changes in the basin. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Myers, 1991 | "...main agent of def is the 'shifted cultivator' or displaced peasant, who, responding to land hunger and general lack of rural devl in traditional farming areas..., feels there is no alternative but to adopt a slash and burn lifestyle in forestlands." They...account for at least 60% of the def, a proportion that is expanding rapidly." They receive less policy attention than the commercial logger, cattle ranchers, and other agents of def.<br><br>Atlantic Coastal Forest reduced to 20,000 sq km or 5% of its original forest cover, w/8000 sq km or 2% of former primary forest still intact. | Brazil's original extent of forest cover: 2.86m sqkm; present extent: 2.2m sq km; present extent of primary forests: 1.8m sq km; current amount of annual def: 50,000 sq km or 2.3%/yr.<br><br>Pressures that drive colonists into Rondonia, Acre, other settlement areas: skewed land distrib, inadequate land-tenure systems elsewhere in Brazil, shaky economy and debt burden, pop growth, show no sign of abating w/in foreseeable future; likely to exacerbate. | def.: complete destruction of forest cover thru clearing for ag of whatever sort (cattle ranching, smallholder ag--planned or spontaneous, lg-scale commodity crop production--rubber and palm oil plantations). Not a tree remains and the land is given over to non-forest purposes. When a forest biomass is so severely depleted resulting in the removal or unsurvivable injury to a great majority of trees, that the remnant ecosystem is a travesty of natural forest. Depletion of the ecosystem that the forest no longer qualifies as forest in any practical sense (occurs w/ overlogging as in SE Asia). |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Nazmi, 1991<br><br>(last comment): since appointment of Lutzenberger to post of Sec of Env, policy reversals have occurred. Tax incentives for ranching have been abolished, construction of BR-364 has stopped. | says the obsession of the military gov'ts that ruled Brazil 1964-1986 w the 2 objectives of security & devl set the stage for def of the Amazon. General Golbery do Couto e Silva belief that vast undev regions presented danger as paths of the enemy's penetration. He argued to "flood the Amazon region w/ civilization." Late '60s-early '70s, military gov't established SUDAM and BASA (Banco da Amazona) to foster econ devl in the region. Since then the forest has been destroyed for cattle ranching, mining, timber production, land ownership.<br><br>policies of tax & fiscal incentives followed by Brazilian gov't for encouraging the devl of the Amazon have resulted in increased def and decreased social benefit. Any gov't policy such as road construction that increases the private benefit more than the social benefit will result in non-optimal incr def. His model suggests that some forest can be converted to a point of optimal social welfare. At same time, gov't incentives for alternative uses of forest will move society away from point of maximum benefit. Gov't needs to stop programs that incr private benefits of def. | says Brazil's gov't policies need to be "revamped".<br><br>Process of destruction began 1966 when gov't passed legislation that granted tax privileges & fiscal incentives for clearing the forest and investment in cattle ranches. Legislation also offered tax relief until 1982 for corporations that invested their profits in the Amazon. Taxes on exports from Amazon region and tariffs on imported equip needed in the region were abolished. Gov't provided ranchers w/loans that carried negative real rates of interest. Some ranches established to obtain low-cost loans, then diverted into more profitable investments; these incentives made cattle ranching most popular form of land use in Amazon. Other econ activities: decline in timber supply in Africa and Asia, companies like GP involved in lumber activities in Amazon. (btwn 1975-1990, estimated regional production of timber rose by 400%). Small-scale ag is encouraged by badly defined land property rights, estimates s-s ag accounts for 150,000 sq km destroyed/yr. | policies (con't):<br>3rd: use of Brazilian Amazon for mining. Programa Grande Carajas est. in 1980 after manganese, nickel, bauxite, copper, gold found there. Pig iron production became main focus. Plan to use eucalyptus as source of charcoa for pig iron prod; required 82,000 ha of native forest per year.