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Title: Assessing Green Gentrification in Historically Disenfranchised Neighborhoods: A longitudinal and spatial analysis of Barcelona

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Abstract: To date, little is known about the extent to which the creation of new municipal green spaces over an entire city addresses social or racial inequalities in the distribution of environmental amenities – or whether such an agenda creates new socio-spatial inequities through processes of green gentrification. In this study, we evaluate the effects of creating 18 green spaces in socially vulnerable neighborhoods of Barcelona during the 1990s and early 2000s. Combining OLS and GWR analysis together with a spatial descriptive analysis, we examined the evolution over time of six socio-demographic gentrification indicators in the areas in proximity to green spaces in comparison with the entire district. Our results indicate that parks built in parts of the old town and in formerly industrialized neighborhoods of Barcelona seem to have experienced green gentrification trends. In contrast, most economically depressed areas and working class neighborhoods with less desirable housing stock that are more isolated from the city center gained vulnerable residents as they became greener, indicating a possible redistribution and higher concentration of vulnerable residents through the city as neighborhoods undergo processes of urban (re)development.

Keywords: green gentrification; environmental gentrification; urban planning; urban sustainability; urban green spaces; revitalization projects; environmental equity; environmental justice; Barcelona.

Introduction

As de-industrializing and post-industrial cities turn toward redevelopment strategies focused on creating or improving green amenities, it is important to examine the impacts of these strategies through a broad lens. It is clear that urban green spaces provide numerous health, social, and ecological benefits. Specifically, green spaces

contribute to improved physical health by encouraging active lifestyles and creating localized conditions that reduce rates of disease associated with air pollution and noise (Chiesura, 2004; Groenewegen, Van den Berg, de Vries, & Verheij, 2006; Lee & Maheswaran, 2011; Gidlöf-Gunnarsson & Öhrström, 2007; Omid et al., 2015). Green spaces may also lead to stronger social connections among area residents and organizations by providing a meeting place to develop and maintain personal ties and regular interaction (Lee et al., 2011; Connolly et al., 2013). In part as a result of improved socialization, residents exposed to green space have a lower likelihood of being in poor mental health (Triguero-Mas et al., 2015). From a development perspective, abundant and high quality green spaces strengthen the identity of an area as an attractive and desirable place to work, live, and visit with upward effects on local economies and real estate values (Baycan & Nijkam, 2009; Dale & Newman 2009; Anguelovski, 2015). In terms of ecological benefits, urban green spaces increase biodiversity, improve storm water absorption, reduce urban heat island effects, and regulate climate emissions. In Barcelona, for example, recent research reveals that urban forests remove over 300 tons of air pollutants every year and prevent 5,000 tons of CO2 emissions from being released into the atmosphere (Baró et al. 2014).

Yet, the benefits of new or restored urban green amenities seem to be unevenly distributed. Studies conducted in cities in the United States reveal that the creation or restoration of green amenities is not always accompanied by an improvement in quality of life for *all* citizens (Gould et al., 2012; Goodling, Green & McClintock, 2015; Wolch et al. 2014; Curran & Hamilton, 2012; Checker, 2011; Gould & Lewis, 2017). Rather, these actions are sometimes part of a process that makes historically disadvantaged residents vulnerable to displacement (Pearsall 2010) and they are often executed with other urban

revitalization initiatives. While new green infrastructure is important for healthier and more livable neighborhoods, it may also lead to localized increases in housing costs, property values, and private capital directed at making areas reflect the preferences of privileged residents (Wolch et al. 2014; Quastel, 2009; Curran et al., 2012; Heynen, Kaika & Swyngedouw, 2006; Pearsall, 2008; Quastel, Moos, and Lynch 2012). The pathway by which green amenities become drivers of displacement is called environmental, ecological, or green gentrification. This process involves "the implementation of an environmental planning agenda related to public green spaces that leads to the displacement or exclusion of the most economically vulnerable human population while espousing an environmental ethic" (Dooling, 2009, p.630). In sum, a broad lens that includes environmental gentrification takes into account the ways in which urban greening may be positive for some but negative for others.

The specter of environmental gentrification raises a question for urban sustainability planning: Does the distribution of new environmental amenities become more or less equitable as cities implement greening agendas? This paper addresses this question through an analysis of the social impact of urban green spaces added to several neighborhoods in Barcelona, Spain over a 15-year period. Specifically, this study examines the distributional outcomes of 18 parks added to the city during the 1990s and early 2000s. It is, to our knowledge, the first city-wide quantitative study of green gentrification associated with parks creation. During this period, the amount of green space in Barcelona doubled when the municipality undertook several urban revitalization projects (Parcs i Jardins de Barcelona, 2007). Most of the new parks were built in Barcelona's low income neighborhoods where green spaces were scarce. We test whether green gentrification occurred in these areas by examining how proximity to the

new parks affected changes in house sale prices, income, educational attainment, country of origin, and age of the local population.

In the sections that follow, we present and contextualize our findings relative to the literature on environmental gentrification and the history of Barcelona. The first section describes the growing scholarly work on environmental gentrification. The second section gives a brief background of urban greening and revitalization in Barcelona during the 1980s, 1990s, and early 2000s. The third section describes our data and methodology for measuring the social effects of rapid greening in Barcelona. The fourth section outlines our findings, highlighting our primary finding that there is evidence of green gentrification around parks in the old industrialized areas of Barcelona (specifically the northeastern district of Sant Martí) and in a limited part of the historic city center (the Ciutat Vella district). The final section offers some concluding remarks and summarizes the contribution of our findings to the growing green gentrification debate within the urban sustainability literature

1. Literature: Recent developments in (green) gentrification

1.1. Defining and identifying gentrification

All gentrification trends embody essentially the same challenge. When a place that had been perceived as undesirable by those in the middle or higher end of the housing market becomes attractive for any of a number of reasons (e.g. global real estate pressures, reduction in crime, physical upgrades, proximity to cultural centers or jobs), affluent or middle-class buyers and investors may begin to see opportunity in that place. Once a critical mass of such buyers purchase property as an investment or a means of

improving their own quality of life, the perception of a “rent gap” in the area expands and more buyers are attracted. The result is that existing lower-income residents are displaced due to a rapid rise from historic rental and sale prices and a swift socio-cultural transition in the neighborhood (Clark, 1988; Smith, 1996). Ironically, the neighborhood “trendiness” that often accompanies this process goes against the preferences of most existing residents and gentrifiers alike.

While there are longstanding disagreements about how to precisely identify gentrification and its associated effects, most scholars working in this area agree that the core dynamics are closely tied to the process first described by Ruth Glass in the 1960s (Glass, 1964; Beauregard, 1986; Smith, 2002; Atkinson & Bridge, 2005). Glass observed a new urban gentry contributing to change in the physical and cultural character of working-class quarters, including area businesses, consumption habits, and internal relationships. As well, reflecting the fact that income and other class-based variables are highly correlated with race and ethnicity in many societies, most scholars find that gentrified neighborhoods tend to experience a marked increase in white populations (Hammel & Wyly, 1996; Bostic & Martin, 2003; Freeman, 2005). As a result of this competition for space, these neighborhoods may become microcosms of larger political disputes over social inequality when lower income residents and residents of color fight displacement by higher income and whiter populations (Newman & Wyly, 2006).

Since the 1990s, gentrification has intensified as a process and as a topic of research. Some scholars argue that during this period it became an overt strategy for city governments interested in revitalizing traditionally marginalized neighborhoods, often

in consortium with private capital and investors (Smith, 2002; Lees & Ley, 2008; Bridge, Butler & Lees, 2012). This move toward a formalized public-private redevelopment policy has contributed to the growth of "super-gentrification" related to global economic investment, "mega-gentrification" in the Global South, and "hyper-gentrification" in expensive real estate markets like Brooklyn, New York (Butler & Lees, 2006; Goh, 2011; Lees, 2012). Intensified gentrification as part of a global urban strategy is charted in the scholarly literature through case-based qualitative research, comparative quantitative analyses, and mixed methods approaches in order to understand the underlying effects on urban geography (Lees, 2000; Barton, 2016).

While researchers have emphasized that, when boundaries are drawn around gentrification processes based on purely quantitative analyses, they tend to be imprecise artifacts of data reporting standards, quantitative data remains the best basis for measuring relative changes across large areas over time. The general quantitative approach to such estimations is to measure change over time across a set of socioeconomic and real estate indicators at the neighborhood or census tract level. The common indicators measured include median income, race, ethnicity, age, level of educational attainment, poverty rate, professional status, home ownership rate, housing values, and rent (Hammel & Wyly, 1996; Bostic & Martin, 2003; Freeman, 2005; Heldcamp & Lucas, 2006; Walks & Maaranen, 2008; Gould et al., 2012; Barton, 2016). Because of data limitations, these indicators are usually measured at the relatively coarse census tract level or its equivalent. Less common quantitative indicators include changes in housing construction, home mortgage lending, social media usage, and number of new businesses such as coffee shops (Barton, 2016). While disagreements continue over which quantitative measures best reflect gentrification processes,

researchers have long argued that changes across several indicators – not just one variable – are needed in order to avoid oversimplification (Hammel & Wyly, 1996; Bostic & Martin, 2003). Through this approach of triangulating across several variables, which sometimes combines quantitative and qualitative data, there is a higher likelihood that what is being observed represents the full complexity of gentrification processes (Pearsall, 2010). At the least, triangulation demonstrates a more robust and comprehensive process of change than would a single indicator.

1.2. Green gentrification and urban sustainability planning

Most recently, a new body of research examines how urban sustainability planning and processes of city re-naturing are incorporated into public-private redevelopment strategies that intensify gentrification processes. This research demonstrates how green infrastructure serves as a catalyst for gentrification, and how the sustainability framework both facilitates and conceals this process. The literature, which is currently mostly situated in the United States and Canada, conceptualizes this phenomenon as green gentrification (Gould et al., 2009), ecological gentrification (Dooling, 2009), and environmental gentrification (Pearsall, 2010; Checker, 2011; Curran et al., 2012; for the few cases to date outside of North America see Sandberg, 2014; Schuetze & Chelleri, 2015). Gould and Lewis (2012, p.121) define green gentrification as the "urban gentrification processes that are facilitated in large part by the creation or restoration of an environmental amenity." What is at stake for scholars in this area is not only the processes by which lower income and non-white populations are systematically denied access to the benefits of urban life, but also the exclusion of the most economically vulnerable residents from access to the localized benefits of ecosystem services (Dooling, 2009; Ernstson, 2013).

