

INFORMAL URBANIZATION: EXAMINING SPATIAL PATTERNS AND PUBLIC  
POLICY INFLUENCES IN THE METROPOLITAN REGION OF CURITIBA, BRAZIL

By

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This thesis is dedicated to my husband, Casey. His support, friendship, and encouragement gave me strength and inspiration.

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## LIST OF ABBREVIATIONS

APA	<i>Áreas de Proteção Ambiental</i> or the Environmental Protection Areas
CGS	<i>Campina Grande do Sul</i> (Municipality in the Study Area)
COHAB	<i>Companhia de Habitação Popular de Curitiba</i> , or the Affordable Housing Company of Curitiba
COHAPAR	<i>A Companhia de Habitação do Paraná</i> , or the Housing Company of the State of Paraná
COMEC	<i>A Coordenação da Região Metropolitana de Curitiba</i> or the Coordination Agency of the Metropolitan Region of Curitiba
FRG	<i>Fazenda Rio Grande</i> (Municipality in the Study Area)
GIS	Geographic Information System
GPS	Global Positioning System
IBGE	<i>Instituto Brasileiro de Geografia e Estatística</i> or the Brazilian Institute of Geography and Statistics
ILD	<i>Loteamentos Irregulares Clandestinos</i> or an Irregular Land Division
IPPUC	<i>Instituto de Pesquisa e Planejamento Urbano de Curitiba</i> or the Institute for Research and Urban Planning of Curitiba
IS	Informal Settlement
RMC	<i>Região Metropolitana de Curitiba</i> or the Metropolitan Region of Curitiba, Brazil
SEHIS	<i>Setor Especial de Habitação de Interesse Social</i> or the Special Sector of Social Interest Housing
SJP	<i>São José dos Pinhais</i> (Municipality in the Study Area)
SUDERHSA	<i>Superintendência de Desenvolvimento de Recursos Hídricos e Saneamento Ambiental</i> (Superintendent of the Development of Hydrology Resources and Environmental Sanitation)
UTP	<i>Unidades Territoriais de Planejamento</i> or the Territory Units of Planning

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The rapid population influx to urban regions in the global south has led to an unprecedented demand for low-income housing. The inability to meet this demand has resulted in the development of entire neighborhoods referred to as informal settlements that are comprised of self-constructed housing that lacks infrastructure and legal permission. The cumulative effect of informal land occupation has swayed regional urbanization patterns. Yet informality is influenced by the limitations posed by the urban system which is a product of various political, economic, environmental and social forces. This study builds on the theory that the spatial trends of informal settlements are a product of various limitations and degrees of tolerance and therefore the patterns are not random. Curitiba's early execution of a myriad of planning initiatives such as regularization, urbanized lot provision, and sustainable watershed plans serves as an intriguing longitudinal case study given the potential for changes in the customary pattern of informal urbanization. This research is needed since the impact of newly implemented public strategies on informal urban growth patterns is poorly understood and public policy has been a powerful influence, whether intended or unintended, on the informal production of space. This study examines informal urbanization patterns before

and after the implementation of key policies in the Metropolitan Region of Curitiba from 1991 to 2007. In addition, this research focuses on analyzing the dominant location circumstances of informality in the RMC.

In many cities, informal settlements typically concentrate along the flanks of metropolitan areas within marginal landscapes in a segregated pattern. This study found that informal settlement followed this generality given the tendency to occupy floodplains, conservation lands, and riverbanks; in a decentralized growth pattern outwards into the urban fringe and periphery, near social interest housing initiative areas and bus service. However, this research found that the high annual growth rate of informal settlements from 1991 to 2002 diminished as a whole and inside aforementioned ecologically fragile landscapes from 2002 to 2007. The strategy used in Curitiba encouraged consolidated development and lessened the overall rate of informal settlement urban growth, most significantly in conservation areas, though it did not diminish the overall consumption of ecologically fragile landscapes. This research found that the government strategy was more sustainable and responsive to the urban poor when both reactive (regularization) and pro-active (increasing the availability of affordable serviced lots) features were incorporated. A balanced reactive, pro-active government strategy could help enforce conservation policies. Although the approach in greater Curitiba is multi-faceted, it did not succeed in de-segregating low-income populations. This research provides insights on informal urbanization and concludes with recommendations on ways to support inclusive sustainable urban development.

## CHAPTER 1 INTRODUCTION

The year 2008 marked the beginning of an era of urban dominance given that urban areas are now the primary place of residence rather than rural hinterlands. In the global south, this urban growth arrived rapidly enough to outpace the provision of basic sanitation such as access to safe drinking water and wastewater facilities. In fact, one-third of all urban dwellers of the global south are left to reside in housing with little to no basic infrastructure (UN-HCA, 2006). These substandard conditions disproportionately result in tremendous public health detriments that are primarily felt by low-income communities (Martinez et. al, 2008). In Brazil, the substandard housing problem is imminent since 84 percent of the population is already urban-based and 86 percent of all new population growth is expected to take place in urban areas (Montgomery et al., 2008). This rapid urban growth has paralleled an unprecedented demand for low-income housing in Brazil that has left an estimated three to eight million in need of housing (FJP, 2001; Fernandes, 2005).

Often impoverished urban new-comers resort to their ingenuity to acquire shelter and this has resulted in the development of illegally built neighborhoods comprised of self-built housing. These self-constructed communities, referred to as informal settlements are basically defined by substandard housing conditions and some form of illegality, such as occupation of land that the dweller does not possess or development not in compliance with government regulations (Gilbert and Gugler, 1994; Ward, 1983).

The rapid development of informal settlements and their hidden character makes it challenging to detect their existence, let alone quantify their extent. Despite this challenge, estimates indicate that between 30 and 80 percent of the urban population of

the global south lives in irregular settlements (Durand-Lasserve et al., 2002) and that over half of the new housing stock is built illegally (UN-HABITAT, 1996). These estimates suggest that informal urbanization can be a major force in the way an urban region expands. Distinct patterns have emerged in the types of landscapes left vacant and unprotected from invasions and where irregular settlement is socially, economically, and politically tolerated in an urban region. In general, the urban poor settle on the left over land, regularly in the least desirable areas of a city (Gilbert, 1998).

Most places where land invasions are tolerated have common characteristics that are rationally grounded based on distinct limitations posed to informal settlers in an urban region. In some instances, informal settlements were planned in a deliberate manner by economic and political interests (Ward, 1983 and Burgess, 1981) and as a result of political circumstances (UN-HABITAT, 1996). Ward (1983) argues that the “widely quoted epithet ‘spontaneous’ is misleading” since “settlements are premeditated and planned by agents” (p. 35). The areas selected for settlement are carefully chosen to ensure tenure longevity and a strong negotiating position for their occupation (UN-HABITAT, 1996). For example, informal settlements often emerge on land dangerous for construction such as floodplains or steep hillsides (UN-HABITAT, 1996) since these areas have little commercial value. While Gilbert and Gugler (1994) draw on the idea that within limits “the poor’s response to ... poverty is rational, innovative, and nearly always more perceptive than... they are given credit for” (p. 117). Several studies point out that informal settlement growth is most likely to occur in the urban fringe and periphery (Griffin and Ford, 1980), in vacant marginal areas (UN-HABITAT, 1996) that have access to bus services and employment (Berner, 2001; O’Hare and Barke, 2003).

Household preferences vary from city to city and the poor's options for housing are severely limited by local conditions (Gilbert and Gugler, 1984).

Another influence of informal settlement is public policy. A study by Dosh and Lerager (2006), found that different public policies were a deciding factor of differences in informal settlement construction and choice of whether to occupy public or private land in Lima, Peru and Quito, Ecuador. In addition, public policy can sway the spatial patterns of informal urbanization. Areas with less stringent regulations might attract informal development since the construction costs are lower (UN-HABITAT, 1996). By examining region-wide geographic patterns of informal urbanization in relationship to public interventions, the influences that public policy has on shaping informal urban patterns, whether intended or unintended can be recognized.

This research examines the set of prevalent locational features that result from limitations posed to informal settlers, in the urban construct of the Metropolitan Region of Curitiba, Brazil (*Região Metropolitana de Curitiba - RMC*) from 1991 to 2007. A comparison of the spatial patterns before and after the implementation of key public policies will help in detecting their influence (or lack thereof) on informal urbanization. The government approach in Curitiba combined social interest housing programs, regularization, and social interest zoning with sustainable watershed, and conservation plans. The implementation of the multi-faceted government strategy for dealing with informal settlement more sustainably in greater Curitiba may have lowered the rate of informal urbanization. The guiding research questions, hypothesis statements, and objectives for this longitudinal study are as follows.

## **Research Questions**

- What are the chief locational trends of informal settlement between 1991 and 2007 in greater Curitiba?
- How has the government strategy influenced (or not) the rate of informal settlement urbanization and prevailing spatial patterns?

## **Hypothesis Statements**

As indicated in literature, new informal settlement growth is most likely to occur in vacant areas located in the urban fringe and periphery that have access to bus service. In the context of the RMC, informal settlement often is located in floodplains, conservation areas, and near rivers and social interest housing programs. The government strategy used in Curitiba helped to reduce the overall informal urbanization rate and encourage consolidated urban growth.

## **Research Objectives**

- Measure the informal urban growth of greater Curitiba from 1991 to 2007 and compare informal urban areas with locational features to detect major spatial patterns.
- Using the findings, discuss the potential reasons for informal urbanization trends, focusing on the influences of the government approach used in Curitiba and conclude, with recommendations on ways to achieve inclusive sustainable development.

## **Relevance to the Field**

This research measures the prevalent types of land circumstances of informal settlement in the RMC to determine how implemented public strategies dynamically influenced informal settlement patterns. This type of evaluation is particularly useful for recognizing the combination of features within urban planning approaches that facilitate inclusive sustainable urban development and growth. Two of the Millennium Development Goal (MDG) targets set out to improve the lives of 100 million slum

dwellers and halve the proportion of the population without basic sanitation and infrastructure (UNDP, 2000). To support the MDG targets, a UN-Habitat (2003) report stressed the need for sub-city level geographic data showing informal settlement areas to assess the conditions of urban poverty and inform public policy. In addition, Agenda 21 calls for the improvement of the social, economic and environmental quality of human settlements, the monitoring of strategy impacts particularly in areas affecting marginalized groups, and the encouragement of sustainable land-use planning practices (UNDSD, 1992).

The resultant geospatial database, a product of this research, could help in the planning for the improvement of informal settlement conditions and pro-actively reduce the tendency for growth to occur in hazardous environmental circumstances. In addition, the recommendations based on this research, provides insights on how urban regions could promote sustainable urban planning and the right of the urban poor to decent housing conditions. The results of this research will be useful on practical and academic levels in the fields of sustainable urban development and planning, affordable housing, growth management, and disaster preparedness.

### **Methods and Scope of Work**

Most academic research within the field of urban planning is distinct in its analysis of complex problems and by its inclusion of a space for comprehensive review of how various forces of a problem interface to yield certain outcomes. Yin (2003, p. 13) points out that “a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident.” The issue of informal settlement is a complicated phenomenon with unclear boundaries that involves economic, social,

political, and environmental factors in a particular urban context. Thus, studying the circumstances of individual urban regions is important for understanding how these contextual forces interact and produce certain outcomes. The flexibility of a case study method provides such a space needed for researching multi-faceted urbanistic matters such as informal settlement.

Yin (2003) offers reasons for single-case study research design such as research that tests a unique or extreme event or for a case that is representative of typical conditions. For this research, Curitiba could be considered a unique case given its early development and implementation of a multi-faceted government strategy for responding to informal settlement that includes social interest, conservation, and sustainable urban planning elements. In addition, the premise behind case studies is to draw insights from context-dependent knowledge that arises from experience and direct observations (Flyvbjerg, 2006). Thus, the pluralistic use of multiple sources of data that details the dimensions of a given reality validates findings and yields a more complete grounded truth (Yin, 2003, Flyvbjerg, 2006). The scope of work for this case study involves the collection and comparison of geographic and population/housing data analyses, direct field observations and interviews with informal settlers and government agents.<sup>1</sup> Essentially this research design allows for a comparison of informal urban spatial patterns before and after government intervention.

The first type of data analysis consisted of detecting informal settlement growth with the use of geographic data and field visits. This step helped to measure spatial

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<sup>1</sup> A mixture of primary and secondary data resources were incorporated in the research. The primary data resources consisted of geographic recordings in the field and survey findings and data resources that were secondary were population count data and aerial photographs.

patterns and the extent of informal urban land conversions during the study time period. The field visits were a crucial part of this research since it allowed for direct observations to be made on the reality of urban development in the region. In a critic on Geographic Information System (GIS) and planning, Lejano (2008) warns of the tendency for geographic-based studies to isolate themselves from “the most legitimate source of integration, which is experience” (p. 273). During the field visits, observations were made on the complexities of urban development and these experiences helped to ground geographic findings in reality. The qualitative data analysis consisted of interviews and surveys and the review of local government plans. The interviews and plan review helped draw conclusions on the underlying reasons for informal settlement locational trends. Overall this research approach integrated various data resources to derive results and conclusions that are useful on multiple levels.

The study area for this research encompasses Curitiba and the significant population concentrations closely connected to Curitiba, in the RMC. The urbanized portions of ten municipalities that surround Curitiba were included in the study area. Akin to counties in the United States, the municipalities in the study area include all of Pinhais and the urbanized portions of Colombo, Fazenda Rio Grande, Almirante Tamandaré, Piraquara, São José dos Pinhais, Araucária, Quatro Barras, Campo Magro, and Campina Grande do Sul (Figure 1-1).<sup>2</sup> The study area boundary, totaling approximately 344,362 acres was outlined to include land at least 1/2 kilometer from known urban areas extending from Curitiba to ensure displaced informal urbanization

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<sup>2</sup> The municipalities included in the study area needed to be at least 75 percent urban (IBGE, 2007). The urban core of Campo Largo, located west from Curitiba was mostly excluded from the study since this urban area is separated by a significant swath of rural land 10 kilometers in width. The 26 municipalities of the RMC were not all included in the study area since several of these municipalities are separated from Curitiba by large rural areas.

was captured. The new informal settlements appearing after 1991 were often located in the municipalities surrounding Curitiba; consequently, their inclusion was critical for more thoroughly measuring informal urban expansion associated with Curitiba. The choice to include the towns located in Curitiba's urban periphery is a unique aspect of this study and it avoids the arbitrary restriction that political boundaries pose. Following the definition of an urban area as being an expanse of land with "a population density that is high relative to the density of the surrounding area" (O'Sullivan, 2009, p. 2), the informal urban growth that is an extension of Curitiba was captured more thoroughly.

The urban growth associated with informal settlements and the resultant spatial patterns are products of various political, economic, public policy, and social dynamics. Consequently, the following section offers a historical perspective and synopsis on Curitiba's urban planning. The second part of the literature review provides an informal settlement background that summarizes the historical origins, urban growth influences, and history of government responses.

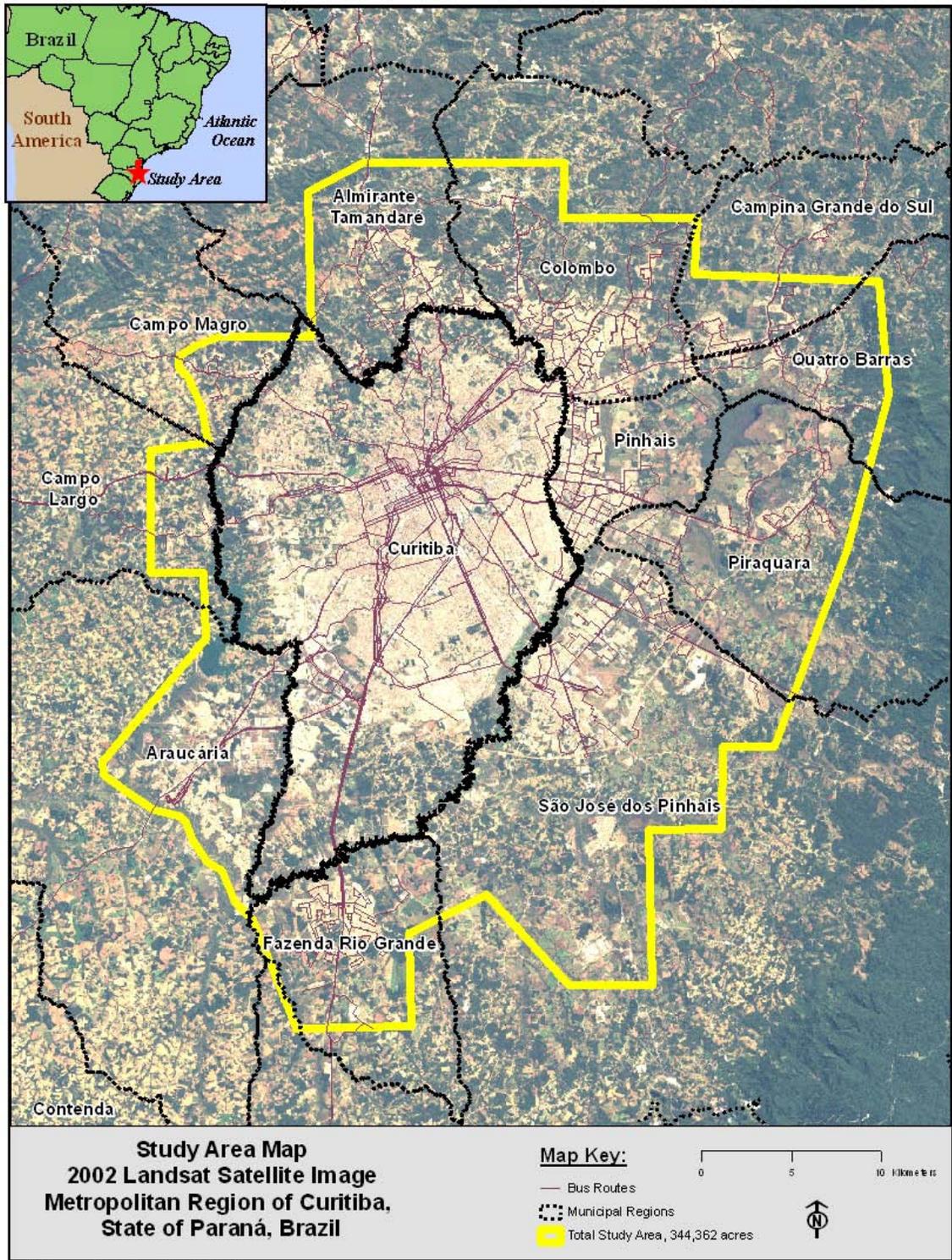


Figure 1-1. Study area map

## CHAPTER 2 LITERATURE REVIEW

### Historical Origins of Curitiba, Brazil

Curitiba is the capital of the state of Paraná in the southern region of Brazil, strategically located 409 kilometers south of São Paulo. Regionally, the city is situated on a plateau at 945 meters of altitude and is bordered to the east by the Serra do Mar mountain range. The name, Curitiba means “abundant with pine trees” (Macedo, 2004) and is in recognition of the Paraná Evergreen Pine (*Araucaria angustifolia*). Five rivers flow through the City of Curitiba including the Passauna, Barigui, Atuba, Belém, and Iguaçu Rivers. Most of these rivers drain into the Iguaçu watershed and are surrounded by floodplains. As shown in Figure 2-1, various natural features including mountains (to the east and north), rivers, and floodplains have largely influenced the path of formal urban growth.



Figure 2-1. Regional view of Curitiba. Source: COMEC, 2008.

The village of Curitiba was founded by Portuguese explorers in 1693. In the beginning, Curitiba served as a gold prospecting supply center and this start helped Curitiba flourish to become an important trading post to cattle ranchers and for those in

need of agricultural goods and pack animals (Schwartz, 2004). In 1842, after Curitiba was chosen as the capital for the state of Paraná, the urban center expanded to surpass its urbanization status of *village* to *city*. This expansion is partially due to the arrival of immigrants, mostly from Germany, Poland, Italy, Ukraine, Japan, Syria, and Lebanon (Rabinovitch, 1992). After gaining railroad access in 1885, Curitiba developed into a lively hub for trade.

Over the course of the 20<sup>th</sup> Century, Curitiba's population grew quickly. In fact, the population of Curitiba reached 180,000 persons in 1950, then rapidly swelled to 430,000 inhabitants in 1960, and has tripled to approximately 1.8 million in 2007 (IBGE, 2009). The extraordinary growth over the last century in Curitiba is reflected by some of the highest urbanization rates in all of Brazil. One of the main sources for this rapid growth is rural-urban migrations brought on by agricultural modernization and industrial development (Schwartz, 2004). Once Curitiba's population approached ½ million during the 1960 decade, informal settlement became more significant (MC et al., 2007).<sup>3</sup> The pace of urbanization in the City of Curitiba seemed to fuel informal settlement growth.

The economic and quality of life opportunities offered in Curitiba have been linked to the urban growth rate. In 2007, most of the formal employment was in the industrial sector (38 percent), followed by the service (26 percent), commercial (25 percent), and construction (seven percent) sectors (MTE and IPARDES).<sup>4</sup> Curitiba has become a place with ample employment opportunities and this is evidenced by an unemployment rate that has remained below seven percent for most of 2007 (IPARDES and IBGE). Today

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<sup>3</sup> Translated by author.

<sup>4</sup> These figures do not include employment in the informal sector – a common source of labor for low-income persons.

different industries have clustered in the Metropolitan Region of Curitiba (*Região Metropolitana de Curitiba – RMC*) and the effects of urbanization economies have led to economic benefits for job-seekers and employers alike.<sup>5</sup> Former Mayor Cassio Taniguchi (2005) points to quality of life advancements in the city, mostly related to improved education, as attracting growth. Nationally, Brazilian urban regions of the south are more affluent in comparison to the northeastern region (Franko, 2007). However, great income inequality has been an unequivocal characteristic of Brazil for multiple decades and Curitiba is no exception. In 1991 and 2000, all of the municipalities in the study area had a lower Gini coefficient than Curitiba – in other words, the periphery municipalities had less drastic income inequality than Curitiba.<sup>6</sup> Although the periphery towns were less unequal, most had greater rates of poverty than Curitiba (IBGE, 2004). Collectively these ratings reflect income divisions between Curitiba and most of the exterior towns in the study area. The rapid population growth in Curitiba was partially stimulated by economic growth and quality of life opportunities though it has led to income segregation in greater Curitiba. Along with economic considerations, urban planning policies have influenced urban growth in Curitiba.

### **Historical Summary of Urban Planning in Curitiba, Brazil**

Since the mid-20<sup>th</sup> century, several land-use plans and infrastructure improvements have been developed to manage the urban growth in Curitiba. The first comprehensive master plan for Curitiba was developed in 1943 by the French urban

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<sup>5</sup> O’Sullivan (2009) describes urbanization economies as the crossover of different industry clusters or agglomeration economies in one urban area.

<sup>6</sup> The respective Gini coefficient ratings for 1990 were 0.55 for Curitiba and an average of 0.458 for the other municipalities (IBGE). The closer the Gini coefficient rating is to one, the higher degree of income inequality.

planner, Alfred Agache (Macedo, 2004). The Agache Plan consisted of elements that recommended a wide spatial distribution of avenues; the layout of districts or specialized centers secondary from the downtown with functions such as civic and university; several codes and zoning restrictions; and measures to conserve open spaces and guide development to accommodate future growth (IPPUC, 2007). The enduring components of the plan are the widened avenues and the designation of specialized centers.

Continued street widening and the fear of replicating the sprawling growth of São Paulo, incited the development of another Master Plan. Subsequently, a national competition was held and architect Jorge Wilhelm produced the winning master plan for Curitiba (Schwartz, 2004). Although there have been minor modifications to zoning and land-use regulations, the concepts presented in the 1965 Master Plan of Curitiba has generally guided urban development till today.

The guidelines of the 1965 Master Plan of Curitiba are (IPPUC, 2007):

- Linear growth of a center served by tangential fast-traffic roads;
- Hierarchy of city streets;
- Preferred development of the city along the northeast-southwest axis following historic and spontaneous trends;
- Multiple centers;
- Increased density;
- Expansion and adjustment of green areas;
- Delimitation of areas of pedestrian domain; and
- Creation of a unique urban landscape.

One of the key elements of the 1965 Master Plan was the establishment of a linear branch road network that is reinforced by land use and bus transport features. Basically the linear plan directed high-density growth and intensive land uses along five axes and each of these axes are comprised of three parallel streets.<sup>7</sup> The trinary

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<sup>7</sup> The intense densification surrounding these five axes gradually tapers as one travels away from an axis.

arterials (or three parallel streets) have a central road that accommodates two exclusive bus lanes in the interior and one bus lane in each direction on either side. Since many of the axes connect to centers of activity, the polycentric radial spatial structure of Curitiba was fortified.

In addition to bus transit improvements, the adoption of the 1965 Master Plan led to the formation of two integral planning organizations: the Affordable Housing Company (COHAB) and the Urban Research and Planning Institute of Curitiba (IPPUC). IPPUC was instituted to guide the implementation of the plan, specify and lead several projects, and manage the comprehensive development of Curitiba (Macedo, 2004). In 1971, the military dictatorship in power at the time, appointed Jaime Lerner, an architect and planner, and former director of IPPUC to the position of mayor of Curitiba (Schwartz, 2004). During his tenure, Jaime Lerner challenged conventions by testing urban planning innovations in Curitiba. Some of the initiatives that took place during his tenure include the conversion of a car-oriented road to a downtown pedestrian street in 1972, the creation of the Green Exchange recycling and employment program in 1989; and the conservation of periphery linear parks that function as storage for flood waters in the 1970s to 1980s (IPPUC, 2007). Perhaps, one of the most acclaimed urban improvements augmented during Lerner's tenure, is the bus rapid transit system.<sup>8</sup> This integrated bus network extends into other metropolitan districts and influences urbanization patterns, even those associated with informal settlement.

After 1985, the federal government shifted from a military dictatorship to a democracy and this shift affected local governments particularly in requirement of

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<sup>8</sup> The bus rapid transit agency in Curitiba estimates that 2.4 million trips are accommodated daily by the bus service (URBS, 2007).

elections. In addition, a new national constitution was adopted in 1988 which lifted censorship, encouraged public participation, and gave Brazilian local governments the responsibility to regulate policy areas that were previously managed at the federal or state level (Menegat, 2002). Despite the call for public participation, Irazábal pointed out that Curitiba (as of 2005) has largely maintained a top-down mode of urban governance and this is exemplified by the scarcity of citizen education programs and opportunities for citizen dialogue in the development of plans.

To summarize, Cervero (1998) classified planning milestones in Curitiba in three distinct periods including the formative years (1943-1970) that launched “bedrock planning principles that guided development decisions” (p.267), then “an active period (1972-1988) of plan execution”, and lastly the regional transit service refinement period (1989 – 1998). The urban planning in Curitiba and the RMC has continued to progress and in the last several decades, attention has been given to implementing planning initiatives to deal with informal settlement and environmental degradation. The following section provides an overview of informal settlement growth and the government approach for handling the issues.

### **Informal Settlement: Public Policy and Urbanization Patterns**

#### **Defining Informal Settlement**

The concept, informal settlement has been defined as clusters of illegally developed housing. Gilbert and Gugler (1994) elaborate the informal settlement definition to emphasize low-income populations. They suggest that informal settlement communities espouse four characteristics including: self-constructed housing; lack of planning permission; inadequate infrastructure and services; and low-income populations. Informal settlements are commonly referred to as favelas in Brazil, irregular

occupations, squatter settlements, shanty towns, slums, *loteamentos irregulares clandestinos* (irregular/ clandestine land divisions or pirate subdivisions), to name a few. Informal settlements are not always built by the occupiers and instead contracted help is often used. Additionally, not all settlers are home-owners; in fact many are renters (Gilbert and Gugler, 1994). In addition, both privately and publicly-owned lands are occupied by informal settlers.

Although informal urbanization differs from city to city and within the same urban region, Fernandes (1997) described two types of informal urban areas in Brazil including *favelas* and *loteamentos irregulares*. Fernandes (1997) defines *favelas* as land invasions comprised of occupants without any type of property tenure documentation that invade privately or publicly-owned property that often is unsuitable for construction due to ecological or geological conditions. These land invasions are regularly planned and they typically consist of homes or shacks built with varied materials such as red bricks and recycled items (Ferguson, 2005). Fernandes notes that *favelas*:

all look the same: the usually steep, hilly areas are densely occupied, and the spontaneous pattern of the land division is irregular and inarticulate. Combining improvised streets, alleys and staircases, the road system is confusing and not suitable for access or general traffic. *Favelas* lack in almost every element of urban infrastructure and collective equipment, and the precarious standard of most dwellings makes for unhealthy and unsafe daily living (1997, p. 6).

In contrast, *loteamentos irregulares* (also referred to as irregular land divisions or pirate subdivisions) tend to resemble formal developments more than *favelas*; however they are still considered irregular due to precarious technical conditions, improper infrastructure, and noncompliance with government laws (Fernandes, 1997). Even though the land may not be invaded, they are perceived as informal (Gilbert, 1981). Fernandes (1997) details two urban development stages of irregular land divisions

(*loteamentos irregulares*). Initially, lots are delineated by landowners, developers, and in some cases, by occupants. Then the lots are commercialized, whereby some of the less desirable lots are first given freely and then, the more desirable lots are sold at higher rates. This process can be profitable since the potential for the municipality to provide infrastructure and services is heightened as this population becomes voters (Fernandes, 1997). In addition, Fernandes (1997) describes the emergence of a social process in which a portion of those living in central favelas move and buy lots in peripheral *loteamentos irregulares* where the security of tenure is greater.

Generally, favelas are more precarious and unimproved than irregular land divisions, although irregular land divisions tend to be more disconnected from the urban fabric. When applying these concepts to reality, this informal categorization is complicated by mixed *favela-loteamento* conditions, imprecise boundaries, exceptions to definition generalizations, and the changes brought on with land regularization. Following the definitions offered above, this research uses the terms informal settlement to indicate favelas and irregular land divisions and the two are collectively referred to as informal urban areas or informal urbanization.

### **Historical Perspective: Informal Settlement and Government Response**

Around the middle of the 20<sup>th</sup> century, the emergence and expansion of favelas broadened to become a significant phenomenon that penetrated various urban regions in Brazil. Depending on the city, various reasons are offered to explain the growth of informal settlements. In a study on the growth of favelas in São Paulo, Lloyd-Sherlock (1997) described how *cortiços* (or tenements), typically located in central areas of the city, were the main types of popular housing during the late 19<sup>th</sup> century up until the 1940s. Then in 1942, when rent controls on tenements rendered these units less

profitable for developers, several tenants were evicted. The combination of tenement evictions, increased rural-urban migrations, and industrialization are thought to have contributed to the initial formation of São Paulo's favelas (Lloyd-Sherlock, 1997).<sup>9</sup> Often there is not one single reason for informal settlement growth and instead a combination of factors that are political, economic, and social related, interact to spur informal settlement growth.

Before reviewing the main government approaches for dealing with informal settlements, the role of clientelism in interactions between government and informal settlers should be recognized. Throughout different political regimes, the practice of clientelism has been a longstanding characteristic of Brazil's political culture and one of the main forms for participating in politics (Macedo, 2000). Gilbert and Gugler (1994) characterize a patron-client relationship as a reciprocal understanding, made informally through an unequal partnership, where one actor wields more power (the patron) over the other (the client) and as an exchange in which the patron typically grants economic and social favors to the client in exchange for political support. In Brazil, various federal government regimes have used clientelism as a way to respond to housing issues (Macedo, 2000). Even today, the decision of where to upgrade informal settlements outside of Curitiba in the metropolitan region is largely politically-driven.<sup>10</sup>

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<sup>9</sup> The 1942 tenancy law prevented rent increases from occurring more than once every two years and led to the eviction of around 45,000 tenants between 1945 and 1947 (Lloyd-Sherlock, 1997). In addition, it should be noted that the tenements (or *cortiços*) did not necessarily offer better living conditions than favelas; they often had unsanitary unhygienic living conditions. Lloyd-Sherlock (1997) argued that no single factor alone was responsible for the recent growth of favelas and he pointed out other factors such as the decline in wages that contributed to the growth of favelas during the 1970-1980 decades.

<sup>10</sup> An interviewee said that the decision where to regularize informal settlements in the RMC is politically based.

As informal settlements have grown, various government approaches have emerged. During the 1950s and 1960s, the federal government opted to focus on the development of public housing. The Affordable Housing Foundation (*Fundação da Casa Popular*- FCP) established in 1946, during the populist regime, was set up to supply low-income housing in Brazil (Macedo, 2000). Although the FCP's role was expanded in 1952 to include social services, finance, public works and research, the program suffered from not setting income limits for participation to low-income persons and from clientelism political practices (Macedo, 2000). The public housing program experienced problems with not being able to meet the mounting housing demand and with discriminatory allocation practices (Sietchiping, 2005).<sup>11</sup>

In the mid 20<sup>th</sup> Century, slum eradication interventions emerged as a response to rampant informal settlement growth in many cities. These interventions proved to be extremely deficient and actually amplified the number of families in need. In the site and service scheme, centrally located favelas were cleared after evicting the inhabitants and sometimes these families were relocated to newly serviced lots outside of existing urban areas, often far from jobs. In addition, inadequate lots were typically in place and families often became disconnected from their social networks. Thus these families often abandoned the subsidized units in favor of new land invasions.

