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Urban Land Markets and Urban Land Development:

An Examination of Three Brazilian Cities: Brasília, Curitiba and Recife

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Urban Land Markets and Urban Land Development

An Examination of Three Brazilian Cities: Brasília, Curitiba and Recife

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Introduction

This paper synthesizes and extends the results of urban land market studies carried out in three Brazilian cities—Brasília, Curitiba and Recife.[1] The purpose of the studies is to empirically assess the performance of urban land markets in different cities and to gauge the feasibility of applying the Land Market Assessment methodology in Brazil.[2] The project involved the collaboration of several organizations: The World Bank, Instituto de Pesquisa Econômica Aplicada (IPEA), Secretaria de Estado de Desenvolvimento Urbano e Habitação (SEDUH), Instituto de Pesquisa e Planejamento Urbano de Curitiba (IPPUC), and Fundação de Desenvolvimento Municipal (FIDEM). The field research was carried out in 2003.

The paper is organized into seven sections. The following section provides a brief overview of urban land market research. The next section summarizes urbanization and housing markets in Brazil. The third section elaborates on the selection of the three cities and their profiles. The fourth section provides a general description of population, urban land development, and housing for the cities. Next, the paper provides a detailed spatial examination of these demographic, land use, and housing trends. The sixth section examines the effects of location, infrastructure, titling, and other factors on residential land prices. The final section outlines conclusions and policy implications.

Overview of Urban Land Markets

Urban land markets play a critical role in shaping urban development outcomes—determining the location, density, form and price of residential, commercial and industrial development. Urban land markets are driven by both demand and supply factors. On the demand side, population growth, income, and level of economic activity determine how

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[1] Three reports were issued in August 2003: *Análise do Mercado de Solo Urbano no Distrito Federal e Entorno*, *Análise do Mercado de Solo Urbano em Curitiba*, and *Análise do Mercado de Solo Urbano na Regiao Metrõpolitana do Recife*.

[2] Dowall, D. E. 1995. *The Urban Land Market Assessment: A New Tool for Urban Management*. Washington and Nairobi: The World Bank and UNCHS.

much land is demanded to support development. Urban land supply is determined by topography and physical conditions, patterns of land ownership, availability of infrastructure—roads, water, electricity—and government regulations. The interaction of urban land market demand and supply determines urban land prices. If urban land supply is very responsive to demand, land prices will tend to reflect the productive value of land. On the other hand, if urban land markets are constrained and cannot effectively respond to demand pressure, land prices will tend to be much higher—exceeding their productive value. These constraints are often the result of restrictive land use regulations, inadequate network infrastructure to support urban land development, unclear property ownership and titling records, and the actions of landowners to drive up land prices by withholding land from the market.

Over the past 40 years, an extensive literature has been produced on urban land markets in Latin America. However, this literature has been very theoretical and qualitative in style, and quantitative analysis of urban land markets is strikingly absent from this body of work. The present study, seeks to address this gap in the literature by providing a systematic quantitative assessment of urban land market performance in three Brazilian cities.

Urbanization in Brazil continues to gain momentum. Brazil's cities have grown rapidly over the past thirty years. This growth creates enormous pressure on cities to accommodate development—provision of urban services, access to land for housing, and titling and registration systems.

Profile of Urbanization and Housing Markets in Brazil

Brazil is a highly urbanized country whose urban population, already comprising a massive 81.2% of the population, continues to expand. While population growth declined from 1.93% between 1980 and 1991 to 1.63% from 1991 to 2002, the rate of urbanization continues to increase, growing at a rate of 2.45% a year. While many of Brazil's larger cities absorbed migrants throughout the twentieth century, the current trend in urbanization is marked by a growth of second-tier cities. According to Brazil's 2000 Census, 73% of Brazil's population lived in municipalities with fewer than 20,000 inhabitants.

During the 1991–2003 period, the Brazilian economy attracted foreign investment, alligned itself with transnational production chains, and strengthened its competition in world markets. The period was characterized by a reduction of growth in the global cities of Rio de Janeiro and São Paulo and the emergence of dynamic new centers such as

Fortaleza, Manaus, and Brasília-Goiânia. Urbanization in the 1990s was a result, in part, of an economic orientation to foreign markets that created a large decentralized network of "islands of productivity" (*ilhas de productividade*), dotted with strong highway and port infrastructure which only became reinforced with large foreign investment in the automotive industry and the mechanization of agriculture (IPEA et al. 2001a: 35, 38, 41, 86). While the population of São Paulo and Rio de Janeiro sluggishly grew at 1.45% and 0.77%, respectively, from 1991–1996, the population of several second-tier cities boomed. These included Cabo Frio (4.62%), Itajaí (4.54%), Petrolina/Juazeiro (4.36%), Brasília (3.64%), Curitiba (3.43%), Goiânia (3.30%), and Belém (2.39%). In several of these cities, the rate of population growth doubled in peripheral areas. For example, in Belém between 1991 and 1996 the population in the periphery grew at an explosive 19.05%; in Goiânia, it grew 7.90%, and in Brasília, 7.56% (IPEA et al. 2001a: 62-65).

Migrants to these cities confronted substantial shortages of affordable housing. According to a report by SEDU/Presidência da República and the Fundação João Pinheiro (2001), each year approximately sixty percent of the one million new families who enter the housing market are unable to pay the down payment and monthly financing payments to acquire formal housing.[3] As a result of limited financing,[4] low salaries, the overregulation of land markets, and the high cost of regulated housing, Brazil suffers from a housing deficit calculated to encompass 20 million people and 6.7 million homes. It is worth noting that the shortage is concentrated in urban areas—representing 81.3% of the deficit (SEDU/Presidência da República and Fundação João Pinheiro 2001).

Left with few housing options in the formal sector, a large number of Brazilians resort to options in informal settlements. A recent report by several Brazilian government agencies and the World Bank calculated the explosiveness of the informal housing market: the authors estimated that a staggering 65% of new homes built took place in the informal housing market[5] (Grupo de Trabalho Caixa Economia Federal, IPED, FINDIEC-

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[3] Formal housing refers to dwellings constructed in government-approved subdivisions, complying with building codes and regulations.

[4] The housing shortage is also due to the lack of public and subsidized housing. In thirty years (1964–1995), the Housing Financial System (*Sistema Financeiro de Habitação*) produced approximately 18% of the housing stock (*Grupo de Trabalho Sobre Habitação para Formular Política Nacional de Desenvolvimento Urbano para o Brasil*, 1996).

[5] The informal housing market includes *favelas*, *condomínios* and *loteamentos clandestinos*. These are units that are located in unauthorized subdivisions or buildings that do not have construction permits.

UnB, World Bank 2002). According to official estimates, 5.4 million Brazilians are either homeless or reside in inadequate, overcrowded, and often dangerous housing which often lacks basic infrastructure such as potable water and sanitation (SEDU/Presidência da República and Fundação João Pinheiro 2001).[6]

Brazilian cities vary greatly in the quality of their response to rapid urbanization and the proliferation of informal settlements. In terms of planning, according to Brazil's Census Bureau (IBGE), of a total of 5,506 municipalities in 1999, 4,444 registered multi-year investment plans, 840 were planned according to a master plan (*plano diretor*), 1,548 had urban land subdivision ordinances, and 1,187 implemented zoning laws (IBGE 2001). At the national level, in 2001 the Brazilian government reinforced planning by passing the Statute of the City (*Estatuto da Cidade*) which mandates that Brazilian municipalities over 20,000 people issue a master plan at least every five years. The Statute also provides legal support to enable municipalities to promote land tenure programs, regulates adverse possession rights, and legitimates several new urban legal instruments, such as collective land tenure and the concession of special use for housing purposes (Fernandes 2001: 19). This Statute, combined with the increased involvment in slum upgrading at the local level, has made Brazil a venue for some of the largest and most innovative slum upgrading programs in Latin America. The Interamerican Development Bank's support of the multimillion dollar *Favela Barrio* upgrading program in Rio de Janeiro and São Paulo's Guarapiranga project are but some of the many innovative planning interventions in Brazil.

City Justification and Profiles: Brasília, Curitiba, Recife

Given these trends, the study team decided to study three different cities which had experienced growth in the nineties, been impacted by global economic integration, and had responded in varying ways to the housing deficit. Another important consideration was the selection of cities from different geographic regions in Brazil and the selection of cities whose land regulations and planning differed so as to be able to evaluate how different regulations affect land markets. The team selected three cities to evaluate: Brasília, Curitiba, and Recife. The study areas of the three cities include the metropolitan areas limited by the commuting distance, defined as the distance in which a family could look for housing in the next ten years. In Recife, the study area covers 2,742 km^2, including

[6] 75% of these families have income less than three minimum monthly salaries while 46% live in northeastern Brazil.

a total population of 3.2 million in fourteen municipalities.[7] The Brasília study area is composed of the federal district and five neighboring municipalities[8] with a total population of 2.4 million (2000) and an area of 7,619.2 km^2. The area of Curitiba, comprising thirteen municipalities,[9] covers 2,082 km^2 with a population of 2.6 million (2000). A more in-depth profile of these three cities follows.

Brasília

There is no city quite like Brasília. Designed in the shape of an airplane by Lucio Costa and Oscar Niemeyer, it was inaugurated as Brazil's capital in 1960. Immediately afterwards, legislation was passed to preserve the original layout, restricting the growth of housing markets near the city center.[10] Years later in December 1987, at the request of then-Governor José Aparecido de Oliveira, Brasília's master plan was registered with UNESCO as a World Heritage site, making the area the first 20th Century monument to achieve the protection of the United Nations (Braga and Falcão 1997: 112). Due to these rigid restrictions, the subdivision of large lots, and the proliferation of condominiums, the city rapidly grew throughout the 1980s with the enlargement of the surrounding areas of Valparaiso, Novo Gama, Águas Lindas, Luziânia, and Santo Antonio do Descoberto. These areas eventually transformed from "satellite cities" or dormitory suburbs of Brasília to areas with their own economy and identity (Subsecretaria de Política Urbana e Informação and Secretaria de Estado de Desenvolvimento Urbano e Habitação 2003: 18, 31). Indeed, though Brasília was designed to be an administrative center, the city's economy today is more diverse than imagined: the administrative sector only accounts for 20.9% of all employment (IPEA et al. 2001a).

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[7] The fourteen municipalities include Recife, Olinda, Paulista, Abreu e Lima, Igarassu, Itamaracá, Itapissuma, Araçoiaba, São Lourenço da Mata, Moreno, Camaragibe, Jaboatão dos Guararapes, Cabo de Santo Agostinho, and Ipojuca.

[8] These include the municipalities of Aguas Lindas de Goiás, Santo Antônio do Descoberto, Cidade Ocidental, Valparaíso, and Novo Gama.

[9] Besides the municipality of Curitiba, the area includes Araucária, Fazenda Rio Grande, São José dos Pinhais, Pinhais, Piraquara, Colombo, Almirante Tamandaré, Campo Magro, and four municipalities of prospective habitation in the next ten years: Campina Grande do Sul, Quatro Barras, Campo Largo and Mandirituba.

[10] In 1960, Article 38 of Law n. 3.715 (the Santiago Dantas Law) stated that, "any change in the Plano Piloto [master plan], which determines the urban layout of Brasília, is dependent upon Federal Law."

The restriction of land markets engendered perverse effects on the spatial distribution of the city's inhabitants. In 1991, 90% of homeowners who earned less than the minimum salary lived outside of Brasília in one of the "satellite cities," while 57% of homeowners who earned more than ten minimum salaries resided within the original layout of Brasília (*Plano Piloto*). As only one-fourth of residents live within the *Plano Piloto* and 70% of formal jobs are located there, low-income and middle-income residents are forced to live 12–76 kilometers from their workplace and suffer some of the highest transportation costs in all of Brazil (IPEA et al. 2001a). During the 1990s, Brasília began to seriously address the problems affecting low- and middle-income residents of peripheral areas. Between 1987 and 1994, the local government implemented the Housing Program for Low Income Settlements of the Federal District (*Programa Habitacional de Assentamentos de Baixa Renda do Distrito Federal*) which sought to relocate families from irregular settlements to nearby formalized housing with access to the electrical grid and sewerage. In eight years (1987–1995), 109,128 lots were created for low-income families, benefitting a population of over 600,000 inhabitants. From 1995–2000, the federal district implemented various specialized slum upgrading programs through such programs as *Programa Habitacional de Assentamento para População de Baixa Renda, Pró-Moradia, Endereço Limpo Legal, and Habitar Brasil*. Nevertheless, these programs—consisting of the extension of water and sanitation infrastructure and the construction of semi-urban lots in Recanto das Emas, Santa Maria, Privê, and Lucena Roriz—were inadequate in assisting a significant number of residents. Together they benefitted only 12,402 families (IPEA et al. 2001c: 124).

Curitiba

Curitiba, capital of the state of Paraná, is a leader in municipal planning in Latin America lauded for its rapid bus lines and progressive land use planning. Through measures adopted throughout the 1970s and 1980s, the city induced its population to reside near public transit lines and created several social programs that were espoused by its famed mayor, Jaime Lerner. More recently, Curitiba has benefitted from a massive level of investment, especially from multinational corporations. With the liberalization of Brazil's economy, the Curitiba Metropolitan Agglomeration (AMC) has benefitted from the spill-over growth and industrial deconcentration of nearby São Paulo since 1993. The AMC became one of the most important centers for the automotive industry, biotechnology, oil refining, commerce and services, chemical production, and metals. The most significant investments between 1996 and 1998

included Renault (US$1 billion), Audi/Volkswagen (US$800 million), BMW/Chrysler (US$500 million), the chemical company of Petrobrás – Repar (US$500 million), the ceramic tile company Incepa (US$200), and the telecommunications firm, Telepar (US$200 million). Curitiba's high quality of life combined with its robust economic growth have attracted thousands of Brazilians to the city, making it one of the fastest growing cities in the country. The city's population grew at 3.03% and 3.44% from the periods of 1980–1991 and 1991–1996, respectively (IPEA et al. 2001a: 103–104, 360).

Unfortunately, Curitiba was not prepared to deal with this explosive level of urbanization. The accelerated growth led to the population of peripheral areas lacking adequate infrastructure. Since 1992, informal settlements have grown in several infrastructurally inadequate areas of the AMC, like water basins and public property. To deal with informal housing, the government implemented two main projects: *Lote Fácil* and *Lote Legal*. *Lote Fácil* consisted of the integration of informal lots through urban design and land use parameters established by the Instituto de Pesquisa e Planejamento de Curitiba (IPPUC). Complementing this program, *Lote Legal* seeks to regularize informal settlements and relocate at-risk residents to urbanized lots by reconstructing their homes and assisting them both psychologically and technically during the relocation process (IPEA et al. 2001a: 124, 169, 173–175).

Recife

Historically Recife, as with many urban centers in the northeast, has had some of the highest rates of inequality in Brazil. On one hand, the region maintains a dynamic services sector (finance, software development, consulting, marketing, insurance, and advertising) that responds to the demand from markets in NAFTA, the EEC, and other centers in northeast Brazil, such as Salvador and Fortaleza (IPEA et al. 2001b: 142).[11] On the other hand, the city has one of the highest rates of poverty in Brazil and many of its residents live without basic services. Approximately 37.3% of individuals in 2000 earned less than the monthly minimum wage, compared to the national average of 33.5% (Fundação de Desenvolvimento Municipal 2003: 26-27). The housing deficit in Recife is equally disturbing, estimated at 122,000 homes in 2000 (ibid.).

[11] The GDP of Pernambuco State was estimated at 17% of the GDP of the northeast and represents 2.3% of Brazil's GNP. According to data from IBGE (2000), Pernambuco's GDP is composed of agriculture (8.49%), industry (31.19%), and services (60.32%) (IPEA et al. 2001b: 142).

Recife has a solid tradition in designing instruments for urban land tenure. To provide access to affordable land for the city's growing poor population, in 1987 the city passed law nº 14.947/97 which instituted an innovative land titling program known as the Plan of Regularization of Zones of Special Interest (*Plano de Regularização de Zonas Especiais de Interesse Social, PREZEIS*). This pioneering program gives *favela* residents security of tenure, the right to receive infrastructure and government services, and allows them to participate in decision-making at the neighborhood and city levels.[12] According to the IPEA et al. study of Recife (2001b), the local government designated 65 areas as zones of special interest (ZEIS), corresponding to 200 *favelas* and including approximately 300,000 people.

Brasília, Curitiba and Recife: Population, Urban Land Development, Gross Population Density, and Housing

The three cities represent a wide variation of urbanization and development. Total population for the year 2000 ranges from 2.4 million for Brasília, to 2.6 million for Curitiba, to 3.3 million for Recife. Brasília has the fastest rate of population growth, a compound annual average increase of 4.7%. Recife is the slowest growing at 1.5%. Curitiba is growing at 2.7% per year. In absolute terms, all three cities add a significant number of people to their population base each year. Brasília adds over 90,000 persons per year, Curitiba adds over 60,000, and Recife adds nearly 47,000 persons per year (see Table 1).

The total land area of the three cities ranges from 208,159 hectares for Curitiba, to 276,143 hectares for Recife, to 612,376 hectares for Brasília. In all three cities, the total amount of urbanized land area ranges from 109,629 hectares for Curitiba, to 61,648 hectares for Brasília, to 37,669 for Recife. In terms of the proportion of total land area that is urbanized, Curitiba is the most urbanized, with 52.7% of its total land area developed. In Recife, 13.6% of its total land area is urbanized. Brasília is the least urbanized, with 10.1% of its land area urbanized. These ranges reflect the geographic scope of each city's administrative area. Brasília, as a federal district, has a large administrative area. Recife and Curitiba are considerably smaller. Substantial urban land development took place in these three cities between 1991 and 2000. During this nine-year period, Brasília, Curitiba and Recife converted 6,110, 19,970 and 21,435 hectares, respectively (see Table 2).

[12] For a deeper discussion of the impact of PREZEIS, see Souza (2001).

Table 1. Population Growth Trends in Brasília, Curitiba, and Recife Metropolitan Regions, 1991–2000

CITY	POPULATION		ABSOLUTE INCREASE	ANNUAL AVERAGE INCREASE	COMPOUND ANNUAL GROWTH RATE (%)
	1991	2000			
Brasília	1,592,000	2,403,000	811,000	90,100	4.7
Curitiba	2,051,000	2,594,000	543,000	60,300	2.7
Recife	2,917,000	3,339,000	422,000	46,900	1.5

Table 2. Total Land Area and Urbanized Land Areas in Brasília, Curitiba, and Recife Metropolitan Regions, 1991–2000

CITY	TOTAL LAND AREA (HECTARES)	URBANIZED LAND DEVELOPMENT (HECTARES)				ABSOLUTE INCREASE 1991–2000	ANNUAL AVERAGE INCREASE	COMPOUND ANNUAL GROWTH RATE (%)
		1991 Urbanized Land (hectares)	1991 % of Total Land Area Urbanized	2000 Urbanized Land (hectares)	2000 Percent of Total Land Area Urbanized			
Brasília	612,276	40,213	6.6	61,648	10.1	21,435	3,573	7.4
Curitiba	208,159	89,659	43.1	109,629	52.7	19,970	2,219	2.3
Recife	276,143	31,559	11.4	37,669	13.6	6,110	679	2.0

Comparing urban land conversion trends with changes in population provides a rough assessment of the overall efficiency of urban land use. Table 3 presents changes in population, urban land use and average and marginal rates of change in population density. The differences across the three cities are striking. In the case of Recife, population densities are relatively high—ranging from 89 to 92 persons per hectare of urbanized land for 1991 and 2000. Densities in Brasília are considerably lower, averaging 39 persons per hectare of urbanized land for both 1991 and 1997. Curitiba has the lowest population density, ranging from 23 to 24 persons per hectare of urbanized land for 1991 and 2000.

The marginal rates of change in density compare the changes in population relative to changes in urban land use. In the case of Brasília, the marginal rate of change of 38 persons per hectare is very close to the

average and therefore results in a stable pattern of population density between 1991 and 1997. In the case of Recife, where the 1991 population density is relatively high at 92 persons per hectare, the marginal rate of change is lower—69 persons per hectare. This results in a decline in the average rate of population density between 1991 and 2000. In low density Curitiba, the marginal rate of change in the population density is higher than the 1991 average—27 persons per hectare and leads to an increase in average population density between 1991 and 2000.

These population density patterns have important implications for how much land will be needed to support future population growth in each city. For example, in Recife, an increase of 10,000 persons will likely result in a 145-hectare increase in urban land development. In Brasília, the same 10,000-person increase translates into an increase in urban development of 265 hectares. In Curitiba, the same 10,000 increase in population leads to an increase of 368 hectares, more than twice the amount of land required in Recife and 39% more than required in Brasília.

