

ENVIRONMENTAL IMPACTS OF URBAN SPRAWL IN LONDRINA, PARANÁ, BRAZIL

Maurício Polidoro^{1*}, José Augusto de Lollo² and Mirian Vizintim Fernandes Barros³

¹ Department of Civil Engineering, Federal University of São Carlos, São Paulo, Brazil

² São Paulo State University, Ilha Solteira, São Paulo, Brazil

³ Londrina State University, Londrina, Parana, Brazil

Received 4 January 2011; received in revised form 10 September 2011; accepted 15 November 2011

Abstract:

Public policies encouraging the insertion of large industrial and commercial developments near highways, associated to exclusionary housing policies, have shaped over the past decades a new urbanization phenomenon; the sprawl. This is largely characterized by discontinuous and fragmented occupation, with random population densities. This phenomenon brings environmental and social impacts to the urban and rural population, in addition to a great burden for the Government. In line with this and considering the lack of discussion about the topic, this paper discusses some of those impacts observed in Londrina – PR, Brazil. The influence of urban sprawl in this city has shown to impact traffic, waterproofing rates and green areas, in addition to underutilizing the infrastructure due to large urban voids and vacant lots. With the data presented here, it is hoped that debates emerge on the importance of rethinking the plan, so that everyone can have legal access to the city (endowed with infrastructure), as well as the importance of developing strategies to contain urban sprawl.

Keywords: Londrina; impacts; urban sprawl; urban planning

© 2011 Journal of Urban and Environmental Engineering (JUEE). All rights reserved.

* Correspondence to: Maurício Polidoro. E-mail: mauricio.polidoro@gmail.com

INTRODUCTION

Urban policies in Brazil have made much progress in recent decades, affording advantages to municipalities to invest in various sectors that range from education, to health, including housing projects and road systems, generally under the Master Plan.

However, large projects directly sponsored by federal or state governments, such as housing developments and roads that run through several counties, inevitably go against planing attempts for the cities, considering the consequences of projects of such magnitude.

The availability of optimal production and connection disposal routes with other regions eventually encourage industrial and commercial developments in its surroundings, which in turn attracts residential settlements, hence increasingly breaking away from occupying the consolidated center.

This dilemma, combined with the attractiveness of urban expansion areas near the rural area by real estate developers, has led to the construction of large low population horizontal gated communities, which outline an inequitable city with a discontinuous occupation standard, thereby generating numerous urban voids.

This phenomenon, labeled by Americans as urban sprawl, is the main characteristic of American cities, and in recent years it has shown that such socioenvironmental and urban impacts generate substantial burden to the Government and lead to the degradation of social relations in cities.

Therefore, this article will discuss how this phenomenon occurs in Londrina, pointing to some impacts resulting from sprawl occupation. To this end, the first part brings a conceptual discussion that presents a systematic analysis of the phenomenon.

Next, it indicates how the phenomenon occurs in Londrina and then presents empirical data on the impacts of the occupation and its relation to the reduction of green areas, with the transport system and the burden to the government due to infrastructure underutilization (urban drainage, water supply and sewage) and some environmental impacts of sprawl.

THE URBAN SPRAWL PHENOMENON

There are several definitions by the authors on urban sprawl. Burchell (2003) points out that this is a low density occupation phenomenon, a leapfrog development in which urban growth occurs in a discontinuous manner, leaving urban voids and spreading onto rural areas or urban fringes, creating an environment called by some as *urban* areas. In more detail, Morris (2005) in the book proposed to understanding all dimensions of urban sprawl in

American suburban areas, proposes five different characteristics for the phenomenon. Below is an adaptation of the division proposed by the author, applied to the Brazilian reality.

1. **Low-density project** – numerous low-density independent residential subdivisions (horizontal and vertical condominiums) propagated by urban landscape. Small towns are replaced/induced by “commercial/industrial strips”, in other words, placing large developments along highways encourages the emergence or orientation of urban fabric development;
2. **Lack of multi-use development standards** – Lack of schools, workplaces, cafes, shops, restaurants, offices, public buildings and walking-distance homes.
3. **Car dependence** – with the basic city-life daily functions spread out, the car is the only means of transport, considering the precarious public transport. In addition, the new suburbs and apartment buildings are designed to have more car parking.
4. **Walking is eliminated** as a safe way to go anywhere, thus reducing the quantity and quality of sidewalks and social interaction;
5. **Traffic congestion (*gridlock*)** – The hierarchical divisions of the roads that are usually connected to a higher arterial road, saturate certain areas at peak times. The lack of alternative routes and geometric design flaws of the streets impair transport of pedestrians and cars.
6. **Inadequate public transit** – Mass transport is inadequate, poorly designed (generally or at the beginning, not linked to land use planning), with the exception of transport (usually private and inter-cities transport) that uses the main roads (streets and highways).

These characteristics result from a set of actions that involve the planning and management of the urban area that prompts the sprawl at various levels. To demonstrate a proposal discussed by Ewing (1997); Burchell (1998, 2002); Downs (1998); Duany (2000); Plater-Zyberk & Speck (2000), and Orfield (2002), Polidoro (2010) and Aurand (2007), the following systematic is presented, adapted to the Brazilian reality:

- **Sprawl as land-use standard** – refers to the way in which occupation occurs, independent of its use (residential or commercial);
- **Sprawl as a consequence of land-use standard** – refers to the effects caused by the form of land use or occupation, such as a socio-spatial segregation and environmental pollution due to the use of transport.
- **Sprawl as a result of government structure/actions** – refers to the institutional base that allows for such

land-use policies; it is also characterized by the difficulty of government branches (Executive x Legislature, for example) to reach a consensus regarding the implementation of regulatory instruments for urban land use, such as zoning and urban expansion. It can also be characterized by a lack of metropolitan articulation for land use planning in bordering areas.

Morris (2005), in an analysis of American sprawl, draws attention to the human impact of the phenomenon and says that the degradation of social relations caused by the sprawl lifestyle leads to a society of strangers, isolating the elderly, hence adding to a greater tendency for depression.

