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THE QUALITY OF URBAN ENVIRONMENTS IN THE BRAZILIAN AMAZON

(Accepted January 11, 1999)

ABSTRACT. In the Brazilian Amazon during the 1980s, urban population growth outstripped rural growth, and by 1991, most of the region's population resided in urban areas. Much of this urban growth involved establishment of unplanned housing with inadequate infrastructure, which resulted in rising pollution. This paper compares indicators of environmental quality in urban populations of the Amazon in 1980 and 1991, and among different kinds of urban populations in 1991. The results show that environmental quality in the region deteriorated during the 1980s as the production of and exposure to environmental hazards rose while resources to ward off hazards eroded. The findings also show that environmental quality was particularly poor in more rapidly growing urban centers. The urban Amazon may not afford an adequate standard of living and this may generate out-migration from the region.

KEY WORDS: Brazil, Amazon, urbanization, population, environmental quality

INTRODUCTION

The Amazon region of Brazil is by now well-known for land cover changes. A large body of research documents numerous negative ecological and human consequences of land cover conversion. However, deforestation is not the only question of importance concerning changes in environmental quality in the Amazon. By the early 1990s, most of the region's population lived in urban rather than rural areas. This was because urban population growth proceeded rapidly during the 1980s, due to a 'rural exodus' within the Amazon and to 'urban frontier' migration from outside the region. Urban growth in the Amazon largely involves the concentration of landless and underemployed populations in new frontier towns or in the peripheries of established centers. In many cases, new settlements are unplanned, so they lack adequate sanitation infrastructure, leading to pollution. The rapid growth, concentra-

Social Indicators Research **49:** 181–212, 2000.

tion of population and pollution deteriorate urban environments and undermine the quality of life for urban households. It is likely that urban environmental quality in the Amazon deteriorated during the 1980s. Moreover, it is possible that environmental quality by the early 1990s was poorer in urban areas showing the most rapid recent growth. If these trends hold in fact, they constitute cause for worry about the quality of life in the Amazon, a frontier once dubbed a ‘promised land.’ However, little research has focused on the quality of urban environments in the Amazon.

The purpose of this paper is to call attention to environmental issues of the ‘urban frontier’ in the Amazon region, which many suppose to be a largely rural area where deforestation is the major problem. This study considers three dimensions of urban environmental quality: the production of environmental hazards, through industrial, sewage and waste pollution; the degree of protection from such hazards, through high quality housing construction and amenities; and the capacity to defend against environmental hazards, as indicated by household income and access to health care. Using census data and municipal health services statistics, I present a battery of indicators for each dimension of urban environmental quality. The analysis compares the indicators for 1980 and 1991, a period of rapid urbanization, and then focuses on environmental quality in different kinds of urban areas of the Amazon in 1991. Specifically, I compare urban populations of old and new municipalities, distinct regions within the Amazon, and different sizes. Two general findings emerge. First, during the 1980s, the scale if not also the prevalence of production of and exposure to environmental hazards rose at the same time as resources against such hazards eroded. Second, by 1991, urban environmental quality in the Amazon was poor, but varied among different kinds of urban centers, and was especially precarious in newer and smaller urban areas, and in the frontier. These findings could imply that the quality of life in the ‘urban frontier’ may continue to deteriorate and, like the rural frontier before it, generate out-migration, this time from the Amazon altogether.

URBAN GROWTH AND ENVIRONMENTAL QUALITY IN THE BRAZILIAN AMAZON

The Legal Amazon, a state planning region that subsumes the watershed, covers approximately 5 million square kilometers, or nearly 60% of Brazilian territory.[1] In 1980, the population of the Legal Amazon was 11.2 million, of which 5.1 million, or about 45% lived in urban areas (IBGE, 1982).[2] Between 1980 and 1991, rural population in the Amazon grew by 1.4% per year, while urban population grew more than three times as fast, at 5.4% per year. By 1991, the population of the region had grown to 16.3 million, of which 9.2 million, or about 56% lived in urban areas (IBGE, 1996). Thus, during the 1980s, the region shifted from a predominantly rural to a largely urban population.

Existing literature focuses on migration when accounting for urbanization in the Amazon. Some work discusses the 'rural exodus' of population pushed out of the closing agricultural frontier within the region. Some farmers left frontier areas because of poor crop yields, which led to foreclosure on rural properties (Henriques, 1988; Moran, 1984; Ozorio de Almeida, 1992; Smith, 1982; Wood and Schmink, 1979), while others moved due to land speculation, which fostered rural population turnover (Martine, 1982), and still others migrated because of threats and violence perpetrated by ranchers and mining firms seeking to expand their landholdings (Branford and Glock, 1985; Schmink and Wood, 1992). These constraints produced an exodus of small farmers, a relatively unskilled workforce, many of whom moved to nearby towns seeking jobs (Browder and Godfrey, 1997; Mougeot and Aragón, 1983). Other research points to eminently urban changes occurring within the Amazon that fostered an 'urban frontier' by attracting population from the rural frontier or from outside the region to growing urban areas. During the 1970s, state planning focused investment in the Amazon on urban areas as 'growth poles' (Becker, 1995), but during the 1980s, Brazil's debt crisis forced reductions in state spending, which allowed for spontaneous rather than planned urban growth. Public and private enterprises established enclaves of industrial operations with 'company towns' (Browder and Godfrey, 1997, ch. 3; Hébette, 1991; Sawyer, 1987), complemented by 'sister cities' of unemployed migrants seeking work (Roberts, 1991). In addition, gold strikes occurred in several places at a time of high gold prices and rural land conflicts (Schmink and Wood, 1992, ch. 8), attracting large populations to mining sites, which often grew into new urban areas (Cleary, 1990; MacMillan, 1995).

Urban growth in the Amazon largely proceeds by expansion of unplanned settlements. Urban areas with growing economies accumulate population through the accretion of new housing built by the latest additions to the local labor force. In pre-existing urban centers, new settlements appear in peripheral areas, often along key transportation arteries or near industrial parks (Browder and Godfrey, 1997, ch. 5; Mitschein et al., 1989). In new frontier towns, new settlements may consist almost entirely of improvised housing (Browder and Godfrey, 1997, chs. 6–7; Roberts, 1991, ch. 5). In either case, urban growth often proceeds through construction of poor quality housing and without the extension of adequate sanitation or other infrastructure. The sudden and haphazard nature of urban growth in the Amazon in turn bears important implications for the quality of urban environments in that region.

Rapid urban population growth in the Amazon generates environmental problems that differ from those of rural areas. In rural areas, maintenance of good environmental quality largely involves land management to secure productivity and avoid soil degradation. Rural environmental quality is thus a question of sustaining livelihoods through extractivism or agricultural production. Urban environmental quality raises many other issues. Urbanization involves the concentration of large populations in dense agglomerations, in close proximity with many sources of pollution. The limited literature that exists on urban environmental quality points to a common handful of consequent problems.