Table 3. Trends in Population and Urban Land Development in Brasília (1991–2000), Curitiba (1991–2000), and Recife (1991–2000)*

CITY	YEAR	POPULATION	URBAN LAND USE (HECTARES)	GROSS POPULATION DENSITY/ URBANIZED HECTARE	MARGINAL CHANGE IN POPULATION DIVIDED BY MARGINAL CHANGE IN URBAN LAND USE, 1991–2001
Brasília	1991	1,592,000	40,213	39.54	37.8
Brasília	2000	2,403,000	61,648	39.00	
Curitiba	1991	2,051,000	89,659	22.9	27.2
Curitiba	2000	2,594,000	109,629	23.7	
Recife	1991	2,917,000	31,559	92.4	69.1
Recife	2000	3,339,000	37,669	88.6	

* The study relies on Brasília population data from 2000 and urban land use data from satellite maps taken in 1997.

Although there is no optimal gross population density for urban development, it is useful to compare population density patterns of Brasília, Curitiba, and Recife with other Latin American cities. Table 4 provides estimates of gross population density for other cities in Latin America. Density patterns of Latin American cities indicate that overall gross population densities range from 34.6 to 101 persons per hectare. With the exception of Curitiba, this range tends to include the population densities for Recife and Brasília. In the case of Brasília, the large land area of the federal district tends to reduce overall gross densities. However, in the case of Curitiba, the gross density seems low in comparison to other Latin American cities.

Table 4. Population, Land Area and Density, Selected Latin American Cities, 1990

CITY	POPULATION	LAND AREA (HECTARES)	GROSS POPULATION DENSITY (PERSONS PER HECTARE)	SOURCE
Bogota	5,484,200	158,700	34.6	Brinkhoff, 2003
Buenos Aires	7,974,000	115,700	68.9	Bertaud, 2004
Caracas	1,822,465	43,300	42.1	Brinkhoff, 2003
Mexico City	8,235,700	149,900	54.9	Brinkhoff, 2003
Rio de Janeiro	5,480,800	54,265	101.0	Bertaud, 2004
Santiago	4,518,100	55,700	81.1	Simmonds and Hack, 2000
Sao Paulo	15,416,400	203,800	75.7	Simmonds and Hack, 2000

Sources: http://alain-bertaud.com; Thomas Brinkhoff, http://www.citypopulation.de/index.html; and Roger Simmonds and Gary Hack, Global City Regions: Their Emerging Forms, London: Spon, 2000.

Table 5. Population Distribution, by Distance from the City Center 1991–2000

DISTANCE FROM CITY CENTER (KM)	BRASÍLIA		CURITIBA		RECIFE	
	1991	2000	1991	2000	1991	2000
0–5	222,270 (0.140)	225,286 (0.094)	705,951 (0.344)	727,301 (0.280)	484,567 (0.166)	497,915 (0.149)
6–10	140,814 (0.088)	170,765 (0.071)	820,392 (0.400)	963,860 (0.372)	1,073,322 (0.368)	1,182,787 (0.354)
11–20	340,707 (0.214)	480,534 (0.20)	447,116 (0.218)	749,328 (0.289)	1,019,329 (0.349)	1,237,991 (0.371)
21–30	618,958 (0.389)	793,832 (0.330)	968,232 (0.472)	1,649,296 (0.636)	152,280 (0.052)	192,238 (0.058)
Over 30	269,016 (0.169)	732,423 (0.305)	3,334 (0.002)	3,334 (0.001)	187,685 (0.064)	228,034 (0.068)
Total	1,591,765 (1.000)	2,402,840 (1.000)	2,050,792 (1.000)	2,594,464 (1.000)	2,917,183 (1.000)	3,338,965 (1.000)

Population Density Gradients

Another method for comparing population density is to examine population density gradients. The density gradient measures the relationship between population density and distance from the city center. Normally, as cities expand, population density gradients "flatten out" as people move to suburban rings of the metropolitan area to find housing (Mills 1972). This flattening out is the result of two changes in the gradient—first, the population at the center declines, and second, there is a decline in the rate at which population density falls with distance from the city center. Empirical research has shown that the following simple exponential function provides a reasonable basis for describing the pattern of declining population density in metropolitan areas:

$$D_x = D_0 e^{-gx}$$

where D_x is the population density at x kilometers from the city center, D_0 is the population density at the center of the city, and g is a population density gradient parameter to be estimated from the data.

Table 6 presents the results of separate regression models estimating the population density gradients for Brasília, Curitiba and Recife. The gradients for Curitiba and Recife take the expected form—a large value for D_0 and a negative value for the gradient (g). Although the regression models are statistically weak, Brasília, on the other hand, does not reflect the population density pattern found in market-based cities. It looks more like the population density gradients found in former socialist cities—Moscow, St. Petersburg, and Warsaw during the 1970s and 1980s—reflecting policies to disburse housing to areas outside the DF (Bertaud and Renaud 1997).

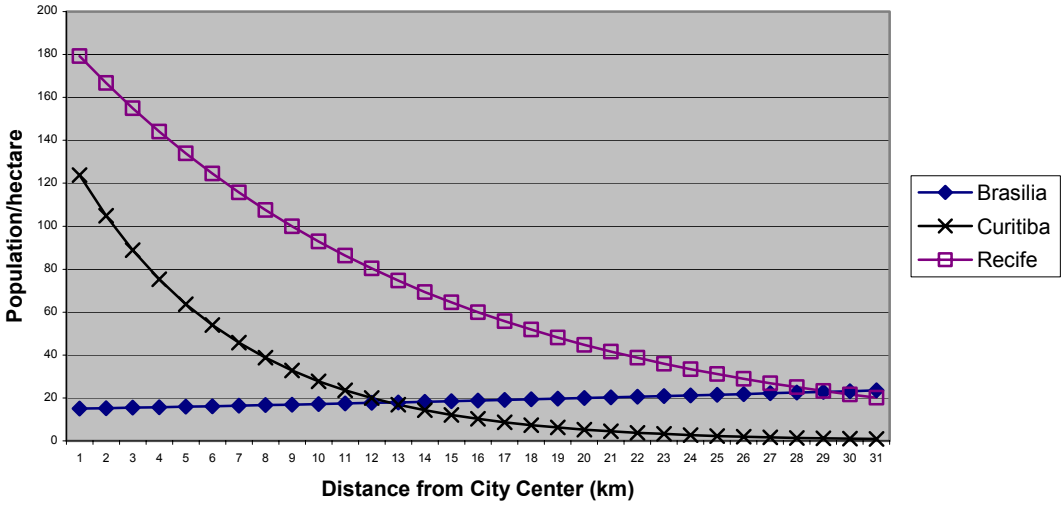
Figure 1 illustrates the population density functions for the three cities for the year 2000. Recife's gradient has the highest intercept, at 165 persons per hectare, and has a relatively flat but negative gradient of -7.3%, indicating that its population density declines at 7.3% per kilometer. Curitiba, has a lower intercept value—124 persons per hectare—and a steeper negative gradient of -16.6%. This is interesting since Curitiba is regarded as having a very efficient transportation system—suggesting that its gradient should be flatter. However, incomes and wages in Curitiba are higher than in Recife and therefore travel time costs are higher.

Table 6. Population Density Gradients: Brasília, Curitiba and Recife, 1991 and 2000

CITY	YEAR	INTERCEPT (D_0)*	GRADIENT (g)	R^2
Brasília	1991	4.39 (2.642)	+.054 (2.186)	0.062
Brasília	2000	15.00 (6.727)	+.015 (.115)	0.000
Curitiba	1991	140.33 (31.030)	-.201 (-17.186)	0.690
Curitiba	2000	123.84 (30.678)	-.166 (-14.395)	0.606
Recife	1991	164.84 (42.637)	-.076 (-10.833)	0.317
Recife	2000	179.29 (45.872)	-.073 (11.006)	0.324

* Density in persons per hectare. T-statistics in parentheses.

Figure 1. Population Density Gradients: Brasília, Curitiba, and Recife, 2000



Brasília's very low population density intercept of 15 persons per hectare reflects the fact that the center of Brasília is comprised of nonresidential activities and open spaces. Its density gradient is positive, indicating that population density increases with distance from the center. Formal residential areas are located outside the central city area, and informal residential developments are located well beyond the capital's center.

Housing Stock Trends in the Three Cities

During the 1990s, all three cities produced substantial housing units (see Table 7). In order to tentatively gauge the size of the housing stock—both informal and formal—the study relies on two sources of data: (1) the IBGE 1991 and 2000 Censuses and (2) detailed local studies on estimations of the housing sector in the three cities.[13] According to local

[13] In Brasília, local housing data was provided by maps and studies from the *Secretaria de Estado de Desenvolvimento Urbano e Habitação* (SEDUH) and through information contained in the master plans (*planos diretores*) of surrounding municipalities. The local sources for Recife included two studies from FIDEM: *Estudo sobre a caracterização da Pobreza Urbana na RMR – PROMETRÓPOLE* (2000), which identified the location and size of Recife's informal settlements, and the *Projeto do Mercado Imobiliário Informal* (2002), which outlined the boundaries of lots in Recife. In Curitiba, the study team relied on sources from a variety of institutions including property tax registries (*imposto predial e territorial urbano* [IPTU]), data on property transactions collected by the *Sindicato da Habitação do Paraná* (SECOVI), land market data from the *Instituto de Pesquisa e Planejamento Urbano de Curitiba* (IPPUC), materials from municipalities surrounding Curitiba, and regional data from the *Coordenação da Região Metropolitana de Curitiba* (COMEC).

estimates, Brasília added 167,682 units between 1991 and 2000—a 46.8% increase. In Curitiba, the housing stock increased by 199,655 units between 1991 and 2000—a 37.4% increase. In Recife, the housing stock grew by 35.1% between 1991 and 2000, registering a 234,240 unit increase. With the exception of Brasília, housing stock growth rates substantially exceeded the rate of increase in the population (see Tables 1 and 7). It is common for the housing stock to grow at a faster pace than population when household size is falling and when the housing market is responding to a backlog of unmet demand. In the long run housing stock growth should closely match the rate of increase in household formation.

In Brazil, as in other countries, it is useful to differentiate between formally and informally provided housing. Formal provision refers to housing development that is located on legally subdivided and permitted land, where there is clear title to properties. The design of the subdivision and the housing units follows all government regulations and standards. Informal housing, on the other hand, refers to housing development that does not follow government regulations and standards and is frequently on lands that are illegally subdivided or occupied. Table 8 provides a breakdown of housing production for the three cities into formal and informal categories.

Table 7. Housing Growth Trends in Brasília, Curitiba and Recife Metropolitan Regions, 1991–2000

CITY	HOUSING UNITS		ABSOLUTE INCREASE	ANNUAL AVERAGE INCREASE	COMPOUND ANNUAL GROWTH RATE (%)
	1991	2000			
Brasília	357,639	525,321	167,682	18,631	4.4
Curitiba	533,172	732,827	199,655	22,184	3.6
Recife	668,299	902,539	234,240	26,027	3.4

Table 8. Formal and Informal Housing Stock in Brasília, Curitiba, and Recife Metropolitan Regions, 1991–2000

BRASÍLIA				
TYPE OF HOUSING	**1991**	**% SHARE**	**2000**	**% SHARE**
Formal	351,803	98.4	482,189	91.8
Informal	5,836	1.6	43,132	8.2
Total	357,639	100.0	525,321	100.0

CURITIBA				
TYPE OF HOUSING	**1991**	**% SHARE**	**2000**	**% SHARE**
Formal	499,062	93.6	684,891	93.5
Informal	34,110	6.4	47,936	6.5
Total	533,172	100.0	732,827	100.0

RECIFE				
TYPE OF HOUSING	**1991***	**% SHARE**	**2000**	**% SHARE**
Formal	-	-	667,818	74.0
Informal	-	-	234,721	26.0
Total	-	-	902,539	100.0

* The absence of data for 1991 is explained by the city's absence of a cadastre for the metropolitan area. In the mid 1990s, a modernized cadastre was developed, which was used to calculate the 2000 data. Flávio de Souza, of the Department of Architecture and Urbanism of the Universidade Federal de Alagoas, cited research from a 1993 study by the *Secretaria do Planejamento e Meio Ambiente* calculating that 30.6% of the housing stock in Recife was informal (SEPLAN-PCR 1993; cited in Souza 2001).

Formal housing makes up the majority of the housing stock in the three cities, ranging from 92% of the stock in Brasília, to 94% in Curitiba, and 74% in Recife as of 2000. However, in the case of Brasília and Curitiba, there is evidence that the portion of informally produced housing is increasing. Informal housing production in Brasília increased by

639.1% between 1991 and 2000, a compound annual increase of 22.9% (versus 3.6% per year for formal housing). This dramatic difference in growth rates drove up the portion of total informal housing stock—from 1.6% in 1991 to 8.2% in 2000.

In Curitiba, the pattern is similar. Between 1991 and 2000, the informal housing stock increased by 205%, a compound annual increase of 8.3%. Formal housing stock increased by 87.5%, a compound annual increase of 7.2%. As a result, Curitiba's share of informal housing increased from 7.4% to 1.5% over the 1991–2000 period.

A Closer Look: Spatial Patterns of Population, Urban Development, Population Density and Housing in the Three Cities

In this section, we examine the spatial structure of the three cities, looking at the distribution of population, the compactness of urban land development in terms of population and housing, and urban land use. Examination of the spatial distribution of population in the three cities provides the opportunity to compare and contrast the overall compactness of urban development. We measure compactness by calculating the cumulative percentage of total population located within specific radii of the city center. Compactness will change over time depending on the spatial distribution of residential development taking place between 1991 and 2000.

Tables 9, 10 and 11 and Figures 2, 3, and 4 array the spatial distribution of population for the three cities for 1991, 2000 and change between 1991–2000 according to seven distance bands, expressed in terms of distance (kilometers) from the city center. In order to foster comparison, the bands are defined to reflect the overall spatial distribution of the three cities.

Table 9. Spatial Distribution of Population: Brasília, Curitiba and Recife, 1991

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	POPULATION	% OF TOTAL	POPULATION	% OF TOTAL	POPULATION	% OF TOTAL
0–5	4,525	0.3	466,467	22.7	335,685	11.5
5.1–10	118,395	8.9	963,747	47.0	106,250	36.7
10.1–15	114,125	8.6	269,572	13.2	740,296	25.4
15.1–20	214,030	16.1	174,146	8.5	372,413	12.8
20.1–25	275,331	20.7	57,633	2.8	151,707	5.2
25.1–30	357,021	26.8	106,449	5.2	601,47	2.1
30+	248,991	18.7	12,780	0.6	187,685	6.4
Total	1,332,418	100.0	2,050,792	100.0	2,917,183	100.0

Figure 2. Spatial Distribution of Population: Brasília, Curitiba and Recife, 1991

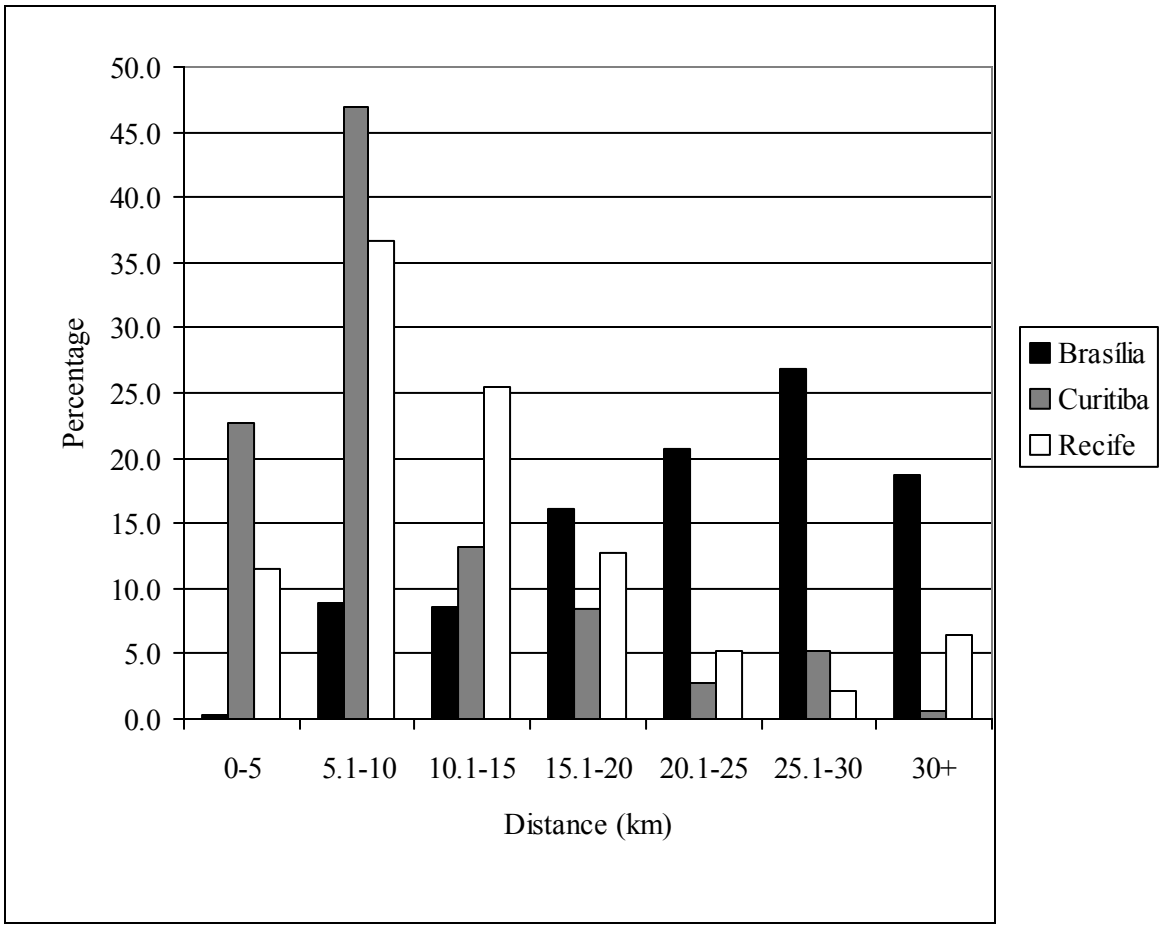


Table 10. Spatial Distribution of Population: Brasília, Curitiba and Recife, 2000

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	POPULATION	% OF TOTAL	POPULATION	% OF TOTAL	POPULATION	% OF TOTAL
0–5	6039	0.3	480,872	18.5	344,205	10.3
5.1–10	152,212	7.4	1,051,713	40.5	1146,924	34.3
10.1–15	140,754	6.8	422,786	16.3	869,114	26.0
15.1–20	334,091	16.5	296,169	11.4	488,738	14.6
20.1–25	319,336	15.5	120,767	4.7	183,384	5.5
25.1–30	497,216	24.2	193,643	7.5	78,566	2.4
30+	607,222	29.4	28,513	1.1	228,034	6.8
Total	2,056,870	100.0	2,594,464	100.0	3,338,965	100.0

Figure 3. Spatial Distribution of Population: Brasília, Curitiba and Recife, 2000