Green gentrification literature highlights the social-ecological underpinnings of processes of urban exclusion and calls attention to the need to avoid a "post political" approach to urban sustainability (Swyngedouw, 2010; Keil & Whitehead 2012). While on the surface the provision of green infrastructure is a politically neutral goal that is often couched within consensual planning processes, in practice green space provision may subordinate social equity or public sector planning to lucrative real estate development (Bunce, 2009; Checker, 2011). Thus, green gentrification is an essential consideration for any urban sustainability model that seeks to simultaneously promote ecologically and socially responsible urban planning. Without such critical discourse, sustainability is likely to be reduced to a vehicle for promoting a green lifestyle that appeals only to wealthy, eco-conscious residents and adopts a technocratic approach to environmental problems (Checker, 2011; Anguelovski, 2015). In this circumstance, municipal representatives and sustainability advocates who uncritically accept calls for more urban green space may, possibly against their own intentions, create new socio-spatial inequities (Pearsall & Pierce, 2010).

1.3. Environmental gentrification dissected: The green space paradox

Research on environmental gentrification contributes to the extensive literature on inequitable access to green spaces in cities and environmental justice. Indeed, it has been shown that higher income and whiter populations have greater access to trees, parks and natural settings, urban public recreation resources, and maintenance funds for parks (Wolch et al., 2005; Dahmann et al. 2010, Pham et al. 2012). Urban reforestation programs also sometimes benefit only owner-occupied (and generally higher-income) neighborhoods (Perkins, Heynen, & Wilson, 2004). In contrast, low-income,

disadvantaged groups and people of color, especially in the United States, often occupy areas where green spaces are either scarce or poorly maintained (Heynen, Perkins & Roy, 2006; Anguelovski, 2015). Addressing such distributional inequities has become an urban planning priority, with many US cities developing new strategies to increase and restore green amenities in low-income areas (Curran & Hamilton, 2012; Wolch et al. 2014).

Despite the commitment from cities to address past inequities, the creation of urban green amenities in low-income areas generates a *green space paradox* (Curran & Hamilton, 2012). Neighborhood-scale case studies thus far indicate that the greater the number, size, and quality of urban green spaces in an area in transition, the more attractive and desirable it becomes, thus favoring the displacement of minority groups toward unwanted (and likely less green) areas (Pearsall, 2009; Dooling, 2009; Goodling et al., 2015). In the 1990s, the restoration of Brooklyn, New York's Prospect Park led to a massive increase in new construction in certain areas around the park and a corresponding change in the race and class composition of those areas toward a wealthier and whiter population (Gould et al., 2012). In the Harlem neighborhood of New York City, selective sustainability policies attracted investors to build high end housing and eventually displaced low income residents (Checker, 2011). In Portland, Oregon sustainability plans promoted green investment in the city core, ultimately contributing to the demarcation of racialized poverty (Goodling et al., 2015). In each of these cases, the green amenities were touted by real estate developers, public agencies, and local politicians as competitive advantages, placing the environmental and economic benefits of greening in tension with the social benefits. These results, though, have only been found in isolated examples of specific neighborhoods within studies

focused on competitive and entrepreneurial urbanism mostly in North America. No city-level (or larger) examination tests whether this trend holds across a wider geography and in other contexts. As a result, the robustness and transferability of these findings remain to be seen.

The green space paradox extends to efforts to merge economic growth priorities with environmental values in the remediation of formerly industrial sites. A wide range of literature focuses on the gentrification effects of locally undesirable land uses (LULUs) cleanup – especially brownfield sites – and of the ensuing sustainable urban projects. Numerous examples of environmental cleanup have been shown to make a neighborhood attractive for gentrification and displacement of the populations who suffered the consequences of industrial development, while richer homeowners capture the gains in their property assets (Banzhaf et al., 2006; Steil & Connolly, 2009; Essoka, 2010; Pearsall, 2010; Eckerd, 2011; Gamper-Rabindran, Shanti, & Timmins, 2011; Curran et al., 2012,; Pearsall, 2013; Anguelovski, 2015). These studies show that brownfield redevelopment can generate environmental gentrification by increasing the vulnerabilities of certain populations – especially the elderly – to stressors such as geographic displacement (Pearsall, 2009). Yet, attempts at conducting city-wide assessments of the impacts of environmental clean-up and associated green space creation on neighborhoods have mostly focused on indicators of potential displacement such as increased property values rather than actual displacement of residents (Immergluck, 2009; Pearsall, 2010).

Given the increasing evidence of a green space paradox, there are calls for developing new types of urban research on environmental inequalities (Schweitzer, 2007). Even

though scattered case studies have identified gentrification pressures in a specific neighborhood or community as a result of restored or new green amenities, no large-scale study has actually measured whether greener cities, or cities that have overtly adopted a strategy of urban greening, become more or less racially and socially equitable. Rather, scholarship is limited to the examination of demographic or real estate trends after specific site-based environmental remediation projects or to case studies of community resistance against fears of displacement (Pearsall and Anguelovski, 2016). There is much need for larger-scale research taking into account the entire process of urban greening, and demonstrating whether this process creates more social and racial inequities – or not – in the distribution of environmental amenities over an entire city.

This study begins to fill this gap in the literature by quantitatively testing the extent to which the implementation of a citywide greening agenda in Barcelona improved the equitable distribution of new environmental amenities or created new inequities. Our objective was also to focus on the production side of gentrification associated with urban green space in certain neighborhoods. Barcelona is an ideal case for such analysis because it embarked on an aggressive program to bring the social and ecological benefits of urban green spaces to all parts of the city beginning in the 1980s. As well, in the context of increased calls for a lower-carbon society, Barcelona is emblematic of many cities in Europe and the United States that developed sustainability plans with heavy emphasis on increasing or improving parks, forests, ecological corridors, streams, community gardens, and urban farms (Wolch, Bryne & Newell, 2014; Baycan et al., 2009). In the Barcelona case, the main objectives of the urban sustainability plan developed between 2002 and 2012 included enhancement of the city's natural heritage; protection of open spaces and biological diversity; and expansion of the number of

urban green spaces (Compromís Ciutadà per la Sostenibilitat 2002-2012). This plan, entitled *Citizen's Commitment to Sustainability*, is typical of urban sustainability plans at the time in that it defined broad principles and objectives, but relied heavily on enhancing green space as a concrete expression of abstract sustainability goals. In the study that follows, we analyze whether pursuit of these goals met the underlying intentions of the sustainability agenda.

2. Background: The transformation and greening of democratic Barcelona

In the 1970s, the legacy of Francisco Franco's dictatorship left many Spanish cities with a poor quality built environment and with enormous deficits in schools, cultural centers, health services, public transportation, and even basic infrastructure such as street paving, water, and sanitation (Saurí et al., 2009). Such deficits were apparent in all areas of Barcelona municipal services including public parks and gardens (El verd: plantejament i diagnostic verd, 2010). After the first municipal democratic elections of 1979, Barcelona's City Council decided to prioritize increasing the number of parks and gardens through implementation of new urban plans. During this time, green spaces were primarily designed to provide meeting places and playgrounds for children and elderly residents (Saurí et al. 2009). These spaces were emblematic of early post-Franco urban revitalization projects that were focused on addressing social needs; responding to residents' demands; and improving the quality of urban spaces and neighborhood plazas (See Image 1 below).

Image 1. Creueta del Coll Park (1976). *Source:* Barcelona City Council.

In 1986, when Barcelona was awarded the 1992 Olympic Games, a new stage of urban redevelopment began (Anguelovski, 2014). Barcelona's public green spaces shifted almost entirely toward the mega-event demands of the Olympics (Image 2). The City Council began to negotiate directly with developers that built the necessary infrastructure rather than with neighborhood groups about the design and placement of green and public space. During this period of "strategic urbanism," the social component present in the initial creation of green spaces during the early 1980s diminished (Monclús, 2003; Montaner, 2004; Anguelovski 2014). The new Olympic parks were designed as aesthetic amenities for tourism with relatively scarce opportunities for neighborhood-scale social interactions. They had fewer places for sitting and holding neighborhood meetings or other social and cultural activities (Saurí et al. 2009).

Image 2. (a) Port Olímpic Park (1992). *Source*: The Authors. **(b)** Poblenou Park (1992). *Source*: Barcelona City Council.

Following the 1992 Olympic Games, the third stage of post-Franco redevelopment was characterized by the City Council's efforts to leverage the newfound international appeal of Barcelona in order to grow real estate values and tourism. During most of the 1990s, public parks design and construction was strongly linked to economic development schemes, and often used private funds (Saurí et al. 2009; Montaner, 2004; Anguelovski, 2014). For local community groups, these spaces were seen as part of a "social cleansing" in the core of Barcelona meant to wipe out the material and symbolic identities of the traditional neighborhood groups (Garcia-Ramon et al., 2000) (Image 3), including neighborhoods such as El Raval. As a result, many activists in the historic center of the city resisted the emerging "Barcelona Model," which the City Council argued provided a balance between social needs and urban economic growth (Capel, 2005; Casellas, 2006; Saurí et al., 2009; Anguelovski, 2014;). For the activists, this type of urbanism ignored the daily challenges of life in Barcelona and displaced longtime residents in favor of global elites and tourists.

Image 3. Barceloneta Park (1996). *Source: The Authors.*

The fourth stage of the post-dictatorship redevelopment began toward the end of the 1990s, when the municipality focused on redeveloping the last of the large areas of formerly industrial space. The 2004 "Universal Forum of Cultures" was designed at this time as a business venture that created an international event center (Blanco, 2009). Also at this time, the Poble Nou neighborhood near the sea in the Sant Martí district, which had already seen large-scale development in the early 1990s, was targeted for a luxury residential project known as "Diagonal Mar." The project was anchored by the Diagonal Mar Park (Image 4) – built as the second largest public park in Barcelona – and contained expensive condominiums, three hotels, three office buildings, and a shopping mall. The Diagonal Mar Park was the central component of the project's sustainability strategy, but was widely criticized for being planned without citizen input and for its focus on aesthetics rather than social spaces (Anguelovski, 2014; Saurí et al., 2009).

Image 4. Diagonal Mar Park (2002). *Source:* Barcelona City Council.

While the creation of public parks and gardens in Barcelona in the 1980s emphasized repairing the social fabric of post-Franco Barcelona, by the beginning of the 1990s and especially after the success of the 1992 Olympic Games, public green spaces were designed to meet the needs of private developers and started to lose the link with neighborhood groups that grew out of the post-Franco neighborhood organizing movement. This transition culminated with the building of Diagonal Mar Park, in which designers neglected almost all social functions and imposed a type of urbanism that privileged upper class residents, large development groups, and the work of high end architects (Borja, 2004). Knowing this evolution, it is essential to understand how environmental amenities shape who benefits in the mid- and long-term from improvements in quality of life in Barcelona.

