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What predicts the demand and sale of vacant public properties? Urban greening and gentrification in Chicago

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ABSTRACT

Many post-industrial U.S. cities have developed programs to promote the greening of publicly-owned vacant lots, including initiatives in which homeowners can purchase nearby lots and turn them into yards or community gardens. These initiatives can result in greener landscapes in marginalized communities, but we know little about the spatial patterns of vacant land disposition and whether demand for and sale of publicly-owned lots are stronger in gentrifying neighborhoods. We examined the Chicago Large Lot Program and used neighborhood sociodemographic, environmental, and safety factors to predict the demand and sale of vacant lots. We found that the demand for Large Lots was significantly higher in tracts showing early signs of gentrification between 2000 and 2015 (those with higher increases of college graduates and White residents) and for tracts located closer to downtown. Also, the percentage of Large Lots sold was significantly larger in areas closer to downtown and farther from Lake Michigan but not associated with gentrification, which might be due to neighborhood political forces seeking to retain public control of vacant lots in gentrifying neighborhoods. Although other studies show that urban greening precedes gentrification, our findings suggest that the demand for urban greening might also follow early gentrification.

1. Introduction

Many post-industrial U.S. cities have high amounts of vacant land in their urban cores due to wealthy White residents moving to suburban areas after World War II and, more recently, the loss of manufacturing jobs (Németh & Langhorst, 2014; Newman, Bowman, Jung Lee, & Kim, 2016; Newman, Gu, Kim, Bowman, & Li, 2016; Newman, Park, Bowman, & Lee, 2018). Vacant land is a particularly severe issue in Midwestern cities, which are home to about half of the country's vacant residential lots (Newman, Bowman, et al., 2016). Several of these cities, including Detroit and Chicago, have launched vacant lot greening programs to foster the revitalization of high-vacancy residential neighborhoods experiencing high crime and low social capital, and other programs to foster residential development on vacant lots (Heckert & Kondo, 2018; Schilling & Logan, 2008). Research to date on selected greening programs has shown that greened vacant lots can provide benefits such as added recreation space, lower crime, improved public health outcomes, and higher property tax revenue (Branas et al., 2011; Dewar, 2006; Heckert & Kondo, 2018; Heckert & Mennis, 2012; Kondo, Hohl, Han, & Branas, 2016; Stern & Lester, 2020). Thus, urban planners and civic groups are increasingly looking to vacant lot revitalization in high-vacancy cities as "the new urban green," which can improve the quality of life of residents living in marginalized areas (Heckert, 2015; Pearsall & Lucas, 2014, p. 121).

But broader investigations on the social benefits of urban greening also show that these benefits are rarely equitably distributed (Wolch, Byrne, & Newell, 2014). A growing literature has shown that some urban greening efforts, including the construction of new parks and greenways, can spark "environmental gentrification" (Anguelovski, 2016; Immergluck & Balan, 2018; Rigolon & Németh, 2018, 2020). Environmental gentrification is characterized by an influx of new residents – who tend to be college-educated, upper-income, and often White – to previously undervalued areas due in part to the establishment of environmental amenities, and in this sense, some greening efforts *precede* the influx of new residents (Anguelovski, 2016; Anguelovski, Connolly, Masip, & Pearsall, 2018; Rigolon & Németh, 2020). Specifically, a recent study in ten U.S. cities found that new greenway parks that include trails and new parks located near downtown have fostered gentrification (Rigolon & Németh, 2020). The increase in rents and property taxes following the construction of some

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green spaces can contribute to the displacement of some longtime, low-income residents of color (Anguelovski, 2016; Goossens, Oosterlynck, & Bradt, 2019). Even people of color who are not displaced by environmental gentrification might experience other negative outcomes, such as being stigmatized and marginalized in new green spaces (Harris, Rigolon, & Fernandez, 2020; Harris, Schmalz, Larson, & Fernandez, 2020).

The relationships between "cleaned and greened" vacant properties and gentrification have been understudied. Understanding such relationships can inform strategies for redeveloping high-vacancy neighborhoods to arrest population loss and prevent the displacement of their most vulnerable residents (see Newman et al., 2018). Although some researchers have speculated that greened vacant lots might not lead to environmental gentrification the way formal parks do (Rupprecht & Byrne, 2018), others have suggested that greened vacant properties trigger environmental gentrification by increasing the value of nearby residential properties (Anderson & Minor, 2017; Draus, Roddy, & McDuffie, 2014). Studies in Philadelphia support this latter claim by finding that greened vacant lots were linked to increased property values for nearby residential units (Heckert, 2015; Heckert & Mennis, 2012).

The processes to green vacant properties, including changes in land ownership, may influence the connections between gentrification and urban greening. In particular, several "side yard" programs in the U.S. rely on the sale of city-owned vacant lots to people who own property on the same block to address urban vacancy issues and enhance the greening of marginalized neighborhoods (Crauderueff, Margolis, & Tanikawa, 2012; Ganning & Tighe, 2015). Framed as privately-led greening initiatives (Hackworth & Nowakowski, 2015), the purchasers of city-owned vacant lots can enlarge their yards, create community gardens, and in some cases build new housing (Crauderueff et al., 2012; Ganning & Tighe, 2015). Many side yard programs sell vacant lots at an extremely low price, such as one dollar (City of Chicago, 2020; City of Louisville, 2017; City of Milwaukee, 2017; City of Muskegon, 2013) or less than $250 (City of Toledo, 2017; Cuyahoga Land Bank, 2017; Detroit Land Bank Authority, 2014). Thus, resident-led greening and beautification in high-vacancy neighborhoods can accomplish both personal and community goals (Stewart et al., 2019).

But selling a diverse range of properties all for the same low price could also lead to an unbalanced pattern of demand and sales, as not every publicly-owned vacant lot in a given city has the same market value. In general, we know that different neighborhood sociodemographic (e.g., race/ethnicity, cycles of gentrification and out-migration), environmental (e.g., access to amenities), and safety (e.g., crime incidents) characteristics influence the demand for residential properties (Crompton & Nicholls, 2020; Harris, 1999; Immergluck &

Table 1
Descriptive statistics for census tracts.

	Mean (sample)	SD (sample)	Range (sample)	Mean (city)
Large Lots				
Demand (DV)	1.09	1.17	0.1–6.91	–
Percent sold (DV)	15.71%	14.74%	0%–56.25%	–
Available lots	37	30.99	10–181	–
Total applications	30.86	28.96	1–184	–
Sociodemographic factors				
Median household income	$26,995	$9026	$12,036–$56,908	$50,434
Percent college graduates	12.19%	8.45%	0.5%–45.7%	36.5%
Percent NH White	2.32%	3.19%	0%–17.78%	32.3%
Percent NH Black	86.98%	17.04%	11.57%–100%	30.6%
Median gross rent	$864	$180	$364–$1336	$987
Median home value[c]	$132,076	$46,537	$53,300–$265,000	$225,200
Percent renters	66.05%	17.24%	17.5%–94.8%	55.89%
Percent NH White homeowners	3.79%	7.28%	0%–57.38%	60.90%
Change in income 00-15[a,b,c]	+$1945	$7923	−$12,766–+$37,743	+$10,954
Change in percent college graduates 00-15[a]	+4.25%	6.93%	−7.7%–+34.97%	+8.9%
Change in median gross rent 00-15[a,b]	+$433	$120	+$67–+$690	+$450
Change in home value 00-15[a,b]	+$37,514	$37,979	−$166,180–+$166,179	+$73,573
Change in percent minorities 00-15[a]	−0.92%	2.46%	−15.71%–+4.57%	+0.85%
Environment				
Percent vacant housing units	24.74%	9.07%	5.83%–48.42%	12.69%
Percent vacant parcels	25.66%	11.85%	8.07%–73.05%	13.04%
Distance from CBD (miles)	6.45	3.06%	2–15	5.53
Rail station within ½ mile (dummy)	0.23	0.42	0–1	0.19
Tract on the west side (dummy)	0.30	0.46	0–1	–
Presence Large Lots previous sales (dummy)	0.45	0.5	0–1	0.12
Percent households in public housing	2.88%	7.81%	0%–40.5%	1.94%
Population density (people per acre)	17.20	7.80	0.66–39.84	29.72
Distance from Lake Michigan (miles)	3.87	1.72	0–7.5	3.32
Park in the census tract (dummy)	0.66	0.47	0–1	0.59
Large park within ¼ mile (dummy)	0.53	0.50	0–1	0.42
Employment Access Index	63,110	33,590	21,132–206,493	103,474
Safety				
Crimes per acre	3.76	2.07	0.11–11.58	2.66
Violent crimes per acre	0.36	0.21	0.006–1.08	0.21
Property crimes per acre	0.81	0.37	0.04–2.39	0.88

Notes. All data for the sample refer to census tracts with at least 10 available Large Lots; n = 124. Except for data describing change (2000–2015), crime per acres in 2016, and households living in public housing in 2016, Employment Access Index for 2016, all other sociodemographic data are from the 2012–2016 ACS. NH = non-Hispanic.

[a] Variables describing gentrification.

