EPA Public Access

Author manuscript

Urban For Urban Green. Author manuscript; available in PMC 2021 October 01.

About author manuscripts

Submit a manuscript

Published in final edited form as:

Urban For Urban Green. 2020 October 1; 54: 126778. doi:10.1016/j.ufug.2020.126778.

Examining the effects of green infrastructure on residential sales prices in Omaha, Nebraska

F.-A. Hoover¹, J.I. Price², M.E. Hopton^{*}

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Solutions and Emergency Response, Water Infrastructure Division, Cincinnati, OH 45268, United States

Abstract

Green infrastructure (GI), practices consisting of using vegetation and soil to manage stormwater runoff (e.g., rain gardens, vegetated roofs, bioswales, etc.), has been adopted by cities across the world to help address aging water infrastructure, water quality, excess water quantity, and urban planning needs. Although GI's contribution to stormwater control and management has been extensively studied, the economic value of its benefits is less known. In Omaha, NE, GI projects have been completed in several public parks. Using a repeat-sales model based on 2000–2018 housing data, we examined the effect of GI on the value of single-family homes within various buffer distances of parks where GI was installed. After controlling for changes associated with home deterioration and renovation, non-stationary location effects, and time-invariant characteristics, we did not find any statistically significant relationships between housing values and GI. This finding is consistent with the notion that homeowners place little value on modifications to existing greenspace, but may also stem from homeowners' lack of familiarity with GI practices or data limitations.

Keywords

Green infrastructure; Repeat-sales; Ecosystem services; Greenspace amenity; Residential property sales; Hedonic analysis

^{*}Corresponding author at: US EPA, 26 W. Martin Luther King Dr., MS 689, Cincinnati, OH, 45268, United States. hopton.matthew@epa.gov (M.E. Hopton).

¹Present address: National Socio-Environmental Synthesis Center, Annapolis, MD 21401

²Present address: School of Freshwater Sciences, University of Wisconsin–Milwaukee, Milwaukee, WI 53211.

CRediT authorship contribution statement

F.-A. Hoover: Conceptualization, Methodology, Software, Investigation, Validation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **J.I. Price:** Conceptualization, Methodology, Software, Validation, Investigation, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization, Software. **M.E. Hopton:** Conceptualization, Methodology, Resources, Supervision, Project administration, Data curation, Writing - original draft, Writing - review & editing, Visualization.

Declaration of Competing Interest
None.

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ufug.2020.126778>.

1. Introduction

Green infrastructure (GI; or green stormwater infrastructure) is an approach that leverages the properties of soil and/or vegetation to increase detention capacity of water- or sewersheds to help manage stormwater using natural processes of the water cycle (Berland et al., 2017). Although there is some confusing terminology regarding GI (e.g., Fletcher et al., 2015), we define GI as any infrastructure installed with the explicit intent of managing stormwater using vegetation and soil. GI technologies such as rain gardens, bioswales, green roofs, or larger stormwater control measures (e.g., constructed wetlands or grassed buffer strips) can help reduce total runoff volumes, peak flows, and pollutants in stormwater from urban landscapes (Bell et al., 2017). In recent decades, municipalities across the United States (US) have adopted GI to mitigate flood risk, enhance water quality, and improve riparian habitats in downstream waters (Hall, 2010). Ancillary to stormwater benefits, GI has the potential to provide benefits such as reduced heat island effects, improved aesthetics, and other ecosystem services (Frey et al., 2015; Hoover and Hopton, 2019), which are often evoked by planners considering the merits of green versus gray stormwater infrastructure (Jaffe, 2010).

Improvements to community livelihoods and well-being from GI feature prominently in many environmental-focused governing agencies such as the US Environmental Protection Agency (EPA) (e.g., US EPA, 2013) and the European Commission (European Commission, 2019), in research examining the distribution of green development, practices, and benefits (including GI), and to whom benefits are provided (e.g., Berland et al., 2015; Heckert and Rosan, 2016; Landry and Chakraborty, 2009; Hoover and Hopton, 2019; Li et al., 2015; Rigolon, 2017). Unfortunately, there is limited empirically-based research available on the value of GI benefits to aid planners weighing the costs and benefits of various infrastructure options. This analysis estimates the monetized value of benefits that accrue to homeowners living near new GI installations, which include benefits from improved aesthetics and, depending on homeowner's knowledge of GI, perceived reductions in flood risk. Benefits related to downstream improvements in water quality and riparian habitats are not captured in this analysis. In addition, unequitable distributions of GI development, its benefits or services, including unintended consequences like green gentrification (Rigolon and Németh, 2020) are growing in interest and concern within urban greenspace management and research. Although this analysis does not explicitly address the distribution of GI benefits, it is important to quantify the benefits as a first step to insuring they are distributed more equitably.