Additionally, a culture of individualism is intensified due to the influence of television, causing other factors such as urban violence, loneliness and the stunted development of children. However, most authors focus their empirical analysis of sprawl mainly on the environmental consequences in the cities. Su (2010), for example, discusses the relationship of green areas in the urban fringe with the reduction of agricultural areas in China. He also shows that with the help of government programs, ecological conservation areas have been maintained against urban expansion.

Tu (2007) examines the impact of sprawl in Boston, regarding water quality, and how urban expansion has influenced surface waters. Similarly, Ritter (2008) evaluates the sprawl relationship with air pollution in Germany, using mathematical models in a GIS environment.

Wang (2001) (UPGS – Urban Peripheral Green Spaces) presents the relationship of green area preservation in the urban fringe, bringing the concept of urban peripheral green spaces (UPGS). He mentions the difficulty of maintaining these spaces due to the uncontrolled urbanization advance in the urban limits.

The author points out that UPGS are essential to maintain air quality within urban areas, and to protect areas for agriculture and environmental preservation, yet the rapid expansion processes (which encourage sprawl) are like the villains in the preservation of ecological corridors.

However, Hasse & Lathrop (2003) emerge as the research study that most includes the size of sprawl impacts using data and indicators applied to the municipality of New Jersey, USA.

These propose the indicators of land use efficiency (population density), agricultural areas, forest conservation areas, natural swamp areas, and waterproof areas.

The feasibility of the research is guaranteed due to research investment in the detailed subjects and recent census data, as well as the acquisition of medium and high resolution satellite images at different times.

URBAN SPRAWL IN LONDRINA – PR

The process of urban expansion of Brazilian cities is closely linked with the issue of the urbanization process itself, which increased in intensity after the 1970s. It falls outside the scope of this paper to examine the history of urbanization, which has already been discussed exhaustively. However, is it necessary to understand the early years of the development of Brazilian cities, so that they may also serve as a justification for the adoption of the proposed terminology.

Brazil’s population grew by approximately 355% in the second half of the 20th century (between 1940 and 1991), representing an increase of almost 80 million inhabitants. Lima (1998) stated that this growth was 750% in the urban environment. This panorama is clearly observed in the country’s large urban agglomerations, which concentrate most of the population. Grostein (2001) reported that 47% of the country’s population is concentrated in 49 metropolitan regions and non-metropolitan urban agglomerations. Brazil’s 12 metropolitan regions are home to 33.6% of the Brazilian population.

Impelled mainly by the late industrialization process and strong rural-urban migration, Brazilian cities began to accumulate a stock of low-qualified labor, low salaries and high unemployment rates. Costa (1978) claims that: [...] Thus, this population has no possibilities of obtaining the housing conditions and

Table 1. Characteristics of Urban Sprawl

Sprawl as land-use standard	SPRAWL as a consequence of land-use standard	SPRAWL as a result of government structure/actions
Development of low density regions, especially with individual houses (singles)	Loss of areas for agriculture and/or farms; urban voids	Decentralized planning / Difficulty of articulation at a metropolitan level
Segregationist use and occupation	Housing developments and gated communities located in scattered points; urban voids	Fragmentation of responsibilities between jurisdictions in relation to planning (example: zoning)
Urban sprawl (non-contiguous development)	Transport dependence (mainly cars) for displacement; urban voids	
Development of commerce in “corridors”		
Development of urban areas in rural perimeters (“rurbans”)	Inter-municipal conflicts; environmental and neighborhood impacts	Difficulty in articulating at metropolitan level

Source: Polidoro (2010).

services that characterize minimum standards of urbanization (Costa, 1978, p.84).

The Brazilian city thus emerges as a space of contradictions – on the one hand, a portion of the population that manages to insert itself into the new territorial division of labor, and on the other, an excluded portion whose survival is tied to improvisation.

This scenario characterizes distinct paradoxical processes of urban expansion, one based on illegality and the other on legality, but both vitiated by exclusion. On the one hand, one sees the occupation of hills and valleys, of riverside and roadside areas – the slums – which Rolnik (1999) calls risky urbanism¹. On the other hand there is government-financed occupation – large housing estates. Characterized as major federal and state government public housing projects located far away from the city center, they lack a complete infrastructure and access to goods and services, as well as quality public transportation.

The location strategy of these mass-produced homes far from the city center is also based on the need to supply labor close to industrial districts and outflow axes (highways). In Brazil, such neighborhoods are common, especially in the regions of São Paulo, Campinas, Ribeirão Preto and Londrina, for instance.

Londrina is located in the southern macroregion of Brazil, in the north-central mesoregion of Parana, in a strategic geo-economic position, both in terms of demographics, physiographics, and the circulation network by regional, state or interstate roads (**Fig. 1**). Designed to accommodate only 20,000 inhabitants, the urban area of Londrina had a rapid growth, mainly on account of the coffee development that culminated in the growth of commerce, representing the city’s high economic development rates and features among the main cities in Brazil. Thus, the population that was basically rural eventually migrated to the urban areas, following the national trend, hence causing intense urbanization.

The genesis of the urban occupation of Londrina initially began in the central area in the early 1930s, as stated by Fresca (2009): The construction of the central area should be understood as a double trajectory: the first one refers to physically building the city, in other words, deforestation, splitting lots, street access, constructing buildings, houses, etc. This was a trajectory that required some time before the rising equity took shape. And the second one refers to the processes that generated the centrality and the conformation of the central area (Fresca, 2007, p. 151).

The circular shape region in the center of **Fig. 2** is the location of the Metropolitan Cathedral, one of the city’s touristic sights, and the dual highway to the west is the Higienópolis Avenue that divides the center into two parts: to the east, the central hub of commerce, somewhat sparse, with some specialized commercial streets, and the pedestrian-only street, and to the west there is a more specific and higher standard of income commercial region, especially in the Belo Horizonte, Santos and Paranaguá streets (paralleled to Higienópolis Avenue). This region, in addition to middle and upper class shops, has sophisticated restaurants and bars.