First, there is the question of the production of urban air and water pollution, whether by industrial activities or residential sewage and waste. In the eastern Amazon, charcoal production for fuel in iron smelters is an important industrial activity (e.g., Monteiro, 1995). However, most literature on environmental quality in the urban Amazon focuses on the potential for water pollution due the lack of piping and treatment of sewage (Ribeiro, 1994). The proliferation of unplanned settlements implies that many neighborhoods emerge without sanitation facilities, so sewage and trash are released into the environment, causing ecological damage and creating health hazards for human populations. In Belém, the largest city in the Amazon, only 14% of households had sewage lines in 1980, while 47% used sewage pits in outhouses (Santos et al., 1992: 55–56). In Manaus, the second-largest city in the region, 21% of households had sewage lines in 1984 (Melo and Moura, 1990: 443). These cities probably constituted the highest such percentages in the Amazon at the time. In smaller urban centers, land invasions and unplanned settlements are more predominant (Roberts, 1992). As a result, in smaller urban areas it is more common to have untreated sewage near households (Browder and Godfrey, 1997: 188, 236). Two other issues concerning production of pollution deserve mention: trash disposal and use of wood for cooking. Where trash collection is not available, solid waste is either burned (emitting air pollutants), buried (presenting an environmental hazard to the neighborhood), or thrown in rivers (polluting potential water sources). In addition, use of wood for cooking in urban areas can contribute to air pollution.

Second, all literature on environmental quality in the Amazon focuses on the quality of housing as a means of protection against pollution, weather and diseases (Sawyer, 1993; Santos et al., 1992; Ribeiro, 1994; Melo and Moura, 1990, ch. 8). The proliferation of unplanned settlements often results in housing of haphazard construction, whether due to limited resources among the families involved or contestation over land claims that may encourage structures that can be built rapidly rather than solidly. Consequently, housing construction often affords limited protection from pollution, weather and communicable diseases. In addition, poor housing often has poor water sources and limited access to amenities. Piped drinking water is often unavailable in unplanned settlements, and may be contaminated by wastes from the same or neighboring housing. In Belém in 1990, 80% of households had piped water (Santos et al., 1992: 44); in Manaus in 1984, this figure was 95% (Melo and Moura, 1990: 443). In frontier towns, the percentage of households with piped water ranges from 23% (Roberts, 1991: 205) to 55% (Browder and Godfrey, 1997: 188). Further, electricity and amenities are often limited in urban housing in the Amazon. While electrification is nearly universal in Manaus (Melo and Moura, 1990: 443), in frontier towns it is often limited (Browder and Godfrey, 1997: 188, 236) or available only through clandestine means (Roberts, 1991: 205). In particular, refrigerators are limited but important to preserve food that may otherwise become contaminated. Protection from pollutants, weather and disease is particularly important to young children, who are especially susceptible to communicable diseases, among the leading causes of death to people under five years of age (Wood and Lovell, 1990).

Third, a substantial portion of the urbanization literature on the Amazon focuses on problems of underemployment and poverty. In urban areas of the Amazon, both are common, and they undermine the capacity of households to marshal resources to remove hazards or treat diseases (Alexandre and Caillaux, 1995). Existing work suggests that many urban jobs are informal, rarely offering injury or unemployment benefits (Becker, 1995; Cleary, 1993; Godfrey, 1990; MacMillan, 1995; Martine and Turchi, 1988; Roberts, 1991; Sawyer, 1987). Further, it is well-known that wages, while not the lowest in Brazil, often fall below the minimum wage established by the government (Butts and Bogue, 1989; IBGE, 1995). Finally, some have voiced concerns about the limited availability of health services in urban areas of the Amazon (Yarzabal et al., 1992).

From this discussion emerge three dimensions of urban environmental quality that are pertinent in the case of the Amazon: the production of environmental hazards, whether by industrial or residential pollution of air or water; exposure to pollution, weather and diseases via poor housing quality and limited utilities and amenities; and availability of resources to fend off diseases and environmental contamination, whether through income, social security or health care. With indicators of each of these dimensions, we can assess environmental quality among urban populations in the Brazilian Amazon.

MEASUREMENT OF ENVIRONMENTAL QUALITY IN THE BRAZILIAN AMAZON

The Amazon is a developing region in many ways, including the quality of available statistics. Registration of vital statistics is limited, and few indicators are available in much geographic detail for an annual series of measures. Perhaps the best data sources on urban environmental quality in the Brazilian Amazon are the 1980 and 1991 Demographic Censuses. Sample data from these censuses allow for special tabulations of many urban environmental indicators. The 1980 data come from a 25% sample of households enumerated in Brazil, and the 1991 data come from a 10% sample of households in municipalities with 15,000+ population, and 20% samples from municipalities with under 15,000 population. The data include a large set of comparable variables from which we can derive indicators of urban environmental quality at two points in time for the entire Amazon region. In the data I identified households and populations in urban areas of the Brazilian Legal Amazon, and tabulated the number of people or households with specific characteristics for each municipality in the region. I chose the municipality as the unit of analysis because most have a single or highly predominant urban center. I consulted existing literature on urban environmental indicators, both for Brazil and elsewhere, and where possible chose measures used by others (OECD, 1997; IBGE, 1995; Ribeiro, 1995; Santos et al., 1990). Taking existing work as a guide, I developed a group of indicators for each of the three dimensions of environmental quality outlined above.

Indicators of Production of Environmental Hazards

Six concepts allow for an assessment of the production of environmental hazards in urban areas of the Amazon. These concepts include urban population size, migration, industrial activity, sewage, waste disposal and cooking fuel. Except where otherwise noted, indicators are available in comparable form from both the 1980 and 1991 census data. ‘Population size’ refers to two indicators: urban population, the resident population in the administrative seat of a municipality, which gauges the absolute scale of a given urban area; and the percent urban, the urban population as a percentage of the total municipal population, which gauges the scale of urban relative to rural populations. By ‘migration’ I mean the non-natives who arrived in an urban area since the date of the previous census, as a percentage of the urban population. The percentage of the population who are migrants measures the extent of recent urban settlement. ‘Industrial activity’ is the economically active population (EAP) in transformative industries, ranging from metallurgy to construction, as a percentage of the overall urban EAP, defined as the remunerated population ages 15 to 65. Percent EAP in transformative industries is a proxy measure for production of industrial pollution. ‘Sewage’ refers to the percentage of urban housing units in one of four categories: units with city sewage lines, septic tanks, pits (in outhouses), or no sewage. The distribution of housing units among these categories gauges the extent of sewage released into the urban environment. ‘Waste disposal’ is the percentage of urban housing units in one of four groups: units with city trash collection, those who dispose of waste by burning, burial, or throwing it in bodies of water, largely rivers. Waste disposal indicators show the degree to which urban households can remove trash from outside their residences. Finally, ‘cooking fuel’ concerns the choice of fuel: relatively clean-burning gas or more carcinogenic alternatives such as wood. The percentages of units using gas or wood gauge the residential contributions to urban air pollution.

