São Paulo peri-urban dynamics: some social causes and environmental consequences

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ABSTRACT This paper shows that the demographic growth of São Paulo's Metropolitan Area is very uneven. While the centre of the city is losing population, its farthest suburbs are growing quite fast. Furthermore, those fast growth areas are the poorest of the metropolitan area, with less infrastructure than other areas within the region and high levels of deforestation and informal land use. The objective of this paper is two-fold: first, it explains the reasons for these intra-urban dynamics by showing that the city is losing population in exactly the places where real estate investments are growing most significantly; second, it seeks to explore the environmental consequences of this pattern of urban sprawl – such as the occupation of environmentally protected areas – by presenting data on forest cover reduction. The approach is original in that it contrasts socioeconomic, demographic and environmental trends within the city of São Paulo according to the rate of population growth of each of the city's areas, instead of employing the more conventional comparison of municipalities.

KEYWORDS deforestation / environmental degradation / informal settlements / land markets / peri-urban areas / population growth / São Paulo's Metropolitan Area / urban sprawl

I. INTRODUCTION

The general argument of this paper is that the connection between population growth and urban environment should not be considered in an abstract way, as if all urban environments and institutional contexts were the same. The interplay between population and environment must be considered in the context of "concrete territories", with all their institutional complexity and social and environmental diversity. In the case of São Paulo's Metropolitan Area, we propose that the particular dynamics of the land market – affected by land use regulations and public policies (i.e. transportation and housing) – strongly influence the dynamics of urban sprawl and its environmental impacts.

This argument contrasts with the Brazilian expectation that the decline in the rate of population growth would positively impact this metropolis, reducing the need for public investment in urban infrastructure and social policies.[1] In fact, between the 1970s and the 1990s, the rate of population growth declined remarkably in the São Paulo Metropolitan Area, from 4.5 per cent to 1.5 per cent a year, falling to the Brazilian national average. Different demographic projections, such as the one produced by the

1. To some extent, this local hypothesis relates to the

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São Paulo State Bureau of Statistics (SEADE), forecast a stable population for the metropolitan area in the near future.[2] However, the expectations of a more sustainable development have not been fulfilled: while the centre of the city is losing significant population, the share of the population in peri-urban areas is still growing very fast, going from 19 per cent in 1991 to 30 per cent in 2000. As a result, the region still demands strong public investment in transportation and other urban infrastructure, with considerable environmental impact for the city.[3]

In view of these elements, the first objective of this paper (Section II) is to investigate the evidence of urban sprawl. In Section III, we explain why this intra-urban dynamic is taking place by comparing spatial patterns of population growth and real estate investments. We intend to show that – surprisingly – the city is losing population exactly in the same places where real estate investments are growing most significantly.[4] Population growth, on the other hand, happens mainly in areas where the price of land is low.

In Section IV, we argue that this sprawl is producing an important land use transformation, leading to the destruction of the natural environment around the metropolitan area and the contamination of water sources. We show that the urban sprawl is connected to the deforestation and occupation of environmentally protected areas, especially those with fewer environmental restrictions, such as the APAs (*Área de Proteção Ambiental*, or environmentally protected areas) and APMs (*Área de Proteção de Mananciais*, or water source protection areas).[5] In spite of this evidence, the connection between population growth and environmental degradation in São Paulo's peri-urban area is not clear-cut, as is implied by most environmental literature.[6] Finally, in a brief conclusion, we explore the arguments presented here from the point of view of public policy.

II. URBAN SPRAWL AND PERI-URBAN AREAS

The demographic growth of São Paulo's Metropolitan Area has been very unevenly distributed in the past decade. While the central areas of the most important municipalities within the region – including São Paulo (expanded downtown area), Guarulhos (northeast), ABC (southeast) and Osasco (west) – have lost population in absolute terms, some areas located on the outskirts of the city have expanded very fast. Map 1 presents the spatial distribution of the population growth of census survey areas (*áreas de ponderação*) for the urbanized area of São Paulo metropolis, which consists of 21 municipalities.[7]

The areas located in the external ring of the region have experienced a significant population growth rate of more than 3 per cent, and often more than 5 per cent, a year. We can also observe that there are practically no census areas in the expanded downtown part of the city that present positive growth, the only exceptions being Paraisópolis and Heliópolis, São Paulo's largest shanty towns.

Contrary to the American medium- to high-income urban sprawl,[8] the demographic growth of the Brazilian peri-urban regions results from the extension of existing poor areas, almost all of which are located in the suburbs in the case of São Paulo.[9] As to the high- and medium-income areas of the city, most are losing population, with Alphaville and Vila Andrade in the western part of the city being the only exceptions.

so-called "urban transition theory", which assumes that the long-term reduction of rural–urban migration would lead cities to achieve a more sustainable pattern of development. See Livi-Bacci, M and G De Santis (1998), *Population and Poverty in Developing Countries*, Oxford University Press, International Studies in Demography, Oxford.

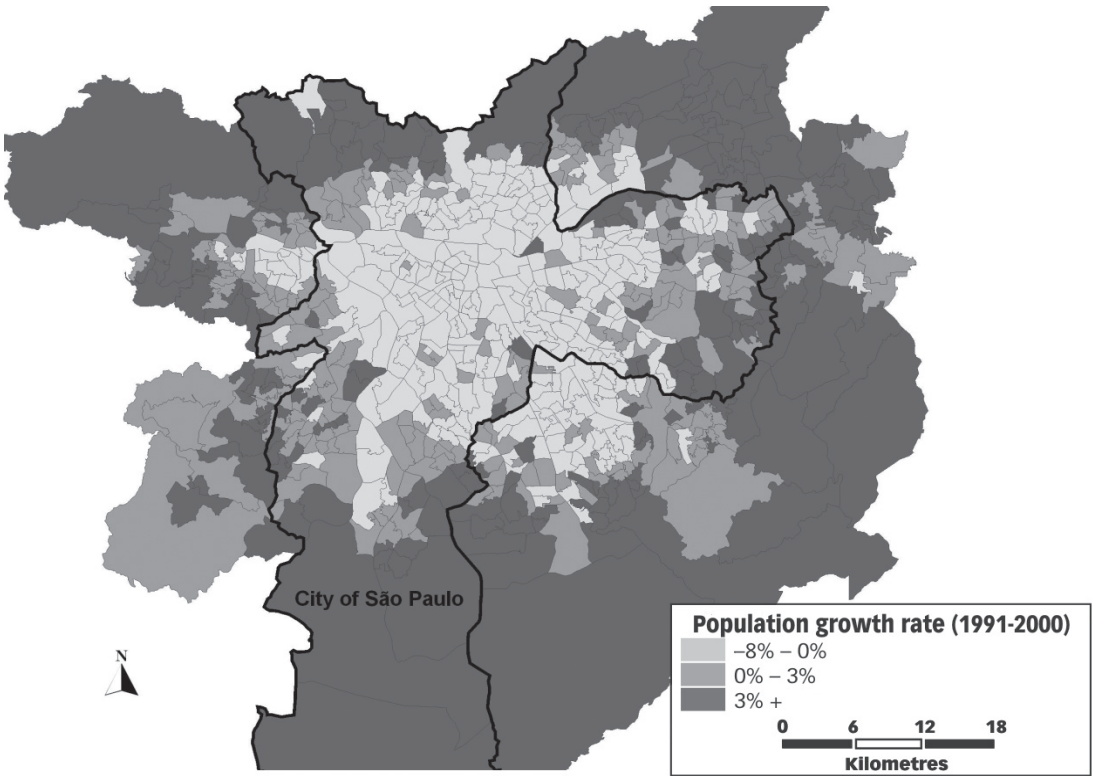
2. Waldvogel, B C (2003), "Projeção de população como instrumento de planejamento", *São Paulo em Perspectiva* Vol 17, No 3–4, pages 67–79.