3. Data and Methods

3.1. Data

Our data collection focused on the period of Barcelona's redevelopment that ran from the time when the first Olympic Games parks were built in 1992 through the construction of the Sant Martí parks in 2004.[1] Within this period, the municipality built roughly 30 new parks and gardens (Santigosa, 1996). For this study, in order to assess whether residents from more socially vulnerable neighborhoods benefit over time from green space creation, we selected parks built within those neighborhoods with a per capita income below Barcelona's average that historically had poor access to green space. We assessed income through the use of public census data and consulted staff members from the *Institut Municipal de Parcs i Jardins de Barcelona* (Barcelona's Park and Gardens Institute) and the *Office for Green Spaces and Biodiversity* in order to understand the historic greening trends in neighborhoods. Based on the results, the spatial coverage of our study considers 5 contiguous districts (out of 10 within the city) that comprise the northeastern half of Barcelona (Figure 1). These districts contain 18 parks and gardens constructed during our study period. They include the historic center of the city within the Ciutat Vella District and the neighboring Sant Martí district, where Diagonal Mar park was constructed. Our study area also includes three districts that are traditionally working class residential areas of the city: Horta-Guinardó, Nou Barris, and Sant Andreu (Figure 1).

[1] We considered starting our study with the parks built in the mid-1980s, but quantitative data was only scarcely available for this period.

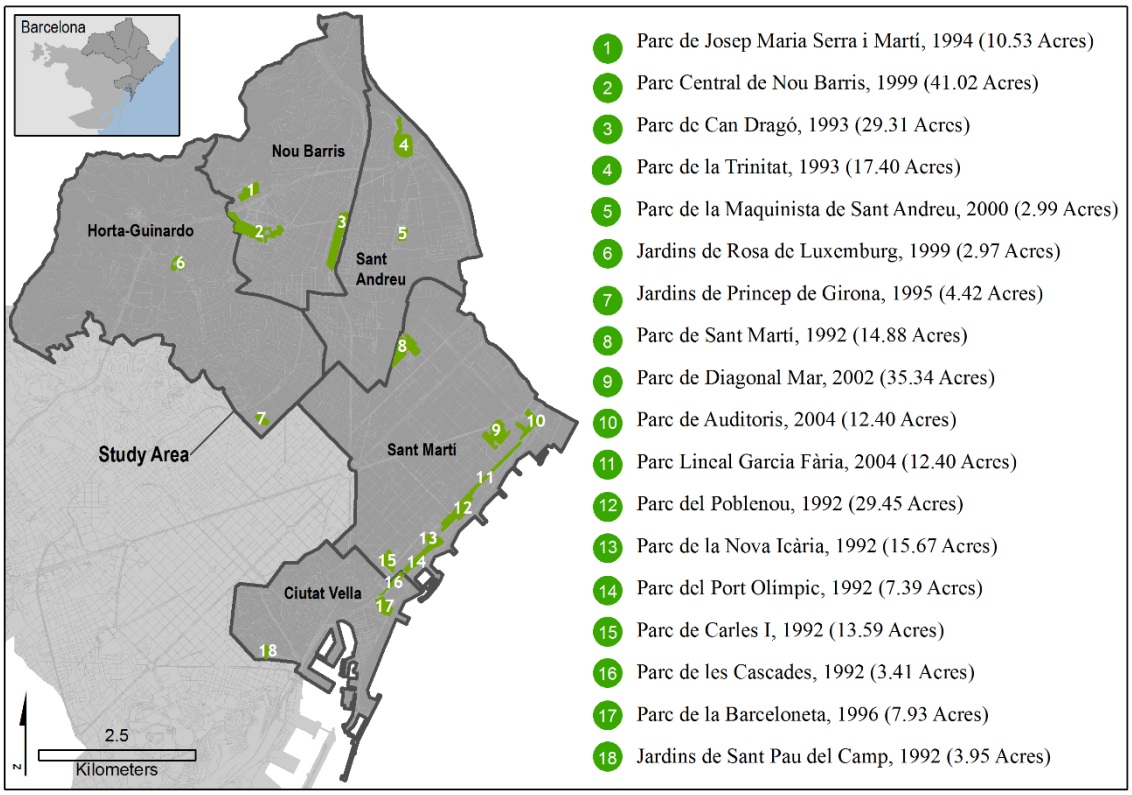

Figure 1. In green, parks built between the period 1992–2004 within the Ciutat Vella, Sant Martí, Sant Andreu, Nou Barris, and Horta-Guinardó districts.

In order to analyze possible gentrification trends in the areas surrounding the parks, we gathered the highest resolution data available. During our period of study, Barcelona's administrative structure was divided into the following territorial divisions (from largest to smallest): 10 districts, 73 neighborhoods, 248 small research zones (SRZ), and 1919 census tracts.[2] Data for all indicators were not available for each of these territorial divisions because of the multiple ways in which the City of Barcelona compiled and kept track of data. As a result, we gathered data at the SRZ level for home sale values and household income.[3] We gathered data at the census tract level on percent of population with a bachelor's degree or higher[4]; percent of population over 65 years old

[2] Residents' instruction level was gathered with a varying methodology. As a result, there were 1,582 census tracts for the year 1996 and 1,482 census tracts for the year 2006 regarding residents' instruction level.
[3] Home sale data available from 1992 to 2001. We used an index of family economic capacity for the years 1991 and 1996, and territorial distribution of household income for the years 2000, 2005 and 2008.
[4] Bachelor's degree data available for 1991, 1996, 2001, and 2004 to 2006.

living alone[5]; percent of immigrant population whose nationality is from the Global North[6]; and percent of immigrant population whose nationality is from the Global South.[7] We extracted this data from several published sources produced by municipal agencies. The population and household census data was obtained from the Statistics Department of the City of Barcelona. The municipality conducted a population census and registry of residents every 5 years during the 1990s and then changed its methodology in the 2000s. As a result, socio-demographic data is reported for the years 1991, 1996, 2001, and the period of 2004 to 2006. Data on home sale values was obtained from an annual publication called *El mercat inmobiliari a Barcelona,* produced annually from 1992 until 2001 by the Municipal Department of Fiscal Studies. These publications are the only known systematic analyses of real estate values in Barcelona available for the 1990s and 2000s. Our study period reflects quite homogenous growth patterns in housing values and in the influx of residents both from the Global North and South. It stops before the 2008 financial crisis (which brought losses in housing values and substantial emigration out of the city).

While home sale values, household income, and population with a bachelor's degree or higher are common variables within gentrification studies, the other variables reflect unique aspects of Barcelona in terms of context and available data. Barcelona is representative of Spain's high home ownership rate, which leads to very low residential mobility because people tend to stay in their homes for most of their lives. This limits vulnerabilities for displacement to those who are renting and those who can no longer afford their neighborhood amenities but cannot easily get elsewhere to get basic services.

[5] Age structure data available for 1991, 1996, 2000, and 2004 to 2008.
[6] Data available at Census Tract level for the 1991, 1996, 2000, and 2004 to 2008. Countries included: All European countries, United States and Japan. Canada or other Asian countries within the Global North are not included in this indicator since data for these countries are mixed with the other American or Asian Global South countries.
[7] Data available for 1991, 1996, 2000, and 2004 to 2008.Countries included: All African, Asian and Latin American countries, except Japan.

Thus, one key indicator population of displacement in Barcelona is comprised of the elderly living alone who are likely to be among the only populations that would be inclined to move because of rising costs and changing demographics in their area. Socially vulnerable elderly residents are also more likely to be renters according to staff members from the City of Barcelona.

Another particularity of measuring population movements in Barcelona is that data is not available on race or ethnicity. However, if race and ethnicity data is used in the context of gentrification studies to measure the extent to which those considered "other" within a city are displaced by real estate trends, a comparison of new arrivals from the Global North with those from the Global South is of interest for analogous reasons. In comparison with other EU countries such as France or the UK, Spain (and Barcelona in particular) has a much more recent history of diversified and intensified immigration from countries in the Global South, making this variable quite indicative of ethnic and racial diversity in the city.

The majority of the Global South immigrant communities came to Barcelona in the 1990s and early 2000s from Latin America (especially Ecuador, Bolivia, Colombia), North Africa (Morocco, Algeria, Nigeria, and Senegal) and Asia (especially Pakistan, China, and the Philippines). For instance, between 1991 and 2007, the number of Moroccan nationals increased from 1,727 to 13,314 throughout the city (Departament d'Estadìstica, Ajuntament de Barcelona). Most of those immigrants have a primary or secondary education and came for lower-wage work opportunities, which makes them quite vulnerable to displacement. In another example, 80% of Ecuadorian nationals have either a primary or secondary education diploma (Samper and Moreno, 2008). Ac-

cording to data from the Statistics Department from the City of Barcelona and from the Fundació Acsar (2011), a substantial portion of those residents live within our study area (Ciutat Vella (The Old Town), Sant Marti, Nou Barris, and Sant Andreu). In 2008, Global South immigrants from North Africa and Ecuador comprised most of the 39.7% of Ciutat Vella residents that were foreign born, joining others from Pakistan and the Philippines. Meanwhile, the majority of Global North immigrants (especially Italians, French, Germans, Romanians, British, Russians, and North Americans) came for high-wage work opportunities (except a sizable proportion of Romanians) or because of high-end real estate purchase and investment opportunities, and moved largely to neighborhoods such as the Born (in the Northern part of the old town) and Poble Nou, as well as several neighborhoods outside of our study area (Personal interviews with municipal staff (2015); Departament d'Estadica del Ajuntament de Barcelona). Indicative of the level of influx in these neighborhoods, between 1991 and 2007, the number of French nationals citywide increased from 1,994 to 11,447. These variables and trends, then, provide an admittedly imprecise but still valuable way of accounting for the lack of information on race and ethnicity in Barcelona.

3.2. Analysis Methods

In this study, we sought to understand whether the distribution of new environmental amenities became more or less equitable as Barcelona implemented its greening agenda through two analytic strategies. First, we examined how the housing and population trends changed over time near parks. Second, we used local and global regression techniques to parse out whether distance to parks is a causal driver of this change or whether

the observed differences over time are simply reflective of larger socio-demographic conditions.

We analyzed changes in housing and population indicators near parks by averaging the values for tracts or SRZ that overlap buffers around the 18 new parks and gardens in our study area at three distances of relative proximity to parks (100 meters, 300 meters, and 500 meters). For the purposes of analysis, we condensed parks that are clustered together and built at the same time into one buffer, yielding a total of 13 buffers areas reported in the results below. We also compared changes in the areas around parks with district-wide changes over the same period. We used varied study periods for each of the parks. For the starting point of the study period we used the data that coincides with the year of the park's creation (or the closest year for which data was available) and, for the ending point, we used the latest comparable data available. This method resulted in measurement of a 4- to 12-year period of change around each park, depending on when it was built and on data availability.

We also used local and global regression techniques to explore spatial variation in the relationship between proximity to the parks as an independent variable explaining various housing and population indicators including residents' instruction level, residents' nationality, elderly residents living alone, and household income level. The proximity to the parks was calculated using the Euclidean distance from each tract centroid or SRZ centroid to the nearest park boundary. We performed ordinary least squares (OLS) and geographically weighted regression (GWR) models for two years, 2000 and 2008 (note that we used 2001 and 2006 data for residents' instruction level due to data limitations). We could not perform the regression analysis with the data corresponding to percentage

of increase during a period because the municipality modified census tracts between years. In order to avoid introducing serious error into our analysis, we simply compared regression coefficients for the data as reported from 2000 with those from 2008.