Indicators of Exposure to Environmental Hazards

Given a battery of indicators about the production of environmental hazards, I developed a group of measures of exposure to such hazards. Five concepts are pertinent here: child exposure, housing construction, density of occupancy, water quality, and amenities. By ‘child exposure’ I mean children under age five as a percentage of the total urban population. This gauges the degree to which children are represented in an urban population and subject to urban environmental hazards. ‘Housing construction’ can mean many things, but the variable that is most often used concerns wall construction. This refers to the percentage of housing units in three categories of wall material: brick, wood or mud (which includes improvised materials). Wall construction indicates the degree of protection via the permanence of a structure, where brick is better than wood, which is better than mud. ‘Density of occupancy’ refers to the number of persons per room in a housing unit. It is available only for 1991. Density of occupancy is the percentage of units with <1, 1 to <2, and 2+ people per room, corresponding to low, medium and high densities. Higher densities allow for rapid transmission of communicable diseases and therefore greater exposure to environmental hazards. ‘Water quality’ is the percentage of urban housing units in three categories of water service: city pipe into the household, city pipe outside, or well or other source, including rivers. The distribution of households among these categories indicates the degree of exposure to potentially polluted water. Finally, ‘amenities’ refers to three variables: the percent of urban housing units with electricity, a refrigerator, and a water filter. The first measures the capacity to procure energy for lights and other amenities; the second indicates availability of the means to preserve food from spoilage. The percentage of urban housing units with water filters, available only from the 1991 census, indicates the extent to which households have a means of access to safe water aside from city pipes.

Resources to Defend Against Environmental Hazards

Given the production of and exposure to environmental hazards such as pollution and communicable diseases, a third dimension of environmental quality concerns the resources available to urban households should a member be malnourished, ill or injured. Three concepts occur frequently in existing work on social indicators using Brazilian data: income, social security and access to health care. ‘Income’ here refers to total household income, in terms of minimum salaries (MS), a level of income developed from cost of living indexes in Brazil. The income indicators are the percent of households earning <1 MS, 1 to <5 MS, 5 to <10 MS or 10+ MS.[3] Income indicates the capacity for households to improve housing quality or purchase amenities and health care. By ‘social security’ I mean the percentage of household heads with jobs that enable contributions into state support plans. This is taken as a proxy for job benefits, that is, resources earned in addition to income. ‘Access to health care’ refers to two indicators: medical establishments per 1000 urban population, a proxy for degree of availability, and hospital beds per medical establishment, a proxy for quality of care via capacity for overnight or extended stays. Municipal data on access to health care come from Brazilian health care statistics. Such data are available for 1981 and 1989, which serve for indicators around 1980 and 1991, respectively (IBGE, 1983, 1991).

COMPONENTS OF THE ANALYSIS

The Amazon exhibits rapid urbanization, but urban growth proceeds in different kinds of urban areas. Urban environmental quality has therefore likely altered over time, while varying among distinct types of urban centers. This raises two broad questions about differences in urban environmental quality in the Amazon. First, there is a debate about whether the quality of life has improved or eroded over time. Haller et al. (1996) take issue with a number of other authors and argue that material living standards in the Amazon improved between 1970 and 1980. They present a measure of socioeconomic development, a factor weighted index using per capita measures of access to material goods (refrigerators, televisions and cars), education and electricity, and show a pronounced improvement during the 1970s. Their findings raise questions about changes during the 1980s, particularly in the Amazon's burgeoning urban areas, especially concerning environmental quality. The first part of the analysis therefore compares indicators of urban environmental quality in the Amazon for 1980 and 1991. Using a series of comparisons, we can gauge the ways in which urban environmental quality improved or eroded in the Amazon during a period of rapid urban growth.

A second set of questions concerns differences among urban areas in the region. The Amazon is enormous, and existing literature on urbanization suggests that urban centers may differ substantially from one part of the region to another (Browder and Godfrey, 1997). The second component of the analysis therefore compares urban environmental quality in 1991 in different kinds of urban areas of the Amazon. I draw on the urbanization literature to make three kinds of distinctions. First, we must distinguish between urban areas of differing status, among newly-formed and older, more established urban areas. Among the 1991 urban areas, I do this by distinguishing among the municipalities which had administrative seats in 1980, and municipalities created after 1980. Comparison of pre- and post-1980 municipalities affords a crude differentiation between older, more established urban areas and those which emerged during the 1980s. The Amazon urbanization literature points to poorer environmental quality in the newer towns, many of which exhibited explosive and unplanned growth during the 1980s (Browder and Godfrey, 1997; Ribeiro, 1994; Roberts, 1992; Sawyer, 1993). Second, it is important to recognize that the entire Legal Amazon is not a frontier in the sense of being a region of rapid growth, particularly by migration. Figure 1 shows a regionalization of the Amazon into the remote, frontier and settled subregions. The remote Amazon is a pre-frontier with low population density and slow population growth. The frontier, the subject of most of the urbanization and environmental quality work reviewed here, is the subregion that underwent the most rapid urbanization and urban migration during the 1980s. The settled subregion is a post-frontier, a consolidated area with relatively high population density and slow growth. This regionalization allows only broad distinctions, and neglects differences within each subregion, but it allows a more informed view of geographic differences in Amazonian urbanization than simply speaking of the region as a whole. Given the relatively rapid pace of change in the frontier, we should expect lower urban environmental quality there than in the settled or remote subregions. A third and final distinction is simply between urban populations of differing sizes. A review of the 1991 size distribution of urban areas in the Amazon identified clusters of municipal urban populations that fall in the following five population categories: $<$2,000; 2,000–9,999; 10,000–49,999; 50,000–149,999; and 150,000 and up. The largest category includes state capitals and selected other large urban populations, while the smallest includes settlements that could barely be considered urban. The three smallest categories include most boomtowns in the Amazon, many of which grew from rural areas or villages during the 1980s. Urban environmental quality should in many respects improve as we move toward larger size categories. This is my expectation regarding income and piped water and sanitation. But in other regards, such as crowding and health care access, there may not be a positive relationship. Together, distinctions among municipal urban populations by their age status, subregion and size will afford useful comparisons of urban environmental quality within the Amazon.

These comparisons provide the basis for the third and final component of this study, a series of multiple classification analyses (MCA) where urban age status, subregion and size category all serve as independent variables that help account for differences in

Figure 1. Municpalities and subregions of the Legal Amazon in Brazil, 1991.

urban environmental quality. The MCA allows us to gauge the effect of each predictor on the environmental indicators, adjusted for the effects of the other independent variables.

FINDINGS

Recent Changes in Urban Environmental Quality in the Amazon

Table I presents indicators for the three dimensions of urban environmental quality in 1980 and 1991. First, it shows that production of urban environmental hazards grew during the 1980s. In large part, this worsening was due to growth of urban scale rather than compositional changes. Urban populations in the Amazon nearly doubled in eleven years, growing from 5.1 to 9.2 million. The proportion of migrants in urban populations was unchanged between 1980 and 1991, as was the proportion of the urban EAP in transformative industries. The slow relative change in these two measures hides the rise in the scale of urban growth and industrial activity. Sewage sanitation worsened in the sense that the proportion of households with sewage lines declined. While sewage tank use grew, the relative share of households with inadequate or no sewage remained the same, implying a rise in the absolute amount of untreated sewage in urban areas during the 1980s. Regarding cooking fuel, the relative decline in use of wood in 1991 to one-half the 1980 level was offset by the doubling of the urban population during the same period.