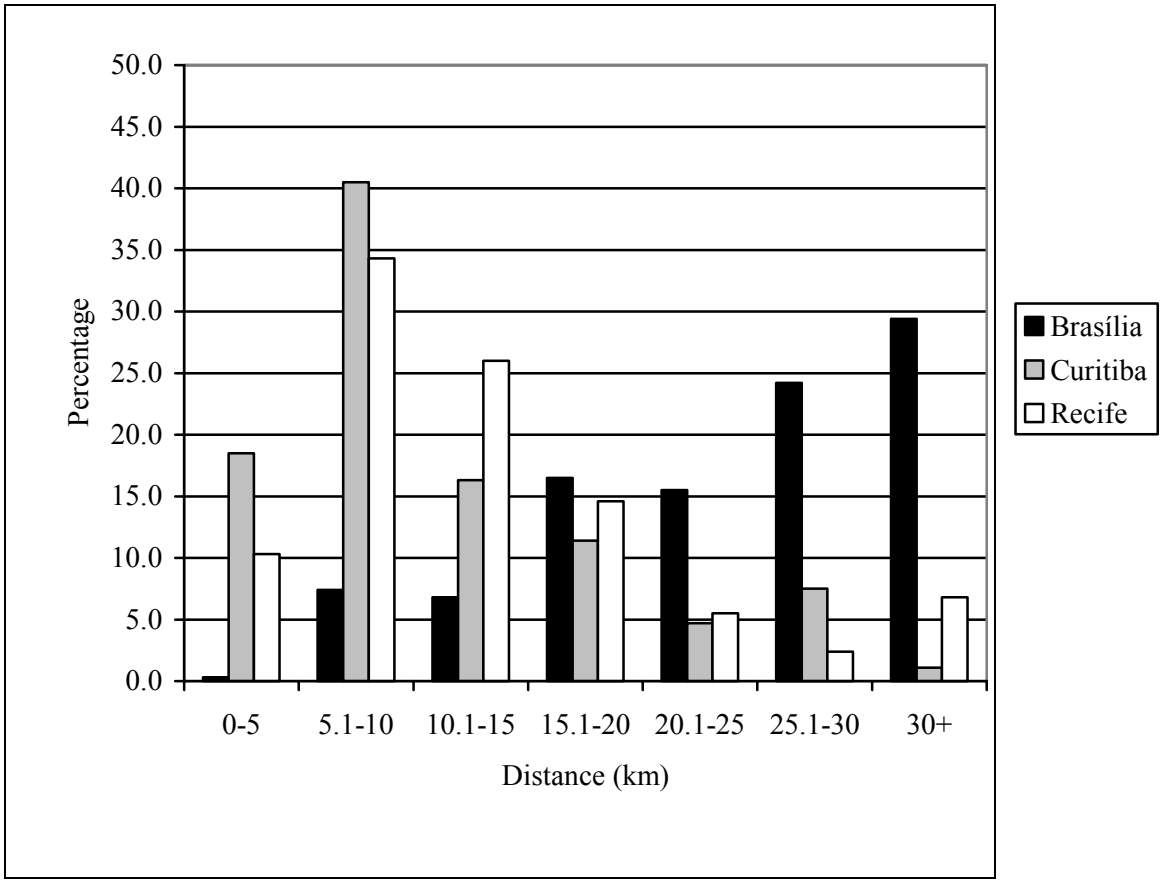
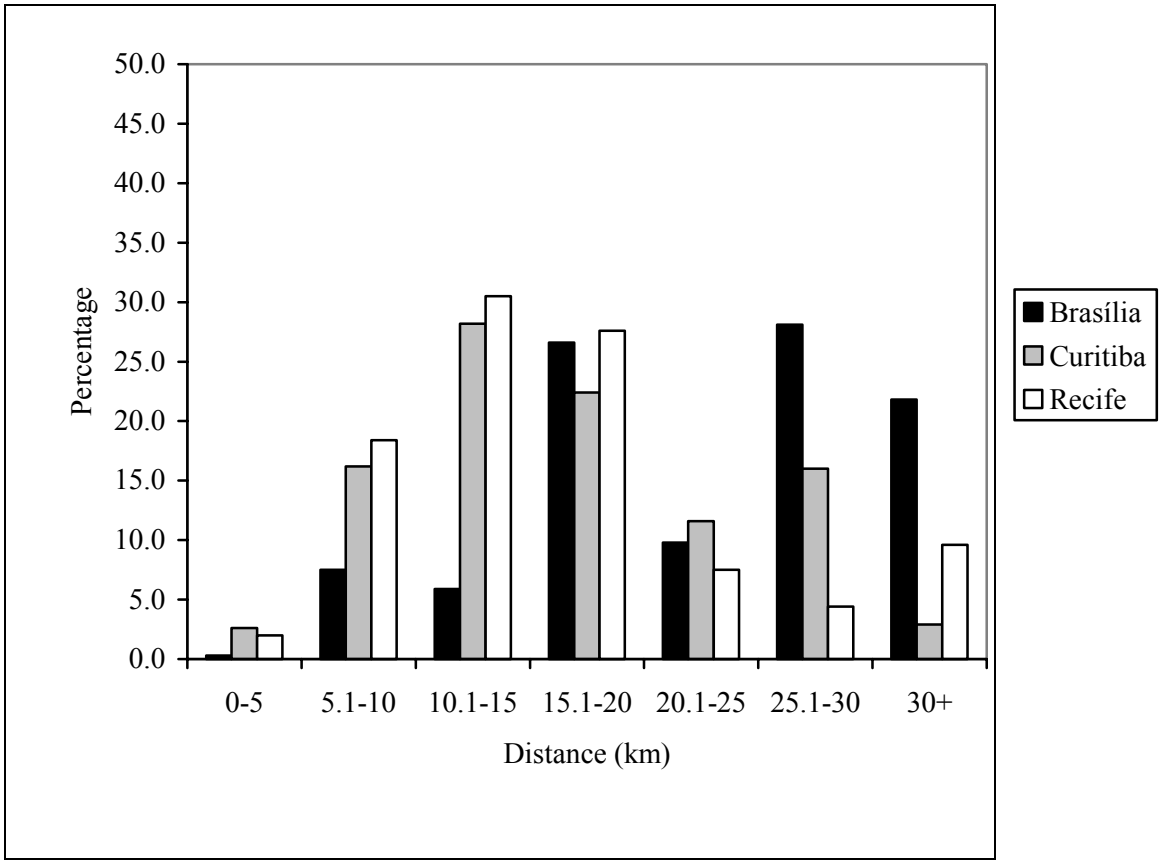


Table 11. Spatial Distribution of Population Change: Brasília, Curitiba and Recife, 1991–2000

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	POPULATION CHANGE	% OF TOTAL CHANGE	POPULATION CHANGE	% OF TOTAL CHANGE	POPULATION CHANGE	% OF TOTAL CHANGE
0–5	1,514	0.3	14,405	2.6	8,520	2.0
5.1–10	33,817	7.5	87,966	16.2	77,674	18.4
10.1–15	26,629	5.9	153,214	28.2	128,818	30.5
15.1–20	120,061	26.6	122,023	22.4	116,325	27.6
20.1–25	44,005	9.8	63,135	11.6	31,677	7.5
25.1–30	126,885	28.1	87,195	16.0	18,419	4.4
30+	98,286	21.8	15,733	2.9	40,349	9.6
Total	451,197	100.0	543,672	100.0	421,782	100.0

Figure 4. Spatial Distribution of Population Change: Brasília, Curitiba and Recife, 1991–2000



Comparison of the spatial distribution of 1991 and 2000 population and the change in population between 1991 and 2000 reveals several interesting results. The first and most dramatic finding is that Brasília's population is distributed quite differently than Curitiba's and Recife's—most of its population is concentrated far from the city center. In 1991, over half (53.6%) of Brasília's metropolitan population was located more than 25 kilometers from the city. By 2000, the percentage had declined somewhat, to 50%, but still remained distinctly different from the spatial patterns in the other two cities. The percentage of population located within 10 kilometers of Brasília's center averaged about 8% for both 1991 and 2000.

In sharp contrast, in 1991 nearly 70% of Curitiba's population resided within 10 kilometers of the city center. By 2000, Curitiba's population had begun to decentralize and 58.5% of the total metropolitan population was located within 10 kilometers of the center. Peripheral population in Curitiba was low in comparison to Brasília—less than 6% in 1991 and less than 9% in 2000 of the total population residing more than 25 kilometers from the central city.

In Recife, the patterns are similar. In 1991, over 48% of the population resided within 10 kilometers of the city center. In 2000, the portion was 44%. Recife's peripheral population was about the same as Curitiba's and well below that of Brasília. In 1991, 8.5% lived more than 25 kilometers from the city center. In 2000, the figure increased to 9.2%.

The spatial distribution of population in the three cities between 1991 and 2000 largely reflected the baseline spatial structure of 1991. In Brasília, about half of the population growth took place in areas more than 25 kilometers from the center. It is significant to note that approximately 27% of the population change took place in the distance band of 20.1–25 kilometers—reflecting the growth in the area northeast of the city center. This decentralized, sprawling pattern of population change suggests that planning restrictions and government ownership of land introduces profound distortions into the urban land market. Since development is blocked in areas adjacent to the city center, residential growth is forced to the periphery.

In Curitiba, population growth moved out beyond 10 kilometers from the city center. Between 1991 and 2000, nearly half of the increase took place in areas between 10 and 20 kilometers from the city. This suggests that Curitiba has been relatively successful in achieving compact development—channeling growth into areas that are contiguous to existing urban areas.

In Recife, approximately 58% of the increase in population between 1991 and 2000 occurred between 10.1 and 20.1 kilometers from the city center. Like Curitiba, Recife's growth has been compact, moving out beyond the densely developed core.

Tables 12, 13 and 14 and Figures 5, 6 and 7 provide breakdowns of developed urban land for the three cities for 1991, 1997, 2000 and change in urban developed land between 1991 and 1997/2000. In the core of Brasília (within 5 kilometers), less than 10% of the total urban land area is developed.[14] In contrast, over 90% of the land in the core of Curitiba is developed. In Recife, the portion is nearly 40%. (About half of Recife's core, however, is in the ocean; thus, about 80% of its developable core is urbanized.) Over the 1991 to 1997/2000 period, very little additional land was urbanized. In Brasília, net new urban development in the core—conversion of vacant land to urban uses—is effectively zero (1 hectare). In Curitiba, net urban development in the core increased by 14 hectares, and in Recife, was the greatest increase at 48 hectares.

As far as urban land development beyond the core, Curitiba's and Recife's urban development is concentrated in the 10- to 25-kilometer bands. Between 1991 and 2000, 81% of Curitiba's change in developed, urbanized land was located in this 10–25 kilometer band. In Recife, 73% was similarly located. In contrast, in Brasília, less than 50% was located within 10 to 25 kilometers. In fact, approximately 53% of urban land development in Brasília between 1991 and 1997 took place beyond 25 kilometers from the city center—suggesting that Brasília is sprawling.

What are the implications of these alternative forms of urban land development in the three cities? There are three important issues that emerge from our comparison. First, cities that sprawl—such as Brasília—consume more land per person than those that develop compactly. Brasília developed 19,620 hectares of land to accommodate 811,000 persons—24 hectares per 1,000 additional persons. In contrast, Recife developed 6,738 hectares of land to accommodate 422,000 additional persons—16 hectares of land per 1,000 persons. However, Curitiba developed 19,220 hectares of land to accommodate 543,000 additional persons—35 hectares of land per 1,000 persons suggesting that Curitiba experienced substantial low-density development.

[14] The total area of the core is 7,850 hectares—π*radius^2.

Table 12. Spatial Distribution of Urban Land Development: Brasília, Curitiba and Recife, 1991

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL
0–5	733	2.2	7,232	8.1	3,086	9.8
5.1–10	8,743	26.0	20,321	22.7	8,983	28.5
10.1–15	5,707	17.0	19,260	21.5	6,854	21.7
15.1–20	6,929	20.6	21,594	24.1	5,057	16.0
20.1–25	2,659	7.9	10,049	11.2	2,921	9.3
25.1–30	3,752	11.1	9,909	1.1	1,414	4.5
30+	5,144	15.3	1294	1.4	3,244	10.3
Total	33,666	100.0	89,659	100.0	31,559	100.0

Figure 5. Spatial Distribution of Urban Land Development: Brasília, Curitiba and Recife, 1991

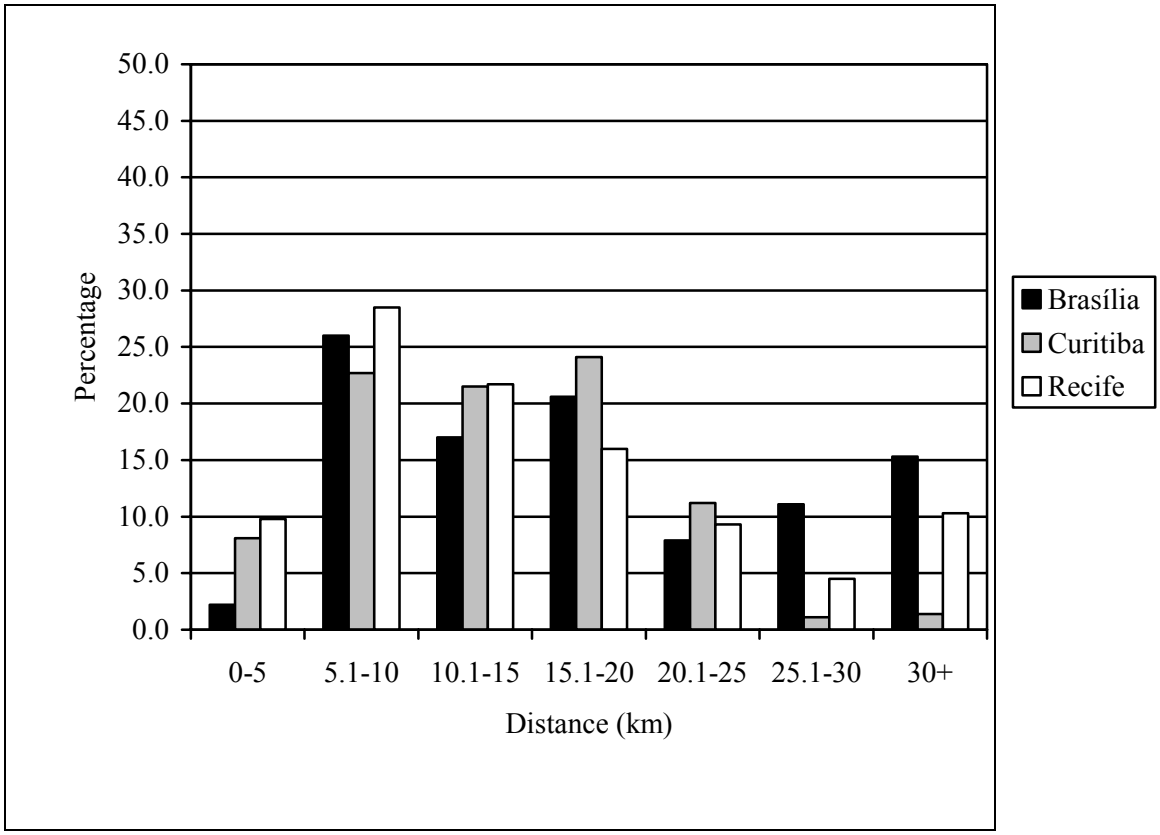


Table 13. Spatial Distribution of Urban Land Development: Brasília, Curitiba and Recife, 1997/2000

DISTANCE CATEGORY (KM)	BRASÍLIA, 1997		CURITIBA, 2000		RECIFE, 1997	
	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL
0–5	734	1.4	7,246	6.6	3,134	8.4
5.1–10	9,602	18.0	21,278	19.4	9,374	25.0
10.1–15	7,151	13.4	23,325	21.3	8,275	22.1
15.1–20	10,926	20.5	28,861	26.3	7,123	19.0
20.1–25	5,632	10.6	14,452	13.2	3,747	10.0
25.1–30	6,035	11.3	13,361	12.2	1,911	5.1
30+	132,207	24.8	1,106	1.0	3,855	10.3
Total	53,287	100.0	109,629	100.0	37,420	100.0

Figure 6. Spatial Distribution of Urban Land Development: Brasília, Curitiba and Recife, 1997/2000

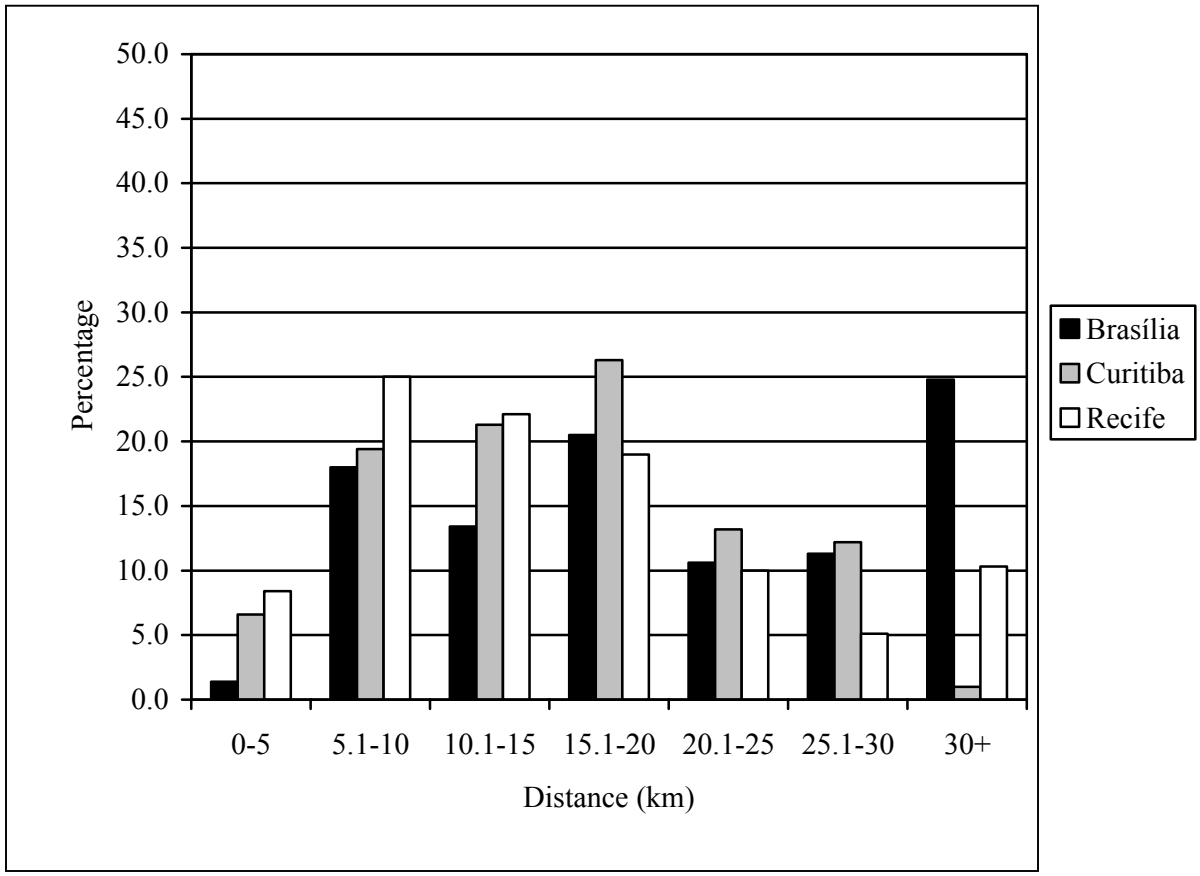
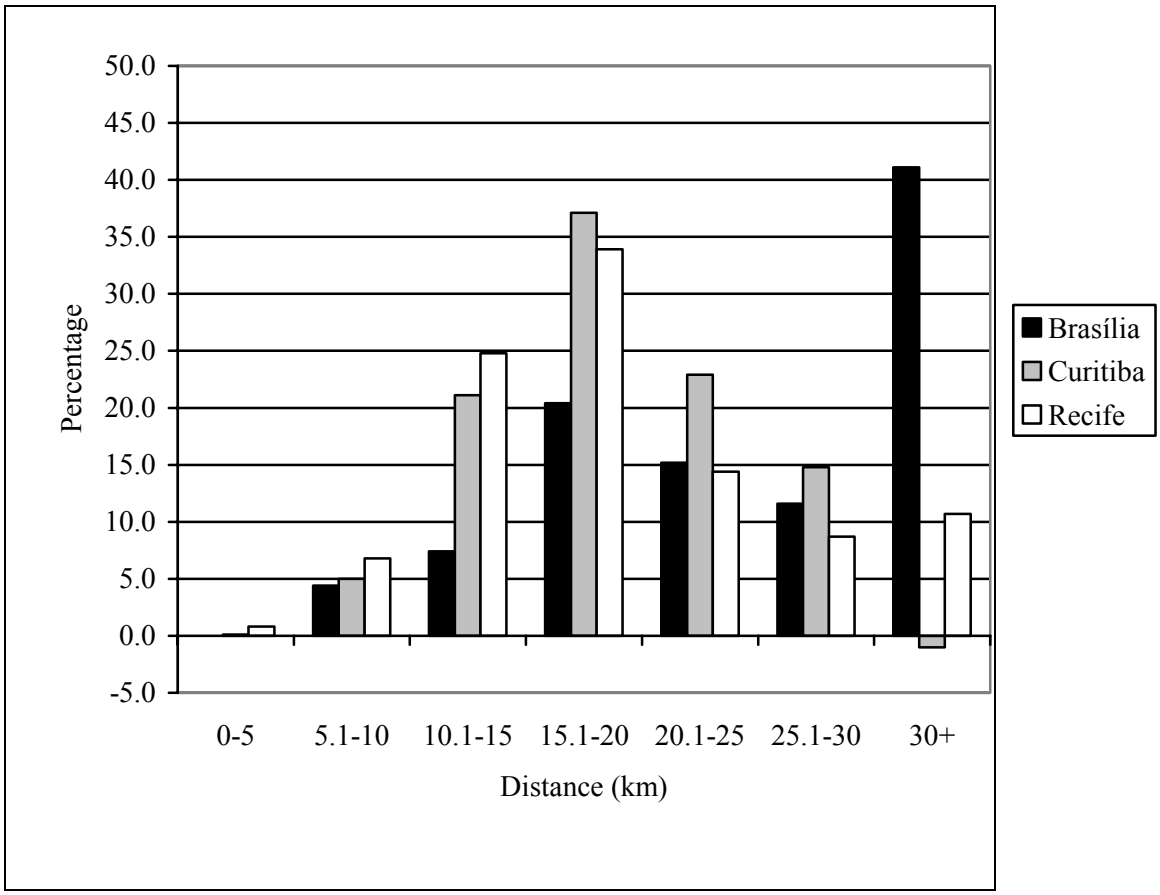


Table 14. Spatial Distribution of Change in Urban Land Development: Brasília, Curitiba and Recife, 1991–1997/2000

DISTANCE CATEGORY (KM)	BRASÍLIA 1991–1997		CURITIBA 1991–2000		RECIFE 1991–1997	
	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL CHANGE	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL CHANGE	URBAN LAND DEVELOPMENT (HA)	% OF TOTAL CHANGE
0-5	.5	0.0	14	0.1	48	0.8
5.1-10	860	4.4	957	5.0	391	6.8
10.1-15	1,444	7.4	4,065	21.1	1,421	24.8
15.1-20	3,997	20.4	7,133	37.1	1,942	33.9
20.1-25	2,973	15.2	4,403	22.9	827	14.4
25.1-30	2,283	11.6	2,836	14.8	497	8.7
30+	8,063	41.1	-188	-1.0	611	10.7
Total	19,620	100.0	19,220	100.0	6,738	100.0

Figure 7. Spatial Distribution of Change in Urban Land Development: Brasília, Curitiba and Recife, 1991–1997/2000



A second factor is the welfare implications of forcing population to travel greater distances to the center of the city. As Bertaud and Buckley have suggested for India, low-density urban sprawl introduces significant transportation costs on residents. A good comparative measure of compactness is the average per capita distance from the city center (Bertaud 2001). This is calculated as the weighted average distance of each population in each zone. In 2001, the average per capita distance for Brasília was 24.3 kilometers; for Curitiba it was 11.2 kilometers; and for Recife it was 13.1 kilometers. In all cases, the average per capita distance to the city center increased between 1991 and 2001. In 1991, Brasília's average was 22.5 kilometers, Curitiba's was 9.75 kilometers, and Recife's was 12.62 kilometers. In a recent paper, Bertaud and Bruckner (2004) illustrated that cities with restrictive development controls take up more space and have lower consumer welfare due to increased commuting costs. Given the fact that distances are approximately twice as great in Brasília than they are in Curitiba or Recife, there is clearly a compelling case for assessing the welfare implications of the capital's dispersed spatial structure.[15]

The third impact is that more compact development economizes on urban infrastructure costs, whereas low-density sprawling development typically requires higher infrastructure costs per capita.