In Curitiba, similar favela removal approaches (*desfavelamento*) commenced in 1967 after informal settlement intensified in the city (MC et al., 2007). This approach proved ineffective given that informal settlements continued to swell even after 20 percent of the population was relocated and nine neighborhoods were eradicated (MC et al.,

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<sup>11</sup> The main beneficiaries of these earlier public housing programs were often civil servants and middle income families (Sietchiping, 2005).

2007). In addition, the adoption of stricter inspection and building municipal codes aggravated the situation. Then during the 1970s and 1980s, when the nationwide financial crisis impacted the region, irregular housing growth prolonged. Surveys conducted from 1974 to 1979 estimated that approximately 4,083 homes in 35 informal settlements expanded to include 6,067 homes in 46 settlements (MC et al., 2007). As shown in Table 2-1, the annual rate of informal housing growth accelerated at a rapid pace, climbing over 10 percent during the 1980 decade and then to 20 percent during the beginning of the 1990 decade (MC et al., 2007). Then, after 2000, the annual rate of informal housing reduced from 17 percent to 1.7 percent. The factors associated with this decrease, particularly related to the government approach will be discussed later.

Table 2-1. Rate of informal housing increase from 1974 to 2005, in Curitiba

Year	Number of Domiciles	Annual Rate of Domicile Increase (%)	
1974	4,083		
1979	6,067	1974 to 1979	9.72%
1982	7,716	1979 to 1982	9.06%
1987	11,929	1982 to 1987	10.92%
1996	33,778	1987 to 1996	20.35%
2000	57,333	1996 to 2000	17.43%
2005	62,267	2000 to 2005	1.72%

Data Sources: IPPUC, COHAB, and domicile counts obtained from MC et al., 2007. Table by author.

Beginning in the 1960 and 1970 decades, Turner (1967, 1968) and Mangin (1967) argued for the upgrading of informal settlements as the solution to the affordable housing problem. The advantages of upgrading favelas over public housing relate to increased functionality, flexibility in housing structures, lack of rent, potential for leasing extra rooms (Macedo, 2000) and decreased costs in comparison to public housing (Roy, 2005). In the 1980 decade, the upgrading strategies were first implemented in Belo Horizonte and Recife, Brazil (Fernandes, 2003). The upgrading approaches had

the advantage of dealing with low-income housing demand more effectively since it facilitates incremental development (Peattie and Aldrete-Haas, 1981).

The upgrading of informal settlements, referred to as regularization, has become one of the main forms of government responses to low-income housing issues in developing country cities (Gilbert, 1999). Ward (2003) points out two forms of regularization; the first implements some type of land titling and the second incorporates physical upgrades, service provision, and community development. In Brazil, the term, *urbanização de favela* indicates regularization of informal settlements and this intervention can include the regularization or legalization of land occupation, the installation of infrastructure, and the inclusion of educational and health facilities and social programs (Huchzermeyer, 2004).<sup>12</sup> In some cases, such as in Lima, Peru informal settlements can be regularized or legalized through the granting of a property titles indicating security of tenure but will not receive electricity and other infrastructure provisions (Dosh and Lerager, 2006). Thus, regularization and urbanization is administered differently from city to city and country to country. For example, the Favela-Bairro program in Rio de Janeiro emphasizes granting property titles and in contrast, the Guarapiranga Program in São Paulo incorporated social assistance and public participation and identified new settlement expansion areas (Abiko et al., 2005).

Opposite from the development stages of formal development, informal settlements upgrades generally undergo stages of development that begin with land occupation and home construction and ends with infrastructure and tenure security (Abiko

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<sup>12</sup> The term *urbanização de favela*, translated into English, does not necessarily indicate favela urban growth or informal settlement land development. Instead, this phrase indicates regularization that includes lot organization and community upgrades such as infrastructure installation.

et al., 2005).<sup>13</sup> Perhaps, the most difficult stage of regularization is gaining security of tenure. During the 1990s, the security of tenure movement became a campaign supported by international agencies such as the United Nations Human Settlements Program (UN-HABITAT), in response to problems with property eviction (Durand-Lasserve et al., 2002). Sietchiping (2005) asserts that “[t]he security of tenure approach derives from the assumption that when the residents have the sense of appropriation, they also have the confidence... to invest, upgrade or improve their environment” (p. 284).

The expected benefits associated with land titles grants have been a topic of discussion. In a study examining informal housing in Bogotá, Colombia, Gilbert (1999) concluded that home ownership increased the perception of stability and was used to generate income from rentals; however capital accumulation derived from home sales was low. In review of several case studies in different Latin American countries, Ward (2003) found that “[t]itling took an inordinately long time; it was expensive...; and by the time it was concluded, regularization appeared to add little to the perceived level of security” (p.4).<sup>14</sup> Durand-Lasserve et al. (2002) found that granting individual property titles is rarely possible and as a result, they suggest combining tenure regularization with a range of options that are responsive to the urban and land market such as the provision of service and the increase of affordable shelter options.

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<sup>13</sup> The upgrading of informal settlements typically begins with a preliminary study that provides an assessment of the technical, physical and legal feasibility for regularization and serves to make contact with the inhabitants. After the upgrades are deemed feasible, the registration of existing residents commences and the project is designed. The plans for subdividing lots and installing each lot with water, electricity, roads, drainage, telephone and sewer are drafted, normally in a manner that benefits the greatest number of families (Abiko et al., 2005). Lastly, the plans are executed and titles are granted.

<sup>14</sup> The 12 case studies that underwent review were located in Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Peru and Venezuela. Ward (1983) argues that “[i]ntervention at the level of the supply of land... is likely to have far greater repercussions” (p.34) than regularization.

The cost of regularization has been a topic of research. A study conducted by Abiko et al. (2005) examining the costs of favela upgrade programs in Rio de Janeiro, Salvador, and São Paulo found that upgrades can cost two to three times more than the hypothetical costs of urbanizing a formal residential development. Cost increases can be attributed to the construction in areas unsuitable for development and the need for additional facilities such as the construction of flood control structures and drainage storage areas. In addition, increased infrastructure and relocation costs raised the overall expenses for regularization (Abiko et al., 2005). The choice in where to regularize is influenced by locational factors. Ward (2003) discusses how variations in informal occupant's perceived rights and in their extent of illegality, can influence their potential for regularization and longevity of tenure. In summary, regularization has become one of the main mechanisms for responding to informal settlement yet it has been burdened with irregularity in its implementation, inefficiency, and high costs.

In 2001, the Brazilian federal government created a law referred to as the City Statute and formed an agency, called the Ministry of Cities.<sup>15</sup> The Ministry of Cities formulated nationwide guidelines to address the issues of informal settlements more comprehensively (Fernandes, 2005). The City Statute proposed the use of various planning tools to make urban land accessible to low-income families, to control speculation in areas designated for social interest, to expedite the process of regularization of tenure, and to concede rights of use without formal property ownership. For example, the City Statute provides a provision for settlers to convene as a group to appeal for property

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<sup>15</sup> The 2001 City Statute is an outcome of the 1988 Constitution of Brazil. Prior to the 1988 Constitution, the social function of property was first recognized in 1937 (Fernandes, 1997). Then in 1988, the Constitution legally recognized two local government land provisions: private property rights as the "basic principle of the economic order" and the "social function" of property when it conforms to the master plan of the city (p. 20, Fernandes, 1997).

ownership on land they have occupied for at least five years (*usucapião coletivo* or collective adverse possession) (Macedo, 2008). Another legal tool, the real right to use concession (*Concessão de Direito Real de Uso*) is a frequently used mechanism to acquire publicly owned land through a 50-year lease contract (Macedo, 2008). In addition, the new policy stipulates that public administrations “offer concrete and acceptable conditions for the relocation of residents” and that “the right to housing continues to prevail” (Fernandes, 2005, p. 6). Overall, the City Statute recognizes instruments for legalizing land tenure for regularized informal settlements, stipulates the production of comprehensive plans, and promotes policies that allocate land for social interest purposes.

An example of a policy supported by the City Statute is social interest zoning. In cities with rapidly growing economies and populations, urban market forces and land speculation tends to inflate property values and intensify shortages in the housing stock and in the amount of serviced property. Fernandes (1997) articulates the consequences of pervasive speculation – an increase in the amount of vacant plots and a discontinuous urban fabric. In response to these issues, social interest zoning prevents land speculation in certain areas through land ownership and subdivision provisions (Maia, 1995). In addition, social interest zoning legally permits regularization procedures and typically has more lenient development code restrictions. Basically, social interest zoning allows low-income families the opportunity to improve their housing conditions without the pressures of eviction. Social interest zoning has been implemented in some Brazilian cities (examples include Recife, Curitiba, and Porto Alegre).<sup>16</sup> An overview of the policies implemented during the study time period, such

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<sup>16</sup> Typically, families residing in social interest zoning contribute to municipal revenues by paying property taxes and public fees (Macedo, 2008).

as social interest zoning, in response to the informal settlement issues in the study area is provided in the last section of Chapter 3.

### **Major Factors of Informal Urban Growth**

Great economic growth in a region can translate into increased housing demand and unmet housing needs. Those who are unable to compete in this bidding war for homes and land must find other shelter options and most are excluded from purchasing desirable lots and housing.<sup>17</sup> Generally, without government intervention, properties containing infrastructure that are perceived to be desirable and cost-effective for development also tend to not experience informal settlement. In a study examining 52 cities of the global south, Arimah (2000) found that the spatial organization and scale of infrastructure networks can alter the spatial trends of housing demand. In addition, if the provision of infrastructure falls short of demand, the supply of improved land will become inelastic and result in rapidly escalating land and housing prices (Arimah, 2000). Consequently, the urban market dynamics and the provision of infrastructure could be influencing the spatial trends of informal development.

Another factor that impacts the availability of low-income housing and the capacity to self-construct housing is related to the availability of home loans. In fact, Ferguson and Navarrete (2003) suggests that a sustainable housing program in the global south should include viable finance options and small subsidies for critical infrastructure in addition to the provision of a broad range of affordable housing solutions including

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<sup>17</sup> A probit model examining Brazilian housing markets identified statistically significant demographic characteristics as increasing the likelihood for occupancy in informal settlements including: higher unemployment, lower quality of employment, lower level of schooling, higher household sizes, lower age, lower salaries, and location in metropolitan regions (Morais et. al, 2005). Although these are common characteristics of informal settlers, population variation exists such as the level of income (extreme poverty to moderate income).

serviced lots and regularization. In 1964, the National Housing Bank (*Banco Nacional da Habitação* –BNH) of Brazil was set up to finance housing and home ownership. However, in 1967, after a high number of loan defaults, the bank shifted to fund mostly middle-income housing (Macedo, 2000). Consequently, the BNH was abolished in 1986. The Federal Savings Bank (*Caixa Econômica Federal*) instituted a building materials program for informal settlements; however, there was no national policy that effectively articulated the goals (Fernandes, 2005). Up until 2001 there were few if any available home loan options, particularly for low-income populations. Then, in 2002, the Federal Savings Bank funding was reinstated and this organization began to provide housing loans to Brazilians of all income brackets.

Many researchers point to public policy as a substantial driver of informal occupation. In developing countries, Roy (2005) suggests that affordability accrues in the absence of formal planning and regulation. Payne (2001) discusses how confusing, complicated regulations, often “based on some notional assessment of what is accepted in Europe or North America” favor those with more resources (p. 311). Minimum standards of development and infrastructure intended to protect persons from living in hazardous conditions might push the poor to unplanned hazardous areas. Lengthy administrative barriers for development impede incremental housing improvements and tend to preclude the urban poor from securing legal housing (Payne, 2001). The formal zoning requirements for development in central areas tend to foster middle to high income development while the lack of a stringent regulatory environment in the periphery has encouraged low-income settlement in the city outskirts (Fernandes, 1997). A comparative study, contrasting Quito, Ecuador and Lima, Peru found that

public policy was the deciding factor of differences in the conditions of building construction and public versus private land occupation (Dosh and Lerager, 2006). In summary, various public policies could impact where informal settlements tend to emerge and their resultant spatial patterns, whether intended or unintended.

In Curitiba, urbanization has progressed quickly and the amount of land suitable for development and serviced with infrastructure that is affordable to low-income populations has diminished. As discussed in the economic growth section, Curitiba has experienced substantial economic growth and as a result of this, housing and serviced land prices have accrued and these price increases likely have led to population density increases. Curitiba regulates development with zoning codes and uses several other planning instruments in the municipality, though it is uncertain if over-regulation has pushed the urban poor to the city outskirts into unregulated areas. The newly implemented social interest policies in Curitiba were formulated to cater to low-income populations and are considerably less stringent than typical zoning and building regulations (see last section of Chapter 3 for more information on these policies). Thus, the role that public policy maintains in displacing or influencing informal settlement patterns merits analysis. In addition, after 2002, the reinstatement of home loan provisions likely supported the purchasing of homes and imparted capital needed for making home improvements or additions.

The institution of government fees such as through a municipal tax structure, can affect the availability of vacant land in Curitiba. During a discussion with the Curitiba Finance Department, the progressive real estate taxation system was explained. Progressively higher tax rates are charged for property sales above R\$30,000. In

addition, the property taxes are greater for vacant land (one to three percent) than they are for residential (0.2 to 1.1 percent) or commercial land uses (0.35 to 0.8 percent). Consequently, Curitiba uses these property taxes to incentivize the development of vacant parcels and reduce land speculation activities.

The urban system of each city involves different political, economic, environmental, and social factors and the interactions between these factors result in different outcomes, particularly pertaining to the spatial patterns of informal urban growth. The urban system also poses limitations in where the urban poor are tolerated, not evicted, and in where their existence is more likely to endure. Based on these limitations, the following section describes the common spatial trends of informal settlements and applies applicable locational theories to the case of Curitiba.

### **Spatial Characteristics of Informal Settlements**

Research, mostly presented through case studies, offers some basic guidelines on the typical geographic locations of informal settlements in an urban region. Fernandes (2005) noted that most Brazilian cities with more than 500,000 residents have informal settlements and 80 percent of cities with a population of 100,000 - 500,000 have informal settlements. This estimate indicates that informal settlements in Brazil are often located in large cities.

Informal occupations often appear in areas hazardous for development, in vacant areas in the outskirts of cities where regulations are not enforced or nonexistent. The UN-HABITAT Program (1996) pointed out that many new informal settlements have emerged on land dangerous for housing construction such as floodplains or steep hillsides since the 1960s. Sietching (2005) described the common types of landscapes at risk of irregular occupation and these include: marginal or lower valued

property near industrial areas and markets, riparian areas or wetlands, steep slopes, dumping grounds, and road right-of-ways. Many of these locational factors are in areas that are difficult, illegal, and expensive to develop. Consequently, informal settlement could be tolerated by land owners more often on land with low development value.

Berner (2001) contends that land must meet two prerequisites for informal settlement: first the parcel has to be accessible by public transport, and second, it has to have a source of water. Gilbert (1998) argues that the expansion of self-help housing in Latin America is regularly associated with public transportation improvements. A spatial and temporal analysis of Rio de Janeiro found that informal settlements were primarily perched on the hillsides in a scattered fashion throughout the city, with the older favelas more centrally located than the newer ones, and their distribution was strongly influenced by access to public transit and employment (O'Hare and Barke, 2003). These studies suggest that access to critical amenities such as bus service, water, and employment could be influential locational factors.

In critical response to the notion that Latin American cities are evolving into North American western cities, Griffin and Ford (1980) developed a model, based on an examination of over one hundred Latin American cities that depicted the trends in the socioeconomic organization of Latin American urban areas. This model identified the prevalence of informal settlements to develop along the urban periphery. Overall Griffin and Ford (1980) outline a city structure that includes a "...viable central business district [CBD], a spine/sector, and a series of rings of decreasing residential quality" (p. 405). Ford (1996) later updated this model by adding a market section next to the CBD, a shopping mall and industrial sector in the suburban areas.

The urban region of Curitiba exudes several of Ford's spatial patterns, such as in having a distinct CBD. The extent that informal settlements dominate the urban periphery will be discussed in the data findings section of this research. However, some signs indicate that gradual decentralized urban growth is occurring in greater Curitiba. During the 1990 decade, the metropolitan growth rate surpassed the City of Curitiba's rate (see Table 4-1). Today Curitiba has little vacant land available for development and the only remaining area for low-income housing is located in the southern urban fringe (IPPUC, 2009). Curitiba has become compact to the point of increasing the amount of densification and verticalization of development to house newcomers yet these high-rise developments are neither simple nor inexpensive to construct. A building structure that is over two stories in height requires special materials and skilled labor – both of which are limited resources for low-income populations (O'Sullivan, 2009).

In addition, the growth of the secondary urban centers and conurbations in greater Curitiba has become more pronounced and contiguous since the 1980s. The term *conurbation* has been used to describe an urban growth trend observed since the early 20<sup>th</sup> Century. Park and Burgess (1967) describe the conurbation phenomenon as expanding a city's limits concentrically to merge into a variety of neighboring towns of which connect to each other to coalesce into one continuous population agglomeration. For example, adjacent to the eastern edge of Curitiba, the towns of Colombo, Pinhais, and São José dos Pinhais have merged into one continuous conurbation. Regionally, the conurbation development of greater Curitiba reflects tension between the push of polycentric urban growth and pull of concentric urban growth towards the urban core. The role that conurbations maintain in housing low-income populations has been explored little yet is

recognized by the local government as substantial residential areas. Serra et al. (2004) found that the informal housing supply has increased by 205 percent between 1991 and 2000 and nearly half of this stock increase is located in regions 10 to 20 kilometers from central Curitiba (Serra et al., 2004). Yet a substantial portion of the formal housing stock growth (34 percent) is located in the 10 to 15 kilometer ring (Serra et al., 2004). This study suggests that both informal and formal housing growth spurred conurbation development in the RMC.<sup>18</sup>

Many of the major spatial trends generally apply to the Metropolitan Region of Curitiba (RMC) though each city context has slight differences in the major informal urban landscape characteristics given that whatever vacant land is deemed low in value, marginal, and undevelopable varies contextually. The societal organization and environmental circumstances specific to Curitiba limits and influences informal settlement trends. The conurbation growth of the RMC could be pushing informal development in the urban fringe and periphery. In addition, the physical terrain of the RMC has a substantial portion of river and floodplain areas. In fact, around 23 percent of the total study area consists of riparian and lake areas and 9 percent of floodplains. Predominantly located outside of the city limits of Curitiba, around 29 percent of the study area is within conservation areas.<sup>19</sup> Consequently, informal urbanization near rivers, floodplains, and conservation areas could constitute a large proportion of the marginal landscapes experiencing informal occupation in greater Curitiba. In addition, a

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<sup>18</sup> Around 31 percent of the RMC population lives in substandard housing (Serra et al., 2005).

<sup>19</sup> Using GIS, the calculation of natural feature areas was based on GIS data from IPPUC, Mineropar and SUDERHSA. Conservation areas are defined as UTP and APA conservation regions and parks. Approximately 4 percent of the study area is within karst topography. Generally karst areas were located in terrain, underlain by dissolving rock formations usually comprised of limestone or dolomite.

City of Curitiba municipal report suggested that informal settlements tended to locate in areas not of interest to real estate sectors and clustered along railroads, highways, near high-tension electrical transmission lines, land with low property values (*fundos de vale*), flood prone areas, and environmental protection areas during the 1960 to 1980 decades (MC et al., 2007).

This research will explore the major spatial trends of informal urban areas likely present in the study area, including location in floodplains and conservation areas and near rivers, public housing, and bus service and the tendency for decentralized growth. Lastly, the rate of informal urbanization could have decreased as the public programs and other features increased the access to viable affordable housing options.

This literature review offered a theoretical background for this research. The historical background of Curitiba summarized the urban planning and urbanization of greater Curitiba to provide a context for this research and the subsequent literature review described informal settlement and history of policy approaches. A more detailed description of the public policies implemented in the case study area during the study time period and a description of the potential spatial pattern influences is provided in the final section of Chapter 3. A method for exploring the research conjectures is described in the following section.

## CHAPTER 3 METHODOLOGY

Following a case study method that focuses on the mixed methods research approach, this study used both quantitative and qualitative data. The qualitative data included plan review and interviews while the quantitative data analyses included remote sensed land cover classifications, area change measurements, and population/domicile calculations. The spatial trend analysis was guided by interview responses and in return, the interviews helped in explaining the rationale of many of the spatial trend findings. Collectively these linkages served to reinforce each other and enhance results.

Basically, the method involves geographic analyses of informal urban growth and identification of spatial trends. To determine the urbanization patterns, the extent of the urban area for 1991, 2002 and 2007 was classified using remote sensing tools. Using the resultant built land covers and following a rule-based method that integrated analysis using various geographic datasets and high resolution aerial photographs, the informal urban areas were demarcated. The informal urban areas were examined for dominant locational circumstances and urban form changes associated with pertinent public programs. Interviews with members of informal communities and government agents were conducted to determine the perceptions on informal urban spatial patterns and to learn about the potential influences of public policy. The policy influences were measured with the use of geographic analyses and the review of several local government plans. Lastly, a set of policy recommendations, emphasizing the attainment of inclusive sustainable urbanization in light of the research results was offered. A more detailed description of the methodology is described below.

## **Method for Measuring Urban Growth**

To identify the locational determinants of informal settlement in greater Curitiba from 1991 to 2007, geographic analyses was conducted. Remote-sensed imagery and aerial photographs datasets were employed to identify the extent of urbanization during the study time period. Remotely sensed data provides an extremely useful instrument for identifying the alterations of land within and proximate to urbanized areas and for measuring the extent of urbanization (Jenks and Burgess, 2000). In addition, remote sensing facilitates regular observations of explicit patterns of land cover changes over a large geographic area (Schneider and Woodcock, 2008). Moller-Jensen et al. (2005) used Landsat TM and ETM+ imagery to analyze the expansiveness of urban growth in Accra, Ghana and found the approach to be cost-effective and simple for monitoring growth and detecting patterns.

Studies measuring the extent of residential types of urbanization must overcome challenges related to the complexity of a polluted spectral signature that includes a mixture of vegetation and urban pixels (Jensen, 2005). Consequently, the verification of land cover categories required extensive visual interpretation of orthophotographs and field visits recorded with a Geographic Positioning System (GPS). This land cover classification required the collection of training samples that are representative of individual land cover classes. Essentially these samples help train the classification algorithm to create a land cover geographic dataset (Jensen, 2005).<sup>1</sup> Training samples collected during 2008 and 2009, were used to classify the 2007 image since these

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<sup>1</sup> The training classification algorithm is based on means, standard deviations, and covariance matrices for each image pixel.

conditions most closely reflect 2007 circumstances. As a result of these field visits, around 85 training samples were collected in various informal urban areas, 200 in formal urban areas, and 130 in vegetative areas. A summary of the training sample types is provided in Appendix B.

The Landsat TM and ETM+ satellite imagery was chosen as the data source for the land cover classification analysis since this satellite image type is freely available and it caters to regional studies dating back to 1990.<sup>2</sup> In addition, the Landsat image includes a large swath of land covering the entire study area in a single image. Using Erdas Imagine, a supervised classification approach was employed that relied on training samples based on geographic data, field study, and high resolution aerial photographs. As described below, a simple set of land cover classes were chosen according to study purposes.

### **Land Use Land Cover Classification Categories**

- 1. Water:** Water features covering areas such as rivers, lakes, dams, drainage ponds, wetlands with substantial amounts of standing water and canals were categorized.
- 2. Barren/Bare Soil:** Large areas with exposed soil and fields cleared of a great amount of vegetation were classified as bare soil/barren. Often this barren land was cleared in preparation for agricultural, mining, or for formal residential/urban development (for the purpose of installing infrastructure).
- 3. Vegetation:** This category includes areas predominately comprised of fields, vegetated areas and green spaces. Golf courses, agricultural areas with vegetation, parks, yards, and community gardens fit within this category. Areas designation in this category may consist of a mixture of vegetation, shrubs and canopy cover.
- 4. Built/Urban:** Built or urbanized areas, such as mixed use, commercial, industrial, and residential developments were categorized. Other examples within this category include big-box retail uses, airports, warehouses, industry, parking lots, large hotels, large gas stations and railroad features. Mining facilities were included in this definition given the building impact; though, the mining pits were categorized

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<sup>2</sup> The Landsat TM and ETM+ data sources are INPE, 2008 and UMGLCF, 2008.

as Barren/Bare Soil. In addition, this category also could include a housing initiative area supported by a government agency or public-private partnership.<sup>3</sup>

The decision rules chosen for the supervised classifications were the maximum likelihood, non-parametric rule and the minimum distance, parametric rule. After attaining classified images, a majority filter with a three-by-three-pixel moving window was applied to ascertain the most prevalent land cover types throughout the study area. The resulting classification of the 2007 satellite image was used as a basis for the classification of the 1991 and 2002 satellite images. To account for errors particularly within the rural-urban transition area, edits were made for all three classifications using available Geographic Information System (GIS) datasets that were higher in spatial accuracy than the satellite images. Jensen (1982) discussed the difficulty with measuring landscape changes in newly developed regions that contain a mixture of agriculture, residential, and industrial land uses. As expected, the newly developed urban areas required editing to better reflect actual conditions.

### **Summary on Land Cover Classification Accuracy**

The accuracy was tested for the latest study year since the field visits were conducted closest to the 2007 time period and given that the other classifications followed the logic produced from the 2007 classification. As shown in Appendix B, the supervised classification for the 2007 Landsat TM satellite image yielded an overall accuracy of 91 percent. The training sample points used to test the accuracy of each

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<sup>3</sup> Urban/built land covers often are identified by the presence of impervious surfaces such as roads, buildings and parking lots. The urban concept has been defined as an area with at least 50 percent impervious surfaces (Schneider and Woodcock, 2008; Arnold and Gibbons, 1996).

class were randomly selected with the use of Hawth's Tools to eliminate spatial biases.<sup>4</sup> The Kappa analysis "is a discrete multivariate technique of use in accuracy assessment" (Jensen, 2005, p. 506) that compares the classified image to the reference data and produces a K statistic. The overall Kappa statistic for the 2007 classification was 81 percent and this indicates "strong agreement or accuracy between the classification map and the ground reference information" (Jensen, 2005, p. 508). The producer's accuracy measures the likelihood that the reference pixel is correctly classified and the evaluation detects the error of omission (Jensen, 2005). In other words, this test indicates how well a certain area can be classified. True to its name, the user's accuracy is a measure of how useful and reliable the classified image is in its ability to represent the reality in the field. For example, the results suggest that 95 percent of the time the producer was able to consistently identify the built class correctly and 93 percent of the time the user would find built areas while out in the field.

The water and built classes yielded the most accurate results in comparison to the other categories. More training samples were collected for the built and vegetation classes while few bare soil/barren training samples were collected due to accessibility issues. In addition, the bare soil/barren category has a similar signature to the built category; thus the results required editing to improve accuracy particularly in the urban-rural transition region. Overall, the identification of built areas proved useful for narrowing down the scope of review for identifying informal urban areas and measuring the patterns of regional urban growth.

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<sup>4</sup> Half of the total training sample points were used to test for accuracy. Hawth's tool is a freely available extension that can be used with ArcView GIS software.

## Method for the Identification of Informal Urban Land Uses

The resultant urban areas derived from the land cover classifications were used to narrow the scope for detecting informal urban land uses. Basically, the classification helped identify land that had been developed from 1991 to 2007 and these developed landscapes were analyzed for informal building patterns and other indicators of informality. For this study, 'informal urban' signifies a cluster of housing that primarily serves low-income persons and possesses inadequate housing facilities and infrastructure that was built in unlawful circumstances. This definition encapsulates informal settlements, favelas, and *loteamentos irregulares* (irregular land divisions) and follows the definition provided in the literature review.

Initially, a classification that included an informal urban class was attempted using the Landsat satellite imagery. The shortcoming in the method became quickly apparent when viewing the known locations of informal communities – many of these housing clusters were linear in shape and small in size (around nine acres on average). Thus, it was difficult to separate the small patches of informal uses from large swaths of formal urban uses.<sup>5</sup> As such, high resolution aerial photographs taken during 1990, 2000, 2007-2008 and Google Earth aeriels were used for deciphering detailed building and lot organization features in a separate method (described in the following section). Jensen (2005) mentions that few land-use classification techniques solely rely on satellite

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<sup>5</sup> In addition, the 30-meter spatial resolution offered in the Landsat imagery was too low for detecting small built features. Differentiating between land uses or different human impacts to land, required the use of other baseline datasets that can decipher human uses (Jensen, 2005). Jensen and Cowen (1999) discuss the importance of high spatial resolution of satellite imagery and suggest a minimum of five meter spatial resolution (0.8 to 16.4 feet) for capturing individual buildings in the urban/suburban fringe areas. A general rule for classification is that a minimum of four pixels are needed to identify an object – this means that the spatial resolution should be at least one-half the diameter of the smallest object of interest (Jensen and Cowen, 1999). Several small informal settlement homes are six meters in width, thus the imagery used for their detection should have three meter spatial resolution.

imagery; in fact many use a classification hierarchy technique, rule-based modeling, and geographic analyses. Thus, a method for capturing informal urban uses was developed that incorporated rule-based modeling and geographic analyses. These techniques were developed based on the inductive logic drawn from the review of the known locations of informal settlements.

The Municipal Plan of Social Interest Housing for Curitiba (MC, 2008) pointed to several common locational circumstances of known informal occupations areas. The report indicated that 63 percent of the total irregular occupations are located partially or totally in permanent preservation areas, 38 percent were in flood areas, and 14 percent were under and near electrical transmission lines.<sup>6</sup> During the research field visits, it became apparent that informal settlements were often located in floodplains, near rivers, and wetland areas. The fact that one neighborhood was referred to as the *Pantanal* (wetland) cued in on this spatial linkage. Similar to other geographic studies, the field visits were crucial for linking on-the-ground characteristics with indicator features visible from an aerial perspective. In other words, these connections helped develop spatial pattern logic useful for differentiating between informal and formal housing development typologies. Secondly, geographic datasets, detailed maps, and plans were collected that were indicative of informal settlements.

An informal urban area detection method was customized to the specific conditions in the Metropolitan Region of Curitiba (*Região Metropolitana de Curitiba – RMC*) and was formulated based on field visits, interviews with government agents, review of municipal plans in the region, use of census data, and other aerial photograph

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<sup>6</sup> Translated by author.

and geographic datasets.<sup>7</sup> In addition, the logic drawn on informal settlements showed location often in ecologically fragile landscapes (such as floodplains) and conservation areas (the Territory Units of Planning or *Unidades Territoriais de Planejamento* – UTP areas and the Environmental Protection Areas or *Áreas de Proteção Ambiental* – APA areas) and in lower-valued land along the urban fringe and periphery. Subsequently, the informal urban areas were identified based on this logic and a rule-based method that guided the filtering of the built areas.

Within the informal urban areas, land undergoing regularization and that was an irregular land divisions (ILDs) were categorized. In comparison with the more precariously built informal settlements, there was difficulty with identifying ILDs through aerial interpretation since these areas might be more regular and formal in appearance. Thus the ILD areas recognized in a local government plan produced by the City of Curitiba were preserved and this categorization did not extend outside of the city limits of Curitiba. The areas that were categorized as informal urban undergoing regularization signified communities that were in the construction stages of regularization during the classification year. In other words, after emerging from the planning stage of regularization, only the informal urban areas undergoing physical regularization improvements and changes such as road alignment and housing relocation were categorized as regularizing informal urban areas. The regularizing areas were identified during field visits with government contacts, according to

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<sup>7</sup> Essentially the best available resources were collectively used to filter and guide the identification of informal urban areas.

information derived from master plans, and when regularization improvements were discernible through aerial photograph analysis.<sup>8</sup>

In sum, the built classifications (for 1991, 2002, and 2007) were categorized into formal urban, informal urban, and regularization urban use categories throughout the study area. Inside the city limits of Curitiba, the ILD areas were categorized. Details on the method for detecting the informal urban categories are provided below.

### **Steps for Informal Urban Detection: Indicators and Rule-Based Categorization**

Using the logic drawn from known informal settlement locations in the City of Curitiba, several steps were taken to delineate informal urban areas. This detection method relied on the best available data outlets, many originating from local government entities in the RMC, and a set of indicators. The use of ArcView and other GIS tools facilitated this detection. As discussed above, the detection process began with the identification of at-risk areas. Then these areas at-risk for informal occupation were scrutinized for informal development features common in the RMC with the use of high resolution aerial photographs. Lastly, these areas were filtered with census data and other indicators, and when possible, verification from a person knowledgeable on informal settlement in the RMC.