If the production of urban environmental hazards worsened during the 1980s, it becomes critical to know whether exposure to such hazards declined. Table I suggests that environmental quality improved somewhat in this regard. The proportion of urban populations under 5 years of age declined, though the absolute number of young children in urban areas actually grew. However, the percentage of housing units with brick walls rose to over 50%, while those with mud walls declined to only 10%. Water sources also improved, as households receiving water piped inside rose to 50%, while the percentage using wells and other sources declined to 31%. Ownership of amenities improved, with access to electricity rising to nearly 90% of households in 1991. Moreover, by 1991 a majority of households had a refrigerator.

While exposure to environmental hazards appears to have declined overall, their increased production leads us to wonder whether urban households in the Amazon garnered greater resources to defend against hazards. Here the results are not encouraging. The distribution of income generated by households worsened from 1980 to 1991. The percentage of households with less than one MS rose from 17% in 1980 to nearly 26% in 1991, while the percentage earning one or more MS in the other three categories all declined. Moreover, the relative availability of benefits deteriorated, as the percentage of household heads who contributed to social security declined from 47% to 36%. The income and social security findings point to the growth of an urban informal sector in the Amazon, evidence of a shift in the urban economy toward low-paid and temporary or insecure jobs.[4] Access to health care gives little cause for optimism: the number of medical establishments per

TABLE I

Comparable indicators of environmental quality for urban areas, Brazilian Legal Amazon, 1980 and 1991

Indicators	1980	1991
Production of environmental hazards		
Urban population	5,116,740	9,165,653
Percent urban population	45.6	56.0
Percent migrants	24.0	23.6
Percent EAP in transformative industries	13.2	11.1
Sewage: Percent units with city line[1]	8.9	3.9
Percent units with sewage tank	18.8	30.3
Percent units with sewage pit	56.7	54.0
Percent units with No sewage	12.0	11.9
Cooking fuel: Percent units using gas[2]	70.4	83.6
Percent units using wood, other	24.6	13.9
Exposure to hazards		
Percent of urban pop. under 5 years of age	16.0	12.9
Walls: Percent units with brick	41.0	51.2
Percent units with wood	40.1	38.6
Percent units with mud	15.4	10.2
Water: Percent units with city pipe inside	40.9	50.5
Percent units with outside city pipe	18.5	16.4
Percent units with well or other source	38.1	31.3
Amenities: Percent units with electricity	67.2	89.8
Percent units with refrigerator	47.3	64.8
Resources against hazards		
Household income: Pct. households earning <1 MS	17.4	25.6
Percent households earning 1 to <5 MS	56.7	52.6
Percent households earning 5 to <10 MS	13.9	11.8
Percent households earning 10+ MS	9.3	7.6
Percent household heads paying Social Security	46.8	35.9
Health care: Medical estabs. per 1000 urban pop.	0.3	0.4
Hospital beds per medical establishment	17.8	10.5

[1] Percentages for groups of variables may not add to 100.0 due to rounding and loss of cases with missing values.
[2] Approximately 2% of cases for cooking fuel are excluded because they did not have a stove.
Sources: IBGE, Censos Demográficos 1980 e 1991, Microdados das Amostras.

1000 population was somewhat greater in 1991 than in 1980, but the number of beds per establishment dropped by nearly half during the same period.

The Quality of Urban Environments in the Brazilian Amazon, 1991

Given that urban environmental quality worsened in many ways in the Amazon during the 1980s, it is important to know where the problems were the greatest. The remainder of the analysis focuses on urban environmental quality in 1991. Tables II, III and IV compare environmental quality indicators in municipal urban populations by age, subregion and size, respectively.

Urban Environmental Quality in 'Old' and 'New' Urban Areas

Table II compares 'old' urban populations, in municipalities established by 1980, and 'new' urban populations, in municipalities established during the 1980s. The table first notes that nearly 90% of the Amazon's urban population lived in urban areas of older municipalities. However, important differences exist among old and new urban populations. Because new urban populations will become older with time, it is important to know if old urban populations had better environmental quality. The worsening environmental quality in the Amazon raises the question of whether it was due to deterioration of old urban areas, or to the emergence of new ones. A finding that new urban areas had better environmental quality could imply a worsening of old and aging new urban areas over time.

In most regards, this is not the case. In accord with existing literature, old urban populations overall show higher environmental quality, suggesting that deterioration during the 1980s occurred in part due to the emergence of many new urban areas. To begin with, production of environmental hazards appears worse in new centers. The percent migrants is much greater in new urban areas, pointing to the importance of recent arrivals and unplanned housing. Proportionally more housing units had sewage lines or tanks in old areas; over 80% of housing units in new areas had inadequate sewage (i.e., sewage pits or no sewage). Waste disposal also shows important differences. Over 50% of households in old urban areas had their trash collected, while most households in new centers either burned or buried their trash in their neighborhoods. And in relative terms,

TABLE II

Indicators of environmental quality for old and new urban areas, Brazilian Legal Amazon, 1991

Indicators	Old center	New town	Total
Production of environmental hazards			
Percent of urban population	88.8	11.2	100.0
Percent migrants	20.7	45.9	23.6
Percent of EAP in transformative industries	11.0	11.8	11.1
Sewage: Percent housing units with city line	4.3	0.3	3.9
Percent units with sewage tank	32.2	15.4	30.3
Percent units with sewage pit	51.7	72.0	54.0
Percent units with no sewage	11.8	12.3	11.9
Waste disposal: Percent with city collection	53.6	35.1	51.5
Percent units using fire	21.4	33.6	22.8
Percent units using burial	19.4	25.5	20.1
Percent units using rivers	2.4	1.1	2.2
Cooking fuel: Percent units using gas	85.1	71.9	83.6
Percent units using wood, other	12.5	24.6	13.9
Exposure to hazards			
Percent urban pop. under 5 years of age	12.7	14.2	12.9
Walls: Percent units with brick	54.0	29.7	51.2
Percent units with wood	35.9	59.9	38.6
Percent units with mud	10.1	10.3	10.2
Density: Pct. units with <1 person per room	61.7	63.0	61.9
Percent units with 1 to <2 people per room	28.4	29.0	28.5
Percent units with 2+ people per room	9.9	8.0	9.7
Water: Percent units with city pipe inside	54.2	22.4	50.5
Percent units with outside city pipe	16.8	12.6	16.4
Percent units with well or other source	27.3	62.2	31.3
Amenities: Percent units with electricity	91.4	77.1	89.8
Percent units with refrigerator	66.9	48.5	64.8
Percent units with water filter	53.1	60.2	53.9
Resources against hazards			
Household income: Percent earning <1 MS	25.5	26.1	25.6
Percent households earning 1 to <5 MS	52.2	56.3	52.6
Percent households earning 5 to <10 MS	12.1	9.6	11.8
Percent households earning 10+ MS	7.9	5.4	7.6
Percent heads paying social security	37.0	26.8	35.9
Health: Medical estabs. per 1000 urban pop.	0.4	0.7	0.4
Hospital beds per medical establishment	11.5	5.9	10.5

Source: IBGE, Censos Demográfico 1991, Microdados da Amostra.

twice as many households urban areas cooked with wood. Thus, the potential for water and air pollution was considerably higher in new than old urban areas.