1.1. Property value and green infrastructure

Historically, research valuing the urban environment focused on blue and greenspace (e.g., parks, cemeteries, open space, lakes, trails), and most commonly used hedonic housing models (e.g., Anderson and West, 2006; Cho et al., 2009; Waltert and Schlöpfer, 2010; Brander and Koetse, 2011; Ichihara and Cohen, 2011; Saphores and Li, 2012; Panduro and Veie, 2013; Mazzotta et al., 2014; Escobedo et al., 2015; Schlöpfer et al., 2015; Noor et al., 2015; Czembrowski and Kronenberg, 2016; Votsis, 2017; Belcher and Chisholm, 2018; Isely et al., 2018; Liebelt et al., 2018; Vandegrift and Zandoni, 2018). Many of these studies have

shown an increase in property value with greater proximity to a desirable greenspace (e.g., park, water body, or lake), and a decrease in value for less desirable spaces like cemeteries (e.g., Waltert and Schlöpfer, 2010; Panduro and Veie, 2013). Although estimated relationships vary, in general, a positive relationship between greenspace and property values is echoed across the literature (e.g., Schlöpfer et al., 2015; Czembrowski and Kronenberg, 2016). In fact, a meta-analysis of 12 studies (predominantly US-based studies) valuing greenspace (e.g., parks, forests, agricultural lands), showed an average increase in housing prices of around 0.1 % with each 10 m decrease in distance to open space (Brander and Koetse, 2011). This positive relationship between property values and greenspace also appears in cities outside of the US. For example, there was a significant positive relationship between managed vegetation and public housing apartments based on one year's sales data in Singapore (Belcher and Chisholm, 2018) and apartment rentals increased in price with the size of the nearest greenspace when analyzed at the city scale in Leipzig, Germany; although this effect, as well as the effect of distance to the nearest greenspace, vary considerably when data are analyzed at a smaller spatial scale (Liebelt et al., 2018).

Numerous studies on property value effects from greenspace exist in the literature, however the relationship between property values and GI is not as well examined. A search of the literature found some hedonic papers that examined the effect of GI on property values, notably Netusil et al. (2014); Ward et al. (2008); Ichihara and Cohen (2011), and Jarrad et al. (2018). Netusil et al. (2014) evaluated relationships between property values and green street projects (e.g., sidewalk bioswales, grassed swales, curb extensions, and corner bump-outs) in Portland, OR. Results from the preferred model specification revealed that property values were nonlinearly correlated with distance to the nearest project and the age of the nearest project. Specifically, property values were negatively correlated with green street projects until a distance of 1.5 miles (~2.4 km) and negatively correlated with newer projects until 4.4 years after their installation. Similarly, Ward et al. (2008) examined the relationship between property values and bios-wales in Seattle, WA, finding a 3.5–5 % premium for homes in green street areas. Ichihara and Cohen (2011) measured the effect of green roofs on rental prices in New York, NY, and found rents averaged 16 % higher for buildings with green roofs than those without. However, their model did not control for differences in apartment quality or other amenities, so results may be subject to omitted variable bias. Jarrad et al. (2018) used a repeat-sales model to estimate the effects of urban stream restoration projects, several of which were undertaken primarily to mitigate stormwater runoff, on property values in Portland, OR. Estimated effects vary considerably, depending on distance, project phase (e.g., pre-project, post-project, mature), and project type, but little evidence was found to suggest that stream restoration systematically increased nearby property values (Jarrad et al., 2018).

The paucity of studies suggests there is a need for research that specifically examines the relationship between property values and GI. Research that evaluates this relationship, while controlling for neighborhood characteristics (e.g., school districts), environmental characteristics (e.g., proximity to greenspaces), and structural characteristics (e.g., number of bedrooms or bathrooms), is needed to build a better understanding of economic benefits from GI and urban greenspace to aid city planners considering the costs and benefits of various GI projects.

1.2. Objective

Our objective is to examine whether GI affects residential property prices. Using data from Omaha, NE, USA we estimate a repeat-sales model—an extension of the standard hedonic property model—to evaluate how the installation of GI features in existing public parks affects nearby property values. Omaha was selected because of recent city-wide efforts to improve its stormwater and sewer systems, which includes an emphasis on using GI, and the availability of suitable property sales records. Our preferred model specifications control for a wide range of structural, neighborhood, and environmental characteristics, and consequently mitigate potential omitted variable bias. These characteristics are implicitly controlled with the repeat-sales approach, although they do not explicitly enter the estimated regression model. Our results offer insight into the capitalization of GI benefits into property values, which may prove useful to planners as cities increasingly include mandates for GI in planning and construction. Moreover, our analysis contributes to the limited literature on this topic by using a repeat-sales model that mitigates possible bias and produces more accurate economic values.

2. Methods

2.1. Study site

The City of Omaha, NE, USA has a land area of 127.09 mi² (329 km²), a population of 408,958, the median household income is \$53,789, and more than 15 % of residents are persons in poverty (US Census Bureau, 2010). Omaha is comprised of both municipal separate storm sewer system (MS4) and combined sewer system (CSS) networks, with the CSS predominately on the eastern side of the city along the Missouri River. In 2009, Omaha initiated efforts to reduce combined sewer overflow events and improve water quality in the Missouri River and Papillion Creek. CSS overflows were common prior to these efforts, with over 55 events occurring per year (US EPA, 2020). Infrastructure improvements were guided by a 15-year plan (which was subsequently extended) to address regulatory requirements, including: The Clean Water Act, EPA's Combined Sewer Overflow Control Plan, and Nebraska Department of Environmental Quality's Administrative Consent Order (City of Omaha, 2010a, 2010b).