<br><br>cattle ranching is profitable only because of gov't subsidies and fiscal incentives (not profitable on its own). Overgrazing profitable due to policies, low interest rates, land spec., & tax benefits. But, only about 3% of SUDAM's cattle projects located in Rondonia, and the def. is very high there; more than 90% of the state is under the jurisdiction of INCRA. Return to def activities unusually high in Amazon due to badly defined land ownership regulations. Migrants given temp ownership rights to land upon clearing the forest, then exchanged for perm titles after minimum residence of 5 yrs is met.<br><br>**2 factors make def a way of life in Brazilian Amazon: government policies and ill-defined property rights.** |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Nepstad, et al., 1991 | ranching, logging operations transforming the mtf of e Amazonia into pastures and regrowth forests. New ecosystems are ag unproductive, biologically impoverished, and more flammable than what they replace. | most early newcomers to Amazonia came along hwy that was completed in 1964, connecting Belem at mouth of Amazon river, w/ Brasilia, and settled in state of Para. From 1975 to 1988, area of cleared forest incr from 8700 to 120,000 sq km of the state's territory (0.7%-9.6%). | Paragominas in NE Para, became one of many frontier towns. It became a regional center for the Amazonian cattle industry, which was stimulated by federal incentives (investment tax credits, subsidized rural credit), and escalating land values. By 1985, 23% of Paragominas had been cleared & planted in pasture. Some ranches have failed in the region, but the lumber industry has expanded, stimulated by incentives and expanding domestic market for Amazon woods. From 1 sawmill in 1970 to 200 in 1990. |
| Neto, 1989 | President Jose Sarney quoted INPE scientists that 5.12% of the rf had been cleared since colonization of Brazil began in 1500. But INPE meant that was a % of the total area of Brazil, not a % of the total area of rf, which is smaller. | | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Pearce, 1992 | says there has never been anything inevitable about the rate of destruction of Amazon rf. 30 years after invasion, which culminated in the orgy of forest burning by mostly poor colonists in the late 1980s, followed a deliberate gov't policy, devised by military rulers in early 1960s. This encouraged migration into Amazon by building roads and offering generous tax and other incentives to industry & land spec. | | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Posey, 1989 | | FUNAI (the Brazilian Indian Foundation) resp. for Indian affiars, the only legal institution that could represent or defend native peoples. Corrupt. A former president of FUNAI sold gold and timber rights on Indian lands. Paternalism as much a part of national fabric as the carnaval; all to easy to mask attempts to thwart native independence movements w/rhetoric about helping Indians make decisions about what is best for them. Rarely have Indian leaders been heard." | modern land use practices in Amazon are unsustainable; destroying Indian societies destroys vital source of info on how people can live and enrich, rather than destroy, the forest.<br><br>Caboclos ignored, expelled from lands as squatters (posseiros), forced into poverty and dependency in sprawling slums (favelas) where they pay the price of devl.<br><br>Brazil's Indian pop have declined from 8m at time of first European contact, to less than 200,000 today. 87 Indian groups have become extinct during this century in Brazil alone. W/each decimation of each group, world loses thousands of years of knowledge of adaptation to tropical ecosystems. Rapid pace of econ devl. not halted even long enough to take note of what it is about to destroy" |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Rainforest Action Network Factsheet #15, 1991 | "estimated in absence of recent & reliable data: in Brazil in 1988, 50m acres/78,125 sq mi cleared=size of Nebraska; 12m acres/18,750 sq mi burned. Economic value of 1 ha in Peruvian Amazon: $6820 if intact forest is sustainably harvested; $1000 if clearcut for commercial timber; $148 if used as cattle pasture | | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Repetto, 1990 | gov't policies that encourage exploitation--in particular excessive logging and clearing for ranches & farms--are largely to blame for the accelerating destruction of tfs.<br><br>logging often first step in def; may be followed by complete clearing and shift to new land uses--cattle ranching and inappropriate modes of agric. In Acre, pastures quickly lose productivity, and can carry few cattle, revenue from rubber & Brazil nuts is 4x higher than that from cattle ranching.