Tables 15, 16 and 17 and Figures 8, 9 and 10 provide tabulations of population density by distance from the city center for the three cities for 1991 and 2000. There are sharp density contrasts among Brasília, Curitiba, and Recife. In the areas within 10 kilometers of the city center, densities in Curitiba and Recife are five to ten times greater than in Brasília. Densities on the periphery of Brasília are five to ten times higher than for Curitiba, and about twice as high as Recife. In the case of Curitiba, there is evidence of significant very low-density suburban development in the areas beyond 10 kilometers—despite its success with the development of high-density development corridors.

[15] In fact, average distance per capita figures for other national capitals, such as Moscow (10.57 km), Paris (10.24 km), and London (12.63 km), are less than half of Brasília's despite the fact that they have larger populations.

Table 15. Spatial Structure of Population Density: Brasília, Curitiba and Recife, 1991

DISTANCE CATEGORY (KM)	BRASÍLIA	CURITIBA	RECIFE
	Population Density Population/Urbanized Land (hectares)	Population Density Population/Urbanized Land (hectares)	Population Density Population/Urbanized Land (hectares)
0–5	6.2	64.5	108.8
5.1–10	13.5	47.4	119.0
10.1–15	20.0	14.0	108.0
15.1–20	30.9	8.1	73.6
20.1–25	103.5	5.7	51.9
25.1–30	95.2	10.7	42.5
30+	48.4	9.9	57.9
Total	39.6	22.9	92.4

Figure 8. Spatial Structure of Population Density: Brasília, Curitiba and Recife, 1991

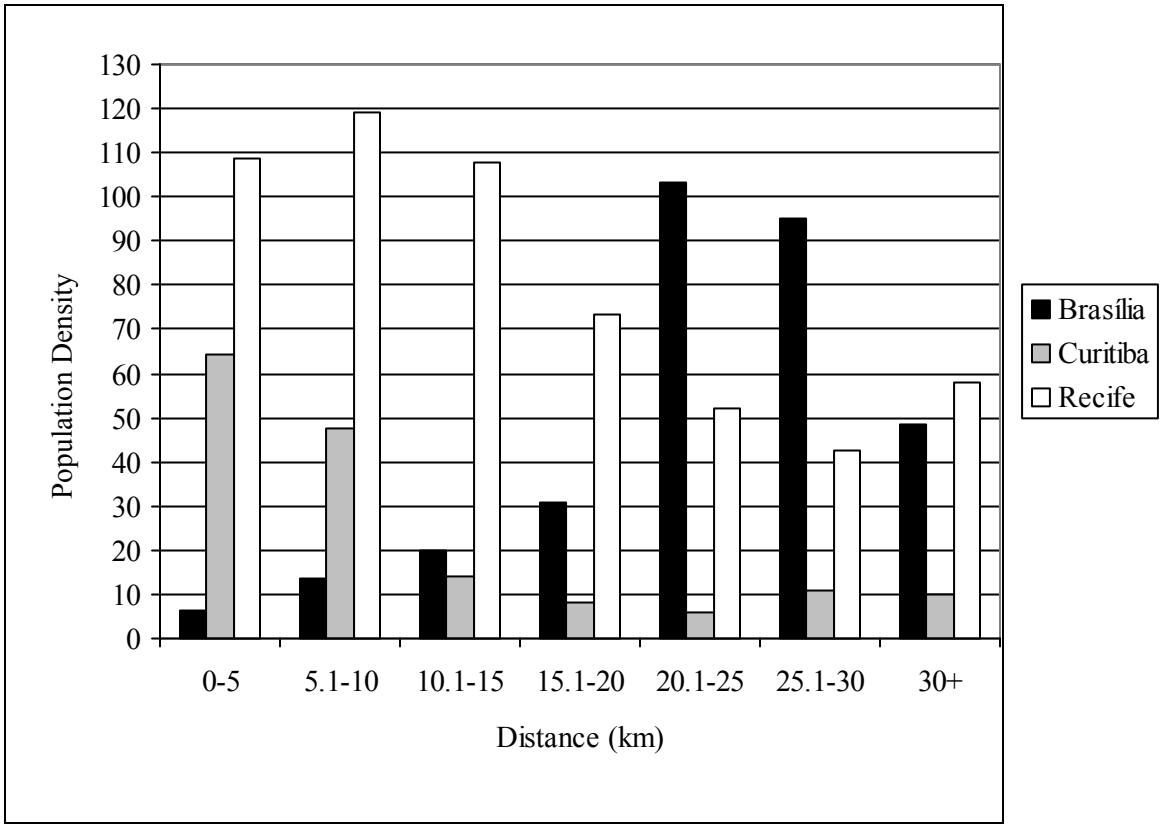


Table 16. Spatial Structure of Population Density: Brasília, Curitiba and Recife, 2000

DISTANCE CATEGORY	BRASÍLIA	CURITIBA	RECIFE
	Population Density Population/Urbanized Land (hectares)	Population Density Population/Urbanized Land (hectares)	Population Density Population/Urbanized Land (hectares)
0–5	8.2	66.4	109.8
5.1–10	15.9	49.4	122.4
10.1–15	19.7	18.1	105.0
15.1–20	30.6	10.3	68.6
20.1–25	56.7	8.4	48.9
25.1–30	82.4	14.5	41.1
30+	46.0	25.8	59.2
Total	38.6	23.7	89.2

Figure 9. Spatial Structure of Population Density: Brasília, Curitiba and Recife, 2000

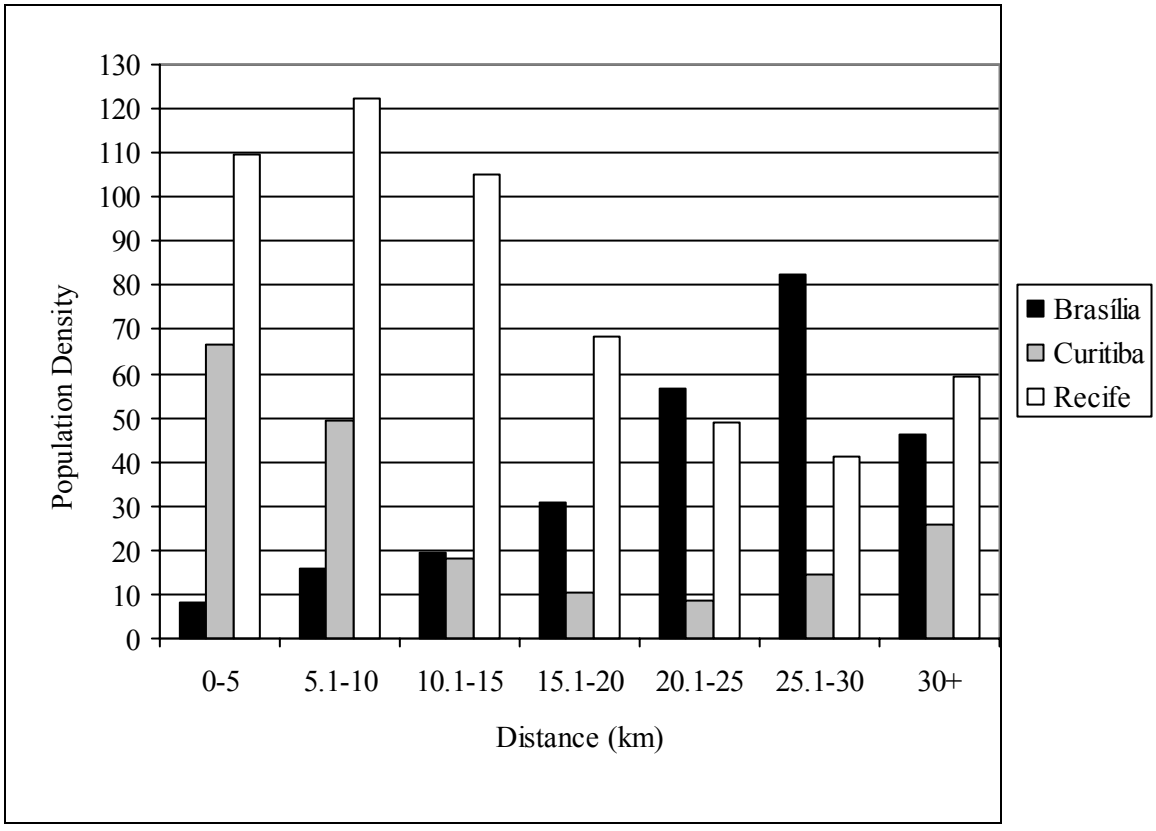
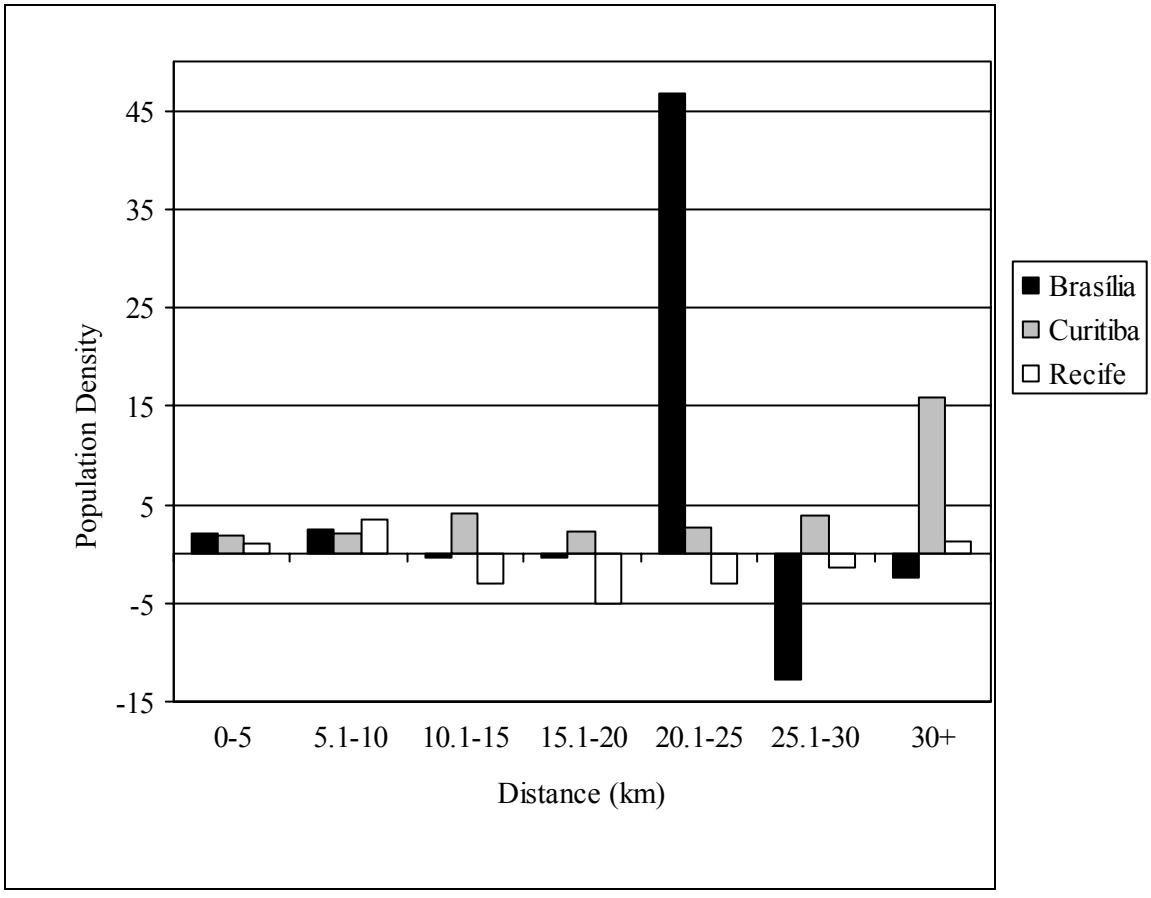


Table 17. Change in Spatial Structure of Population Density: Brasília, Curitiba and Recife, 1991–2000

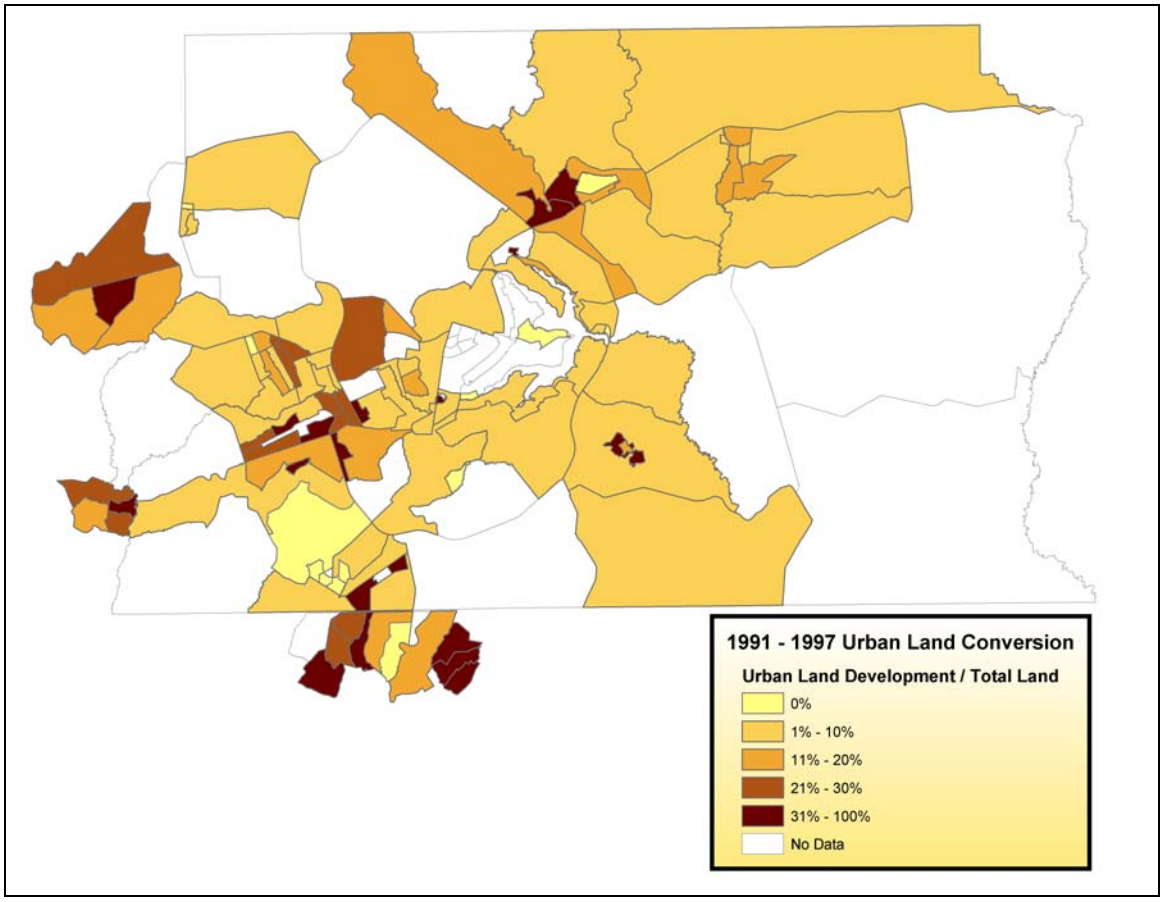
DISTANCE CATEGORY	BRASÍLIA	CURITIBA	RECIFE
	Change in Population Density Population/Urbanized Land (hectares)	Change in Population Density Population/Urbanized Land (hectares)	Change in Population Density Population/Urbanized Land (hectares)
0–5	2.0	1.9	1.0
5.1–10	2.4	2.0	3.4
10.1–15	-0.3	4.1	-3.0
15.1–20	-0.3	2.2	-5.0
20.1–25	46.8	2.7	-3.0
25.1–30	-12.8	3.8	-1.4
30+	-2.4	15.9	1.3
Total	-1.0	0.8	-3.2

Figure 10. Change in Spatial Structure of Population Density: Brasília, Curitiba and Recife, 1991–2000

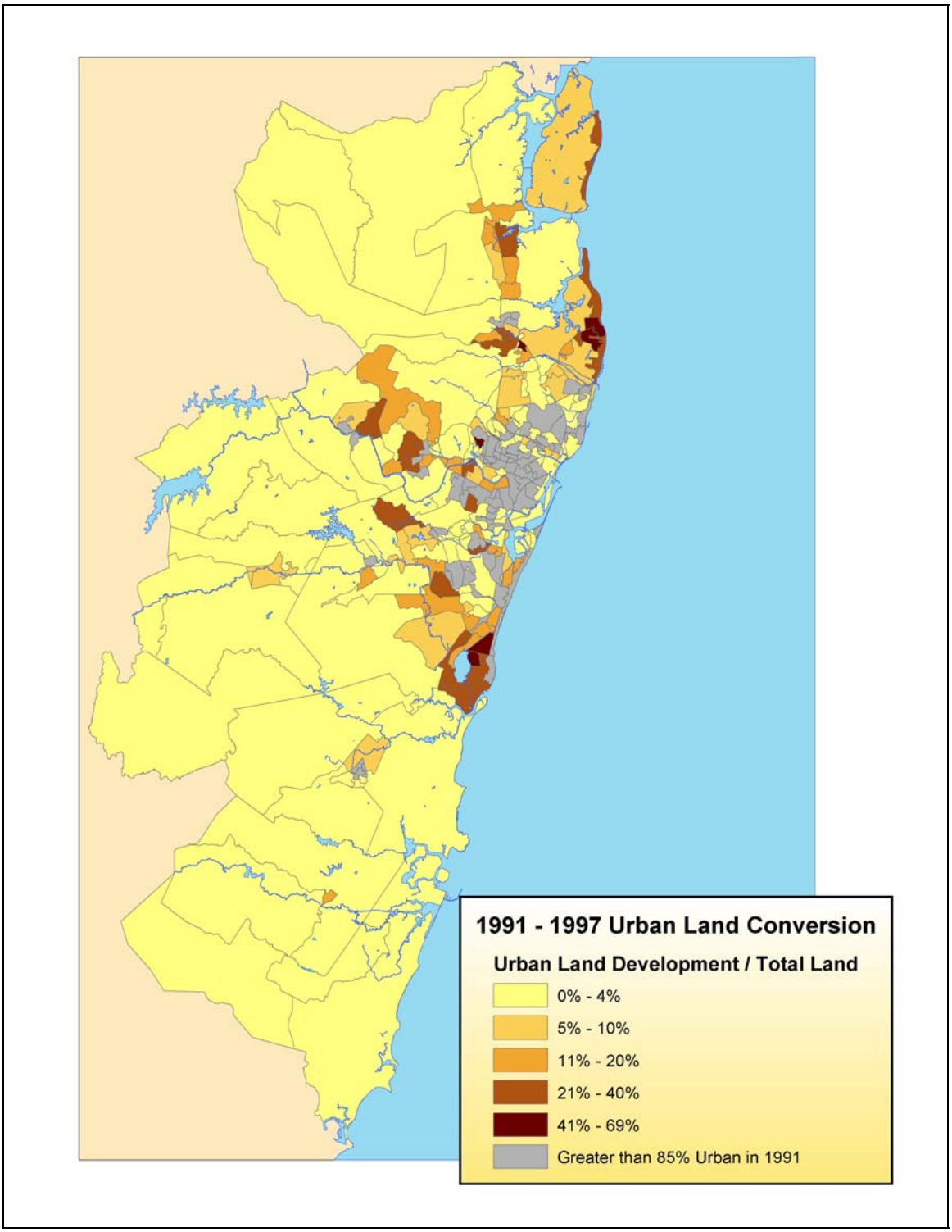


Maps 1, 2 and 3 illustrate spatial trends in urban land development between 1991 and either 1997 or 2000 for Brasília, Curitiba and Recife.