To date, dozens of sewer separation projects have been completed or are presently under construction, with additional projects in the design and planning stages (Clean Solutions for Omaha, 2019). More generally, Omaha has encouraged communities throughout the city to adopt GI to help manage stormwater runoff (City of Omaha, 2014, 2010b). Starting in 2009, Omaha installed a series of nine demonstration GI projects and ten best management practice (BMP) projects (historically large scale stormwater projects like detention basins or constructed wetlands), eight of which were installed in public parks (Fig. 1 and Table 1) (A. Szatko, 2018, personal communication, 24 August). For the repeat-sales analysis, we targeted these eight GI installations (Fig. 1). The remaining projects were excluded from the analysis because they were either on private property and thus not necessarily evident to nearby homeowners or were associated with new or redevelopment initiatives (e.g., new buildings, major renovations, etc.) and therefore their effects on property values could not be isolated.

2.2. Data preparation and analysis

We obtained records of all arm's-length residential property sales (i.e., transactions between unrelated parties acting in their own self-interest) and associated housing characteristics for January 2000–August 2018 from the Douglas County Assessor. We cleaned the data, consistent with standard practice, by removing sales records not pertaining to single-family homes, townhouses, or duplexes in Omaha and sales records missing essential information (e.g., sales price, sales date). Following Shultz (2017), we also excluded sales records for homes with plots > 1 acre ($n = 1020$), sales < \$20,000 ($n = 2528$), and statistical outliers with regards to price per area unit ($n = 1622$). The excluded properties are likely to be non-arm's length transactions, located in peri-urban areas not part of the typical residential housing market, or to contain errors on their sales records.

Repeat-sales models evaluate the appreciation (or depreciation) of a property's value, and thus only consider properties that have transacted (i.e., sold) on more than one occasion. Our dataset contained 30,733 properties that transacted multiple times between 2000 and 2018, of which 21,845 are in neighborhoods where GI was installed in an existing public park (hereafter GI-park). Of the 21,845 properties, 67 % sold two times, 25 % three times, 7 % four times, and 1 % five or more times. Properties that exhibited a ± 20 % change in their finished area between sales, suggesting rebuilding or major additions to the home, were dropped because structural characteristics are assumed to be constant in repeat-sales models. The existing literature offers no guidance for selecting this threshold (i.e., ± 20 %); consequently, as described below, we conduct a sensitivity analysis using alternate thresholds. We also control for changes in a home's overall condition.

Properties sold on multiple occasions in the same year are problematic because they produce sales pairs without a time difference between transactions (Case et al., 2006; Cohen et al., 2016; Jarrad et al., 2018). There have been various approaches used to address this issue (Case et al., 2006); we elected to randomly select a single observation from sales records pertaining to the same property and sales year. From the remaining transactions, sales pairs were created between consecutive sales of the same property. Hence, a property that transacted on two occasions yielded a single sales pair and a property transacted on three occasions yielded two sales pairs. Our final dataset consisted of 25,472 sales pairs (Table 2). On average, real prices appreciated by 2% between sales. Likewise, the average finished area and average condition, as measured on a five-point scale from excellent to poor, increased slightly between sales.

Data on GI were obtained from Clean Solutions for Omaha (2009) and the City of Omaha Planning Department (<https://planning.cityofomaha.org/>). Clean Solutions for Omaha reports contain descriptions of Omaha's efforts to reduce combined sewer overflows, including detailed information on many of the GI projects. The City of Omaha Planning Department provided information on non-CSS related GI in Orchard Park and Prairie Lane Park, as well as other GI projects that were installed mostly on private property and as part of new construction or renovation (e.g., new apartment complex, fully renovated duplex). We ignored the latter projects, instead focusing our analysis on public parks where the effect of GI on housing prices can be plausibly identified. Using ArcGIS software (ver. 10.5; ESRI, Inc., Redlands, CA), we matched each property to the nearest GI-park. Of the 25,472 sales

pairs, 0.4 % are adjacent to a GI-park, 2.9 % are > 0–0.25 km from a GI-park, and 4.2 % are > 0.25–0.5 km from a GI-park. Our treatment group is comprised of the sales pairs located in proximity to a GI-park (i.e., < 0.5 km) and where GI was installed between sales transactions. Nearly 2% of sales pairs ($n = 477$) meet these criteria.