### **Identification of at-risk areas with the use of indicators**

The areas deemed at-risk for informal housing were identified through the use of a set of indicators that indicates substandard housing clusters and hazardous living

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<sup>8</sup> After regularization, an informal community might experience infrastructure and building layout changes. The changes often visible from an aerial perspective were: road alignment and widening changes, the installation of drainage structures, removal of extremely precarious homes in environmentally sensitive areas, and the construction of nearby public housing. The extent of these infrastructure improvements varies since there are no rigid standards for reaching a minimal or maximum level of regularization. Figure 2-2 shows an example of the regularization changes before and after regularization.

conditions. The census data from the Brazilian Institute of Geography and Statistics or *Instituto Brasileiro de Geografia e Estatística* (IBGE) proved to have several data features useful for detecting informal settlement. The IBGE domicile dataset has a land tenure referred to as a clustered substandard housing sector type (or *especial de aglomerado subnormal*). The identification of these substandard housing clusters was not reliant on self-reporting from residents and instead the census interviewer analyzed the housing situation and classified the land tenure based on observations (Serra et al., 2005). However, this dataset was only available for 2000 and for housing areas with over 50 dwelling units. Thus many areas would be missed with solely relying on this dataset. As a result, several other indicators based on physical characteristics were examined and compared to aerial photograph features including new housing located near existing informal settlements, homes converging in a riparian area (within 50 meters of a river or stream), and housing located along floodplains, steep slopes, karst areas, drainage valleys, and in an APA or UTP conservation area or park. With the use of detailed orthophotographs, these at-risk areas were analyzed for development features specific to informal settlements and were narrowed down to outline only the informally built urban areas.

### **Visual interpretation**

Land-use identification often involves visual interpretation of detailed aerial photographs since this analysis provides a wealth of information on the human uses of land and land development differences. Based on a review of the aerial features of known locations of informal settlements in Curitiba, common development characteristics for informal settlements in the RMC were recognized in geo-rectified

aerial photographs.<sup>9</sup> Generally, the development features discernible from detailed aerial photographs were:

- **Lots:** Irregular lot sizes, often extremely small, arranged in a manner in which it is difficult to distinguish where the lots begin and end. The lot boundaries might not be visible in denser areas.
- **Homes/Buildings:** Scattered placement of buildings that often lack direct access to a road and that fail to include few if any building setbacks. The homes often cluster around a thin vegetative feature, such as a stream, river, or flood valley or they might be perched in non-quadrangular angles along a hillside. In other words, the arrangement of the clustered homes follows the shape of the natural feature such as a hill and river. Homes might resemble shacks and be precarious in their construction and the home layout often is diverse and non-uniform.
- **Roads/Blocks:** Several unpaved roads that are inconsistent in their width, arranged in non-uniform block sizes and shapes, contrasting in size, width and shape. The roads might be extremely narrow in width or in some areas there may not be any roads near housing clusters. The road system generally might be confusing and too narrow for access.
- **Materials:** A wide assortment of roofing and housing materials. The formal areas tend to consistently use orange/red terra-cotta roof shingles in residential areas and gray/white flat roof materials in industrial areas while the informal areas tended to use a wide range of roofing materials such as tin, wood, and terra-cotta. Extremely detailed aerials are needed to detect the building materials, thus this aerial indicator is less useful.

As described above, the detection of the collective arrangement of the lot, building, and roads was easily recognizable when the orthophotographs were examined at a scale of 1:20,000 meters or less. In addition, the aerial photographs were useful for eliminating other formal types of urban areas such as industrial and commercial areas. The use of another land use land cover dataset for the region helped with this filtering process (2000, SUDERHSA). The presence of more informal indicators identified

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<sup>9</sup> Generally, the pattern and layout of informal settlements showed several physical commonalities such as scattered buildings and lots and an irregular road network. As discussed earlier, the aerial photographs used for identifying informal land uses needed to have around three meter spatial resolution. Basically, the aerial photographs should be detailed enough to decipher the location of individual buildings and roads.

through visual identification increases the probability of informality, particularly in terms of the lack of standard full infrastructure. As such, all of the built areas containing several of the abovementioned informal indicators were filtered based on their location in other indicative regions.<sup>10</sup> The next step requiring filtering based on rules is described below.

### **Rule-based filtering**

Various indicators were identified and the built areas were filtered with these common locational characteristics in the informal urban identification process. Several of these filters indicate precarious and hazardous development circumstances located in areas which typically are not legal to develop according to land use regulations in municipal plans. In addition, other filters used in this identification were based on identification from knowledgeable government agents and municipal plans and housing data. For example, the IBGE census GIS data provided information on the location of improvised shelter areas and domiciles without bathing and waste-water facilities and areas with concentrations of low-income levels.<sup>11</sup> These locations often were indicative of inadequate living conditions.<sup>12</sup> Consequently, urban areas with clusters of improvised domiciles or homes without bathing and waste-water facilities were scrutinized. The substandard agglomeration area proved to be the most useful census indicator, thus these areas were examined and narrowed down to outline only the

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<sup>10</sup> In the RMC and other areas of Brazil, the substandard infrastructure features are often indicative of informal settlements since many informal urban areas do not have infrastructure such as sewage and drainage facilities and fully paved roads. However, other cities with less infrastructure overall might have different commonalities other than substandard infrastructure that are indicative of informal urban areas.

<sup>11</sup> Improved domiciles indicate habitation situations similar to homeless circumstances in the US.

<sup>12</sup> Another study used domicile IBGE data resources and housing indicators such as inadequate waste-water facilities and improvised housing to quantify the housing deficit in Brazil (Serra et al., 2005).

developed areas with substandard characteristics, as described in the visual interpretation method. The rule-based method for filtering at-risk features and rating is provided below.

Table 3-1. Rules for informal urban categorization

Rating	Rules
5	<ul style="list-style-type: none"> <li>○ If identified as an informal settlement or invasion by government agencies during field visits or indicated by a local government planning document or data, then the 'informal urban' designation was appointed.</li> </ul>
4	<ul style="list-style-type: none"> <li>○ If the area is in a special substandard agglomeration area (<i>especial de aglomerado subnormal, IBGE</i>) and deemed substandard through the visual interpretation of aerial features, then the 'informal urban' area was recognized.</li> <li>○ If the area is located in an UTP area (particularly if the housing was in a consolidated urban area) and deemed substandard through the visual interpretation of aerial features, then the 'informal urban' area was outlined.</li> <li>○ If through review of detailed aerial images, the area shows substantial evidence of regularization at a later date in which there is relocation, construction of public housing, and lot and road alignment, then the 'urban informal' or regularization land use was recognized.</li> </ul>
3	<ul style="list-style-type: none"> <li>○ If the housing cluster is within 50 meters of the edge of a river or stream feature and the area was deemed substandard by the visual interpretation of aerial features, then the 'informal urban' category was designated.</li> </ul>
2	<ul style="list-style-type: none"> <li>○ If the housing cluster (partially or fully) is within a floodplain or karst region and the area was deemed substandard by the visual interpretation of aerial features, then the 'informal urban' class was designated.</li> </ul>
1	<ul style="list-style-type: none"> <li>○ If the housing area is within a steep slope or drainage path in a valley, and deemed substandard through the visual interpretation of aerial features, then 'informal urban' was designated.</li> </ul>

The informal urban areas were compared to census data and were examined for substandard housing indicators such as homes without bathing and waste-water facilities and for income levels below six monthly minimum wages (per 2000, IBGE census data).

The areas were ranked according to accuracy and likelihood of informality. For example, an area identified as an informal settlement by a government agent during a

field visit was given a five rating. The areas that espoused several characteristics of different rankings (such as location in a floodplain and identification in a master plan) were assigned the highest possible ranking. In general many of the informal urban areas were associated with several indicators. A summary of the rankings derived from the informal detection method for 2007 are provided below in Table 3-2. Approximately 76 percent of the acreage of informal urban areas was ranked highly as a four or five while the remaining 24 percent was ranked in the lower range from one to three. The rankings show that most of the areas were identified based on guidance from local government agents and plans and crucial census data indicators.

Table 3-2. Ranking results of informal detection for 2007

Ranking	Description of Ranking	GIS Acres	Percent of Total
1	Housing area is located within a steep slope or drainage path in a valley.	570	9%
2	Located within a floodplain or karst region	246	4%
3	Located 50 meters from the edge of a river or stream feature	697	11%
4	In a substandard agglomeration area (2000, IBGE); or UTP area; or shows substantial physical evidence of regularization at a later date	1,047	17%
5	Verified through field visit, by local government agent, or indicated as informal in master plan map or per GIS data	3,697	59%
Total		6,257	100%

Using the aforementioned method, the informal areas were outlined for 2002 and 2007. Then the geographic locations of built areas within the 1991 land cover classification that intersected with the 2002 informal urban areas were outlined. A set of detailed historical aerial photographs taken in 1991 were available for some areas

within Curitiba. These 1991 images were reviewed to correct informal urban areas in the 1991 geographic dataset. The informal urban areas that were fully regularized and no longer informal by 2002 would have been missed - though regularization largely had not been implemented in Curitiba prior to 1991. Given the data limitations for 1991, the identification of these informal urban areas generally was less rigorous than later years. Overall the use of filtering helped to improve the overall effectiveness of informal urban area detection.

### **Discussion on Informal Urban Identification Method**

Many informal urban areas had distinct land development patterns; however the informal urban pattern was not completely homogeneous from neighborhood to neighborhood. There were slight differences depending on the context (see Figure 3-1). In a more established urban neighborhood, the informal building pattern was denser while in a more exterior community, located in an urban-rural transition area the building pattern was slightly more dispersed, vegetated, and less dense. These varied conditions were observed during field visits and during geographic analyses. Generally, the identification of informal urban areas is challenging especially when considering the small size of informal settlement clusters (on average informal urban areas were seven acres in size for all three study years), their rapid development, and the hidden quality of their existence. Subsequently, the informal urban areas that contain more visible physical conditions indicative of substandard housing and development in precarious circumstances might have been identified more often than those informal areas with less apparent physical characteristics.

This informal settlement detection method strives to capture a greater amount of informal urban areas and improve the accuracy, particularly in comparison to the



Figure 3-1. 2000 orthophotograph map: variations in informal urban areas

method used by IBGE. The extent that the findings were verified varied from town to town. The areas with comprehensive informal settlement location information indicated by municipal plans were available for Curitiba and Fazenda Rio Grande. The areas visited in the field with the accompaniment of government agents primarily took place in the eastern conurbations. Thus the rule-based rating gives a higher number for these areas to indicate greater identification confidence (see Table 3-2).

Overall, informal detection methods are limited by several issues particularly in the inability to account for the full informal settlement population. The lack of available property title information and difficulty with retrieval hindered the detection of the whole informal settlement population in the RMC. In addition, the areas that had a greater proportion of formal land uses in comparison to informal housing were not categorized as informal (needed at least 50% informal housing) and this could have lowered the amount of informal housing detected. In response to these limitations, this method was formulated to utilize the best available data resources and techniques for detecting small pockets of informal settlement. After detecting informal urban areas, the resultant locations were compared for their prevalence with major locational trends using GIS tools and the method for this analysis is described briefly in the following section

### **Method for Analyzing Spatial Patterns**

The types of spatial patterns measured in the informal urban areas from 1991, 2002, and 2007 were related to urban growth or major locational features. The urban growth trends were measured using urban population density calculations, the elasticity of urban sprawl measurement, and through visual interpretation. In addition, the informal urban areas were compared with geographic datasets representing common locational determinants including floodplains, rivers, karst features, conservation areas,

bus lines, electrical transmission lines, and steep slopes. The use of ArcView, Spatial Analyst, and other GIS tools facilitated this analysis and was particularly helpful in deciphering the strength and prevalence of trends (such as the I-Moran's spatial autocorrelation tool). Often the informal urban areas converging inside locational features (such as floodplains, conservation areas, and karst regions) were extracted to measure the portion of informal urban areas that overlap in a particular feature, using GIS tools. This simple extraction technique facilitated acreage calculations and helped determine the amount of informal urban areas that are located within a particular geographic feature. In addition, distance measurements (as the crow flies) from a feature of concern were used to determine proximity trends. For example, the amount of informal urban areas within 500 meters of a bus line was calculated. Often the rate of growth formula was used to measure whether patterns and trends were accelerating or diminishing from 1991 to 2007.<sup>13</sup> Collectively this geographic analysis helped to create a foundation of what constitutes the dominant spatial conditions that informal settlers disproportionately face in the RMC.

### **Community and Government Agent Interview Methods**

The interviews, a part of this research, were collected mostly during the summer of 2009 in addition to a few reconnaissance interviews held earlier in 2008. Informal settlers were interviewed, with the accompaniment of a Housing Company of the State of Paraná (COHAPAR) staff member, in the Zumbi informal settlement, a community that is undergoing regularization. The community surveys sought to ascertain the perceptions and opinions of the informal settlers on what factors (if anything) influenced

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<sup>13</sup> The formula used to calculate the average annual growth rate is:  $((\text{Later Year} - \text{Earlier Year}) / \text{Earlier Year} / \# \text{ of years}) * 100$ .

settlement location outcomes.<sup>14</sup> These surveys were initially offered as interviews and if the participant indicated a preference for writing responses, paper surveys were provided. In total, 30 participants provided responses to the community surveys/interviews. In addition, periodic interviews with government agents whom are involved with housing and urban growth management were carried out in 2008 and 2009. These interviews were informal and open-ended in nature but were all guided by a drive to comprehend the reasons for informal urbanization trends. The findings derived from the community surveys and government agent interviews are interspersed alongside other similar geographic-based results. The purpose of these interviews and surveys was to compare spatial trends that arise from the geographic analysis. Given the nominal and non-numerical character of the community survey responses, descriptive statistics such as frequencies were calculated to evaluate survey findings. In addition to interviews, a review of the municipal and regional plans was conducted as a part of the qualitative portion of the research method. The findings from the plan review are provided in the following section.

## **The Case of Curitiba: Public Policy Influences from 1991 to 2007**

### **Social Interest Initiatives in the Study Area**

In response to informal settlement and affordable housing issues, several planning initiatives have been implemented from 1991 to 2007 in Curitiba such as regularization, social interest zoning, and lot and public housing provision programs. Consequently, a review of the major social interest policies and the conceivable ways they could potentially impact the urban growth patterns is provided.

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<sup>14</sup> Community survey questions and a summary of responses are provided in Appendix A.

The Special Sector of Social Interest Housing (*Setor Especial de Habitação de Interesse Social—SEHIS*) was adopted by Municipal Decree in the 2000 Master Plan of Curitiba and many areas are designated SEHIS. Prior to its adoption, Decree 901/80 already declared areas of social interest in order for the Affordable Housing Company of Curitiba (COHAB) to implement public housing programs (MC, 2008).<sup>15</sup> As articulated in the Municipal Plan (2008), the SEHIS is viewed as a great advancement especially since different formalization parameters were adopted and additional social interest lots were produced. The basis for where and how much land is allocated under SEHIS is vague other than the fundamental limitation posed by the amount of available land. According to the zoning regulations, SEHIS should be designated in areas deemed compatible to the ‘public interest’ and where the infrastructure provision a part of regularization might complement other social interest habitation programs (MC, 2008). Besides the recently designated social zones in Parolin and Vila Formosa, most of the SEHIS zones are located in the outer edges of Curitiba. Many of the SEHIS areas had already experienced informal settlement before attaining their social interest designation and several of these areas are in the process of regularization. Consequently, the choice in where to designate SEHIS zoning in Curitiba seems to be linked to locations already experiencing informal settlement. The extent that informal settlement is clustered near SEHIS zones and other social interest habitation programs will be explored along with the overall level of income level segregation.

There are several integral social interest programs allowed in the SEHIS and social interest housing regions. Describing all of these programs would take another

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<sup>15</sup> SEHIS zoning policies were translated by author.

chapter, thus a review of a few key social interest program features that influence spatial patterns is emphasized. One of the key programs, referred to as Lot Partnership (or *Parceria Lotes*), is a public-private partnership that allows approved low-income recipients an opportunity to self-construct a home on a lot serviced with minimum infrastructure including water, sewage, electricity, and improved roads (COHAB, 2007). The Lot Partnership program requires that the lots be on average, 160 square meters in size (over 20 dwelling units per acre) and offers financing options for 15 year terms (COHAB, 2007). Over 26,000 of these urbanized lots have been provided through this particular lot partnership program. The rapidly growing neighborhood, Bairro Campo de Santana in the southern edge of Curitiba, contains urbanized lots a part of this program. Around 68,000 urbanized lots have been offered to low-income recipients since 2007 (MC, 2008). Additionally, a residential leasing program (referred to as the *Programa de Arrendamento Residencial*) offers exclusive leasing of homes for applicable low-income households with the option to purchase (COHAB, 2007). The housing units a part of the residential leasing program mostly encircle Curitiba in neighborhoods along the south, east, west and north edges.<sup>16</sup>

The pivotal feature of this serviced lot provision program is in its direct impact on increasing the supply of land to low-income populations that is suitable for development. In fact, Berner (2001) contends that “housing poverty is largely determined by land supply and allocation” (p. 295) and is diminished even further when there is a scarcity of affordable land suitable for development. Using this idea, the Municipality of Curitiba

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<sup>16</sup> The residential leasing program offered approximately 5,535 units by 2007 in the Campo Comprido, Tatuquara, CIC, Bairro Novo, Cajuru, and Santa Cândida Neighborhoods. Depending on the household income, the finance interest rate ranges from 0.5 to 0.7% with a repayment term of 15 years (COHAB lecture, 2007).

(2008) has allocated the largest share of the total provisions in the form of urbanized lots. Increasing the availability of serviced lots could be seen as a more pro-active measure for addressing informal settlement that is fueled by a dearth of affordable land suitable for development.

Another innovative mechanism used in Curitiba by COHAB that often replenishes the finances available in the Municipal Housing Fund for social interest programs is the use of a transfer of development rights (TDR) mechanism (*Solo Criado* or created land) (Macedo, 2008). Funds are garnered for affordable housing and social interest programs by charging developers fees for variances and special permissions in approved areas for increasing the built area and intensity beyond what zoning currently allows. In exchange for greater development intensity such as the allowance of additional stories on a high-rise, affordable housing in the form of single-family and multi-family dwelling units, serviced lots, and regularized occupations, has been subsidized. Despite the fact that these funds are subject to fluctuations in the real estate market, this TDR tool helped amplify the volume of affordable housing options and serviced land in Curitiba (MC et al., 2007). As a whole, the TDR tool subsidizes infrastructure and sanitation improvements for low-income populations yet it reduces land speculation and enables more intense use of urbanized land (Macedo, 2008).

### **Informal Settlement Regularization in the Study Area**

Another crucial social interest program in Curitiba and the Metropolitan Region of Curitiba (RMC) is the regularization of informal settlements (or *regularização fundiária*). As described earlier, regularization can vary in the types of improvements that are added to an informal settlement. In Curitiba, the implementation of the regularization and urbanization program mostly began during the 1990 decade (MC, 2008). The

objectives of the regularization program are to install basic infrastructure gradually, accelerate the legalization process of tenure, promote educational programs, and strengthen mechanisms to control new invasions (COHAB, 2007). The regularization process in Curitiba typically begins with the provision of basic infrastructure (water, electricity, and sewage systems), construction and establishment of social facilities, and registration of an approved lot layout.

In the RMC, regularization only recently commenced in 2003 beginning with the Zumbi pilot project in Colombo, as a part of the Right to Housing Program led by the Housing Company of the State of Paraná (COHAPAR). The regularization of the Zumbi informal settlement required changes in the neighborhood building pattern such as infill development and a small amount of housing relocations from extremely hazardous areas to compactly built new housing, located nearby.<sup>17</sup> A new regularization approach, underway in the periphery town of Pinhais in 2009, involves a public-private partnership between COHAPAR and a private company called Terra Nova to help carry out part of the regularization efforts (UP, 2009).

Depending on the initial urban form and density of an informal settlement, the act of regularization might increase the rate of infill and consolidation (see Figure 3-2). The organization of lots into more uniform sizes might free up new lots and the construction of multi-family public housing (often for housing relocations) adds more compactly built

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<sup>17</sup> The scope of regularization used in Zumbi was extensive and it included infrastructure provision, installation of drainage control structures, construction of around 280 homes for relocated families and the regularization of around 1,800 lots, construction of a new health center, and the institution of income generation, environmental education, and construction training programs. The Zumbi Program involved COHAPAR, Secretaria de Desenvolvimento Urbano/Paraná Cidade/BID, Fundo de Desenvolvimento Urbano, Sanepar, City of Colombo, Copel, and other public organizations. Similar to the SEHIS zone in Curitiba, the City of Colombo designated the Zumbi area as zones of Special Interest and Permanent Preservation (based on an interview in 2008 and translated by author).

dwelling units. In addition, the provision of piped sewage infrastructure eliminates the need for septic tank drainage fields and rustic tanks on lots.<sup>18</sup> As done in the Zumbi regularization process, some programs might include the construction of a garbage collection warehouse for those residents who are employed as waste pickers. This new waste storage facility might help free up space, formerly used to store waste, and create room needed for additional lots. Generally, as infrastructure is added and homes become more stable, home owners might invest in the construction of a second story addition. These second stories might serve as rentals to supplement household incomes.<sup>19</sup> The collective addition of these new dwelling spaces might increase the housing supply, and as a result, limit the need to invade land. Though some regularized areas might experience price increases because of neighborhood amenities and infrastructure.<sup>20</sup> Increases in the supply of rentals that are more affordable for low-income populations and consolidation from regularization could reduce the informal urbanization rate in Curitiba.

Several caveats should be recognized when analyzing the spatial patterns of regularization. In the situation in which an informal urban area is extremely dense

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<sup>18</sup> A rustic tank is a septic tank without a drainage field.

<sup>19</sup> Gilbert and Gugler (1994) found that as informal settlements age and gain infrastructure and services, the proportion of renters increased. In a study examining five legalized informal neighborhoods in Bogotá, Colombia, Gilbert (1999) found that over half of the informal homes had tenant occupants and collectively the tenant households outnumbered the owners.

<sup>20</sup> Varied land pricing have emerged in some regularized communities in Rio de Janeiro and the increase in land prices might spur density increases. In a study analyzing informal land markets in over 500 favelas, Abramo (2007) recognized five distinct sub-market trends of residential mobility in favelas undergoing consolidation in Rio de Janeiro and pointed out external determinants of price based on building freedom and the presence of social reciprocity networks that allow for the bartering of services. In addition, the mere installation of infrastructure and granting of title increases the lot prices by 47 to 49 percent alone (Abramo, 2007). This study contends that price structures in informal settlements have formed and that a rational-based informal market exists. However, this study does not analyze other towns outside of Rio de Janeiro.

without enough roads and suitable space between homes, these communities would likely not experience additional consolidation with the implementation of regularization. In addition, newly developed informal settlements can consolidate naturally as they age and as new housing extensions are built to accommodate extended family members or friends that migrate (Gilbert and Gugler, 1994). Largely informal settlements, particularly those newly developed on the edge of the city tend to consolidate and increase in density as these communities mature. In addition, regularization that includes infrastructure installation and service provisions could attract new informal settlement in nearby locations since there may be opportunities for new-comers to connect to installed infrastructure.

Excluding regularized housing, Table 3-3 shows the rate of informal housing increase in Curitiba, Brazil. While the 1987 to 1996 time frame experienced an astronomically increase in the rate of informal housing, by 2000 the annual rate of informal housing production declined. The economic crisis in Brazil that culminated in

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Table 3-3. Informal housing growth, excluding homes undergoing regularization, from 1974 to 2005, in Curitiba

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Year	Number of Domiciles	Annual Rate of Increase		Regularized homes
1974	4,083			
1979	6,067	1974 to 1979	9.72%	
1982	7,716	1979 to 1982	9.06%	
1987	10,187	1982 to 1987	6.40%	1980 decade, 1742
1996	33,078	1987 to 1996	24.97%	1990 to 1996, 700
2000	37,621	1996 to 2000	3.43%	1996 to 2000, 19712
2005	42,814	2000 to 2005	2.76%	2000 to 2005, 19453

Data Sources: IPPUC, COHAB, and MC et al., 2007. Table by author.

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the late 1980s likely spurred a greater amount of substandard housing growth and then Curitiba's social interest programs gained momentum during the mid 1990s and it could have influenced reduced rates of informal urbanization. This research will explore this

finding more thoroughly by evaluating the urban areas surrounding Curitiba to detect whether informal settlement was merely displaced into the outskirts of Curitiba.

As a whole, Curitiba has initiated several innovative programs undergoing implementation that offer a variety of serviced and regularized lots and public housing dwelling units. The Municipality of Curitiba (2008) estimates that 57 percent of the total 120,664 social interest and affordable housing provisions (excluding housing undergoing regularization) are urbanized lots and 43 percent are apartments and houses.<sup>21</sup> The concentration of these programs in the social interest zones and other affordable housing initiative areas likely sparked rapid development in the urban fringe. Moreover, these provisions have accumulated substantially – a cumulative estimate suggests that almost 40 percent of the total provisions have been allocated since 2000 (MC, 2008 and MC et al., 2007). In addition, the use of public-private partnerships and TDR funding mechanisms has helped to enlarge these efforts. As such, this tremendous effort in Curitiba could reduce the rate of informal urbanization.

A majority of these initiatives take place in Curitiba and not in the surrounding region (COHAB, 2007) and these projects tend to be built on cheaper land located at the edges of the urban region. For example, in 1992 the serviced lot provision program was initiated in Sítio Cercado (west edge of Curitiba), in Bairro Novo, and Tatuquara areas (south edge of Curitiba) (MC et al., 2007).<sup>22</sup> As described in the aforementioned section, various programs are undergoing implementation in Curitiba and collectively

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<sup>21</sup> Including housing in regularization processes, around 42 percent of the total provisions are serviced lots. In 2008, the City of Curitiba estimates a rate of production under 3,000 provisions a year (MC, 2008). Translated by author.

<sup>22</sup> In addition, the Cajuru social interest program, located on the eastern edge of Curitiba, commenced in 1997 (MC et al., 2007).



Figure 3-2. Regularization of the Zumbi Informal Settlement: urban form changes from 2000 to 2007, orthophotograph map

these programs are referred to as the government approach or strategy for responding to informal settlement issues. Largely, the government response to urban poverty in Curitiba has encouraged informal settlement to concentrate in social interest zones, social initiative areas (or affordable housing program areas), and near areas undergoing regularization. Curitiba's social interest housing program appears to incorporate many sustainable features such as affordable housing options, regularization, and more lenient regulations in social interest areas that allow for progressive housing construction. Many of these initiatives could spur density increases and consolidated development.

### **The Environmental Protection of Land in the Study Area**

The 1988 Brazilian Constitution mandated the protection of the natural environment, particularly the forests, fauna, and plant features and the prevention of pollution through the use of zoning tools that limit land uses, occupation intensity, and protect the environment (GEP, 2006). As discussed earlier, Curitiba adopted most of the zoning restrictions during the 1960s to 1970s, and other large municipalities a part of the study area including Colombo, Pinhais, and São José dos Pinhais have adopted zoning code in 2005 (GEP, 2006).

Along with use restrictions, State Decree 1751/1996 authorized all watersheds deemed valuable to the region be declared areas of environmental protection and special interest (GEP, 2006; Macedo, 2000). Referred to as Environmental Protection Areas (*Áreas de Proteção Ambiental* – APA areas), many of these watersheds are the source of drinking water for the population in the region.<sup>23</sup> The criteria for use and

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<sup>23</sup> Another State Decree (4267/2005), adopted in 2005, added the Baixo Pequeno Watershed to the environmental protection region. State Decrees and zoning policies were translated by author.

occupation of APA areas were defined according to local needs and characteristics. Later in 2000, federal law 9985 was instituted, referred to as the National System of Conservation and Natural Units (*O Sistema Nacional de Unidades de Conservação da Natureza* – SNUC) and this law necessitated the designation of conservation areas into two categories: integral protection and sustainable use (GEP, 2006). The sustainable use category permits some land use as long as biodiversity and natural resources are maintained. In the study area, all of the APA areas were designated for sustainable use and several parks were protected.

In addition to APA areas, Territory Units of Planning (*Unidades Territoriais de Planejamento* - UTPs) were established under state law 1248/98. This law instituted sustainability principles, as a part of the Integrated System of Watershed Management and Protection in the RMC (*Sistema Integrado de Gestão e Proteção aos Mananciais da RMC* - SIGPROM/RMC), and articulated which areas could be used for the right of housing and conservation purposes (GEP, 2006).<sup>24</sup> The UTPs are divided into four areas including: areas of restricted occupation, areas of advised occupation, areas of consolidated urbanization, and rural areas. These areas were defined according to the local character and in a way to advance the objectives of the state law. The consolidated urban areas mainly consist of informal urban uses (these areas are also referred to as social interest areas). The innovative feature of the law is in the use of development exchanges. The land that is in the public's interest for preservation such as forests and riverbanks are restricted from development in exchange for occupation in other approved UTP areas.

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<sup>24</sup> Translated by author.

All of these conservation areas, mostly located along the edges of the study area, pose limitations to development though the degree that these laws are enforced is uncertain.<sup>25</sup> The informal occupation in these periphery areas has merited enough attention to create specialized policies for permitting the informal occupation of land, in response to low-income housing needs. Therefore, the amount of informal settlement and rate of informal development expansions in UTP, APA, and park conservation areas will be measured.<sup>26</sup>

The above review of the public policies implemented during the study time period described several probable ways that informal urbanization patterns could be influenced. The affordable housing approach could have spurred density increases, consolidated informal development, and concentrated low-income development. In contrast, the conservation policies could have deterred informal urban growth in ecologically fragile areas. Chapter 4 provides the data analysis and research findings on informal urbanization spatial patterns and in light of these findings, discusses the effects of public policy.

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<sup>25</sup> Figure 4-14 shows the location of conservation areas. The study area includes the Pinhais UTP (established under 808/99 and 4466/2001), Guarituba UTP (established under 809/99 and 6314/2006), Itaqui UTP (established under 1454/99), Quatro Barras UTP (established under 1612/99), and Campo Magro UTP (established under 1611/99).

<sup>26</sup> The UTP, APA, and zoning laws were translated by author.

## CHAPTER 4 DATA ANALYSIS AND RESEARCH RESULTS

Using the method explained in Chapter 3, the data analysis and results are organized to first describe the urban growth trends in the study region and then, the spatial patterns of informal urban areas. Initially the major urbanization growth trends including population growth, urban growth, and consolidation are described for the study area from 1991 to 2007. Then the results on the informal urban growth rates and spatial patterns (such as the tendency for decentralization) are offered. The next section provides an analysis and discussion on the major public policies potentially influencing informal urban patterns (such as density and consolidation increases) inside and outside of Curitiba. Lastly the major locational features of the informal urban areas (such as location in a floodplain, river buffer, conservation area, near public housing, and bus service) are analyzed for their prevalence and degree of influence. At the conclusion of this chapter, a summary of the findings is provided to compare the results and describe the study area holistically.

### **Population Growth Findings**

Measuring the changes in population counts and growth rates is critical for characterizing the patterns of new urban growth such as in detecting population density increases. As shown in Table 4-1, the populations in Curitiba and the Metropolitan Region of Curitiba (*Região Metropolitana de Curitiba - RMC*) both have increased since 1975. However, since 1991 the rates have diverged. In 1991, the RMC annual population growth rate climbed above Curitiba's annual growth rate and has remained higher till today. In addition, the proportion of the RMC population living outside the City

of Curitiba has steadily increased since 1991 from 36 to 44 percent. These findings indicate that new population growth is decentralizing into periphery municipalities.

Table 4-1. A comparison of population growth in Curitiba and the Metropolitan Region of Curitiba

Year	Curitiba Population	Average Annual Growth	RMC Population	RMC Average Annual Growth
1970	608,417		820,766	Not Available
1975	765,716	5.17%	1,013,279	4.69%
1980	1,025,979	6.80%	1,441,743	8.46%
1985	1,285,027	5.05%	1,772,689	4.59%
1991	1,315,035	0.39%	2,063,654	2.74%
1996	1,476,253	2.45%	2,431,804	3.57%
2000	1,587,315	1.87%	2,725,629	3.02%
2007	1,797,408	1.90%	3,230,000	2.64%
2009	1,851,215	0.43%	Not Available	Not Available

Data Source: IBGE, various years.

