Migration dynamics in Brazil's major biomes

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Abstract. Based on initial considerations on the differences among Brazil's major biomes, this paper asks questions on population movements within and between biomes. With a view to identifying where population-environment relations are more or less favorable, the paper asks: What are the major inter-biome streams? Which biomes have the greatest internal mobility? The central hypothesis is that the most urgent situations are found, not in the high-profile Amazon and *cerrado*, but in the Atlantic Forest, the *caatinga* and in the Coastal Region. The conclusion is that favorable trends in population processes will only produce favorable results if land-use planning allocates population to favorable sites and if economic development is based on environmental considerations. Conclusions do not fit current assumptions on regional development because attention is generally given only to population growth and not its distribution.

Introduction

Among world nations, Brazil has one of the greatest ecological and cultural diversities. Such diversity provides greater resilience to Brazilian development, with more degrees of freedom than most countries enjoy. This paper is a report on a project to examine population dynamics according to the boundaries of Brazil's major biomes, as opposed to traditional political-administrative boundaries. First results have presented population trends according to these regions, which have distinct capacities to support human activity and which manifest distinct degrees of environmental risk. (Hogan, 2001). Conclusions do not support past or current views on where job-creating (population attracting) investments should occur, but call attention to the need to identify the distinct roles each area has in answering the competing needs of economic development and environmental preservation.

To examine the importance of using natural ecological boundaries for organizing population analysis, to assess the urgency of potential environmental damage from population concentrations (and concomitant economic activities) and to produce better data for establishing conservation priorities, we have created a geographically referenced data base which assigns each of Brazil's 5,652 municipalities to one of the country's seven major biomes: the Amazon Forest, the Semi-arid Region (*caatinga),* the Atlantic Forest, the savanna-like *cerrado*, the great wetlands of the *Pantanal*, the Southern pampas and the Coastal Region (Hogan, 2001). The data base was created on the basis of IBGE-Ibama definitions of the country's principal biomes.[1] Considering the large number of

[1] Ibama has recently identified the *ecoregions* of Brazil's seven major biomes. Ecoregions are biogeographical units with well identified natural boundaries, as apposed to alternative biogeographical divisions based on the distribution of species of some group of organisms whose boundaries are not yet well

municipalities, the fit can be taken to be reasonably dependable.[2] A more refined fit, using census tracts as units, may be justifiable in some situations, for example, in studying edge effects (impacts on the boundaries of preservation units by their surrounding areas), or specific areas undergoing intense transformations.[3]

The biome as a unit of population analysis

One of the problems inherent to population-environment research is the unit of analysis question. While we may often want environmental information on specific population groups (families, communities, age-sex categories) when examining the **effects** of environmental change (E→P), the overwhelming majority of research in this area seeks to relate population variables to environmental change, examining the **causes** of environmental change (P→E). Here we confront the problem of defining the most appropriate natural, ecological unit. River basins (Hogan, 1997) and forest regions (Bilsborrow and Hogan, 1999; Sydenstricker-Neto, 2004; Sawyer 1984), for example, have emerged as useful ways to organize population-environment analyses. This paper analyzes population dynamics according to Brazil's major biomes. Research at the national level in Brazil generally examines trends at the level of five major regions, organized according to state boundaries: North, Northeast, Central-West, Southeast and South. When environmental questions are raised, these units often serve as proxies for the Amazon Forest, the Semi-arid Region (*caatinga)*, the neotropical savannas (*cerrados*), the Atlantic Forest (*Mata Atlântica*) and the Southern pampas, respectively. This approach dilutes and obscures relations between these two orders of phenomena, often over- or understating the impact of population factors on environmental change.

While there is an inherent gain in using real vs. proxy data, how much difference does it make? The answer: it depends. The analysis reported here seeks to contribute to changing the focus of population-environment studies to "natural" boundaries and to developing a better understanding of dynamics in each of these biomes. But what have we gained from this laborious process, which the use of the standard regions as proxies for the biomes did not already allow?

Table 1 presents a comparison between conventional regions and biomes, in four cases for which the overlap is most pronounced, and for which they are commonly interchanged in contemporary debate: Amazônia/North, *Cerrado*/Center-West, Atlantic Forest/Southeast and Semi-arid/Northeast. The North region – the largest in terms of territory – contains some areas which are not part of the Amazon Forest, and which include an additional population of nearly 1.8 million. Density is slightly higher in the forest; urbanization slightly less; and the annual growth rate somewhat smaller. But by these

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know. The principal criteria used by Ibama in the definition of the country's 78 ecoregions were abiotic (interfluvial regions, altitude, relief, soils, geology, precipitation, flood cycles, tide effects) and biotic (phytogeographic and zoogeographic, associated with known groups of mammals, birds, amphibians, reptiles and butterflies). The more refined analysis of these ecoregions constitutes a new stage in this project.

[2] This is, of course, a relative assessment: in the State of São Paulo there are 645 municipalities in a territory of 248 808 km^2, while in the State of Amazonas, with 1 577 820 km^2, there are 62 municipalities. The possibility of correlating socio-demographic and natural phenomena is much greater in the first situation.