2.3. Repeat-sales model

We estimate a repeat-sales model, which, as noted above, evaluates the change in a property's value between sales. These models, relative to a traditional hedonic approach, are less susceptible to omitted variable bias because time-invariant characteristics drop out of the estimable equation. To see this, consider a simple repeat-sales specification (Eq. 1):

$$\ln\left(\frac{P_i}{\tilde{P}_i}\right) = \ln\left(\frac{\gamma X_i^{\alpha_1} Y_i^{\alpha_2} e^{\alpha_3 Z_i + \varepsilon_i}}{\gamma \tilde{X}_i^{\alpha_1} \tilde{Y}_i^{\alpha_2} e^{\alpha_3 \tilde{Z}_i + \tilde{\varepsilon}_i}}\right) = \alpha_2 \ln\left(\frac{Y_i}{\tilde{Y}_i}\right) + \alpha_3 (Z_i - \tilde{Z}_i) + (\varepsilon_i - \tilde{\varepsilon}_i) \quad (1)$$

where the tilde denotes values associated with the first transaction of sales pair i , P the sales price, X a vector of time-invariant determinants, Y and Z vectors of time-variant determinants, ε an independent and identically distributed (i.i.d.) error term, and α_2 and α_3 parameters to be estimated. After differencing, the dependent variable (i.e., the ratio of sales prices) is solely a function of time-variant determinants and error terms. The model does not require comprehensive information about a property's structural, neighborhood, and environmental characteristics; these characteristics are implicitly controlled because of the structure of the repeat-sales model, even though they do not explicitly enter the estimated model. When preferences for time-invariant characteristics are non-stationary (i.e., they vary over time), the repeat-sales model can be extended by interacting these characteristics with time variables (e.g., time trends, annual fixed effects) to capture the evolution of estimated parameters. Although they reduce omitted variable bias, repeat-sales models are inefficient in their use of information because properties transacted only once in the sample period are excluded from the analysis. Parameter estimates may therefore be biased if systematic differences exist between properties transacted on one occasion and properties transacted on multiple occasions (Hansen, 2006). We consider omitted variable bias to be a more pressing concern than issues caused by reduced sample size, and thus regard the repeat-sales model as the preferred modeling approach. Case et al. (2006) provide a thorough overview of potential repeat-sales model specifications and associated estimation issues.

We specify the following repeat-sales model to evaluate how the installation of GI in public parks affects nearby property values:

$$\ln\left(\frac{P_i}{\tilde{P}_i}\right) = \beta_A \ln(A_i) + \beta_R \ln(R_i) + \sum_{h=1}^H \beta_{Cj} C_{ih} + \beta_D D_i + \sum_{j=1}^J \sum_{k=1}^K \beta_{Njk} N_{ijk} + \sum_{l=1}^L \beta_{Sl} S_{il} + \beta_W W_i + \sum_{m=1}^M \beta_{Gm} G_{im} + (\varepsilon_i - \tilde{\varepsilon}_i) \quad (2)$$

$$A_i = (Age_i - \widetilde{Age_i}) / \widetilde{Age_i}$$

$$R_i = Area_i / \overline{Area_i}$$

$$C_{ih} = Condition_{ih} - \overline{Condition_{ih}}$$

$$D_i = (Trend_i - \overline{Trend_i}) \times Downtown_i$$

$$N_{ijk} = (Year_{ik} - \overline{Year_{ik}}) \times Neighborhood_{ij}$$

$$S_{il} = Season_{il} - \overline{Season_{il}}$$

$$W_i = ConstPrd_i - \overline{ConstPrd_i}$$

$$G_{im} = GI_{im} - \overline{GI_{im}}$$

where β denotes a parameter to be estimated and the tilde, i , P , and, ε are defined as before. A complete description of each variable and its definition is available in Appendix A. Although a home's structural features are assumed to be constant in a repeat-sales model, it is important to control for changes in property values resulting from deterioration and home modifications (e.g., renovations, maintenance). Consistent with extant literature (Francke, 2010; Cohen et al., 2016; Jarrad et al., 2018), we account for age-related deterioration using a measure based on the relative change in a home's age (*Age*) between the first and second transaction of a sales pair. We also control for changes in a home's finished area (*Area*) and the overall housing condition (*Condition*), with the latter being a vector of indicators for whether a home is in excellent, good, average, fair, or poor condition. Goetzmann and Spiegel (1995) suggest including an intercept term in repeat-sales models, which would otherwise drop out, to capture non-temporal appreciation associated with unobserved home modifications. Although numerous studies have adopted this approach (Case et al., 2006; Baron et al., 2016; Cohen et al., 2016; Jarrad et al., 2018; Beltrán et al., 2019), we prefer to control for home modifications explicitly using changes in a home's finished area and overall condition. Finished area, defined here to include finished basement area, can increase (or decrease) between sales due to home additions or renovations. Similarly, a home's condition, as determined by an assessor, can change between sales due to damage, renovation, or refurbishment. Nearly 11 % and 32 % of sales pairs in our sample exhibit a change in their finished area and condition, respectively.

Recent studies find the effects of a home's location on its sales price are non-stationary (Case et al., 2006; Jarrad et al., 2018). To account for this possibility, we interact indicators

for a home's neighborhood (*Neighborhood_j*) with indicators for its year of sale (*Year_k*)—creating neighborhood-specific price indexes that capture variation in sales-year effects across neighborhoods. Neighborhoods are defined as Omaha's identified distinct geographic areas: Downtown, Midtown, Central, North, North Central, Northwest, South, South Central, Southeast, West, East, Elkhorn, and Millard. Likewise, we incorporate an interaction between a home's distance to downtown (*Downtown*) with an annual time trend (*Trend*), allowing the effect of proximity to downtown to evolve linearly. The model also contains a vector of seasonal indicators (*Season*) to control for seasonal differences in the housing market between sales-pair transactions. Given that GI features were often installed as part of extensive CSS projects, we include an indicator for homes within 0.5 km of a GI-park that transacted during a project's construction phase (*ConstPrd*). These periods ranged from 12 to 25 months. Within the repeat-sales model, this variable controls for construction-related disruptions in road networks between sales pair transactions.