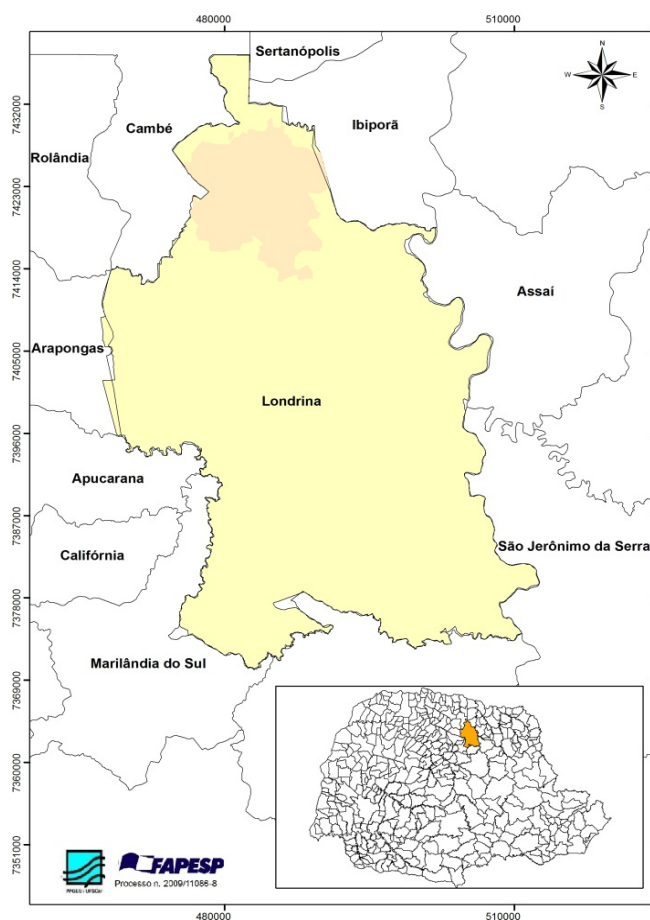


Fig. 1 Contextualization of Londrina in Paraná State.

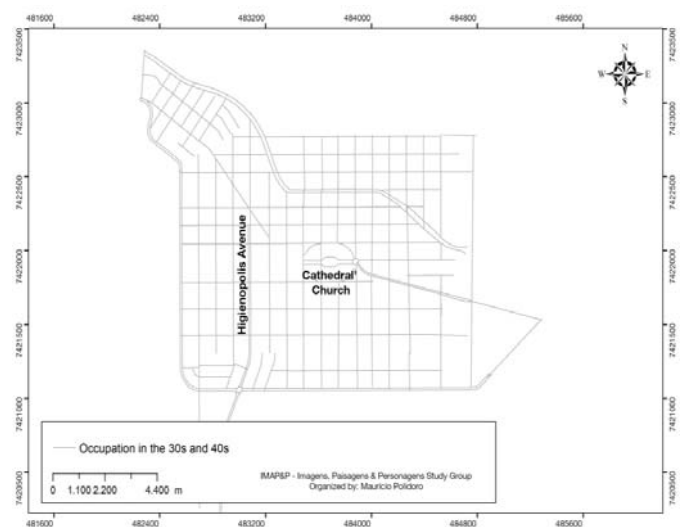


Fig. 2 Road genesis of Londrina.

Starting in 1950, the occupation went to the periphery located mainly in the northern part of the city. After 1960, the occupations became sparser, giving rise to the sprawl phenomenon, outlining large urban voids.

The creation of Lake Igapó, the construction of the Londrina airport and improvement of the BR-369 highway are indicated by Razente (1983) as the agents that contributed to the urban sprawl and land speculation. The higher income population was

concentrated around the lake, while the highway brought on the emergence of industries and lower income occupations.

In the same decade, Londrina ordered from São Paulo the Master Plan for Urban Development, of a technocratic nature, which placed much emphasis on developing zoning and the road system, hence intensifying the occupation that spread to the center-neighborhoods, according to Casaril (2009).