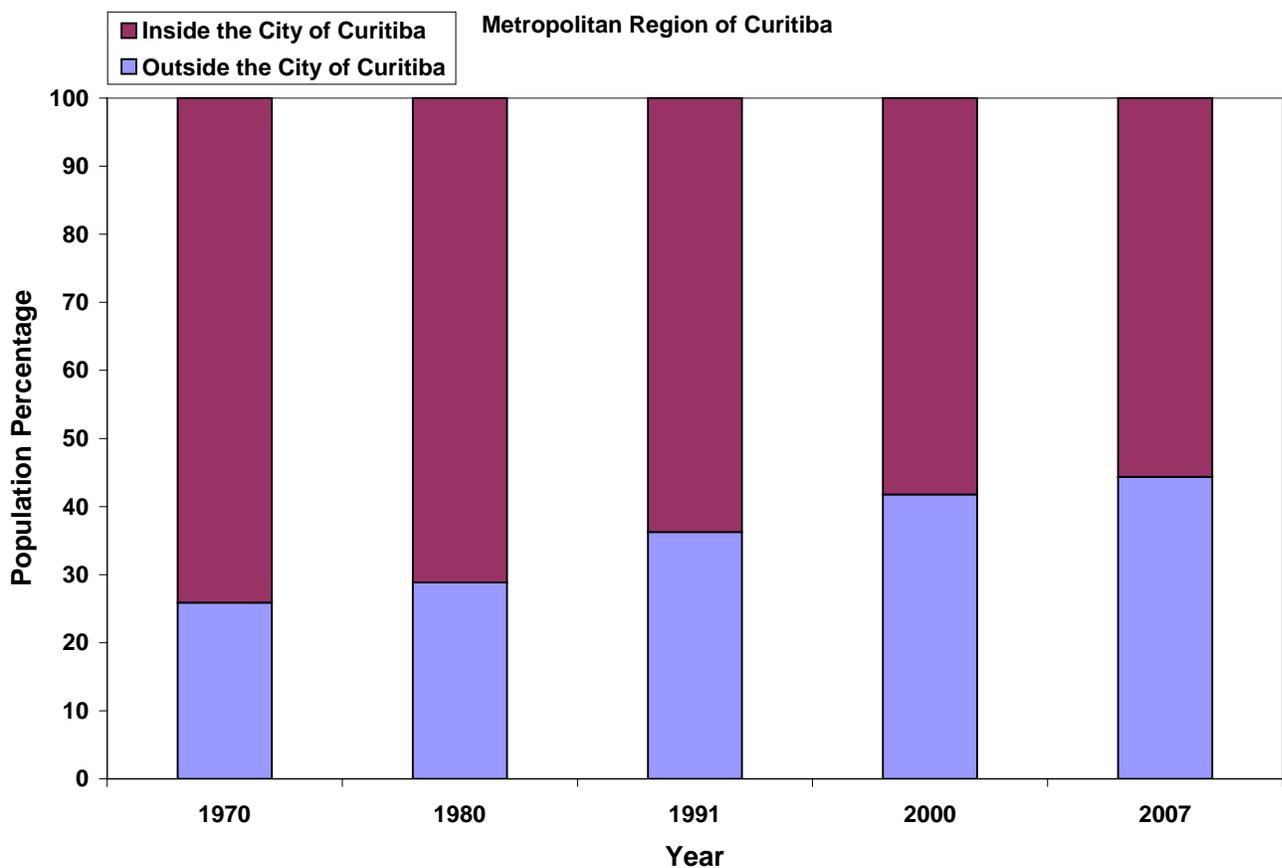


Figure 4-1. Portion of urban growth inside and outside of Curitiba, in the Metropolitan Region of Curitiba

Table 4-2. A comparison of population growth in Curitiba and the periphery towns

	Curitiba	Almirante Tamandaré	Araucária	Campina Grande do Sul (CGS)	Campo Magro	Colombo	Fazenda Rio Grande (FRG)	Pinhais	Piraquara	Quatro Barras	São José dos Pinhais (SJP)
1991 Population	1,315,035	54,030	61,712	19,343	12,129	117,767	24,997	75,516	31,366	10,007	127,455
2000 Population	1,586,848	88,139	94,137	34,558	20,364	183,331	63,031	102,946	72,838	16,149	204,202
Average Annual Growth Rate, 1991-2000	2.30%	7.01%	5.84%	8.74%	7.54%	6.19%	16.91%	4.04%	14.69%	6.82%	6.69%
2007 Population	1,797,408	93,055	109,943	35,396	22,325	233,916	75,006	112,038	82,006	18,125	263,622
Average Annual Growth Rate, 2000-2007	1.90%	0.80%	2.40%	0.35%	1.38%	3.94%	2.71%	1.26%	1.80%	1.75%	4.16%
Average Annual Growth Rate, 1991-2007	2.29%	4.51%	4.88%	5.19%	5.25%	6.16%	12.50%	3.02%	10.09%	5.07%	6.68%

Data source: IBGE census, various years. The study area municipalities are only provided. The formula used to calculate the average annual growth rate is:  $((\text{Later Year} - \text{Earlier Year}) / \text{Earlier Year} * 100) / \# \text{ of years}$ .

Table 4-2 dissects the overall regional growth by separating out the study area population counts for each of the ten periphery towns that surround Curitiba. This table shows a high annual population growth rate from 1991 to 2007 in several conurbations. The highest average annual population growth rates from 1991 to 2007 were in Fazenda Rio Grande (FRG), Piraquara, São José dos Pinhais (SJP), and Colombo. From 1991 to 2007, both of the populations of SJP and Colombo doubled and from 1991 to 2002, the population of Piraquara doubled. Since the beginning of the 21<sup>st</sup> Century, some of these conurbations have become more significant in their urban magnitude. These results show that the conurbations with population concentrations over 100,000 persons and a more urban character are more prone to population increases.<sup>1</sup> Generally the increases in urban growth can be attributed to a great amount of rural-urban migrations. However, in recent years, a portion of the new arrivals are described as inter-migrations and urban-urban migrations.<sup>2</sup> These particular migrants are moving from one town to another town in the same region instead of originating from the rural hinterlands. These trends indicate a decrease in the amount of new-comers accustomed to rural living; thus there might be less of a need for semi-rural single-family housing that has space for livestock.

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<sup>1</sup> Urban portion of the population in periphery towns: São José dos Pinhais - 263,622 persons, 89.75 percent urban; Colombo - 233,916 persons, 95.44 percent urban; Pinhais - 112,038 persons, 97.81 percent urban; Araucária - 109,943 persons, 91.36 percent urban; Almirante Tamandaré - 93,055 persons, 96.01 percent urban; Piraquara - 82,006 persons, 80.91 percent urban and Fazenda Rio Grande - 75,006 persons, 94.15 percent urban (IBGE, 2007).

<sup>2</sup> During the 1995-2000 time period, 50 percent of the migrants and immigrants in the RMC were from the interior portion of the state of Paraná; 42 percent originated from other states and countries; and 7 percent were from other urban areas in the RMC (2008, MDC).

## Urban Growth Data Analysis Findings

The urban growth from 1991 to 2007 is portrayed through a series of figures and tables. Table 4-3 provides the resultant land cover classification acreages. Figures 4-2, 4-3, and 4-4 show the 1991, 2002, and 2007 classifications geographically with a series of maps. Overall the proportion of the study area with built land covers has increased by ten percent from 1991 to 2007 to result in a total built area that encompasses 34 percent of the total study area, in 2007.

The total share of built acreages located outside of Curitiba in the study area has steadily increased over the course of the study time period from 37 to 44 percent. Though 56 percent of total built area is located within the city limits of Curitiba and this share still remains higher than outside the city limits (66,492 acres of built land, in 2007). However, the margin of difference of urbanized land inside and outside of Curitiba has increasingly narrowed. If these rates continue, the urbanization outside of Curitiba will eventually become larger in size than the area of development in Curitiba and these urban areas might continue to grow together to create larger conurbations.

Table 4-3. Urban area growth from 1991 to 2007

1991			2002		
Land Cover	Acres	Portion of Total Area	Land Cover	Acres	Portion of Total Area
Built	85,824.71	24.92%	Built	110,918.19	32.21%
Vegetation	232,752.37	67.59%	Vegetation	206,351.77	59.92%
Water	6,083.38	1.77%	Water	9,409.47	2.73%
Bare Soil	19,701.18	5.72%	Bare Soil	17,682.20	5.13%
Total	344,361.64	100.00%	Total	344,361.64	100.00%

Table 4-3. Continued

2007		
Land Cover	Acres	Portion of Total Area
Built	118,397.55	34.38%
Vegetation	200,005.90	58.08%
Water	7,603.32	2.21%
Bare Soil	18,354.87	5.33%
Total	344,361.64	100.00%

\*Acreages were derived using GIS tools and are approximate.

### Urban Growth Changes from 1991 to 2007

As shown in Table 4-4 and Figure 4-5, the proportion of total built landscape has increased to cover 34 percent of the total study area by 2007. The average annual change in urban land conversions has reduced from 2,281 acres to 1,496 acres per year; indicating a significant decline in the rapidness of urban growth. Other than the municipalities of Campo Magro and Araucária (on the west edge), most towns experienced a reduction in the rate of urbanization during the 2002-2007 time period in comparison to the rapid urban growth from 1991 to 2002.

Several major construction changes occurred during the 1991 to 2002 time period. The development of a dam referred to as the *Represa do Rio Irai*, in the eastern edge of the study area transformed the region and likely resulted in hydrological modifications, particularly in downstream areas. These impacts likely prevented the natural flow of water to floodplains in much of the eastern and southern portions of the study area and stabilized peak flow dispersed from flood events. In addition, after 1991, the construction of a major arterial, referred to as *Roan Contorno Leste*, connected Quatro Barras to São José dos Pinhais (SJP). Both the road addition and the dam installation likely facilitated development in the region.

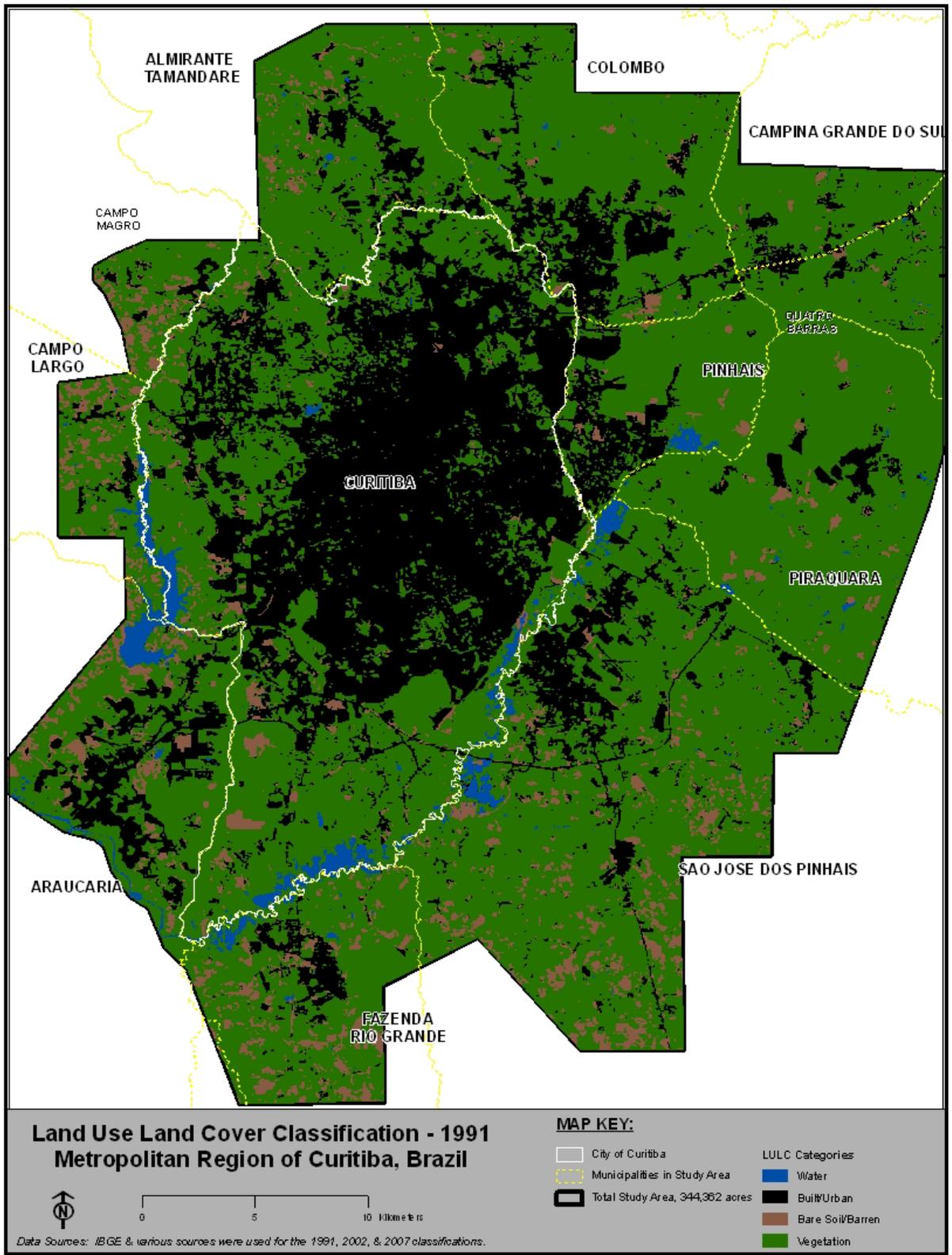


Figure 4-2. 1991 land use land cover classification map

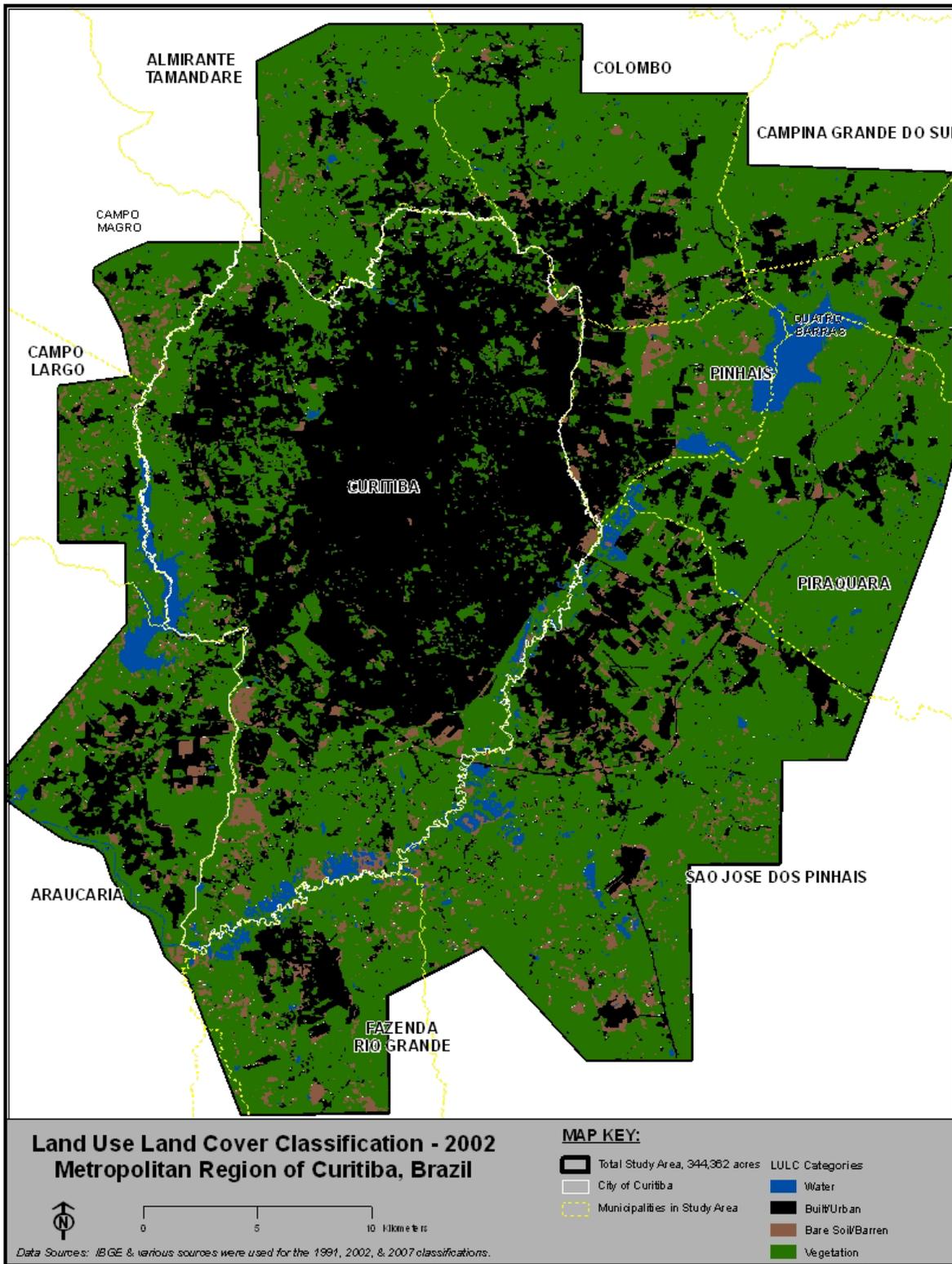


Figure 4-3. 2002 land use land cover classification map

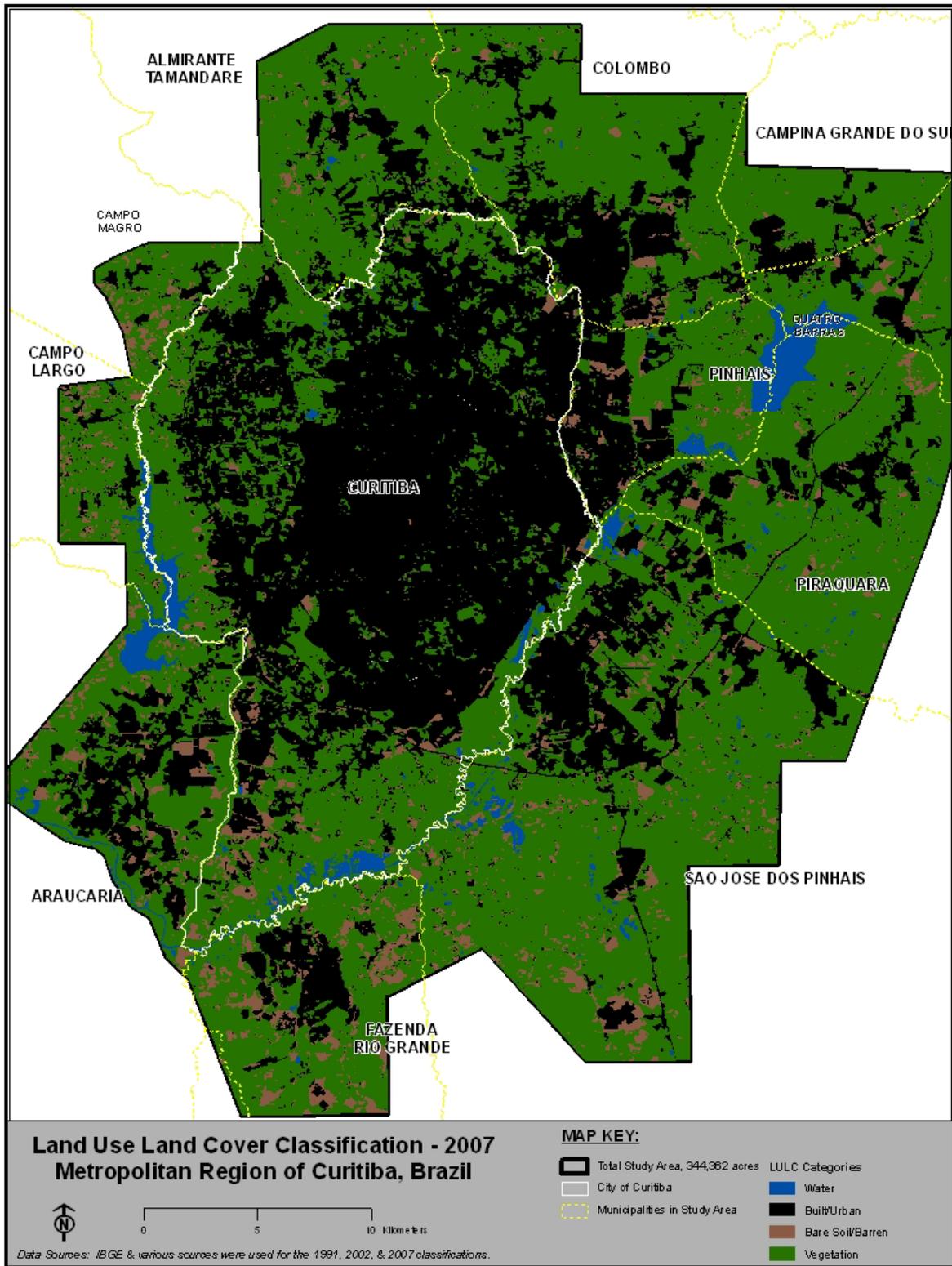


Figure 4-4. 2007 land use land cover classification map

Holistically, the areas urbanizing the most rapidly are located at the edges of the main urban fabric, often in periphery municipalities. A great amount of new urban growth emerged in Piraquara during the 1991-2002 decade. Much of this new urban growth in Piraquara is associated with informal development. The municipalities of Pinhais, Fazenda Rio Grande (FRG), and Almirante Tamandaré also experienced substantial growth, associated with a mixture of formal and informal uses during the 1991-2002 decade that continued into the 2002-2007 time period. An interviewee recalled the rapid intense growth in the periphery towns of Colombo and FRG. The respondent referred to FRG as merely a bus stop in 1980 and today considers this same area a town with over 75,000 residents. SJP too experienced steady urban land conversions over the course of the entire study period. The newly urbanized areas in the northern and western edges of SJP are associated with informal housing while much of the urban growth in the interior, south, and east are associated with industrial urban growth –sometimes associated with the regional airport.

Except for the southern fringe of Curitiba, most of the new large pockets of urban growth that were built from 2002 to 2007 are more formal in nature. The urbanized areas of Campina Grande do Sul and Quatro Barras mutually experienced a great deal of growth mostly formal in nature. In addition, a Volkswagen/Audi plant was built next to BR 376, in the southern extremity of the study area, far from the main urban fabric. Similarly, Araucária experienced new urban growth associated with various formal uses and informal settlement along the edges proximate to environmentally sensitive areas.

Collectively, this urban growth has accumulated to form a contiguous urban extension along most of the perimeter of Curitiba. In addition, four secondary centers

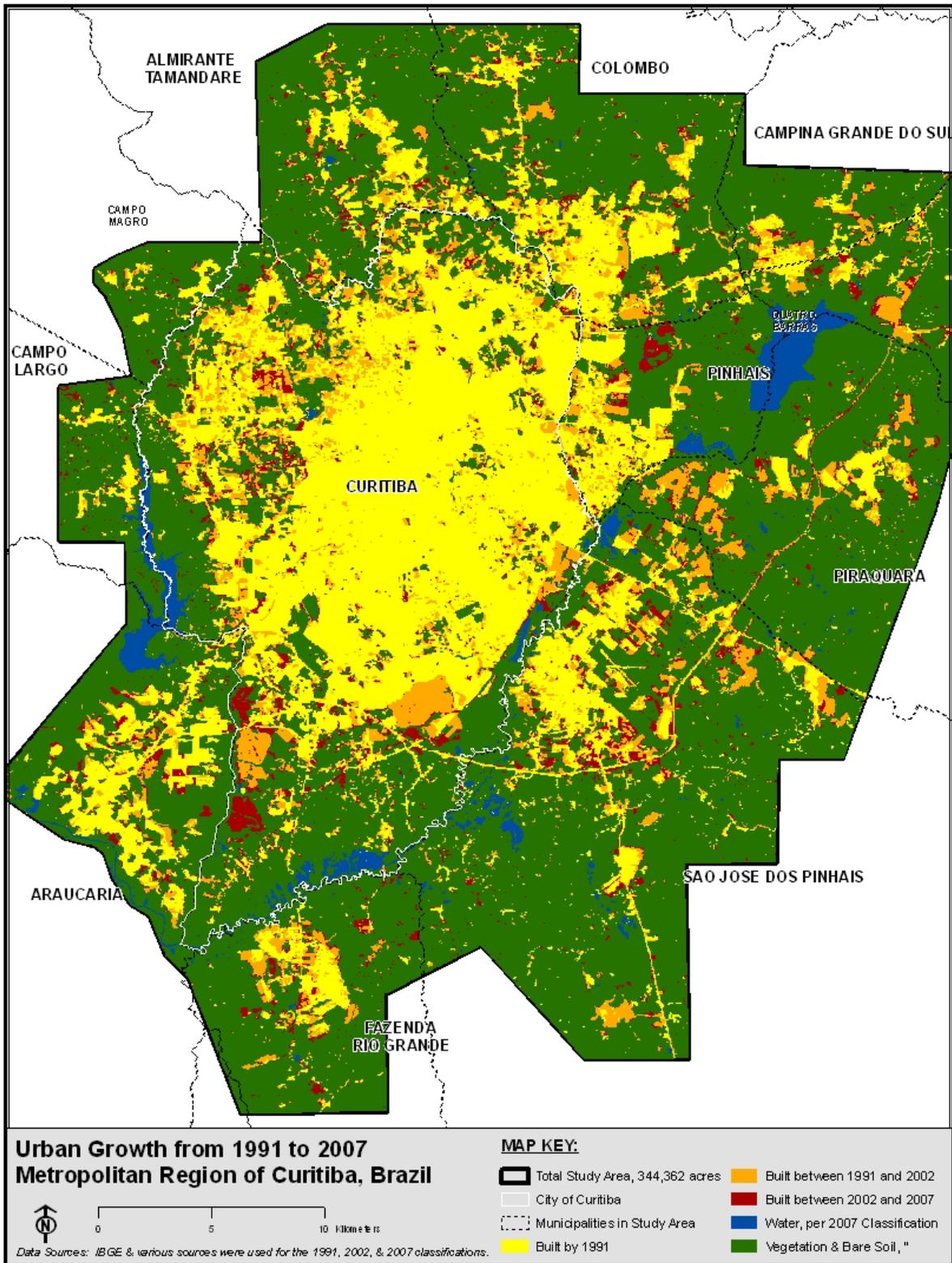


Figure 4-5. Map of urban growth changes from 1991 to 2007

have consolidated substantially around Curitiba and these include: SJP located to the southeast; Almirante Tamandaré to the north; FRG to the south; and Araucária to the southwest of Curitiba. These centers fortify the polycentric organization of the urban system. However, the urban growth pressure for these urban centers to connect can be observed with the emergence of new conurbation development (part of which is informal) that has appeared at the fringe over the last several decades. The next section examines the pattern of urban expansion from 1991 to 2007 in the study area.

Table 4-4. Urban area growth changes from 1991 to 2007

Land Cover	Average Annual Change 1991-2002	Average Annual Change 2002-2007
Built	2,281.23 Acres	1,495.87 Acres
Vegetation	-2,400.05 Acres	-1,269.17 Acres
Water	302.37 Acres	-361.23 Acres
Bare Soil	-183.54 Acres	134.53 Acres

\*Acreages were derived using GIS tools and they are approximate.

### Urban Expansion: Fragmented or Compact?

Tendencies towards consolidated or fragmented urban growth were measured over the course of the study time period. Using a basic formula referred to as the elasticity of urbanized land formula, urban sprawl and the rate of consolidation can be detected.<sup>3</sup> A number over one indicates urban sprawl whereas a number below one indicates more compact growth (O'Sullivan, 2009).

<sup>3</sup> The concept, urban sprawl, typically associated with forms of urban growth in the US, is defined as scattered and expansive low-density development with buildings separated by swaths of land, with a lack of mixed use neighborhoods, inaccessible road network, and noncontiguous development (referred to as dispersed, leap-frog, or strip) without a centralized activity center in the outskirts of an urban area (Ewing et. al, 2002). The elasticity of urban growth is the ratio of change in new urban land conversions divided by the percent change in urban population growth.

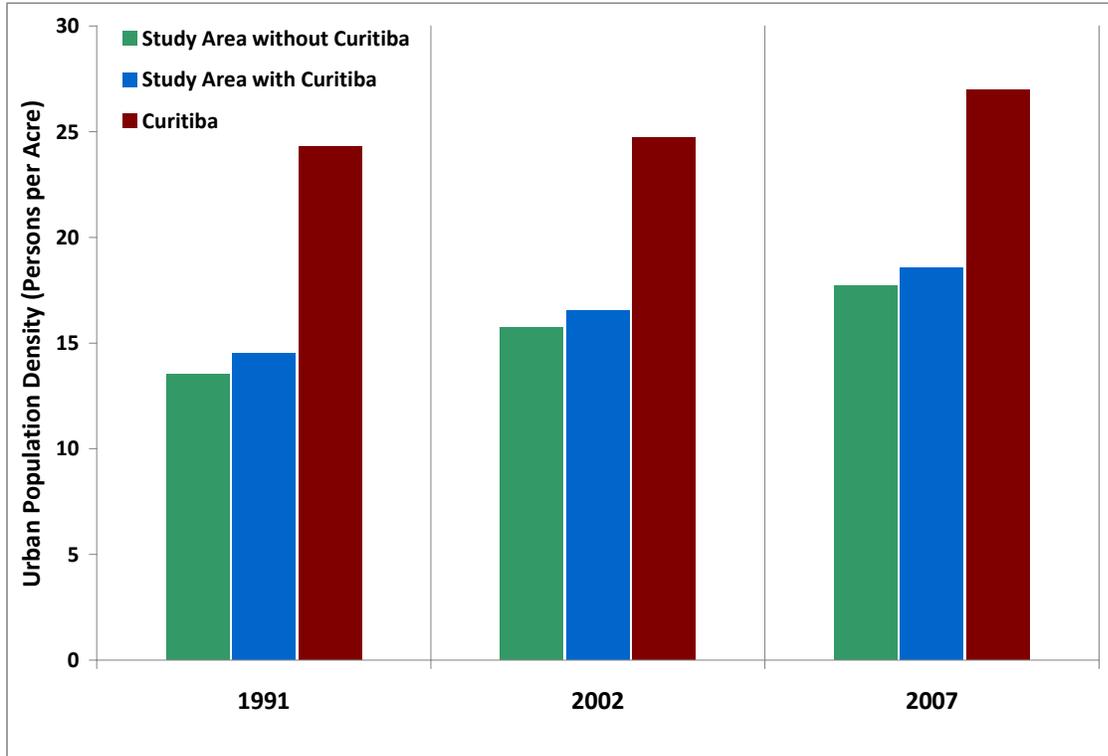


Figure 4-6. Urban population density, in the study area

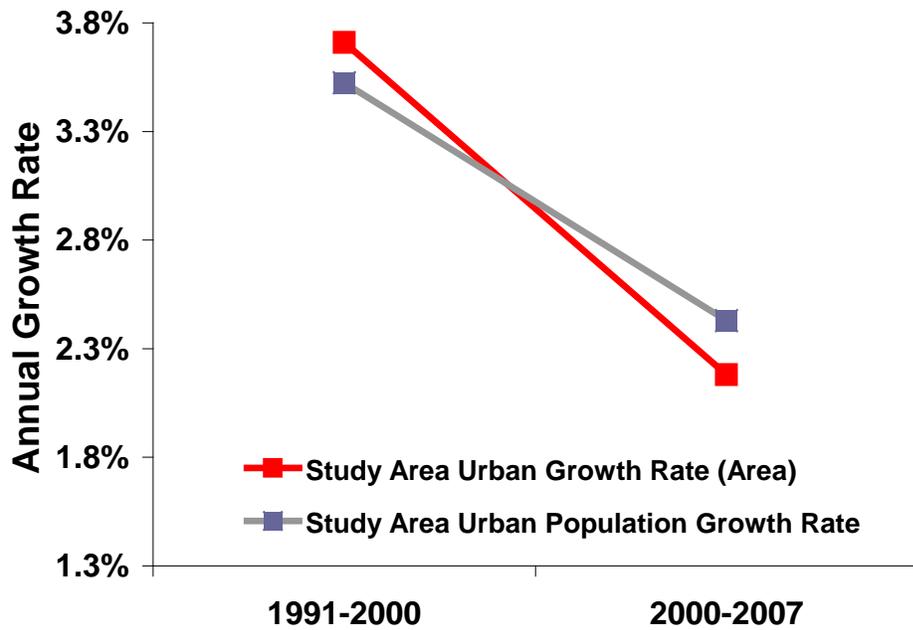


Figure 4-7. Comparison of the urban population growth rate with the rate of urban area

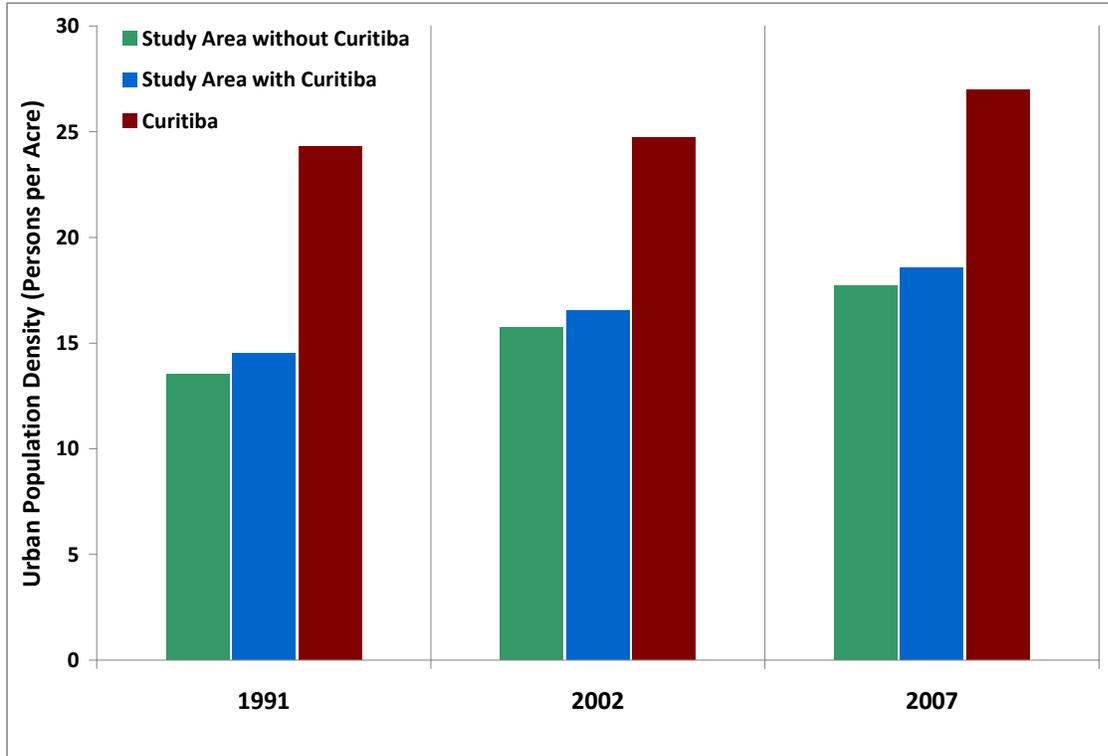


Figure 4-6. Urban population density, in the study area

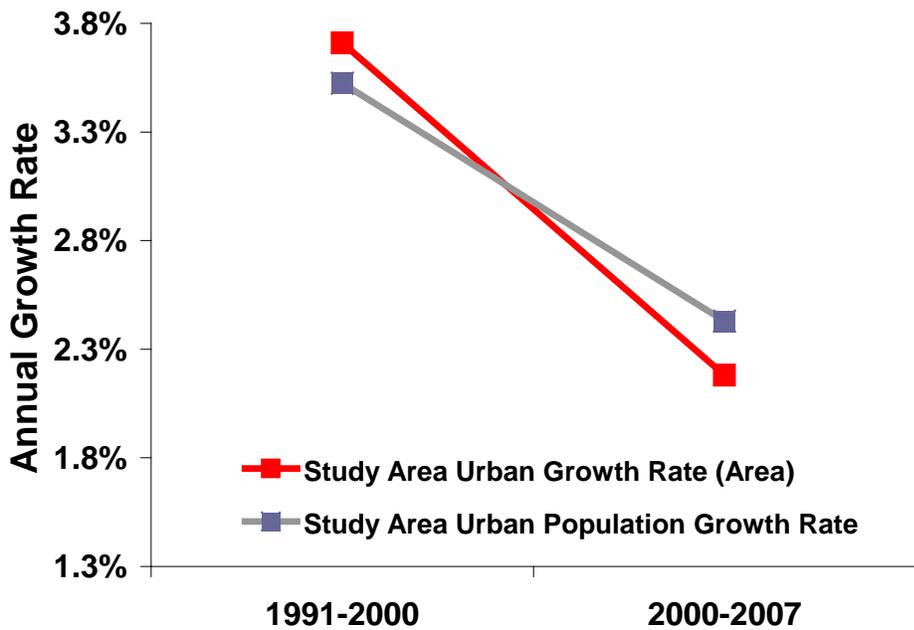


Figure 4-7. Comparison of the urban population growth rate with the rate of urban area expansion

From 1991-2002, the elasticity of sprawl value was 0.92 while from 2002-2007, the value, 0.4, was much lower. These findings suggest that the urban growth pattern from 2002 to 2007 was more consolidated. As portrayed in the urban growth change figures, the rate of urban land conversions decreased since 2002, as the rate of consolidation and infill development escalated. Figure 4-7 reiterates these findings by comparing the urban population growth rate with the rate of urban land conversions in the entire region. The urban land conversion rate dipped below the urban population growth rate from 2002 to 2007 indicating that the rate of urban expansion was lower than the annual urban population growth rate. In other words, there were fewer new urban land conversions yet more population additions. In addition, Figure 4-6 shows that the urban population density in the study area (whether inside or outside of Curitiba) increased from 1991 to 2007. The findings on the growth of informal urbanization and a description on how informal urbanization played a role in increasing the rate of consolidation is provided in the following section.