[b] Not adjusted by inflation.

[c] Expressed in $1000 in the regression models.

Smith, 2006; McMillen & McDonald, 2004; Troy & Grove, 2008). Also, as a study of vacant land in New Orleans showed, residents of affluent neighborhoods may be more likely to purchase city-owned vacant properties than residents in low-income areas (Ehrenfeucht & Nelson, 2013). Besides this study, however, there is a lack of research on the demand and sale patterns of publicly-owned vacant land in U.S. cities.

1.1. The present study

The primary goal of this study is to examine which census tract-level sociodemographic, environmental, and safety characteristics predict property owners' demand for vacant lots and their sale patterns in the City of Chicago's Large Lot Program. Given what we know from previous work on greening and gentrification, we anticipate that property owners' demand and sale of vacant lots will be higher in areas showing key indicators of gentrification – those areas with comparatively large increases of White, college-educated, and affluent residents. Although mounting evidence indicates that gentrification *follows* the creation of some green spaces (Anguelovski et al., 2018; Rigolon & Németh, 2020), the extent to which gentrification might also *precede* urban greening is unknown. We expect gentrification to also precede greening because evidence suggests that new wealthy residents of gentrifying neighborhoods have successfully advocated for green investments that primarily serve their needs, such as dog parks (Grier & Perry, 2018; Hamilton & Curran, 2013). Examining whether gentrification precedes greening can advance the literature on environmental gentrification by clarifying how neighborhood demographics might influence subsequent greening initiatives.

We hypothesize that demand and sale of Large Lots will be higher in census tracts at the early stages of gentrification (Hypothesis 1.1 for demand and 1.2 for sale). Our study focuses on areas of Chicago's south and west sides, which are the targets of the Large Lot Program. In these areas, census tracts do not show advanced stages of gentrification due to their high vacancy rates, their generally low access to public amenities, and stigma associated with them (see Table 1 below). Here, we define tracts at the early stages of gentrification as those which have experienced comparatively high increases in the percentage of college graduates and White residents, but have yet to see substantial rises in housing prices and residents' incomes (Bates, 2013; Hackworth & Smith, 2001; Kerstein, 1990). In other words, neighborhoods at the early stages of gentrification see the influx of individuals who are "highly-educated but only tenuously-employed or modest-earning professionals" (e.g., artists, recent college graduates), most of whom are White, before more substantial development occurs and wealthier new residents move in (Bates, 2013; Beauregard, 1990; Hackworth & Smith, 2001; Kerstein, 1990; Rose, 1996, p. 134).

In addition, we hypothesize that the demand and sale of Large Lots will be higher in places with more desirable environmental characteristics and higher safety. Specifically, we expect demand and sale to be positively associated with shorter distances from downtown (Hypotheses 2.1 and 2.2, demand and sale, respectively), lower housing and land vacancy rates (Hypotheses 3.1 and 3.2), and lower crime rates (Hypotheses 4.1 and 4.2; see Crompton & Nicholls, 2020; Harris, 1999; Immergluck & Smith, 2006; McMillen & McDonald, 2004; Troy & Grove, 2008).

We also recognize that contexts for vacant lot demand and sale may differentially vary across urban neighborhoods and not follow a generalizable pattern (see Heckert & Kondo, 2018). A secondary goal of this study is to shed light on reasons for potential divergent patterns between demand and sale of vacant lots in Chicago's Large Lot Program. Thus, we explored possible explanations for those divergent patterns by analyzing qualitative data on the sale process for Large Lots. Evidence from this study aims to provide insight to policymakers and urban planners on strategies to implement vacant lot greening programs to maximize the potential for equitable outcomes for longtime residents.

Fig. 1. Example of a "cleaned and greened" vacant lot in Chicago's Large Lot Program used as a community garden.

2. Chicago's Large Lot Program

To address the issues associated with its more than 11,000 city-owned residential vacant parcels, the City of Chicago (2020) launched the Large Lot Program in 2014. One of the goals of this program, which grew out of the Green Healthy Neighborhoods plan (City of Chicago, 2014), is to promote the greening of city-owned residential vacant properties in the city's south and west sides, which have high shares of low-income Black residents and are characterized by high land vacancy. In this program, the City has been selling city-owned residential vacant lots to property owners who own land on the same block for just one dollar (City of Chicago, 2020). Owners of lots purchased through the Large Lot Program can use these properties to expand private yards, start community gardens or playgrounds, or even build housing units (City of Chicago, 2020) – see Fig. 1 for an example of a greened lot. Lots sold through this program – hence referred to as "Large Lots" – have an average size of 3135 square feet (approximately 291 square meters), which is about the same size as a standard lot in Chicago (3125 square feet). To achieve a minimum level of care, owners of Large Lots are required to mow the grass and fence the lots (if not adjacent to their original lots). Owners also need to pay property taxes for their newly purchased Large Lots. Further, to preclude the transfer of land to developers for real estate speculation, new Large Lot owners need to retain ownership for at least five years (City of Chicago, 2020).

As of 2019, the City of Chicago completed seven rounds of sales of Large Lots. The program started in 2014 with approximately 400 Large Lots sold in the Greater Englewood area, which is one the lowest-income and highest-vacancy communities in the city, and the East Garfield Park neighborhood (City of Chicago, 2020). The sixth round of sales, by far the most extensive, started in fall 2016 and included a much broader range of neighborhoods with city-owned vacant properties, comprising neighborhoods that saw some investment before the Large Lot Program was implemented, and that round of sales resulted in selling approximately 800 additional Large Lots by April 2018 (City of Chicago, 2020).

For each round of sales, the city-owned vacant lots zoned as residential are made available for sale within certain areas. After property owners submit applications to purchase lots, the city can approve or deny sales. Denials can be linked to insufficient documentation, failure to pay past-due taxes or fees, or to plans to dedicate certain properties to public use in the future (Chicago Department of Planning and Development, personal communication). If more than one property owner applies to purchase the same lot, the city gives precedence to the owner of the adjacent lot (City of Chicago, 2020).

We focused on Chicago's Large Lot Program for three reasons. First, Chicago has removed affordability barriers to the sale of publicly-owned vacant properties by selling lots for just one dollar (City of Chicago, 2020). Second, Chicago has recently experienced differential rates of redevelopment across low-income communities of color, representing gentrification and disinvestment processes within the same city (Betancur, 2011; Duda, Percel, & Smith, 2017). Although some Latino and Black neighborhoods on the west and near south sides are gentrifying, probably due to their closer proximity to downtown and their access to rail transit, other majority-minority areas are still heavily disinvested and losing population (Betancur, 2011; Duda et al., 2017). Such variability makes Chicago's Large Lot Program a compelling case study to uncover the connections between gentrification and urban greening in the context of vacant lot repurposing.

Third, two recent studies we conducted show that resident-led efforts in the context of the Large Lot Program have contributed to the beautification and greening of previously dilapidated properties in ways that would enhance environmental justice in high-vacancy communities (Gobster, Hadavi, Rigolon, & Stewart, 2020; Stewart et al., 2019). In the first study, we surveyed Large Lot owners from the initial round of sale (response rate 71%, N = 197) and found that 77.7% and 55.8% of respondents considered keeping the lot "neat and clean" and improving "the attractiveness of [their] lot" as extremely important reasons to buy a Large Lot, respectively (Stewart et al., 2019). Conversely, only 18.3% and 15.2% of respondents saw "investment for future resale" and "building housing on it" as extremely important reasons to buy a Large Lot, respectively. In the second study, we conducted a systematic visual assessment of landscape changes made by owners of the same properties purchased in the first study (N = 424 lots), using field audits. We did not find variation in the percentage of land cover with buildings on it before (2011–2014) and after the sales (2015–2016), but we discovered statistically significant increases in the percent of lots with gardens (6.8% before and 18.8% after) and in the percent of lots with mature trees in good condition (5.7% before and 21.2% after) (Gobster et al., 2020). Our results are confirmed by data from the City of Chicago, showing that among the 1246 lots sold through September 2018, Large Lot owners requested only 16 building permits (1.2%; Ramos & Ali, 2018). These findings show that, in the early stages of ownership, Large Lot owners are more interested in greening and beautifying their lots than using them to generate revenue.

3. Methods

We conducted a sequential quantitative-dominant mixed-methods study, following a quantitative-qualitative-quantitative sequence (Leech & Onwuegbuzie, 2009). We began the study with multivariate regressions to predict demand and sale (primary goal; quantitative), and finding divergent patterns, analyzed focus group transcripts and reviewed information from public media to identify possible explanations (secondary goal; qualitative). And because those explanations hinted at divergent spatial patterns in the ways Large Lot sale might follow demand, we then ran a geographically-weighted regression (GWR) to examine in which neighborhoods demand was more strongly associated with vacant lot sales. The design is sequential because our quantitative results from multivariate regressions informed the purpose of our qualitative analyses, which in turn informed the second quantitative analysis (GWR); the design is quantitative-dominant because the regression analyses respond directly to the upfront literature review and hypotheses, reflecting a greater weight in assessing the research outcomes (Leech & Onwuegbuzie, 2009). The qualitative findings help clarify the quantitative results in ways that bring complementary insight for explanation (see Greene, Caracelli, & Graham, 1989).