[3] The doctoral dissertation of Humberto Alves (2004) on the Ribeira Valley in São Paulo State (the last important remnant of the Atlantic Forest), is the first such study in Brazil. See his paper in this meeting, "Demographic dynamics and socio-economic development as drivers of deforestation in the Brazilian Atlantic forest: a GIS integration of census and remote sensing data at different spatial scales."

general characteristics, the differences between biome and region are negligible. In the *cerrado*, the comparison yields different conclusions. Many parts of the *cerrado* are not continuous with the core and many states outside the Center-West region have areas classified as *cerrado*. Approximately 1.5 million people live in these areas. Considering all *cerrado* areas (the biome), density is higher and urbanization lower; and the biome is growing at a considerably slower rate. The *cerrados* of the Center-West are currently being devastated, and this devastation is associated with population growth, especially urbanization; areas of *cerrado* in the state of São Paulo, on the other hand, transformed in earlier phases of development, have undergone population decline over recent decades.

Table 1. Population characteristics of Brazilian regions and biomes, 2000.		
1a. Amazônia		
	Biome	Region
Population	11,108,689	12,900,704
Area (km^2)	3,293,761	3,852,968
Density (persons/km^2)	3.37	3.35
Percent urban	69.6	69.9
Annual growth rate (%)	2.76	2.86
1b. *Cerrado*		
Population	13,059,943	11,636,728
Area (km^2)	1,598,065	1,606,446
Density (persons/km^2)	8.17	7.23
Percent urban	77.5	86.7
Annual growth rate (%)	1.88	2.39
1c. *Caatinga*		
Population	16,025,804	47,741,711
Area (km^2)	677,687	1,553,917
Density (persons/km^2)	23.65	30.69
Percent urban	61.1	69.1
Annual growth rate (%)	1.34	1.31
1d. Atlantic Forest		
Population	108,451,907	72,412,411
Area (km^2)	1,493,020	924,574
Density (persons/km^2)	72.64	78.20
Percent urban	86.7	91.0
Annual growth rate (%)	1.56	1.62
Source: IBGE, 2000 population census.		

Brazil's Northeast is its poorest region, an area of out-migration for more than a century. The popular image – reproduced in art, literature and the popular imagination – associates the region with the *caatinga*. The semi-arid biome, however, is less than half the size of the region and has only slightly more than one-third of the its population. The

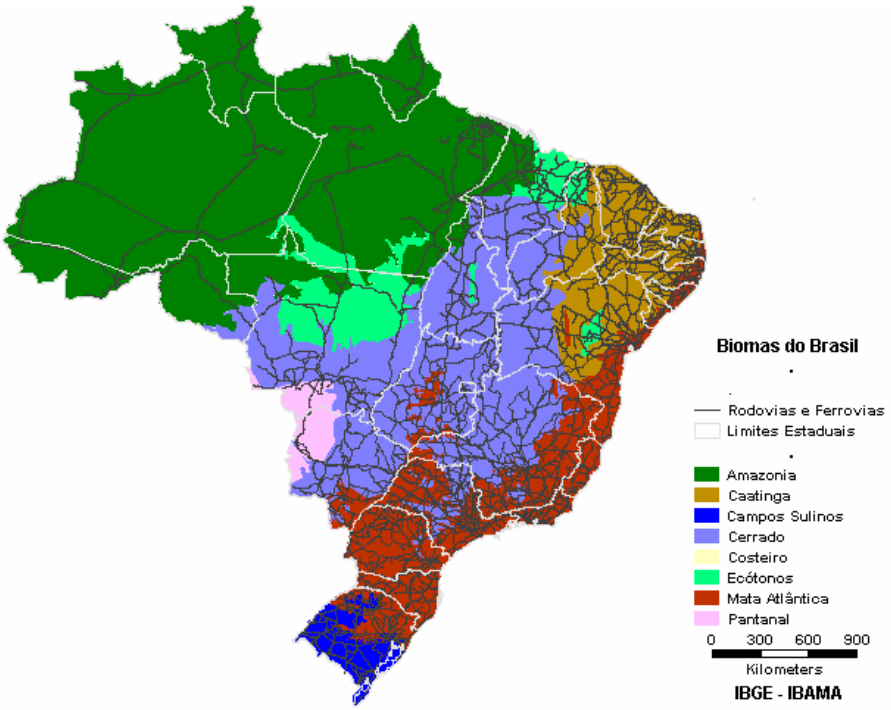
Northeast region includes a more hospitable coastal region, which is more densely populated and more urban; considering the region's out-migration, growth rates of both region and biome are low, and very similar to each other. The comparison of the Southeast with the Atlantic Forest is the most tenuous of these comparisons. The largest existing remnants of this forest are in this region, it is true, and this explains the popular association. But the ecological unit of the biome includes large areas in the Northeast and South regions, where 90% of the forest has disappeared; these areas are today densely populated. The biome, then, has a larger population but is somewhat less dense, less urban and is growing at a somewhat lower rate.