### **Informal Urban Growth Results**

Figure 4-8 visually maps out the informal urban growth changes in the study area and Tables 4-5 to 4-7 offer various acreages and rates of growth for the informal urban areas from 1991 to 2007. In several tables, the acreages of properties undergoing regularization were separated since regularized properties transition from informal to formal urban land uses. As discussed in the method, the properties were identified as undergoing regularization if they had experienced some sort of substantial community upgrade in the informal area beyond the planning stages.<sup>4</sup> Table 4-7 shows that for all

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<sup>4</sup> There are several informal communities in periphery towns, such as Campo Magro and Guarituba that by 2009 were emerging from the planning stages and entering into construction stages of regularization.

three study years, over 80 percent of the informal urban properties in Curitiba were informal settlements rather than irregular land divisions. By 2007, around 30 percent of the total informal urban areas inside of Curitiba underwent regularization. In contrast, only 4.5 percent of the total informal areas outside of Curitiba were undergoing regularization. More regularization has taken place in Curitiba; in fact around 85 percent of the total portion of regularizing informal urban areas is located inside Curitiba. This is not surprising since the City of Curitiba has been implementing regularization longer than the other jurisdictions in the study area.

Analogous to the reduced rate in urban expansion, the results reveal a substantial decline in the annual rate of new informal urbanization from 2002 to 2007. Whether the values include or exclude areas undergoing regularization, the rate of additional informal urban acreage added to the study area from 1991 to 2002 was substantially higher than the rate of additional informal urban acreage from 2002 to 2007. In fact, Table 4-6 shows that the rate of informal growth decreased by over 150 acres per year and this trend continued even when including the properties undergoing regularization. Correspondingly, Figure 4-8 shows a great amount of new informal growth that appeared by 2002 and few new informal areas in 2007. Generally, most of the informal areas grew adjacent to existing informal areas. The urban form for much of the informally built areas is often linear and elongated in shape. These shapes often conform to the silhouette of riparian features. In some areas, the informal areas were linear in shape since they insulated a particular intensive land use such as railroads, electrical transmission lines, or an industrial complex. Often an individual informal

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However, these were not considered as undergoing regularization given that the construction activities had not taken place by 2007.

urban area would enlarge over time near a natural feature, particularly if no regularization program was underway. The dominant ecological and hazardous features of a local region might have a powerful influence on shaping informal settlements and this was visually obvious in the RMC.

Comparing the 1991 informal urban areas to the 2002 sites shows a general outward shift whereby more informal areas are located farther out in the periphery. The decentralizing pattern of informal urban growth is not unusual and is verified by the more interior location of informal settlements that were in existence since 1978 (IPPUC, map). Generally less informal settlement takes place in the dense urban core and older serviced areas. The urban fringe portion of Curitiba, encircling the urban core within a distance of eight kilometers, had the highest portion of informal settlement for all three study years (over 70 percent). However, the percentage in the periphery (beyond eight kilometers) has increase by five percentage points since 2002 (21 to 27 percent). These findings suggest that informal urban development gradually is decentralizing outwards, farther from the urban core.

The informal settlement identification found few new informal settlements in areas isolated from the urban fabric since 2002. Though, earlier, during the 1991-2002 decade, more expansive informal growth occurred than during 2002-2007, particularly in the Municipality of Piraquara. Generally, most of the new informal urban areas, larger in size, were more often contiguous to the existing urbanization or settlement rather than occupation in areas isolated from the urban fabric. Regionally, the informal urban spatial patterns seem to be guided by a tendency to locate on land without infrastructure but with a potential for obtaining infrastructure given its close location to serviced areas.

Table 4-5. Informal urban area growth from 1991 to 2007

Inside Curitiba					
	IS, no Reg.	IS, in Reg.	ILD, no Reg.	ILD, in Reg.	Total, inside Curitiba
1991	1,519.2	*N/A	104.2	*N/A	1,623.4
2002	1,623.8	748.1	257.2	35.6	2,664.7
2007	1,654.5	717.3	339.3	141.9	2,853.1
Outside of Curitiba, in the study area					
	IS, no Reg.	IS, in Reg.	Total, outside Curitiba		Overall Total
1991	1,423.7	*N/A	1,423.7	1991	3,047.1
2002	3,227.6	*N/A	3,227.6	2002	5,892.3
2007	3,249.1	155.20	3,404.3	2007	6,257.4
Total Share	Outside of Curitiba	Inside of Curitiba	Acronyms:		
1991	46.7%	53.3%	IS: Informal Settlement		
2002	54.8%	45.2%	ILD: Irregular Land Division		
2007	54.4%	45.6%	Reg. Regularization Process		

\*Notes: growth is presented in approximate acreages derived using GIS tools.

Table 4-6. Average annual rate of change for informal urban growth

Description	During 1991-2002:		During 2002-2007:		During Entire Study Time Period:	
Excluding Regularization areas	187.4	3.7%	26.8	0.53%	137.2	4.5%
Including Regularization areas	258.7	8.5%	73.0	1.2%	200.7	6.6%

\*Notes: results are presented in acres per year (used GIS) and annual rate of increase.

Table 4-7. Informal urban percentages

	Inside Curitiba				Outside Curitiba, in the study area	
	ILD to Total	IS to Total	Total in Reg.	Total no Reg.	Total in Reg.	Total no Reg.
1991	6.4%	93.6%	*N/A	*N/A	*N/A	*N/A
2002	11.0%	89.0%	29.4%	70.6%	*N/A	*N/A
2007	16.9%	83.1%	30.1%	69.9%	4.6%	95.4%

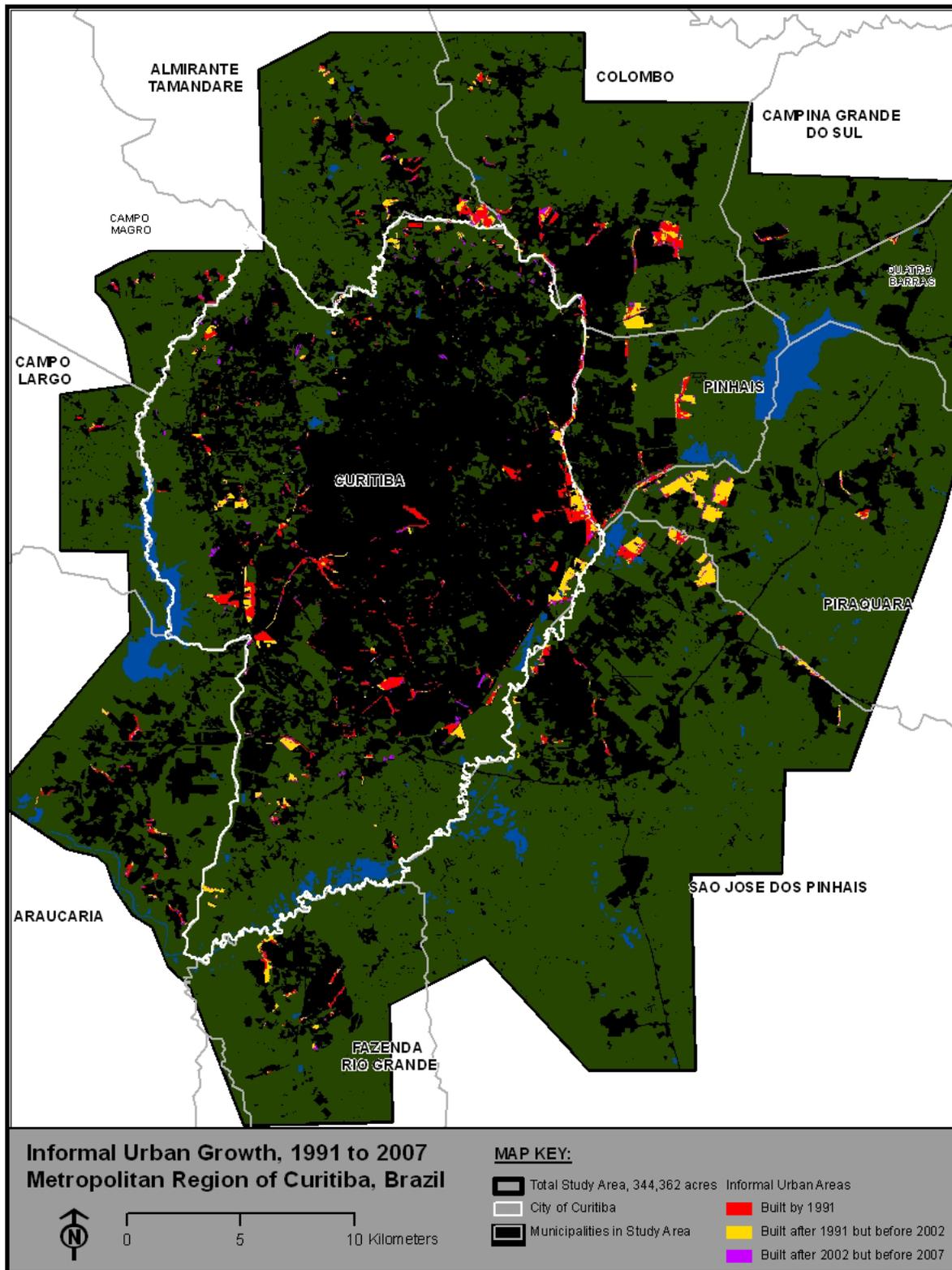


Figure 4-8. Map of informal urban growth, 1991 to 2007

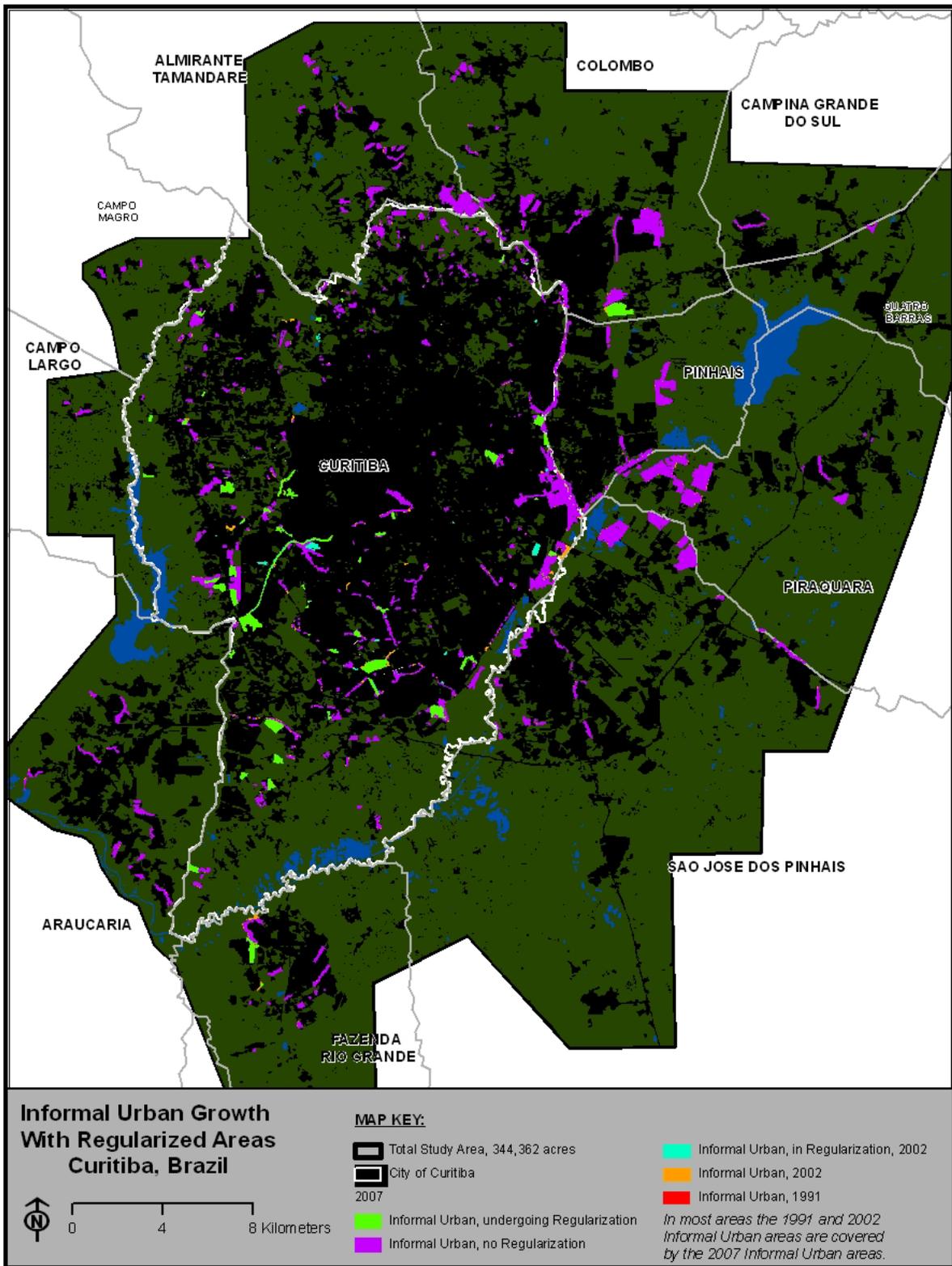


Figure 4-9. Map of informal urban growth and regularized areas

Informal settlers attempt to connect to serviced areas regardless of how poor the land conditions are for development. In addition, the amount of informal urban areas in comparison to the total built areas in the study area increased from two percent in 1991 to 5.3 percent in 2002 and 2007. Overall, the informal urban areas comprise a small percentage of the total built area.

Figure 4-9 shows where informal settlements and irregular land divisions are undergoing regularization. A local government interviewee mentioned that irregular land divisions typically are easier to regularize given the propensity for more lot organization, preservation of minimum road widths needed for infrastructure, possession of some valid property titles, and location outside of conservation areas. Despite this point, there was a higher portion of informal settlements undergoing regularization than irregular land divisions – perhaps this difference is a reflection of the greater amount of informal settlements in the region.

### **Discussion on the Decline of Informal Urbanization**

The coinciding reductions in overall urban growth and informal urban growth show that the informal urbanization rate does in fact influence the overall regional growth, though the rate of influence is uncertain. Figure 4-10 compares the urban growth rate to the informal urban growth rate for the total study area. As the informal urban growth rate declined, the urban growth reduced; however, their reduction rates are not fully in accordance. This rate comparison suggests that there might have been an increase in other types of formal urban growth such as industrial and formal residential from 2002 to 2007 that leveled out the reduction in urban growth. The reasons behind the reduced informal urban growth rate after 2002 are multiple. As such, a discussion on key changes and public policy influences is offered.

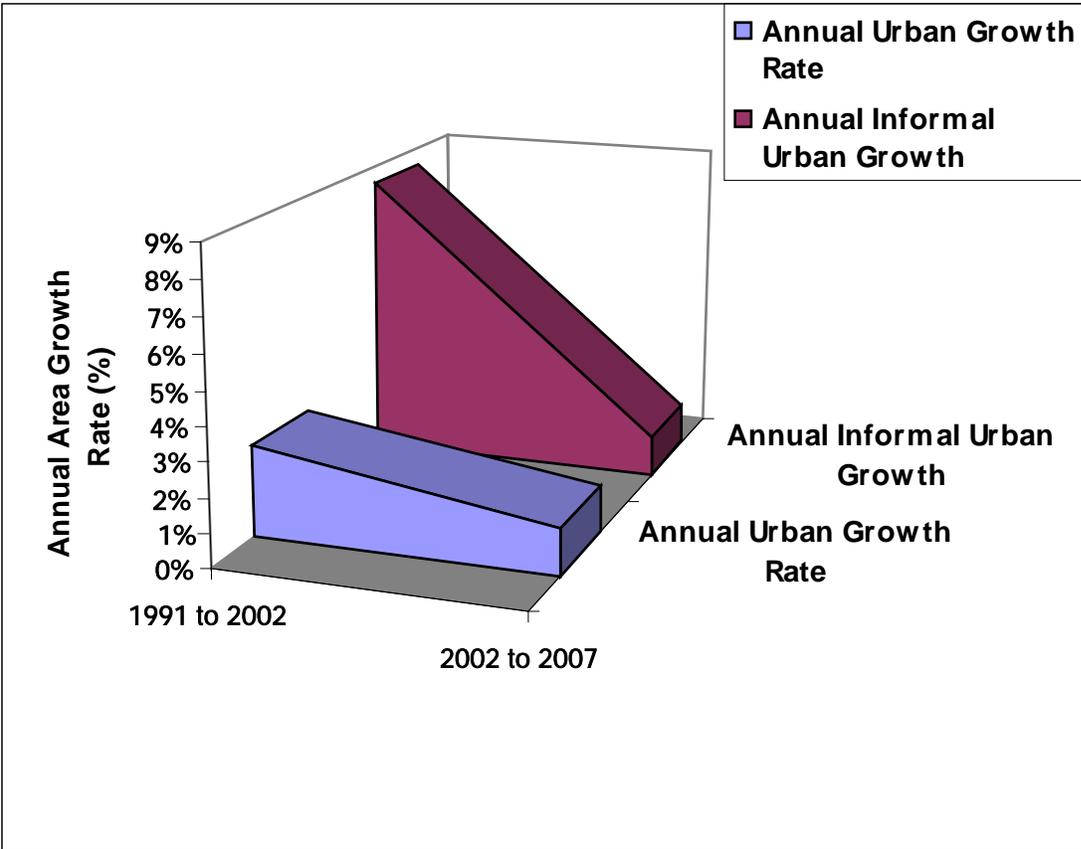


Figure 4-10. Comparison of informal to overall urban area growth rates

### Discussion on Influential Factors for Reduced Informal Urbanization

During the 1990 decade, Brazil was still recovering from a national economic crisis and a substantial portion of new-comers from 1991 to 2002 were rural-urban migrants that were in search of economic opportunity. However, changes in the type of migrants have emerged and not all new-comers originate from rural areas. An urban migrant could have different housing preferences and this could affect the expansiveness of the development pattern. The survey responses, a part of this research, showed that 23.3 percent of the respondents originated from the interior part of the state of Paraná, 20 percent from the Metropolitan Region of Curitiba (RMC) but outside of Curitiba, 17 percent from outside of the state (some from São Paulo), and 13

percent from the City of Curitiba.<sup>1</sup> These findings suggest that a portion of RMC newcomers are originating from urban areas. These new urbanites might be accustomed to living in apartments and other types of shared residential spaces. Thus, the consolidation of development patterns might partially reflect changing housing preferences of urban new-comers.

An interviewee pointed out key infrastructure changes that might be influencing informal settlement growth. Many streets were paved in the urban portions of the RMC as a part of a region-wide campaign referred to as Universal Streets (or *Plano Mil*). In fact, 1,000 kilometers of roads were paved in the city and along transit routes. This street paving program began with a campaign in 1997, then plan development in 1998, and the spreading of asphalt on the roads from 2000 to 2002. The respondent also pointed out that the installation of water, electricity and sewage infrastructure in every home is a state goal. In certain areas, these new infrastructure improvements might have affected growth patterns. Various influential public policies and social interest programs were implemented during this time period. The influence of these social interest programs was analyzed using geographic measurements, observations, and available population and domicile counts.

### **Analysis of Public Policy Influences on Informal Urbanization**

Several public policy changes emerged during the study time period that could have impacted the rate of informal growth.<sup>2</sup> Inside the city limits of Curitiba, various

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<sup>1</sup> Full survey responses are provided in Appendix A. Another survey conducted by COHAPAR (2008) found that 25 percent of the Zumbi informal settlement residents migrated from the exterior and the rest originated from the RMC (based on an interview in 2008).

<sup>2</sup> A complete summary of the public policies administered during the study time period is provided at the end of Chapter 3.

social interest programs were implemented beginning in the early 1990s. Outside of Curitiba, the Territory Units of Planning (or UTP) conservation/social interest program commenced in 2000 and regularization of informal settlements was implemented only in a select few neighborhoods after 2002.

Many of the public policies could encourage population density increases. To explore this potential effect, a map showing the overall population densities for 2000 in comparison to informal urban areas and social interest programs in Curitiba is provided (Figure 4-11).<sup>3</sup> The map shows high population densities along the edges of the urbanized fabric and in many of the informal urban areas and social interest program areas. In fact, the population densities in the southeastern and west edges are comparable to the population densities in the downtown area. In comparison to 1991 population densities, several of the social interest initiative areas and informal settlements undergoing regularization experienced overall population density increases.

To analyze the urbanization influence of the social interest programs further, the patterns of informal urbanization and rate of development was analyzed inside program boundaries. Inside of Curitiba, the social interest housing zones (SEHIS) and the Affordable Housing Company of Curitiba (COHAB) social interest initiative program boundaries were available while outside of Curitiba, the data was less reliable; thus

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<sup>3</sup> Figure 4-11 shows the population densities provided in the 2000 census dataset (IBGE). This data only shows the population density for areas that IBGE defined as urban – consequently the white areas, in the map indicate no data. The census dataset was not available for 2007. The informal urban areas include areas undergoing regularization and areas not undergoing regularization.

observations on the built pattern in and near UTP conservation areas were made in the subsequent section.<sup>4</sup>

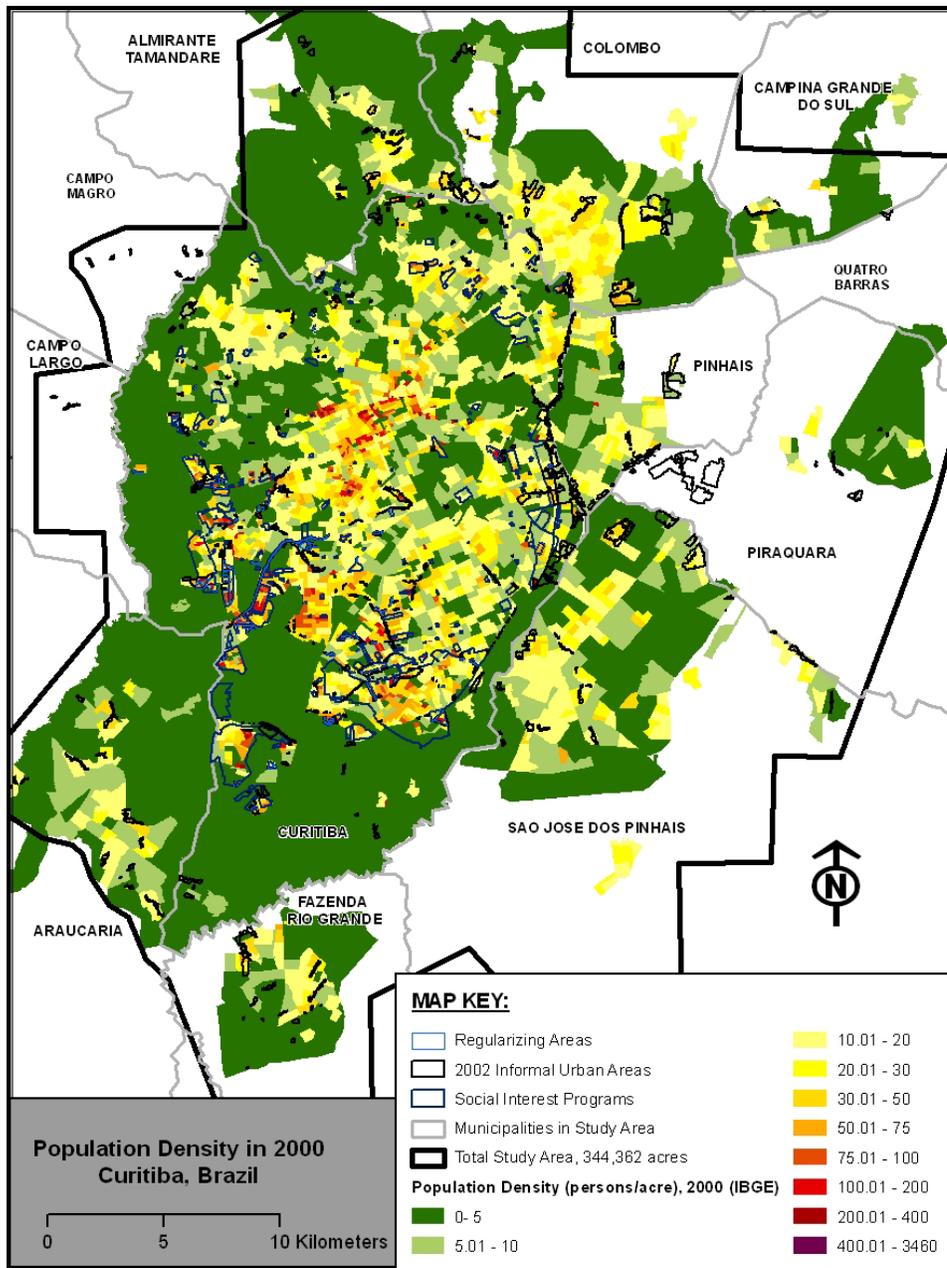


Figure 4-11. Map of population densities in informal urban areas and affordable housing program areas and social interest zones, in 2000

<sup>4</sup> After 2002, COHAB only had jurisdiction over implementing social interest housing programs inside of Curitiba and other agencies such as COHAPAR are leading social interest housing programs outside of the Municipality of Curitiba.

## **Inside of Curitiba: Public Policy Influences on Informal Urbanization**

Inside of Curitiba's city limits, several areas were designated as the special sector of social interest housing zone (SEHIS) in 2000 and various regularization programs and serviced lot and housing provision programs took place in these zones. As shown in Figure 4-12, the SEHIS areas experienced rapid growth during the study time period. Initially in 1991, only 42 percent of the 6,075 acres of SEHIS zoned property was developed and then by 2007, 88 percent of the total area was built (see Table 4-9). This means that around 2,800 acres of new urbanization, partly produced informally, was built over the course of 16 years. Figure 4-12 portrays the rate of rapid consolidation visually and illustrates the initial stages of development in the SEHIS zones by showing the transition of cleared lots from bare soil/barren to built land cover in later years.

Another factor influencing the consolidation of urban growth is related to regularization (see last section of Chapter 3). Regularization in Curitiba mostly began during the 1990 decade while in areas outside of Curitiba in the study area, regularization commenced later in 2002, in a few areas. Regularization could have increased the supply of housing and rentals though there was no data available to measure rental supply changes and limited data to compare domicile supply changes.

As shown by the COHAB social interest initiative boundaries in Figure 4-12, other programs were implemented in and nearby the SEHIS areas.<sup>5</sup> During a government agent interview, a respondent offered reasons for the high urban growth in the social interest zoning region. The respondent described the Bairro Novo region, situated in a

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<sup>5</sup> The social housing interest initiative boundaries (labeled as COHAB initiative areas) are shown in the 2007 SEHIS zoning map, located on the bottom of the page, in Figure 4-9.

SEHIS zone in the south, as having higher housing densities than downtown Curitiba. In addition, the respondent described a public-private partnership program in which a serviced plot is given to a beneficiary whom is responsible for the construction of a home. The respondent stated that the housing programs in Bairro Novo focus on lot provision and lately, public housing is rarely constructed.<sup>6</sup> The interviewee also described the rapid urbanization in and near various social interest program areas in the Tatuquara and Campo de Santana neighborhoods, located in the south edge of the city.

Overall, in Curitiba there are many innovative social interest programs undergoing implementation that offer serviced and regularized lots and dwelling units. The concentration of these programs in the SEHIS zones and social initiative areas of Curitiba likely influenced the rapid development in the urban fringe. Moreover, these social interest provisions have accumulated substantially. In addition, a little under half of the overall provisions (including housing regularization) are serviced lot provisions (MC, 2008; MC et al., 2007; and COHAB, 2007).