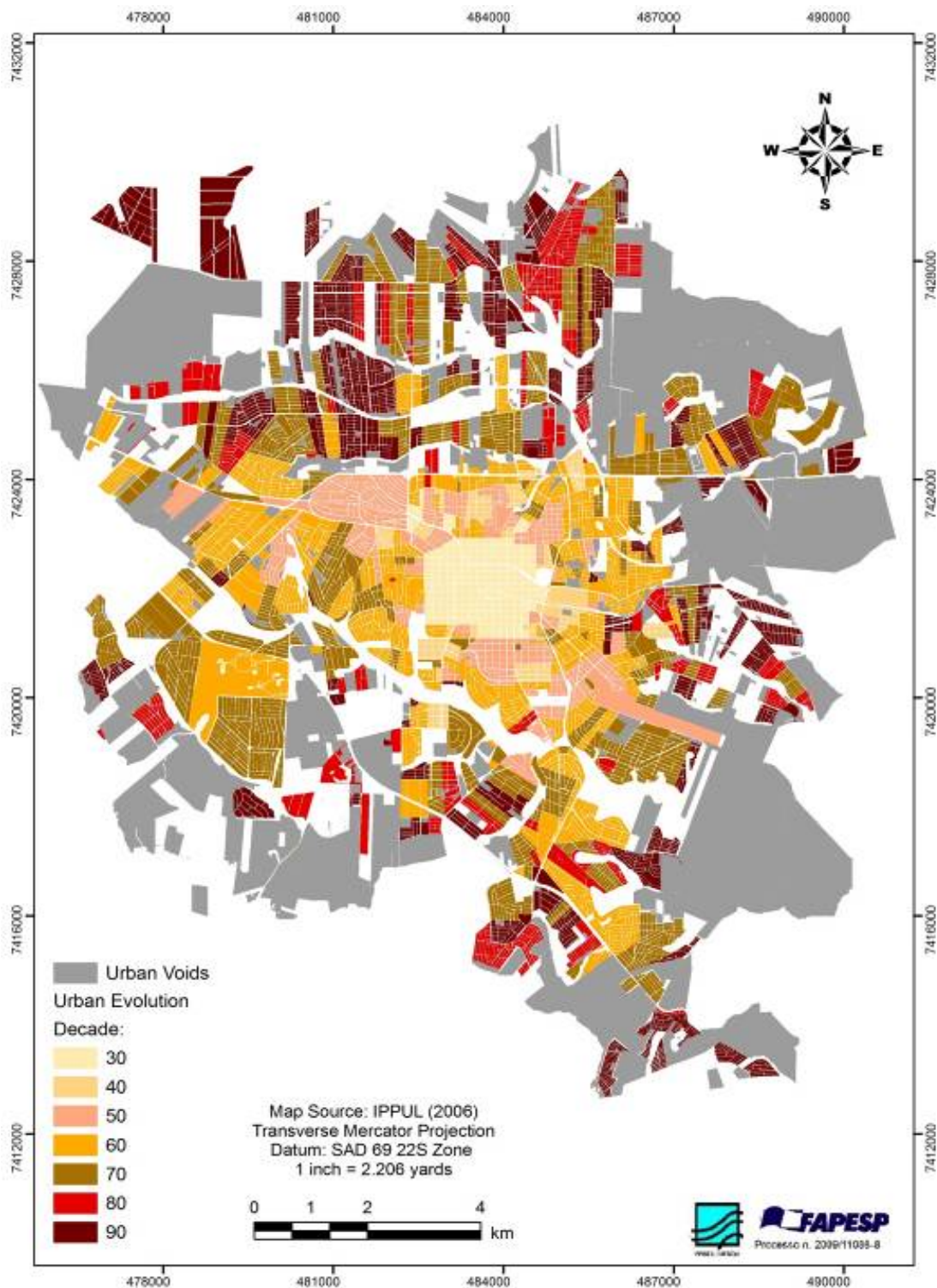


Fig. 3 Changes, by land lots, in Londrina and the urban voids.

The incentive to set up commercial corridors in the center-north direction did not prevent the emergence of shops for higher income segments, which also expanded to the south with the construction of the Shopping Center Catauí and of private universities.

The construction of universities and shopping malls spurred the emergence of numerous subdivided land lots and gated communities, consequently, creating urban voids in the central-south direction, with complete infrastructure, however, underutilized and often obsolete

Starting in 1980, verticalization took on new meaning, and the construction increase was intense, despite the economic downturn in the national

context. Passos (2007) notes that: After 1986, there was a marked increase in the number of constructions of buildings, much higher than those recorded previously, including three straight years in which numbers exceeded the previous decade, of which 147, 136 and 177 buildings were constructed in 1987, 1988 and 1989, respectively (Passos, 2007)

Then, an uneven urban setting began: the center consolidated the highest demographic density along with housing developments in the northern region, to the detriment of many regions without any occupation or with low/medium density, adjacent to the central area, with infrastructure, forming urban voids in the interstices, as can be seen in **Fig. 4**.

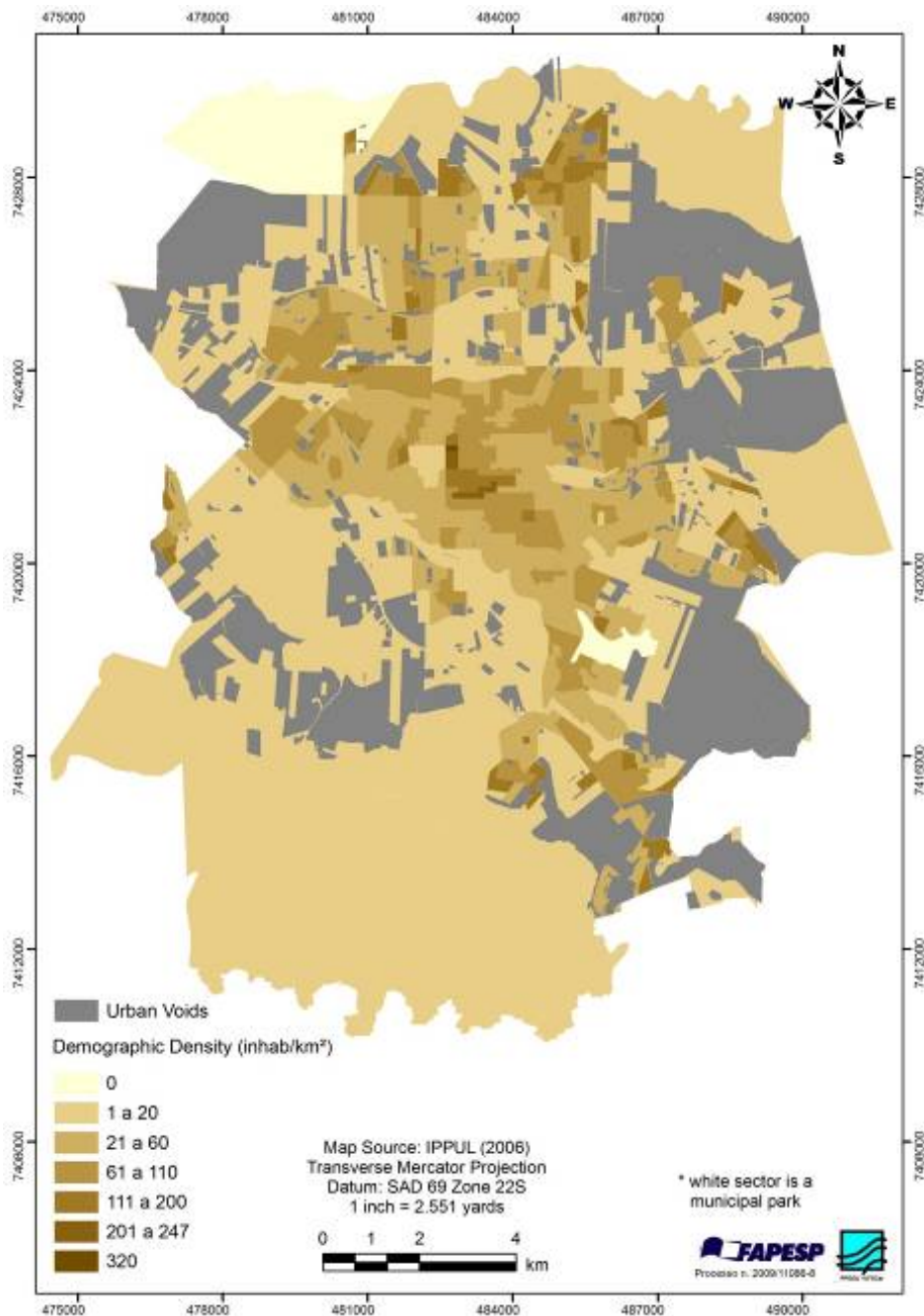


Fig. 4 IBGE Demographic density by sectors in Londrina and urban voids.