3. For an overview of São Paulo's urban and environmental issues, see Bonduk, Nabil and Rachel Rolnik (1979), *Periferia – Ocupação do Espaço e Reprodução da Força de Trabalho*, FAU/USP and Fundação para a Pesquisa Ambiental, São Paulo; also Caldeira, Teresa (2000), *City of Walls: Crime, Segregation and Citizenship in São Paulo*, University of California Press, Berkeley; and Jacobi, P R (1994), "Households and environment in the city of São Paulo: perceptions and solutions", *Environment & Urbanization* Vol 6, No 2, October, pages 87–110.

4. Most of those analyses benefit from the GIS database developed at the Centre for Metropolitan Studies (CEM-Cebrap), where census data (1991, 2000), satellite images and real estate data are all available in GIS format. The authors used Maptitude, Envi and Arcview as their GIS software. See www.centrodametropole.org.br

5. APAs and APMs consist mainly of private land with strong usage restrictions. The Atlantic Forest Biosphere Reserve, the Billings/Guarapiranga water reservoirs and the Serra da Cantareira's APAs are the most important examples.

6. Mather, A S and C L Needle (2000), "The relationships of population and forest trends", *The Geographical Journal* Vol 166, pages 2–13; also Allen, J C and D F Barnes (1985),



MAP 1
Rate of population growth of census survey areas 1991–2000: São Paulo's urbanized area

SOURCE: IBGE, *Demographic Census 1991 and 2000*, IBGE, São Paulo.

In aggregate terms, the recent demographic changes in São Paulo may be considered rather unsettling. While the region as a whole was growing in moderate terms (1.5 per cent a year in the 1990s), the central negative growth areas lost population quite fast (–2.1 per cent a year); in contrast, peri-urban fast growth areas were growing at the impressive rate of 8.1 per cent (Table 1).

As a consequence, the population in negative growth areas decreased from 6.7 to 6 million inhabitants between 1991 and 2000. In slow growth areas (less then 3 per cent a year), it increased from 4.9 to 5.5 million, while in the peri-urban fast growth areas (more than 3 per cent a year) the population grew from 2.8 to 4.9 million inhabitants, a rise of 2.1 million. In 2000, these peri-urban areas represented 30 per cent of the total population of the region. Without their contribution, the urbanized region of São Paulo would have maintained a stable population in the 1990s.[10]

Intense demographic variations of this kind have important consequences for public policy. The expectation that a slower population growth rate would reduce the pressure on public service supply is only partially true. In the new peri-urban areas, the government must build new infrastructure – i.e. streets, schools, healthcare facilities and basic sanitation networks. The persistent horizontal growth of the city requires

"The causes of deforestation in developing countries", *Annals of the Association of American Geographers* Vol 75, pages 163–184.

7. The São Paulo Metropolitan Area is an official definition that includes 39 municipalities. Here, we use only 21 municipalities because of problems with data availability. The municipalities considered here form a continuous urban area that accounts for 92 per cent of the metropolitan area's total population. Census survey areas are the spatial units used in the 2000 census, which allow tabulations for the census survey.

8. Duany, Andres, E P Zyberk and J Speck (2000), *Suburban Nation: The Rise of the Sprawl and the Decline of the*

Table 1
Population and rate of population growth according to groups of areas: São Paulo's urbanized area, 1991–2000

Groups of areas according to population growth rate 1991–2000 (%)	Population 1991	Population 2000	Population growth rate 1991–2000 (%)
–8 to –1.5	2,316,493	1,916,522	–2.08
–1.5 to 0	4,401,256	4,130,804	–0.70
0 to 1.5	3,076,605	3,299,875	0.78
1.5 to 3	1,844,554	2,246,932	2.22
3 to 5	1,259,512	1,772,233	3.87
5+	1,534,626	3,102,189	8.13
Total	**14,433,045**	**16,468,555**	**1.48**

SOURCE: IBGE, *Demographic Census 1991 and 2000, IBGE*, São Paulo.

a continuous extension of the public services network to the peri-urban areas, even when the facilities located in the central areas are not being used to their full potential. It is also important to note that this region covers an area of about 60 kilometres by 70 kilometres, and that the transportation system is crowded and expensive. In other words, it is not realistic to imagine that peri-urban residents would easily access services available only in central areas.[11]

Peri-urban areas also show, unsurprisingly, the worst socioeconomic indicators, with high levels of poverty, illiteracy and unemployment. Table 2 shows that family income in very negative growth areas (8.1 minimum

TABLE 2
Socioeconomic and sanitation indicators of São Paulo's urbanized area, 1991–2000

	Groups of areas according to population growth rate (%) 1991–2000						
	–8– –1.5	–1.5 – 0	0–1.5	1.5–3	3–5	5+	Total
Family income*	8.11	4.75	3.26	2.70	1.87	1.66	3.86
Average years of schooling of heads of household	9.89	8.14	7.08	6.44	5.89	5.55	7.27
Unemployment rate (%)**	13.13	16.32	19.31	21.68	23.72	24.93	19.32
Proportion of afro-descendants (%)	13.87	20.88	31.12	37.30	41.85	44.99	30.12
Proportion of children aged 0–4 (%)	5.39	6.95	8.74	9.86	10.73	11.68	8.82
Water (%)	99.86	99.79	99.41	97.99	95.39	92.00	97.69
Sewage (%)	97.94	94.84	87.64	80.11	74.66	59.46	83.74
Household density	2.92	3.36	3.56	3.69	3.77	3.83	3.50

*In minimum wages (ca. US$ 150 in 2006).
**Does not correspond to official unemployment estimates due to differences in the methodology adopted by the Brazilian census.

SOURCE: IBGE, *Demographic Census 1991 and 2000*, IBGE, São Paulo.

American Dream, North Point Press, New York.

9. Torres, H G (2002a), "Population and the environment: a view from Brazilian metropolitan areas", in D Hogan, E Berquó and H Costa, *Population and Environment in Brazil*, CNPD/ABEP/NEPO, Campinas, pages 147–166.

10. IBGE data (1991 and 2000 censuses) clearly indicate that the strong population growth in peri-urban areas stems from the migration of people external to the metropolitan area. The potential migration from downtown areas to peripheral ones, together with stable growth, would not be enough to explain the impressive growth of peri-urban areas. According to the data available, although such areas accounted for only 19 per cent of the urban sprawl population in 1991, during the 1990s they became the destination of 42 per cent of migrants from other states, and of 46 per cent of migrants coming from the northeast of Brazil. See Torres, H (2005), "A fronteira paulistana", in E Marques and H Torres (editors), *São Paulo: Segregação, Pobreza Urbana e Desigualdade Social,* Editora do Senac, São Paulo.

11. See reference 9.

wages) is almost five times higher than that of fast-growing peri-urban areas (1.7 minimum wages). These income differentials are associated with high levels of unemployment and illiteracy, and can also be expressed in terms of sanitation indicators – i.e. water supply, garbage and sewage collection. This poor and illiterate peri-urban region also concentrates the largest proportions of children aged 0–4 (11.7 per cent) and afro-descendants (45 per cent).[12]

This kind of urban sprawl has significant environmental consequences with regard to transportation and pollution. Peri-urban housing means longer journeys and additional air pollution;[13] and poor peri-urban areas means not only a lack of sanitation and pollution of rivers and streams, but also deforestation and destruction of the natural landscapes that still surround São Paulo.[14]

III. URBAN SPRAWL AND LAND MARKETS

Between 1995 and 2003, there was significant residential real estate investment in São Paulo. Private companies embarked on more than 7,500 residential projects, including nearly 400,000 residential units, 3 million square metres of floor area and almost US$ 10 billion in private investment.[15] These figures refer to private company projects alone and do not include investments made by families and individuals. Surprisingly, the bulk of such investment took place in areas that lost a significant share of their population between 1991 and 2000. Evidence of this argument is presented in Map 2.