The message of this comparison is that with the possible exception of Amazônia, the biomes do not overlap with conventional regions; in some cases the differences are considerable. The demographic differences are not so great, however, and the gain in this approach is not a new understanding of Brazilian population dynamics, but a closer, more precise view of what is happening in its major ecological regions.

Population and Environment in Brazil's Major Biomes

A country as diverse as Brazil must be seen in the overall context of the differential distribution of its population and resources. In assessing the prospects for sustainable development, it is clear that not all socially desirable goals can be met in all points of the nation's territory. If we are to understand the possibilities and limits of economic activities (and the jobs and population movements inspired by these activities) in Brazil's remarkable ecological diversity, we must start by examining the present situation.

Biomes of Brazil



Amazon Forest

Outside Brazil, the Amazon Forest tends to monopolize the attention of the population-environment debate. Brazil's largest formation, it has an area of 3,293,761 km^2, a humid climate and a large variety of vegetation, from forest to savanna-like areas at low elevations. The principal environmental problem of the Amazon is deforestation, which occurs from fires provoked by the expansion of agricultural activities and by the exploitation of lumber. Data from the Environment Ministry register an increase in the pace of deforestation in recent years. In the last three decades, 620,000 km^2 have been deforested, reaching a record 26,130 km^2 in 2004 (Salati and Nobre, 2005). This situation has long provoked concern, first in Brazil and later internationally, and for much of world opinion represents Brazil's major environmental dilemma. Its population of 11 million in 2000, however, was concentrated in cities (70%), not in forest lands. And overall population density of 3.37 persons/km^2 is extremely low. It is difficult to conclude that "population pressure" is responsible for the environmental threats facing the Amazon, bearing in mind that interregional migration, including frontier migration, was declining by 2000. The driving forces of deforestation have been identified and well-documented over the last 20 years. It has not been the land-hungry poor and their large families who bear the greater responsibility, but economic interventions, in the name of financial gain or national security. The Amazon region, considering its important biological diversity, its numerous indigenous groups and generally poor soils, would not be a major focus of economic development from a sustainability perspective. Large population contingents are not supported by extensive agriculture. Indeed, in the state of Amazonas, half the population lives in the capital of Manaus, sustained by an enclave of duty-free production of electronics. This is an arrangement whose days are numbered, but reveals the limited possibilities for absorbing population in the extensive forested regions.

The population-environment equation in the Amazon is not now in a critical state, but neither can it be seen in the future as an important alternative for population settlement. The crucial factors are large-scale economic development projects, such as those planned in the government's (now shelved) *Avança Brasil* project. The environmental consequences of this program of infra-structure development were predicted to be disastrous (Laurence, 2000). Sustainability, from the perspectives of the region's biodiversity and its limited capacity to support large populations, reserves this region as the low-density area which it is today. Not population policy, but economic-ecological policy must be tailored to this end.

Cerrado

Within Brazil, environmental concern is also extended to the *cerrado*, the Pantanal and the Atlantic Forest. The *cerrado*, the second largest biome, has undergone dramatic transformation in recent decades (Hogan et al., forthcoming) and its undervalued biodiversity has only recently received greater attention.

The *cerrado*, with an almost entirely tropical climate, is a complex of different forms of vegetation which have variable physiognomies and floristic compositions, forming an ecological mosaic. According to Goodland and Ferri (1979), the *cerrado* is "a mixture of low trees and a well developed herbaceous strata." (cited in SMA, 9)[4] This neotropical

[4] The core of the *cerrado*, considered the most characteristic and continuous portions, occupies 1,500,000 km^2 in the Central Brazilian Plateau, in the states of Goiás, Tocantins, Federal District, part of Minas Gerais,

savanna occupies 22% of the country's surface area; half of the biome is "under direct human use, and about 35% of its total natural cover has been converted into planted pasture and crops" (Oliveira and Marquis, 2002, vii). In the description of Warren Dean (1995), it is in an inland area

> *...where rainfall becomes too scarce and too seasonal to support forest, [that] the savanna begins. This formation of widely spaced, low scrub woodlands and tall grasses is resistant not only to drought but also to fire, which occurs naturally across this landscape. The savanna, called* cerrado*, occupies an immense swath of the interior, almost a quarter of all Brazilian territory" (Dean, 1995, 9).*

The *cerrado* (concentrated in the states of Mato Grosso, Mato Grosso do Sul, Goiás and the Federal District) has an area of 1,598,065 km^2 and a 2000 population of 13,059,943. While international concern for its biodiversity is more recent, Brazil's second largest ecosystem is a valuable national resource. The region has undergone rapid development over the last three decades. In this period, the region has moved from (1) a sparsely populated area of subsistence agriculture to (2) a major migration destination for land-seeking migrants from other regions to (3) dynamic, export-oriented monoculture. This has been a rapid process, coinciding with the modernization of Brazilian agriculture; increasing mechanization and government incentives have contributed to the transformation of vast extensions of land to the production of grains (especially soybeans, but also cotton, corn and rice) and cattle-raising. Great expectations have been placed on an expanding world market for soybeans and Brazil's comparative advantage in this field.