Examining the new urban growth from 1991 to 2007 fulfilling a social interest function in Curitiba showed that 27 percent of all the new urbanization emerging during the study time period contained informal urban areas and/or social interest programs or zoning in Curitiba. The share of this total area (estimated at 4,233 acres) dedicated to social interest initiative functions (part of COHAB) is 50 percent, to SEHIS zones (not overlapping) is 21 percent, and to informal settlement is 29 percent. The share of the

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<sup>6</sup> As described in the literature review, the lot partnership program has provided more lots than the other programs. In this program, the city is responsible for improving the roads and the state is responsible for providing water, energy and sewage infrastructure. Although there is a standard building plan for the homes, enough flexibility is offered for variation in home design and in the allowance of home expansion. Different types of financing for apartments and homes are offered (based on interview held in 2009 and COHAB, 2007)

new informal settlements in Curitiba emerging after 1991 that are undergoing regularization is 33.5 percent. These numbers suggest that approximately 81 percent of the new urban growth with a social interest function in Curitiba is either undergoing regularization or is a part of some other social interest initiative and/or zoning. This finding indicates that a substantial portion of new urban land conversions, one in every three acres, has been dedicated to a social interest function within the municipality of Curitiba. The average housing density in the social interest areas with lot provision programs is around 20 homes per acre in 2005. In addition, the housing density in areas involved with regularization inside of Curitiba is around 24 dwelling units per acre while the non-regularized areas have on average, four less homes per acre than the regularizing areas.<sup>7</sup> Consequently, these new social interest housing areas and regularized neighborhoods support a high housing density.

Overall, this analysis showed that almost one in every three urban acres newly converted to urban uses between 1991 and 2007 was dedicated to informal settlement and for social interest initiative purposes and 81 percent of this total is either undergoing regularization or is a part of a social interest program or zone. These findings show that the social interest strategy in Curitiba has contributed to density increases and the rate of consolidation in a substantial portion of newly emerging urban growth inside the city of Curitiba. Though a majority of these programs take place in Curitiba and not in the surrounding region. Consequently the urban growth impacts (consolidation and density increases) brought on by the social interest programs described above were mostly felt inside of Curitiba but not outside of Curitiba's city limits in the study area.

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<sup>7</sup> Domicile counts inside of each informal urban neighborhood were only available for 2000 and 2005 and not for earlier years.

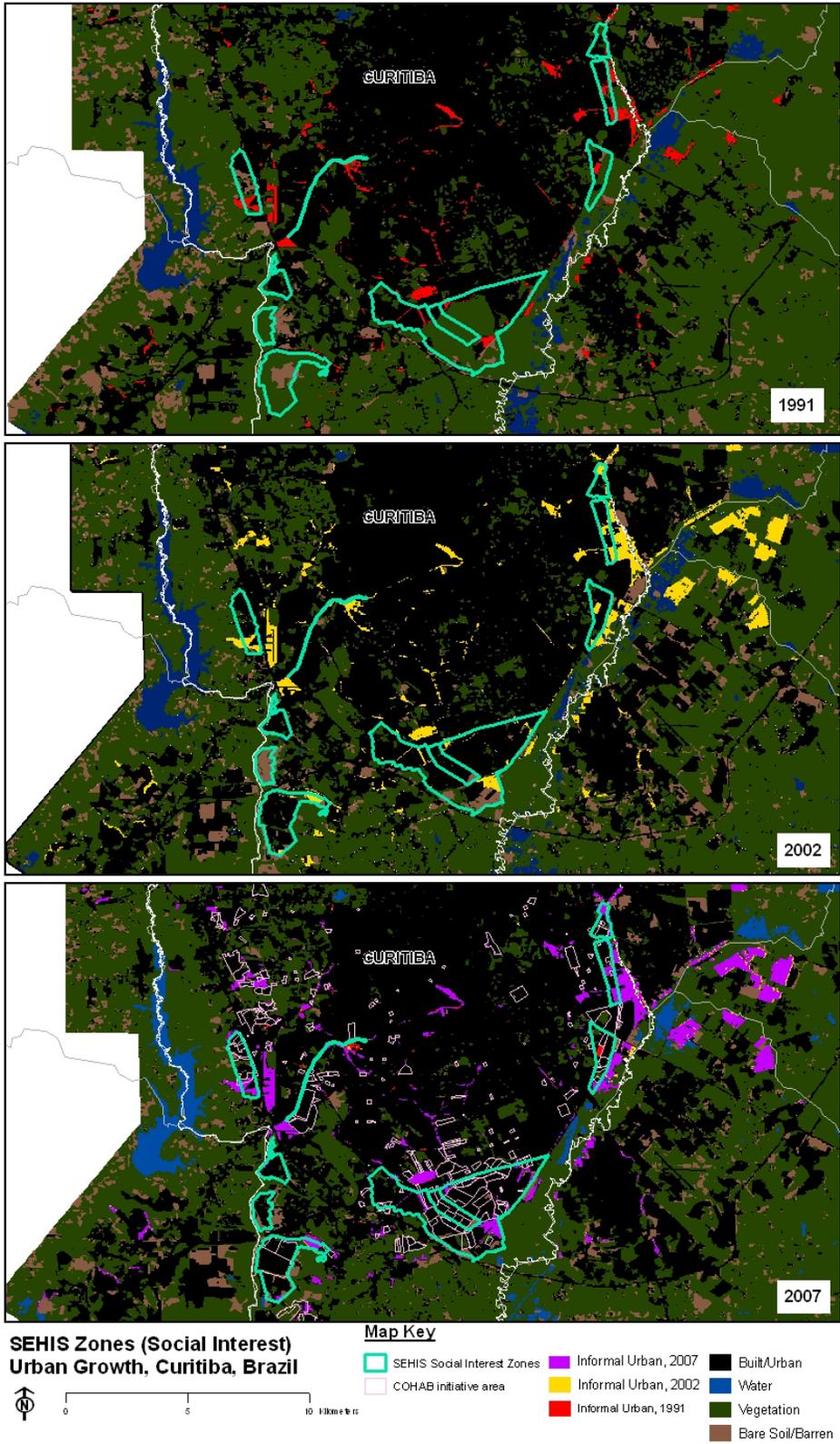


Figure 4-12. Map of social interest zone urban growth from 1991 to 2007

However, as shown in a comparison of the informal urbanization rates inside and outside of Curitiba in Table 4-8, the reduced rate of new informal growth from 2002 to 2007 was felt both inside and outside of Curitiba. This reduced informal growth rate outside of Curitiba indicates that the informal growth associated with Curitiba had not been displaced into the periphery.

Table 4-8. Average annual informal area growth, inside and outside of Curitiba

	Inside Curitiba			Outside of Curitiba, in the study area		
	Acres	Percent	Excluding Reg. Areas	Acres	Percent	Excluding Reg. Areas
1991-2002	94.7	5.8%	1.4%	258.7	8.5%	8.5%
2002-2007	37.7	1.4%	1.2%	73	1.2%	0.1%

\*Notes: The annual rate of growth is shown in acres added per year and percent change. Acreages are approximate and were calculated using GIS tools. Reg. indicates Regularization areas.

Table 4-9. Urban area growth in social interest zones

	1991	Percent	2002	Percent	2007	Percent
Area Built	2,521 Acres	41.5%	4,839 Acres	79.7%	5,326 Acres	87.7%
Annual Rate of Development	1991-2002:	8.4%	2002-2007:	2.0%		

\*Total area of Special Sector of Social Interest Housing zones (SEHIS) is approximately 6,075 acres. Acreages are approximate and were calculated using GIS tools.

### Outside of Curitiba: Reduced Informal Urbanization

Outside of Curitiba, the decreased rate of urban growth from 2002-2007 is influenced by other factors since the implementation of regularization only began in a select few areas by 2007. The decreased urban expansion rate might be attributed to development consolidation that typically emerges after initial settlement. In fact, new informal settlements immersed in the rural-urban transition area seem to settle at lower housing densities during the initial stages of occupation and as these informal

settlements in rural-urban transition areas age, they consolidate. As the land becomes more secure for informal settlement, others join the community such as relatives by settling on nearby vacant land unprotected from their occupation.

Given that some of the periphery towns have a greater portion of informal urban areas than others, the informal urban growth in each of the surrounding periphery towns are presented in Tables 4-11 and 4-12. The urban population density graph, Figure 4-13, shows density changes from 1991 to 2007 and is based on urban population counts (IBGE, various years) and built area calculations.<sup>8</sup> FRG and Campo Magro experienced steady density increases while Almirante Tamandaré, Pinhais, and Campina Grande do Sol experienced slight decreases in density. The addition of new industrial and formally built residential areas (with lower densities) in Pinhais and Campina Grande do Sol possibly triggered a decline in urban population density while the tremendously hazardous building issues in the karst areas of Almirante Tamandaré might have reduced the rate of development.

As illustrated in the bar graph (Figure 4-13), the population densities for most of the larger periphery towns with populations over 100,000 increased substantially since 1991. In fact, the periphery towns of Colombo, SJP, and Piraquara increased in density tremendously and these towns also have the highest proportion of informal urban areas and UTP social interest/conservation areas within their limits. Examining the informal urban growth from 1991 to 2007 visually shows areas designated for social interest in the UTP program areas did experience infill development.

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<sup>8</sup> The density, presented as persons per acre, might appear higher than other estimates for the region given that most other estimates include rural, non-developed land in the calculation. Only the urban land acreages derived from the study classifications were used to calculate the population density.

To examine the rate of consolidation in periphery towns with a substantial portion of informal urbanization, Tables 4-10 and 4-11, compares the amount of informally built land in each town compared to the total amount of informal area in all of the periphery towns. The urban growth in Piraquara, the town with one of the largest informal settlements in the RMC contained around 19.4 percent of total share of informal urban area thus this area likely was influenced by informal development patterns.<sup>9</sup> Comparing density with rates of informal urbanization shows a great deal of densification in Piraquara from 2002 to 2007. Viewed jointly, the urban areas of Colombo and São José dos Pinhais have over 1,450 acres of informal uses in 2007 – collectively, 42.7 percent of the total amount of informal urban areas in the periphery towns of the study area. These two urban centers also experienced substantial increases in population density and reduced rates of informal urban land conversions from 2002 to 2007 in informal urban areas. In addition, Colombo and FRG had some neighborhoods undergoing regularization by 2007 and these efforts could have influenced the substantial reduction in the informal urban land conversion rate from 2002-2007.<sup>10</sup> Lastly, the periphery towns, Almirante Tamandaré (13 percent) and Pinhais (10.5 percent) also have a substantial amount of informal urban areas but these areas experienced slight decreases in urban population density from 2002 to 2007. Thus it is uncertain whether the informal urban areas in these towns consolidated.

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<sup>9</sup> The Guarituba informal settlement had entered into the plan development stages as a part of a regularization effort by 2007 but physical improvements began around 2009.

<sup>10</sup> The overall built land conversion rate for FRG had dropped, though not as drastically as the informal land conversion rate. Thus formal urban growth has continued in FRG.

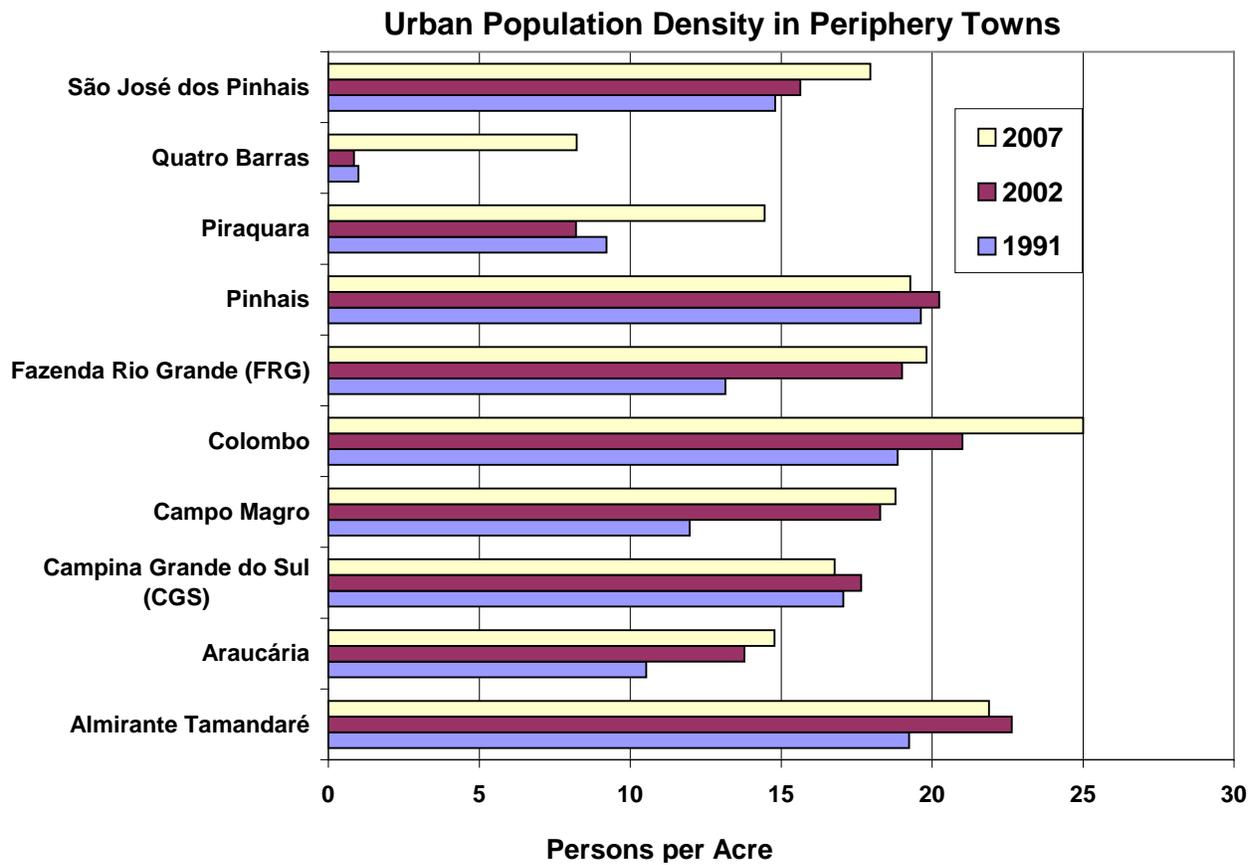


Figure 4-13. Urban population density changes in periphery towns

Table 4-10. Informal urban areas in periphery towns

Municipality	Informal Areas, 1991, Acres	Portion of Total	Informal Areas, 2002, Acres	Portion of Total	Informal Areas, 2007, Acres	Portion of Total
Almirante Tamandaré	245.19	17.22%	406.34	12.59%	440.58	12.96%
Araucária	114.43	8.04%	166.71	5.17%	188.69	5.55%
Campina Grande do Sul	13.53	0.95%	24.83	0.77%	29.32	0.86%
Campo Largo	17.75	1.25%	19.99	0.62%	20.87	0.61%
Campo Magro	41.40	2.91%	50.52	1.57%	61.69	1.81%
Colombo	412.32	28.96%	741.33	22.97%	783.65	23.06%
Fazenda Rio Grande (FRG)	75.03	5.27%	200.37	6.21%	173.06	5.09%
Pinhais	210.92	14.82%	344.19	10.66%	359.34	10.57%
Piraquara	60.14	4.22%	641.04	19.86%	660.20	19.42%
Quatro Barras	5.70	0.40%	14.25	0.44%	14.88	0.44%
São José dos Pinhais	227.27	15.96%	618.04	19.15%	666.71	19.61%
Total	1,423.67	100.00%	3,227.62	100.00%	3,398.98	100.00%

\*Notes: A small portion of the eastern edge of the Municipality of Campo Largo, outside of the main downtown urban area of Campo Largo and on the western edge of Curitiba was included. The total acreage of informal urban areas includes areas outside of the City of Curitiba.

Table 4-11. Comparison of periphery towns informal urbanization rates

Municipality	Informal Urban Land		Total Built Areas	
	1991-2002 Annual Rate	2002-2007 Annual Rate	1991-2002 Annual Rate	2002-2007 Annual Rate
Almirante Tamandaré	5.97%	1.69%	3.51%	1.81%
Araucária	4.15%	2.64%	1.51%	1.76%
Campina Grande do Sul (CGS)	7.59%	3.62%	6.61%	1.56%
Campo Magro	2.00%	4.42%	1.61%	2.15%
Colombo	7.25%	1.14%	3.61%	1.44%
Fazenda Rio Grande (FRG)	15.19%	-2.73%	6.78%	2.88%
Pinhais	5.74%	0.88%	2.93%	2.83%
Piraquara	87.82%	0.60%	14.62%	2.26%
Quatro Barras	13.64%	0.88%	8.16%	3.11%
São José dos Pinhais	15.63%	1.57%	4.70%	2.48%

\* Notes: CGS and Quatro Barras have less than one percent of the total amount of informal areas. Campo Largo was excluded.

## **Discussion on Increased Density in Periphery Towns**

These findings show that the holistic urban growth patterns in several of the larger periphery towns (Colombo, SJP, and Piraquara) may have experienced densification in informally built areas. The density increases and consolidation in the towns of FRG and Colombo could be connected to regularization but Piraquara and SJP likely experienced density increases for other reasons such as consolidated development in the social interest regions of the UTP program and continued densification processes after initial settlement. Thus, the urban growth pattern changes underway in informal urban areas, sometimes a result of community upgrade and social interest programs have influenced the density changes in the urban fabric only partially outside of Curitiba. Moreover, there is too little of information on the specific housing increases to accurately measure the influence that the UTP social interest program has on consolidating informal development and restricting development in conservation areas.

Holistically, the regularization in Colombo, FRG, and Curitiba could support density increases. In the other areas such as Piraquara, the densification process could have been effected by UTP program implementation and initial informal settlement consolidation processes. Collectively the urban population density in the entire study area has increased overall from 1990 to 2007. In addition to informal urban pattern changes, this trend might generally reflect region-wide infrastructure improvements, overall reduced supply of urban land ideal for development, and decreases in the rate of population growth. Overall, these findings indicate that the social interest strategy inside of Curitiba and partially outside of Curitiba likely has played a role in the consolidation and densification changes in the region. These results show a regional shift towards more compact growth but this growth may not be fully sustainable given

the tendencies for infringement in environmentally sensitive areas. As such, results are provided below that compares the quantity of informal urban areas in hazardous and ecological fragile areas and then, the results of the spatial trend analysis are offered.

## **Locational Determinants Results**

### **Findings on Hazardous and Ecological Fragile Spatial Trends**

The amount of informal urban land within the karst, conservation lands, floodplains, and the 50 meter buffer of rivers in 1991, 2002, and 2007 was calculated and these acreages are provided in Table 4-12.<sup>15</sup> Maps showing informal urban growth in conservation lands, karst regions, floodplains and riverbanks are in Figures 4-14 and 4-15. Table 4-12 demonstrates the strength of these locational determinants by describing the share of informal settlement within each of them. Viewing the properties collectively that are either in a floodplain, conservation area, 50 meter river buffer, or karst region, showed that 95 percent of the informal urban areas were in one or more of these features in 2002 and 2007 and 92 percent in 1991. In other words, on average, over 90 percent of the informal urban areas were located within a hazardous and/or environmentally sensitive landscape feature that is common in the Metropolitan Region of Curitiba (*Região Metropolitana de Curitiba - RMC*).

Along with a reduced informal urbanization rate since 2002, the annual rate of informal urban growth taking place in conservation areas, karst regions, riparian areas, and floodplains has declined. The rate of informal urban occupation in conservation lands reduced drastically from 23 percent to 1.3 percent during 2002-2007 in

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<sup>15</sup> The steep slope parameter could not be assessed given data restrictions. Although a small percentage of informal settlement has occurred near high-voltage electrical transmission lines and railroads, these indicators were not as prevalent outside of the Municipality of Curitiba.

comparison to the earlier decade.<sup>16</sup> Likewise, the annual rates of informal urban growth within floodplains and karst regions both dropped by over five percent after 2002. The least substantial decline in the rate of informal urbanization occurred in riverbank areas.

Even though the annual rate of growth has largely declined, the total development footprint of informal areas located in conservation lands, karst features, riverbanks, and floodplains increased over the entire study time period. Additionally, over 30 percent of the informal urban communities were situated in a riverbank and around 20 percent of the informal urban area occupied 100 year floodplains during the entire study time period.<sup>17</sup> In other words, as time lapsed, the sheer acreage of informal urban within floodplains continued to gradually increase. The survey responses complement these findings given that 77 percent of respondents mentioned that settling outside of a floodplain was not an important locational factor for them. When droughts emerge the danger of settling within a floodplain might not be visibly apparent.

### **Discussion on Hazardous and Ecologically Fragile Trends**

Largely this decline in the rate of urbanization in environmentally sensitive lands shows progress towards achieving a more sustainable form of development. As discussed in the literature review, the UTP conservation areas in the study area contain areas designated for consolidated informal settlement development. Perhaps these areas have consolidated and this density transfer reduced the impact to other protected

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<sup>16</sup> Conservation areas are defined as UTP or APA conservation areas or parks.

<sup>17</sup> The floodplain areas were geographically located by combining floodplain GIS data from IPPUC that represents 100 year floodplains and areas inundated with flooding during a 1983 flood event and SUDERHSA land use land cover data that provided a flooded areas category (*área alagada*). The land cover data produced by SUDERHSA was derived by visually interpreting 2000 orthophotographs at the 1:20,000 meter scale.

sections in the conservation areas. Overall, the rate of decline in conservation areas was drastic – it went from 23 percent to 1.3 percent.

Still the gradual expansion in the amount of informal urbanization in these ecologically fragile and hazardous landscapes should serve as a warning for looming water quality impacts and increased destruction in the case of a natural disaster scenario. As informal urban growth continues in these landscapes, the severity of damages and greater loss of life from a significant natural disaster or flood event would increase for the most vulnerable sectors of the population. The overall expansion of informal housing, precariously constructed within ecologically fragile lands, indicates a need for sustained efforts on low-income housing initiatives and merits continuous monitoring. If the rate of informal settlement growth accelerates in ecologically fragile terrain that is hazardous for development, the affordable housing, rental and land supplies and accessibility issues should be critically examined. Lastly, the accuracy of assessing informal urbanization in at-risk landscapes is heavily dependent on the accuracy of the source geographic datasets that represent the natural features. Several of the geographic datasets required cross reference and adjustment with more accurate and reliable resources.

Table 4-12. Informal urban areas in environmentally sensitive, hazardous areas

Informal Urban Areas in Conservation Areas			
1991	2002	2007	
570	2,009	2,139	Acres
18.7%	34.1%	34.2%	(share of total Informal Urban)
Annual Rate Increase	1991- 2002	2002-2007	
	23%	1.3%	

Table 4-12. Continued

Informal Urban Areas Located inside Karst Areas			
1991	2002	2007	
58.1	116	124	Acres
1.9%	2%	2%	(share of total Informal Urban)
Annual Rate Increase	1991- 2002 9.1%	2002-2007 1.4%	
Informal Urban Areas Located inside the 50 meter River/Stream Buffer			
1991	2002	2007	
1,095	1,874	2,052.5	Acres
35.9%	31.8%	32.8%	(share of total Informal Urban)
Annual Rate Increase	1991- 2002 6.5%	2002-2007 1.9%	
Informal Urban Areas Located inside Floodplains			
1991	2002	2007	
661.3	1,127.3	1,175.6	Acres
21.7%	19.1%	18.8%	(share of total Informal Urban)
Annual Rate Increase	1991- 2002 6.41%	2002-2007 0.86%	

Data sources for natural feature GIS datasets: IPPUC, COMEC, SUDERHSA, and Mineropar. The conservation area calculation includes UTP and APA conservation areas and parks. The acreages were calculated using GIS tools and are approximate.

### Results on Socio-Economic and Bus Service Locational Trends

In conjunction with recognizing physical land trends, various other infrastructure and socio-spatial characteristics prevalent in the informally developed fabric were analyzed. In general, informal settlements were near regularized areas though it was i

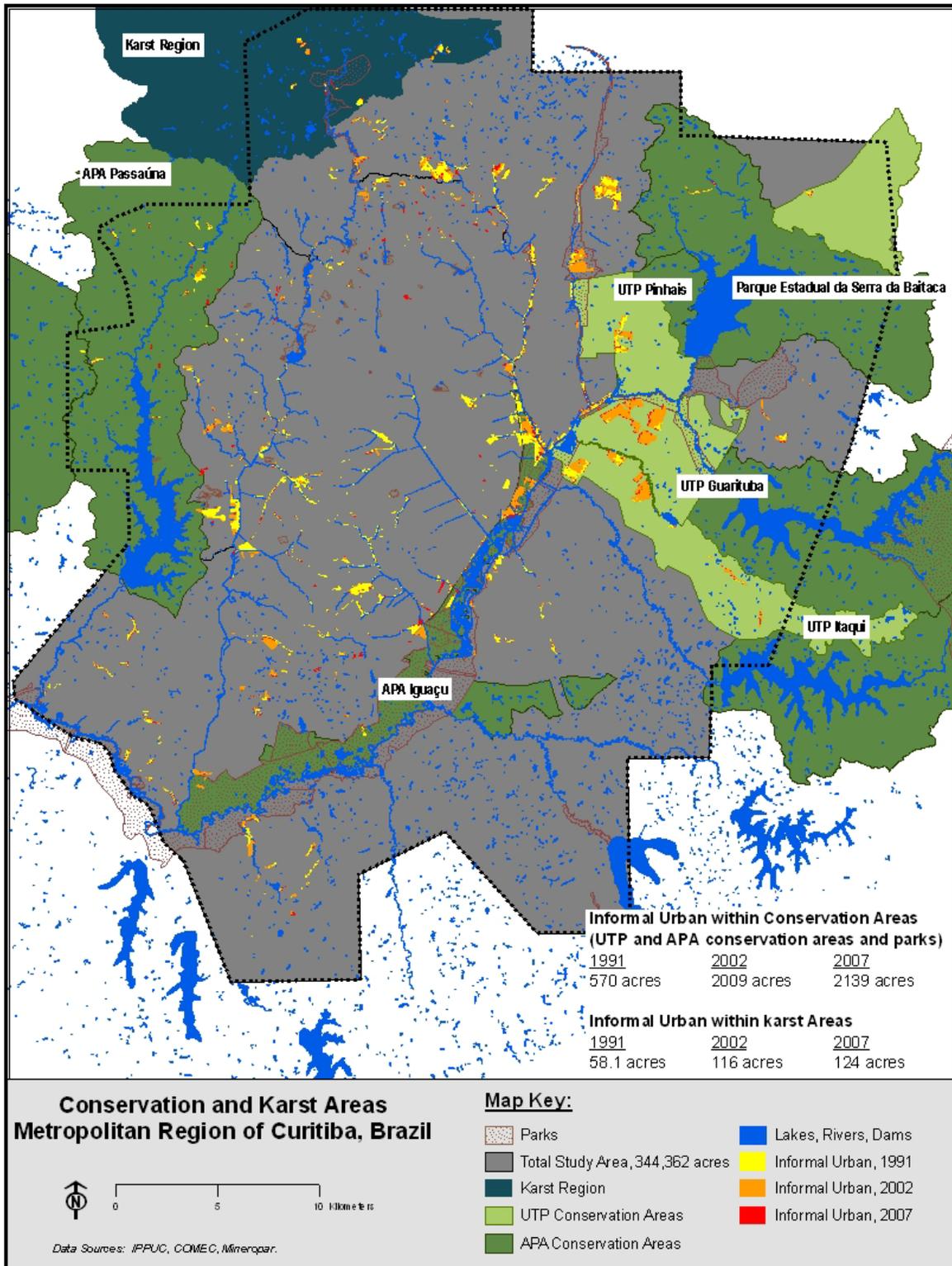


Figure 4-14. Conservation and karst areas map

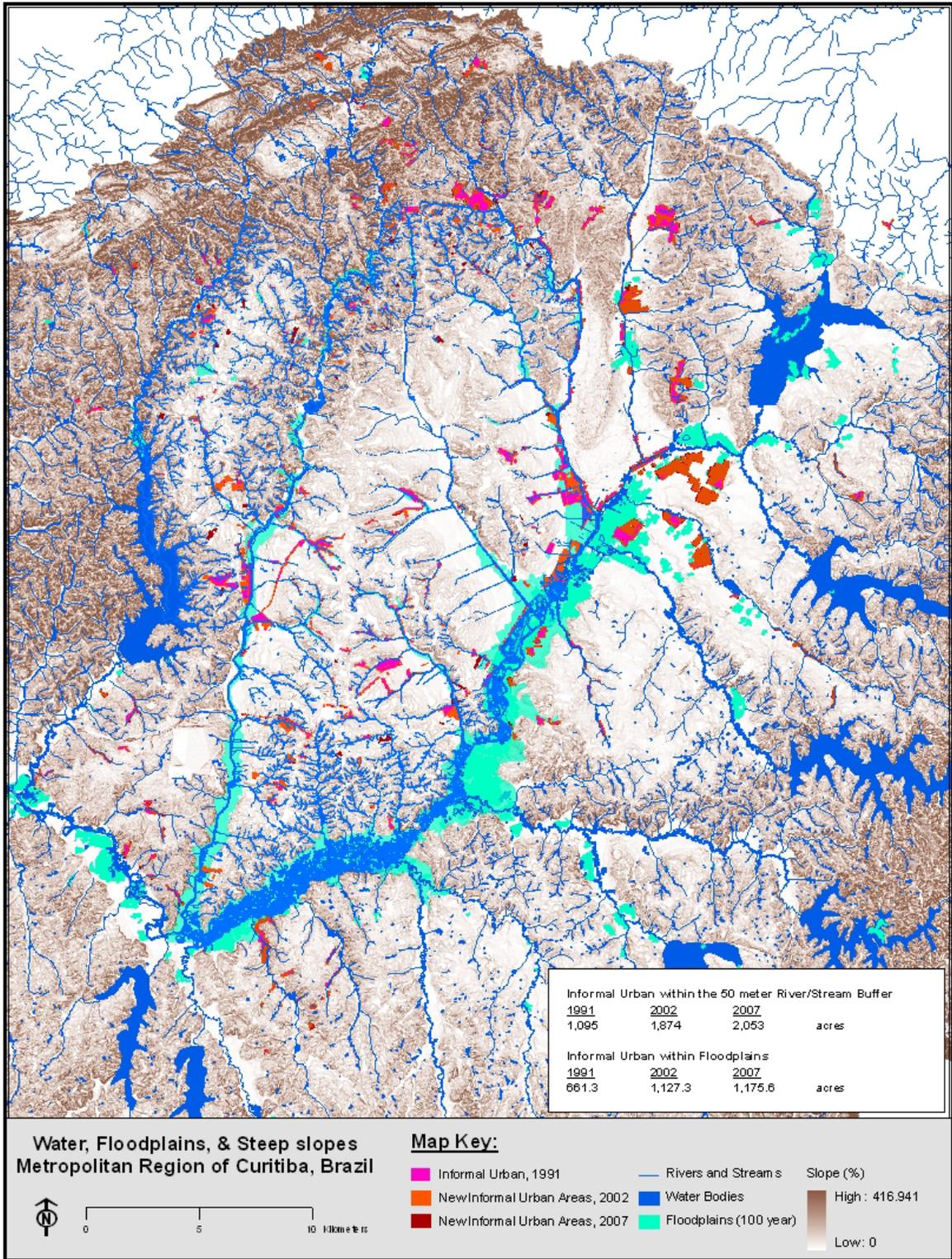


Figure 4-15. Water, floodplains, and steep slopes map

impossible to separate their independent influence since they are intertwined with other indicators such as location near other informal settlements and public housing.

Informal urban areas often converge near social interest initiative areas.<sup>18</sup> Figure 4-16 provides a visual comparison of the location of informal urban areas to social initiative areas built in Curitiba by 2007. Generally the social initiative areas and informal urban areas congregate beside each other along the edges of Curitiba. In regularizing areas, part of this concentration might have been intentional since public housing built for household relocations typically is located as close as possible to the informal areas, so as to not disrupt social networks.

A separate analysis was performed to account for the social interest initiative areas that appear to be connected with an informal area undergoing regularization and this analysis showed that around 45 percent of the informal urban areas inside of Curitiba were within 500 meters of social interest initiative areas from 1991 to 2007.<sup>19</sup> Another calculation, including all the social interest areas showed that around 75 percent of the informal urban areas in Curitiba are within 500 meters of social interest initiative areas. Largely, the juxtaposition of informal settlement with social interest initiative areas is a trend and this concentration has increased socio-economic segregation.

Another sign of a tendency towards socio-economic segregation is the spatial clustering of income brackets. A spatial autocorrelation tool, referred to as Moran I, was

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<sup>18</sup> As discussed in the literature review, the social interest areas contain a variety of programs that offer public housing and urbanized lots.

<sup>19</sup> The geographic dataset showing social interest initiative areas did not differentiate between public housing, serviced lot, and other types of social interest program areas. Thus the individual influence of informal settlement located near public housing could not be determined.

used to measure the rate of income clustering and dispersal in the RMC for 2000. The calculation yielded an index score of 0.86 and this score signified great clustering that has less than one percent chance of random occurrence.<sup>20</sup> Figure 4-18 depicts the income concentrations spatially and shows the clustering of informal urban areas outside of middle and high income neighborhoods. An examination of 87 percent of the informal urban areas inside the census defined urban limits showed that 97 percent of the informal urban areas (for 2002) were located in low and moderate income regions.<sup>21</sup> Together the results yielded from the social interest proximity analysis and income level clustering both imply that socio-economic segregation is a pattern in the region.