In other words, there seems to be a limited connection between housing production by private companies and the strong dynamics of population growth in the far suburbs. Housing units built by private companies have been offered almost exclusively to medium- and high-income families. Only 11 per cent of such projects involved houses or apartments with less than 50 square metres of residential area, which is considered to be more cost-effective for low-income families. However, even those small apartment projects were located in rich areas and were sold as residential hotels that are not affordable by the poor. Overall, private companies never intended to sell residential projects to poor dwellers, since their income levels made such housing units unaffordable for either acquisition or rental purposes. This dynamic is strongly associated with real estate prices. In Map 3, we present the average distribution of land prices in the São Paulo Metropolitan Area.

By comparing Maps 2 and 3, it is possible to observe what seems to be a significant correlation between high land prices and negative population growth. Areas with strong population growth presented mostly low land prices or no real estate development in the past two decades. Although we have little individual data to support such an argument, the ecological data presented here also work as evidence in this case, as almost no private companies invest in the fast-growing poor suburbs. Table 3 summarizes the data available on this issue.

In fact, the data show that the areas with high land prices (and strong real estate investment) are losing population. On the other hand, those with no development, and probably low land prices, are growing faster.[16] Self-built houses in areas with low land prices or in illegal settlements explain the growth of poor suburbs. By analyzing the available information,

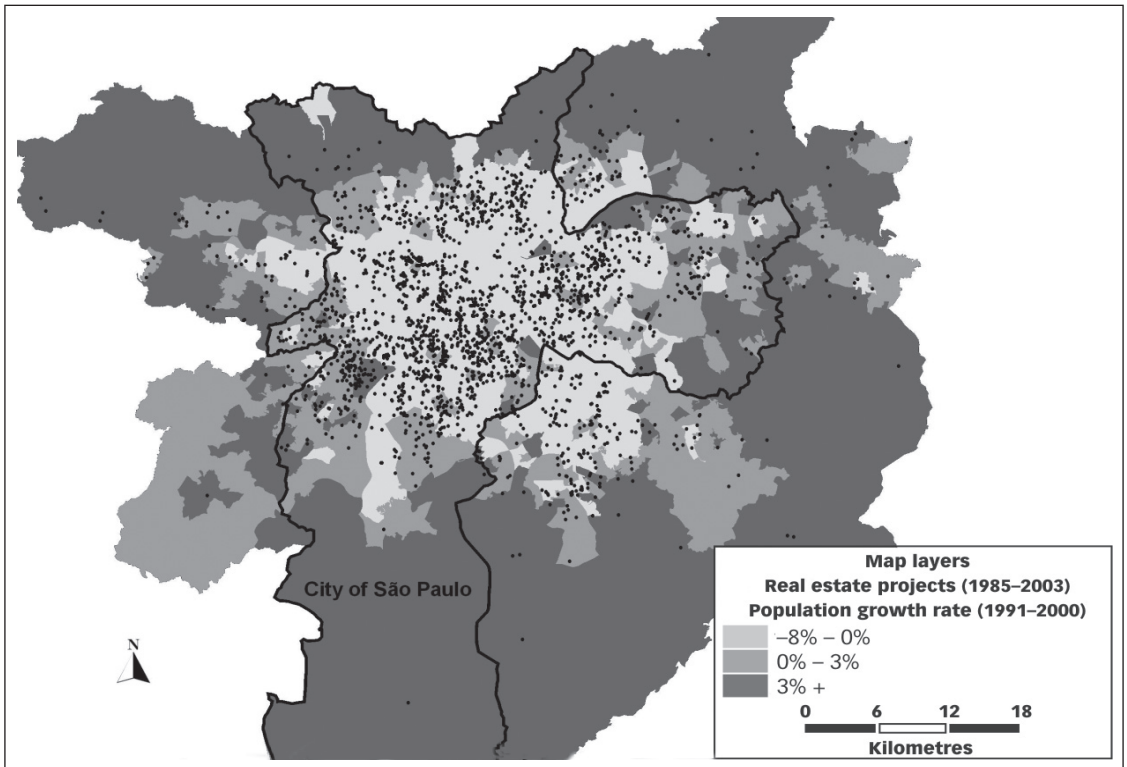
12. It should be noted that the results presented in this paper would have been slightly different had the focus been on a comparison of groups of areas according to the growth in the number of households rather than on population growth, since typically, middle- and upper-income groups comprise smaller families and more single individuals living alone. Focusing on the number of households, however, would not have altered the general conclusions presented here.

13. Most people living in peri-urban areas are poor and tend to use public transport (buses, vans and trains). As a result, air pollution implications for such areas are less severe than if the population were from middle- and upper-income groups that drive private cars.

14. We further discuss this issue in Section IV.

15. See Embraesp *Bulletin 1985–2003*, São Paulo, which registers all new real estate investments advertised in newspapers.

16. The negative growth areas received the largest amount of private investment (70 per cent), while the fast growth areas (growing at more than 3 per cent a year) received only 6 per cent of the total investment between 1985 and 2003.



MAP 2
Real estate investment (1985–2003) and rate of population growth of census survey areas (1991–2000): São Paulo's urbanized area

SOURCE: IBGE, *Demographic Census 1991 and 2000*, IBGE, São Paulo; also Embraesp *Bulletin 1985–2003*, São Paulo.

TABLE 3
Total population and growth rate for areas classified according to their average square metre price of new real estate investment: São Paulo's urbanized area

US$ per square metre (1985–2003)	Population 1991	Population 2000	Growth rate 1991–2000 (%)
No development	5,793,832	7,462,966	2.85
Less than 1,000	4,131,638	4,590,084	1.18
1,000–1,500	4,004,931	3,962,867	–0.12
1,500 +	502,645	452,638	–1.16