<br><br>(impact): as better ag land is concentrated into large, underutilized estates, the growing rural pop is pushed into forested frontiers and upper watersheds. Concentration of landholdings supported by very low ag taxes that make farms/ranches attractive investments for rich people. Lg landholders can easily buy out small farmers (esp. in inflationary setting) who cannot finance investments to raise ag productivity. Many recent migrants into Rondonia & Acre are small farmers & laborers | many policies driven by severe econ pressures afflicting debt-burdened underdevl countries. Pressures exacerbated by practices of developed countries, nat'l & int'l financial institutes.<br><br>def largely consequence of poor stewardship, inappropriate policies, inattention to socioecon problems whose true locus is outside the forest sector. Most developing govt's have not put adequate value on tfs.<br><br>In Brazil, recognized rights of occupancy or possession are awarded on the basis of the area of land cleared; this becomes a mechanism for privatizing land from public forests. Those who obtain ownership soon sell out to larger capitalists, who consolidate the land to establish private ranches and accumulate speculative holdings.<br><br>rapid def generally been linked to difficult economic conditions in many trop countries. They are debt burdened. Pileup in Brazil of ag labor force which outpaced economic growth; so migrants went to the frontier. | In Brazil, where little timber is extracted before forestland is cleared by burning, the resulting loss in commercial timber is about $2.5billion/yr. Value of income derived from nontimber forest products greatly exceeds that of the timber harvest. And, the incomes so derived are the livelihoods of locals, whereas the profits from timber operations are usually captured by distant elites or foreign corporations.<br><br>policies (con't): ranches, lg holdings would be uneconomic w/out heavy gov't subsidies. In Brazilian Amazon, road-building projects financed by gov't and multinational devl banks have fueled land speculation. >600 cattle ranches, averaging more than 20,000ha each, have been supported by subsidized long-term loans, tax credits covering most of the investment costs, tax holidays, and write-offs. The ranches are uneconomic, typically losing >1/2 of their invested capital w/in 15 years. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Salati, et al., 1991 | trend of def Brazilian Amazon changed during '60s, w/opening of hwys which promoted easy, quick access to terra firme areas. Plus gov't incentives for devl in the region=> rapid pop increase, reaching over 15m people in last 2 decades. | | estimates of rates of def range from 5% (INPE, '89) to 12% (Mahar, '88). Annual rates of def range from 17,000 sq km (INPE, '89) to 80,000 sq km (Setzer '89). Fearnside ('90) estimated def rate for past 11 years at 21,000 sq km/yr +/- 2100 sq km/yr.<br><br>Impacts: extinction of flora & fauna expected whenever the diversity of a natural forest ecosystem is replaced by a single species or less diverse ecosystem. Diversity is basis for functioning of tf ecosystem; the higher the # of species present, the higher probability of adaptation to changes in env. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Salati & Vose, 1983 | 100,000 sq km of S & C Amer cleared each year, 1/3 of original forest remains; in Costa Rica 60,000 ha/yr of tf lost to cattle production. SE Asia, >150,000 sq km forest cleared/yr. Equatorial Africa, >1m sq km of forest have been removed.<br><br>At most basic level, def may be due to slash/burn clearance for shifting ag. And, cleared for firewood; 1/3 of world's pop (1.5 billion) rely on firewood for cooking, heating. | "On more organized level" national, int'l logging operations remove economically useful timber, esp in SE Asia. Forests also extensively cleared to provide superficially economical cattle grazing land, esp in Latin America. Gov't policies do much to accelerate def. incl: plans to resettle people to remove pressure on existing areas and cities, and to make "economical" use of the land. Policies implemented by providing cheap land, construction major/minor roads, infrastructure, financial incentives to investors. | nutrients in standing forest; when cut and removed or forest cleared by burning, nutrients lost or leached. Soil fertility rapidly lost, crop yields decline as soil is exhausted. Cattle damaging as nutrients are exported, soil damaged by overgrazing, severe erosion occurs. Land failure after def is the case, no considerable or sustainable benefit is obtained. Wealth of plant/animal species lost, along w/livelihood of indigenous peoples. Nat'l benefit of def is minimal. Selective logging can damage remaining timber, while foreign exchange cost of imported heavy logging equip may equal or exceed foreign exchange earned by exported timber. Seldom does money come back to region concerned. Indigenous people are displaced and the remnants end up in shanty towns, untrained for other ways of earning a living. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Shukla, et al., 1990 | rate of def in Brazilian Amazon from 25,000-50,000 sq km/yr. If continues at this rate, will be gone in 50-100 years. | | Removal of Amazon forest would have tremendous effects on species diversity, & atmospheric chemistry. Amazon basin host to about 1/2 of world's species; the intensity and complexity of plant/animal interactions and the rapid nutrient cycling in the soils make the region vulnerable to external disturbances. Amazon also an important natural sink for ozone and plays imp role in global tropospheric chemistry. |
| Singh, 1993 | deforested area/yr btwn 1980-90:<br>Africa: 4.1m ha<br>Asia: 3.9m ha<br>Latin America: 7.4m ha<br>Total Tropics: 15.4m ha | Rate of def/yr as % (btwn 1980-90):<br><br>Africa: 0.7%<br>Asia: 1.1%<br>Latin America: 0.7%<br>Total Tropics: 0.8% | |
| Sioli, 1987 | devl. ideas come from non-Amazonian people (from N Amer, Japan, Europe, modern centers of Brazil), from a mentality evolved in temperate climates and under diff geographical, historical and social conditions. The plans are conceived to serve that industrial, commercial civilization, not for the local pop's of Amazonia (Indians, caboclos). | | impacts: impoverished soils, surface erosion, compaction of soils, "sandification", floods, silting of rivers, species loss, aesthetic loss. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Skole & Tucker, 1993 | world tf's: as much as 50% of original extent lost to def in last 20 yrs, primarily as result of ag expansion. | | newest rates estimates, using Landsat.<br><br>Impacts on biological diversity: destruction of habitat, isolation of fragments of formerly contiguous habitat, and edge effects w/in a boundary zone btwn forest and def areas. Boundary zone extends into remaining forest; in the zone there are greater exposure to winds, dramatic micrometerological differences over short distances, easier access for livestock, other nonforest animals and hunters. Result: net loss of plant and animal species. |
| Stowe, 1987 | settlers from non-forested areas responsible for about 35% of forest clearance in Latin Amer. (then start practicing shifting ag). Many landless poor would move on their own in areas of overpop and dense forests, like Brazil & Indonesia, but gov't policies accelerate migrations. | endnote: the World Bank has committed $434 million to Brazil for the Northwest Region Integrated Development Program (Polonoroeste), a project which involves the resettlement of hundreds of thousands of people to a large forested area whose soil cannot sustain continous cultivation." | US foreign policy: US timber companies in SE Asia after WWII, but since have left for economic reasons. Says it's a shame they did leave, since US timber company practices were more sustainable than what is being done to the land they left behind (clearcutting). |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Trapasso, 1992 | says Brazil's env legislation (various enacted 1965-88) virtually impossible to enforce, as Amazon (at 5m sq km) is subject to attack from almost any direction for almost any purpose. Forestry dep't has 600 wardens to patrol the Amazon, such an area requires 15-20,000 wardens to do it properly. Says unbridled pop growth, runaway inflation, a series of corrupt gov't administrations driven by greed, and an increasing accessibility to the rf all contribute to its def. | President Fernando Collor de Mello committed to: debt for nature swaps, ban on export of unsawn logs, enforcement of env laws, a domestic natural resources tax to be paid by mining/other companies for use of nonrenewable resources, env impact studies, and policing of Amazon in dry season to prevent burnings by farmers. | says symposia have been hosted by Brazilian organizations to resolve Amazon problems, INPE active in monitoring def rates/extent, INPA does sci research on species and ecosystem loss from def., IGBE collects, updates mapes, IBAMA tries to control fires and illegal activities in forests. |