3.1. Quantitative methods

3.1.1. Data sources

We relied on several secondary data sources to operationalize variables for our models. We obtained geospatial data at the census tract level from the United States Census Bureau (2017) for 2015 and 2016 (American Community Survey, ACS 2011–2015 and 2012–2016, 5-year estimates) that characterizes socioeconomic status, race and ethnicity, and housing prices, tenure, and vacancy. We also collected data from the Longitudinal Tract Data Base (LTDB) describing the same sociodemographic and housing variables for 2000 (Logan, Xu, & Stults, 2014), which we used to calculate changes in sociodemographic and housing values between 2000 and 2015 (see below). We used LTDB data for 2000 due to changes in census tract geographies between 2000 and 2010. LTBD data provide good estimates of sociodemographic variables collected in the 2000 U.S. Census *translated* to 2010 census tract geographies, which match with 2011–2015 ACS data (Logan et al., 2014). Further, we obtained geospatial data from the City of Chicago's (2018) open data portal describing parcels, building outlines, neighborhoods, rail transit stations, parks, and crime statistics for the year 2016. Data describing the geography of Large Lots including their sale status were collected from the Large Lot Program's website (City of Chicago, 2020) for Large Lots sold in 2014 and 2015 and from the city's Department of Planning and Development for Large Lots that were part

of the sixth and largest round of sales (2016–2018). Finally, we obtained data describing public housing units in 2016 from the U.S. Department of Housing and Urban Development (2017) and a measure of access to jobs, the Employment Accessibility Index, from the Center for Neighborhood Technology (2017).

3.1.2. Measures

3.1.2.1. Dependent variables. The two dependent variables were the demand and sale of Large Lots. We operationalized the demand for Large Lots as the average number of applications per lot in a census tract, which is the total number of applications in a census tract divided by the number of available Large Lots in the same tract. The demand variable takes into account that a single Large Lot might receive several applications from multiple property owners. We operationalized sales as the percentage of Large Lots sold in a census tract (i.e., the number of Large Lots sold divided by the number of available Large Lots). The Large Lots that were not sold comprised those that did not receive any applications and those for which applications were rejected.

To calculate these two dependent variables, we only used Large Lot data pertaining to the 2016–2018 round of sales. We chose not to consider previous sales to compute our dependent variables because the number of available Large Lots in each census tract has varied during different rounds of sales. Yet we included one dummy variable that describes whether a census tract comprised Large Lots sold in previous rounds.

3.1.2.2. Independent variables. The independent variables included census tract-level data describing sociodemographic factors, environmental features, and safety characteristics (see Table 1 in the Results section). We developed these three categories based on previous conceptualizations of the factors impacting neighborhood desirability and gentrification (Chapple et al., 2017; Choi, Van Zandt, & Matarrita-Cascante, 2018; Freeman, 2005; Hwang & Sampson, 2014; Rigolon & Németh, 2019). Sociodemographic variables, measured through the 2016 American Community Survey, include socioeconomic status (median household income and percentage of people 25 or older with at least a bachelor's degree), race and ethnicity (percentages of non-Hispanic White and non-Hispanic Black residents), housing costs (median gross rent and median home value), the percentage of renter-occupied housing units, and the percentage of homeowners who are non-Hispanic White.

Measures of gentrification, which are part of our sociodemographic variables, included changes in the following variables between 2000 and 2015: median household income, percentage of people 25 or older with at least a bachelor's degree, median gross rent, median home value, and percentage of people who identify as a racial or ethnic minority. In particular, building on Bates' (2013) work, we defined tracts experiencing early gentrification as those with higher increases in the percentage of people 25 or older with at least a bachelor degree and higher decreases in the percentage racial/ethnic minority people, but not higher-than-average increases in household income and housing prices (see also Hypotheses 1.1 and 1.2). Specifically, we included racial/ethnic composition in our definition of gentrification because in Chicago race and ethnicity have played a central role in the process of gentrification (Betancur, 2002, 2011). Accordingly, two recent reports included the percentage of racial/ethnic groups in their definition of neighborhood change for Chicago and Los Angeles, suggesting that race and ethnicity are central to gentrification dynamics in those cities (Chapple et al., 2017; Nathalie P. Voorhees Center, 2014). We assessed gentrification between 2000 and 2015 to account for neighborhood change in the years preceding the start of the Large Lot sales. We choose 2000 as a starting point because beginning in the late 1990s, most U.S. cities have undergone a "third-wave gentrification" promoted by public agencies building new attractive public spaces (e.g., urban trails) in low-income communities (Hackworth & Smith, 2001; Immergluck, 2009).

Environmental variables represent attributes of a neighborhood that affect its desirability, including location, access to amenities, the quality of the built environment, and the share of subsidized housing (Rigolon & Németh, 2019). In our analysis, we chose a set of variables that express desirability in the context of Chicago's south and west sides, which are low-income neighborhoods that underwent notable public and private disinvestment. The variables we selected include the percentage of vacant housing units, the percentage of residential vacant parcels (those that do not include buildings), the distance from the central business district (CBD), the presence of a rail station within half-a-mile (dummy), location on the west side as opposed to the south side of Chicago (dummy), the presence of Large Lots sold in previous sales (dummy), the percentage of households living in public housing units, population density, distance from Lake Michigan, the presence of a park in a census tract (dummy), access to a large park within a quarter-mile from a census tract (dummy, defined as "citywide," "magnet," or "regional" parks; see Friends of the Parks, 2018), and the Employment Access Index describing accessibility to jobs. We used the west side dummy variable and the percentage of households living in public housing units to measure neighborhood stigma, as the south side of Chicago and areas with high shares of public housing are often perceived as low-resourced and dangerous neighborhoods (McCormick, Joseph, & Chaskin, 2012; Sampson & Raudenbush, 2004; Wilson, 2018). Finally, we used the number of all reported crimes per acre, of violent crimes per acre, and of property crimes per acre in 2016 to operationalize safety as an element of neighborhood desirability. Violent crimes and property crimes were rendered based on the Federal Bureau of Investigation's definitions (Federal Bureau of Investigation, 2010). We calculated all variables with ESRI's ArcGIS (version 10.4).

3.1.3. Unit of analysis and sample size

We compiled all data for the dependent and independent variables at the census tract level, which we used as the unit of analysis for this study. Among the 801 census tracts located in Chicago, 215 included at least one available city-owned Large Lot for the 2016–2018 round of sales. Yet we did not feel comfortable to infer trends about demand and sales for this sample of 215 tracts, as numerous census tracts had a small number of available Large Lots. For example, 57 of those 215 tracts had four or fewer available Large Lots. Thus, we focused on tracts that included at least 10 city-owned Large Lots, which led to a sample of 124 tracts. Similarly, a study of urban parks only considered geographic units with 10 or more observations (Brown, 2008). Choosing tracts with at least 10 city-owned vacant lots allowed us to model demand and sales for tracts with a substantial number of available Large Lots yet still yielded a sufficient sample size (n = 124). Importantly, the 124 tracts in our sample do not differ substantially in overall land vacancy from the entire sample of 215 tracts that include at least one city-owned Large Lot (25.66% vs. 22.21%), as both also comprise several privately-owned vacant lots.

3.1.4. Variable selection and statistical analysis

We built two sets of multivariate ordinary least square (OLS) regression models to analyze how sociodemographic, environmental, and safety characteristics are associated with the demand and sale of Large Lots.[1] A bivariate correlation between Large Lot demand and percent sold showed that the two variables are essentially uncorrelated ($r = 0.078$, $p = 0.391$), which suggests that the variables predicting demand and sale might be different. This difference might be because the Large Lot Program involves a city-managed sales process that includes reviews from elected officials, who might consider the public interest when making decisions about sales (Podmolik, 2015). Thus, because sales might not follow demand in the context of this program,

[1] We conducted the same analyses for census tracts that have at least 5 available Large Lots (n = 158) and the results were ostensibly the same.

we used two different sets of independent variables to predict Large Lot demand and sale.

3.1.4.1. Demand. To select the variables included in the OLS model predicting Large Lot demand, we used a six-step process (see Fig. S1 and Table S1 in Supplementary materials 1), which is a modified version of the "forward selection" method for multivariate regressions (Thompson, 1978). The first step was the identification of a broad set of variables describing sociodemographic, environmental, and safety characteristics based on bodies of literature on urban greening, the determinants of housing prices, and gentrification (see Table 1 in the Results section). Among these 28 variables, some represent constructs included in our hypotheses (e.g., gentrification, distance from downtown), whereas we use others to describe different characteristics of neighborhood desirability (e.g., presence of parks). We started with this large set of independent variables given the dearth of research on what predicts the demand for city-owned vacant properties. The subsequent steps were intended to gradually narrow down the number of potential independent variables to include in the final OLS model.