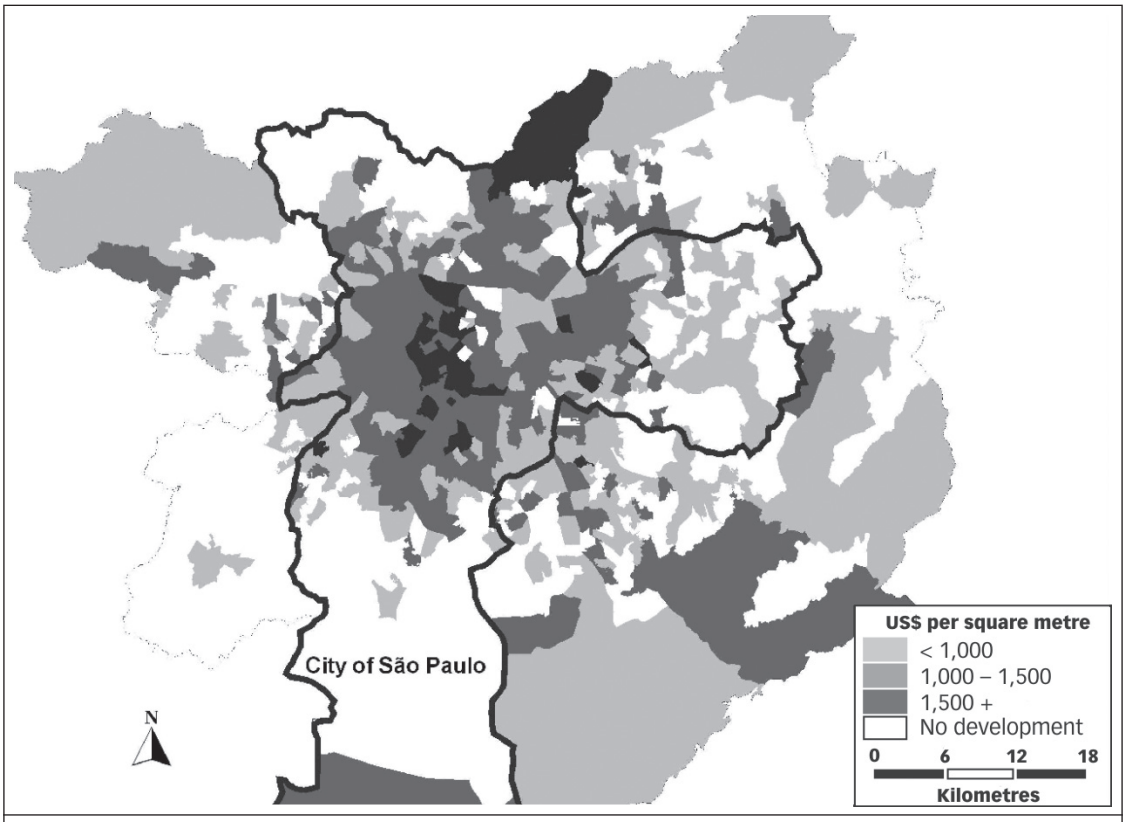
SOURCE: IBGE, *Demographic Census 1991 and 2000*, São Paulo; also Embraesp *Bulletin 1985–2003*, São Paulo.

we also conclude that poor areas receive no investment from private companies, indicating an increase in the already high level of residential segregation.[17]

In summary, we can say that during the 1990s, the metropolitan area received an additional 96,000 households every year.[18] On average,

17. Torres, H G (2004), "Segregação residencial e políticas públicas: São Paulo na década de 1990", *Revista Brasileira de Ciências Sociais* No 54, pages 41–56.

18. The total number of households (occupied or not) reached 3.8 million in 1991 and 4.7 million in 2000 in the 21 municipalities considered in this analysis. This represents a yearly growth rate of 2.3 per cent.



MAP 3
Average square metre price of new real estate investment (1985–2003): São Paulo's urbanized area

SOURCE: Ebraesp *Bulletin 1985–2003*, São Paulo.

investments from private companies were responsible for only 23 per cent of this increase. Public housing projects were almost insignificant,[19] indicating that most new units were built by families and individuals in very far suburbs, which explains the significant peri-urban demographic growth. This also shows that the general pattern described in the 1970s – of poor urban dwellers living in self-built houses in the so-called "peripheries" of the city – is still true for São Paulo in the 1990s.[20]

a. The role of informal markets

Informal settlements are yet another important dimension of this process. Due to the lack of affordable housing, the poor population ends up living in different types of informal settlements, such as flophouses, irregular developments and shanty towns. A recent study by the Secretariat for Housing of the City of São Paulo estimates that at least 25 per cent of its households are in either shanty towns or illegal developments.[21] However, illegality and/or informality in São Paulo should be even higher since it takes place within the context of a complex arrangement of land

19. The data available are quite controversial and incomplete. Considering only the city of São Paulo (which accounts for 60 per cent of the population of the metropolitan area), the average production of new households by the city government was less than 4,000 per year between 1989 and 2003. This does not include the investment in urban regularization and shanty town urbanization. For further information, see Marques, E and C Saraiva (2005), "As políticas de habitação social no município de São Paulo", in Marques and Torres (editors), see reference 10.

20. Kovarick, Lúcio (1979), *A Espoliação Urbana*, Paz e Terra, Rio de Janeiro; also Maricato, E (1979), "Autoconstrução,

use regulations, including building norms, environmental constraints on land occupation, infrastructure regulation on neighbourhood development, zoning, and property rights.

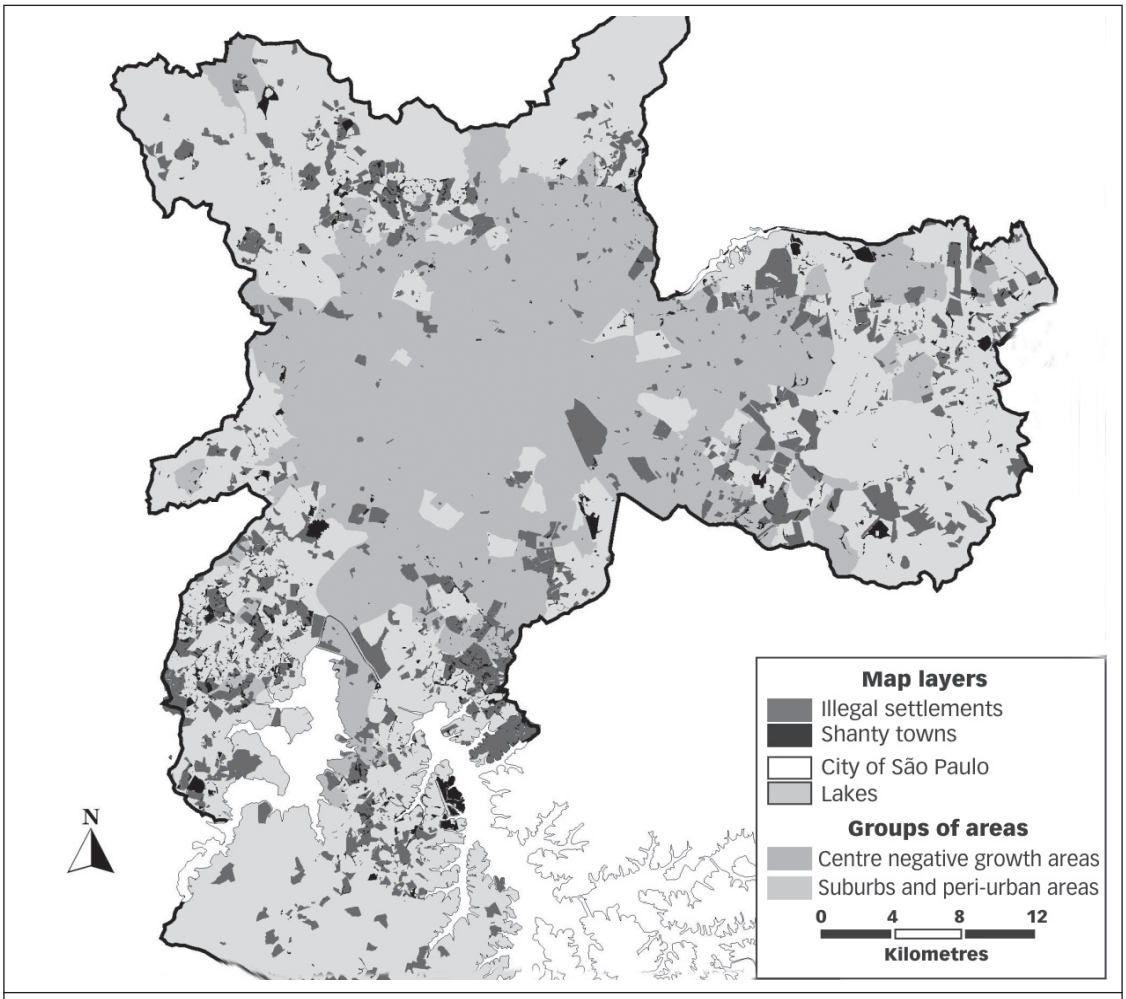
As a consequence, only a small part of the city – which has also been called "the legal city" – is to some extent comparable to a city in a high-income country.[22] Private investment usually takes place in this legal part – i.e. the central areas of São Paulo – while most shanty towns and illegal settlements are located in poor suburbs and in peri-urban areas (Map 4 and Table 4).[23]

Shanty towns are much more frequent in the peri-urban areas (19.3 per cent of the local population) than in the central negative growth areas (4.3 per cent), and the same pattern is replicated by illegal settlements, which contain almost 24 per cent of the population of peri-urban

a arquitetura possível", in Maricato, Ermínia (editor) *A Produção da Casa (e da Cidade) no Brasil Industria*, Alfa-Ômega, São Paulo.