We conducted an OLS regression using a model that assumes the relationships between socio-demographic variables and the distance to parks variable are the same across the entire space (spatial stationarity). Thus, OLS generates a single regression equation that best fits the variables. Because it is possible that this global measure is the best explanation of the relationship between parks and socio-demographics in Barcelona (i.e. space does not matter), we began with this OLS model:

$$\gamma = \beta_0 + \sum_{i=1}^{p} \beta_i \, x_i + \varepsilon$$

In the model, γ represents the dependent variable (a given socio-demographic indicator in this case), $\beta_0$is the intercept, $\beta_j x_j$ are the coefficient and the independent variable (distance to parks in this case), ε represents the error term, and p is the number of independent variables.

Next, to understand the effect of spatial non-stationarity (i.e. the variation in relationships and processes over space (Bailey & Gatrell, 1995)), we use the GWR technique, which is now increasingly employed in geography and other disciplines (Pearsall & Christman, 2012). GWR models test for variation in the relationship across space, and also capture the local variations by weighting closer observations greater than those further away. In this way, GWR provides a local model of the variable or processes researchers are trying to understand or predict by fitting a regression equation to every

feature in the dataset. The GWR equation differs from the OLS equation in that it incorporates the coordinates of each location:

$$\gamma_j = \beta_j(u_j, v_j) + \sum_{i=1}^{p} \beta_i\,(u_j, v_j)x_{ij} + \varepsilon_j$$

In the GWR model, j represents the location, and u_j, v_j represents the coordinates for each location which are multiplied by the local independent variable x_{ij}. In line with the typical goals of spatial regression analyses, we examine both OLS and GWR models to determine which model better predicts the relationship between the dependent variables (socio-demographic indicators) and the independent variable (distance to parks). Our expectation is that part of the variation can be explained by the spatial dependence of both the dependent and independent variables.[8] If this is the case, then distance to parks has a measurable geographic effect on the socio-demographic indicators.

In order to analyze the GWR results, we mapped the local R^2 values to further explore in which census tracts or SRZ proximity to parks (independent variable) has a greater explanatory power and we then mapped the coefficient values. Regression coefficients indicate the strength and type of relationship that the socio-demographic dependent variables have with proximity to parks. If an environmental gentrification process is occurring, we expect a relatively high explanatory value and negative coefficient values for all regressions except for the indicators "residents over 65 years living alone" and "resi-

[8] We used ArcGIS 10.2.2 software package to run OLS and GWR models. Both results were compared based on Akaike Information Criterion (AICc) and both the R^2 and adjusted R^2. Lower values of AICc indicate a closer fit to the data. The R^2 and the adjusted R^2 provide a measure of how well data are adjusted by the model, as the proportion of total variation of outcomes explained by the model. If a model was able to explain 100% of the variance, the fitted values would always equal the observed values and, therefore, all the data points would fall on the fitted regression line.

dents whose nationality is from the Global South." This expected trend would mean that the *closer* we move to the park, the *greater* the increase in household income, home sale values, education levels, proportion of residents from the Global North, and the greater the *decrease* in proportion of older residents living alone, and of residents whose nationality is the Global South.

4. Results: Temporal Change of Socio-Economic Conditions Around Parks

In this section, we present the results of analysis across five indicators of environmental gentrification. We analyze each indicator in the area around parks using 100 meter, 300 meter, and 500 meter buffers. We visualize the relative results from each buffer in the maps below and average the results across all three buffers in the tables. We also present the results of the OLS and GWR analysis for the two sample years under study: 2000 and 2008 (Table 1). In the first steps of the analysis, the results of the Global Moran's I applied to the OLS models demonstrated statistically significant clustering of almost all residuals. The residuals were significantly clustered (p-value<0.05) among all socio-demographic variables for the 2 years analyzed with the exception of residents over 65 years living alone which showed the non-clustering of residuals (p-value=0.19) by the year 2008 (Table 1). The results obtained from both models show that the GWR model presents a significant improvement over the OLS model as evidenced by the increase in the R^2 and the adjusted R^2 and the decrease in AICc (Table 1) in all socio-demographic variables for the two years analyzed.[9] The findings shown in Table 1 are discussed in

[9] The R^2 and the adjusted R^2 obtained from OLS models listed in table 2 explain less than 50 percent of the variance in the relationship between the socio-demographic variables and proximity to the parks,

more detail below for each variable.

		OLS		GWR	
		2000/01*	2008/06*	2000/01*	2008/06*
Residents with a bachelor's degree or higher*	R^2	0.011	0.0014	0.8	0.77
	Adj R^2	0.01	0.0004	0.76	0.72
	AICc	5546.7	7026.6	4510	5781.1
Residents over 65 years living alone	R^2	0.003	0.0018	0.5	0.004
	Adj R^2	0.002	0.0009	0.42	0.0007
	AICc	4918.7	10348.3	3332.1	10350.9
Immigrants from the Global South	R^2	0.007	0.006	0.72	0.61
	Adj R^2	0.006	0.005	0.67	0.54
	AICc	6668.3	7865.1	5605.7	7137.9
Immigrants from the Global North	R^2	0.00005	0.00002	0.62	0.74
	Adj R^2	0.0009	0.0009	0.58	0.7
	AICc	3380.5	6196.3	2523.2	4981.6
Household income level	R^2	0.001	0.002	0.6278	0.55
	Adj R^2	-0.005	-0.003	0.475	0.43
	AICc	1325.9	1286.2	1263.3	1218.8

Table 1. Results of OLS and GWR models for core gentrification indicators.

4.1. Does proximity to new parks contribute to an increase in the percentage of residents with a bachelor's degree or higher?

We expect in the areas just around parks experiencing environmental gentrification that the percent of residents holding a bachelor's degree or higher will increase as we get closer to the park. We see this pattern in all parks built in the Sant Martí, Ciutat Vella, and Sant Andreu districts (See Figure 2 and Table 2 below). The most impressive manifestation of demographic change is found in Sant Martí for the Poblenou Park,

whereas results of GWR show that the R^2 and the adjusted R^2 values seem to be able to explain between 40 and 80 percent of the variance for four of the five indicators. The low R^2 and the adjusted R^2 values obtained for the indicator "percentage of residents over 65 years living alone" show the lack of explanatory power that this indicator has in comparison with the other socio-demographic indicators.

where the percentage of residents holding a bachelor's degree or higher increased by nearly 28 points on average across the three nearby buffer areas around the park against only a 7.59% increase for the district as a whole. The nearby Cascades, Port Olímpic, Nova Icària and Carles I parks also experienced strong changes in comparison with their districts during the same period. Aditionally, for most parks in the Sant Martí, Ciutat Vella, and Sant Andreu districts, we see a progressive increase in the percentage of residents with a bachelor's degree or higher closer to the park; as expected, the area nearest to these parks saw the greatest change. Conversely, parks in Horta-Guinardó and Nou Barris largely saw declines in the percent of residents near the park with a bachelor's degree or higher. These declines were reflective of districtwide trends over the same time period.

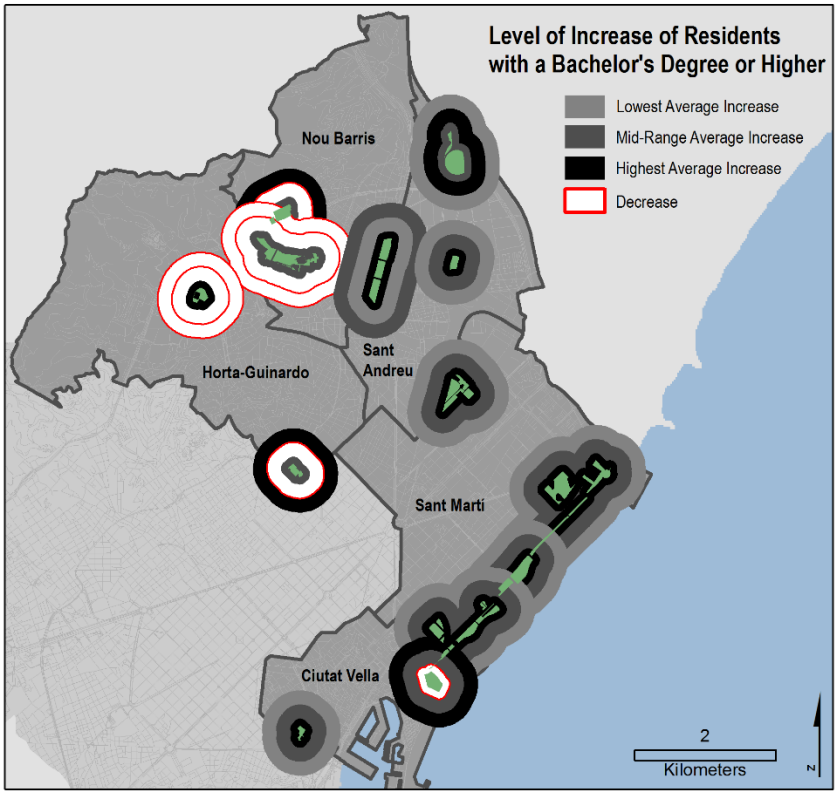

Figure 2. Level of increase of residents with a bachelor's degree or higher around parks. Note that the time periods used to analyze change varied according to when parks were built (see Table 1).

Time Period of Data	Park Name (Year Built)	District	Average Change Near Parks[1]	District
1991 - 2006	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	8.09%	10.52%
	Parc del Port Olimpic[2] (1992)	Sant Martí[3]	**27.92%**	7.59%
	Parc de Sant Martí (1992)	Sant Martí	4.20%	7.59%
	Parc del Poblenou (1992)	Sant Martí	**25.98%**	7.59%
	Parc de Can Dragó (1993)	Nou Barris	**4.56%**	3.02%
	Parc de la Trinitat (1993)	Sant Andreu	**10.29%**	5.21%
1996 - 2004	Jardins Princep de Girona (1995)	Horta-Guinardó	0.08%	2.18%
	Parc de la Barceloneta (1996)	Ciutat Vella	-2.69%	6.12%
	Parc Josep M. Serra i Martí (1994)	Nou Barris	0.12%	0.90%
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	-1.63%	-1.51%
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	**0.54%**	-1.03%
	Parc de la Maquinista (2000)	Sant Andreu	**8.48%**	-1.29%
2004 - 2006	Parc de Diagonal Mar (2002)[4]	Sant Martí	**4.69%**	1.37%

[1]These percentages represent the average values across the 100 meter, 300 meter, and 500 meter buffers.