| Uhl, et al., 1989 | anthropogenic disturbances range from small-scale clearings (slash/burn ag ever since people entered Amazon thousands of years ago) to huge (1-100sq km) disturbances, as for pasture. Human disturbances are abrupt. In past, species could adapt to slow changes brought by climate/natural changes (treefalls, fires, floods). 2nd difference is that human disturbances have long duration relative to natural distur., so nutrient loss and erosion occurs. | | human disturbances will incr. likelihood of fire in Amazonia:<br>1. human activity usually involves fire, so potential for forest fires incr.<br>2. forest cutting leaves debris on ground, so incr. amount of readily combustible material.<br>3. opening of forest canopy incr amount of solar radiation reaching floor and decr rel humidity, allows branches, other debris to dry to point where they ignite easily.<br>4. at basin-wide level, def changes overall climatic patternsn, decr evapotranspiration, total precip, and rel humidity--thereby incr likelihood of fires. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| UNFAO, 1993 | forest inventory data: says there is a wide variation among regions w/respect to completeness/quality of info w/Asia & Pacific better than Latin Amer & Caribbean which is better than African region. Data is about 10 yrs old on average. Many countries have carried out own assessments, have not used appropriate techniques. | world's tfs: average annual def 1980-90 was 15.4 million ha. (0.8% compound annual rate of def). Annual loss of forest cover by region: Latin Amer & Caribbean 7.4 million ha (0.8%), Asia & Pacific 3.9 million ha (1.2%), Africa 4.1 million ha (0.7%). | forests: ecosystems w/minimum of 10% crown cover of trees and/or bamboos, generally associated w/wild flora, fauna and natural soil conditions, and not subject to agric practices.<br><br>deforestation: change of land use w/depletion of tree crown cover to less than 10%. Changes w/in the forest class (from closed to open forest), which negatively affect the stand or site and lower the production capacity, are termed forest degradation. Degradation is not reflected in the estimates. |
| Waters, 1989 | 1985-89, >6 million acres of forest, the size of Vermont, have been razed in Rondonia for subsistence ag. Setzer of INPE found that 20 million acres of virgin rf are burned each year in Brazil's Amazon. State of Acre still has 95% of its original forest cover (but lies just west of Rondonia & may soon be linked by road to the Pacific). | | |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Worcman, 1990 | Pres. Collor considers env a priority on national agenda. Believes if Brazil does not face its env problems, it will have trouble getting external loans to implement new econ devl projects. $ for env programs easy to borrow, he says. | Brazil's rapid growth (average of 7% per year during the 1970s) has contributed to the country's serious env problems: lg construction projects have wreaked havoc in the rf and added to Brazil's huge foreign debt. Balbina dam project in state of Amazonas flooded 900 sq mi of rf; Tucurui dam project in Para flooded 940 sq mi; Polonoroeste colonization project, involving construction of BR-364, was main cause of devastation in Rondonia. | 1965 code requiring logging companies to replant enough trees to match consumption was ignored until recently, when IBAMA (as part of Our Nature) enforced it.<br><br>IBAMA has 600 employees and 5 helicopters to patrol entire Amazon area, which covers 57% of Brazil's territory. Fines imposed for unauthorized burning in the Amazon have brought death threats to the officials. 2 IBAMA rangers were murdered in 1989. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Worcman, 1990 (continued) | satellite data from INPE show that the rate of def btwn Jan '89 to July '90 equaled the average rate of def during the 1980s, about 9250 sq mi/yr.<br><br>5% of Brazil's Atlantic rf remains. | IBAMA (Brazilian Institute of the Env and Renewable Natural Resources) established in Feb '89 as part of Pres. Sarney's Our Nature Program. IBAMA integrated duties of SEMA, the fishery, rubbery, forestry devl institutions.<br><br>Indians have suffered most from env damage to rfs. Population estimated at 1-5 million in year 1500, now about 220,000. In 1989, 50,000 gold miners invaded Yanomami land in northern Amazon, destroying the land and bringing disease/death to the tribe. Pres Sarney signed a decree opening 5% of Indian land to the miners. Pres Collor later reversed Sarney's decision and started an operation to destroy the 110 airstrips that were the miners' access to the rf. | large landowners declared on tv that they would destroy IBAMA's helicopters. Many lg landowners hire gunmen, have their own idea of justice, are not intimidated by police. Amnesty Int'l says since 1980 more than 1000 peasant smallholders have been killed over land disputes in rural areas; the cases are mostly unsolved. Brazil in need of agrarian reform. 1984 Amnesty Int'l data: small farms of 250 acres or less account for 1/2 the number of rural properties, but cover only 3% of the occupied land. Estates of >2500 acres make up less than 1% of the number of rural properties but occupy 43% of the land. |