Considered as unproductive for farming until the use of modern methods since 1970, the *cerrado* has always been considered as not worth preserving.

Especially since the seventies, when soil management methods were developed for the region[5], the *cerrado* has been definitively incorporated into the national economy, and is now seen by planners, investors and farmers as unoccupied and available for agroforestry, cattle raising and large-scale grain production. The intensive use of machinery and agricultural equipment, fertilizers, pesticides, herbicides and selected species have transformed the natural landscape of the region, frequently leading to the depletion of natural resources (desertification) and the contamination of food, soils and water. The original vegetation has been greatly reduced, 37% having been converted to pasture, annual crops such as soybeans, corn and rice and perennial crops such as eucalyptus and pine plantings, as well as such urban-generated land uses as reservoirs, cities and garbage disposal. In many areas, environmental degradation has already led to lower productivity and greater costs. These agricultural activities were rarely introduced with any environmental concern. Local varieties of plants were ignored and instead of adapting farming to the characteristics of the region, especially to the soil, the region's characteristics were adopted to the products. (Shigeo, 1999) The result has been the

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Bahia, Mato Grosso, Mato Grosso do Sul and part of Maranhão, Piauí, and Rondônia. Unconnected portions, forming islands of *cerrado*, are found in Amazonas, Amapá, Roraima, Alagoas, Bahia, Ceará, Paraíba, Pernambuco, São Paulo and Paraná. This fact, in addition to biological and political differences in defining *cerrado*, has led to a range of estimations of total area.

[5] Government policy was fundamental to this process. Embrapa, a research arm of the Ministry of Agriculture, created in the early 1970s, soon developed varieties of soybeans adapted to the climate and soils of the *cerrado*.

compacting of soils, erosion and the genetic impoverishment of the native biota.[6] Environmentalist concern is related to biological diversity, carbon sequestration and watershed protection.

The *cerrado*'s population density (8.17 persons per square kilometer), like the Amazon's, is also remarkable low. Its precocious urbanization (68% in 2000) is testimony to the importance of capital-intensive monocultures of soybeans and cotton in its environmental transformation. In part, these urban populations represent centers of support, including agro-industry, for agricultural activities. But these cities are also reservoirs of unemployed and under-employed poor, who were unable to sustain their families on small farms, in the face of the region's monocultures.

The *cerrado* is a region whose biodiversity must be zealously defended. It is perhaps not so fragile as the Amazon, however, and greater proximity to major urban centers suggests that economic activities can be conciliated with environmental protection. Greater fine-tuning of the population-environment relation will be required to identify those regions and those economic activities which may be sustainably explored. Agro-industry has already begun to shift processing activities to the region, decentralizing job-creation but also decentralizing environmental pollution. From social, economic and demographic perspectives, this development makes sense. But these activities must be accompanied by pollution control and treatment of effluents, and must be carefully located within the region's territory. The population-environment balance is not critical and the *cerrado* may still absorb population, but much more ecological-economic planning is required to reverse the pell-mell development activities of recent decades.

Pantanal

The Pantanal ("…an extensive, low-lying waterlogged plain" (Motta et al., 2002)) is a biologically important area in the Center-West, and not separated in conventional population statistics. The *Pantanal* is one of the world's most significant wetlands. Its diverse fauna include many unique species and current concern for preservation is high on environmentalists' agenda. The driving forces of change, however, are not basically demographic. The *Pantanal's* population (488,215) is small, urbanized (70%) and thinly distributed. While it is the only region whose rural population grew between 1991 and 2000, this increase was only 3,429 of the total increase of 56,095. Its population density in 2000 was Brazil's lowest, at 2.2 persons per square kilometer. Increased tourist activity and proposed agriculture development are major concerns. One of the most important problems is agricultural runoff from rivers which feed into the *Pantanal* from the *cerrado*, provoking both siltation and pollution.

Atlantic Forest and the Coastal Region

The Atlantic Forest, perhaps the most threatened biome at this moment, is one of the world's biodiversity *hotspots*. It is the region where most Brazilian development has occurred and, therefore, the region most transformed. Five centuries ago

[6] An example of inadequate soil use is soybean production in the headwaters of the Taquari, in the North of Mato Grosso do Sul. "The plantations provoke erosion and silting of the river, which result in floods in the Pantanal. To avoid the floods on their properties, farmers dredge the river and end up blocking off its affluents. This then diminishes the oxygenation of the water and kills fish, leading to loss of biodiversity in the river." (WWF, 2001)

> *On the eastern margin of South America there once stretched an immense forest, or more accurately, a complex of forest types generally broadleaved, rain loving, and tropical to subtropical, stretching from about 8º to about 28º south latitude and extending inland from the coast about 100 kilometers in the north, widening to more than 500 kilometers in the south. Altogether the forest covered about a million square kilometers. This complex has been referred to as the Brazilian Atlantic Forest, related to the much larger Amazon Forest but distinct from it. …it is remarkably diverse."* (Dean, 1995, 6)