[2]These figures include the combined averages for 4 parks in the Port Olimpic area. These include Parc del Port Olimpic (1992 Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These include Parc de Diagonal Mar (200 Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 2. Change in percentage of population with a bachelor's degree. Values in bold denote areas where there was more growth in residents with a bachelor's degree than for the district during the same time period.

Our regression results confirm that proximity to parks is inversely related to the residents' instruction level: As the distance to parks decrease, residents' instruction level increase. The OLS models explain very little of the variance in the percentage of residents with a bachelor's degree or higher ($R^2 < 0.01$), in contrast with the GWR models which explain up to 70% of variance for the two years analyzed (Table 1). The GRW model has the highest explanatory power, measured by the local R^2 (values range from 0.4 to 0.5), in some areas surrounding the parks located in the Sant Martí district,

such as Carles I, Nova Icària, Port Olímpic and Poblenou parks for the year 2001, adding the Diagonal Mar, Auditoris and Lineal parks for the year 2006, as well as in the Maquinista Park (Horta-Guinardó). In addition, the negative coefficients values for census tracts around these parks (Figure 3b and 3d below) show that the relationship between residents holding a bachelor's degree or higher and parks' proximity is negative. The GWR model had lower explanatory power in the census tracts around the remaining parks located within the Ciutat Vella, Nou Barris, Sant Andreu and Horta-Guinardó districts. Regression coefficients for the census tracts around those parks show a positive relationship between the explanatory variable and the instruction level. In sum, these findings confirm that the patterns observed in the buffer analysis are significant and that, according to changes in percent of population with a bachelor's degree or higher, the Sant Martí and Ciutat Vella districts seem to be likely areas of environmental gentrification.

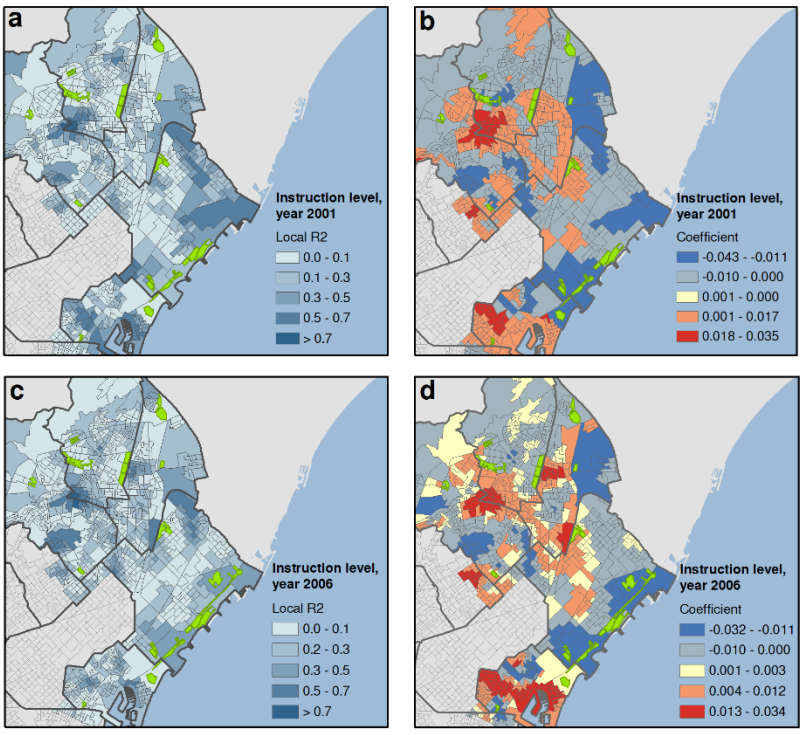

Figure 3. Geographically weighted regression results for percent of residents with a bachelor's degree (dependent) and distance to parks (independent) for 2001 and 2006.

4.2. Does proximity to new parks contribute to changes in the percentage of residents over 65 years living alone?

For areas experiencing environmental gentrification, we expect that the percentage change of residents over 65 living alone decreases closer to parks. Such a trend is occuring in all parks of the Ciutat Vella and Sant Martí districts (Figure 4 and Table 3). This trend does not occur at any other parks with the exception of Princep de Girona Garden in the Horta-Guinardó district. The strong spatial divide in the trend of population over 65 living alone supports the notion raised by the analysis of education variables that there is a separate process of demographic change happening along the parks near the coast from those located further inland. With regard to elderly population living alone, parks near the coast tend to show a greater decrease or slower rate of growth than the districts in which they are located. The Poblenou park is an especially strong example of this trend with a roughly 3% decrease over a short period.

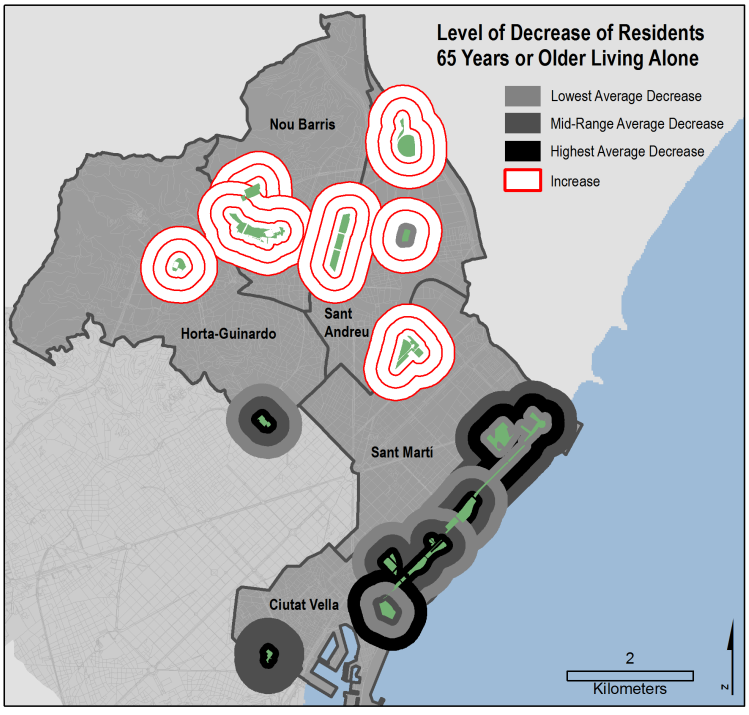

Figure 4. Percentage of increase of residents over 65 years living alone around parks and at district level in the four periods of time.

Time Period of Data	Park Name (Year Built)	District	Average Change Near Parks[1]	District
1991 - 2006	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	-1.64%	-2.18%
	Parc del Port Olimpic[2] (1992)	Sant Martí[3]	**-1.52%**	1.82%
	Parc de Sant Martí (1992)	Sant Martí	3.19%	1.82%
	Parc del Poblenou (1992)	Sant Martí	**-2.97%**	1.82%
	Parc de Can Dragó (1993)	Nou Barris	**2.34%**	2.83%
	Parc de la Trinitat (1993)	Sant Andreu	**0.03%**	2.18%
1996 - 2008	Jardins Princep de Girona (1995)	Horta-Guinardó	**-0.27%**	1.66%
	Parc de la Barceloneta (1996)	Ciutat Vella	-0.91%	-3.22%
	Parc Josep M. Serra i Martí (1994)	Nou Barris	2.43%	1.86%
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	1.30%	0.84%
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	0.87%	0.82%
	Parc de la Maquinista (2000)	Sant Andreu	**-1.38%**	0.45%
2004 - 2008	Parc de Diagonal Mar (2002) [4]	Sant Martí	**-0.18%**	0.06%

[1]These percentages represent the average values across the 100 meter, 300 meter, and 500 meter buffers.

[2]These figures include the combined averages for 4 parks in the Port Olimpic area. These include Parc del Port Olimpic (1992), Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These include Parc de Diagonal Mar (2002), Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 3. Change in percentage of population 65 years or older living alone. Values in bold denote areas where there was less growth in residents over 65 living alone than for the district during the same time period.

While there was no significant clustering of residents over 65 living alone by 2008, the increase in the R^2 and the adjusted R^2 and the decrease in AICc between the OLS and GWR models (Table 1) demonstrate the importance of considering proximity to parks as a non-stationary predictor of the concentration of this population. That is, the general validity of the geographically weighted model lends credence to the conclusion that the spatial divide between more coastal and more inland parks is significant (i.e. not a spatially random process). This result reveals a possible displacement of elderly residents from the central-east areas of Barcelona toward the northern, more affordable, neighborhoods in the city. As exploratory interviews with muncipal staff confirmed,

many residents from the old town (center east of the city) were displaced to the periphery during the 1990s and 2000s due to acute movements of real estate expropriation and/or speculation. It seems from these results that parks serve as an anchor for such demographic shifts.

4.3. Does proximity to new parks contribute to decreases in the percentage of residents from the Global South and to increases in the percentage of residents from the Global North?

If environmental gentrification is occurring, we expect to see an increase in the percentage of residents whose nationality is from the Global North and a decrease of residents whose nationality is from the Global South in the areas surrounding the newly created parks. Overall, immigration has increased rapidly in Barcelona over the period of our study. As a result, we found increases for both Global North and Global South immigrants around all parks. Despite this finding, it is important to note that in all of the Sant Martí district parks and in the Cascades Park of the Ciutat Vella district, the percentage of residents whose nationality is from the Global North increased far more relative to the overall district than other parks (Table 4). As well, the percentage of residents whose nationality is from the Global South tended to increase at lower rates than the overall district (Table 5).

Time Period of Data	Park Name (Year Built)	District	Average Change Near Parks[1]	District
1991 - 2006	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	5.95%	10.64%
	Parc del Port Olimpic[2] (1992)	Sant Martí[3]	**7.40%**	3.22%
	Parc de Sant Martí (1992)	Sant Martí	1.83%	3.22%
	Parc del Poblenou (1992)	Sant Martí	**6.90%**	3.22%
	Parc de Can Dragó (1993)	Nou Barris	1.68%	2.11%
	Parc de la Trinitat (1993)	Sant Andreu	**2.01%**	1.88%
1996 - 2008	Jardins Princep de Girona (1995)	Horta-Guinardó	**4.14%**	3.34%
	Parc de la Barceloneta (1996)	Ciutat Vella	9.32%	12.06%
	Parc Josep M. Serra i Martí (1994)	Nou Barris	1.68%	2.85%
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	2.46%	2.64%
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	2.22%	3.02%
	Parc de la Maquinista (2000)	Sant Andreu	1.74%	2.22%
2004 - 2008	Parc de Diagonal Mar (2002) [4]	Sant Martí	1.71%	2.19%

[1]These percentages represent the average values across the 100 meter, 300 meter, and 500 meter buffers.

[2]These figures include the combined averages for 4 parks in the Port Olimpic area.
These include Parc del Port Olimpic (1992), Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These include Parc de Diagonal Mar (2002), Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 4. Change in percentage of immigrant population from the Global North in the areas around parks and districts. Values in bold denote areas where there was more growth in immigrants from the Global North than for the district during the same time period.