Second, we conducted bivariate correlations between the 28 independent variables and the demand for Large Lots to identify which variables were statistically significantly associated ($p < 0.05$) with the demand for Large Lots (see Pandey & Elliott, 2010). At this stage, we retained some variables of interest that were not significantly associated with the dependent variables but described constructs included in our hypotheses (e.g., percent vacant parcels). Third, we ran bivariate correlations between all 28 independent variables to gauge whether such variables were significantly associated with each other and identify potential suppressor variables (see Fig. S3). In multivariate models, suppressor variables describe independent variables that, although not significantly correlated with the dependent variable, are correlated with other independent variables (Pandey & Elliott, 2010). Suppressor variables increase the size of other regression coefficients and improve the model fit by accounting for "some outcome-irrelevant variation or errors in one or more other predictors" (Pandey & Elliott, 2010, p. 28). To identify potential suppressors, we selected independent variables that, in bivariate correlations, were not significantly associated with the Large Lot demand but that had significant associations with one or more other significant independent variables (see Fig. S1 and Table S1).

Fourth, we ran preliminary OLS models with a subset of independent variables selected through the previous steps and conducted multicollinearity tests, which led to removing variables that showed variance inflation factors (VIFs) above 4.0 (Field, 2013). Fifth, to keep the statistical model parsimonious (see Green, 1991), we ran several other OLS models with combinations of the remaining independent variables; among such models, we chose the one that had a lower Akaike Information Criterion (AIC), indicating better model fit (see step 5 in Fig. S1). And finally, we added potential suppressor variables (see step three) to the OLS models described at step 5 in Fig. S1 and checked whether adding such variables increased the model fit and the effect size of other independent variables (see Fig. S1 and Table S1).

3.1.4.2. Sale. To select variables for the Large Lot sale OLS model, we used the same six-step selection process described for demand, which takes into account model fit, bivariate correlations, and multicollinearity (see Fig. S2 and Table S2). This process resulted in a different set of independent variables than for demand (see Results).

3.1.4.3. Analyses. To check for possible spatial autocorrelation in the models' residuals, we calculated global Moran's *Is* for the residuals of each OLS model. Using the lm.morantest function in R's *spdep* package, we conducted Moran's I tests with distance-based spatial weights matrices considering the two closest neighbors to each census tract. These tests were not significant for the residuals of neither final OLS model (Moran's $I = -0.015$, $p = 0.385$ for the demand model and Moran's $I = 0.020$, $p = 0.181$ for the sale model), indicating the absence of spatial dependence. All standard assumptions for OLS were tested and met.

To uncover the relative importance of sociodemographic, environmental, and safety variables, we used three-step OLS models. For each dependent variable, we first entered predictors describing sociodemographic factors (Model 1), then environmental features (Model 2), and finally safety characteristics (Model 3). We performed all these analyses in R (version 3.5.1) and ran the aforementioned GWR in ESRI's ArcGIS (version 10.4; fixed kernel type and corrected Akaike Information Criterion as the bandwidth method). As for the OLS models, Moran's I tests for the GWR residuals did not show spatial autocorrelation (Moran's $I = -0.018$, $p = 0.733$).

3.2. Qualitative methods

To explore explanations for the different patterns of demand and sale, and specifically the fact that early gentrification was associated with demand but not with sale, we analyzed qualitative data from two different sources. Across the time period of our study from 2015 to the present day, we collected information about the Large Lot Program's sale processes from local media including newspaper, magazine, and public radio sources available online. Specifically, we conducted a web search for articles from the above sources using keywords such as "Large Lot Program", "sales", "sale process," and "alderman" (city council member).

A second source of qualitative data was drawn from transcripts of three focus groups conducted in fall 2015 with 25 Large Lot owners (20 females, 5 males) in the context of another study (Stewart et al., 2019). The focus groups were held in three neighborhoods covered by the Large Lot Program (East Garfield Park, Englewood, and Woodlawn) and re-analyzed for the purpose of this paper. The focus group protocol queried participants about an array of topics related to their purchase and intentions for Large Lot ownership, including challenges of the purchase process and their perceptions of the criteria used in selecting or rejecting applicants for lot ownership. Following each focus group, participants were invited to conduct a member check of the transcripts, which allowed them to redact any information, clarify or add content, and edit their text on the transcript (Kornbluh, 2015). We then conducted a directed content analysis of the transcripts in which the open points from the regression analyses informed the questions we asked through the qualitative data (Elo et al., 2014; Hsieh & Shannon, 2005). We identified relevant excerpts across the 115 pages of text from the combined focus groups that reflected social meanings tied to sale processes, applicant selection criteria, and aldermanic involvement. From this initial pass, we singled out 14 excerpts totaling 10 pages of text as relevant to the open questions that followed the quantitative results. One of the co-authors identified codes that reflected various roles played by aldermen in sale processes, which were then independently analyzed by all of the authors to frame the findings for the qualitative analysis. Inter-rater reliability, which is the level of agreement across coders in the matching of text to themes, was acceptable at 72% (MacQueen, McLellan, Kay, & Milstein, 1998; Youngs, White, & Wodrich, 2008).

4. Results

4.1. Descriptive statistics

The 124 sampled tracts have significantly lower socioeconomic status and a much higher percentage of non-Hispanic Black residents than the City of Chicago as a whole (see Table 1). This is a common occurrence for high-vacancy neighborhoods across U.S. cities (Ehrenfeucht & Nelson, 2020; Ganning & Tighe, 2015), and thus the results of our analyses shown below can only be extended to other marginalized, high-vacancy neighborhoods.

The variables describing gentrification suggest that some of the sampled tracts might have experienced early gentrification but that very few if any are at more advanced stages of gentrification. Indeed, although the sampled tracts have seen only about half the increase in the percentage of college graduates compared to the city as a whole (+4.25% versus +8.9%), the large standard deviation for that variable in our sample (6.93%) suggests that several tracts experienced larger-than-city-average increases in the percentage of college graduates. Fig. S4 in the Supplementary materials includes a map depicting changes in the percentage of people with a college degree for the 215 tracts with at least one available city-owned Large Lot. Similarly, the change in the percentage of racial/ethnic minority residents in the sampled tracts has a large standard deviation compared to the mean change (2.46% compared to −0.92%), showing that the sample includes tracts with a substantial decrease of racial/ethnic minority residents – i.e., with notable increases of White residents. Also, the sampled tracts have experienced a much smaller increase in median household income and median home value compared to the city as a whole (about one-fifth and one-half, respectively).

Further, the sampled tracts had approximately double the housing vacancy and land vacancy rates than the city average, as well as more households living in subsidized housing. Similarly, the numbers of total crimes per acre and of violent crimes per acre were larger in the sampled tracts than the city average, while the sampled tracts experienced slightly fewer property crimes per acre than the city average.

The number of available lots per tract varied between 10 and 181, and the number of applications ranged between 1 and 184 (see Table 1). This resulted in the number of applications per lot (demand) varying between 0.1 and 6.91 in census tracts. The percentage of Large Lots sold in each tract ranged between 0 and 56.25%, with a mean percent sold of 15.71%. Fig. 2 shows that census tracts with at least one available Large Lot are clustered around two major areas on Chicago's south and west sides.

4.2. What predicts the demand for Large Lots?

Table 2 presents the results of OLS models predicting the demand for Large Lots. The variables included in the models were selected based on the process described in Fig. S1 and Table S1 in the Supplementary materials. Our process resulted in the elimination of variables that raised multicollinearity issues (e.g., *percent college graduates*) and those that did not improve model fit (e.g., *population density*).

In Model 1, *percent renters*, *percent NH White homeowners,* and *median home value* are positively associated with demand (see Table 2). Also, *change in percent college graduates 00-15* and *change in percent minorities 00-15* are positively and negatively associated, respectively, with the demand for Large Lots. These two key variables retain significance in Models 2 and 3, showing that census tracts at the early stages of gentrification have higher demands for Large Lots than tracts that were not gentrifying. Also, *change in income 00-15* shows no association with demand in OLS models, which further supports demand being higher in tracts at earlier stages of gentrification.

In Model 2, seven variables are significantly associated with demand. Among the five variables that were significant predictors of demand in Model 1, four remain significant in Model 2 (except for *percent renters*), suggesting that many sociodemographic factors are associated with demand even when controlling for environmental factors. Among the environmental variables, *percent vacant housing units* (approaching significance), *percent vacant parcels* ($p < 0.05$), and *distance from CBD* ($p < 0.001$) are all negatively associated with demand for Large Lots, while *percent households in public housing* is positively associated with demand ($p < 0.05$). In Model 2, AIC decreases compared to Model 1, suggesting that environmental variables improve model fit. In Model 3, adding *property crimes per acre* slightly increases AIC (i.e., lower model fit) compared to Model 2 and does not substantially change the significant associations found in Model 2. This means that, even when controlling for crime, the same sociodemographic and environmental variables remain significant predictors of demand.