The Atlantic Forest, (whose largest intact portions are in the states of Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina, with a territory 1,493,019 km^2) has been reduced to 5% of its extent 500 years ago. In Rio de Janeiro, for example, 20% of the territory is covered by forest, compared to 97% originally; in Minas Gerais, forest extent has declined from 51.7% to 1.5%. Considered together with the Coastal Region, it is Brazil's most populous region, with a 2000 population of 112,092,890. Population density, however, is nearly five times as high in the Coastal Region (305.9 persons per km^2) than in the Atlantic Forest (72.6 persons per km^2.). This is the region in which Brazil's *crab civilization* (because it clung to the shore) has developed. With the exception of timid and short-lived colonization efforts in the Amazon, Brazilian development only began to reach beyond this coastal region in 1960, with the construction of Brasília. Both regions are highly urbanized – 90% in the Coastal Region and 83% in the Atlantic Forest. The latter is also home to a rich biodiversity. Its vegetation is composed of dense forest closer to the ocean, less dense on the steep slopes and open fields on the tops of these slopes.

These are undoubtedly the regions whose population-environment balance is most precarious. Both **source** and **sink** functions of nature have been acutely affected. The limited remnants of the Atlantic Forest were the first to generate protective measures, a movement which continues today. Nevertheless, the forest continues to shrink each year. Most remaining intact areas are in coastal regions, interior portions having been almost completely substituted by agriculture over the centuries. Today, both urban population growth and a growing consumer culture have generated large-scale tourist development on the coast. This development threatens to complete what isolation and lack of other economic options did not do, and the biodiversity of the Atlantic Forest is more threatened than that of the Amazon.

But ecosystem limits to absorbing waste have also been stretched, often beyond the breaking point. Two of the world's largest cities (São Paulo and Rio de Janeiro), along with a large number of smaller (but still large) cities, have sprawled over rich soils, deforested their hinterlands, degraded rivers, lakes, bays and estuaries, contaminated soils and groundwater and saturated local capacities for absorbing solid waste. Accelerated economic development and rapid population growth in the second half of the 20th century created environmental liabilities which will require much time, planning and investment to overcome. In areas like the São Paulo Metropolitan Area, environmental degradation is so severe, pressure on resources so great and water supplies (for example) so limited, that simple remedial measures may never be adequate. The *interiorization* of development and population growth in São Paulo State since the 1970s is a reflection of such problems. Considering the vast social infrastructure in place (transportation, schools, universities and research centers, health care facilities), the region of influence of the Atlantic Forest must continue to meet the needs of a large part of the Brazilian population. Smaller and middle-size cities, however (as in the São Paulo case), may provide greater possibilities for promoting quality of life, including environmental quality, which is the goal of sustainable

development. It must be remembered that earlier efforts to promote the growth of middle-size cities – a generally frustrated effort – were undertaken in the context of rapid population growth, especially urbanization. In today's different demographic context, such planning efforts may be more viable.

The impact region of the Atlantic Forest, then, must continue to be home to most Brazilians. Internal redistribution of economic activity (and population), together with environmental remediation and enforced environmental protection may ameliorate environmental pressure in this region. For the reasons mentioned above, redistribution of population to other regions will play a minor role in bringing population and environment into more harmonious balance. Sustainable solutions must be found within the region itself.

Semi-arid region

The semi-arid *caatinga* is Brazil's poorest region, traditional source of out-migration for more than a century. Euclides da Cunha's classic description, which is the image fixed in the national consciousness, has withstood the test of time: The *caatinga*

> *…repulses the traveler…with its thorns and prickly leaves, its twigs sharp as lances; and it stretches out in front of him, for mile on mile, unchanging in its desolate aspect of leafless trees, of dried and twisted boughs, a turbulent maze of vegetation standing rigidly in space or spreading out sinuously along the ground, representing, as it would seem, the agonized struggles of a tortured, writhing flora. …moribund vegetable growths practically without trunks, and with branches that start at the ground.* (Cunha, 1902, 30)
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> *The leguminous plants, which grow high in other places, are here dwarfed. …like a lacerating haircloth, the caatinga extends over the earth its thorny branches. (p 31)*
>
> *Climb any elevation whatsoever and let your gaze wander, and it will encounter the same desolate scene: a shapeless mass of vegetation, the life drained from it, writhing in a painful spasm*. (Cunha, 1902, 35)

The uncertain rainy season changes this:

> *When the rains come on…the earth becomes transfigured. …when the droughts are not prolonged to a point where they occasion a painful exodus, man may be seen struggling like the trees, with the aid of those reserve forces which he has stored up in the days of plenty. (p 40)…Then, all this comes to an end. The days of torture return; the atmosphere is as asphyxiating; the soil is hard as rock; the flora is stripped bare; and on those occasions when summer ends without the intermittency of rain – the dreadful spasm of the drought.* (Cunha, 1902, 41)