In addition, exposure to environmental hazards was worse among populations of new urban areas in the Amazon. While more young children lived in old urban areas, other indicators suggest greater exposure in new areas. Most households in old centers had brick walls, while most in new areas had wood or mud walls. However, density of occupation was comparable in old and new urban populations. But most old households had water piped inside; most new households had to use wells or other sources, including rivers. Further, proportionally more old households had electricity and refrigerators. Importantly, relatively more new households had water filters, which suggests an alternative strategy (to city pipes) of obtaining clean water.

Finally, Table II allows comparison of resources against environmental hazards among old and new urban populations. With regard to income distributions, relatively more households earned under five MS in new urban areas, though the differences are not large. However, more heads in old urban populations made social security contributions, suggesting more prevalent formal work relations than in new urban areas. Indicators for access to health care show greater access in new urban populations, but higher quality in old urban areas. This finding helps explain the improvement in access but decline in quality; the emergence of new urban populations involved the extension of health care of relatively poor quality in the growing urban network. Overall, Table II suggests that in new relative to old urban areas of the Amazon, environmental quality was poor in terms of production, exposure and resources against environmental hazards.

Urban Environmental Quality in the Remote, Frontier and Settled Subregions

Table III presents indicators of urban environmental quality for the remote, frontier and settled subregions of the Amazon in 1991. One key comparison here is between the frontier and settled subregions, as this allows us to gauge, in a tentative fashion, whether consolidation affords higher urban environmental quality after a transitional frontier stage. It is also worth noting if frontier environmental quality is worse than in the remote, pre-frontier Amazon. In general, given the rapid pace of urban growth in the frontier, we should expect poorer environmental quality there than in the other two subregions.

In terms of production of environmental hazards, urban areas of the frontier exceeded the other two subregions. The percentage of migrants in frontier urban areas was approximately twice those of the other subregions, pointing to greater recent settlement. While industries in the frontier apeared no more geared for transformative activities than elsewhere, production of untreated sewage was greatest there. Nearly 75% of households had inadequate or no sewage in the frontier, more than the remote or settled subregions. Further, nearly 50% of households in the frontier burned or buried their trash in their neighborhoods, more than in the other subregions.

To compound the high production of environmental hazards, urban areas of the frontier exhibit relatively little protection from such hazards. In the frontier, approximately 60% of households had wooden or mud walls, compared to only 32% in the settled subregion. While density of occupancy showed few substantial differences among subregions, water sources were largely inadequate in the frontier. Nearly half of urban households in the frontier procured water from wells or rivers, compared to only 18% in the remote area and 25% in the settled subregion. Similarly, use of amenities was lowest in the frontier, with the exception of water filters. Given the high production of and exposure to environmental hazards, one would hope that urban populations in the frontier of the Amazon could procure greater resources against illness. There is some basis to expect this, as the frontier includes many boomtowns.

This is not the case to a great extent. Approximately 25% of urban frontier households earned under one MS, a percentage comparable to that for the Amazon as a whole. Further, proportionally fewer heads of frontier households paid into social security than either the remote or settled subregions. Access to health care in urban areas of the frontier was somewhat better than the regional average, however. Medical establishments were relatively common in the frontier, indicating fairly good access by Amazonian stan-

TABLE III

Indicators of environmental quality for urban areas in the remote, frontier and settled subregions, Brazilian Legal Amazon, 1991

Indicators	Remote	Frontier	Settled	Total
Production of environmental hazards				
Percent of urban population	24.8	33.0	42.1	100.0
Percent migrants	14.2	35.7	19.5	23.6
Percent of EAP in transformative industries	13.3	11.1	9.9	11.1
Sewage: Percent housing units with city line	2.3	1.5	6.6	3.9
Percent units with sewage tank	31.9	26.2	32.7	30.3
Percent units with sewage pit	56.1	60.8	47.4	54.0
Percent units with no sewage	9.6	11.6	13.3	11.9
Waste disposal: Percent with city collection	56.3	48.0	51.7	51.5
Percent units using fire	22.2	25.3	21.1	22.8
Percent units using burial	13.2	22.8	21.7	20.1
Percent units using rivers	4.8	1.0	1.8	2.2
Cooking fuel: Percent units using gas	87.4	81.1	83.6	83.6
Percent units using wood, other	9.3	16.3	14.4	13.9
Exposure to hazards				
Percent urban pop. under 5 years of age	13.6	13.6	11.9	12.9
Walls: Percent units with brick	36.9	40.1	67.9	51.2
Percent units with wood	58.4	52.2	17.2	38.6
Percent units with mud	4.7	7.7	14.9	10.2
Density: Pct. units with <1 person per room	51.5	65.8	64.3	61.9
Percent units with 1 to <2 people per room	32.4	27.3	27.3	28.5
Percent units with 2+ people per room	16.2	6.9	8.4	9.7
Water: Percent units with city pipe inside	62.1	36.3	55.7	50.5
Percent units with outside city pipe	18.0	13.6	17.7	16.4
Percent units with well or other source	17.5	48.3	25.1	31.3
Amenities: Percent units with electricity	91.6	86.7	91.2	89.8
Percent with refrigerator	70.1	61.9	64.2	64.8
Percent with water filter	41.7	58.8	56.6	53.9
Resources against hazards				
Household income: Percent earning <1 MS	19.1	25.8	28.9	25.6
Percent households earning 1 to <5 MS	52.5	55.6	50.4	52.6
Percent households earning 5 to <10 MS	15.6	10.3	11.1	11.8
Percent households earning 10+ MS	9.8	6.0	7.7	7.6
Percent heads paying social security	40.5	32.0	36.5	35.9
Health: Medical estabs. per 1000 urban pop.	0.4	0.5	0.4	0.5
Hospital beds per medical establishment	5.8	9.7	14.5	8.1

Source: IBGE, Censos Demográfico 1991, Microdados da Amostra.

dards, and there were more beds per establishment in the frontier. Overall, Table III shows that production of and exposure to urban environmental hazards were greatest in the frontier of the Amazon, and moderated to a minor extent by household resources and health care.

Urban Environmental Quality in Urban Populations of Different Sizes

The third and final distinction I make here among urban populations of the Amazon concerns their sizes. Table IV compares indicators of environmental quality among the five size categories of urban populations described previously. Because the large number of categories hinders intepretations from direct comparisons, I focus on gradients in differences, running from the smallest to largest category, rather than specific comparisons.

The indicators of production of environmental hazards suggest that urban populations of different sizes face different hazards. Rapid growth due to in-migration predominated in mid-sized urban populations (10,000 to 149,999) though differences in percent migrants among size categories are not large. The other ‘production’ variables, however, show clear gradients, where different hazards are greatest in either large or small urban populations. For example, transformative industrial activity was greater in larger size categories, implying the possibility of greater industrial pollution than in small urban populations. However, sewage sanitation by city lines and septic tanks were also most prevalent in larger urban populations. In the three smallest size categories, the percentage of households with inadequate or no sewage ranged from 79% and up. A similar gradient appears for waste disposal: the percentage of households with city trash collection rises as we move toward larger size categories. In the three smallest size categories, over 50% of households burned or buried their trash. The same kind of gradient appears for cooking fuel: nearly all households in large urban populations cooked with relatively clean-burning gas, while more households in smaller populations used wood or other fuels. While production of industrial pollution was worse in larger cities, residential production of hazards, on a per capita basis, appears lower.