These results show that the average number of applications per lot in a census tract – representing demand – is higher in tracts that saw larger increases in the percentage of college graduates and larger decreases in the percentage of racial and ethnic minority people, providing support for Hypothesis 1.1. The distance from the CBD is also consistently and strongly associated with the number of applications per lot, showing that Large Lots located closer to downtown are in higher demand, which supports Hypothesis 2.1. This association is visible in Fig. 3, which also shows that tracts on the west side, overall, saw higher demands for Large Lots than those on the south side. We also found support for Hypothesis 1.3, as the percentages of vacant housing units and vacant parcels are associated with demand at the 0.10 and 0.05 levels, respectively, and no support for Hypothesis 1.4, regarding crime. Overall, the strongest predictors of demand are changes in the percentage of college graduates and of racial/ethnic minority people between 2000 and 2015, describing early stages of gentrification, and distance from the CBD (compare the standardized B coefficients in Table 2).

The associations between two other variables and the demand for Large Lots deserve further elaboration. First, *percent NH White homeowners* is positively associated with the demand for Large Lots. Despite this finding, because we have no data on the race and ethnicity of Large Lot Program applicants (the City of Chicago does not collect such data), we cannot claim that higher demand in gentrifying areas is due to White homeowners applying at a higher rate than racial and ethnic minority homeowners. Second, *percent households in public housing* is positively associated with the demand for Large Lots. Although this result seems counterintuitive because of the stigma associated with public housing, it might suggest that nonprofit organizations working with tenants of public housing units might have applied for Large Lots at higher rates to build community gardens and shared playgrounds (see Qin, 2018). Both findings warrant further investigation.

Finally, the adjusted R-squared values are strong for all three models, and the variables in Model 3 explain 65.8% of the variance in the demand for vacant lots. This powerful set of predictive models provides a convincing basis for policy implications.

4.3. What predicts the sales of Large Lots?

Table 3 presents the results of OLS models to predict the percentage of Large Lots sold. We selected variables included in the models based on the process described in Fig. S2 and Table S2 in the Supplementary materials. In that process, we dropped variables that raised multicollinearity issues (e.g., *tract on the west side*) and those that did not improve model fit (e.g., *median household income*).

In Model 1, none of the four sociodemographic variables are significantly associated with the percentage of Large Lots sold. In Model 2, three variables are associated with percent sold: *distance from CBD* (negative, $p < 0.01$), population density (positive, $p < 0.05$), and distance from Lake Michigan (positive, $p < 0.05$), suggesting that tracts closer to downtown, with higher population density, and farther from Lake Michigan saw higher shares of available Large Lots sold. In Model 2, AIC decreases compared to Model 1 (i.e., improved model fit), suggesting that environmental features predict the sale of Large Lots more accurately than sociodemographics.

In Model 3, *distance from CBD* and *distance from Lake Michigan* are the two significant predictors of the percentage of Large Lots sold, whereas population density is positively associated with sales, but its coefficient approaches significance ($p < 0.10$). Distance from CBD is the strongest predictor, as shown by the medium effect size of its standardized coefficient (see Table 3). The AIC in Model 3 is slightly higher than in Model 2, showing that adding *violent crimes per acre* reduces model fit. Finally, although *percent NH Black* and *change in*

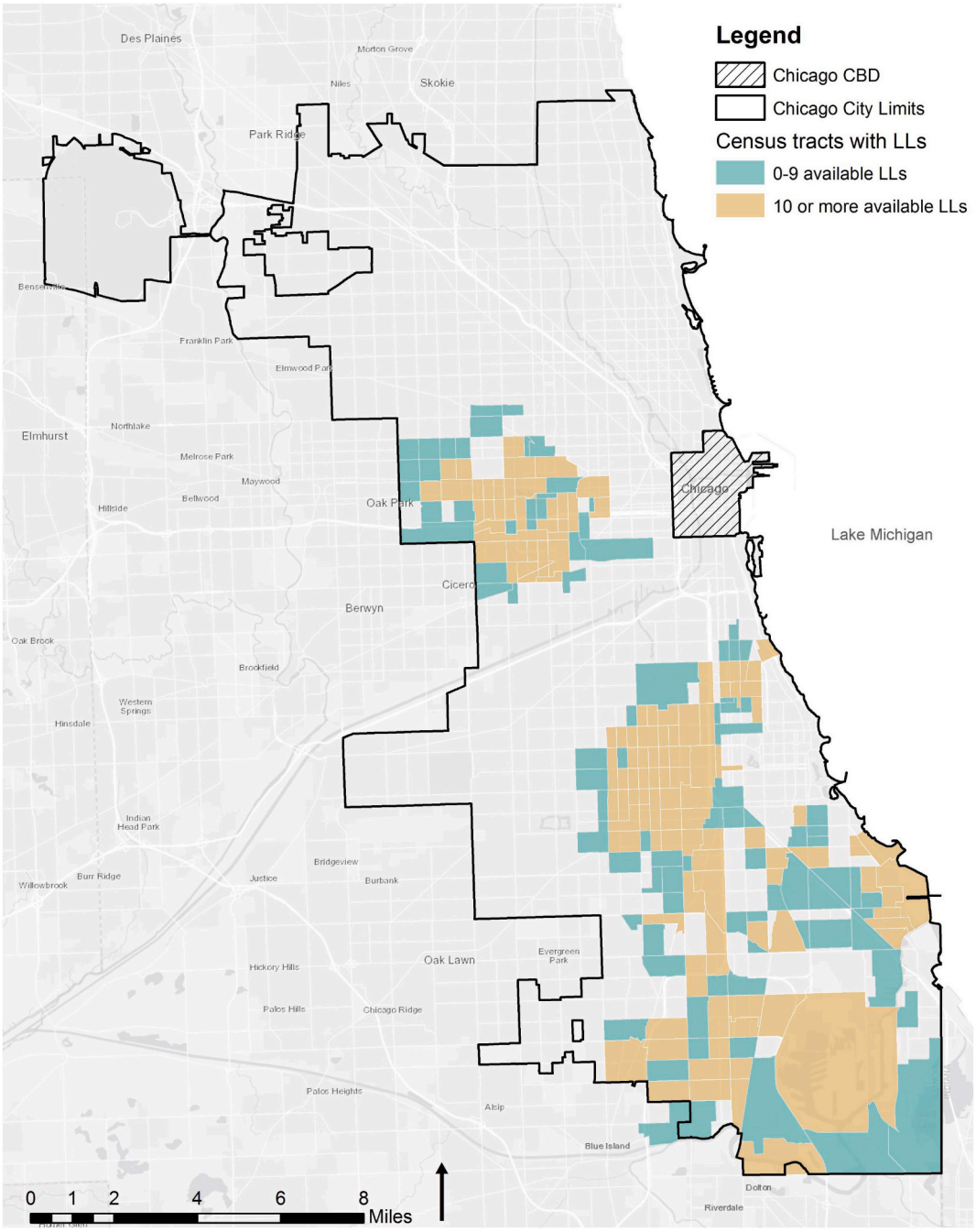

Fig. 2. Location of census tracts with at least one available Large Lot.

percent minorities 00–15 are not significant predictors of sale, we found evidence that they might act as suppressor variables for *distance from Lake Michigan* and *distance from CBD*, respectively (see Fig. S2 and Table S2).

The findings presented in Table 3 show that the percentage of sold Large Lots is not significantly higher in tracts that exhibited some of the early signs of gentrification between 2000 and 2015, thus rejecting Hypothesis 1.2. Yet we found that the percentage of sold Large Lots is significantly higher in tracts that are located closer to the CBD, providing support for Hypothesis 2.2 (see also Fig. 4). These findings show that sales of Large Lots did not "follow" the higher demand for Large Lots in gentrifying neighborhoods but did so in areas located closer to the CBD. Finally, we did not find support for Hypotheses 3.2 (vacant lots and housing) and 4.2 (crime).

The adjusted R-squared is comparatively modest in that 19.9% of the variance is explained in Model 3. Although results exhibit statistically significant relationships, the lower variance explained makes these results less useful to inform policy than the results for demand.

4.4. Why do patterns of demand and sale differ?

As noted, we gathered evidence to understand why the variables describing early gentrification are significantly associated with the demand but not with the sale of Large Lots. Our analysis suggests that one explanation for this difference is that the sale process, intentionally or not, averted a higher percentage of sales in gentrifying census tracts that were also experiencing high demand. Specifically, we learned that the sale process involves a system of checks through Chicago's Department of Planning and Development, followed by final review and approval by the alderman of the ward where the lot is located (Chicago

Table 2
What predicts the demand for Large Lots? OLS models coefficients.