REDUCTION OF BIODIVERSITY AND OF WATERPROOF RATES

For years it was believed that urban sprawl was acceptable, especially in European and North American cities. There were those who believed that urban sprawl was plausible because the population had the right to seek out more isolated areas from the city center, with greener areas and with recreation areas, they believed that these locations would concentrate lower polluting gases, and like in Brazilian cities, the occupation in the vicinity of highways is also considered as a “common” standard of occupation.

Although the idea is in fact a particularly attractive housing idea to the middle and upper classes (the suburbs) and lower classes (areas surrounding roads/highways), it is proved by several authors, such as Burchell, Aurand, Ribeiro, Graves and others, that the low density or discontinuous occupation (leapfrog) of the urban space leads to more problems than solutions for the various urban dilemmas.

The large concentration of cars, buildings and people in denser areas, such as central regions, represents smaller green areas like parks and squares, while more isolated gated communities stand for the image of environmental satisfaction and quality of life.

Ojima (2008) comments on this: If the urban area is more fragmented and with a low density, the need to use automotive transportation increases proportionately. Which indirectly contributes to the increase in GHG emissions. Obviously a good mass transit system would contribute significantly to reducing the use of private transportation, but what we see, especially in Brazil, is an increasing incentive for individual transportation (Ojima, 2008, p. 09).

In Londrina, besides this transport individualization and traffic “bottlenecks”, which consequently create “islands of pollution” due to heavy car use and GHG emissions, it is observed that the concentration of green areas is not proportional to that sort of road loading.

Even with the acceptable green area rates (47% natural areas and 21% preserved green natural areas - permanent preservation) the urban green areas make up only 16%, equivalent to 3.64 km² (Fig. 5).

The urban green areas have their highest concentration in scattered points across the city, which does not contribute to alleviating the most penalized areas with GHG emissions, which are the bottleneck road routes, including the infiltration of stormwaters.

Besides the problem of the lack of green areas for soil impermeabilization, Gonçalves and Polidoro (2009) also indicate that the drainage problems in Londrina include: Especially the micro-drainage devices, whose main problem is undersizing the storm sewers. These situations are the most complex and costly problems to

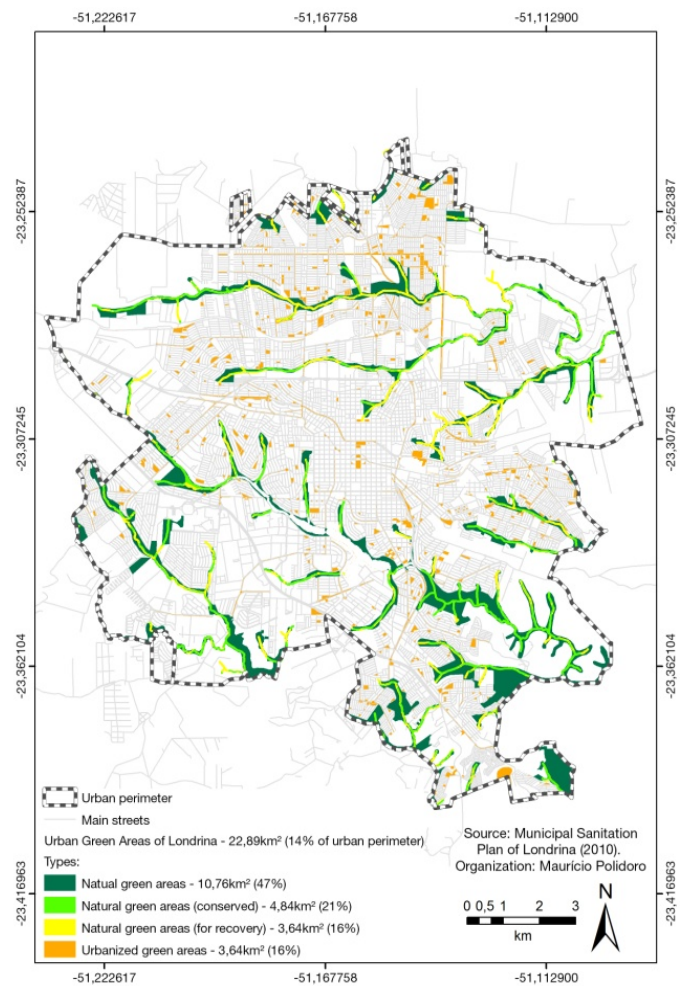


Fig. 5 Green areas in Londrina.
Source: Polidoro (2010).

solve, since they entail implementing new projects, in order to resize the network, besides the high construction costs, both from the standpoint of the direct cost, by removing the paving, replacing components, replacing pavings, and etc., as well as the indirect costs associated with interdicting those areas (Gonçalves & Polidoro, 2009, p. 575).

These problems reflect a poorly planned urban structure that generates more and more problems for the city, such as flooding and erosion points along the slopes of urban rivers. Despite the drainage and waterproofing problems of Londrina transcending the matter of green areas, these could soften the many urban environmental disasters diagnosed in the city (Fig. 6).

As shown in Fig. 7, the locations of drainage problems (involving erosion and clogging of storm sewers) are more often near areas that have a lower vegetation cover ratio.

The regions that have subnormal agglomerations also have recurring problems of drainage and water runoff, especially the most precarious in the northern and extreme south, as these are more socio-economically poor areas.