TABLE IV

Indicators of environmental quality in urban areas of different sizes, Brazilian Legal Amazon, 1991

Indicators	<2,000	2,000–9,999	10,000–49,999	50,000–149,999	150,000+	Total
Production of environmental hazards						
Percent of urban population	0.9	15.2	31.5	13.1	39.2	100.0
Percent migrants	21.2	24.3	28.1	28.5	18.0	23.6
Percent of EAP in transformative industries	6.2	7.9	11.1	11.1	12.3	11.1
Sewage: Percent housing units with city line	0.0	0.2	0.7	3.3	8.0	3.9
Percent units with sewage tank	7.8	10.8	20.1	30.5	45.9	30.3
Percent units with sewage pit	68.6	71.6	66.7	50.8	38.3	54.0
Percent units with no sewage	23.6	17.3	12.5	15.4	7.9	11.9
Waste: Percent with city collection	13.3	22.7	39.0	50.7	73.0	51.5
Percent units using fire	41.5	39.0	29.0	24.3	10.9	22.8
Percent units using burial	32.5	30.9	26.6	21.4	10.4	20.1
Percent units using rivers	1.5	1.6	1.7	1.3	3.2	2.2
Cooking fuel: Percent units using gas	57.3	66.4	77.0	85.9	95.0	83.6
Percent units using wood, other	40.1	31.2	20.5	11.7	2.4	13.9
Exposure to hazards						
Percent urban pop. under 5 years of age	14.2	13.8	13.7	13.3	11.7	12.9
Walls: Percent units with brick	52.2	45.5	43.8	57.3	57.1	51.2
Percent units with wood	31.5	36.2	43.7	29.9	38.7	38.6
Percent units with mud	16.3	18.4	12.5	12.9	4.2	10.1
Density: Pct. units with <1 person per room	59.0	59.7	62.5	63.2	61.8	61.9
Percent units with 1 to <2 people per room	30.9	29.9	29.2	28.3	27.4	28.5
Percent units with 2+ people per room	10.1	10.4	8.3	8.5	10.8	9.7
Water: Percent units with city pipe inside	27.4	32.1	38.4	43.0	69.8	50.5
Percent units with outside city pipe	26.2	24.7	17.5	15.8	12.4	16.4
Percent units with well or other source	44.2	41.3	42.1	39.7	16.0	31.3
Amenities: Percent units with electricity	77.6	79.4	85.4	90.9	96.9	89.8
Percent units with refrigerator	38.9	44.5	55.7	63.5	80.4	64.8
Percent units with water filter	55.0	52.3	52.9	47.5	57.5	53.9
Resources against hazards						
Household income: Percent earning <1 MS	37.2	37.5	30.3	28.6	16.3	25.6
Percent households earning 1 to <5 MS	49.8	48.5	54.1	52.9	53.0	52.6
Percent households earning 5 to <10 MS	6.5	7.4	8.7	10.0	16.7	11.8
Percent households earning 10+ MS	3.9	3.7	4.8	6.1	11.8	7.6
Percent heads paying social security	24.1	21.8	29.0	34.8	47.0	35.9
Health: Medical estabs. per 1000 urban pop.	1.6	0.9	0.5	0.3	0.2	0.4
Hospital beds per medical establishment	2.0	5.7	9.5	14.3	19.8	10.5

Source: IBGE, Censos Demográfico 1991, Microdados da Amostra.

The size of municipal urban populations in the Amazon has more limited effects on exposure to environmental hazards. The proportion of young children is approximately 13% and varies little among urban size categories, the percentage of housing units with brick walls is around 50% and shows little evidence of a gradient, and the percentage of units with two or more people per room is approximately 10% in each size category. However, water sources and amenities do show substantial gradients across size categories. Larger urban populations – particularly the largest category – show higher percentages of housing units with water piped inside, while smaller populations relied more on water from wells and rivers. Similarly, electricity and refrigerators appear progressively more common as one moves from smaller to larger urban populations.

Indicators of resources against environmental hazards show strong and contrasting gradients among size categories. Distributions of earned income were more favorable in larger urban populations: moving from smaller to larger size categories, we find a decline in the percentage of households earning under one MS (from 37% to 16%) and a rise in the percentage earning five or more MS (from 10% to 29%). Similarly, the percentage of urban household heads paying social security rises when one moves from smaller to larger urban size categories. In contrast, access to health care appears to run along an opposing gradient. Medical establishments were relatively scarce among especially large urban populations. It does appear, however, that the quality of health care was higher in large centers, as indicated by larger numbers of beds per establishment. Small urban populations exhibit relatively good access to relatively poor quality health care, while large urban populations experienced more limited access to better care. Overall, Table IV reveals distinct profiles of environmental quality among urban populations of different sizes.

Effects of Urban Status, Subregion and Size Category on Environmental Quality

The foregoing tables indicate that urban age status (old or new), subregion (remote, frontier or settled) and size category (from populations under 2000 to those of 150,000 or more) affect the production of, exposure to, and resources against urban environmental hazards in the Amazon. However, the effects of these three variables on urban environmental quality are in some instances similar. For example, environmental hazards are greater in new urban areas, and in frontier areas. It is possible that the two tend to coincide, that is, that hazards are greater in new areas because they tend to occur in frontier areas. To distinguish among the effects of urban age status, subregion and size category, I conducted a multiple classification analysis (MCA) on each indicator of environmental quality.[5] MCA allows for estimation of the effects of each independent variable on the environmental indicators, adjusted for the effects of the other two predictors.

Table V presents the grand means for each indicator and adjusted effects of selected categories of the three independent variables.[6] Using Table V, we can see whether urban status, subregion and size category exerted independent effects on each environmental indicator. In addition, we can see whether environmental quality is better or worse in specific kinds of urban populations. Table V allows for comparison of environmental indicators between the grand mean and new, frontier, and small (2,000 to 9,999) urban populations, which indicated particularly poor urban quality in the foregoing tables. In addition, Table V includes a column for very large (150,000+) urban populations, which exhibited different hazards and relatively good environmental quality. The MCA results also allow for calculation of environmental quality in each category of urban area, including combinations of categories. To take an example, the grand mean percentage of migrants in municipal urban populations was 23.6%; in new urban areas, this was 23.6 + 17.5, or approximately 41%; in the frontier, this was 23.6 + 9.0, or about 33%; in new urban areas in the frontier, this was 23.6 + 17.5 + 9.0, or 50%. Table V also presents R^2 values that provide a guide as to how well the independent variables account for differences in indicators of urban environmental quality. The first value is 0.492, which implies that urban status, subregion and size category account for nearly half (49%) of the total variance in percent migrants.