21. SEHAB (2003), *Plano Municipal de Habitação*, PMSP, São Paulo.

22. Grostein, Marta (1987), "A cidade clandestina: os ritos e os mitos. O papel da irregularidade na estruturação do espaço urbano no município de São Paulo – 1900–1987", Doctoral thesis, FAU/USP, São Paulo.



MAP 4
Distribution of shanty towns and illegal settlements in the city of São Paulo, 2000

SOURCE: Secretariat for Housing of the City of São Paulo (2002).

areas, but only 9.8 per cent of the population of central areas. In the poor slow growth areas (less than 3 per cent a year), the percentage of population living in shanty towns and illegal settlements is 15.5 per cent and 17.4 per cent, respectively.

23. Unfortunately, we only have data for the city of São Paulo to support this argument.

TABLE 4
Population living in shanty towns and illegal settlements: city of São Paulo, 2000

	Groups of areas			
	Negative growth areas	**Slow growth areas >0 – <3%**	**Fast growth areas >3% a year**	**Total**
Population living in shanty towns	208,478	527,462	430,283	1,166,223
Population living in illegal settlements	470,112	591,009	529,862	1,590,983
Total	**678,590**	**1,118,471**	**960,145**	**2,757,206**
Population living in shanty towns (%)*	4.34	15.50	19.27	11.18
Population living in illegal settlements (%)*	9.80	17.37	23.72	15.25
Total (%)*	**14.14**	**32.87**	**42.99**	**26.43**

*Percentage of population living in shanty towns or illegal settlements in relation to the total population of the group area.

SOURCE: IBGE, *Demographic Census 2000*, IBGE, São Paulo; also Secretariat for Housing of the City of São Paulo, 2002.

Illegal occupation accounts for 43 per cent of the population living in fast-growing peri-urban areas of the city of São Paulo. Such illegal occupation of the poor peri-urban areas seems to be part of the same process that induces the strong rate of population growth in these areas. In the case of São Paulo, there are diverse institutional barriers for the provision of proper infrastructure and social services in irregular and/or invaded areas. This high level of irregularity "justifies" the non-provision of social services or the limits imposed upon their potential availability.

Even when the state decides to invest in irregular settlements, it is more difficult to find proper sites for social facilities on irregular or illegal land. Moreover, the state must follow complex legal procedures in order to appropriate private land and takes longer to find proper land for public facilities close to illegal developments and shanty towns. Sometimes, the state decides not to invest in such areas because of the risk of losing its public investments, since the private landowners may incorporate them later. Lawsuits against public administrators who do not follow the complex set of standard procedures may also be instigated with regard to land use regulations.[24]

It has been argued frequently that informal land use is a major issue for developing countries. Some defend the regularization of land property and the simplification of norms and regulations as important preconditions for further social and economic development in this kind of urban area.[25] However, the links between land use and social policies need

24. Maricato, Ermínia (1996), *Metrópole na Periferia do Capitalismo: Ilegalidade, Desigualdade e Violência*, HUCITEC, São Paulo; also Torres, H G (2002b), *Social Policies for the Urban Poor: The Role of Population Information Systems*, UNFPA Country Support Team for Latin America and Caribbean, Mexico City.

25. "*Only well-functioning land markets can provide an adequate supply of housing, and maintaining these markets is another task that deserves attention from the public sector. Providing universal registration and establishing clear property rights to all urban land will require strengthening existing institutions. Ill-defined land rights render land useless and discourage the redevelopment of entire portions of a city. But simply providing security of tenure creates incentives to improve housing and infrastructure dramatically. To avoid adding to the backlog of problem housing and neighbourhoods, new development must meet basic – but not excessive – compliance standards*." See World Bank (1999), *Entering the 21st Century: World Development Report 1999/2000*, Oxford University Press, New York, page 146.

to be addressed more extensively, since public services must be present even when land regularization is not in force. In the case of Brazil, some of these services are considered even to be constitutional rights.[26]

In summary, in the case of São Paulo, it seems quite clear that the urban sprawl is more strongly related to land market dynamics (and the role of government) than to demographic dynamics per se.[27]

IV. URBAN SPRAWL AND ENVIRONMENTAL DEGRADATION

One of the most significant environmental impacts of the urban sprawl of São Paulo has been its contribution to the massive destruction of the green belt of Atlantic rainforest surrounding the city. The Atlantic rainforest is one of the most endangered ecosystems in the world. Different studies on deforestation estimate that less than 10 per cent of the original forest remains in Brazil and the rate of destruction is still high.[28]

The urban sprawl was followed by a significant destruction of the remaining forests in São Paulo's Metropolitan Area, with little respect for the restrictive environmental legislation that forbids deforestation of the Atlantic rainforest (by-law 750/93). These green areas are part of the so-called Atlantic Rainforest Biosphere Reserve (a UN initiative) and are key for different ecological dynamics, since they serve as ecological corridors and routes for migratory species. They also play a fundamental role in the conservation of water sources.[29]

São Paulo's Atlantic rainforest greenbelt has been partially preserved – especially in its northern and southern parts – mainly because the topography of the remaining areas does not allow for agricultural exploitation. The south region is part of the water sources protection area and its already high population growth has intensified in the last decade. More recently, the northern area of São Paulo around the fringes of the Cantareira moun-tain range has also been growing rapidly.

In 1991, the municipalities of the metropolitan area considered in our study still presented a forest cover of 1,243 square kilometres (34.6 per cent of the metropolitan area), mostly in preserved areas and strategic sites for the protection of water reservoirs. By 2000, the remaining forest cover in the same municipalities was 1,179 square kilometres (32.8 per cent of the region).

These figures are good news in that they indicate the metropolitan area still has a substantial forest cover. However, the data also indicate an important net loss of forest cover (64 square kilometres) during the 1990s, a rate of 5.1 per cent over nine years.[30] Even if this deforestation is not very great when compared to the rate of destruction of other Brazilian areas such as the Amazon rainforest,[31] it is nevertheless quite damaging for São Paulo both because of previous losses and because of the strategic environmental services the forested area provides for the metropolis – i.e. protection of water sources and a reduction in air pollution.

In Map 5, we present the distribution of forested areas in São Paulo in 2000 according to our estimates, highlighting the areas that suffered higher levels of deforestation during the 1990s (more than 2 per cent within the decade). In geographic terms, most of the deforestation took place in some of the far suburbs that experienced significant growth in the 1990s.

It is possible to observe that the city centre is almost completely deforested, while large parts of the suburbs are still covered with forest.

26. For a discussion of these topics, see Budds, Jessica with Paulo Teixeira and SEHAB (2005), "Ensuring the right to the city: pro-poor housing, urban development and tenure legalization in São Paulo, Brazil", *Environment & Urbanization* Vol 17, No 1, April, pages 89–114.