The *caatinga* is Brazil's second most populous region, with a population of 16 025 804 in 2000.[7] Its vegetation is conditioned by its dry climate, which predominates during the winter and is renewed with summer rains. Its vegetation composes an aggressive landscape of species resistant to drought, with occasional islands of humidity, where higher vegetation and more fertile soils are found. The major environmental problem is desertification, aggravated by the intense use of irrigation with inappropriate technology, by the contamination of what water sources are available and by deforestation to obtain firewood and charcoal. The Northeast 2000 population of 40 million (here including the

[7] It should be noted that a significant part of the traditional "Northeast" region is concentrated in the coastal zone. The biome approach permits separating these two distinct ecological realities, and future analysis of this data base will examine these differences.

coastal region) is an inheritance of the region's importance in the production of sugar cane, since colonial days. The more fertile coastal lands, part of the Atlantic Forest, have not supported the region's population for a long time. Subsistence agriculture in the semi-arid backlands is precarious and the Northeast is Brazil's classic case of out-migration. Social concern and political pressure of traditional oligarchies has produced an impressive array of water projects aimed at permitting a sustainable way of life for family farmers. In an area of 677,686 km^2, with a population density of 23.65 persons/km^2 in 2000, however, such projects have generated much environmental concern. It is not only that much of the investment in water projects has benefited only rich landowners, a scandalous remnant of traditional politics as yet unchecked. Such projects as deep wells which tap into non-replenishable *fossil* water and the reversion of the São Francisco River for irrigation of dry lands have been questioned by environmentalists. The history of other nations has provided innumerable examples (McPhee, 1990) of the futility of controlling nature. Only in man's omnipotent imagination is it possible to realize all goals and values in all regions.

Furthermore, the *caatinga*'s biodiversity has its own, largely unrecognized, importance (Conselho, 2004). Thousands of species have adapted to this apparently hostile environment and are not likely to survive transformation to irrigated farmland. The question which must be posed, as it was by economist Celso Furtado many years ago, is whether this large population can be sustainably supported in this region. Declining birth rates will stem secular out-migration, but will this be enough? From a sustainability perspective, it cannot be taken for granted that useful, productive employment can be found for such large numbers in this hostile environment. Continued investment is necessary to rectify centuries of neglect and impoverishment. But it is doubtful that nature can or should be "dominated" to these ends.

Campos do Sul

The *Campos do Sul* savanna, a smaller (257,470 km^2) but distinct ecosystem, is a region of level or slightly hilly lands, with isolated areas of forest and grassy plains. This is a highly urbanized (82% in 2000) region, with a population of 9,802,442 in 2000. One of Brazil's most developed, industrialized regions, its population density is relatively low (38.07 persons/km^2). The small-scale agriculture which predominated for over a century (especially since European immigration in the 19th century) began to lose its viability in the last decades of the 20th century. The region's emigrants were important contributors to colonization efforts in the Center-West and Amazon regions. One of the local consequences of these developments is the regeneration of forest cover over the last decades. Considering the human resources in this area (one of the most educated and skilled populations in the country) and the diminished pressure on natural resources, this may be the region where population-environment balance may be more easily reached. It is not likely, however, to represent an important alternative to the highly urbanized and densely populated Northeast and Southeast.

This brief overview of the population/environment balance reveals the great diversity which characterizes the relations between man and nature in Brazil. This diversity is not homogeneously distributed over the national territory. Differential natural resource endowments and the history of economic and population growth which impacted different

regions at different moments have produced a situation in which the major ecosystems are still clearly visible in demographic and environmental terms. Synthesizing the major differences, which have important consequences for sustainable development, we can emphasize:

1. the Amazon region, still sparsely populated, concentrates most of its population in cities (70%). In terms of national and planetary biological and cultural diversity, this is a region whose development must be carefully monitored. Environmental considerations should be paramount. In the long run, it will be recognized that Brazil was fortunate in that Amazon deforestation began in an era of environmental consciousness. There is still time to preserve, an option not open to many countries. Brazil will harbor, in the future, one of the only undisturbed tropical forests. The long-term advantages far outweigh the short-term gains intense development could bring. This favorable situation depends, for its realization, on maintaining low population densities.

2. the savanna-like *cerrado*, already intensively explored for grain production and cattle-raising, is also important in terms of biodiversity and potential carbon sequestration. Also a sparsely populated (8.2 persons per square kilometer) but highly urbanized (78%) region, the *cerrado* offers more opportunities for environmentally sustainable development. Population growth has not reached a situation of limits, but much care must be taken in locating economic activities in space.

3. the Atlantic Forest and the Coastal Region are the most complex of these biomes. While intact remnants of primary vegetation must be carefully protected, most of this forest has been lost, and the region's economic-ecological vocation has long been determined. In this region, the major environmental challenge is the recuperation of degraded areas and the implementation of long-term environmental safeguards. For extreme cases, such as the São Paulo Metropolitan Area, recuperation will probably have to be accompanied by population deconcentration. This process, already underway, if accelerated, could contribute to the region's sustainability. Considering the limited possibilities in other regions, most of the deconcentration will be in the direction of smaller cities within the region itself. Most likely, this region will also continue to absorb population contingents from the semi-arid region. The greater natural resiliency of this region has permitted – and will continue to permit – greater population densities.