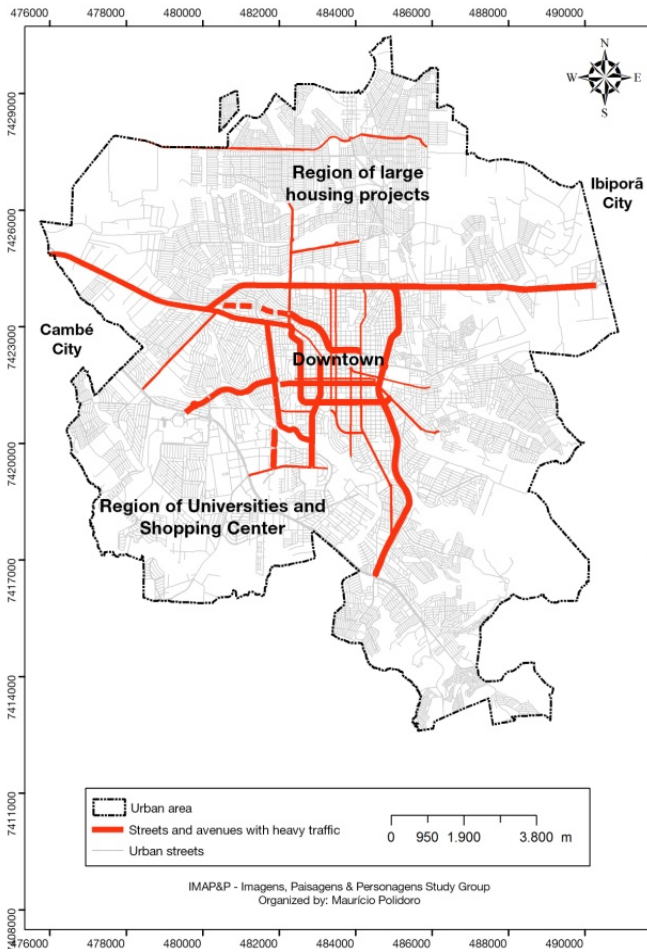


Fig. 6 Green areas; highway loads in Londrina.

latter usually being the most neglected, with basic infrastructure for acceptable living.

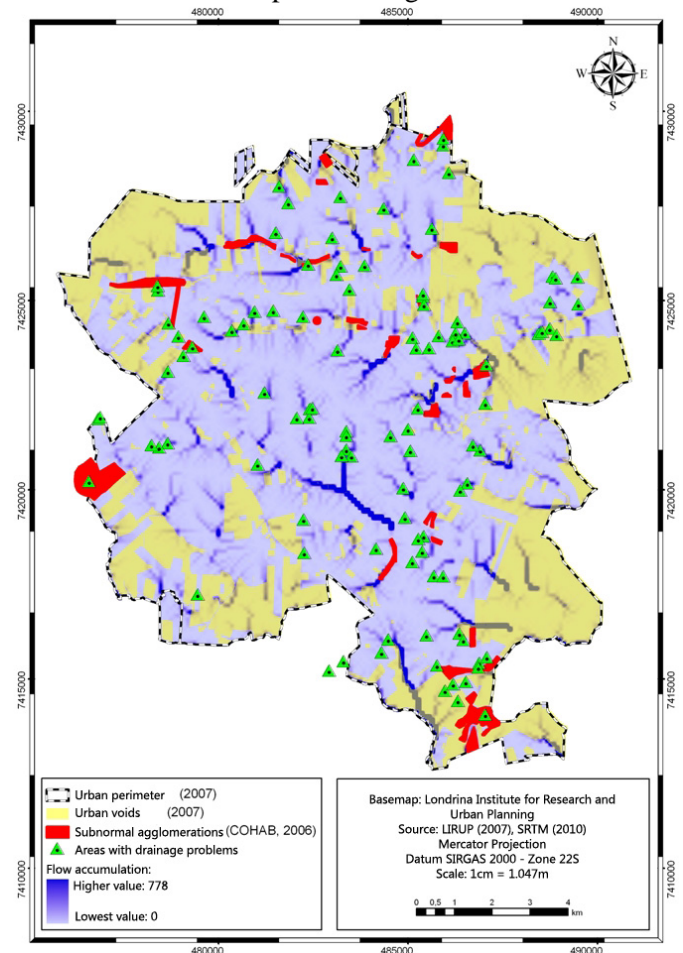


Fig. 7 Problem spots of drainage and water accumulation. Source: Polidoro (2010).

The flow of accumulation points to certain risks for these illegal occupations, especially those in the north and east region, which are located in valley bottoms, and which are often victims of overflowing rivers, representing high vulnerability and risk to public health.

The precarious settlement regions in the extreme north and extreme south, victims of infrastructure problems, also stand out due to the population density (82.51 to 198.02 inhabitants per hectare), while the surrounding areas have much lower concentrated densities.

INFRASTRUCTURE UNDERUTILIZATION

One of the most costly impacts of urban sprawl identified in the literature is infrastructure, keeping in mind that this is offered, almost entirely, by the Government. Scattered urbanization coupled with urban sprawl type of occupation and the generation of urban voids in the interstices of the cities, end up subutilizing or not fully utilizing the infrastructure already in place, which usually starts from the consolidated center to other regions of the city (center-periphery direction), the

These urban voids reduce the demographic density, increase intra-urban distances and increase the costs of infrastructure networks (Ribeiro, 2009).

In Londrina, the water supply service (Fig. 8), which covers nearly 100% of the urban area according to service providers (SANEPAR, 2009), also includes areas with voids, installed in the center-periphery system. This can be seen in the analysis of the residential connections in the water networks in the Municipal Profile (2001; 2002; 2005; 2007).

The rain water drainage network (Fig. 8), on the other hand, covers a smaller percentage of the urban perimeter and is absent in some occupied areas and present in those with urban voids (mostly in neighboring/low-medium density regions to the consolidated/high density center).

The collection and sewage treatment service (Fig. 9) is the one with the lowest coverage ratio in the city, with about 80% of the urban area receiving the service. The peripheries are the regions with the largest voids in such service, while the most expensive regions, regardless of their population density, have full service availability.