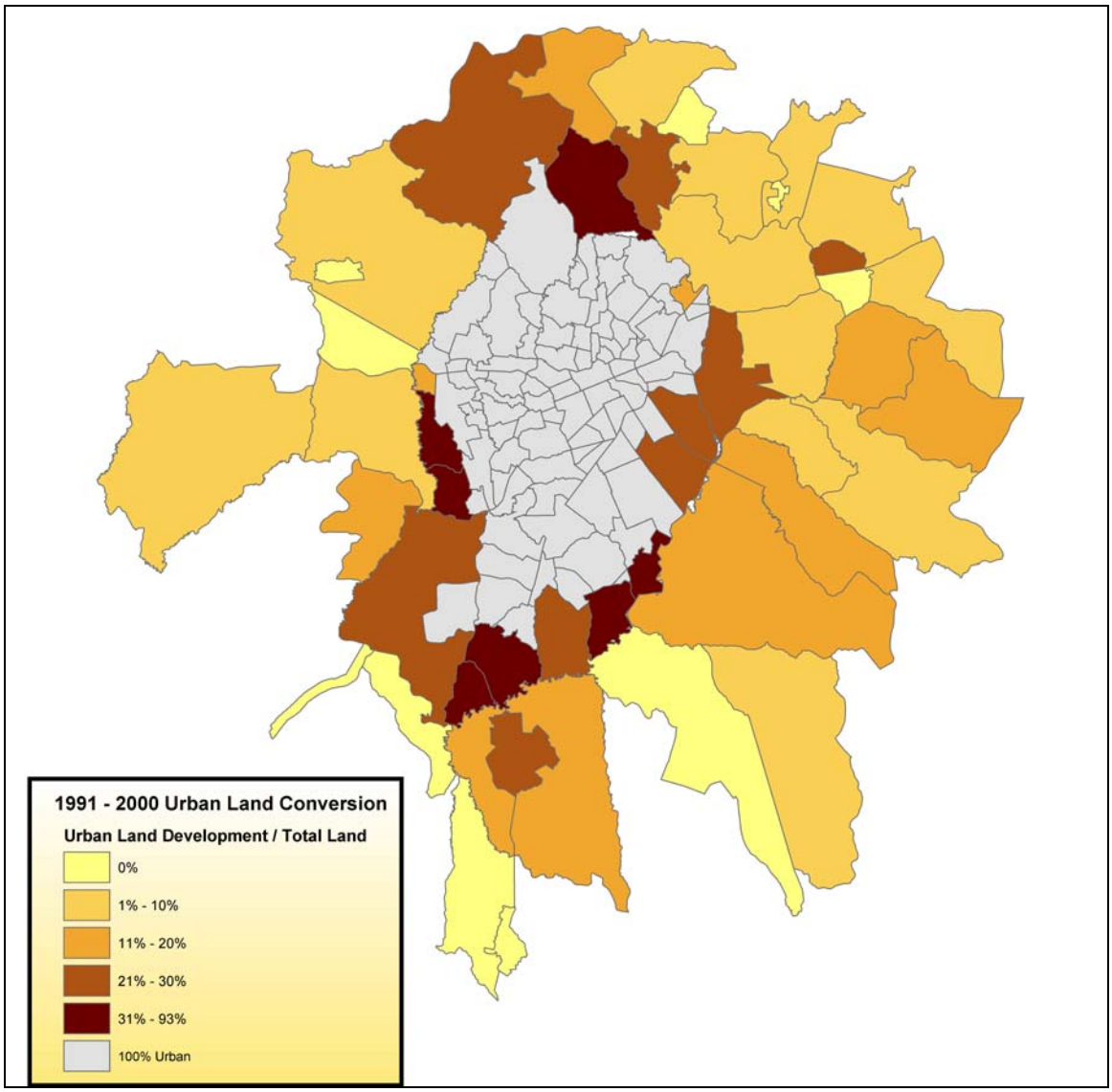
Map 1. Urban Land Conversion: Brasília, 1991–1997



Map 2. Urban Land Conversion: Recife, 1991–1997



Map 3. Urban Land Conversion: Curitiba, 1991–2000



Tables 18–23 and Figures 11–16 provide tabulations of formal and informal housing stock for the three cities for 1991, 2000, and the change between 1991 and 2000. All three cities substantially increased their housing stocks—from 300,000 to over 600,000 units during the 1990s. In Curitiba, most of the housing is located within 15 kilometers of the city—86% in 1991 and 81% in 2000. The situation in Recife is similar with 66% in 2000. In contrast, Brasília's formal housing stock is predominantly located between 15 and 30 kilometers from the city center—65% in 1991 and 66% in 2000. Less than 20% of the city's housing stock is located

within 10 kilometers of the city center. Maps 4 and 5 illustrate the spatial patterns of formal housing stock change between 1991–2000 for Brasília and Curitiba.

The spatial patterns of informal housing are somewhat different from formal housing. Informal housing tends to be more concentrated near the centers of the metropolitan areas. In the cases of Curitiba and Recife, 94% and 89%, respectively, of the informal housing stock in 1991 was located within 15 kilometers of the center. By 2000, the percentage within 15 kilometers in both Curitiba and Recife slightly declined to 92% and 85%, respectively. Maps 6 and 7 illustrate spatial patterns of informal housing stock change for Brasília and Curitiba.

In Brasília, informal housing is effectively shunted to the periphery. In 1991, 61% of informal housing was located more than 15 kilometers from the city center. In 2000, the corresponding figure was 68%.

Table 18. Spatial Distribution of Formal Housing Stock: Brasília and Curitiba, 1991

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA	
	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL
0–5	1055	0.3	109,501	21.9
5.1–10	29,903	8.5	229,650	46.0
10.1–15	31,662	9.0	109,654	22.0
15.1–20	67,194	19.1	26,014	5.2
20.1–25	68,953	19.6	8,557	1.7
25.1–30	92,878	26.4	14,473	2.9
30+	60,158	17.1	1,213	0.2
Total	351,803	100.0	499,062	100.0

Figure 11. Spatial Distribution of Formal Housing Stock: Brasília and Curitiba, 1991

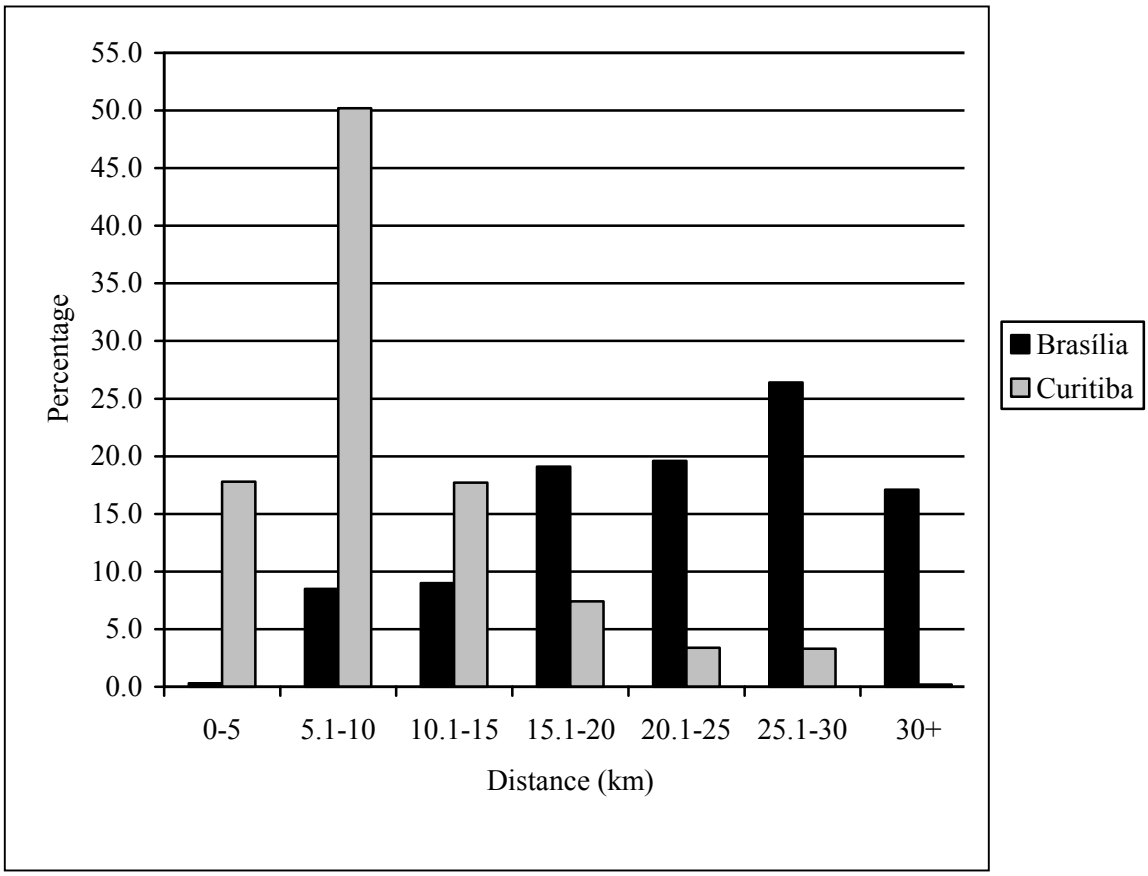


Table 19. Spatial Distribution of Formal Housing Stock: Brasília, Curitiba and Recife, 2000

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL
0–5	2,101	0.4	137,618	20.1	67,343	10.1
5.1–10	48,855	9.3	259,085	37.8	201,165	30.1
10.1–15	38,874	7.4	172,697	25.2	172,173	25.8
15.1–20	111,368	21.2	51,662	7.5	121,535	18.2
20.1–25	85,627	16.3	37,258	5.4	38,919	5.8
25.1–30	148,666	28.3	26,026	3.8	18,846	2.8
30+	89,830	17.1	545	0.1	47,837	7.2
Total	525,321	100.0	684,891	100.0	667,818	100.0

Figure 12. Spatial Distribution of Formal Housing Stock: Brasília, Curitiba and Recife, 2000

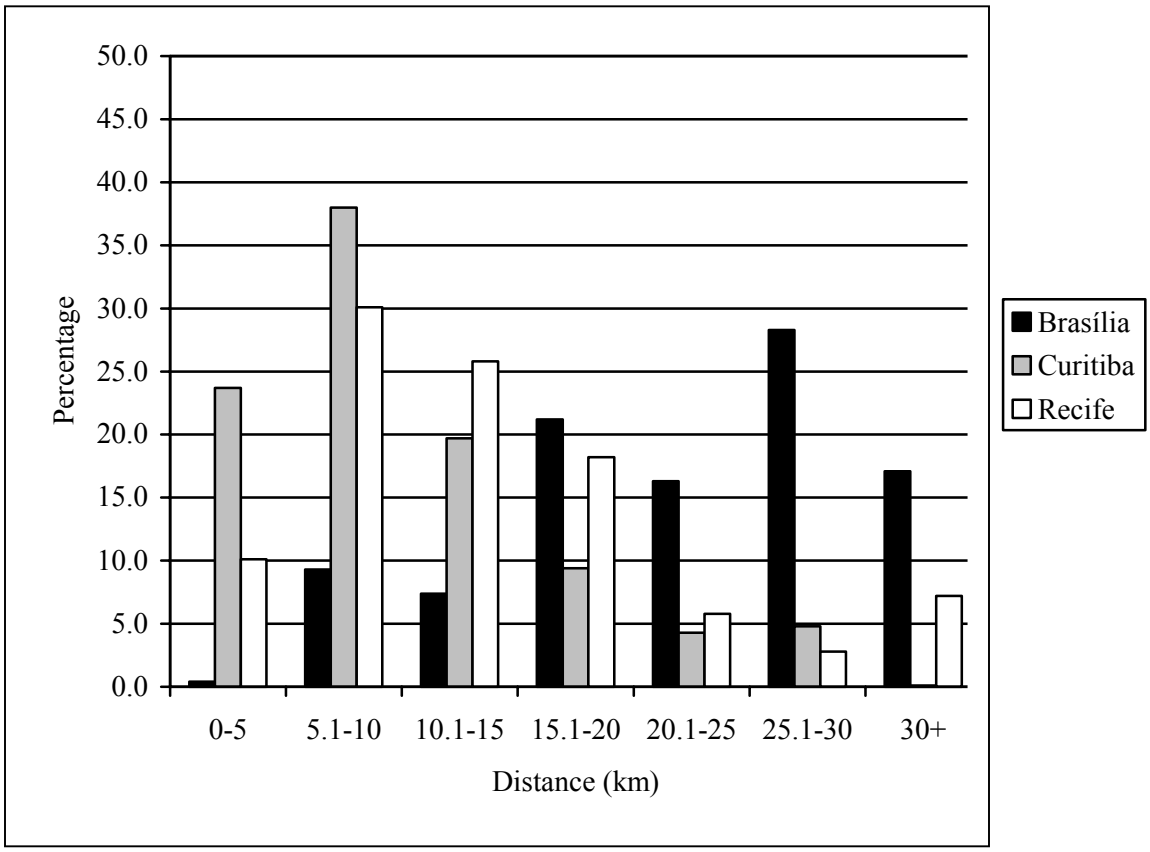
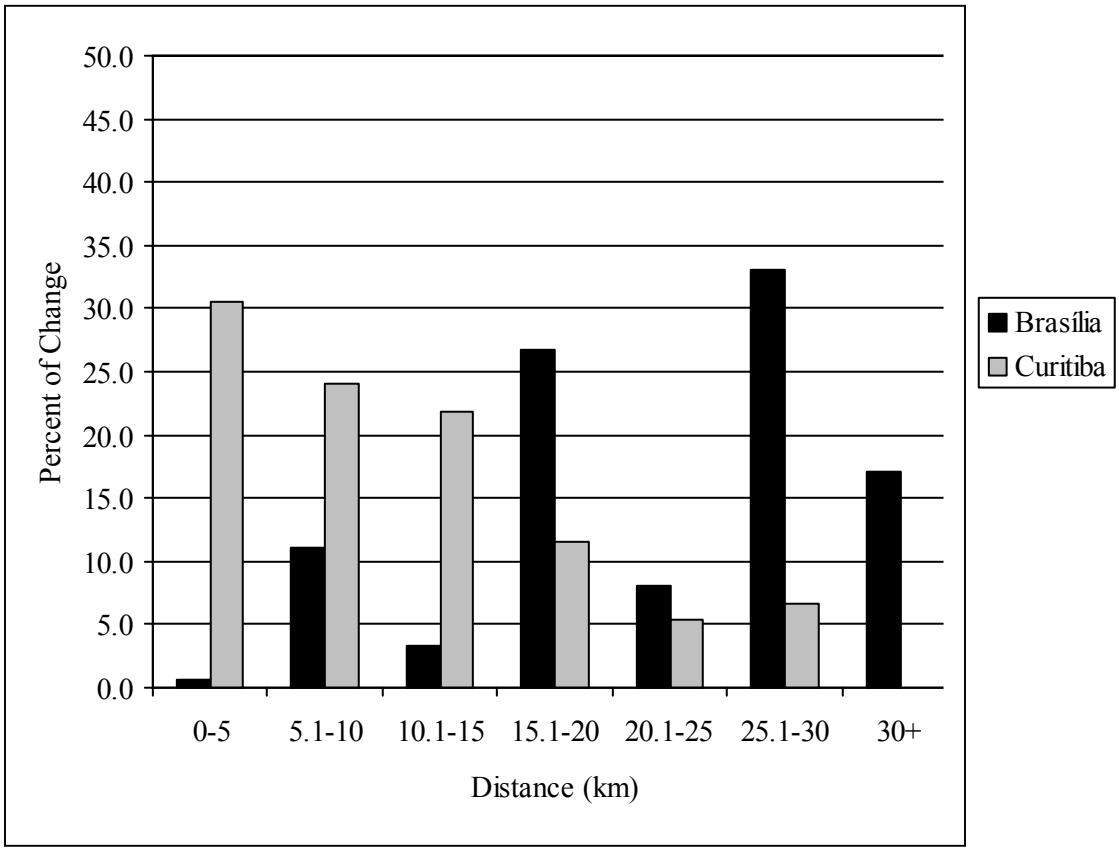


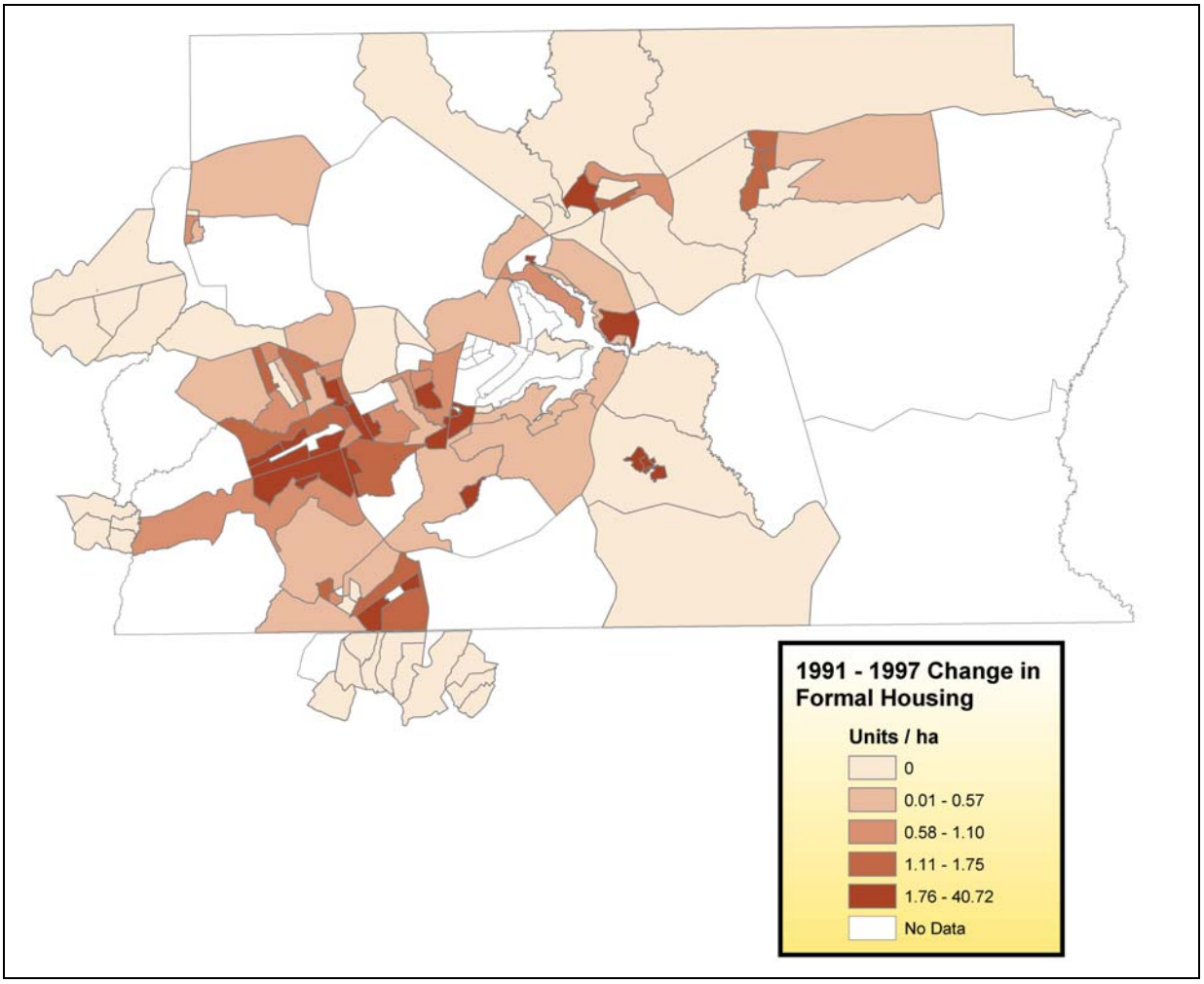
Table 20. Spatial Distribution of Formal Housing Stock Change: Brasília and Curitiba, 1991–2000