The vector of interest contains indicators for our treatment group (*GI_m*); namely, those properties within a specified buffer zone of a GI-park that transacted after a project's completion, when GI was installed. We follow previous greenspace and GI valuation studies in selecting buffer sizes because often there is a distance effect (e.g., Czembrowski and Kronenberg, 2016). We estimate models using a single buffer zone of 0–0.5 km, as well as models using three nested zones: adjacent to a GI-park, > 0–0.25 km, and > 0.25–0.5 km. After differencing, the GI variables in the repeat-sales equation take on the value of 1 if a property is a) within a specified buffer zone and b) GI was installed between sales pair transactions, and 0 otherwise. Because these are non-continuous variables, the percent impact of GI on nearby homes is calculated as $100 * (e^{\beta GI} - 1)$. The model is estimated with generalized least squares using the approach described in Case and Shiller (1989) to address heteroskedasticity related to the temporal drift of property values.

We assess the robustness of results by evaluating their sensitivity to key modeling decisions. Specifically, we estimate models with alternate GI-buffer zone distances and alternate dates for when GI features are assumed to be capitalized into the housing market (e.g., six months prior to when construction began, six months after construction ended). We also estimate models that include a constant term, neighborhood-specific trends, a measure of the GI project's size relative to park size, and that use alternate thresholds for excluding sales pairs with changes in finished area between sales (e.g., $\pm 0\%$ and $\pm 10\%$). Moreover, we estimate a difference-in-difference model to assess whether findings are substantively different when properties transacted on a single occasion are included in the analysis. As with repeat-sales, difference-in-difference is a quasi-experimental method used to, among other applications, quantify the effects of environmental changes on property values (e.g., Guignet, 2013).

3. Results

We present several specifications of the repeat-sales model, which differ in terms of GI-park buffer zones and the set of properties included in the estimation (Table 3). Control variables exhibited the expected signs and relative magnitudes, and R^2 values were consistent with other repeat-sales analyses (Case et al., 2006; Jarrad et al., 2018). Changes in real property values were negatively correlated with changes in age between sale, where Model 1 results

imply that a 1% increase in the age between sales lead to a 3.4 % decrease in the sales price. Likewise, changes in property values are positively correlated with an increase in a home's finished area between sales. This effect is large, with a 1% increase in area having led to a 15 % increase in sales price, suggesting that the variable may be capturing changes associated with major remodeling activities. As a robustness check, we estimated models using only properties whose finished area did not change between sales. Results from these models were not qualitatively different. Housing condition parameters (e.g., excellent, good, fair), estimated relative to the average classification, indicate that homes whose condition improved between sales experienced an increase in their sales price, while homes whose condition declined experienced a decrease in price.

The trend variable for a home's distance to downtown is positive and statistically significant, implying proximity to Omaha's downtown has become less desirable during the sample period, all else equal. This coefficient, due to the structure of the repeat-sales model, does not indicate whether proximity to downtown is desirable or not, only that it has on average become less desirable over time. The magnitude of this effect is small and may stem from relative changes between downtown and other neighborhoods, including possible changes in amenities, demographics, and housing and job market conditions (e.g., home foreclosure rates, employment opportunities). Estimated parameters for seasonal indicators and neighborhood-specific price indexes are not reported but largely conform to expectations. Wald tests showed statistically significant differences in the index parameters between neighborhoods; thus, confirming spatial heterogeneity in neighborhood effects over the sample period. Specifically, a joint hypothesis test of these parameters produces a Wald statistic of 10.03 (p-value = 0.000) for Model 1, 10.03 (p-value = 0.000) for Model 2, 59.24 (p-value = 0.000) for Model 3, 62.89 (p-value = 0.000) for Model 4, and 63.26 (p-value = 0.000) for Model 5. We found no evidence that sales prices were affected by construction from CSS projects.

With regards to GI, Model 1 considers whether GI affects sales prices of properties within 0.5 km of a park, whereas Model 2 disaggregates these properties into homes adjacent to, > 0–0.25 km, and 0.25–0.5 km of a park. None of the coefficients are statistically significant, suggesting GI features have not affected property values. We next considered the possibility that GI effects are obscured by systematic differences in appreciation between properties near to a GI-park and those further away. Models 3 and 4 repeat Models 1 and 2 respectively, using a subsample of properties within 1 km of a GI-park. Again, none of the coefficients are statistically significant. Lastly, because housing markets can take years to respond to changes in environmental amenities (Case et al., 2006; Jarrad et al., 2018) we estimate Model 5, using only those parks where GI was installed prior to 2017 (i.e., where there are at least two years of post-GI property data). Coefficients remain non-significant, although it is notable that the parks excluded from this model are those with the most visible GI features (e.g., wetland, expanded lake) and therefore are the projects most likely to impact property values.