Location near bus access proved to be a crucial factor for informal settlement. A large majority of the informal urban properties in 2007 were located within 500 meters of bus service (96 percent). The extensive bus rapid transit network in greater Curitiba reaches various urban extremities, thus residential access to bus service is not rare. However, it should be determined whether the bus service was installed before or after informal occupation. The only informal urban clusters without any nearby bus route are located in the southwestern edge of Araucária. In addition, a large majority of the survey respondents felt that bus service was an important factor in settlement location (93 percent of respondents).

A large majority of the informal settlements tend to concentrate in the urban fringe and periphery portions of the city structure (see Figure 4-17 and previous section

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<sup>20</sup> The Moran's I tool was used to measure the clustering of income for 2000, in the areas defined as urban by IBGE (census)

<sup>21</sup> Around 63 percent of the 2002 informal urban areas were located in low income census blocks (on average, earn less than three monthly wages a month) and 34 percent were located in moderate income blocks (on average, earn over three but less than six monthly wages a month). Income values were not available for 1991 and 2007.

describing decentralized growth). These concentrations are not perfectly concentric and instead, they emerge outside of the cores of surrounding towns and Curitiba. Generally the older an urban center is, the more likely the urban cores of periphery towns are to be formally urbanized. These older urban hubs are more likely to possess full infrastructure, better transportation access, and basic sanitation services; thus the property values in these serviced areas are higher. Consequently the more mature, intensely urbanized centers, secondary to Curitiba, have experienced their own form of concentric urban growth that contains informal settlement along the urban fringe and in marginal lands.

During a field visit, a government agent pointed out the increased amount of formal residential and commercial development in the more intensely urbanized center of Pinhais. The center of Pinhais is the area closest to downtown Curitiba and therefore, one of the wealthiest in the region. The respondent said that those with less income tend to live closer to riparian areas, on the edge of the urban core. The government agent said the cost differs drastically in Curitiba and Pinhais; for example, they suggested that the cost of a square meter parcel of land in Curitiba was twice the amount of land in Pinhais. Consequently, these low land and housing costs in the peripheral areas might attract informal and formal housing development alike and this could be explored further by examining data on property and building value appraisals.

### **Discussion on Socio-Economic and Bus Service Locational Trends**

The findings suggest that informal urban areas in the study area are often located near bus service and social interest initiative areas, in the urban fringe and periphery. The trend for most informal urban areas to be located near bus service would be a critical feature to improve their livelihood given that most informal residents do not

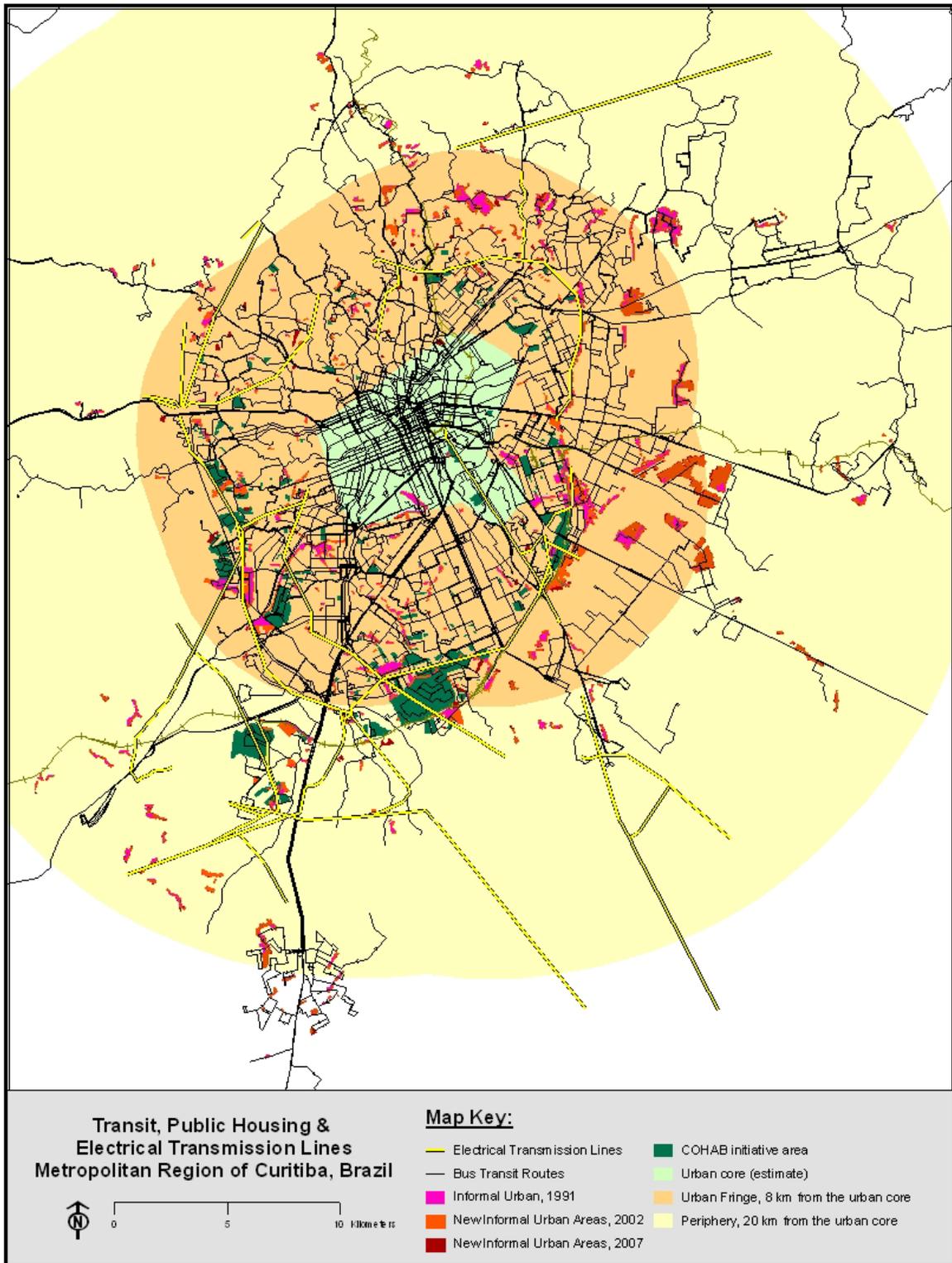


Figure 4-16. Map of bus routes, affordable housing initiative areas, and electrical facilities

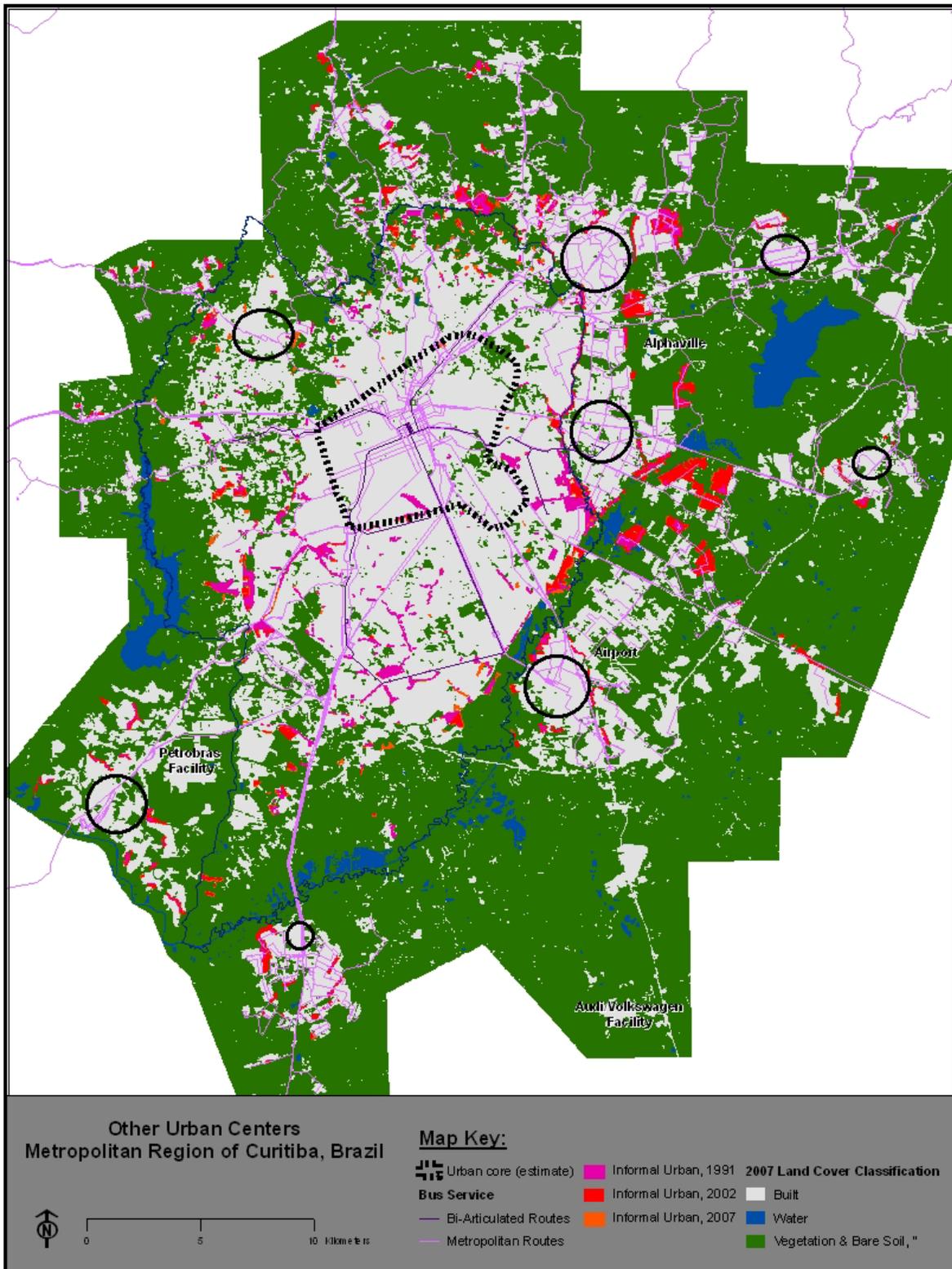


Figure 4-17. Urban centers map

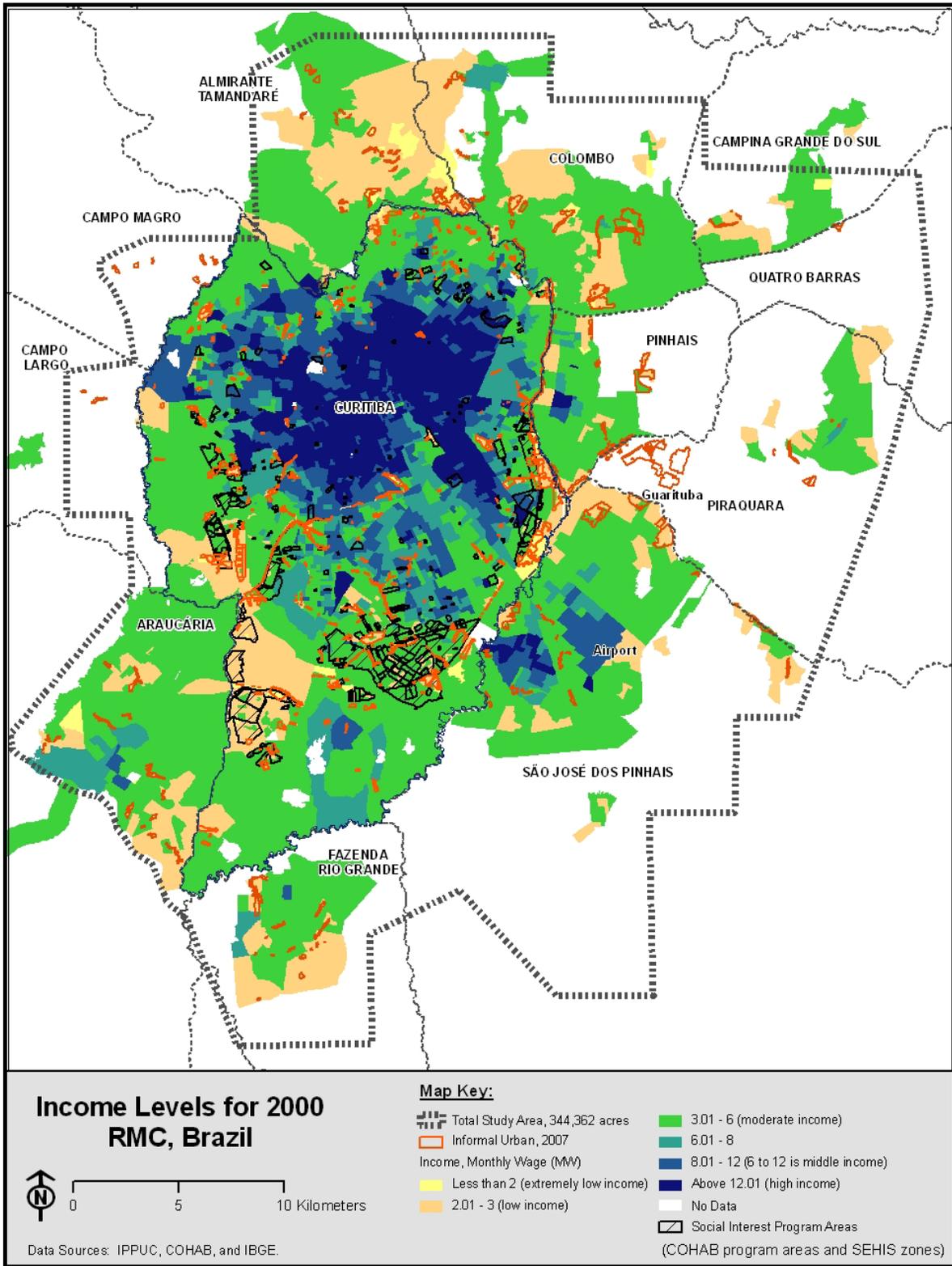


Figure 4-18. Income level concentrations map

possess a car. Although Curitiba excels in providing bus access to most of the citizens in the region, the convenience of this service diminishes the farther a resident is located from an express bus line and their intended destination.<sup>22</sup> The tendency for informal urban growth to occur in the urban fringe and periphery coincides with the location of low property values, land without infrastructure, and several rivers and floodplains. The property value of land in floodplains and riverbanks particularly in the city outskirts is extremely low; consequently property owners are more likely to tolerate and sometimes encourage informal settlement in these locations.<sup>23</sup> Several of these trends could be the outcome of social processes particularly related to increasing income segregation that is also organized by the development quality of the land and utility levels.

### **Key Findings from Community Surveys**

The survey respondents pointed out their preferences for where to live and these responses cue in on the rational considerations for informal occupation of land. For instance, 83 percent thought it was important to settle near existing informal settlements and 93 percent thought it was crucial to be near infrastructure and regularized areas. In addition, 73 percent thought it was important to live close to family and 71 percent found a housing location near employment centers and opportunities ideal. Another ideal circumstance, mentioned by 97 percent of respondents, is to location near social services such as schools, daycares, and health centers.

The community survey respondents offered their viewpoint on the main reasons for the accelerated growth of informal settlements since 1990. Over 30 percent said that

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<sup>22</sup> According to a survey, 50 percent of the employed residents living in the Zumbi Neighborhood spent more than one hour on buses to reach their place of employment (based on an interview, 2008).

<sup>23</sup> Property owners may benefit from informal settlement given the potential for regularization procedures that incorporate infrastructure provision and government compensation for land acquisitions.

the search for employment spurred informal urbanization while 19 percent pointed to the need for less expensive housing and land. Other significant reasons for informal growth were a better quality of life and socio-economic benefits (16 percent) and the lack of money, resources, and financing (13 percent).<sup>24</sup> During a field visit, an interviewee said that everyone wanted to live in Curitiba during the 1980 and 1990 decades because the good reputation of Curitiba had spread. A myriad of reasons generally associated with economic gain and quality of life improvements brought new-comers to the city and spurred informal urban growth.

Other intriguing findings from the survey revealed that many informal residents embraced living outside of the busy urban core. Many respondents did not feel that it was desirable to live near central Curitiba and one respondent found the crime there intolerable. Many respondents expressed happiness with not living in a more 'urban' environment. The respondents discussed advantages and disadvantages to living in the community and the range of these responses is provided in Appendix A.

As a whole, these responses illustrate the settlers' needs for infrastructure, bus access, and services, a better quality of life and closer proximity to employment opportunities, schools, and health centers. Many of the disadvantages to living in an informal settlement are related to the negative externalities commonly associated with concentrated poverty such as crime, prejudice of the favela, and lack of security. Lastly, the survey asked respondents what were the main obstacles for living in the central urban areas. While 63 percent did not want to live in the central urban areas, 17

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<sup>24</sup> Another survey of the Zumbi Informal Settlement found settlement reasons associated with the pursuit of employment, a better quality of life, and availability of inexpensive housing opportunities not available in the City of Curitiba (based on an interview in 2008).

percent of the respondents found land prices to be too expensive and eight percent felt that entrance into city living was limited to those whom are trained professionals.

### **Discussion on Community Survey Findings**

The informal settlers largely expressed preference to settle near areas with a potential for a higher quality of life. These areas often are located on land near infrastructure and regularized areas that offer the potential for infrastructure connection. The location of informal settlements away from desirable community features or services such as schools and full infrastructure could be recognized as a potential trend and a product of the urban system. The preference of settlers to live near other informal settlements might reflect the social acceptance these areas offer and in contrast, the exclusiveness of formal areas. Overall, these responses touch on the importance of having access to economic, services and other quality of life opportunities where they live and point to high land and housing prices as a barrier to living in urban centers.

### **Summary of Research Findings**

The measurement of urban growth in greater Curitiba, derived from remote-sensed land cover classifications, showed substantial urban expansions and decentralized urbanization outwards into the urban fringe and periphery from 1991 to 2007 at the same time as population density increased. The urban growth extended outwards towards secondary urban centers in a polycentric pattern and in several areas the urbanization from these secondary centers connected together to form conurbations that concentrically has expanded Curitiba. The overall urban growth became more compact and consolidated from 2002-2007 in comparison to the 1991-2002 decade. There are multiple forces associated with this shift, many of which delve into economic, social, political, and environmental matters such as region-wide infrastructure

improvements. However, a critical force in density increases and reduced urban expansion is related to informal settlement urbanization.

The rate of new informal urban growth declined drastically from 2002 to 2007 in comparison to the rapid urbanization that unfolded from 1991 to 2002. In addition, the rate of informal urbanization reduced more drastically than the overall rate of urbanization in the study area. Overall, informal urbanization has decentralized and the regional patterns show that informal urban areas generally are located outside of Curitiba's downtown area and around the core of older more established urban centers in the periphery. The frantic informal settlement growth during the 1990 decade was reflective of hard economic times. While the consolidated growth beginning around 2000 signaled economic recovery and it was partially impacted by the implementation of a robust social interest, sustainable planning program. In fact, after 2002, population densities increased in many of the periphery towns with a large amount of informal urbanization and social interest initiatives.

Isolating the influence of government initiatives in specific areas revealed insights on the urbanization trends of this study time period; however this analysis was more successful inside of Curitiba given data restrictions. Inside of Curitiba, the rapid pace of compact development in the social interest zones and initiative areas triggered consolidated informal development and facilitated density increases. In fact, approximately 27 percent of all types of new urban growth consisted of informal settlement and social interest initiative areas in Curitiba from 1991 to 2007 and 81 percent of these newly urbanized areas are either undergoing regularization or are a part of another social interest program or zone. Inside of Curitiba, most of the informal

urban areas undergoing regularization increased in housing density from 2000 to 2005 at an average increase of 4 domiciles per acre. The myriad of social interest programs provided a substantial amount of serviced lots, public housing, and regularized informal settlements. Curitiba's focus on the provision of serviced lots is pro-active and was a driving force in capturing a substantial portion of potentially expansive informal urbanization. Instead of land invasions, these new-comers were directed to serviced land that is more suitable for development. The allowance of progressive housing improvements and gradual construction was a feature that appealed to lot recipients. In addition, the act of regularization could increase densities and the supply of rentals.<sup>25</sup> In Curitiba, many of these programs were well underway during the 1990 decade; consequently the urban pattern effects, such as consolidation and increased density of urban growth were felt mostly inside of Curitiba. Outside of Curitiba, less regularization was underway by 2007 and as a consequence, the resulting implications were less significant. In 2000, the UTP conservation policies restricted development in certain areas and encouraged the consolidation of informal development in social interest regions already experiencing settlement. However, the extent that the UTP program influenced reduced informal urbanization is uncertain. Holistically, various social interest initiatives could have increased density and the rate of consolidation inside and outside of Curitiba however the extent that specific public policy has influenced urban growth patterns should be examined at a later date through a more detailed study that examines the housing densities in individual neighborhoods and key program locations.

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<sup>25</sup> As discussed in the literature review, regularization might eliminate the need for septic tank facilities, necessitate the development of compact housing units and lots, and spur the investment of second-story home expansions that often serve as low-income rentals.

Along with recognizing urban growth patterns, the chief locational determinants of informal settlement were identified. Location near bus access proved to be crucial for informal occupation. In addition, around 45 percent of the informal urban areas in Curitiba were within 500 meters of social interest initiative areas from 1991 to 2007. The strongest geographic indicators for informal urban settlement are location in floodplains, conservation lands, and in riverbanks. Viewing the properties collectively showed that over 90 percent of the informal urban areas were located either in a floodplain, conservation area, 50 meter river buffer, or karst region from 1991 to 2007. However, the results found that the rate at which informal development encroaches in the aforementioned ecologically fragile and hazardous lands has dropped overall since 2002. Although the amount of informal urban invasions in ecologically fragile areas has not declined overall, the rate of new informal urban land conversions in these areas has substantially dropped (by at least five percent in all categories). This decline in the rate of urban land conversions in conservation areas might be attributed to an overall decline in informal urbanization and new conservation laws that encourage consolidated informal development in certain social interest areas.

These research findings imply that location in a floodplain, conservation area, or karst region, in the urban fringe and periphery; and close proximity to a river and bus route could be useful for predicting and monitoring the growth of informal settlement. In fact, if several of these indicators are combined, over 97 percent of the informal urban areas were selected for all three study years (see Table 4-13). However, the strength of some of these indicators has declined (such as location in conservation area, riverbank,

and floodplain); thus the set of indicators useful for predicting informal settlement location might change.

Table 4-13. Combination of spatial variables

Year	Informal Urban Areas within Combination of Indicators	Total Informal Urban Acreage	Share
1991	2,983.4	3,047.1	97.9%
2002	5,787.9	5,892.4	98.2%
2007	6,134.9	6,257.4	98.1%

The combination of features includes areas within 500 meters of bus line; and/or in a karst region, conservation area or floodplain; and/or within 50 meters of a river or stream.

Largely, informal settlement accumulates near other informal settlements, public housing, and social initiative and regularization areas. In addition, informal urban areas mostly were located in low-to-moderate income neighborhoods. Other less prevalent indicators are location in karst regions, steep slopes, and settlement near electrical transmission lines.

Most respondents felt that location near infrastructure was crucial. In addition, they indicated that close proximity to bus service access, family relations, employment centers and opportunities were all important. In addition, the choice in where to settle might be limited to areas outside of desirable community features such as schools and in areas without infrastructure given the strong potential for increased land prices.

An outline of the findings on spatial trend findings is provided in Table 4-14 and Table 4-15 provides a comparison of key government program influences on informal urbanization trends. Both Tables 4-14 and 4-15 summarize major findings derived from this research. The findings stress the need for continual evaluation of the government strategy and public policy influences on informal urbanization outcomes. This

evaluation should be iteratively developed and adapted to ensure that accurate results are yielded. This research was designed to measure the collective influence of the government approach in greater Curitiba to discover ways how they might influence informal urbanization outcomes and encourage inclusive sustainable development throughout the region.

As a whole, the findings suggest that new informal settlement growth is most likely to occur in vacant areas located in the urban fringe and periphery that have access to bus service in the RMC and that location of informal settlement in floodplains, conservation areas, and near rivers and social interest housing programs is a common locational trend however growth in conservation areas, rivers and floodplains has diminished. Consequently the strength of these trends has weakened. Lastly, the results indicate that the government strategy used in Curitiba did help to reduce the overall informal urbanization rate and encourage consolidated urban growth.

### **Discussion on Overall Results**

Collectively these findings indicate that in the case of greater Curitiba, informal settlement location is not random and the prevalent patterns are an outcome of limitations posed on informal settlers. Much of the settlements tend to concentrate on marginal, hazardous lands without infrastructure in areas where their occupation is tolerated and in some cases encouraged because of the potential for land owners to gain infrastructure and government compensation. The settlement location often is near urban infrastructure, perhaps because this land is perceived by residents as having the potential for acquiring infrastructure. In addition, informal settlements typically concentrate around areas where they are socially accepted such as near other informal

settlements, low income neighborhoods, and social interest initiative areas. The existence of common spatial patterns supports the conjecture that there are prevalent

Table 4-14. Summary of spatial trend findings associated with informal urbanization

Spatial Pattern	Description
Decentralization of informal urban areas and location in the urban fringe and periphery	Steady decentralization from 1991 to 2007. From 1991 to 2007, over 70% of all informal urban areas were located in the urban fringe. From 2002 to 2007, the portion of informal urban areas in the urban periphery increased from 21 to 27%.
Informal urbanization in conservation areas	The share increased from 18% in 1991 to 34% in 2002 and 2007. Though the annual growth rate in these areas drastically decreased from 23% (1991-2002) to 1.3% (2002-2007).
Informal urbanization in floodplains	The share was similar for all three study years: 21% in 1991, 19% in 2002, and 18.8% in 2007. Although the annual growth rate in floodplains has decreased from 6.4% (1991-2002) to 0.9% (2002-2007). In addition, 77% of survey respondents did not find location outside of a floodplain an important factor in where they live.
Informal urbanization within 50 meters of a stream or river	The share was similar for all three study years: 36% in 1991, 32% in 2002, and 33% in 2007. However, the growth rate has decreased from 7% (1991-2002) to 2% (2002-2007). The rate of decrease is not as significant as the decline in conservation areas and floodplains.
Informal urban areas location near bus service	Most informal urban areas were located within 500 meters of bus service (96%) and most respondents thought location near bus service was important (93%). The bus service in greater Curitiba is often extended to populations in need.

rationalities for the informal occupation of certain types of landscapes. These residents are not allotted the opportunity to live in a desirable neighborhood with infrastructure

and services and instead their choice in where to settle is determined by where they are tolerated and permitted and how the urban system limits settlement options.

Table 4-15. Key government program influences on informal urbanization

Spatial Patterns & Public Policy Influence	Description
<p>Reduced informal development in floodplains &amp; riverbanks from 2002-2007. Drastic rate reduction in conservation areas: from 23% (1991-2002) to 2.2% (2002-2007).</p>	<p>A combination of social interest programs, development exchanges, and conservation plan (UTP and APA) restrictions.</p>
<p>Table 4-15. Continued</p>	
<p>Inside of Curitiba: Informal settlement location near social interest housing programs and SEHIS zones</p>	<p>75 percent of the informal urban areas were within 500 meters of social interest initiative/zoning areas. Regularization interventions often include public housing development nearby an informal settlement for housing relocations.</p>
<p>Inside of Curitiba: Consolidation and density increases within informal urban areas</p>	<p>From 1991 to 2007, rapid consolidated development in SEHIS zones and social interest initiative areas.</p>
<p>Social interest zones and initiatives</p>	<p>From 1991 to 2007, 27% of all new urban growth was dedicated to a social interest function (81% of these areas are part of a social interest or regularization program) in Curitiba. Around 42% of the total social interest provisions are given in the form of serviced lots in Curitiba. The social interest programs support high housing densities.</p>
<p>Regularization</p>	<p>Around 30% undergoing regularization in 2002 and 2007 and these areas supported slightly higher housing densities than non-regularized areas (domicile counts 2000-2005). Couldn't measure rental increase. Thus, regularization efforts could have partially contributed to density increases though need to measure rental stock changes.</p>
<p>Outside of Curitiba: Partial consolidation and density increases in informal urban areas</p>	<p>UTP social interest areas &amp; regularizing areas could've experienced increased consolidation in a few areas. Visually it appears many informal areas have consolidated and informal urbanization in conservation areas has reduced drastically though more data and further study is needed.</p>

The spatial pattern findings exemplify the ways in which informal settlement communities disproportionately live in hazardous deplorable living environments such as in a floodplain. The strength of these trends illustrates the types of divisions and contrasting circumstances between formal and informal and the urban poor and rich in greater Curitiba. This divide is not always black and white in Curitiba and there are shades of gray in which a mixture of informal and formal residents live side by side, particularly in areas transitioning between these divisions.<sup>1</sup> A reduction in the strength of the informal-formal divisions and trends reflective of social inequality might indicate progress in terms of supporting inclusive sustainable development. Thus, these trends and patterns should be monitored and researched further.

The overall reduction in new land invasions shows signs that other housing options are capturing low-income new-comers. One of the goals of Curitiba's social interest plan was to use mechanisms to reduce the rate of new land invasions. This study shows a reduction in the amount of informal settlement, even in areas beyond Curitiba's political boundaries. These findings are moderated by the uncertainties in whether all informal urban areas were captured through the identification method and by data limitations.

### **Method Transferability**

The basic steps involved with this informal urban identification approach could be applied elsewhere if it is customized to local circumstances. The premise behind the method is to focus informal urban identification by first recognizing the common areas at-risk of informal urban development in a particular region. In the RMC, these at-risk

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<sup>1</sup> Based on field visit observations, several areas had a mixture of informal and formal housing.

areas often included dominant natural features of an urban area that is deemed formally undevelopable (examples include steep mountains prone to landslides, riparian areas, or floodplains). However, the set of informal settlement and irregular land division indicators vary according to the urban context. Accordingly, the development of logic based on local knowledge and the commonalities of known informal settlement locations (such as finding common building patterns) would be critical for detection methods. In addition, local knowledge would be critical for narrowing down the scope of review and for verifying results.

In the RMC, the use of aerial photographs with high spatial resolution was crucial for deciphering the informal urban areas more precisely. Often the informal settlements in Curitiba were small in size and linear in shape; therefore the use of aerial with high enough spatial resolution to see these building features was crucial. Depending on the urban region, informal areas might vary and when urban regions have larger informal settlements, the detection process might be easier and require less detailed orthophotographs. Though, the aerials likely will need to provide high enough spatial resolution (at least ten meters) to see building patterns. Another unique difference of Curitiba in comparison to other urban regions is in the overall amount of informal urban uses – a larger amount of irregular housing neighborhoods is more typical for urban regions of the global south. Nonetheless, both the context of the region and the spatial character of at-risk areas influence the method of identification.

The use of a GPS unit was crucial for collecting training samples and the GIS and Spatial Analyst tools facilitated geographic and spatial examinations. In fact, the overlain comparison of geographic features such as rivers with urban areas and

detailed aerial photographs would have been impossible without GIS tools and data. The use of the best available data resources including geo-rectified aerial photographs, various GPS-recorded field visits in a range of irregularly built areas, population and domicile counts, interviews, and government plans served to complement one another in the discovery and measurement of informal urbanization conditions. Using freely available tools, such as Google Earth satellite imagery would enhance efforts. Although narrowing down the scope of examination to urban areas at risk of settlement is useful, a method should account for atypical informal urban areas through other ways such as through verification procedures.

In many highly urbanized areas of the global south, identifying the location of all the existing informal settlements is nearly impossible and time consuming given their rapid development and elusive circumstances. Thus a balance should be made between attaining highly accurate results and consuming time. Overall, urban planners and local government in any urban region experiencing rapid increases of informal urbanization should make it a priority to detect informal urban growth and work hard to iteratively advance these methods. After this process begins, subsequent updates and modifications should be considerably less demanding.

## CHAPTER 5 RECOMMENDATIONS AND CONCLUSION

### **Recommendations for a more Sustainable Future**

Surprising few studies set in the global south use concepts of sustainable development as a means of evaluation even though rapid urban growth merits this examination today more than ever. The long held definition of sustainability is that actions today should not compromise the ability of future generations to meet their needs (UNESA, 2007). This chapter narrows down the sustainable development discussion by focusing on the results of this study. Jenks and Burgess (2000) applied the sustainability concept to evaluate development by examining the density and compactness of urban form; the amount of mixed uses; types of building layout and diversity; use of passive solar design; support of sustainable transport; and inclusion of green spaces (Jenks and Burgess, 2000). In most Latin American countries, mixed use development and diverse building layout is common and the passive solar design and inclusion of green spaces concepts are beyond the study scope. Thus of these sustainable urban development factors, informal urban growth at risk of developing expansively; disproportionately on environmentally sensitive land; and segregated by income and hazardous, substandard living circumstances were used to formulate recommendations. This research, set in the bustling metropolis of Curitiba, revealed several advancements, useful principles, along with challenges related to informal urban growth. Campbell's (1996) theory of sustainable planning suggests that these interests be recognized and then calls for the formulation of win-win solutions that complements these interests. Using only the applicable results of this study, the informal urbanization in the study area was evaluated.