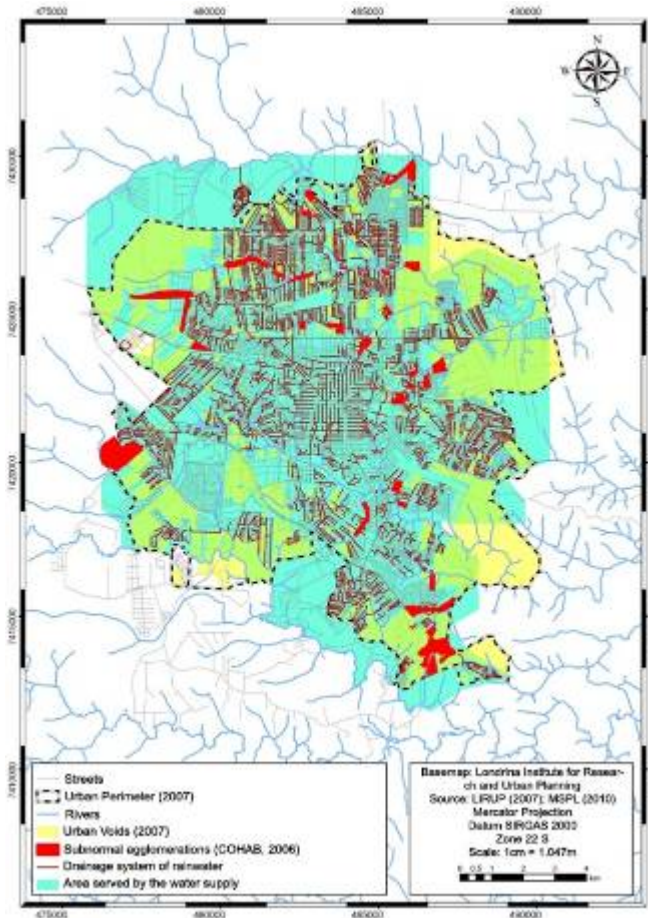


Fig. 8 Areas supplied with water and drainage network in Londrina. Source: Polidoro (2010).

which in turn impacts air quality and people’s lives in their entirety.

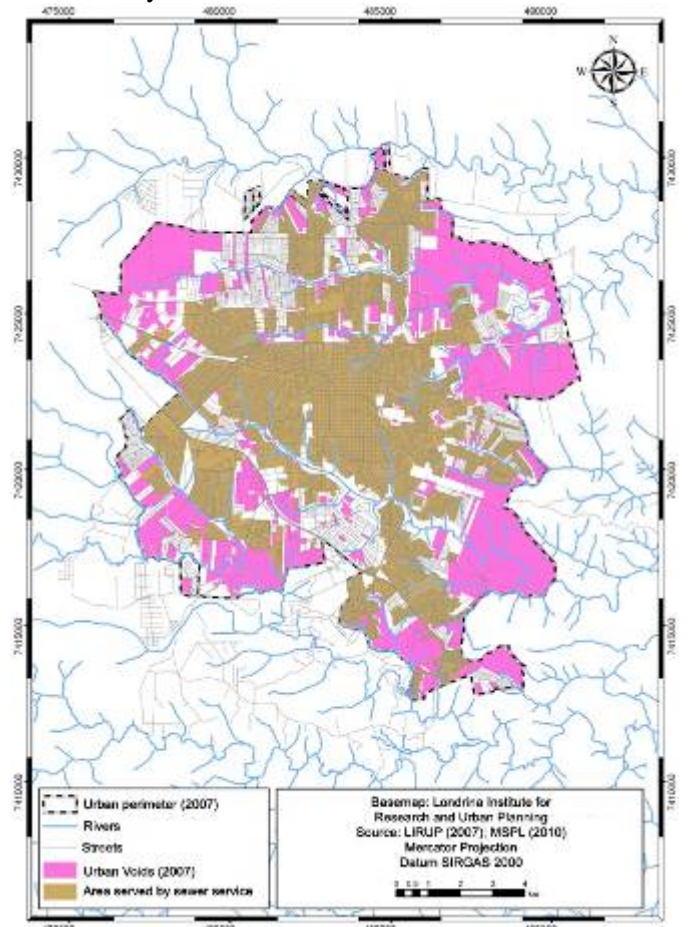


Fig. 9 Sewage collection and urban voids in Londrina.

This infrastructure irregularity, in which the availability of essential public services is unequal in proportion to the urbanized space, generates high land speculation, making the occupied buildings increasingly more valued with the empty urban spaces that are increasingly preserved by the agents that cause unequal urban spaces.

FINAL CONSIDERATIONS

In the American literature, there are recurring studies covering the impacts of sprawl in the environment as well as in the livelihood of the population, as well as the challenges for urban and regional planning.

The American suburbs, notoriously known for bringing together wellness, beauty and family happiness (at least that shown on TV) have then become one of the greatest planning challenges in recent decades.

The advance beyond the city limits, the reduction of agricultural areas and to a large extent the green areas, as well as the concentration of categorized land uses (zoning), have directly impacted the traffic system (usually not integrated with other planning sectors),

Not unlike that country, many of Brazil’s metropolitan areas have followed the same growth standard, in the rise of suburbia, as well as in construction investments and improved highways, which has generated medium and high density occupations in their surroundings, leading the city to form an unequal occupation, in which infrastructure is either obsolete, or overloaded.

Regarding Londrina, this study showed that the uneven population density caused by encouraging large housing construction projects on the periphery, as well as high-income buildings in suburban areas, has caused environmental impacts on the low concentration of green areas, compared to the regions with heavy traffic.

The traffic bottlenecks - another impact of sprawl - is linearly observed in the higher density regions, mainly caused by the distance between where the population lives and works/studies.

It can also be observed that although the water supply reaches 100% of the urban periphery and neighboring areas, the infrastructure is also available for large urban voids, in other words, areas that do not use the service, only for land valorization.

The same scenario is repeated with the sewer system and urban drainage problems and water runoff, the result of incongruous and disjointed urban policies that regulate, on the one hand, zoning by types (strictly residential, commercial or industrial) and on the other hand, does nothing with the urban voids and transportation planning.

This form of planning is a mistake, as one can see with the North American cities that have expansion standards highly similar to the Brazilian ones. The lack of land use regulation to contain the sprawl has slowly brought harmful effects to the environment and to the population.

More studies on the impact of the phenomenon in Brazil are required - usually seen in the mid-sized cities and metropolitan areas - for urban policies to focus on maximum use of already occupied areas, while respecting the environmental and geotechnical limiting conditions.

However, as observed by Pendall & Puentes (2008), sprawl does not occur in the same way in all regions. Thus, it is essential that each research study brings together the characteristics of the phenomenon in order to assess the impacts and propose control policies and measures. Thus, this work has provided a favorable systematic to start debates on this issue.

Acknowledgements The authors thank the Research Support Foundation of São Paulo (FAPESP) for supporting the project “Urban Environmental Impacts in Areas of Expansion: Challenges to Metropolitan Planning”, process number 2009/11086-8. CNPq is also acknowledged for supporting project number 06278. “Digital Atlas of the Metropolitan Region of Londrina – PR – Brazil”. We also thank the Federal University of Sao Carlos for funding this paper.