For the sensitivity analysis, we estimated models using, as described above, modified definitions of key variables and alternate model specifications. These models imply that the

non-significant relationship between home values and GI is robust to key modeling decision. Results from the difference-in-difference model also support our findings.

4. Discussion

The City of Omaha, as well as other municipalities, has demonstrated an interest in how environmental amenities and dis-amenities affect property values. The Douglas County Board of Commissioners, for instance, sponsored a study to evaluate relationships between property values and proximity to floodplains, constructed lakes, and low-impact development in Omaha (Schultz and Schmitz, 2008). Moreover, increased property values are sometimes cited as a justification for implementing GI and other greenspace initiatives (Center for Neighborhood Technology, 2010; Stratus Consulting Inc., 2009; US EPA, 2013). Findings from several studies support this notion, including two analyses that estimate the effects of GI on property values (Ward et al., 2008; Ichihara and Cohen, 2011). But our results fail to support this relationship, a finding similar to those reported by Jarrad et al. (2018) and Netusil et al. (2014)—two other GI-related studies. This result is also consistent with Livy and Klaiber (2016), who found considerable heterogeneity in how local park renovations are capitalized into nearby property values, with some types of renovations having no statistically significant effect on values.

There are several potential explanations for why we do not find a statistically significant relationship between housing values and GI. One likely possibility is that the GI installations included in this study do not benefit nearby homeowners because they are modifications to existing public parks rather than new managed greenspace and may not be perceived as a benefit. In other words, it is possible that small-scale renovations to parks do not add value, or add little value, to an already valued greenspace. The installation of large-scale GI features in existing parks, or the creation of new managed greenspace, may be more highly valued. While home buyers may indeed place little value on installing GI in existing greenspace, we identify three additional explanations for our results. First, the benefits of GI may not have been fully capitalized into housing prices. It can take years for housing markets to respond to changes in environmental amenities (Case et al., 2006; Jarrad et al., 2018). Most of the GI projects included in this analysis were completed within the past 4 years, and it is possible additional years of post-GI sales data are needed to identify their effect. Second, the size of the treatment group (i.e., $n = 477$; 8 GI-parks) may be too small to identify the effects of interest. Additional years of post-construction sales data and the inclusion of other GI-projects, once completed, could address this concern. Third, the low visibility of some GI projects may mean that homeowners are unaware of their existence or benefits. A visual inspection of GI-parks using Google Map viewer showed that some GI is located in areas where no walking paths exist, or away from other park features like playground equipment. If homeowners value GI but are unaware of its existence or benefits, then municipalities interested in justifying GI investments on the grounds of improved property values should consider educational and outreach initiatives. Such initiatives, however, may be complicated by demographic and preference heterogeneity.

Research suggests that residents of different ethnic and racial backgrounds perceive greenspaces and interact with greenspaces in different ways (e.g., Gobster, 1998). Factors

like safety (Lapham et al., 2016; Kuo and Sullivan, 2001), preference and perception (Seymour et al., 2010; Kaplan and Talbot, 1988; Kaplan, 1985), and use (e.g., Hoyle et al., 2017; Gobster and Westphal, 2004) all influence how residents value a greenspace, and this is influenced by cultural norms, expectations of a space, and awareness. For municipalities interested in the economic effects from GI, incorporating an understanding of greenspace use and perception will be vital to building a successful education and outreach program. In-person interviews or surveys of residential perceptions and attitudes towards GI practices can provide information along these lines that supplement economic valuation studies.

5. Conclusion

In this study, we asked what effects the installation of GI had on residential property values in the City of Omaha, NE. A key challenge in this type of analysis is to isolate the effects GI has on property values, particularly given that many GI projects are deployed in concert with other street, utility, or new/re-development projects. To address this concern, we focused on GI features (e.g., detention pond, rain garden, bioswale) installed in eight public parks. GI features were publicly accessible and were not associated with building construction or renovation, although many were a component of large sewer separation projects. Using repeat-sales models and sales data from 2000 to 2018, we evaluated changes in property values for homes within various buffers of GI-parks. The models control for a wide range of structural, neighborhood, and environmental characteristics, and thus mitigate potential omitted variable bias. Results show that GI did not have a statistically significant effect on property values.

Whether this result accurately describes homeowners' values or reflects incomplete information about GI or data limitations is a key question for future research. Subsequent repeat-sales analyses that include more post-GI sales and other GI projects would help address this unknown. Likewise, surveys and interviews of residents can be used to determine how homeowners perceive GI and their understanding of its functions and benefits. This would aid in determining if educational outreach programs are appropriate. We therefore suggest future studies evaluate residential perspectives and attitudes, or survey realtors to determine how GI of any type may influence sale decisions. In either case, housing markets near GI features may not, and indeed are unlikely to, capture the benefits from improved downstream water quality and riparian habitat. The value of these benefits may surpass those provided by GI to nearby homeowners and should be of primary concern when considering the benefits and costs of stormwater management initiatives.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank M. Heberling and B. Demeke for helpful comments on an earlier version of this manuscript, and K. Hopton for proofreading. We also thank Associate Editor N. Kabisch and an anonymous referee for thorough reviews and insight on the manuscript. This research was performed while FAH held a National Research Council Research Associateship Award at the United States Environmental Protection Agency (US EPA). The US EPA funded and participated in the research described herein. Any opinions expressed in this paper are those of the

authors and do not necessarily reflect the views of the Agency; therefore, no official endorsement should be inferred.