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA	
	HOUSING STOCK CHANGE	% OF TOTAL CHANGE	HOUSING STOCK CHANGE	% OF TOTAL CHANGE
0–5	1,215	0.7	28,117	15.1
5.1–10	19,260	11.1	29,435	15.8
10.1–15	5,726	3.3	63,043	33.9
15.1–20	46,329	26.7	25,648	13.8
20.1–25	13,881	8.0	28,701	15.4
25.1–30	57,.435	33.1	11,553	6.2
30+	29,672	17.1	-668	-0.2
Total	173,518	100.0	185,829	100.0

Figure 13. Spatial Distribution of Formal Housing Stock Change: Brasília and Curitiba, 1991–2000



Map 4. Formal Housing Stock Change:
Brasília, 1991–1997



Map 5. Formal Housing Stock Change:
Curitiba, 1991–2000

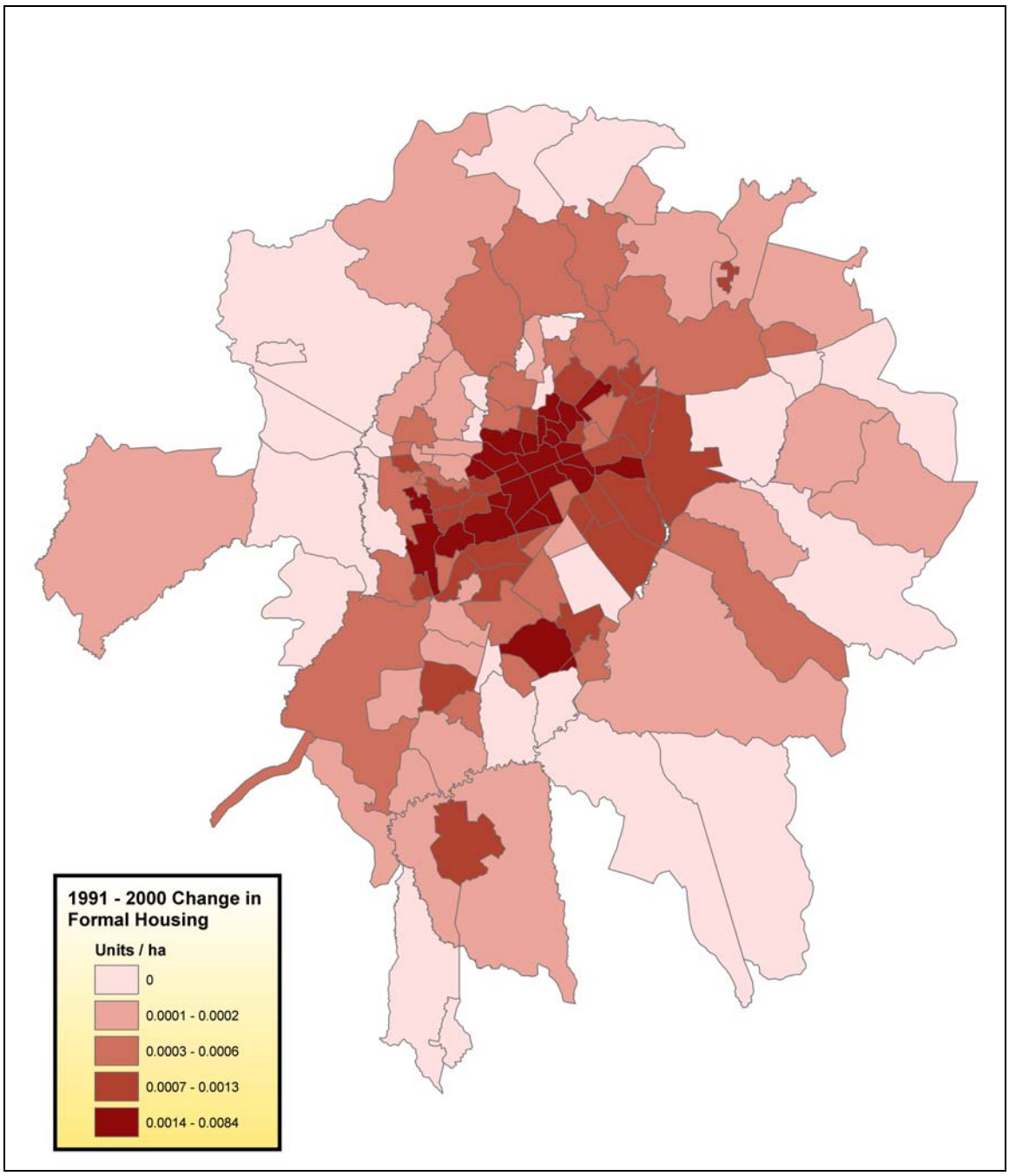


Table 21. Spatial Distribution of Informal Housing Stock: Brasília and Curitiba, 1991

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA	
	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL
0–5	0	0.0	3,586	10.5
5.1–10	169	2.9	16,998	49.8
10.1–15	2,136	36.6	10,891	31.9
15.1–20	2,352	40.3	1,913	5.6
20.1–25	444	7.6	640	1.9
25.1–30	70	1.2	82	0.2
30+	665	11.4	0	0
Total	5,836	100.0	34,110	100.0

Figure 14. Spatial Distribution of Informal Housing Stock: Brasília and Curitiba, 1991

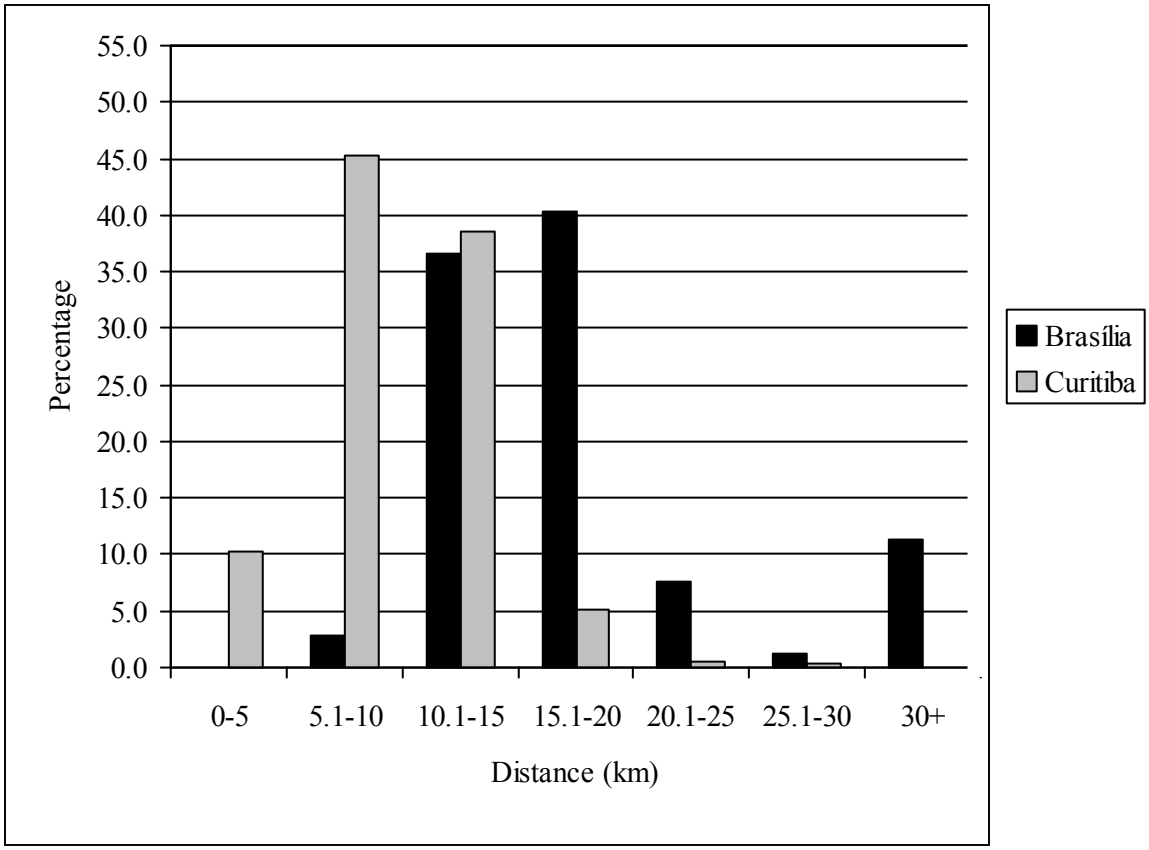


Table 22. Spatial Distribution of Informal Housing Stock: Brasília, Curitiba and Recife, 2000

DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL	HOUSING UNITS	% OF TOTAL
0–5	0	0.0	3,893	8.1	29,166	12.4
5.1–10	302	0.7	21,192	44.2	111,594	47.5
10.1–15	13,414	31.1	18,543	38.7	57,898	24.7
15.1–20	12,940	30.0	2,526	5.3	17,911	7.6
20.1–25	8,066	18.7	1,315	2.7	6,548	2.8
25.1–30	0	0.0	467	1.0	2,240	1.0
30+	8,411	19.5	0	0	9,364	4.0
Total	43,132	100.0	47,936	100.0	234,721	100.0

Figure 15. Spatial Distribution of Informal Housing Stock: Brasília, Curitiba and Recife, 2000

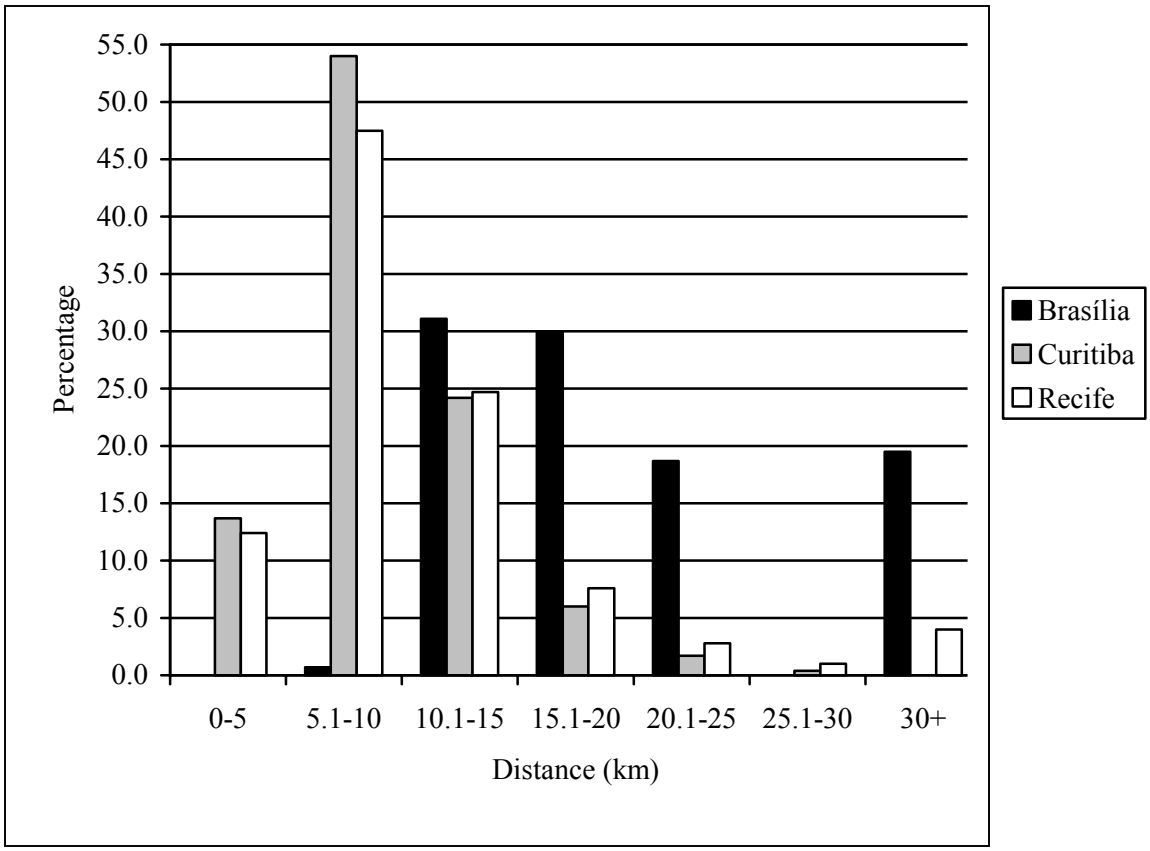
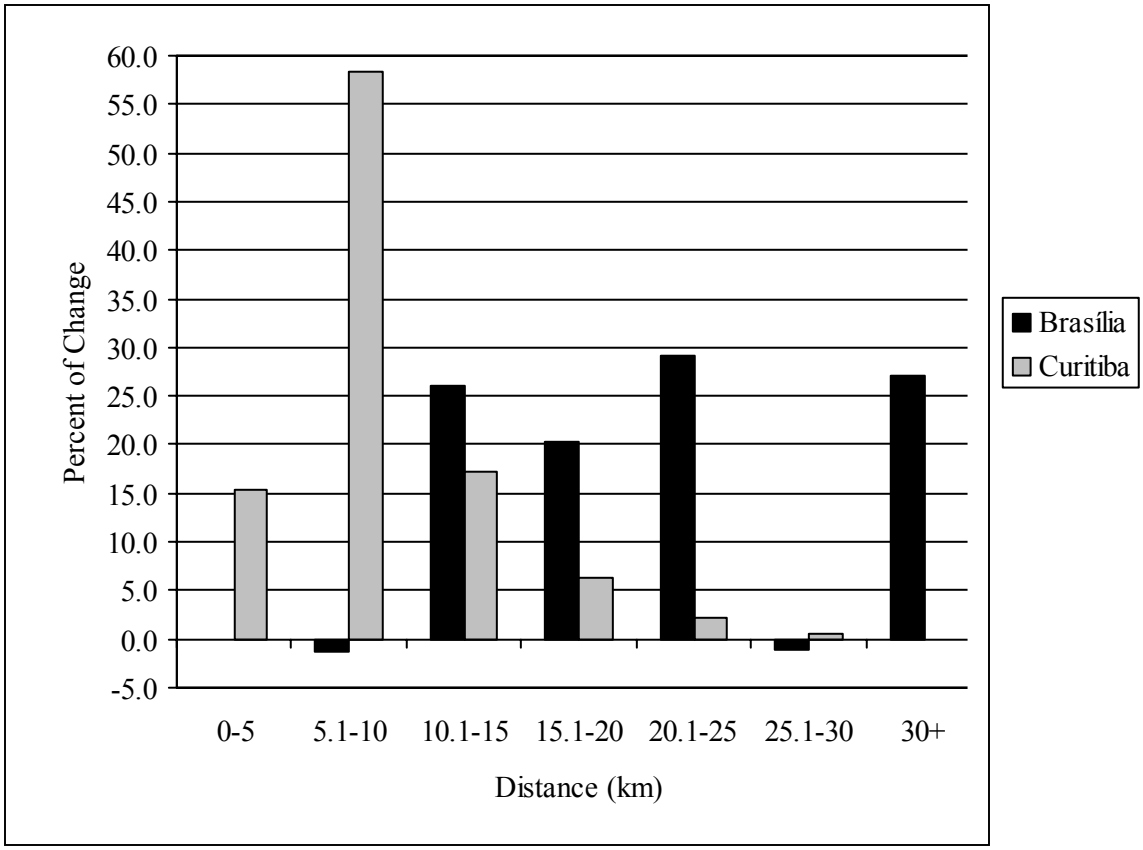


Table 23. Spatial Distribution of Informal Housing Stock Change: Brasília and Curitiba, 1991–2000

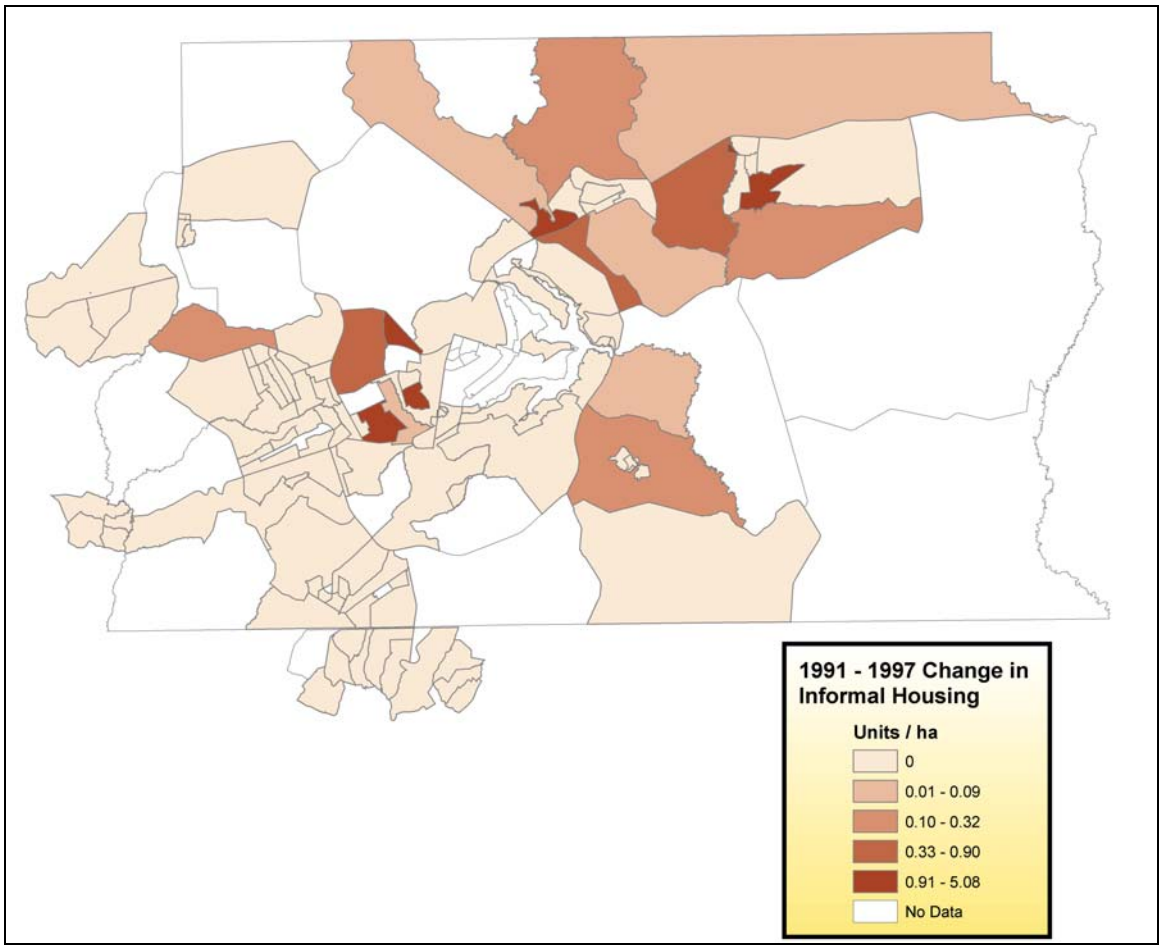
DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA	
	HOUSING STOCK CHANGE	% OF TOTAL CHANGE	HOUSING STOCK CHANGE	% OF TOTAL CHANGE
0–5	0	0.0	307	2.2
5.1–10	133	-1.4	4,194	30.3
10.1–15	11,278	26.0	7,652	55.3
15.1–20	10,587	20.3	613	4.4
20.1–25	7,622	29.2	675	4.9
25.1–30	-70	-1.1		
30+	7,746	27.0	385 *	2.8 *
Total	37,296	100.0	13,826	100.0