In terms of achieving sustainable urban form, encouraging social inclusion and reducing the rate of environmental degradation, Curitiba has advanced and digressed. Since entering the 21<sup>st</sup> Century, Curitiba has promoted a more sustainable urban form with the reduced rate of new informal urbanization, increased rate of consolidation and compact development, and decreased rate of informal land consumption in ecologically fragile areas at-risk of informal settlement. However, the extent that informal urban development consumes ecologically fragile lands that are hazardous for development has not decreased overall. In addition, the region of Curitiba appears to have become more segregated by income. Many of the affordable housing program areas are located next to informal settlements along the urban fringe and periphery of Curitiba and are clustered in areas with cheaper land. Consequently, Curitiba's informal urban areas are concentrated in certain landscapes. As such, recommendations were developed based on the study results and theories of sustainable planning and urban development.

### **Sustainable Urban Form and Growth**

- New locations for social initiative programs should be considered in areas in need of infill development. The redevelopment and adaptive re-use of vacant industrial facilities should be considered for housing and social interest purposes and incentives should be given to developers whom build moderate and low-income housing.
- When deciding where to establish social interest zones and regularize informal settlements, opportunities to promote social integration and support low-income housing expansion nearby all types of developments should be considered. This vacant land allotted for mixed income housing development should not be hazardous and ecologically fragile.
- The regularization program in the study area helped increase the density; this effect was more possible when infrastructure was installed (such as piped sewage facilities) and when additional housing units were added. Early intervention in newly settled areas, that helps guide the housing and lot layout location outside of ecologically fragile areas, will help actively prevent difficult relocations and environmental degradation.
- The development of moderate to high housing density in urban areas that are affordable to low-income populations is seen as another basic factor for promoting social inclusion and sustainable urban growth. However, the construction of extremely high housing

densities that are precariously built should not be encouraged (particularly those at risk of collapsing following a natural disaster or storm event). Public policy should promote and incentivize the attainment of sustainable housing densities that can endure inclement weather and natural disasters and have enough space for basic infrastructure. A minimum lot size should be established (as is done in many of Curitiba's housing programs). At least medium housing density should be encouraged in areas not encroaching into environmentally sensitive areas. Perhaps, regular quality of life surveys could be conducted in regularized areas to ensure that housing consolidation and increased density has not degraded the quality of life or impaired the functionality of infrastructure.

## **Social Inclusion**

- The social implications of the prevailing urban pattern should be evaluated for the degree of inclusion that low-to moderate-income populations are offered as valid citizens deserving of basic sanitation, infrastructure, services (such as medical and education), decent housing conditions, security, schools, and participation in public decisions. The fact that Brazil has mandated the inclusion of the urban poor as integral citizens deserving of infrastructure and social interest support is a step in a more inclusive sustainable direction. Ignoring the existence of informal settlement and failing to build a comprehensive social interest strategy will spur expansive unsustainable development.
- Informal communities prefer to be located within walking distance from public transit routes; thus regularization and social interest zones should be established in areas with sufficient bus access. Curitiba's dedication to providing affordable bus service that is conveniently located promotes social inclusion, however perpetuating long commute times might detract from this progress.
- The social interest zoning proved to be an effective tool at pro-actively guiding new development. However, the concentration of the urban poor in social interest zoning pockets might be creating dense islands of poverty. As such, areas undergoing consideration for social interest zoning designation and regularization should look for opportunities to promote social integration and mixed income neighborhoods.
- In addition, other initiatives that pro-actively increases the supply of affordable low income housing and rentals and reduces segregation tendencies should be considered. A housing voucher program could be instated that provides monetary assistance for low-income residents to live in formal housing areas that are in good condition. Inclusionary zoning tools that require a small percentage of new housing developments to include dwelling units that are affordable to moderate income levels could also be explored.

## **Environmental Preservation and Restoration**

- Curitiba's focus on the provision of urbanized lots in various social interest programs helped pro-actively guide development that might have encroached environmentally sensitive areas in a cost-effective way. However, different types of new-comers might have different preferences. In other cities, low-income new-comers might prefer renting an apartment over self-constructing a home on a serviced lot. Identifying the preferences of new-comers and using these findings could be used as a guide for programs.

- A regional program that educates informal settlement residents on the local ecology and hazards of living within certain types of landscapes in conjunction with programs that foster and incentivize environmental stewardship might be a useful approach. Providing simple education material on what is a floodplain and the dangers with living in these areas might be useful.<sup>2</sup>
- Adding tax credit value or granting monetary incentives for property owners to preserve the most ecologically fragile lands should be considered.
- Choosing to regularize in areas that are located near vacant land without hazardous or ecologically fragile conditions could be used as a tool to guide new growth. Though regularization alone will not significantly reduce informal settlement, particularly in ecological hazardous lands.
- The degree that all types of urban growth encroaches ecologically fragile and hazardous features such as hillsides, floodplains, riverbanks, wetlands and critical habitat areas should be comprehensively examined especially since informal urbanization might emerge near this type of formal development.
- The extent that regularization community upgrades (such as the restoration of riverbanks) improves the water quality of watersheds, particularly those supplying potable water, should be measured to identify opportunities to improve water quality. In addition, the use of innovative low impact development improvements (such as inexpensive pervious pavers and bioswales) could be integrated as a part of regularization.

### **Holistic Considerations**

- Partnerships between agencies working on informal settlement issues throughout the RMC appear to be limited. In all of the facets of sustainability, a need remains to engage in civil dialogue at regular intervals to more effectively deal with informal urbanization and develop a strategy for promoting inclusive sustainable development that is proven to work. These interactions should be facilitated and should include a broad range of stakeholders such as urban planners, different agency representatives, social workers, community leaders, informal settlers, elected officials, and scholars. These periodic multi-stakeholder events involving multiple jurisdictions could help in the development of a learning community, united in furthering sustainable urban development.
- Region-wide efforts have begun with the development of a plan with sustainability objectives, referred to as the Integrated Development Plan for the RMC (GEP, 2006) and with Curitiba's release of several reports on social interest, housing, and conservation area plans (MC, 2008 and MC et al., 2007). As mentioned above, the integration of these plans, the sharing of lessons learned, and evaluation of useful mechanisms encourages praxis. A regional perspective for such a plan that captures the urban-rural transition area in its purview could increase plan effectiveness given the tendency for decentralized and displaced informal settlement.

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<sup>2</sup> An example of this type of environmental stewardship program took place in the Zumbi Informal Settlement. To ensure that the crucial riparian ecosystems were maintained and preserved, tree-planting community events were launched and the participation of the residents was strongly promoted. Estimates indicate that approximately 4,000 trees were planted (Interview, 2008).

- Public participation should be an integral part of sustainable development. The process of regularizing the Zumbi informal settlement included several community meetings and allowed for a couple of community-driven decisions. However, the extent that the public is a part of the decision-making on how to resolve conflicts and develop more sustainably is limited in Curitiba. More opportunities for public input and civil dialogue should be afforded.
- Developing a resource center (akin to a little city hall) in informal settlement hubs might improve transparency and nurture civil dialogue between citizens and government. As observed during research field visits, several informal settlements in the Metropolitan Region of Curitiba (RMC), undergoing the beginning stages of regularization, gained a computer lab in the center of the community that also served as a government office. The act of establishing a computer lab that is staffed with government agents whom are available to share new information and listen, track, and consider community input facilitates this needed dialogue. Other resources and interactions with stakeholders could help promote regular civil dialogue on ways to resolve issues and become more sustainable.
- Gaining funds for social interest programs and sustainable projects is challenging. Curitiba used public-private partnerships and transfer of development right (TDR) tools to help gain private sponsorship for social interest programs. Other tools to incentivize the private development of low-to- moderate income housing (built sustainably) should be considered. In addition, some community improvements and training a part of the Zumbi community regularization was funded by corporate sponsors. Providing a venue for private sponsorship in addition to TDR tools might increase funding revenues.

Using the planner's triangle for sustainable development (Campbell, 1996), a policy balance should be made in lessening environmental degradation through conservation of land and development restrictions along with the promotion of social interest programs that create viable affordable housing and rental options for low-income populations. Quantifying the housing and land need of low-income populations is crucial for keeping pace with social interest needs. The needs for affordable housing could be measured through fluctuations of informal settlement urban growth, housing deficit calculations based on census data (similar to the method used by Serra et al. in 2005), and by quantifying the number of families on the waiting list for public housing and serviced lots. Another signal of disequilibrium between housing and land supply and demand takes the form of rapid inflations in land and home prices. The monitoring

of these signals could be integrated in a sustainable strategy and help with balancing public policy programs.

Overall this discussion is reflective of the many functions and purposes of land: social, environmental, and economic. The environmental function is crucial for many reasons such as the need for clean water and air; the social function of land is fundamental particularly for providing a place to live; and the economic function of land fulfills the need for resources and economic development. The recent policy recognition of the social function of property in Brazil encourages planning to improve the wellbeing of the urban poor. Thus policies should recognize these various land functions and formulate plans and initiatives to meet the diverse needs in a balanced, sustainable manner. Curitiba seems to have begun forging this balance as evidenced by the reduced rate of informal urbanization. Similar to what was done for this research, the implementation of programs should be monitored for reduced rates of informal urbanization and their rate of convergence in ecologically fragile and hazardous landscapes, and the extent that living conditions and quality of life improves in different neighborhoods. The monitoring would benefit from a regional focus given the tendency for informal settlement displacement.

With the use of facilitated stakeholder input , the goals and program suggestions can be culled into categories such as short term and long term; urgent and not urgent; and by degree of importance. This culling might help focus the strategy and manage the implementation of a vision. Achieving inclusive sustainable development is as much a process as it is a plan. This process should embrace needed adaptations based on experiential learning and active reflection, particularly as conflicts and challenges arise.

Overall, these recommendations emphasize ways to formulate an inclusive sustainable urban development strategy with short-term and long-term objectives. Such a strategy would more likely yield sustainable outcomes when it promotes cost effective solutions; prevents impacts to hazardous environmentally fragile landscapes; and improves water quality. In addition, this strategy should support the social integration of low-income populations as citizens deserving of equal access to affordable housing options with basic sanitation and decent living conditions, needed social services, and sustainable transport options.

### **Conclusion**

This longitudinal case study of the Metropolitan Region of Curitiba (RMC) showed distinct spatial patterns in informal urbanization that are based on rational considerations and limitations posed by the urban system. In the study area, informal settlement tended to locate in floodplains, conservation lands, and riverbanks from 1990 to 2007. In addition, the regional pattern of informal settlement growth decentralized as new settlements most commonly emerged in the urban fringe and periphery of the main city and outside of the older more established secondary urban centers. Largely, informal settlements accumulated near other informal settlements, public housing and social initiative areas, and bus service in the study area – thus several socio-economic indicators were recognized along with environmental-based indicators. The characteristics of the urban region influenced these patterns on many levels. For example, the urban region of Curitiba has many rivers and floodplains and only a small portion of karst landscapes, thus there was more informal settlement constructed alongside rivers and in floodplains. Each city context differs in the types of land left vacant and deemed low in value and undevelopable. In addition, informal settlers made

adjustments in where they occupy land according to the degree of tolerance that others bestow.

Another crucial finding was in the reduction in the amount of new land invasions from 2002 to 2007. The implementation of regularization and the government approach to affordable housing in greater Curitiba could have contributed to the reduced rate of informal urban expansion and population density increases. These public policy influences would have been felt more directly inside of Curitiba than in the surrounding urban areas given the early implementation of regularization and other social interest programs in the main urban area.

Another change in the prevailing spatial trends from 2002 to 2007 is in the decline in the rate at which informal development occurred in ecologically fragile and hazardous lands. This decline could be partially attributed to the combination of newly implemented sustainable planning laws and social interest initiatives. The sustainable planning areas (*Unidades Territoriais de Planejamento* or the Territory Units of Planning) located outside of Curitiba in the urban periphery calls for informal settlement consolidation in designated social interest areas in exchange for the conservation of ecologically valuable land. The allowance of informal urbanization in designated areas might have helped to reduce informal urbanization taking place in conservation lands from 2002 to 2007. This study showed that the prevailing pattern of urban growth in informal settlements has changed since the implementation of a more comprehensive government strategy and these policy influences should be given greater attention in future research.

Implemented jointly and effectively, the complementary interface of social interest and conservation public policies can encourage sustainable urban development. Likewise, the interface of affordable housing program provisions and social interest zoning with regularization can serve to pro-actively and reactively respond to the needs of low-income populations. The inclusion of pro-active responses to the low-income housing needs, particularly with serviced lot provisions, supports urbanization outside of ecologically fragile and hazardous land. As long as informal settlement persists in the RMC, regularization typically lessens the environmental impact and improves the housing conditions but the response is reactive in nature and fails to address the affordable housing and land supply issues adequately. In some cases, regularized housing might be surrounded by environmental hazards and this type of development could require drainage structures and modifications to the natural system.

Another consequence of the government approach was the tendency for public housing locations to be built near informal settlement or for settlers to locate near public housing. Holistically, this concentration could contribute to greater socio-economic segregation. As such, the outcomes of Curitiba's public policies should be explored further to learn how to better promote sustainable urban development and develop ways to reduce income segregation without fracturing critical social networks. In addition, further research on the policy implications outside of Curitiba, particularly related to density increase, would be useful. These findings are moderated by the uncertainties in whether all informal urban areas were captured through the identification method and by data limitations.

The implications of this research point to several research needs. A need remains to develop an approach to independently measure the strength of public policy influences of urban growth in a way that accounts for intervening variables contributing to urbanization and consolidation and density changes. Some of the intervening variables pointed out in this study that should be examined further include: the contribution of urban market dynamics pertaining to the supply of serviced land, homes, and rentals; the role of population and migration shifts in shifting housing preferences; the role of housing loans; and the influence of naturally evolving consolidation processes involved with informal settlement. These variables could be combined in a model to better understand the causes and effects of informal urban development patterns. Additionally, to differentiate between whether informal urban growth is attracted to a particular feature or whether the feature was built as a result of informal settlement, the year that the feature was developed and the date of initial informal settlement should be compared. Another research need is to explore ways to use the informal settlement data to assemble an effective disaster preparedness plan. For example, the data created through this research could be used to develop a strategy for mobilizing at-risk populations out of harm's way and it could guide educational strategies that strive to promote home construction improvements to prevent the development of hazardous, unsanitary, and unsustainable living conditions.

Largely, the research results showed several issues and socio-environmental conflicts related to informal settlement in the Metropolitan Region of Curitiba and then explored the influences of key public policies. Though any comparison to Curitiba should recognize its unique characteristics such as the region's lower amount of

informal housing compared to other Latin American urban regions and its active implementation of various planning initiatives.

As shown in this research, the sheer amount of informal settlement is astounding and reflective of a worldwide problem that should not be ignored. Urban regions that fail to address informal settlement and the low-income housing dilemma, as described herein, could confront even greater, more aggravating problems with poor water quality, infectious diseases, concentrated crime, income segregation, and un-sustainable development. In the aftermath of a natural disaster in informal urban areas, the devastation would disproportionately impact the most vulnerable sectors of the population if informal occupation in hazardous areas prolongs. The urban planning and growth management in an urban region experiencing informal settlement cannot be effectively implemented to achieve sustainable outcomes without programs that address low-income housing and informal settlement issues alongside other economic, transportation, and environmental aspects of planning. Holistically, the prevailing pattern of informal settlement largely translates into grave environmental impacts and segregated hazardous living conditions. All residents of a city should be afforded opportunities to secure decent living conditions, regardless of whether one is poor or rich. Yet in the absence of an effective government approach and viable housing options, low-income new-comers tend to occupy low-valued environmentally sensitive land. If this land-use pattern perpetuates, natural resources, particularly related to water, runs the risk of becoming polluted beyond repair. This bleak scenario should be recognized in order to gain the momentum needed to support needed strategies, exchange lessons learned from city to city, and truly realize a more sustainable future.

In summary, this research showed positive advancements on the path towards sustainable development in greater Curitiba given the increased compact urban growth, reduced informal settlement in environmentally sensitive areas, and the improvement in the lives of the urban poor who no longer live in hazardous living conditions. The government approach was more effective for managing urban growth when both reactive (regularization) and pro-active (provision of urbanized lots and availability of home loans) features were incorporated and in return, the implementation of such a balanced approach could help enforce conservation restrictions. Although the strategy in greater Curitiba is multi-faceted, it failed to de-segregate low-income populations and it may encounter problems with meeting future demands for low-income housing. Curitiba is a city proclaimed as a commendable example of urban planning. Consequently, these findings and other research should continue to evaluate promising strategies and adaptively formulate guidelines and improvements on how to develop in inclusive sustainable way even in urban regions experiencing informal settlement.

APPENDIX A  
INTERVIEW AND COMMUNITY SURVEY DOCUMENTS



PO Box 112250  
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352-392-9234 (Fax)  
irb2@ufl.edu

DATE: June 12, 2008

TO: Jennifer J. Cannon  
PO Box 115706  
Campus

FROM: Ira S. Fischler, PhD; Chair. *ISF*  
University of Florida  
Institutional Review Board 02

SUBJECT: Approval of Protocol #2008-U-0574

TITLE: Informal Settlement Urbanization: Exploring the Spatial Patterns and Public Policy Influences in the Metropolitan Region of Curitiba, Brazil during the late 20th Century and Early 21st Century

SPONSOR: None

I am pleased to advise you that the University of Florida Institutional Review Board has recommended approval of this protocol. Based on its review, the UFIRB determined that this research presents no more than minimal risk to participants. Given your protocol, it is essential that you obtain signed documentation of informed consent from each participant. Enclosed is the dated, IRB-approved informed consent to be used when recruiting participants for the research.

It is essential that each of your participants sign a copy of your approved informed consent that bears the IRB approval stamp and expiration date.

If you wish to make any changes to this protocol, *including the need to increase the number of participants authorized*, you must disclose your plans before you implement them so that the Board can assess their impact on your protocol. In addition, you must report to the Board any unexpected complications that affect your participants.

If you have not completed this protocol by June 11, 2009, please telephone our office (392-0433), and we will discuss the renewal process with you. It is important that you keep your Department Chair informed about the status of this research protocol.

ISF:dl

## Termo de Anuência

**Título:** Urbanização de ocupações irregulares: considerações sobre as influências espaciais e de políticas públicas na Região Metropolitana de Curitiba durante o fim do século XX. (IRB#)

**POR FAVOR LEIA ESTE DOCUMENTO EM SUA ÍNTEGRA ANTES DE DECIDIR PARTICIPAR DESSA PESQUISA.**

Este estudo está sendo conduzido por Jennifer Cannon, aluna de pós-graduação da Universidade da Flórida, EUA, cuja orientadora é a Dra. Joseli Macedo, professora desta mesma instituição.

**Objetivo da pesquisa:** investigar como o ambiente regulador e os paradigmas de propriedade influem em modelos de urbanização das ocupações irregulares em uma região metropolitana durante períodos de crescimento intenso até o fim do século XX.

**O que vamos pedir que você faça:** todos os participantes anuentes deverão completar um questionário assim que concordarem com os termos deste documento.

**Tempo estimado para completar o questionário:** aproximadamente 20 minutos.

**Riscos e benefícios:** não há riscos associados ao preenchimento do questionário. Não há benefícios pessoais. Benefícios indiretos incluem a sua ajuda à esta pesquisa.

**Compensação:** os participantes não serão recompensados por preencherem o questionário.

**Confidencialidade:** sua identidade permanecerá anônima. Assim que todas as respostas forem revisadas e tabuladas, seus dados pessoais serão descartados.

**Participação voluntária:** todas as participações serão voluntárias. Não há obrigações futuras para com este estudo. Você não é obrigado a responder todas as questões se não quiser.

**Direito a desistir do questionário:** você poderá desistir de preencher o questionário a qualquer momento sem nenhuma consequência.

**Resultados:** os resultados desta pesquisa serão compilados e sua conclusão será publicada como parte de uma dissertação de mestrado.

Se você tiver alguma pergunta sobre este estudo, por favor entre em contato com: Jennifer Cannon, 534 NE 7<sup>th</sup> Street Gainesville, FL USA, (352) 271-1027, [jjcannon@ufl.edu](mailto:jjcannon@ufl.edu) ou com a Dra. Joseli Macedo, Assistant Professor, Urban and Regional Planning, University of Florida, P.O. Box 115706 Gainesville, FL, USA 32611-5706, ph (352) 392-0997 ext. 461, Fax (352) 392-3308 [joseli@ufl.edu](mailto:joseli@ufl.edu)

Se você tiver alguma dúvida em relação aos seus direitos enquanto participante desta pesquisa, por favor, entre em contato com: UFIRB Office, P.O. Box 112250, University of Florida, Gainesville, FL 32611-2250; Tel: (352) 392-0433.

**Consentimento:** ao assinar este documento e completar o questionário, eu atesto que li e estou de acordo com os procedimentos descritos acima. Foi-me oferecida uma cópia deste termo de anuência para meus arquivos, e eu aceitei participar desta pesquisa voluntariamente.

Participante: \_\_\_\_\_

Data: \_\_\_\_\_

Pesquisador: \_\_\_\_\_

Approved by  
University of Florida  
Institutional Review Board 02  
Protocol # 2008-U-0574  
For Use Through 06/11/2009

**Research Survey on Informal Settlement Urbanization Patterns and their Drivers in the Metropolitan Region of Curitiba from 1991 to 2007**

*Thank you for participating in this survey. Your responses may enhance the understanding of the potentially powerful role that different public policies and other factors have on shaping the urbanization patterns of informal settlements (informal settlements are also referred to as favelas) in the greater Metropolitan region of Curitiba, Brazil. Please answer the questions honestly and to the best of your ability.*

---

- 1) How long have you lived here?
- 2) Where did you live before moving here?
- 3) What are the advantages of living here? What are the disadvantages?
- 4) Indicate your opinion on whether the following factors influence (or do not influence) the choice in a location of an informal settlement or respond with 'yes' if the factor is important and 'no' if the factor is not important.<sup>1</sup>

Factors	extremely important	very important	fairly important	somewhat important	not so important	makes no difference
a. Close proximity to family relations						
b. Close proximity to existing employment						
c. Close proximity to employment centers & opportunities						
d. Close proximity to the central city						
e. Close proximity to a bus route						
f. Area that is less noticeable to Governmental Entity						
g. Area that is more noticeable to a Governmental Entity						
h. Area near Existing Squatters						
i. Area near social services (schools)						
j. Area near infrastructure (electricity, potable water or sewage services)						
k. Area outside of floodplains						
l. Government offers titles to property						
m. Area near regularization						
n. Other:						

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<sup>1</sup> Some respondents found the ranking of importance confusing. Thus the survey was simplified and respondents were asked whether these factors were important or were not important.

- 5) What are some barriers for living near central Curitiba or Colombo?
  - 6) In your opinion, what are the main reasons for the accelerated growth of informal settlements since 1990?
  - 7) Do you any other comments about living here that you would like to share with me?
- Your participation is greatly appreciated. Another short survey is anticipated for this research. You may be contacted within a year. If interested in results of any of these surveys, please contact Jennifer Cannon at [jjcannon@ufl.edu](mailto:jjcannon@ufl.edu). Thank you!*

## **Appendix A. Community Survey Responses<sup>2</sup>**

Question 1: How long have you lived here? *(Please note that the Zumbi Settlement was thought to have experienced settlement beginning in the early 1990s.)*

- 0 to 5 years: 4 responses, 13.3 percent
- 5 to 10 years: 6 responses, 20 percent
- 10 to 15 years: 9 responses, 30 percent
- Above 15 years: 11 or 37 percent
- Average of 13.1 years

Question 2: Where did you live before moving here?

- From the interior of the state of Paraná: 7 responses, 23.3 percent
- From the RMC outside of Curitiba and Zumbi: 6 responses or 20 percent
- From Outside of the State: 5 responses, 16.67percent
- From Curitiba: 4 responses, 13.33 percent
- Lived in Zumbi most of their lives: 2 responses, 6.67 percent
- Unknown, left blank: 6 responses, 20 percent

Question 3: Advantages and disadvantages of living in an informal settlement			
Advantages		Disadvantages	
Employment/work opportunities	18.18%	No disadvantages	20.00%
Good place overall	15.15%	Violence/danger/crime	30.00%

<sup>2</sup> In addition to the author, Lianne Guerra Jepson verified and contributed to the translation of these surveys.

Near big city/downtown and everything is close	12.12%	Far from family	3.33%
Sewage system, water, basic sanitation, good infrastructure	9.09%	Many things left to do in Neighborhood (to improve the neighborhood)	3.33%
People, social action, companionship, unity of residents	9.09%	Need better infrastructure	3.33%
Easy access to bus	9.09%	Health	3.33%
Peace, tranquility	6.06%	School is far from housing	3.33%
Education/school	6.06%	Prejudice of the favela	3.33%
Far from floods	3.03%	Lack of security	3.33%
Good security	3.03%	<i>(27% had no responses)</i>	
Many legal persons	3.03%		
Health center	3.03%		
Quality of life	3.03%		

Question 4: Indicate your opinion on whether the following factors influence (or do not influence) the choice in a location of an informal settlement. Respond with 'yes' if the factor is important and 'no' if the factor is not important.

4A: Close proximity to family relations, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	22	73.3	73.3	73.3
	2	8	26.7	26.7	100
	Total	30	100	100	

4B: Close proximity to existing employment, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	20	66.7	71.4	71.4
	2	8	26.7	28.6	100
	Total	28	93.3	100	
Missing	System	2	6.7		
Total		30	100		

4C: Close proximity to employment opportunities, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	20	66.7	69	69
	2	9	30	31	100

	Total	29	96.7	100
Missing	System	1	3.3	
Total		30	100	

4D: Close proximity to the central city, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	43.3	44.8	44.8
	2	16	53.3	55.2	100
	Total	29	96.7	100	
Missing	System	1	3.3		
Total		30	100		

4E: Close proximity to a bus route, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	27	90	93.1	93.1
	2	2	6.7	6.9	100
	Total	29	96.7	100	
Missing	System	1	3.3		
Total		30	100		

4F: Area that is less noticeable to governmental entity, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	7	23.3	26.9	26.9
	2	19	63.3	73.1	100
	Total	26	86.7	100	
Missing	System	4	13.3		
Total		30	100		

4G: Area that is more noticeable to a governmental entity, yes = 1, no = 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	22	73.3	78.6	78.6
	2	6	20	21.4	100
	Total	28	93.3	100	
Missing	System	2	6.7		
Total		30	100		

4H: Area near existing irregular occupations, yes = 1, no = 2

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		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	24	80	82.8	82.8
	2	5	16.7	17.2	100
	Total	29	96.7	100	
Missing	System	1	3.3		
Total		30	100		

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4I: Area near social services (i.e. schools, daycares, health centers), yes = 1, no = 2

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		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	29	96.7	96.7	96.7
	2	1	3.3	3.3	100
	Total	30	100	100	

---

4J: Area near infrastructure (such as electricity, potable water or sewage services), yes = 1, no = 2

---

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	28	93.3	93.3	93.3
	2	2	6.7	6.7	100
	Total	30	100	100	

---

4K: Area outside of floodplains, yes = 1, no = 2

---

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	7	23.3	23.3	23.3
	2	23	76.7	76.7	100
	Total	30	100	100	

---

4L: Government offers titles to property, yes = 1, no = 2

---

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	25	83.3	89.3	89.3
	2	3	10	10.7	100
	Total	28	93.3	100	
Missing	System	2	6.7		
Total		30	100		

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4M: Within or near area with regularization, yes = 1, no = 2

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		Frequency	Percent	Valid Percent	Cumulative Percent
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Valid	1	27	90	93.1	93.1
	2	2	6.7	6.9	100
	Total	29	96.7	100	
Missing	System	1	3.3		
Total		30	100		

Question 5. What are the obstacles/barriers for living near central Curitiba or Colombo?

Response Category	Number	Percent of total
No obstacles because they don't want to live there	15	62.50%
Land is expensive	4	16.67%
Must be a trained professional	2	8.33%
More stores, shopping and recreation spaces for children that take up the space	1	4.17%
Neighborhoods in the center are more dangerous	1	4.17%
Bus delays	1	4.17%
Total Responses	24	

Question 6: In your opinion, what are the main reasons for the accelerated growth of informal settlements since 1990?

Response Category	Number of responses	Percent of total
Lack of work in the interior	4	12.50%
To find work	6	18.75%
Lack of opportunities	2	6.25%
Better Quality of Life	2	6.25%
Socio-economic factors	1	3.13%
Need for less expensive land	3	9.38%
Lack of Affordable Housing opportunities	3	9.38%
Lack of money, resources and financing	4	12.50%
Violence	1	3.13%
Conflict with land occupation	1	3.13%
Location Near family	1	3.13%
Government contributions	1	3.13%
Near bus	1	3.13%
Difficult to work in Curitiba	1	3.13%
Live near Colombo	1	3.13%

Total (There are over 30 responses since some respondents offered more than one reason.)

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32

100.00%

APPENDIX B  
SATELLITE IMAGERY DETAILS AND LAND USE LAND COVER CLASSIFICATION

Landsat TM and ETM+ satellite images used for land use land cover classification				
Type	Date	Resolution	Source	Geometric Correction
TM	9/12/1991 - Spring	TM: 30 X 30 Meter for all bands except the thermal band	Radiometrically and geometrically corrected (INPE)	20 usable Ground Control Points, total RMS error of 13.3470
ETM+	9/2/2002 - Spring	ETM+ has 15 X 15 Meter resolution for panchromatic	Radiometrically and geometrically corrected to 50 RMS error (UMGLCF)	Used this image for the geometric correction
TM	7/6/2007 - Winter	TM: 30 X 30 Meter for all bands except the thermal band	Radiometrically and geometrically corrected (INPE)	29 usable Ground Control Points, total RMS error of 9.889

Accuracy results for the 2007 land use land cover classification					
Class Name	Reference Total	Classified Total	Number Correct	Producers Accuracy	Users Accuracy
Built/Urban	305	313	291	291/305 = 95.41%	291/313 = 92.97%
Water	18	10	10	10/18 = 55.56%	10/10 = 100%
Vegetation	118	125	109	109/118 = 92.37%	109/125 = 87.2%
Bare Soil/Barren	22	15	10	10/22 = 45.45%	10/15 = 66.67%
Totals	464	464	421		

Overall classification accuracy =	90.73%	
Kappa (K <sup>^</sup> ) statistics		
Overall Kappa Statistics =	0.8092 81%	
Class	Kappa	Percentage
Built	0.7949	80%
Water	1.0	100%
Vegetation	0.8283	83%
Bare Soil/Barren	0.6501	65%

Training samples collected in 2008 and 2009

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Category	Based on Geographic Data and Field Study	Based on Geographic Data	Total for Each Category
Bare Soil	11	52	63
Vegetation	130	188	318
Irregular Land Division	1	16	17
Informal Urban	84	131	215
Regularization Areas	9	14	23
Formal Urban	218	240	458
Water	18	39	57
Total Training Samples	471	680	1151

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All of the training samples were verified based on available high-quality geographic data and geo-rectified aerial photographs. To ensure that 'pure' training samples were retrieved for each of these categories, the points were adjusted in ArcGIS and moved into the center of a patch of land cover, at least 90 square meters in size, in areas that were representative of individual categories. Areas with a mixture of land covers were designated according to the more dominate land cover. Training sample collection focused on retrieving a broad representation of built landscapes especially in the informal urban areas. Several areas were inaccessible out in the field (such as bare soil areas) and as a result aerial photographs (with a resolution greater than ten meters in accuracy) and other geospatial datasets were used as a basis for creating additional training samples.

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## BIOGRAPHICAL SKETCH

Jennifer Cannon was born in Spokane, Washington and graduated from Mead High School in 1995. She moved to Bellingham, Washington to earn a Bachelor of Arts in Environmental Policy and Planning at the Huxley College of the Environment, at Western Washington University, in 2000.

Jennifer Cannon is an urban, environmental, and community planner that has expanded her scope of work from the Pacific Northwest, to the Southeastern United States, to international planning topics. She worked as a community planner in Seattle, Washington and in this position, planned and implemented the public outreach for a range of transportation improvement and environmental cleanup projects. She then worked as a Geographic Information System analyst, environmental planner, and project manager in Gainesville, Florida before returning to academia to complete a Master of Arts in urban and regional planning and pursue certification in Latin American studies at the University of Florida. As a part of an international housing research initiative, Jennifer researched methods for quantifying housing deficits and informal housing in Brazil in a graduate student assistant position. Jennifer was a scholarship recipient for a study abroad course in Brazil, and in 2008, she was awarded a field research grant from the Latin American Studies Department.