Appendix A

Table A1

Table A1

Variable Definitions.

Variable	Definition
A	$A = (Age - \widetilde{Age}) / \widetilde{Age}$; Age = home's age in years
R	$R = Area / \widetilde{Area}$; $Area$ = home's finished area in square meters
C : Excellent	C : Excellent = Condition: Excellent - $\widetilde{Condition: Excellent}$; Condition: Excellent = 1 if the home is in excellent condition, and 0 otherwise
C : Good	C : Good = Condition: Good - $\widetilde{Condition: Good}$; Condition: Good = 1 if the home is in good condition, and 0 otherwise
C : Fair	C : Fair = Condition: Fair - $\widetilde{Condition: Fair}$; Condition: Fair = 1 if the home is in fair condition, and 0 otherwise
C : Poor	C : Poor = Condition: Poor - $\widetilde{Condition: Poor}$; Condition: Poor = 1 if the home is in poor condition, and 0 otherwise
D	$D = (Trend - \widetilde{Trend}) \times Downtown$; $Trend$ = annual time trend; $Downtown$ = home's Euclidian distance to downtown in kilometers
W	$W = ConstPrd - \widetilde{ConstPrd}$; $ConstPrd$ = 1 if the sales transaction occurred during the projects contruction period, and 0 otherwise
G : 0–0.5km	G : 0–0.5km = GI : 0–0.5km - $\widetilde{GI$: 0–0.5km; GI : 0–0.5km = 1 if the home is within 0.5km of the nearest GI-park and GI was installed at the time of the sales transaction, and 0 otherwise
G : Adjacent	G : Adjacent = GI : Adjacent - $\widetilde{GI$: Adjacent; GI : Adjacent = 1 if the home is adjacent to the nearest GI-park and GI was installed at the time of the sale transaction, and 0 otherwise
G : 0–0.25km	G : 0–0.25km = GI : 0–0.25km - $\widetilde{GI$: 0–0.25km; GI : 0–0.25km = 1 if the home is between 0 and 0.25km of the nearest GI-park and GI was installed at the time of the sales transaction, and 0 otherwise
G : 0.25–0.5km	G : 0.25–0.5km = GI : 0.25–0.5km - $\widetilde{GI$: 0.25–0.5km; GI : 0.25–0.5km = 1 if the home is between 0.25 and 0.5km of the nearest GI-park and GI was installed at the time of the sales transaction, 0 otherwise
N_{jk}	$N_{jk} = (Year_k - \widetilde{Year_k}) \times Neighborhood_j$; $Year_k$ = 1 if the sales transaction occurred in year k , and 0 otherwise; $Neighborhood_j$ = 1 if the home is in neighborhood j , and 0 otherwise. <i>Neighborhoods are defined as Omaha's identified community areas: Downtown, Midtown, Central, North, North Central, Northwest, South, South Central, Southeast, West, East, Elkhorn, and Millard.</i>
S_l	$S_l = Season_l - \widetilde{Season_l}$; $Season_l$ = 1 if the sales trasaction occurred in season l , and 0 otherwise

Note: Tilde denotes values associated with the first transaction of a sales pair.

References

- Anderson ST, West SE, 2006 Open space, residential property values, and spatial context. Reg. Sci. Urban Econ 36, 773–789. 10.1016/j.regsciurbeco.2006.03.007.
- Baron A, Zhang W, Irwin E, 2016 Estimating the capitalization effects of harmful algal bloom incidence, intensity and duration? In: A Repeated Sales Model of Lake Erie Lakefront Property

Values Paper Presented at the Agricultural and Applied Economics Association Annual Meeting Boston, MA 10.22004/ag.econ.236589.