Table V shows that production of environmental hazards in urban areas of the Amazon depended largely on size category rather than urban status or subregion. While the percentage of migrants varied mostly among old and new as well as the frontier and other subregions, size category shows effects that are usually larger and always significant for the other ‘production’ indicators. In the case of sewage, the percentage of households with lines or tanks was only 11% in smaller urban areas ((3.9 + 30.3) + (−3.6 − 19.0)), compared to a mean of 34%, and 54% in the largest cities, with

TABLE V

Multiple classification analysis of environmental quality indicators with urban status, subregion and size category, urban areas of the Brazilian Legal Amazon, 1991

		Adjusted effects [1]				
				Size category		
Indicators	Grand mean[2]	Status: new	Subregion: frontier	2,000–9,999	150,000+	R^2
Production of environmental hazards						
Percent migrants	23.6	+17.5**	+9.0**	−2.6**	−1.7**	0.492**
Percent of EAP in transformative industries	11.1	+2.2**	−0.1**	−3.7**	+1.5**	0.247**
Sewage: Percent housing units with city line	3.9	+0.9**	−1.5**	−3.6**	+4.2**	0.230**
Percent units with sewage tank	30.3	−1.2	−0.3	−19.0**	+15.6**	0.471**
Percent units with sewage pit	54.0	+2.1	+2.4**	+17.0**	−15.6**	0.506**
Percent units with no sewage	11.9	−1.8	−0.7**	+5.6**	−4.2**	0.176**
Waste: Percent with city collection	51.5	+3.0	+1.0	−29.8**	+23.0**	0.499**
Percent units using fire	22.8	+0.0	−0.5	+16.6**	−12.6**	0.358**
Percent units using burial	20.1	−3.2	+1.4**	+11.2**	−10.0**	0.274**
Percent units using rivers	2.2	−0.3	−1.1**	−0.4*	+0.6*	0.204**
Cooking fuel: Percent units using gas	83.6	−0.6	+0.4*	−17.5**	+11.6**	0.543**
Percent units using wood, other	13.9	−0.4	−0.3*	+17.8**	−11.8**	0.529**
Exposure to hazards						
Percent urban pop. under 5 years of age	12.9	+0.2	+0.3**	+0.9**	−1.2**	0.457**
Walls: Percent units with brick	51.2	−10.1**	−7.3**	−4.9**	+4.8**	0.432**
Percent units with wood	38.6	+12.4**	+10.5**	−3.8	+1.9	0.452**
Percent units with mud	10.2	−2.3	−3.3**	+8.7**	−6.7**	0.259**
Density: Pct. units with <1 person per room	61.9	+0.3	+4.6**	−3.5**	+1.8**	0.347**
Percent with 1 to <2 people per room	28.5	−0.1	−1.6**	+1.8**	−1.8**	0.183**
Percent with 2+ people per room	9.7	−0.2	−3.0**	+1.7**	0.0**	0.415**
Water: Percent units with city pipe inside	50.5	−10.6**	−8.9**	−16.5**	−16.9**	0.545**
Percent units with outside city pipe	16.4	−7.4**	−3.0**	+10.2**	−6.0**	0.182**
Percent units with well or other source	31.3	+16.9**	+12.1**	+6.4**	−11.0**	0.431**
Amenities: Percent units with electricity	89.8	−6.3**	−0.6	−9.2**	+6.4**	0.500**
Percent units with refrigerator	64.8	−3.6*	+1.2**	−19.9**	+15.7**	0.655**
Percent units with water filter	53.9	+6.9**	+5.4**	−3.8**	−6.3**	0.235**
Resources against hazards						
Household income: Percent household earning <1 MS	25.6	−7.25**	−7.0**	+13.0**	−10.4**	0.453**
Percent households earning 1 to <5 MS	52.6	+3.4**	+2.5**	−5.0**	+1.3**	0.197**
Percent households earning 5 to <10 MS	11.8	+2.0**	−0.8**	−4.7**	+5.0**	0.573**
Percent households earning 10+ MS	7.6	+17.5**	−1.0**	−4.0**	+4.3**	0.537**
Percent heads paying social security	35.9	+1.5**	−1.7**	−14.2**	+11.2**	0.568**
Health: Medical estabs. per 1000 urban pop.	0.4	0.0	0.0	+0.4**	−0.2**	0.233**
Hospital beds per medical establishment	10.5	−0.7	+0.6**	−7.1**	+3.9**	0.157**

[1] Adjusted effects refer to deviations of given categories from the grand mean, adjusted for the effects of the other independent variables. Significance values refer to F-ratios (df = 7,500) for each independent variable from which the category is drawn, where * $p < 0.05$, ** $p < 0.01$.

[2] Grand means refer to the mean of indicator values for municipalities, weighted by urban population size.

little or no modification on the basis of urban status or subregion. Conversely, the percentage of households with inadequate sewage ranged to 89% in small urban populations down to 46% in large cities. Waste disposal follows similar differentials. In small urban populations, the percentage of households with piped water inside the unit was 22%, compared to the grand mean of 52%, and 75% in large cities. At the same time, 71% of units in small urban areas burned or buried their waste, compared to 43% overall and 20% in large populations. Finally, the percentage of units cooking with wood was 32% in small urban areas, compared to 2% in large populations. These findings indicate two things: first, small urban areas in the Amazon had much greater per household production of environmental hazards; and second, urban status and subregion do not exert effects on the production of hazards which are independent of size differentials.

In contrast, differences in exposure to environmental hazards emerge among categories of all three independent variables. The quality of housing construction varied largely by urban status and subregion. The percentage of housing units with brick walls was 51% overall, but only 41% in new urban areas, 34% in new towns on the frontier, and 29% in small new frontier centers. Conversely, wood construction was 39% overall, but 51% in new urban populations and 62% in new frontier towns. Similarly, water sources appear worse in new, frontier and small urban centers. The percentage of households using wells or rivers was 31% overall, and 48% in new areas, 60% in new frontier populations, and 67% in new frontier areas that were also small. Access to electricity and ownership of a refrigerator were also lower in new and small urban centers, though use of water filters was greater in new frontier urban populations. These findings indicate that urban status, subregion and size category all exert important independent effects on some key indicators of exposure to urban environmental hazards. Exposure appears greater in newer, smaller urban populations in the frontier.

With respect to resources against environmental hazards, size category again exerts the strongest independent effects, but often in tandem with urban status and subregion. All three independent variables influence the distribution of urban household incomes. Incomes under one MS appear most common in small urban areas, and those of one to five more common in new and frontier areas. Large urban areas show substantial differentials toward higher incomes that exceed the effects of the other variables. Similarly, the percentage of households contributing to social security varied largely by size category, with proportionally fewer contributors in small urban populations. Access to health care also varied in terms of urban population size, with greater access in smaller areas and better quality in large cities. These findings suggest that resources against environmental hazards, while poor overall, are no worse in new and frontier urban areas than elsewhere in the Amazon, only in small urban populations.