REFERENCES

- Aurand, A.G. (2007) Is smarth growth for low-income households: a study of the impact of four smarth growth principles on the supply of affordable housing. *Ph.D. Thesis*, University Of Pittsburgh, 451p.
- Burchell, R. (1998) *The costs of Sprawl. Revisited. Transportation Cooperative Research Program Report*. 39. Washington, DC: National Academy Press.
- Burchell, R. (2002) *The Costs of Sprawl. Transportation Cooperative Research Program Report*. 74. Washington, DC: National Academy Press.
- Casari, C.C. (2009) A expansão físico-territorial da cidade de Londrina e seu processo de verticalização: 1950–2000. *Rev. Geografia (Londrina)* **18**(1), 65–94.
- Costa, L.C. (1978) Aspectos político-administrativos do planejamento urbano. In: Toledo, A.H.P. & Cavalcanti, M. (Orgs) *Planejamento Urbano em Debate*. Cortez & Moraes. São Paulo.
- Downs, A. (1998) How America's Cities Are Growing. *Brookings Rev.* **16**(4), 8–12.
- Duany, A., Plater-Zyberk, E. & Speck, J. (2000) *Suburban Nation: The Rise of Sprawl and the Decline of the American Dream*. New York – NY: North Point Press.
- Ewing, R. (1997) Is Los Angeles-style sprawl desirable? *J. Am. Plan. Assoc.* **63**(1), 107–125. doi: [10.1080/01944369708975728](https://doi.org/10.1080/01944369708975728)
- Fresca, T.M. (2007) Área central de Londrina: uma análise geográfica. *Rev. Geografia (Londrina)* **16**(2), 143–166.
- Goncalves, M., Polidoro, M. & Silva, D.F. (2009) Análise dos índices de impermeabilização do solo utilizando Geoprocessamento: proposta de atualização do decreto nº. 402/1980 para projetos de drenagem no município de Londrina-PR. *Proc. II Seminário de Recursos Hídricos da Bacia Hidrográfica do Paraíba do Sul*. Taubaté-SP.
- Grostein, M.D. (2001) Metrôpoles e expansão urbana: a persistência de processos “insustentáveis”. *Rev. São Paulo Perspectiva* **15**(1), 13–19.
- Hasse, J.E. & Lathrop, R.G. (2003) Land resource impact indicators of urban sprawl. *Applied Geogr. J.* **23**(2), 159–175. doi: [10.1016/j.apgeog.2003.08.002](https://doi.org/10.1016/j.apgeog.2003.08.002)
- Lima, R.S. (1998) Expansão urbana e acessibilidade – o caso das cidades médias brasileiras. MSc. Thesis, Universidade de São Paulo. São Carlos-SP. 91p.
- Morris, D.E. (2005) *It's a sprawl world after all: the human cost of unplanned growth – and visions of a better future*. Gabriola, BC : New Society Publishers.
- Ojima, R. & Hogan, D.J. (2008) População, urbanização e ambiente no cenário das mudanças ambientais globais: debates e desafios para a demografia brasileira. *Proc. XVI Encontro Nacional de Estudos Populacionais*. 13p.
- Orfield, M. (2002) *American Metropolitcs: the new suburban reality*. Washington, DC: Brookings Institution Press. 2002.
- Passos, V. R. L. A verticalização de Londrina: 1970/2000. MSc. Thesis, Universidade Estadual de Londrina. Londrina, 2007.
- Pendall, R. & Puentes, R. (2008) Land-use regulations as territorial governance in U.S. metropolitan areas. *Boletín de la A.G.E.* **46**, 181–206.
- Polidoro, M. (2010) Sprawl urbano em Londrina: Desafio ao planejamento urbano. *MSc. Thesis*, Universidade Estadual de Londrina. 76p.
- Plano Municipal de Saneamento Básico de Londrina (2011) Prefeitura Municipal de Londrina. Available in: <http://www.londrina.pr.gov.br>.
- Razente, N. (1983) Ocupação do espaço urbano de Londrina. MSc. Thesis, Universidade Federal de Pernambuco, 393p.
- Ridder, K., Lefebvre, F., Adriaensen, S., Arnold, U., Beckroegge, W., Bronner, C., Damsgaard, O., Dostal, I., Dufek, J., Hirsch, J., Inpanis, L., Kotek, Z., Ramadier, T., Thierry, A., Vermoote, S., Wania, A. & Weber, C. (2008) Simulating the impact of urban sprawl on air quality and population exposure in German Ruhr area. Part II: development and evaluation of an urban growth scenario. *Atmosph. Environ. J.* **42**(30), 7070–7077. doi: [10.1016/j.atmosenv.2008.06.044](https://doi.org/10.1016/j.atmosenv.2008.06.044)
- Ribeiro, E.L., Silveira, J.A.R. & Viana, E.R.V. (2007) Controle do Sprawl Urbano, e Inclusão Social: o caso da cidade de João Pessoa-PB. *Proc. IV Simpósio Internacional de Ciências Integradas*. 12p.
- Rolnik, R. (1999) Exclusão territorial e violência. *Rev. São Paulo Perspectiva* **13**(4), 100–111.
- Su, W., Gu, C., Yang, G., Chen, S. & Zhen, F. (2010) Measuring the impact of urban sprawl on natural landscape pattern of the Western Taihu Lake watershed, China. *Land. Urb. Plan. J.* **95**(1). 61–67. doi: [10.1016/j.landurbplan.2009.12.003](https://doi.org/10.1016/j.landurbplan.2009.12.003)

- Tu, J., Xia, Z-G. & Clark, K.C. (2000) Impact of urban sprawl on water quality in eastern Massachusetts, USA. *Environ. Manag.* **40**(2), 183–200.
- Wang, X. (2001) Type, quantity and layout of urban peripheral green space. *J. Forest Res.* **12**(1), 67–70. doi: [10.1007/BF02856805](https://doi.org/10.1007/BF02856805)

ⁱ It should be noted that “risky urbanism” is also present in the occupation of hills and valleys by high standard homes, which also constitute environmental risks.