27. Sabatini, F, G Cáceres and J Cerda (2001), "Residential segregation pattern changes in Chile's main cities: scale shifts and increasing malignancy", Paper presented at the International Seminar on Segregation and the City, Lincoln Institute of Land Policy, 26–28 July, Cambridge, Mass.

28. Fundação SOS Mata Atlântica (1998), *Atlas da Evolução dos Remanescentes Florestais e Ecossistemas Associados do Domínio da Mata Atlântica no Período 1990–1995*, Fundação SOS Mata Atlântica/Instituto Nacional de Pesquisas Espaciais, São Paulo; also Dean, Warren (1995), *With Broadax and Firebrand: The Destruction of the Brazilian Atlantic Forest*, Stuart B Schwartz, New York.

29. Marcondes, M J A (1999), *Cidade e Natureza: Proteção dos Mananciais e Exclusão Social*, Studio Nobel / Editora da USP / FAPESP (Coleção Diade Aberta), São Paulo; also Lino, L F (editor) (1992), *Reserva da Biosfera da Mata Atlântica. Plano de Ação. Vol 1: Referências Básicas*, Consórcio Mata Atlântica e Universidade Estadual de Campinas.

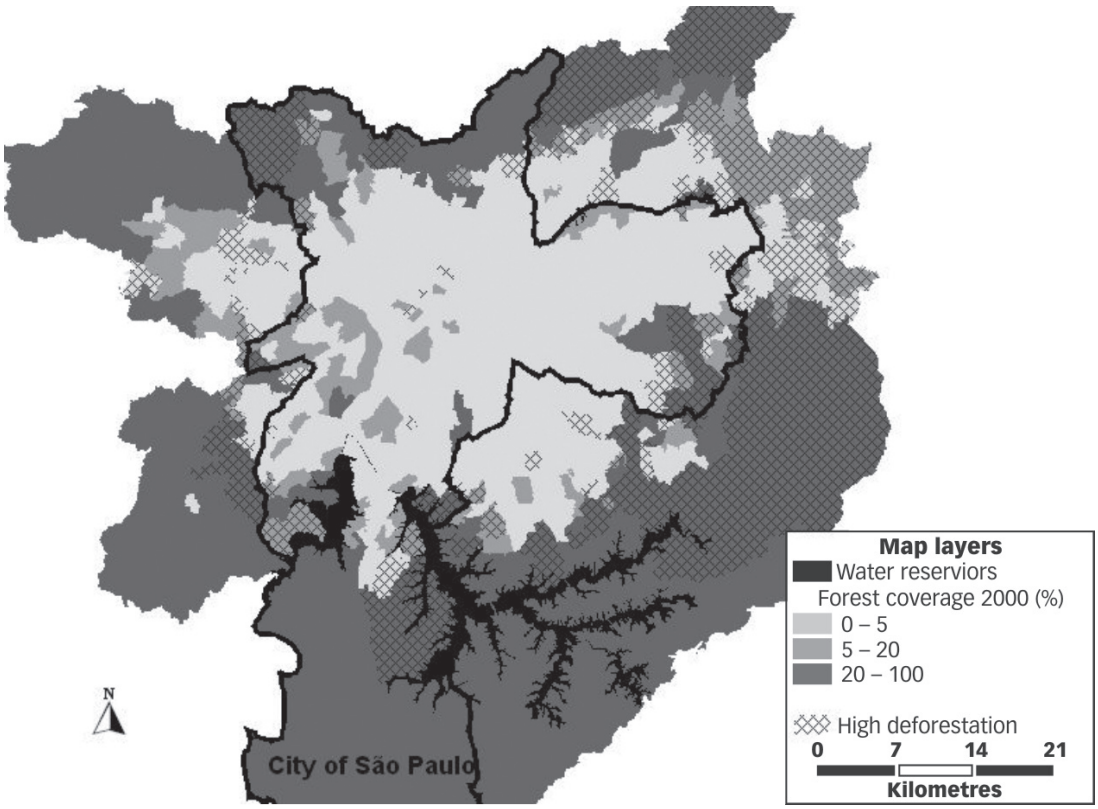
30. Such an estimate simply subtracts the forested areas accounted for in 1991 from the ones in 2000. Therefore, it also includes forest plantation and forest regeneration areas.

31. PRODES–INPE (2004), *Monitoramento Ambiental da Amazônia por Satélite*, accessible at www.inpe.br.

In this account, we have not considered pasture or grassland, although secondary forest succession and reforestation areas are included in our estimates.

In addition, Map 5 shows that the region where the most important water sources for São Paulo are located – the reservoirs of Billings and Guarapiranga in the south of the city – presents not only significant deforestation but also rapid population growth. The consequences of such dynamics are of concern and subject to extensive debate by the local press. The annual investment needed to preserve such reservoirs is impressive. Other alternatives would imply, for example, bringing water from Vale do Ribeira, located further down south. Such an expansion of the water network would demand huge public investment due to the distances and topographic difficulties involved.

It is also important to note from Map 5 that the areas highlighted as having experienced high deforestation (more than 2 per cent of area deforested during the 1990s) showed a total population of 1.7 million in 1991 and 2.8 million in 2000, a growth rate of 5.3 per cent a year. Considering this evidence, we try to interpret this forest data by



MAP 5
Forest coverage and areas with high level of deforestation: São Paulo's urbanized area, 2000

SOURCE: CEM–Cebrap Satellite images: Landsat TM 1991 and Landsat ETM 2000.

TABLE 5
Changes in forest cover between 1991 and 2000: São Paulo's urbanized area

	Groups of areas according to population growth rate (%) 1991–2000						
	–8 – –1.5	–1.5 – 0	0 – 1.5	1.5 – 3	3 – 5	5+	Total
Total area (km²)	255.46	383.35	323.71	434.31	650.90	1,542.43	3,590.16
Forest coverage 1991 (km²)	9.37	13.13	26.36	129.84	313.20	751.28	1243.18
Proportion of forested land 1991 (%)	3.67	3.43	8.14	29.90	48.12	48.71	34.63
Forest coverage 2000 (km²)	10.18	12.94	24.10	123.67	295.99	712.34	1,179.22
Proportion of forested land 2000 (%)	3.98	3.38	7.44	28.48	45.47	46.18	32.85
Change in forested area 1991–2000 (km²)	0.81	–0.20	–2.26	–6.17	–17.21	–38.94	–63.96
Change in forested area 1991–2000 (%)	0.32	–0.05	–0.70	–1.42	–2.64	–2.53	–1.78
Spatial distribution of deforestation (%)	–1.27	0.30	3.53	9.65	26.91	60.88	100.00

SOURCE: CEM–Cebrap satellite images: Landsat TM 1991 and Landsat ETM 2000.

employing the same geographic divisions previously used for analyzing demographic trends (Table 5).

In 2000, 46 per cent of the fastest-growing peri-urban areas (more than 5 per cent population increase a year) were still forested, particularly in the north and the south, while the very negative growth areas showed a forest cover of only 4 per cent. Ironically, the rate of population growth is strongly positive in forested areas and negative in denser urban ones. In addition, more than 87 per cent of all forest cover in São Paulo's urbanized area is in peri-urban regions, totalling more than 1,000 square kilometres.

Available data show that fast-growing areas (more than 3 per cent population increase a year) presented a net loss of 56 square kilometres of forest cover between 1991 and 2000 – i.e. a reduction of 5 per cent of their original 1991 coverage. In other parts of the city the loss was less significant, and even includes a small growth in the forested area of some central parts of the city (in the very negative growth areas).