Time Period of Data	Park Name (Year Built)	District	Average Change Near Parks[1]	District
1991 - 2006	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	**30.67%**	31.06%
	Parc del Port Olimpic[2] (1992)	Sant Martí[3]	**7.10%**	9.83%
	Parc de Sant Martí (1992)	Sant Martí	**7.58%**	9.83%
	Parc del Poblenou (1992)	Sant Martí	**7.97%**	9.83%
	Parc de Can Dragó (1993)	Nou Barris	**7.72%**	11.93%
	Parc de la Trinitat (1993)	Sant Andreu	15.24%	9.21%
1996 - 2008	Jardins Princep de Girona (1995)	Horta-Guinardó	**8.28%**	9.16%
	Parc de la Barceloneta (1996)	Ciutat Vella	**10.43%**	25.11%
	Parc Josep M. Serra i Martí (1994)	Nou Barris	**5.90%**	13.72%
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	**8.36%**	11.62%
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	**5.33%**	7.59%
	Parc de la Maquinista (2000)	Sant Andreu	**4.84%**	8.72%
2004 - 2008	Parc de Diagonal Mar (2002) [4]	Sant Martí	**1.72%**	2.86%

[1]These percentages represent the average values across the 100 meter, 300 meter, and 500 meter buffers.

[2]These figures include the combined averages for 4 parks in the Port Olimpic area. These Olimpic (1992), Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These in Mar (2002), Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 5. Change in percentage of immigrant population from the Global South in the areas around parks and districts. Values in bold denote areas where there was less growth in immigrants from the Global South than for the district during the same time period.

The OLS results for both residents whose nationality is from the Global South and residents whose nationality is from the Global North suggest that the OLS model very poorly fit the data ($R^2 <$ 0,005%). In contrast, the GWR model explains 72% and 61% of the (overall) variance in the percentage residents whose nationality is from the Global South and 62% and 74% of the variance in residents from the Global North, for the years 2000 and 2008, respectively.

The local GWR maps (Figure 5a) show that the census tracts around the parks with the best explanatory power regarding residents whose nationality is from the Global South (around 30% of the variance), are located around Barceloneta Park and Cascades Park in the Ciutat Vella district, and in the Carles I, Port Olímpic and Nova Icària parks in the Sant Martí district. The coefficient values around these parks reveal a positive relationship between residents whose nationality is from the Global South and proximity to parks (Figure 5b). A positive correlation between variables means that when the distance to parks increases, the percentage of residents whose nationality is from the Global South also increases. For the year 2008, the GWR model performs best in the census tracts around parks located in Sant Martí (with the exception of Poblenou and Lineal parks). The regression coefficients show higher positive values (Figure 5e) in the census tracts around these parks: The closer we move to those parks, the greater the decrease of residents whose nationality is from the Global South.

Regarding the residents from the Global North variable, for the year 2000, the greatest explanatory power and the negative coefficient values are found in the census tracts around the Barceloneta, Port Olímpic, Nova Icària and Poblenou parks (Figure 5c and 5d). For the year 2008, census tracts with a higher explanatory power and negative coefficients values are located around Poblenou and Sant Martí parks (Figure 5g and 5h). That is, as we move away from these parks, there is a decrease of residents whose nationality is from the Global North.

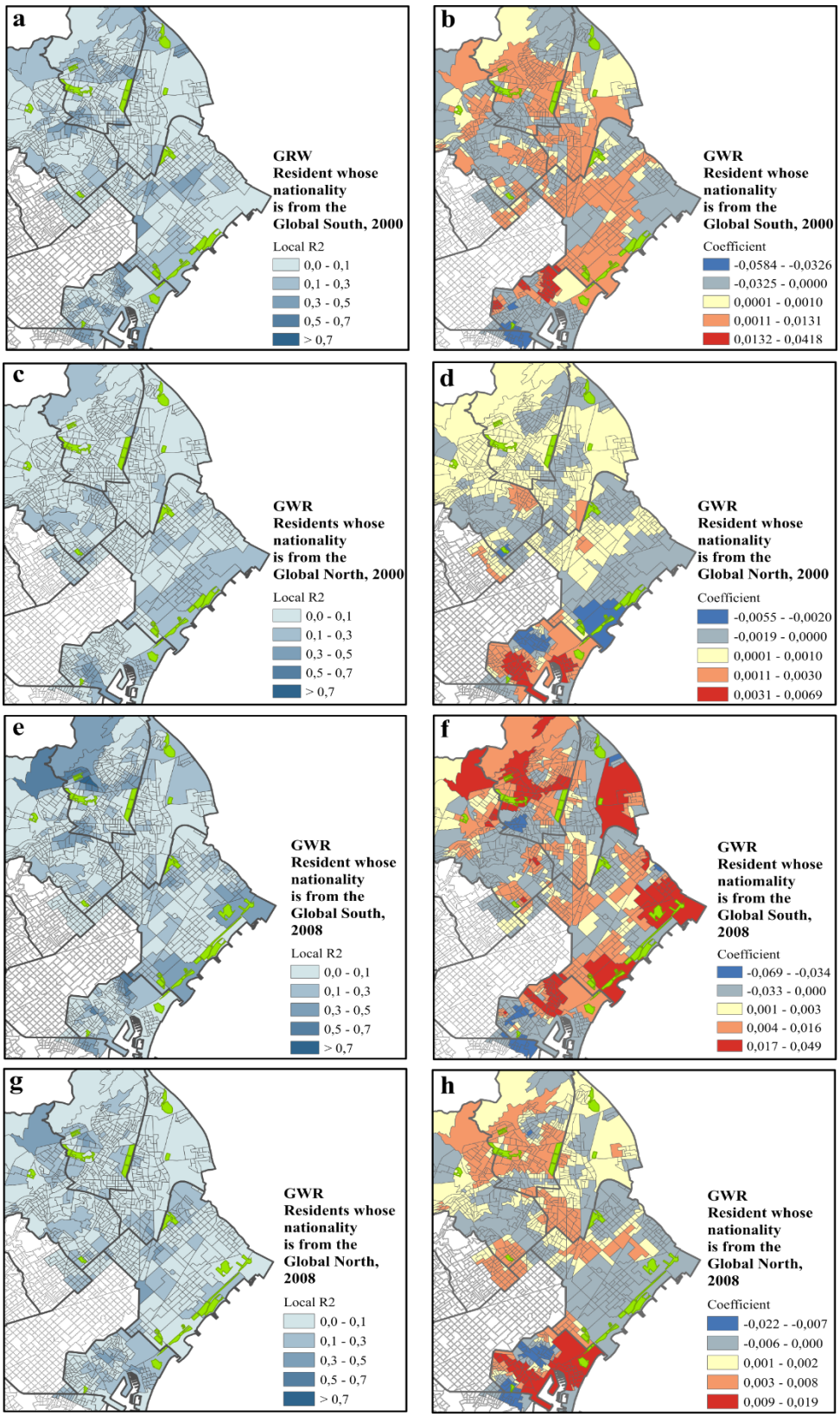

Figure 5. Geographically weighted regression results: percent of Global North / Global South immigrants (dependent) and distance to parks (independent) for 2001 and 2008.

4.4. Does proximity to new parks contribute to changes in household income level?

If environmental gentrification is occurring, we expect to see an increase in household income relative to the district as a whole for the areas in close proximity to parks. Our analysis shows that the buffer areas around parks located in the Sant Martí district and around the Cascades Park in the Ciutat Vella district experienced the greatest increase in household income levels (Figure 6). While we have a gap in comparable income data due to a change in the methodology used by the city which required us to exclude three parks from the income analysis (Table 6), it is clear from the data we do have that some areas near parks experienced markedly high change in income of residents. Specifically, the area immediately surrounding (100 meter buffer) the Port Olímpic parks and Poblenou Park saw a 26.7% and 20.5% increase in family income respectively. These were compared to a 2.8% increase in the Sant Martí district as a whole (where these parks are located) over the same time period. Relative to changes around other parks, these increases in family income were considerably higher.

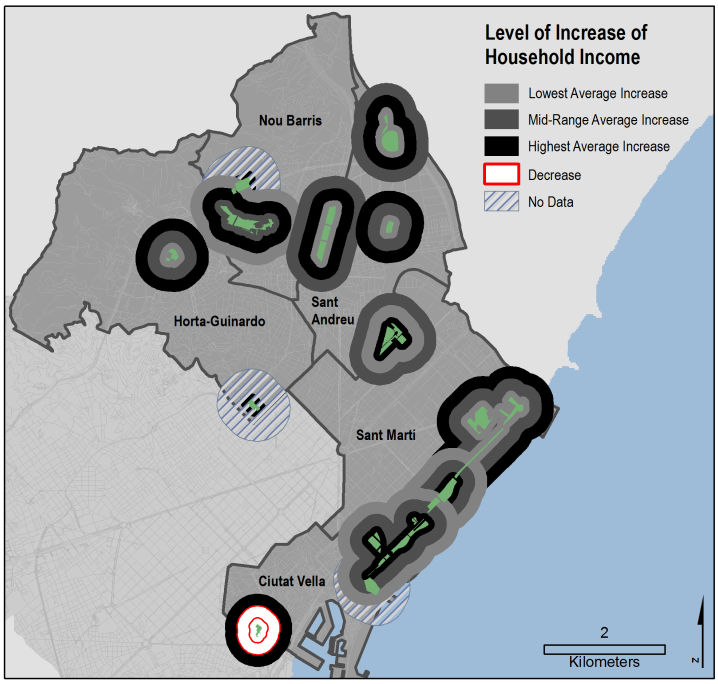

Figure 6. Percentage of increases in household income around parks and at district level in the four periods of time.

Time Period of Data	Park Name (Year Built)	District	Average Change Near Parks[1]	District
1991 - 1996	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	**9.24%**	-0.15%
	Parc del Port Olimpic[2] (1992)	Sant Martí[3]	**19.21%**	2.80%
	Parc de Sant Martí (1992)	Sant Martí	1.14%	2.80%
	Parc del Poblenou (1992)	Sant Martí	**14.42%**	2.80%
	Parc de Can Dragó (1993)	Nou Barris	1.34%	2.71%
	Parc de la Trinitat (1993)	Sant Andreu	**5.08%**	1.10%
1996 - 2004	Jardins Princep de Girona (1995)	Horta-Guinardó	NO DATA	NO DATA
	Parc de la Barceloneta (1996)	Ciutat Vella	NO DATA	NO DATA
	Parc Josep M. Serra i Martí (1994)	Nou Barris	NO DATA	NO DATA
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	**10.46%**	6.99%
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	3.88%	7.13%
	Parc de la Maquinista (2000)	Sant Andreu	0.79%	4.92%
2005 - 2008	Parc de Diagonal Mar (2002) [4]	Sant Martí	**4.20%**	2.10%

[1]These percentages represent the average values across the 100 meter, 300 meter, and 500 meter buffers.