	Model 1. Enter sociodemographics		Model 2. Enter environment		Model 3. Enter safety	
	Unst. B (Std. error)	Stand. B	Unst. B	Stand. B	Unst. B	Stand. B
(Constant)	**−1.035***** (0.303)		0.929^ (0.499)		0.963^ (0.528)	
Percent NH White	0.011 (0.030)	0.031	0.012 (0.029)	0.034	0.0123 (0.029)	0.033
Percent renters	**0.011**** (0.004)	**0.169****	0.009^ (0.004)	0.131^	0.009^ (0.004)	0.135^
Percent NH White homeowners	**0.028*** (0.013)	**0.178***	**0.030*** (0.013)	**0.187***	**0.030*** (0.013)	**0.185***
Median home value	**0.007***** (0.001)	**0.294*****	**0.004*** (0.001)	**0.175***	**0.004*** (0.001)	**0.177***
Change in income 00–15	0.005 (0.010)	0.040	0.0004 (0.010)	0.003	0.0001 (0.010)	0.001
Change in percent college graduates 00–15	**0.037**** (0.013)	**0.217****	**0.038**** (0.013)	**0.223****	**0.038**** (0.013)	**0.224****
Change in percent minorities 00–15	**−0.125***** (0.032)	**−0.261*****	**−0.102**** (0.031)	**−0.213****	**−0.102**** (0.031)	**−0.215****
Percent vacant housing units			−0.014^ (0.008)	−0.108^	−0.014^ (0.008)	−0.105^
Percent vacant parcels			**−0.017*** (0.007)	**−0.169***	**−0.017*** (0.007)	**−0.169***
Distance from CBD			**−0.105***** (0.026)	**−0.273*****	**−0.107***** (0.028)	**−0.279*****
Percent households in public housing			**0.022*** (0.010)	**0.146***	**0.022*** (0.010)	**0.146***
Property crimes per acre					−0.048 (0.231)	−0.015
AIC	286.392		270.834		272.786	
R^2_{adj}	0.604		0.661		0.658	
F	27.79***		22.78***		20.7***	

n = 124. Note: All VIFs are smaller than 2.5.
Coefficients in bold are statistically significant at the 0.05 level or better.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.
^ $p < 0.10$.

Department of Planning and Development, personal communication). In practice, each set of checks has resulted in the denial of sale for some applications. In the former case, some applications were rejected due to incomplete forms or an applicant's past-due bills with the city, such as water bills and parking tickets. In the latter case, aldermen and the Department of Planning and Development sought to retain certain properties to promote uses that would benefit the general public, such as community gardens, future affordable housing developments, and grocery stores (Moore & Vevea, 2018; Podmolik, 2015; Qin, 2018; Wu, 2019). The city has also directly invested in greening city-owned land through programs that provide employment and job training for residents living in the Large Lot neighborhoods (Freskos, 2019).

Focus groups with residents (Stewart et al., 2019) shed further light on the role of aldermen in the sale process of Large Lots. Overall, participants' perceptions of aldermen's involvement in the sale of Large Lots tended to vary by neighborhood, which might signal differences across the city in the way aldermen valued the Large Lot Program. For example, many residents in East Garfield Park, a neighborhood experiencing early gentrification, saw the sale process as complex and not fully transparent. One participant who was disappointed she did not get the Large Lot that was across from her building stated "……*it* [the sale] *has to be approved by the alderman. That's the final step. So, he would have never of approved it because the lot is right behind her building….. So, I would never have gotten it anyway*." Another responded to a question about selection criteria with the following: "*the alderman had probably something to do with it or had some sort of, uh, thumbs up, thumbs down…… I mean, it's not, it was not a completely transparent process by any stretch of the imagination.*" Residents in other neighborhoods not experiencing gentrification, such as Englewood, saw the Large Lot sale process as easy and transparent, with little involvement from the local alderman. When discussing the sale process, a participant in the Englewood focus group stated "*… so everyone knew going in, it was first come first serve… the website did a really good job of explaining what that criteria was, you know, uhm, first come first serve….so the criteria was very, very clear.*" In the Woodlawn focus group, participants portrayed their alderman as detached from the sale process. Said one of the Woodlawn participants, "….*we got another phone call* [from the city] *later, that said we needed to talk to the alderman. And I'm like, we should have known this a long time ago, this is several months later* [after submitting the application, yet]….*the alderman wasn't even clear that he had to, that, that I needed to call* [him]." Collectively, evidence from the focus groups suggests that the roles of aldermen in the sale process varied greatly based on the neighborhood, which reflects Chicago's decentralized approach to politics and neighborhood planning (Zhang, 2011).

Given these divergent views about the Large Lot sale process between East Garfield Park (early gentrification) and Englewood (not gentrifying), we ran a geographically weighted regression (GWR) to check whether the association between demand (independent variable) and sale (dependent variable) varied between gentrifying and non-gentrifying communities. We expected that the association between demand and sale would be positive and stronger in non-gentrifying neighborhoods, as respondents in Englewood saw the sale process as easy and transparent. The GWR results confirm our expectations and reinforce what we heard from focus group participants. Fig. 5 shows that the associations between demand and sale are positive and strong in areas that are not gentrifying and further from downtown, such as Englewood and the neighborhoods south of it (yellow, orange, and red shading); and such associations are negative or close to zero in places experiencing earlier gentrification and closer to downtown, such as East Garfield Park (blue and green shading). For these reasons, we concluded that sales followed demand in non-gentrifying areas and those further from downtown.

5. Discussion

The findings of this study shed light on the complex connections among vacant land sales, gentrification, and urban greening. We found the demand for Large Lots in Chicago to be higher in census tracts showing early signs of gentrification between 2000 and 2015, specifically, those tracts with larger increases of college-educated people and larger decreases of racial and ethnic minority people. Yet we also found the percentage of Large Lots sold was not higher in gentrifying tracts compared to non-gentrifying tracts, perhaps due to checks and balances used by the City of Chicago (see below). These findings differ from those of previous research conducted in New Orleans, where residents in affluent neighborhoods purchased higher shares of city-owned vacant lots compared to those in lower-income areas, perhaps due to higher purchase prices in New Orleans than Chicago (Ehrenfeucht &

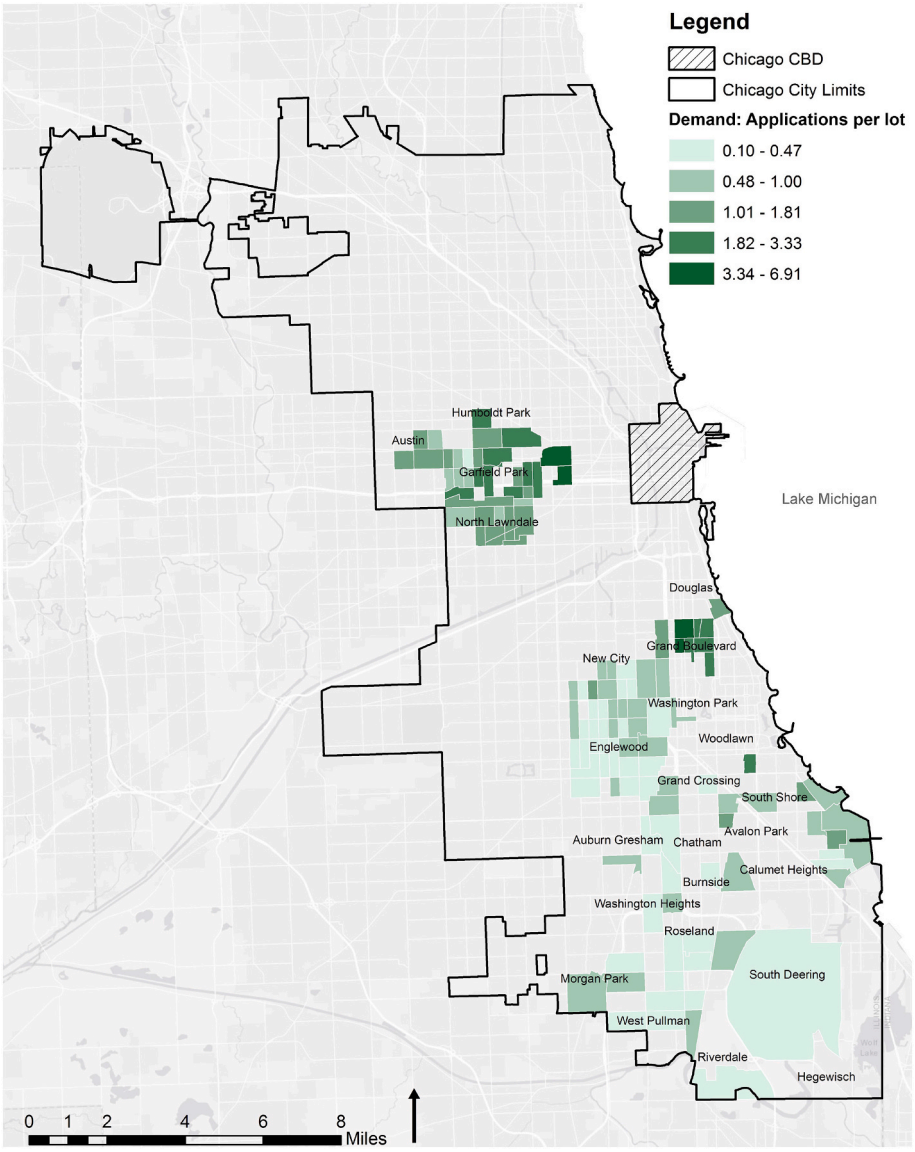

Fig. 3. Demand: Applications per lot in the sampled census tracts.

Table 3
What predicts the sale of Large Lots? OLS models coefficients.