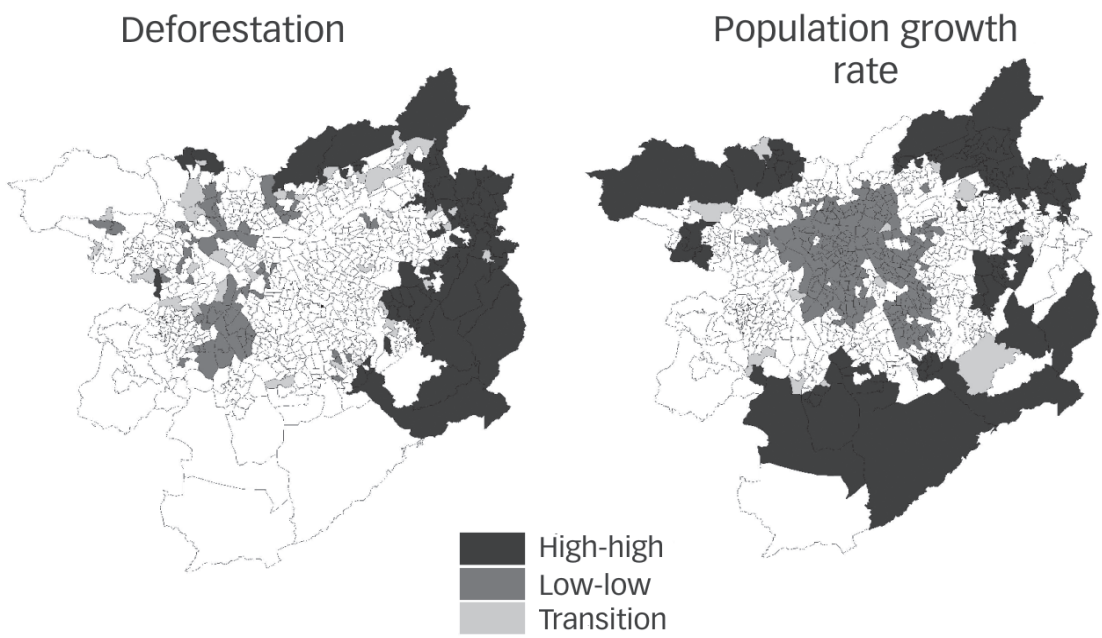
However, this kind of ecological data cannot establish precisely the connections between population growth and deforestation. While it is clear that most deforestation occurs in areas with very fast population growth, it is not a feature exclusive to such areas.

Even though almost all deforestation is taking place in the fast growth (peri-urban) areas, it is true that in a few cases, strong deforestation occurs in the negative and slow growth areas. It should also be considered that not all fast-growing areas present high deforestation rates; in fact, some of them even show forest regeneration. In this context, public intervention should consider a targeted approach, for instance focusing on the eastern part of the city, which concentrates an important share of forest loss.

In light of these problems, we have tried to test such arguments through different spatial statistical models. First, we tested a space regression model,[32] which did not present a strong correlation between population growth rate and deforestation. Second, we used Moran techniques (LISA map) to try to observe the relationships between clusters of deforestation and clusters of population growth.[33] The results are shown in Map 6.

32. Anselin, L (1996), "Interactive techniques and exploratory spatial data analysis", West Virginia University Regional Research Institute Working Paper No 9627.

33. Moran and LISA are techniques to measure and locate cluster occurrences.



MAP 6
Clusters of deforestation and population growth rate rate (LISA map): São Paulo's urbanized area, 1991–2000

SOURCE: CEM–Cebrap satellite images: Landsat TM 1991 and Landsat ETM 2000; also IBGE, *Demographic Census 1991 and 2000*, IBGE, São Paulo.

Map 6 shows that deforestation is highly concentrated in the eastern part of the metropolitan area, while the cluster of high population growth rate is spread across the suburban areas. The eastern cluster of high deforestation alone is responsible for 71 per cent of all forest loss observed in the region, with a deforestation rate of 5.8 per cent that reduced its forest cover to 44.8 per cent in 2000.[34]

The data indicate that although population growth and deforestation seem to be connected in some regions, this cannot be perceived as a general rule for understanding deforestation dynamics. The eastern cluster could also be explained by other factors, such as agricultural activities and land use regulation, although these are not necessarily valid for other suburban areas.[35]

34. This area also presented a significant rate of population growth (5.4 per cent a year).

35. We do not have much information on metropolitan agricultural activities, but in the following section we will discuss land regulation by exploring the connections between deforestation and environmental regulation.

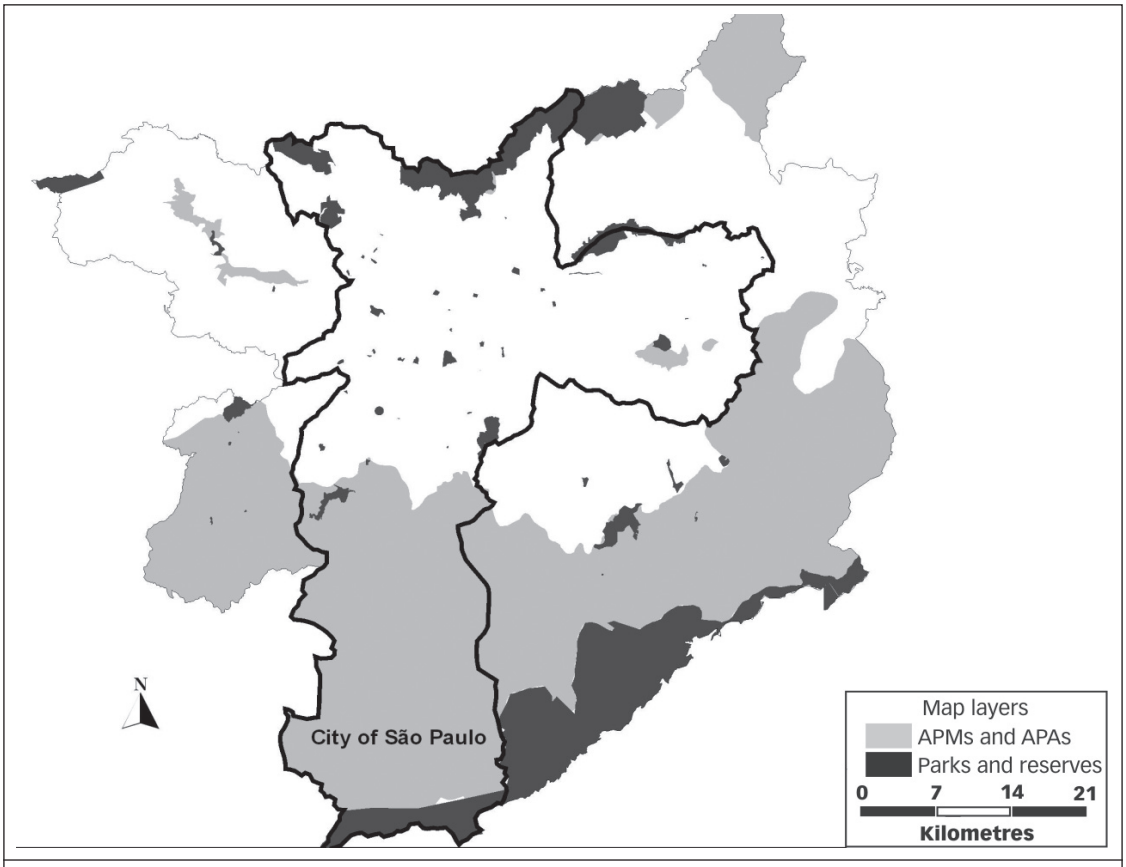
a. Deforestation and environmental regulation

Green areas and water sources are protected in São Paulo by national, state and local legislation that define different types of protected areas. In the case of São Paulo, the most important are as follows:

- Areas of Environmental Protection (Áreas de Proteção Ambiental – APAs). This type of conservation area allows for the private use of natural resources according to the limitations of the law. Land use is enforced by the federal government agency IBAMA.