[2]These figures include the combined averages for 4 parks in the Port Olimpic area. These include Parc del Port Olimpic (1992), Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These include Parc de Diagonal Mar (2002), Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 6. Percent change in family income by distance from park and district. Values in bold denote areas where there was more growth in family income than for the district during the same time period.

The spatial statistical models reinforce the importance of these parks as a driver of increased family income. The OLS models barely explain the variation in household income level ($R^2 < 0.001$) for the two years analyzed, signifying that global processes not accounting for space do not explain the variance in household income level. Meanwhile, the GWR model explains up to 62% of the variance in household income for the year 2000 and up to 50% for the year 2008 (Table 1). The SRZ around parks in the Sant Martí district have the greatest explanatory power for the first year analyzed (Figure 7a).

For the second year, the Sant Martí district parks and the Trinitat Park have the highest explanatory power, with R^2 around 0.3 (Figure 7c). In addition, the relationship between household income values and distance to parks is strongly negative in all the SRZ surrounding the Sant Martí district parks, for both years 2000 and 2008 (Figure 7b and 7d): As we approach parks, there is significant increase of household income level.

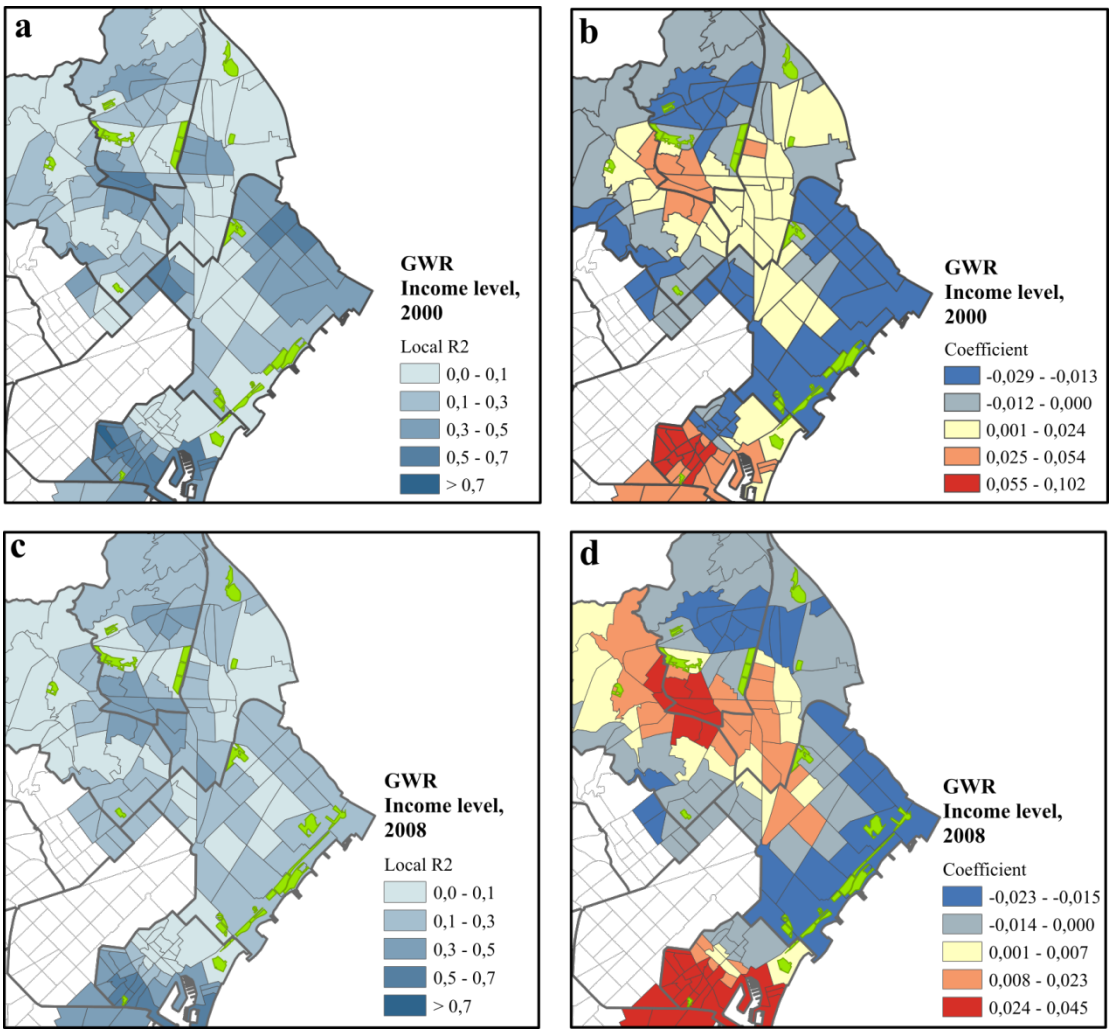

Figure 7. Geographically weighted regression results: household income (dependent) and distance to parks (independent) for 2001 and 2008.

4.5. Does proximity to new parks contribute to changes in home sale values?

In terms of home sale values, we see an interesting trend that runs counter to the

changes over time for other variables around parks and perhaps points toward a different effect of parks on home sale values. It is important to note that our data is incomplete in this category due to a gap in data collection by the municipality for the early 2000s, which limited our ability to compare across time for 4 park areas (Table 7). However, the data we do have shows that, in contrast with the other variables tested, only parks in the historically working class districts of Horta-Guinardó, Sant Andreu, and Nou Barris generated increases in home sale values around the perimeter that were greater than those for the district as a whole. Specifically, the Princep de Girona Gardens (Horta-Guinardó district), Can Dragó Park (Nou Barris district), and Trinitat Park (Sant Andreu district) underwent the most significant increases compared to the overall district. In the 100 meter area around these parks, home sale prices increased between 78% and 87%. Meanwhile these districts only saw between a 56% and 66% increase over the same time period.

The same trend did not hold for the park areas near the coast where population demographics did change quite dramatically. In these areas, home sale values started from a somewhat higher point when the parks were built. Home sale prices near parks in the Sant Martí district rose between 62% and 76% compared with a 96% rise districtwide. The same held for the Ciutat Vella district (the historic city center), which saw greater than 100% increases across the two time periods studied but had lower increases directly next to the new parks (note that the area next to Barceloneta Park is largely commercial making the low increase in home sale prices difficult to interpret). This counter-trend likely demonstrates that when it comes to home sale values there are more important factors than proximity to parks for the Ciutat Vella and Sant Martí districts. It is also important to note that the rebranding of these areas from a real estate

perspective began in the early 2000s, meaning we may not be seeing the full home sale price effect in our limited data. In these areas, parks are an amenity that younger, wealthier, and more educated buyers choose to be near but they are not necessarily the primary driver of increased home values. This stands in contrast to areas that have not experienced as significant changes in demographics where parks appear to be primary interventions in the real estate markets that increase home sale values nearby faster than for the district as a whole.

Time Period of Data	Park Name (Year Built)	District	Change Near Parks	District
1992 - 2000	Jardins de Sant Pau del Camp (1992)	Ciutat Vella	76.79%	107.76%
	Parc del Port Olimpic[1] (1992)	Sant Martí[2]	71.97%	95.63%
	Parc de Sant Martí (1992)	Sant Martí	62.42%	95.63%
	Parc del Poblenou (1992)	Sant Martí	75.59%	95.63%
	Parc de Can Dragó (1993)	Nou Barris	**84.68%**	56.37%
	Parc de la Trinitat (1993)	Sant Andreu	**77.96%**	65.97%
1996 - 2004	Jardins Princep de Girona (1995)	Horta-Guinardó	**86.51%**	65.73%
	Parc de la Barceloneta (1996)	Ciutat Vella	16.04%	101.63%
	Parc Josep M. Serra i Martí (1994)	Nou Barris	**58.69%**	56.25%
2000 - 2008	Parc de Nou Barris (1999)	Nou Barris	NO DATA	NO DATA
	Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	NO DATA	NO DATA
	Parc de la Maquinista (2000)	Sant Andreu	NO DATA	NO DATA
2004 - 2008	Parc de Diagonal Mar (2002)[3]	Sant Martí	NO DATA	NO DATA

[1]These figures include the combined averages for 4 parks in the Port Olimpic area. These include Parc del Port Olimpic (1992), Parc de les Cascades (1992), Parc de la Nova Icària (1992), and Parc de Carles I (1992).

[3]Note that some of these park areas extend into the Ciutat Vella District.

[4]These figures include the combined averages for 3 parks in the Diagonal Mar area. These include Parc de Diagonal Mar (2002), Parc Lineal Garcia Fària (2004), and Parc dels Auditoris (2004).

Table 7. Percent change in the average of median home sale values for all small research zones immmediately surrounding parks and the median value for the district. Values in bold denote areas where there was more growth in median home sale value than for the district during the same time period.

4.6. Where is environmental gentrification occurring in Barcelona?

In order to determine the parks and gardens that appear to be associated with green gentrification (and thus have followed the trends we expect), we assigned one point to parks with buffer areas that outpaced their districts for a given indicator and added the points to form a composite score from the five indicators above (Table 8). For bachelor's degrees, we identified parks with greater increases than the district for the same period of time in any buffer areas. For eldery population living alone, we identified parks with greater decreases than the district for the same period of time in any buffer areas. For the immigrants from the Global North variable, we identified parks with greater increases than the district for the same period of time in any buffer areas that also did not have greater increases than the district for residents whose nationality is from the Global South. In short, this variable identifies parks with above average increases in Global North populations *and* below average increases in Global South populations. Finally, because we are missing data for income or home values for some parks, but have one or the other for all parks, we use income as the fourth variable and use home values as a proxy when income is not available. Therefore, a score of 4 would imply gentrification is occurring near parks across all indicators measured here. As well, had there been any indication from the GWR analysis that spatially controlled models were less predictive than global models, we would have disqualified that variable as a measure.

Park Name (Year Built)	District	Bachelor's Degree	65 or Older Living Alone	Global North	Income	Home Sales	Total
Jardins de Sant Pau del Camp (1992)	Ciutat Vella	0	0	0	1	0	1
Parc de la Barceloneta (1996)	Ciutat Vella	1	1	0	0	0	2
Jardins Princep de Girona (1995)	Horta-Guinardó	0	1	1	0	1	**3**
Jardins de Rosa de Luxemburg (1999)	Horta-Guinardó	1	0	0	0	0	1
Parc de Can Dragó (1993)	Nou Barris	1	0	0	0	1	2
Parc Josep M. Serra i Martí (1994)	Nou Barris	0	0	0	0	1	1
Parc de Nou Barris (1999)	Nou Barris	1	0	0	1	0	2
Parc de la Trinitat (1993)	Sant Andreu	1	0	0	1	1	2
Parc de la Maquinista (2000)	Sant Andreu	1	1	0	0	0	2
Parc de Sant Martí (1992)	Sant Martí	0	0	0	0	0	0
Parc del Poblenou (1992)	Sant Martí	1	1	1	1	0	**4**
Parc de Diagonal Mar (2002)	Sant Martí	1	1	0	1	0	**3**
Parc del Port Olimpic[1] (1992)	Sant Martí	1	1	1	1	0	**4**

Table 8. Overall green gentrification indicator scores for parks within the study area. Values in bold denote areas where strong or moderate green gentrification seems to have ocurred.