	Model 1. Enter sociodemographics		Model 2. Enter environment		Model 3. Enter safety	
	Unst. B	Stand. B	Unst. B	Stand. B	Unst. B	Stand. B
(Constant)	25.328 (6.146)		**21.253**** (7.117)		**21.262**** (7.154)	
Percent college graduates	−0.370 (0.226)	−0.235	0.001 (0.223)	0.0007	−0.0002	−0.0001
Percent NH Black	−0.077 (0.070)	−0.099	−0.098 (0.066)	−0.125	−0.097 (0.068)	−0.125
Change in percent college graduates 00-15	−0.009 (0.281)	−0.005	−0.247 (0.268)	−0.128	−0.247 (0.270)	−0.129
Change in percent minorities 00-15	0.014 (0.510)	0.002	0.785 (0.494)	0.145	0.786 (0.498)	0.145
Distance from CBD			**−1.342**** (0.416)	**−0.309****	**−1.347**** (0.443)	**−0.310****
Population density			**0.345*** (0.146)	**0.202***	0.348^ (0.191)	0.204^
Distance from Lake Michigan			**1.495*** (0.674)	**0.193***	**1.500*** (0.696)	**0.194***
Violent crimes per acre					−0.225 (8.010)	−0.003
AIC	994.893		974.822		976.821	
R^2_{adj}	0.045		0.206		0.199	
F	2.447^		5.560***		4.823***	

n = 124. Note: All VIFs are smaller than 3.5.
Coefficients in bold are statistically significant at the 0.05 level or better.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.
^ $p < 0.10$.

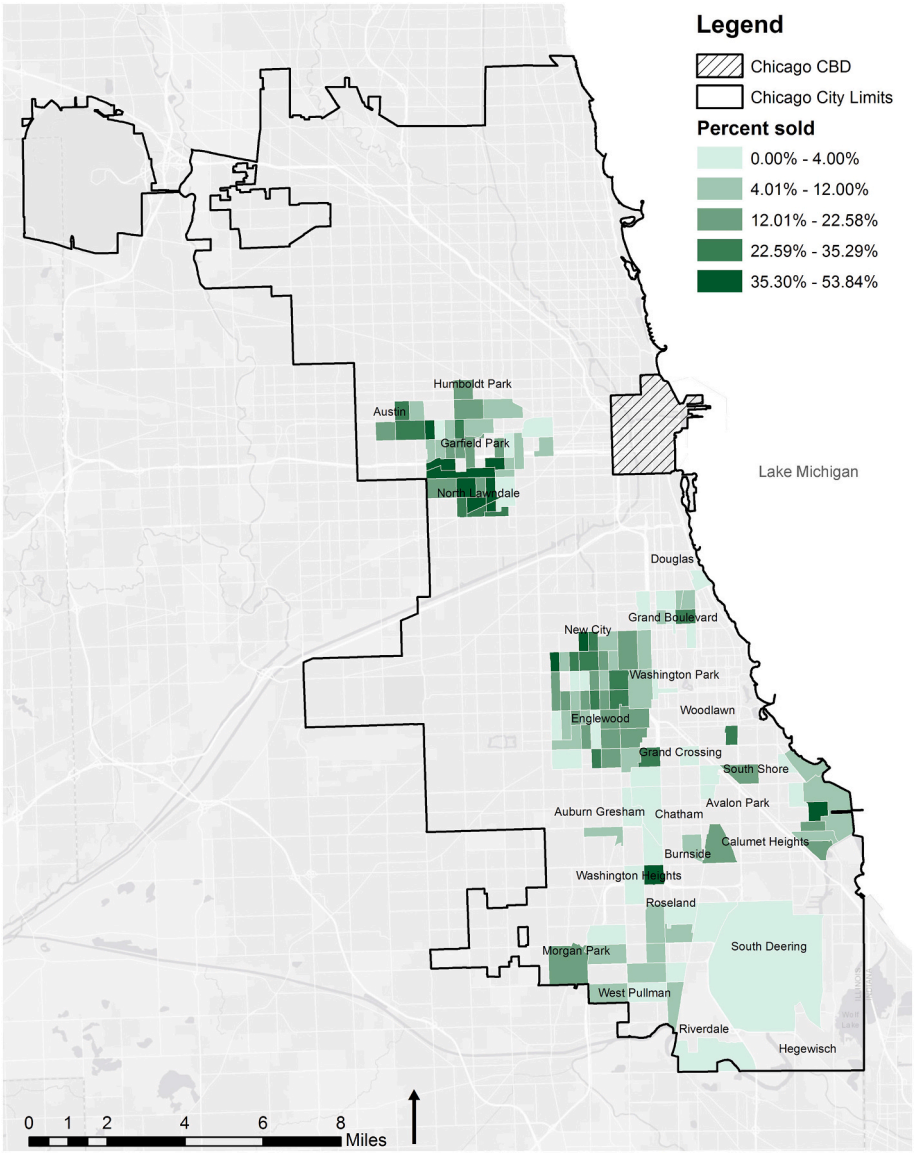

Fig. 4. Sales: percent of Large Lots sold in the sampled tracts.

Nelson, 2013). Also, our findings on factors that predict stronger demand for Large Lots – including proximity to the CBD, a higher percentage of White homeowners, and lower land vacancy rates – align with previous research about factors that determine higher land values (see Crompton & Nicholls, 2020; Harris, 1999).

Because our previous studies show that Large Lot owners mostly purchased vacant lots for greening and beautification purposes and that signs of greening are evident on the ground (Gobster et al., 2020; Stewart et al., 2019), the findings of the present investigation suggest that the demand for urban greening is higher in areas at the early stages of gentrification than in neighborhoods that have not shown signs of a transition. Specifically, our findings broaden the idea from previous environmental gentrification research that certain new green spaces *precede* gentrification in surrounding areas (Anguelovski, 2016; Anguelovski et al., 2018; Goossens et al., 2019; Immergluck & Balan, 2018; Rigolon & Németh, 2020) and suggest that urban greening, albeit implemented by residents and not by the public sector, might also *follow* the early stages of gentrification. Indeed, our study suggests that residents of neighborhoods at the early stages of gentrification might be seeking to produce new private or semi-public green space by greening vacant lots. Our data do not identify whether newcomers or the longtime neighbors are responsible for that increased demand for green space, but other studies have found that newcomers to gentrifying neighborhoods have contributed to such increased demand thanks to their political power (Grier & Perry, 2018; Hamilton & Curran, 2013). In the context of previous literature showing that some greening initiatives can lead to gentrification (Anguelovski et al., 2018; Immergluck & Balan, 2018; Rigolon & Németh, 2020), the results of this study suggest that environmental gentrification might act in cycles, with greening both preceding and following gentrification.

In this study, we also found that the variables describing early gentrification are significantly associated with the demand but not with the sale of Large Lots. Based on our analysis of several qualitative data sources, we suggest that the sale process might limit sales of city-owned vacant lots in areas experiencing early gentrification. This might have happened because applicants had past-due bills with the city, or because aldermen sought to retain some properties for community uses, with residents in different neighborhoods expressing diverse views about the transparency of the sale process. Research on other programs shows that transferring lots from public to private ownership involves some “behind-the-scenes” mechanisms (Dewar, 2006; Ganning & Tighe, 2015), and in Chicago, such mechanisms may have helped retain