DISCUSSION

In the context of deforestation and global warming, attention to the Amazon tends to focus on rural populations, but urbanization of the region presents problems of environmental quality which are serious in their own right. The rapid urban growth of the Amazon often involves expansion of unplanned settlements, and during the 1980s, environmental quality improved only marginally at best. The scale if not the percentage of urban populations in poor urban housing served to increase the production of and exposure to environmental hazards, while resources to defend against such hazards became less accessible. By 1991, 60% of households had inadequate sewage, while 30% procured water from wells or rivers, sources exposed to potential sewage contamination. At the same time, one-quarter of households earned less than one minimum salary, and only a third contributed to social security. The same indicators suggest a significantly worse situation in new, frontier and small urban areas.

The limited gains and variable level of urban environmental quality reflects the closing of the rural frontier without the emergence of a sustainable dynamic sector of the urban economy. Many authors have noted that the Brazilian frontier offers limited prospects for autonomous landownership and agricultural production to smallholders (Hébette, 1991; Martine, 1982; Sawyer, 1986; Schmink and Wood, 1992). More recently, others studying urban areas in the Amazon have noted the fleeting opportunities offered by extractive booms and construction projects (Godfrey, 1990; Roberts, 1991). In particular, upward mobility in urban frontier areas of the Amazon is limited (Browder and Godfrey, 1997: 265). This has given rise to patterns of repeating or chronic migration among rural and urban areas within the Amazon as populations seek jobs – largely poorly paid and temporary in nature – in an informal labor market (Browder and Godfrey, 1997, ch. 8; Cleary, 1993; Macmillan, 1995). The rapid accretion and turnover of populations in urban areas of the Amazon results in construction of unplanned housing which fosters poor environmental quality, particularly through production and exposure to untreated sewage in water sources, but also through the perpetuation of a lack of resources to manage illness.

The conditions giving rise to haphazard urban growth in the Amazon have changed little since 1991. The role of the Brazilian state has remained limited, implying a scarcity of support for agriculture. In areas with stiff competition for land, rural violence has grown. These conditions serve to push populations out of the rural agricultural frontier. Instead, mineral and timber extraction have boomed and subsided as the dynamic elements of the rural economy. Another consequence of state retreat during the 1990s has been the decentralization of administration in peripheral areas of Brazil. This has meant the creation of new municipalities through state mandates for new administrative seats. The continued importance of extractive booms and the creation of new municipal centers has encouraged the growth of young urban areas. This pattern of urbanization – state-mandated decentralization to municipal control during a period of a rural-to-urban population shift – gives rise to many new, small urban centers in frontier areas of the Amazon. The findings of this paper suggest that urban environmental quality in these areas is particularly poor. With the expansion of populations in new, small urban centers in the frontier, it is likely that urban environmental quality in the Amazon has continued to deteriorate during the 1990s.

This would seem to argue for policies that encourage population movement toward larger cities, but such a shift would merely imply a relocation of urban environmental problems within the region. Large urban areas in 1991 showed proportionally lower levels of untreated sewage discharge and use of water from wells or rivers, along with higher household income levels. However, the scale of population in large cities still implies substantial absolute amounts of pollution and exposure, and higher wages may be offset by higher costs for basic necessities. The arrival of additional populations potentially means construction of more unplanned housing in already crowded urban centers, perhaps hindering improvements in environmental quality.

Rather than encouraging a population shift toward larger cities to improve overall urban environmental quality, economic policies would do better to fix populations, whether on the land or in existing urban areas. This is a critical element in discussions of sustainability in the Amazon. Unsustainable rural production systems, whether in agriculture or various extractive economies, generate haphazard urbanization and lead to growth of urban populations living in areas with poor environmental quality. But while there are many experiments with ecologically sustainable production systems underway (Anderson, 1990; Redford and Padoch, 1992; Serrão and Homma, 1993), it is questionable whether they can be economically sustainable for substantial segments of the Amazon population, now approaching 20 million (Browder, 1992; Homma, 1992).

Failing the success of policies or economic alterations that fix populations in the Amazon, it is likely that poor urban environmental quality, paired with the rural exodus, will lead to migration out of the region. With chronic migration as an adaptive strategy to economic insecurity and an informal labor market, some populations in the Amazon will continue to move to either dynamic urban centers experiencing booms or large cities with better opportunities. But for many, the closure of the rural frontier, the exhaustion of extractive booms and the poor quality of urban housing will perpetuate further migration, some of which may be directed out of Amazon toward more established regions of Brazil.

ACKNOWLEDGEMENTS

I thank André Junqueira Caetano and an anonymous reviewer for providing valuable comments on earlier versions of this paper, and Charles H. Wood for providing funding and facilities that made this work possible.

NOTES

[1] The Legal Amazon includes the states of Acre, Amazonas, Amapá, Mato Grosso, Pará, Rondônia, Roraima and Tocantins, as well as municipalities in Maranhão west of the 44th meridian and Goiás north of the 13th parallel (SUDAM, 1995).

[2] The definition of ‘urban’ used by IBGE, the Brazilian statistical agency, comprises resident populations of municipal (county) and district (subcounty)

seats. Note that this definition does not have a lower size limit. However, in 1991, 99% of the urban population resided in municipalities with urban populations of 2000 or more, and the majority of these populations resided in municipal rather than district seats.

[3] Inflation was extremely high in Brazil during the economic crisis of the 1980s, so the value of the Brazilian Cruzeiro (Cr$) differed in 1980 and 1991. To directly compare income distributions for the two censuses I used the 'real' income variable from the 1991 data, which states income in minimum salaries equivalent to 1980 minimum salaries. This procedure equates one MS in 1980 as Cr$ 4149.60 with one MS in 1991 as Cr$ 46,145.04 and accords with IBGE (1996, pp. 46–47) and Wood (1998).

[4] To check these findings I constructed two alternative indicators of household resources. As an alternate to household income, I considered the earned income of the household heads, and found that the percentage earning under one MS rose from 31% in 1980 to 48% in 1991. This rise is even larger than the rise in overall household income under one MS, and suggests that households increasingly adopted multiple-earner strategies. As an alternate to social security, I calculated the proportion of household heads who had an employee identification card (*carteira assinada*), indicating formal employment by an employer. This information was only available in 1991, but indicated that only 26% of household heads had formally employed positions with potential benefits. This figure is lower than the estimate from social security, and confirms a proportional decline in formal urban employment during the 1980s.

[5] I employ MCA rather than conventional OLS regression here because the output from MCA allows easy comparison among different categories. MCA yields adjusted effects from grand means rather than intercepts, which allows for easy computation of differences in environmental indicators. In the MCA presented here, I weighted the cases by their population size, scaled to a proportion of the municipalities in the Amazon in 1991 (N = 508). This allowed for representation of urban populations in proportion to their relative sizes, rather than treating large cities as representative as small villages. It also allows for reproduction of the values for environmental indicators for the Legal Amazon presented in Tables I–IV, presented in Table V as grand means. If large and small populations differ in terms of the environmental quality indicators, then weighted MCA will yield effects that highlight such differences. The same applies to the urban status and subregion variables. If urban areas in different categories of these variables differ by size and by environmental quality, the weights will highlight such differences. Weighted MCA yielded stronger models without altering the results of unweighted MCA. Adjusted effects and R^2 values were greater in weighted MCA, but the substantive conclusions from the two runs do not differ.

[6] Statistical significance refers to F-ratios for the effect of the independent variable from which the category was drawn.

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