4. the semi-arid *caatinga* faces enormous difficulties – perhaps insurmountable – in the effort to balance population and environment. With its inheritance of poverty and high population growth, the solutions proposed may not be environmentally sustainable. Sustainable development may require investments and job-creation for this population in environmentally more amenable areas.

5. the savannas of Southern Brazil offer limited possibilities for absorbing population. Considering its relatively well-educated population and higher levels of development, this region – if development is directed toward modern industrial and service sectors – should be able to retain its current population.

6. the *Pantanal* continues to be a thinly populated region, a situation which has not changed in the last decade. Its environmental integrity is both its most important natural inheritance and its most important basis for development. Tourism, however, must be closely monitored to avoid unsustainable pressure on resources. The population mobility represented by tourist movements is not so readily calculated as the population data presented here, but it is surely an important factor in the sustainable development of the region.

Inter-biome migration, 1980-2000

While this demographic picture does not pose dramatic prospects for environmental integrity, the most volatile dimension of population change, migration, has now – and will always have – the potential for the disruption of nature. What are migration trends in Brazil's major biomes? Do current trends point to problems in the short or long term? Is economic development proceeding in such a way as to conciliate population distribution with the conservation of natural resources?

The Brazilian census asked, in 1991 and 2000, the municipality of residence five years before the census date. This permits us to examine migrants (those who have resided fewer than ten years in the current municipality), according to the biome of residence in 1986/1991 and 1995/2000. The matrices in Tables 2 and 3 present these data. Almost always, the largest numbers are on the diagonal, i.e., when people move from one municipality to another, most remain within the same biome. In the 1986-1991 period, this was not the case only for the Pampas region (where slightly more migrants came from the Atlantic Forest) and in the Pantanal (which received twice as many migrants from the Atlantic Forest as from within the Pantanal; the numbers are small, in any case). The importance of the Atlantic Forest as origin is seen in all biomes and this is repeated in the 1995-2000 period. For the Pantanal, again, there are nearly twice as many migrants form the Atlantic Forest as from the Pantanal itself.

Table 2. Migrants according to biome of residence in 1995 and 2000.

Biome of residence in 1995	Biome of residence in 2000							
	Amazônia	Coastal Region	Pampas	Cerrado	Atlantic Forest	Semi-arid Region	Pantanal	Total
Amazônia	555 610	75 665	776	45 074	79 743	14 685	1 066	828 818
Coastal Region	62 664	281 987	642	15 616	256276	31 284	213	675 601
Pampas	1 638	708	57 153	2 073	84 178	397	87	146 721
Cerrado	43 909	6 739	811	521 574	299782	21 019	13 985	987 274
Atlantic Forest	86 911	215 162	49 311	354 073	7320602	218 597	22 723	8 368 214
Semi-arid Region	27 265	40 484	444	80 208	520 974	638 202	786	1 357 137
Pantanal	1 925	286	118	17 772	27 518	343	12 885	62 927
Total	949 620	695 602	110 840	1 209 603	9186487	1 039 061	54 952	13 886 266

Source: Population Census, 2000. These totals include the ecotones and those migrants who did not declare their prior residence.

Table 3. Migrants according to biome of residence in 1986 and 1991.

Biome of residence in 1986	Biome of residence in 1991							
	Amazônia	Coastal Region	Pampas	Cerrado	Atlantic Forest	Semi-arid Region	Pantanal	Total
Amazônia	399 896	73 417	807	36 048	89 954	19 528	1 717	685 888
Coastal Region	64 036	277 258	499	12 811	275 083	38 430	357	703 048
Pampas	994	528	61 752	2 350	88 706	245	194	155 437
Cerrado	41 606	7 160	1 231	465 873	306 968	21 222	11 203	914 087
Atlantic Forest	128 885	236 474	62 423	372 002	7 336 525	239 812	24 606	8 518 456
Semi-arid Region	41 324	48 093	328	79 481	543 803	844 156	923	1 614 985
Pantanal	1 930	258	149	17 773	28 357	150	11 812	62 176
Total	2 741 787	2 693 821	508 644	4 065 743	39 326 319	4 846 754	172 574	56 518 875

Source: Population Census, 1991. These totals include the ecotones and those migrants who did not declare their prior residence.

This detailed analysis should not divert our attention from the tremendous change in the order of magnitude of the migration phenomenon. By the definition employed here, the number of migrants in Brazil declined from 56 million in 1991 to 13 million in 2000. Intense urbanization, accompanied by the economic preeminence of Southeast Brazil, produced large-scale migration during the 1950-1980 period. This movement has run its course, and current migration patterns reflect lower volumes, less long-distance movement and greater short-distance mobility, as well as significant return migration.

A look at the most recent migratory movements confirms these trends and permits a view of the consequences for biomes considered as conservation priorities. In this paper, we capture recent migration with one indicator of migration – the number of migrants who have resided for under one year in the municipality of destination. We take this as an indicator of the intensity of movement experienced in each biome. This number includes migrants both from other biomes and from other municipalities within the biome, excluding those natives who were returning to their place of birth.