Using these indicators, we find that several parks in the Sant Martí and Ciutat Vella districts including the Poblenou Park and the Port Olímpic parks experienced strong environmental gentrification (4 out of 4 rating). These parks were built in a time of significant urban revitalization associated with the Olympic Games. In addition, the Diagonal Mar parks in the Sant Martí district experienced moderate environmental gentrification (3 out 4 rating). Likewise, the Princep de Girona Garden in the southern area of the Horta-Guinardó district got a 3 out 4 rating, which is due, most likely, to its proximity to the more desirable and commonly understood to be gentrified Gracià neighborhood. The GWR findings support these areas as those where distance to parks is a significant predictor of the given indicator, suggesting that these findings are not random artifacts of other geographic processes. All other parks located in the northwestern zone of Barcelona and in parts of the Ciutat Vella district did not produce green gentrification trends according to our results (0 to 2 out of 4 rating). Figure 8 below summarizes the results of the descriptive analysis.

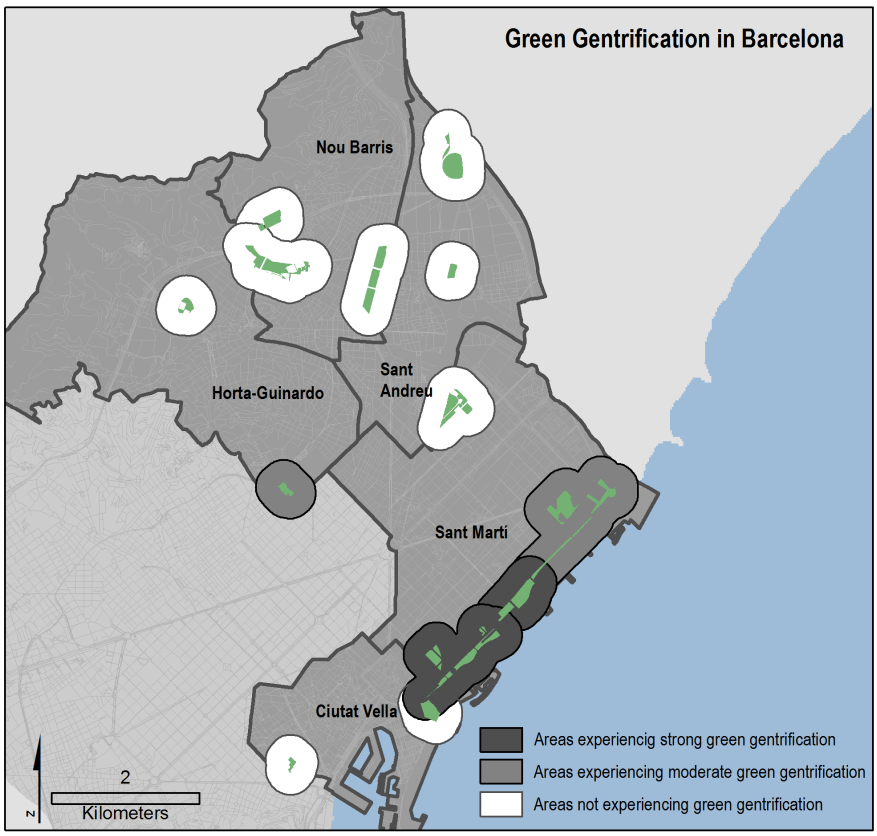

Figure 8. Areas where strong, moderate, and no green gentrification seem to be occurring.

5. Discussion and conclusion.

In this study, we tested the extent to which the implementation of a greening agenda and the creation of new parks and gardens in historically underserved neighborhoods made the distribution of new environmental amenities more equitable – or whether such an agenda has created new inequities. Our paper contributes to the literature on green gentrification by exploring the relationship between newly created parks in distressed areas of a large global city (Barcelona) and socio-demographic characteristics generally associated with gentrification. Through this research, we also add to the nascent body of research on OLS and GWR regressions and their applications to gentrification studies. The comparison and application of these regression models demonstrated if and where spatial relationships with parks mattered, thus allowing us to see if the trends in the data

were significantly related to the introduction of parks and reflective of environmental gentrification.

In contrast to previous green gentrification research, which tends to focus on a single urban site or neighborhood (i.e., Gould and Lewis, 2017) and examines whether the presence of one green amenity may be associated with gentrification, the geographic area of this study includes a large portion of a city, and our conclusions combine spatial descriptive analysis with regression analysis. Our GWR regression results indicate that the proximity to a park variable has a greater explanatory power (than OLS models) among the residents' instruction level, residents' nationality and household income level variables and a fairly strong explanatory power for the "residents over 65 years living alone" variable.

Our descriptive and spatial analyses reveal the presence of a green space paradox in several areas under analysis: Green gentrification seems to have occurred in the census tracts and small research zones around most of the parks built in the Sant Martí district, one park built in the Ciutat Vella in 1992 (the parks Cascades analyzed with the Port Olímpic parks buffer), and the Princep de Girona Garden (Horta-Guinardó district) built in 1995. The areas around these parks experienced an above average increase for their district in residents with a bachelor's degree or higher (except in Princep de Girona Garden), residents from the Global North (except Diagonal Mar[10]), household income or home sale values, and a decrease in the population over 65 living alone. Furthermore, the GWR results reveal that the higher local R^2 values among all parks are located around those parks.

[10] Note that Diagonal Mar is known to have attracted a very substantial number of rather wealthy expatriates from Europe and the US. It is likely that our buffers averaged away these increases and that our data is from a time period that is just before these increases.

It is important to note that such socio-demographic changes have been accompanied or followed by revitalization projects promoted and sponsored by the Municipality of Barcelona and by private developers over the same period of time. For instance, in the Sant Martí district, and most especially the neighborhoods where many new parks are located, large urban renewal projects were implemented (Saurí, Parés & Domene, 2009). One case in point is the "22@" plan which is converting a formerly industrial area into a leisure and residential neighborhood as well as a center for new business and IT investment. Clearly, these parks are anchors for wider redevelopment agendas that helped bring about the green gentrification we observe.

As for the parks in the remaining parts of the Ciutat Vella district and the northwestern portion of Barcelona, our analysis results suggest that census tracts and SRZ around parks did not experience green gentrification trends. The northwestern portion of the city is a long-time working class residential area with a strong presence of immigrants and older migrants from other regions of Spain, especially in the Nou Barris district. In those areas, while urban revitalization projects also took place in the 1980s and 1990s, they were not as visible, publicized, and implemented over as large of a scale as in the northeastern part of the city. Much of the housing stock in these neighborhoods comes from the Franco era and the late 1970s; it is of lesser quality and likely not as attractive for potential gentrifiers (and real estate re-developers) as the more recent or historic housing stock. Those neighborhoods are also more isolated from cultural amenities in the city center and suffer from greater territorial stigmatization due to their higher proportion of lower-income or working-class residents.

It is worth highlighting that the results for the old district of Ciutat Vella are mixed. Areas surrounding the Barceloneta Park and Sant Pau del Camp Garden have not undergone green gentrification, as both the descriptive and regression analyses show. The Sant Pau del Camp Garden is a very small space located in the Raval neighborhood in one of the densest areas of Barcelona, and the Barceloneta Park is located in an area that is only partially residential (it is also surrounded by railway tracks and office buildings), which makes our results difficult to interpret. Yet, the Parc de les Cascades (one of the Port Olímpic parks), a breathier and greener park located between Ciutat Vella and Sant Marti districts, seems to show strong green gentrification trends. It is likely that spaces with complex land uses like most in the Ciutat Vella district are best understood through qualitative analyses.

In sum, our study indicates clear green gentrification trends in several historically underserved areas of Barcelona. It also reveals that the impacts of park creation in socially vulnerable neighborhoods depend on their context of creation, setting, and overall built environment. In Barcelona, it seems that green gentrification has occurred in parks located in more desirable neighborhoods such as the old industrial (and waterfront) areas within the Sant Martí and Ciutat Vella districts or in the southern area of Horta-Guinardó. In parks located in extremely dense distressed neighborhoods such as the Raval in Ciutat Vella, or in neighborhoods with a semi-old building stock associated with the dictatorship or early transition projects, green gentrification appears to not have taken place.

Additionally, several areas surrounding many of the Ciutat Vella parks and northwestern districts of Barcelona have gained more residents whose nationality is from the Global

South as well as retiree residents living alone over the years, which means that the creation of new parks and gardens seems to have benefited more vulnerable residents over the years and increased their access to environmental goods. However, as some of our exploratory interviews revealed, it is possible that those residents were pushed out and displaced from other neighborhoods where gentrification occurred, such as the Ciutat Vella district (old town) or Sant Martí. Previous studies of population movements and urban changes in Barcelona have already identified such trends and revealed the exclusion, displacement, and isolation of socially vulnerable residents – especially the elderly – due to real estate speculation and urban redevelopment in Barcelona's central area (Anguelovski, 2014). Some of our exploratory interviews have also confirmed this hypothesis.

Furthermore, the North-Western neighborhoods are also less well connected to the center of the city; they have parks in close proximity to highways; and the overall housing and public equipment infrastructure is of lower quality than other parts of the city. Some of them, especially Nou Barris, have been particularly affected by home foreclosure and budget cuts in social welfare support. In other words, residents might have greater access to green space but not to other socio-environmental goods that would also contribute to higher well-being and livability. Barcelona illustrates a form of green goods polarization and re-segregation –privileged residents living in greener and desirable neighborhoods versus socially vulnerable groups confined into greener yet socially fragmented and isolated neighborhoods.

The identification of such socio-spatial dynamics and flows create new challenges and

opportunities for gentrification research: Future studies should attempt to track displacement and population reconfiguration through an entire urban area and take into account that, while the most historically underserved and marginalized neighborhoods might benefit from newly created green areas, the concentration of historically marginalized groups displaced from gentrifying neighborhoods to those neighborhoods (such as the northwestern districts of Barcelona) might increase. Such population flows might then create new forms of socio-spatial segregation. Even though residents might well benefit from a new park or garden, they might also become more isolated from former social networks, support systems, resources, or transportation connections from which they benefited in their former neighborhood. Future studies should also take note of the somewhat anomalous results for home values, which highlight the importance of triangulating across multiple variables. These results also raise the point that parks may fuel, but not primarily drive gentrification processes. Finally, future studies should seek to expand methods like GWR that help to parse out the causal role of parks and other green infrastructure in processes of gentrification.

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