# Rates and Processes of Amazon Deforestation

## *Processes and Policies*

| Source | Causes | Policies | Comments/Impacts |
|---|---|---|---|
| Wood, 1990 | Since WWII, shift in def from temperate to tropical regions. Millions of ha of cf cleared for other uses. Several interlocking socio- economic and political factors: inequitable land distribution, entrenched rural poverty, rapidly growing populations which push landless peasants onto forest lands that contain infertile soils; gov't subsidized expansion into forests by plantations growing export crops, timber companies, cattle ranches; gov't sponsored pop relocation to frontier regions. | area estimated to be def/yr in Brazil is 8m ha (uses Repetto, '90 as source). Most int'l attention focuses on Brazil. Brazil has largest area def each year, but its rate (2.2%/yr) is lower than many other countries (Ivory Coast has rate of 11.4%).<br><br>ecopolitical hierarchy: trop def is perceived differently by policy makers at different political levels. Locally, def affects shifting cultivators and growing # of rural peasants. The same problem, multiplied over thousands of locations and combined w/extensive logging, exacerbates the global issue of accelerated buildup of carbon dioxide. | ecopolitical layers: (insert hierarchy here): local, national, multilateral relations, global issues.<br><br>Fundamental obstacle facing scientists is that most policy makers demand clearcut problems and pragmatic policy options (or at least the appearance of progress to appease constituents); scientists often work against a background of debated theories, often incomplete data, rarely results in quick, unambiguous solutions. Social scientists need to better understand and explain to policy makers the forces that accelerate deforestation. |
| Woodwell, 1991 | amount of carbon held in forests is about 2x the amount in the atmosphere. Def releases in a short time the carbon in trees and soils that has accumulated over decades or centuries.<br><br>Brazil is engaged officially in plundering the Amazon for timber, minerals, fish, and land. US not a good example as it continues to destroy Alaska's Tongass Nat'l Forest. | accurate data on rates of def are difficult to obtain for political reasons. Objective appraisals await repeated applications of satellite imagery. The driving force of def is often politics feeding greed. | losses of species and losses of soil fertility are irreversible; they are also unnecessary. The losses are a large step toward guaranteeing poverty for years to come for the nations involved. To ameliorate warming of the earth, def must cease globally; old-growth stands must be protected, and shift to expanding the area in forests. These changes require political advances rather than technical or scientific insights. |

# Rates and Processes of Amazon Deforestation

## *Process and Policy Chart Sources*

Michael H. Glantz, Amara Tandy Brook and Patricia Parisi 17 July 1997
*Environmental and Societal Impacts Group/National Center for Atmospheric Research*, Boulder, Colorado, USA*
**National Center for Atmospheric Research is sponsored by the National Science Foundation*

Aldous, Peter. 1993. "Tropical Deforestation: Not Just a Problem in Amazonia." *Science.* Vol. 259. March 5. p.1390.

Allem, Antonio C. 1991. "Pleas, Plights and Environment: Part II." *The Environmentalist.* Vol. 11, No. 2, pp. 131-143.

Allen, Julia C. and Douglas F. Barnes. 1985. "The Causes of Deforestation in Developing Countries." *Annals of the Association of American Geographers.* Vol. 75. No. 2. pp. 163-184.

Barbier, Edward B., Joanne C. Burgess, Anil Markandya. 1991. "The Economics of Tropical Deforestation." *Ambio.* Vol. 20, No. 2. April. pp. 55-58.

Binswanger, Hans P. 1991. "Brazilian Policies that Encourage Deforestation in the Amazon." *World Development.* Vol. 19, No.7. pp. 821-829.

Bird, Chris. 1991. "Medicines from the rainforest." *New Scientist.* August 17. pp. 34-39.

Booth, William. 1989. "Monitoring the Fate of the Forests from Space." *Science.* Vol. 243, March 17. pp. 1428-1429.

Braga, Carlos Alberto Primo. 1992. "Tropical Forests and Trade Policy: The Cases of Indonesia and Brazil." *World Bank Discussion Papers.* Vol. 159. pp. 173-196..

Bundestag. 1991. *Protecting the Tropical Forests.* German Equente Commisssion Report.

Bunyard, Peter. 1987. "The Significance of the Amazon Basin for Global Climatic Equilibrium." *The Ecologist.* Vol. 17, No. 4/5. pp. 139-141.

Buschbacher, Robert J. 1986. "Tropical Deforestation and Pasture Development." *BioScience.* Vol. 36, No.1. January. pp. 22-28.

Connor, J.D. 1992. "Ungreen Machine: Brazil's Environmental Fakery." *The New Republic.* Vol. 24, July 13 & 20. pp. 24-26.

**Rates and Processes of Amazon Deforestation**
***Process and Policy Chart Sources***


Editors. 1987. "Tropical Forests: A Plan for Action." *The Ecologist.* Vol. 17, No. 4/5. pp.129-133.