- Areas for Water Source Preservation (Áreas de Proteção a Mananciais – APMs). This form of conservation area is regulated by the São Paulo state legislation (by-laws 898/75 and 9866/97) that establishes policy for water source areas, including the metropolitan reservoirs of Billings and Guarapiranga. It also allows for the private use of land. As mentioned before, the enforcement of this legislation is quite inefficient. There are 1.8 million people living in such areas, even though 17 out of the 39 municipalities in the São Paulo Metropolitan Area have more than 50 per cent of their land protected by this regulation.
- Parks, forest reserves and urban green areas, under local or state jurisdiction.[36] These areas are basically government property and their occupation by private dwellers is forbidden. The most important and preserved remnants of the Atlantic rainforest are located in parks in the southernmost portion of the metropolitan area. In the north,

36. The state parks in the metropolitan area are: Cantareira, Alberto Löefgren, Jaraguá, Juquery, Jurupará, Várzea do Embu-Guaçu, Guarapiranga and Estação Ecológica de Itapeti. See www.if.sp.gov.br.



MAP 7
Distribution of protected environmental areas: São Paulo's urbanized area

SOURCE: São Paulo State Government (1998), *Atlas of the Environmental Conservation Units of São Paulo State*, São Paulo.

TABLE 6
Changes in the forest cover between 1991 and 2000 according to land use status: São Paulo's urbanized area

	Parks and reserves	APMs and APAs	No protection	Total
Total area 1991 and 2000 (km²)	279.01	1,465.02	1,846.13	3,590.16
Urban area 1991 (km²)	15.57	142.24	1,005.56	1,163.37
Forest cover 1991 (km²)	224.10	769.04	250.06	1,243.20
Urban area 2000 (km²)	12.05	159.82	1,152.17	1,324.04
Forest cover 2000 (km²)	228.65	725.29	225.28	1,179.22
Proportion of forested land 2000 (%)	81.95	49.51	12.20	32.85
Change in forested area 1991–2000 (km²)	4.55	–43.74	–24.79	–63.97
Change in forested area 1991–2000 (%)	1.63	–2.99	–1.34	–1.78

SOURCE: CEM–Cebrap satellite images: Landsat TM 1991 and Landsat ETM 2000.

the public parks of Cantareira and Jaraguá – sponsored by the state government – also include important remnants of native forest with medium to advanced stages of forest succession. Both the western and eastern areas of the city are less protected by the presence of parks and reserves.

Map 7 and Table 6 present the spatial distribution of these protected environmental areas within the urbanized area of São Paulo.

For analytical purposes, we have aggregated APAs and APMs into a single category due to the similarity of their legal characteristics – i.e. land property status (private) and the possibility of land use under the terms of the environmental regulation. In the year 2000, together they accounted for 40.8 per cent of the total metropolitan area and for 61.5 per cent of its forest cover, while parks and reserves represented 7.8 per cent of the total area and 19.4 per cent of the forest cover. The areas under no environmental protection equalled 51.4 per cent of the territory, but only 19.1 per cent of its forest cover.

When considering deforestation data regarding land use status, there are some surprising results. While non-protected areas lost some of their remaining forest between 1991 and 2000 (1.3 per cent), and parks and reserves presented some level of forest regeneration (1.6 per cent), which was to be expected, the other protected areas (APAs and APMs) presented significant forest loss, corresponding to 3 per cent of their territory, or 43.7 square kilometres. Such unexpected results strongly suggest that this form of environmental legislation is not working as planned.

In general terms, the data indicate that environmental legislation (APAs and APMs) is unable to control land occupation, population growth and forest loss. The so-called "law of water source protection" (by-law 9866/97) could not limit urban expansion around major lakes and forest remnants in the southern part of the metropolis. On the contrary, the law has produced a reduction in land prices, which has led to the expansion of illegal occupation and consequent pollution of water sources and deforestation.[37] For example, in a one-kilometre buffer zone around the two major reservoirs of Guarapiranga and Billings, the population has grown from 554,000 in 1991 to 881,000 in 2000, or 4.3 per cent a year.

37. Marcondes, M J A (1996), "Urbanização e meio ambiente: os mananciais da metrópole paulista ", Doctoral thesis, FAU/USP, São Paulo.

V. CONCLUSION

The factors that produce the urban sprawl in the São Paulo Metropolitan Area are quite complex and relate to the role of different government branches (regulation, taxation, infrastructure, housing policy, etc.) and private companies. For instance, there is some evidence that the urban expansion of the suburbs is related to the continuous increase in land prices in the central areas of the city.[38] However, further research is still needed to substantiate this argument.

The high concentration of social, environmental and legal problems in the far suburbs makes them very ill-suited to population growth, which ironically persists and expands. However, it is not necessarily true that this pattern of growth – i.e that all city growth is focused on the "periphery" – must continue. Currently, there is a significant amount of unoccupied land in central parts of the metropolitan area – especially in the old industrial belt and along some railroad corridors.

These trends seem to be related to land market rationales. Were population growth to occur in denser areas, much of the current damage could be reduced. From our point of view, only a significant change in the dynamics of local land markets could allow for a more sustainable pattern of growth.[39] The land available in central parts has remained unoccupied both because of its high price and because of the lack of public policies that could redirect it to low-income dwellers and housing projects. Taxation rates, for instance, could be more extensively used to stimulate vertical building and penalize vacant lots. Current zoning regulations also prohibit tall buildings in large, high-income, low-density neighbourhoods, significantly restricting the possibilities for other families to live in areas that have full infrastructure.

A second key dimension refers to poor migrants, who should not be blamed for moving to these least-structured suburbs. Overall, migration movements are decreasing and poor families are the first to be affected by the degradation of the environment, not only through their exposure to environmental hazards and vectors of contagious diseases but also because their places of residence are less protected in terms of facilities and/or construction patterns that could avoid such hazards.

Therefore, the most significant issue here is how to change such unfortunate trends. The idea that restrictions on land use alone could cope with such problems is quite naïve, since so far they have not been able to properly regulate the illegal settlements in São Paulo. Urban environmental legislation, for instance, often falls victim to such logic. The example of the "law of water sources protection" in stimulating land occupation is just one tragic example of the failure of a series of attempts to enforce land regulation.

Finally, it should be noted that there has been a significant change in the Brazilian legal framework for urban areas. Since the 1988 Constitution, a substantial number of new laws have emerged, including the 2001 City Statute and the establishment, in 2003, of both the Ministry of Cities and the National Council of Cities, which could produce a whole new legal–urban order.[40] However, at this time it is still unclear whether such changes are going to really impact the current urban expansion trends.

38. See Marques, E (2005), "A dinâmica imobiliária de incorporação em período recente", in Marques and Torres (editors), see reference 10.

39. In other words, we totally agree that density should be stimulated in order to reverse such a trend. See Martine, George (2001), "The sustainable use of space: advancing the population/environment agenda", Paper presented at the Cyber Seminars of the Population–Environment Research Network, accessible at www.populationevironmentresearch.org.

40. Fernandes, Edésio (2007), "Implementing the urban reform agenda in Brazil", in this issue of *Environment & Urbanization*.

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