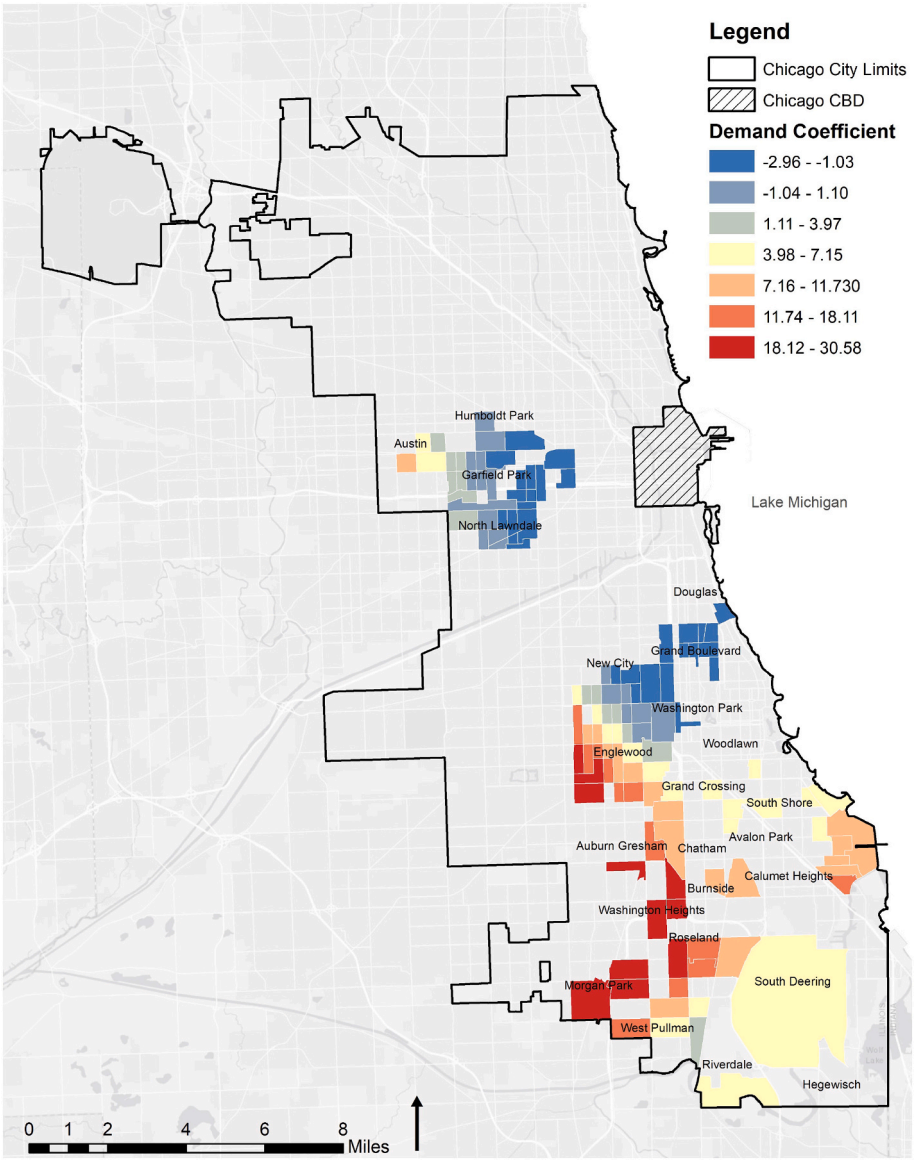

Fig. 5. GWR: associations between demand and sale of Large Lots varying by census tract ($R^2_{adj} = 0.25$).

valuable city-owned vacant lots in gentrifying neighborhoods for community benefits despite their high demand. These complex mechanisms can occur in cities that enable city council members to exert significant control over land use and land sales decisions, which often has inequitable impacts for people of color (Walz & Fron, 2019). Thus, our results about the diverging patterns of demand and sales might have been different in cities with governance structures wherein local control by city council members is not as strong as in Chicago, as sales might have followed demand more directly.

5.1. Implications for policy and program development

The findings of this study can help planners and elected officials foresee where the demand for publicly-owned vacant lots will be higher and support their objectives of empowering low-income communities of color in long-disinvested neighborhoods. Along with related research, our work can inform vacant land management for cities experiencing differential rates of reinvestment and other policies to limit environmental gentrification.

First, our findings from Hypotheses 1 and 2 suggest that cities may use publicly-owned vacant properties located near downtown and in areas at the early stages of gentrification to establish or expand community land trusts (CLTs). CLTs can be effective tools to limit the negative impacts of gentrification such as the displacement of longtime low-income residents of color (Choi et al., 2018; Loh, 2015). Rather than selling publicly-owned lots in gentrifying areas to individual owners, cities could directly manage a CLT or transfer lots to nonprofit-run CLTs under the condition that such lots are used to benefit marginalized communities (see Safransky, 2014). For instance, the Dudley Street Neighborhood Initiative, a CLT in Boston, is particularly notable due to the integration of affordable housing, urban greening, urban agriculture, and job creation (Lawrence, 2002; Loh, 2015). Other land trusts, such as Chicago's NeighborSpace, preserve land for community gardens to help increase access to healthy food (NeighborSpace, 2018).

Second, high-vacancy cities could implement side yard programs that take into account these uneven patterns of redevelopment in low-income neighborhoods (see also Pearsall, Lucas, & Lenhardt, 2014). Our findings from Hypotheses 1, 2, and 3 suggest that such programs could classify high-vacancy neighborhoods into different categories based on recent rates of gentrification (with parameters similar to those used in this study) and on assessed property values (see also Ganning & Tighe, 2015). Properties could be sold for one dollar in areas that have not

been gentrifying as a means to stimulate greening and economic development. But sales in gentrifying and more desirable neighborhoods, such as those close to the CBD, could undergo additional scrutiny so they yield more benefits to a city and neighborhood residents. In these areas, cities could use an array of policy tools including: limiting sales to preserve some properties for public use, including community gardens and playgrounds; prioritizing sales to CLTs (Choi et al., 2018); implementing community engagement strategies to decide future uses for publicly-owned vacant land; requiring the inclusion of affordable housing units in lots that are redeveloped (e.g., for Chicago, an inclusionary zoning ordinance for Large Lots); differentiating sale prices based on the buyer's income (Ganning & Tighe, 2015) and neighborhood desirability; and using the revenue from more expensive sales to support housing trust funds or urban greening programs. Thus, rather than leaving decisions about sales to the discretion of city council members, cities would be better off developing comprehensive strategies that consider a neighborhood's vulnerability to gentrification and need for public properties.

Finally, our argument supported by our findings and previous research (Anguelovski et al., 2018; Immergluck & Balan, 2018; Rigolon & Németh, 2020) that environmental gentrification might act in cycles suggests that cities have tools to avert gentrification both before and after greening initiatives are implemented. Specifically, if future research supports that gentrification precedes greening, our findings suggest that planners and policymakers should prioritize greening initiatives in low-income minority neighborhoods that are least susceptible to gentrification, including those with high shares of existing subsidized affordable housing. Also, when large green investments such as greenways are implemented in neighborhoods that are already more vulnerable to gentrification, such as those close to downtowns (Rigolon & Németh, 2020), planners and policymakers should pair those significant green space investments with strong initiatives to preserve or produce affordable housing (Immergluck & Balan, 2018; Pearsall & Anguelovski, 2016). In high-vacancy areas, affordable housing initiatives might include the transfer of city-owned vacant land to forms of collective ownership such as CLTs (Safransky, 2014). These and other strategies can help planners and policymakers maximize greening for marginalized communities while limiting the negative consequences of gentrification (Gould & Lewis, 2017).

5.2. Limitations and future research

This study has a series of limitations that call for future research on the relationships between gentrification and urban greening. First, due to the secondary nature of our dataset, we do not know whether the longtime residents or the newcomers of gentrifying neighborhoods contributed to a higher demand for Large Lots. In future research, more detailed data about program applicants could help uncover which sociodemographic groups lead to increased demand for private and semi-public green space in gentrifying neighborhoods. Similarly, future studies could examine the role of CLTs in demand and sales dynamics of side lot programs, including in which types of neighborhoods CLTs are most active (e.g., gentrifying or disinvested) and how they use the land (e.g., housing, gardens). And future work could examine whether demand for new public green spaces like parks also increases after a neighborhood experiences early gentrification.

Second, we did not assess the impact of Large Lot sales on gentrification because it is too early to analyze sociodemographic changes that might be related to the implementation of Chicago's program. Future longitudinal studies could investigate how tract-level sociodemographic and housing variables will change in areas where numerous vacant properties have been sold through side lot programs. Further, future work could examine gentrification trends both before and after the implementation of greening projects, including how ongoing gentrification prior to greening might shape gentrification after greening. For example, it might be that a new park built in an already gentrifying area will lead to stronger increases in housing prices than a similar park built in a disinvested area (see Rigolon & Németh, 2020). Finally, sale processes of publicly-owned vacant lots to private residents are more complicated and challenging to understand than patterns of demand for such lots. Future research could analyze sale processes through in-depth interviews with project stakeholders and policy analysis to gather evidence on effective strategies for equitable greening in policies to re-purpose vacant lots.

6. Conclusion

In this study, we analyzed what predicts the demand and sale of publicly-owned vacant properties in high-vacancy, post-industrial cities. This investigation was motivated by concerns about environmental gentrification associated with some urban greening initiatives and by the social and public health benefits of greening vacant land. Focusing on Chicago's Large Lot Program, we found that the demand for Large Lots was substantially higher in census tracts that showed early signs of gentrification between 2000 and 2015 and that are located in closer proximity to downtown. This suggests that the demand for privately-led urban greening might be higher in a city's gentrifying neighborhoods, showing that privately-led greening initiatives might also follow gentrification. Thus, our study broadens the scope of the environmental gentrification literature (rather than casting doubt on previous findings) by complementing what others have examined: Whereas previous research found that gentrification follows some greening initiatives (Anguelovski et al., 2018; Immergluck & Balan, 2018; Rigolon & Németh, 2020), here, we show that gentrification might also precede greening.

We also found that although the percentage of Large Lots sold is higher in tracts near the CBD, with higher population density, and farther from Lake Michigan, the share of sold Large Lots was not associated with variables describing gentrification. Thus, Chicago has retained ownership of large amounts of vacant lots in neighborhoods that are experiencing early gentrification. These findings suggest that additional layers of review can help preserve public ownership options and ensure equitable outcomes for vacant land greening in increasingly desirable gentrifying areas.

CRediT authorship contribution statement

Alessandro Rigolon: Conceptualization, Methodology, Formal Analysis, Visualization, Writing- Reviewing and Editing. William P. Stewart: Conceptualization, Formal Analysis, Writing- Reviewing and Editing. Paul H. Gobster: Conceptualization, Formal Analysis, Writing-Reviewing and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2020.102948.

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