Editors. 1988. "Ecologists make friends with economists." *The Economist.* October 15. pp.25-28.

Editors. 1989. "A treasure trove in the trees." *The Economist.* Vol. 312, September 2. pp.S10-12.

Editors. 1991. "Deforestation Slows." *Science.* March 22. p. 1425.

Fearnside, Philip M. 1989a. "Deforestation in Brazilian Amazonia: The Rates and Causes of Forest Destruction." *The Ecologist.* Vol. 19, No. 6. Nov/Dec. pp. 214-218.

Fearnside, Philip M. 1989b. "Deforestation and Agricultural Development in Brazilian Amazonia." *Interciencia.* Vol. 14, No. 6. Nov/Dec. pp. 291-297.

Fearnside, Philip M. 1989c. "A Prescription for Slowing Deforestation in Amazonia." *Environment.* Vol. 31, No. 4. May. pp. 16-20, 39-40.

Fearnside, Philip M. 1986. "Spatial Concentration of Deforestation in the Brazilian Amazon." *Ambio.* Vol. 15, No. 2. pp. 74-81.

Filho, Joao Meirelles. 1985. "The Perils of Deforestation." *World Press Review.* May. p.33.

Hecht, Susanna. 1990. "What's Really Killing the Rainforests?" *The Animals' Agenda.* April. pp. 32-33.

Hecht, Susanna. 1989. "The Sacred Cow in the Green Hell: Livestock and Forest Conversion in the Brazilian Amazon." *The Ecologist.* Vol. 19, No. 6. Nov/Dec. pp.229-234.

Hildyard, Nicholas. 1989. "Amazonia: The Future in the Balance." *The Ecologist.* Vol. 19, No.6. Nov/Dec. pp. 207-210.

Houghton, Richard A. 1990. "The global effects of tropical deforestation." *Environmental Science & Technology.* Vol. 24, No. 4. pp. 414-422.

Houghton, Richard A. 1991. "Tropical Deforestation and Atmospheric Carbon Dioxide." *Climatic Change.* Vol. 19. pp. 99-118.

**Rates and Processes of Amazon Deforestation**
***Process and Policy Chart Sources***


Jackson, Peter. 1983. "The Tragedy of our Tropical Rainforests." *Ambio.* Vol. 12, No. 5. pp. 252-254.

Kiracofe, Bruce E. 1989. "Development Planning and Monitoring with a Land Information System: A Proposed Case Study in the Brazilian Amazon." Papers and Proceedings of Applied Geography Conferences. Vol. 12. pp. 152-158.

Leopoldo, Paulo. 1989. "Deforestation in the Amazon Region." *Interciencia.* Vol. 14, No.6. Nov/Dec 1989. p. 283.

LeTacon, Francois, and John Laker Harley. 1990. "Deforestation in the Tropics and Proposals to Arrest It." *Ambio.* Vol. 19, No. 8. Dec. pp. 372-378.

Lewis, Scott. 1990. *The Rainforest Book.* Natural Resources Defense Council, Living Planet Press: Los Angeles.

Lugo, Ariel E. 1988. "The Future of the Forest." *Environment.* Vol. 30, No. 7. September. p. 17.

Lutzenberger, Jose A. 1987. "Who is Destroying the Amazon Rainforest?" *The Ecologist.* Vol. 17, No. 4/5. pp. 155-160.

Mahar, Dennis J. 1989. *Government Policies and Deforestation in Brazil's Amazon Region.* World Bank Publication.

Malingreau, Jean-Paul and Compton J. Tucker. 1988. "Large-Scale Deforestation in the Southeastern Amazon Basin of Brazil." *Ambio.* Vol. 17, No. 1. pp. 49-55.

Manchete. Dec 1989. graphs/maps.

McCloskey, Michael and Heather Spalding. 1989. "Measuring the Destruction of Tropical Rainforests." Draft report, Sierra Club: Washington, DC, June 30.

Millikan, Brent H. 1992. "Tropical Deforestation, Land Degradation, and Society." *Latin American Perspectives.* Issue 72, Vol. 19, No. 1. Winter. pp. 45-72.

Molion, Luiz Carlos B. 1989. "The Amazonian Forests and Climatic Stability." *The Ecologist.* Vol. 19, No. 6. Nov/Dec. pp. 211-213.