* 25+

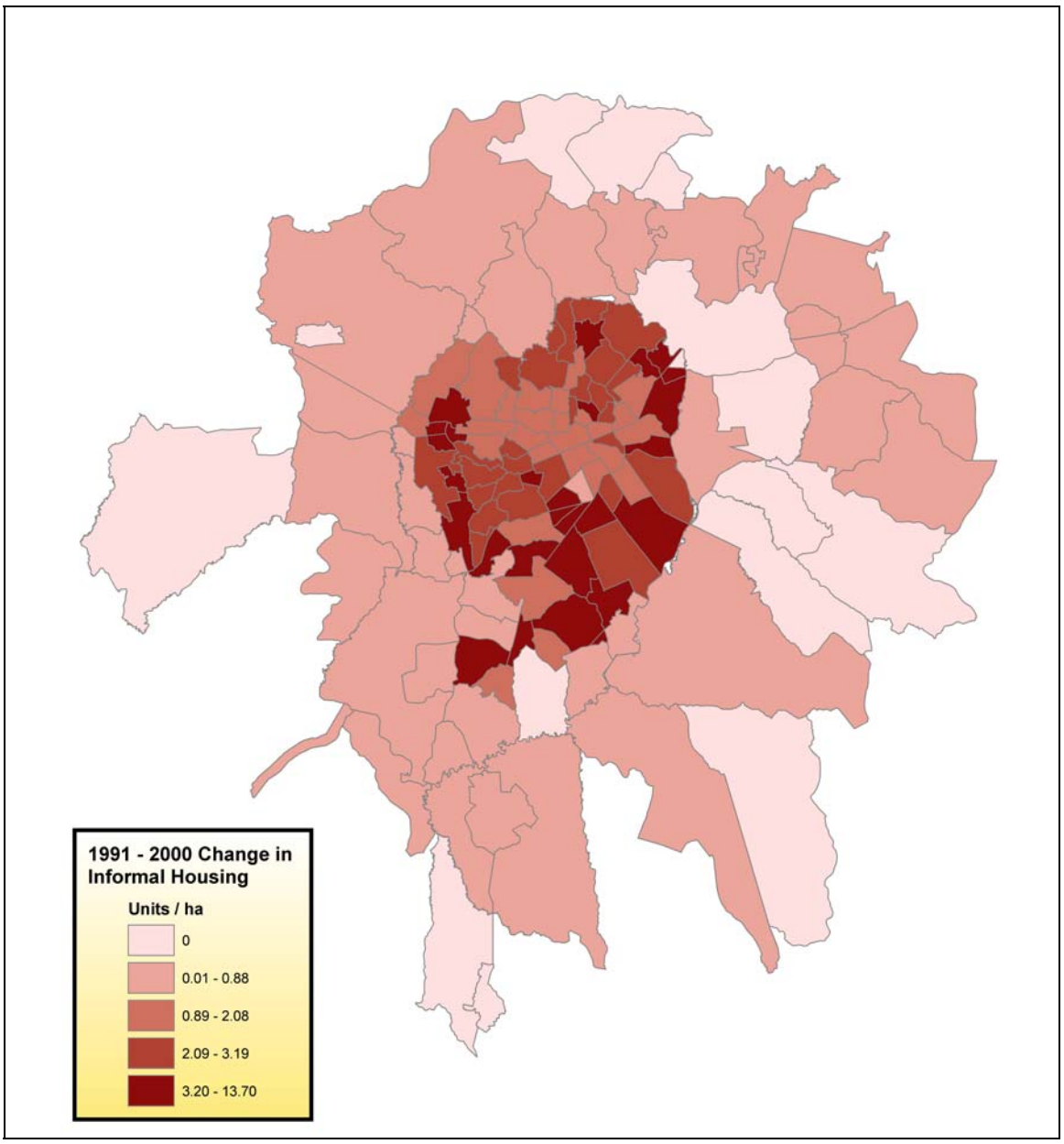
Figure 16. Spatial Distribution of Informal Housing Stock Change: Brasília and Curitiba, 1991–2000



Map 6. Informal Housing Stock Change:
Brasília, 1991–1997



Map 7. Informal Housing Stock Change:
Curitiba, 1991–2000



The Effects of Location, Titling, Infrastructure and Plot Size on Residential Land Prices in the Three Cities

In this section, we examine residential land values. Land value data from the three cities were gathered through a systematic survey of real estate brokers. (For a complete explanation of the process, see D. Dowall, 1995 and 2003). Price data were gathered for various types of residential plots in each geographic zone of each city. Price data are therefore available by distance from the city center and according to whether plots are legally titled, have access to infrastructure (electric, water, paved roads), and whether they are under or over 500 square meters in size. Data were collected for two time periods between 2000 and 2003. All price data presented in the report are in 2003 constant prices. Over the 2000–2003 period, the IPCA (*Indice Nacional de Preços*) increased by 32.9% and the IPCA has been used to adjust prices upwards to 2003 terms. The section starts by presenting overall descriptive statistics of residential land values. It then proceeds to report on the results of three multivariate regression models that seek to gauge the independent effects of distance, title, infrastructure, and plot size.

Table 24 and Figure 17 present mean plot prices for the three cities. Interestingly, current plot prices (unadjusted for inflation) did not increase as rapidly as the IPCA, and therefore are higher in the earlier years—for Brasília, 209 reais per square meter in 2001 and 142 reais in 2003; for Curitiba, 67 reais per square meter in 2000 and 66 reais in 2002; and for Recife, 74 reais per square meter in 2001 and 71 reais in 2003. This suggests that real plot prices have not kept pace with inflation. It is also noteworthy that residential land prices are considerably higher in Brasília than in Recife and Curitiba, averaging 142, 71, and 66 reais, respectively, in 2003. While there are a myriad of factors shaping residential land prices, high per capita and household incomes in the capital probably explain much of the difference—higher incomes mean higher ability to pay for housing, driving up land prices. It may also be the case that strict land use planning and development controls in Brasília limited the supply of land for residential development, particularly in the more centrally located areas, and resulted in higher land prices.

Provision of infrastructure has a clear and positive impact on residential plot prices in the three cities. As illustrated in Table 24 and Figure 17, the mean 2002/2003 value of plots with infrastructure (measured by the presence of paved roads) ranges from 139 reais in Brasília,[16] to 108 reais in Curitiba, and 97 reais in Recife. These means are

[16] In Brasilia, calculations of mean for plots with and without infrastructure excludes plots located within 10 kilometers of the city center. These plots were excluded

all greater than corresponding prices for plots without infrastructure: in Brasília, 47 reais; in Curitiba, 38 reais; and in Recife, 42 reais. These patterns reflect the positive impact that infrastructure provision has on land values. Below, we present a more rigorous analytical examination of the effects of infrastructure on land prices.

Although to a lesser extent, the provision of title of property ownership also positively affects residential land prices. As illustrated in Table 24 and Figure 17, the mean 2002/2003 value of plots with title ranges from 147 reais in Brasília, to 68 reais in Curitiba, and 78 reais in Recife. These means are all greater than corresponding prices for plots without title: in Brasília, 122 reais; in Curitiba, 66 reais; and in Recife, 64 reais. We have also found that the existence of both infrastructure and title positively affects prices. In Table 24 and Figure 17, the mean 2002/2003 value differential for plots with both infrastructure and title and without is 73 reais versus 29 reais for Curitiba and 73 reais versus 17 reais for Recife. Maps 8, 9 and 10 illustrate mean plot prices for the three cities.

We also found that plot size affects per-meter prices of plots, although the impact is variable across the three cities (see Table 24 and Figure 17). In the case of Brasília, large plots have higher prices per square meter—266 reais as compared to 184 reais for plots under 500 square meters. Since it is normally the case that smaller plots have higher prices per square meter, the results in Brasília may reflect the fact that there is a scarcity of large plots in the metropolitan area. In both Curitiba and Recife, per-square-meter plot prices are higher for small plots than for large plots—72 reais versus 57 reais for Curitiba and 71 reais versus 70 reais for Recife.

The above results are highly general since they do not incorporate the effects of location into the calculations of means. Table 25 and Figure 18 provide tabulations of mean plot prices per square meter based on distance from the central city.

Plot prices in Brasília display the same unique patterns as for population density and housing. Plot prices in 2003 increase as distance from the center increases, up to 10 kilometers, and gradually decline out to 30 kilometers. Beyond 30 kilometers, plot prices are much lower (but still more than double comparable prices in Curitiba and Recife). This distinct pattern of land prices is the result of strict land use planning controls in Brasília, limitations on housing in the core, and strict exclusion of

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because of the small sample size of plots, especially those without infrastructure. As a result the mean values for plots with and without infrastructure are lower than for the overall sample means—higher priced center city plots are excluded.

Table 24. Mean Plot Prices by Infrastructure Service and Title in 2000, 2001, 2002 and 2003 for Brasília, Curitiba and Recife in Constant 2003 Values (Reais per Square Meter)

DISTANCE CATEGORY		BRASÍLIA		CURITIBA		RECIFE	
		2001	2003	2000	2002	2001	2003
All plots		209	142	67	66	74	71
Infrastructure	With	164[a]	139[a]	109	108	102	97
	Without	157[a]	47[a]	38	38	44	42
Title	With	223	147	68	68	81	78
	Without	193	122	66	66	67	64
Infrastructure and Title	With	213	144	73	73	77	73
	without	*	*	29	29	18	17
Plot Size	< 500m^2	184	153	72	71	75	71
	>500m$_2$	266	99	57	57	73	70

[a] Means exclude plots located within 10 kilometers of the city center.
* Sample size less than 30
Deflators: 2000=1.329; 2001=1.244; 2002=1.147 and 2003=1.000.

Figure 17. Mean Plot Prices by Infrastructure Service and Title in 2002–2003 for Brasília, Curitiba and Recife in Constant 2003 Values (Reais per Square Meter)

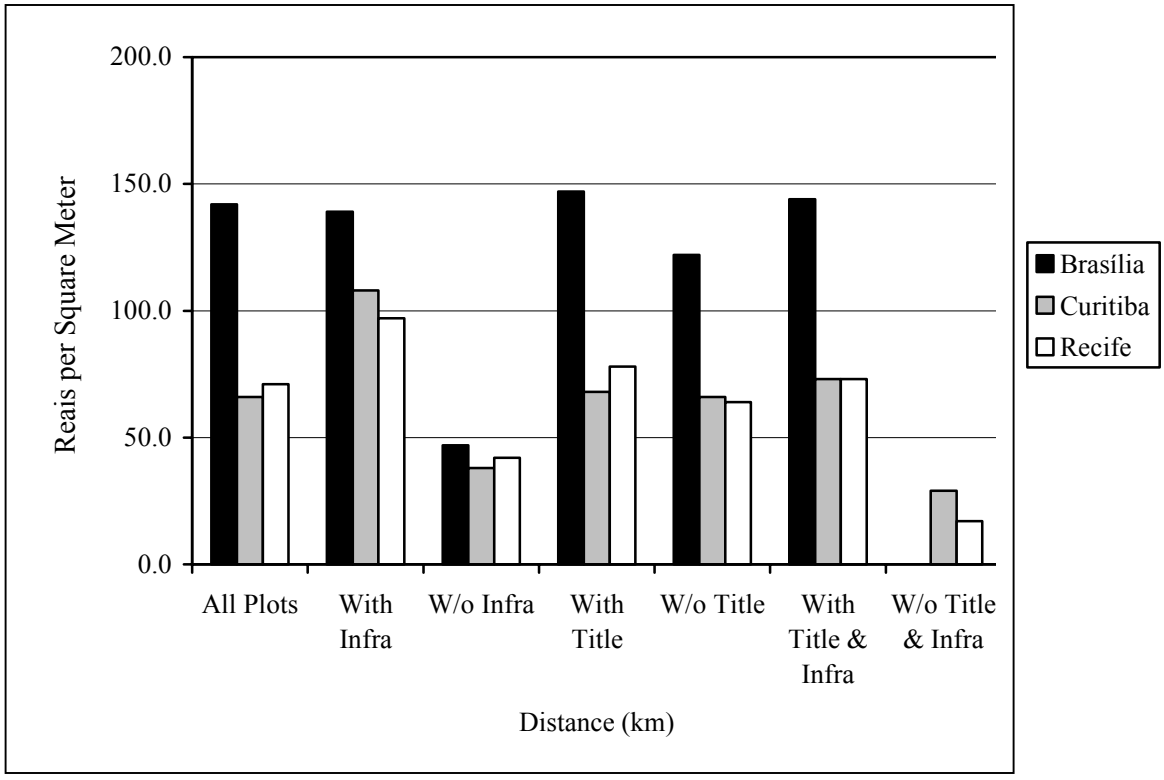
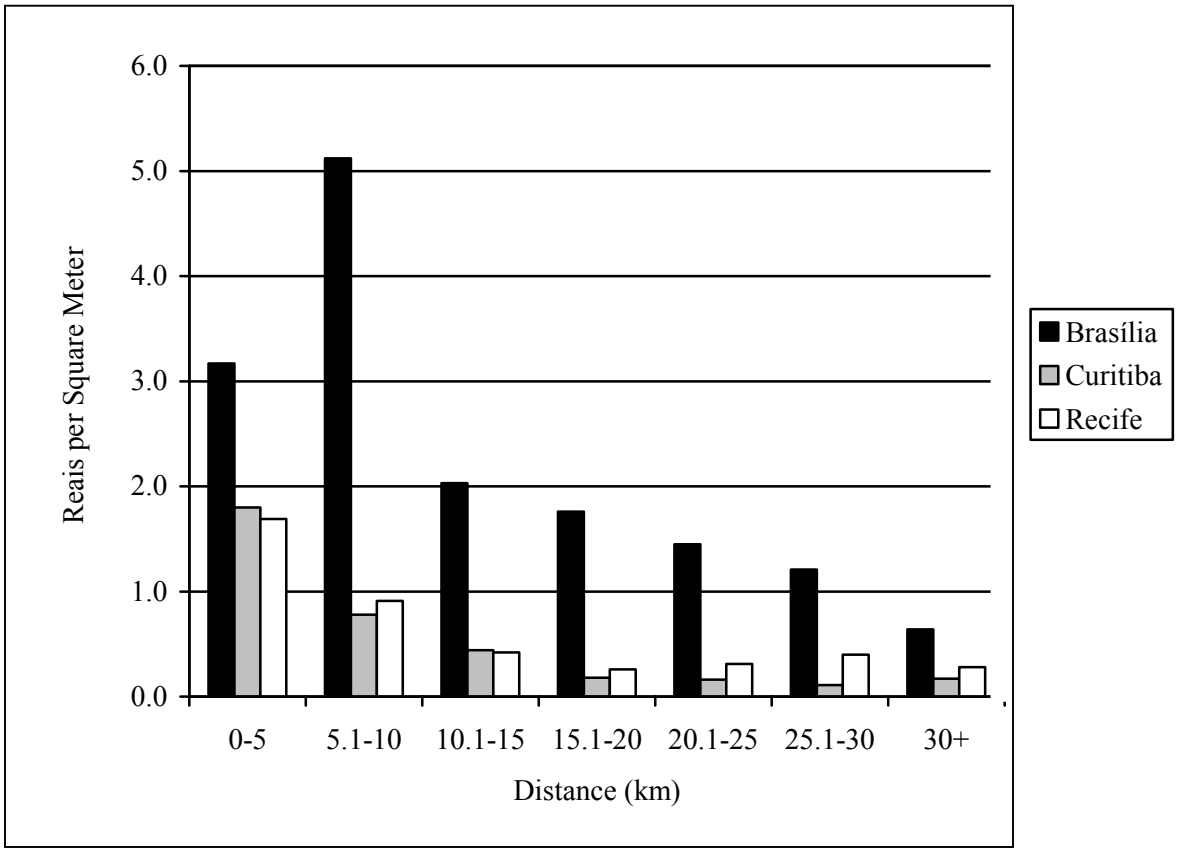


Table 25. Mean Plot Prices by Distance from City Center in 2000, 2001, 2002, and 2003 for Brasília, Curitiba and Recife in Constant 2003 Values (Reais per Square Meter)

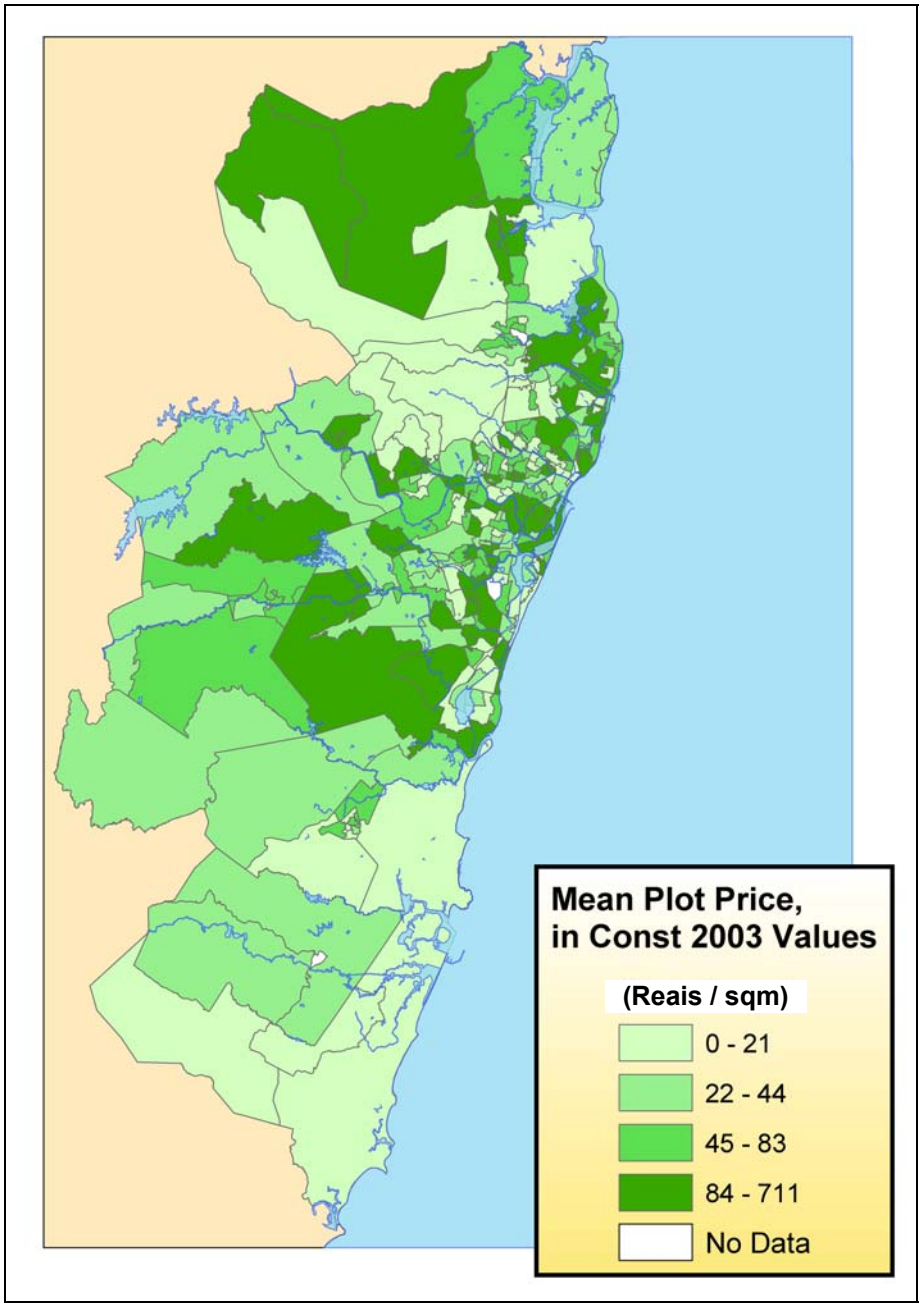
DISTANCE CATEGORY (KM)	BRASÍLIA		CURITIBA		RECIFE	
	2001	2003	2000	2002	2001	2003
0–5	222	317	185	180	173	169
5.1–10	802	512	78	78	96	91
10.1–15	156	203	42	44	45	42
15.1–20	176	176	18	18	27	26
20.1–25	124	145	15	16	34	31
25.1–30	168	121	12	11	38	40
30+	200	64	19	17	27	28
Total	233	142	67	66	74	71

Deflators: 2000=1.329; 2001=1.244; 2002=1.147 and 2003=1.000.