In 1980, these migrants totaled 5,327,294, declining by four million by 2000, a dramatic sign of how the population mobility which characterized Brazilian society from 1950 to 1980 has changed. The decline was 46.5% from 1980 to 1991 and 55.3% between 1991 and 2000. At the biome level, the rhythm of this decline varied. In the most recent decade, declines were steep in the two most populous regions – the Atlantic Forest (60.3%) and the *caatinga* (63.6%) – and much more modest in the regions which provoke most concern today, the Cerrado (29.5%) and Amazônia (10.0%). The smaller Pampas region suffered the greatest relative decline (81.8%). These mixed results call attention to the declining pressures in the most populated, devastated region of the Atlantic Forest, where environmental management measures may now operate in a more favorable demographic regime. It should e noted, however, that although the volume of movements has declined considerably in 20 years, the Atlantic Forest still accounts for 58.8% of the mobility observed.

When we examine the share of recent migrants according to the biome of destination (see Tables 4 and 5), a clear picture emerges. In Amazônia and in the *cerrado*, recent migrants doubled their importance in 20 years, now accounting for 8.3% and 14.1%, respectively, of migrants with under one year's residence. This growth has been at the expense of the Atlantic Forest, principally, and the Coastal Region, while the Pampas, the *caatinga* and the Pantanal saw little change. This reinforces the view that, while these two reigons still account for a smaller part of total mobility (22.4%), the rate of growth of this share means that sustainable alternatives for the economic insertion of these migrants is crucial. Again, the Atlantic Forest still accounts for most mobility (58.5%), but the decline over 20 years suggests that there is room for policy responses to work.

Table 4. Decline in the volume of recent migration: percent decline in the number of migrants with under one year's residence in 1991 and 2000, by biome of residence in the census year.

Census interval	Amazônia	Coastal Region	Pampas	Cerrado	Atlantic Forest	Semi-arid Region	Pantanal	Total
1980-91	47.2	51.6	43.3	38.1	49.4	28.2	55.8	46.5
1991-2000	10.0	64.3	81.8	29.5	60.3	63.7	49.1	55.3

Source: Population Census, 1980, 1991, 2000.

Table 5. Recent migration, by biome of residence in the census yuear: percent of migrants with under one year's residence in 1980, 1991 and 2000.

Year	Amazônia	Coastal Region	Pampas	Cerrado	Atlantic Forest	Semi-arid Region	Pantanal
1980	4.2	5.2	0.8	7.7	69.7	8.1	0.4
1991	4.1	4.7	0.9	8.9	65.9	10.9	0.4
2000	8.3	3.7	0.4	14.1	58.5	8.9	0.4

Source: Population Census, 1980, 1991, 2000. These numbers do not sum to 100% because the ecotones are not represented here.

Conclusions

This brief review of population-environment concerns in Brazil's major ecological formations reveals the great diversity of situations in the country, as well as the greater range of possibilities for achieving population-environment balance, compared to other countries. But it is time to begin to ask hard questions about centuries-long settlement patterns and their sustainability in the centuries ahead. Brazil has some room for maneuver. Optimizing quality of life suggests that the sooner consensus is reached on the "ecological-economic vocations" of different regions, the greater will be the possibility of achieving this optimum.

The large regions presented here are subject to two major qualifications. Firstly, many of these regions are not so homogeneous as this classification supposes. Ecologists have identified sub-categories in each of these regions and they may (probably) have different demographic characteristics. Secondly, overlapping boundaries, in transition zones known as ecotones, have distinct ecological properties. Not analyzed in this paper, these zones account for a not inconsiderable population of 7,218,464 but a low population density of 7.35 persons per square kilometer). In these ecotones, the mix of natural conditions has permitted peculiar and unique combinations of plant and animal species, interacting in a more fragile equilibrium. In this paper, they represent a residual category,

which suggests a more detailed analysis in the future. In both cases, the consequences of human presence – numbers, their distribution and economic activities – will have distinct consequences. Their study represents a further phase in the research reported here.

The bottom line of this analysis is that population growth continues to be the red herring of contemporary environmentalism. As long as attention can be focused on population growth, responsibility can be laid at the doorstep of individual reproductive behavior. The solution would be at the individual level. But the record-high deforestation of Amazônia in 2004 is not the result of population pressure, but of the expansion of soybean production and lumbering. Until environmentalist concerns change production and consumption patterns, this is unlikely to change. The Plan of Action from the Cairo conference gave equal time to population and production/consumption patterns. But in many cases, and the Brazilian situation is one of them, this solomonic solution does not reflect today's reality. Insistence on the population factor becomes a diversionary process.

Attention is diverted from economic factors, which are paramount, and from the population factor with the most potential for provoking environmental change, migration. The analysis presented in this paper suggests that there are windows of opportunity in the current demographic regime. Regional development planning, which will have consequences for redirecting migration movements, must increasingly take into account the economic-ecological role of different regions. Current population trends, including migration, are favorable in Brazil; it remains to be seen whether this advantage will be used in the most positive way.

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