Monastersky, Richard. 1993. "The Deforestation Debate: Estimates vary widely over the extent of forest loss." *Science News.* Vol. 144. p.26-27.

**Rates and Processes of Amazon Deforestation**
***Process and Policy Chart Sources***


Myers, Norman. 1988. "Tropical Deforestation and Climatic Change." *Environmental Conservation*. Vol. 15, No. 4. Winter. pp. 293-298.

Myers, Norman. 1991. "Tropical Forests: Present Status and Future Outlook." *Climatic Change*. Vol. 19. pp. 3-32.

Nazmi, Nader. 1991. "Deforestation and Economic Growth in Brazil: Lessons from Conventional Economics." *Centennial Review*. Vol. 35, No. 2. Spring. pp. 315-322.

Nepstad, Daniel C., Christopher Uhl and Emanuel A.S. Serrao. 1991. "Recuperation of a Degraded Amazonian Landscape: Forest Recovery and Agricultural Restoration." *Ambio*. Vol. 20, No. 6. September. pp. 248-255.

Neto, Ricardo Bonalume. 1989. "Disputes about destruction." *Nature*. Vol. 338, April 13. p. 531.

Pearce, Fred. 1992. "First aid for the Amazon." *New Scientist*. March 28. pp. 43-46.

Posey, Darrell A. 1989. "Alternatives to Forest Destruction: Lessons from the Mebengokre Indians." *The Ecologist*. Vol. 19, No. 6. Nov/Dec. pp. 241-244.

Rainforest Action Network Factsheet 15. 1991. Rainforest Action Network: San Francisco, California.

Repetto, Robert. 1990. "Deforestation in the Tropics." *Scientific American*. Vol. 262, No.4. April. pp. 36-42.

Salati, E., et al. 1991. "Forests: Their Role in Global Change, with Special Reference to the Brazilian Amazon." in *Climate Change*. Proceedings of 2nd World Climate Conference, Geneva, 1990. Edited by Jager, J., and Ferguson, HL. Cambridge University Press. pp. 391-395.

Salati, Eneas and Peter B. Vose. 1983. "Depletion of Tropical Rainforests." *Ambio*. Vol.12, No. 2. pp. 67-71.

Shukla, J., C. Nobre and P. Sellers. 1990. "Amazon Deforestation and Climate Change." *Science*. Vol. 247, March 16. pp. 1322-1325.

Singh, KD. 1993. "Global Forest Resource Assessments." *Tiger Eye Newslette*. No. 5, Spring. p. 4.

**Rates and Processes of Amazon Deforestation**
***Process and Policy Chart Sources***


Sioli, Harald. 1987. "The Effects of Deforestation in Amazonia." *The Ecologist.* Vol. 17, No. 4/5. pp. 134-138.

Skole, David and Compton Tucker. 1993. "Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988." *Science.* Vol. 260. June 25. pp.1905-1910.

Stowe, Robert C. 1987. "United States Foreign Policy and the Conservation of Natural Resources: The Case of Tropical Deforestation." *Natural Resources Journal.* Vol.27, No. 1. pp. 55-101.

Trapasso, L. Michael. 1992. "Deforestation of the Amazon: A Brazilian Perspective." *GeoJournal.* Vol. 26, No. 3. March. pp. 311-322.

Uhl, Christopher, et al. 1989. "Disturbance and Regeneration in Amazonia: Lessons for Sustainable Land-Use." *The Ecologist.* Vol. 19, No. 6. Nov/Dec. pp. 235-240.

UNFAO. 1993. "Summary of the Final Report of the Forest Resources Assessment 1990 for the Tropical World." UNFAO Eleventh Session of the Committee on Forestry, March 8-12. Rome, Italy.

Waters, Tom. 1989. "Fall of the Rainforest." *Discover.* January. p. 40.

Worcman, Nira Broner. 1990. "Brazil's Thriving Environmental Movement." *Technology Review.* October. pp. 43-51.

Wood, William B. 1990. "Tropical Deforestation: Balancing regional development demands and global environmental concerns." *Global Environmental Change.* Dec. pp. 23-41.

Woodwell, George M. 1991. "Forests in a Warming World: A Time for New Policies." *Climatic Change.* Vol. 19. pp. 245-251.