Figure 18. Mean Plot Prices by Distance from City Center, 2002–2003, for Brasília, Curitiba and Recife in Constant 20 03 Values (Reais per Square Meter)

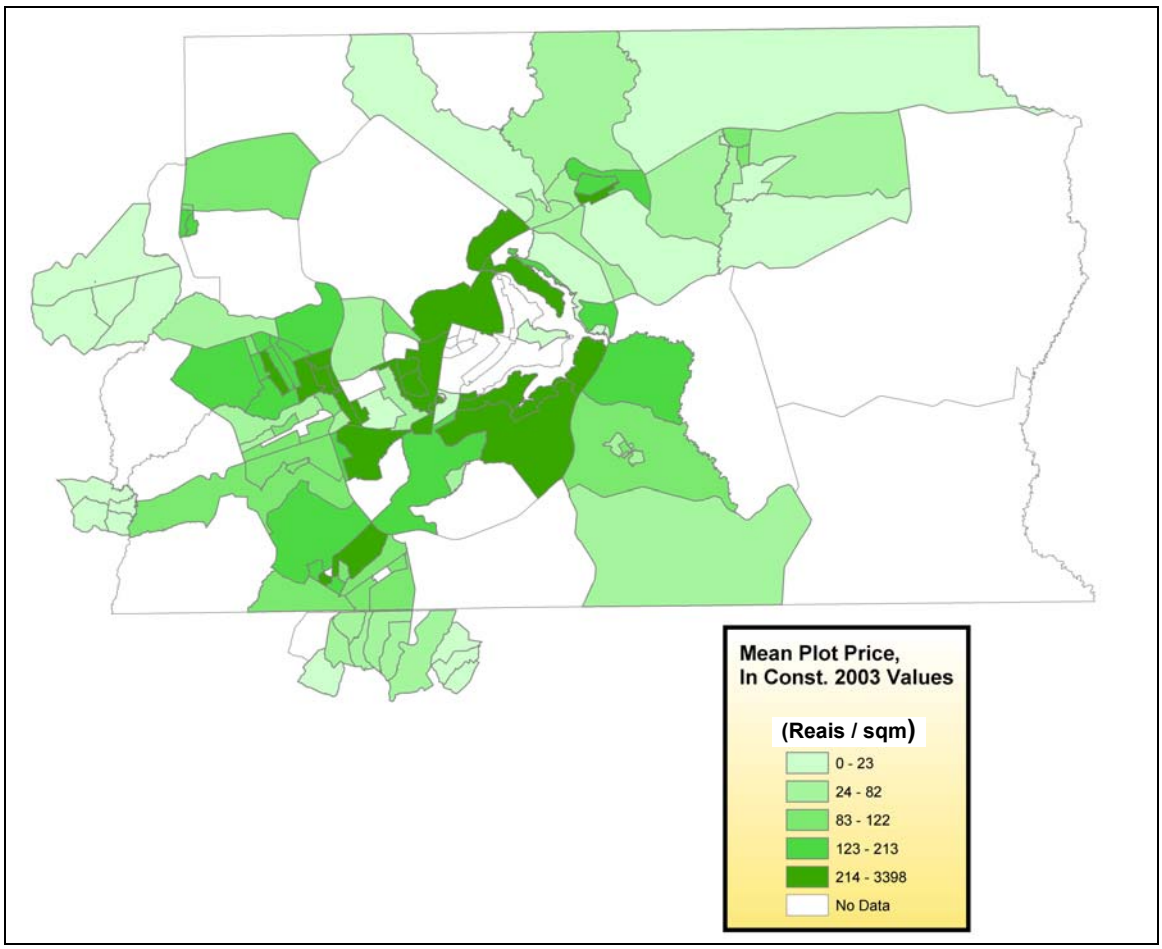


Map 8. Mean Plot Price: Recife
in Constant 2003 Values



informal housing within the federal district. Beyond the federal district, informal housing is more common and there is an active market for unauthorized houses and condominiums.

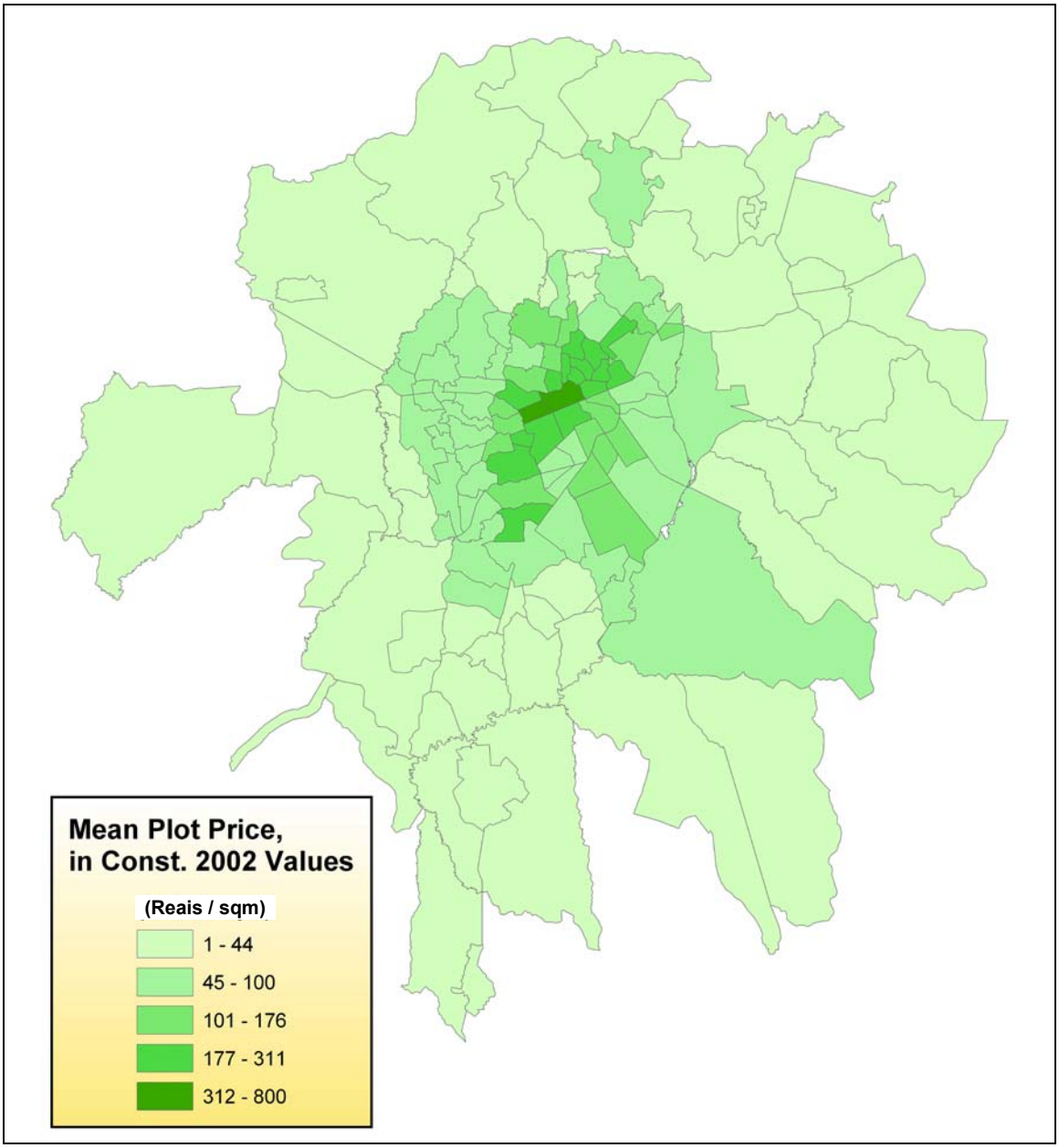
Map 9. Mean Plot Price: Brasília
in Constant 2003 Values



Plot prices in Curitiba and Recife display more conventional patterns. Prices are highest at the center of the city and then decline consistently with increasing distances. In 2002, prices in Curitiba were 180 reais per square meter; beyond 10 kilometers, prices range from 44 reais to 11 reais per square meter, depending on location. Interestingly, prices beyond 30 kilometers are higher than in the 25–30 kilometer band, 17 reais versus 11. Further investigation is needed to ascertain what factors cause this up-tick in prices.

In Recife, plot prices are highest in the city center at 169 reais and decline steadily with increasing distance. At the periphery, plot prices average 28 reais, considerably higher than Curitiba, but well below comparable levels in Brasília.

Map 10. Mean Plot Price: Curitiba
in Constant 2002 Values



Comparing plot prices over time (2000–2002 and 2001–2003), suggests that prices in both Curitiba and Recife have been fairly constant in real, inflation adjusted terms. In Brasília, real inflation adjusted prices appear to have declined in suburban areas, while increasing in the core (0–5 kilometers).

Table 25 and Figure 18 present tabulations of residential land prices by distance from the city center. They reveal a striking difference between the highly planned city of Brasília and Curitiba and Recife. In the cases of Curitiba and Recife, residential land prices systematically decline from the city center. In Curitiba, 2002 prices of plots located within five kilometers of the city center average 180 reais. Farther out, from 5–10 kilometers, the mean price falls to 78 reais. This pattern continues all the way out to the 25–30 kilometer band, where prices fall to 11 reais. However, beyond 30 kilometers, prices pick up a bit to 17 reais. In Recife, plot prices decline from 169 reais to 28 reais at the edge.

In Brasília, land prices increase from the center out to 10 kilometers. From 10 to 30 kilometers, prices remain very high (particularly in comparison to the other two cities). This pattern appears to reflect the strict land use development regulations that exist in Brasília, with opportunities for housing restricted to limited areas in and around the center, and most residential development located 10 to 20 kilometers from the center (see Figure 18). This pattern in prices reflects the population density aspects discussed above in a previous section.

The tabulations of mean plot prices according to plot characteristics and location, indicate that prices are strongly affected by these factors. In the remaining portion of this section, we attempt to isolate the effects of each of these factors by building two multivariate regression models to predict residential plot price—one for 2002–2003 price data and one for 2000–2001 price data. In developing the models, we took an exploratory approach, utilizing two functional forms (linear and log-linear) and a step-wise process for determining which independent variable to include in the models. In the case of the linear model, the dependent variable was constant per-square-meter plot price. Independent variables include distance from city center and a range of dummy variables to indicate the presence of a range of plot characteristics—provision of infrastructure (electric, water, paved roads), availability of title, and plot size (over or under 500 square meters). In order to test for potential interaction effects, we also included a variable that captured the presence of both title and infrastructure. In the case of the log-linear model, the dependent variable was the log (base e) of constant per-square-meter plot price. The log-linear model used the same independent variables.

The step-wise process iteratively adds independent variables to the regression model in an attempt to build the most robust model. It results in various model specifications, depending on the explanatory power of added variables. Model runs indicated that the log-linear specification was the most robust. Tables 26 and 27 present the results of the log-linear

models for Brasília, Curitiba and Recife for 2002–2003 and 2000–2001. In Table 26, the step-wise modeling results in three distinct models for each city.

In the case of Brasília, the best model incorporated distance, pavement dummy and plot size. It excluded, electric, water, title, and pavement-title. Overall, the model is highly predictive, with an adjusted R^2 of 0.585. All of the independent variables are significant at the .000 confidence level and have the expected signs (constant is positive, distance is negative, pavement is positive, and plot size is negative).

The 2002 model for Curitiba is also very significant. It has an R^2 of .656. The Curitiba model includes constant, distance, pavement, pavement-title and plot size. All of the independent variables are significant at the .000 confidence level and have the expected signs.

Table 26. Stepwise Regression Results:
Brasília, Curitiba and Recife, 2002 and 2003,
Dependent Variable: Log (base e) of Constant Reais per Square Meter

	BRASÍLIA 2003		CURITIBA 2002		RECIFE 2003	
	BETA	SIGNIFICANCE	BETA	SIGNIFICANCE	BETA	SIGNIFICANCE
CONSTANT	6.055 (27.873)	.000	4.469 (76.191)	.000	3.968 (108.869)	.000
DISTANCE TO CBD	-.089 (-13.737)	.000	-.117 (-49.931)	.000	-.047 (-28.910)	.000
PAVEMENT DUMMY	1.027 (7.373)	.000	.748 (19.676)	.000	.639 (20.710)	.000
TITLE DUMMY					.194 (6.440)	.000
PAVEMENT AND TITLE DUMMY			.391 (7.215)	.000		
PLOT SIZE DUMMY	-.993 (-6.313)	.000	-.419 (-11.295)	.000		
ADJUSTED R^2	.585	df =175	.656	df= 1921	.394	df=2500

T statistics are in parentheses.

The Recife model has the lowest R^2 of the three cities—.394. It includes constant, distance, pavement, and title. All of the independent variables are significant at the .000 confidence level and have the expected signs.

Table 27 presents model results for 2000–2001 years. There are no results for Brasília. The results for Curitiba and Recife, however, were robust and are generally similar to the results for 2002–2003 presented in Table 26.

Tables 28 and 29 interpret the results of the five models. The constant values are presented in the first row of both tables. The constant value is the estimated value of the plot located at the center of the city, with no paved road, no title and small plot size. For the 2002–2003 years, the constants range from 426 reais for Brasília, 87 reais for Curitiba, and 53 reais for Recife. For 2000–2001 (Table 29), the constant values are 86 reais for Curitiba and 56 reais for Recife.

Table 27. Stepwise Regression Results: Brasília, Curitiba and Recife, 2000 and 2001, Dependent Variable: Log (base e) of Constant (Reais per Square Meter)

	BRASÍLIA 2001		CURITIBA 2000		RECIFE 2001	
	BETA	SIGNIFICANCE	BETA	SIGNIFICANCE	BETA	SIGNIFICANCE
CONSTANT			4.451 (75.473)	.000	4.024 (109.862)	.000
DISTANCE TO CBD			-.116 (-49.243)	.000	-.048 (-29.356)	.000
PAVEMENT DUMMY			.760 (19.883)	.000	.636 (20.491)	.000
TITLE DUMMY					.198 (6.515)	.000
PAVEMENT AND TITLE DUMMY			.396 (7.269)	.000		
PLOT SIZE DUMMY			-.439 (-11.766)	.000		
ADJUSTED R^2			.653	df=1921	.396	df=2500

T statistics are in parentheses.

Table 28. Interpreted Regression Results:
Brasília, Curitiba and Recife, 2002 and 2003,
(from Table 26)

Bold figures are estimates of dependent variable (plot price per square meter [Reais])

	BRASÍLIA 2003	CURITIBA 2002	RECIFE 2003
Constant value, no paved road, no title and small plot (reais per square meter)	**426**	**87**	**53**
Value adjustment for having paved road (factor and reais per square meter)	2.79 => **1,189**	2.11 => **184**	1.89 => **100**
Value adjustment for having title (factor and reais per square meter)			1.21 => **64**
Value adjustment for having both paved road and title (factor and reais per square meter)		1.47 => **128**	
Value adjustment for having large plot (factor and reais per square meter)	.370 => **158**	.658 => **57**	
Distance value adjustment per kilometer from city center (factor and reais per square meter)	-.089 intercept value at 10 kilometers **175**	-.117 intercept value at 10 kilometers **27**	-.047 intercept value at 10 kilometers **33**

The second row of Tables 28 and 29 presents estimates of the effect of having a paved road on plot prices. There are two numbers in each cell. The first number is the shift effect (adjustment value) of having a paved road. For example, in the case of Brasília in 2003, the constant value is multiplied by 2.79 (a 179% increase) to estimate the adjusted price of a plot located at the city center, with a paved road, no title and small plot size. The estimated value is 1,189 reais. The effects of pavement (which should be thought of as a proxy for infrastructure) are very strong in all three cities. Presence of infrastructure adds a land price premium of 179% in Brasília, 111% in Curitiba, and 89% in Recife.

The third row of Tables 28 and 29 presents estimates of the effect of title on land prices. This effect shows up only in Recife and indicates

Table 29. Interpreted Regression Results:
Brasília, Curitiba and Recife, 2000 and 2001,
(from Table 27)

Bold figures are estimates of dependent variable (plot price per square meter [Reais])

	BRASÍLIA 2001	CURITIBA 2000	RECIFE 2001
Constant value, no paved road, no title and small plot (reais per square meter)		**86**	**56**
Value adjustment for having paved road (factor and reais per square meter)		2.14 => **184**	1.89 => **106**
Value adjustment for having title (factor and reais per square meter)			1.22 => **62**
Value adjustment for having both paved road and title (factor and reais per square meter)		1.49 => **128**	
Value adjustment for large plot (factor and reais per square meter)		.645 => **55**	
Distance value adjustment per kilometer from city center (factor and reais per square meter)		-.116 intercept value at 10 kilometers **27**	-.048 intercept value at 10 kilometers **53**

that title adds about 20% to the price of a plot. However, if we combine the effects of pavement and title, effects show up in Curitiba. As row four of Tables 28 and 29 indicate, the value adjustment for having both infrastructure and title increases plot prices by 47%–49%. It is interesting to note that, unlike pavement, title does not generate as consistent and large effects. While this result requires further exploration, it may be the case that Brasília's planning and regulatory system overwhelms the effects of title. Virtually all plots in the federal district have title, and the presence or absence of title is only relevant on the fringes of Brasília's metropolitan area. In Curitiba, title on its own does not generate statistically significant effects. Only when combined with infrastructure does the effect surface.

Here it may be the case that titled but unserviced plots have prices that are similar to untitled and unserviced plots.

The fifth row of Tables 28 and 29 provides estimates of the effects of plot size on plot price per square meter. In Brasília for 2003 and Curitiba for both 2000 and 2002 and in Recife for 2001 and 2003, the price of large plots per square meter is well below the per-square-meter price of smaller plots. This seems to reflect market experience elsewhere.

Finally, row six of Tables 28 and 29 provides estimates of the effect of location (measured in terms of distance from the city center) on plot prices. These adjustment factors, referred to as price gradients, estimate the percentage change in plot prices relative to increases in distance. For example, in the case of Brasília in 2003, for each one kilometer increase in distance from the city center, the price of a plot decreases by 8.9%. At a distance of 10 kilometers from the city, the constant price is reduced to 175 reais (versus 426 reais at the city center).At 10 kilometers from the center, the constant is worth only 41% of its city center value. In Curitiba, the gradient is -.117, and at 10 kilometers from the center, the constant is reduced to 27 reais (versus 87 reais)—it is worth only 31% of its city center value. In the case of Recife, the gradient is
-.047. At 10 kilometers, the constant is worth 33 reais—62% of its city center value.

Interestingly, the slope gradient for Curitiba is high in absolute terms (-.117), indicating that distance drives down prices more per kilometer than in either Brasília (-.089) or Recife (-.047). This seems counter-intuitive given Curitiba's reputation for an efficient mass transit system. The result may be more of a reflection of the relatively high wages in Curitiba and therefore the higher opportunity cost of travel time. Recife's low price gradient is most likely due to its lower incomes and lower opportunity costs of travel.

Conclusions

This report has presented the results of land market assessments in three Brazilian cities. There are several overarching conclusions that can be drawn from the effort. First, it is feasible to carry out such assessments. Second, they result in the compilation of socio-economic, land use and land price information that is useful for gauging the effectiveness of urban planning, infrastructure provision and land titling. Third, the results indicate that urban land market dynamics in less regulated cities (Curitiba and Recife) perform well and reflect patterns and trends found in other cities around the world.

Spatial patterns of urban development dramatically vary between the highly planned Brasília and the more market-driven cities of Curitiba and Recife. Average distance per capita in Brasília is more than double the levels of Curitiba and Recife. Data on formal housing stock patterns indicate that housing is abundant in the core areas of Curitiba and Recife—over half of Curitiba's stock is located within 10 kilometers of the city center, and in Recife, 40% is located within 10 kilometers. In contrast, less than 10% of Brasília's formal housing stock is located within 10 kilometers of the center.

Prices of residential land in suburban areas of Curitiba and Recife are in the 30–40 reais per square meter range. For plots of 400 square meters, this works out to between 12,000–16,000 reais (US$4,000–US$5,300). In the case of Brasília, significant land market distortions were identified. Population is forced to commute longer distances and land prices are about 5 times higher in suburban areas than in Curitiba and Recife. Plots in suburban areas of Brasília range from 150–200 reais per square meter. For 400 square meter plots, prices average 60,000–80,000 reais (US$20,000 to US$26,700).

With respect to infrastructure provision and its effects on land prices, the results indicate that infrastructure investment have significant positive effects on land values. The results in the three cities indicate that infrastructure provision can increase land prices by 89%–179%. This suggests that there is ample scope for financing infrastructure provision through property taxation, land value capture or other fiscal mechanisms.

With respect to provision of title, the evidence is less compelling. In the case of Recife, the analysis consistently identified statistically significant positive effects generated by titling. There, the provision of infrastructure increased land prices by approximately 20%. In the case of Curitiba, the joint provision of infrastructure and title increased prices by nearly 50%. Again, this suggests that there is scope for financing titling projects through some form of property taxation or value capture.

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