- Belcher RN, Chisholm RA, 2018 Tropical vegetation and residential property value: a hedonic pricing analysis in Singapore. *Ecol. Econ* 149, 149–159. 10.1016/j.ecolecon.2018.03.012.
- Bell CD, Tague CL, McMillan SK, 2017 A model of hydrology and water quality for stormwater control measures. *Environ. Model. Softw* 95, 29–47. 10.1016/j.envsoft.2017.05.007.
- Beltrán A, Maddison D, Elliott R, 2019 The impact of flooding on property prices: a repeat-sales approach. *J. Environ. Econ. Manage* 95, 62–86. 10.1016/j.jeem.2019.02.006.
- Berland A, Schwarz K, Herrmann DL, Hopton ME, 2015 How environmental justice patterns are shaped by place: terrain and tree canopy in Cincinnati, Ohio, USA. *Cities Environ. (CATE)* 8, 1–15.
- Berland A, Shiflett SA, Shuster WD, Garmestani HC, Goddard D, Herrmann L, Hopton ME, 2017 The role of trees in urban stormwater management. *Landsc. Urban Plan* 162, 167–177. 10.1016/j.landurbplan.2017.02.017. [PubMed: 30220756]
- Brander LM, Koetse MJ, 2011 The value of urban open space: meta-analyses of contingent valuation and hedonic pricing results. *J. Environ. Manage* 92, 2763–2773. 10.1016/j.jenvman.2011.06.019. [PubMed: 21763064]
- Case B, Shiller R, 1989 The efficiency of the market for single family homes. *Am. Econ. Rev* 79, 45–56. 10.3386/w2506.
- Case B, Colwell PF, Leishman C, Watkins C, 2006 The impact of environmental contamination on condo prices: a hybrid repeat-sale/hedonic approach. *Real Estate Econ* 34, 77–107. 10.1111/j.1540-6229.2006.00160.x.
- Center for Neighborhood Technology, 2010 The Value of Green Infrastructure: A Guide to Recognizing Its Economic Environmental and Social Benefits CTN, Chicago, IL.
- Cho SH, Kim SG, Roberts RK, Jung S, 2009 Amenity values of spatial configurations of forest landscapes over space and time in the Southern Appalachian Highlands. *Ecol. Econ* 68, 2646–2657. 10.1016/j.ecolecon.2009.04.017.
- City of Omaha, 2010a Omaha Master Plan; Omaha by Design Retrieved from. <https://urbanplanning.cityofomaha.org/omaha-master-plan/master-plan-elements>.
- City of Omaha, 2010b Omaha Master Plan; The Environment Element Retrieved from. <https://urbanplanning.cityofomaha.org/omaha-master-plan/master-plan-elements>.
- City of Omaha, 2014 Omaha Regional Stormwater Design Manual Retrived from. City of Omaha Environmental Quality Control Division <https://omahastormwater.org>.
- Clean Solutions for Omaha 2019 <http://www.omahacso.com/projects/completedprojects/>.
- Cohen J, Blinn CE, Boyle KJ, Holmes TP, Moeltner K, 2016 Hedonic valuation with translating amenities: mountain Pine Beetles and host trees in the Colorado Front Range. *Environ. Resour. Econ* 63, 613–642. 10.1007/s10640-014-9856-y.
- Czembrowski P, Kronenberg J, 2016 Hedonic pricing and different urban green space types and sizes: insights into the discussion on valuing ecosystem services. *Landsc. Urban Plan* 146, 11–19. 10.1016/j.landurbplan.2015.10.005.
- Escobedo FJ, Adams DC, Timilsina, 2015 Urban forest structure effects on property value. *Ecosyst. Serv* 12, 209–217. 10.1016/j.ecoser.2014.05.002.
- European Commission, 2019 Review of Progress on Implementation of the EU Green Infrastructure Strategy. SWD (2019) 184 final, Brussels 24.5.2019
- Fletcher TF, Shuster WD, Hunt WF, Ashley R, Butler D, Arthur S, Trowsdale S, Barraud S, Semadeni-Davies A, Bertrand-Krajewski J-L, Mikkelsen PS, Rivard G, Uhl M, Dagenais D, Viklander M, 2015 SUDS, LID, BMPs, WSUD and more – the evolution and application of terminology surrounding urban drainage. *Urban Water J* 12, 525–542. 10.1080/1573062X.2014.916314.
- Francke M, 2010 Repeat sale index for thin markets: a structured time series approach. *J. Real Estate Financ. Econ* 41, 24–52. 10.1007/s11146-009-9203-1.
- Frey M, Kosco J, Williams C, LaDuca A, 2015 Green Infrastructure Opportunities That Arise During Municipal Operations EPA Office of Wetlands, Oceans and Watersheds, Washington, DC EPA Number 842-R-15-002.

- Gobster PH, 1998 Urban parks as green walls or green magnets? Interracial relations in neighborhood boundary parks. *Landsc. Urban Plan* 41, 43–55. 10.1016/S0169-2046(98)00045-0.
- Gobster PH, Westphal LM, 2004 The human dimensions of urban greenways: planning for recreation and related experiences. *Landsc. Urban Plan* 68, 147–165. 10.1016/S0169-2046(03)00162-2.
- Goetzmann WN, Spiegel M, 1995 Non-temporal components of residential real estate appreciation. *Rev. Econ. Stat* 1, 199–206. 10.2307/2110007.
- Guignet D, 2013 What do property values really tell us? A hedonic study of underground storage tanks. *Land Econ* 89, 211–226. 10.3368/le.89.2.211.
- Hall A, 2010 Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater With Green Infrastructure EPA Office of Wetlands, Oceans and Watersheds, Washington, DC EPA Number 841-F-10–004.
- Hansen J, 2006 Australian house prices: a comparison of hedonic and repeat-sales measures. *Econ. Rec* 85, 132–145. 10.1111/j.1475-4932.2009.00544.x.
- Heckert M, Rosan CD, 2016 Developing a green infrastructure equity index to promote equity planning. *Urban For. Urban Green* 19, 263–270. 10.1016/j.ufug.2015.12.011.
- Hoover FA, Hopton ME, 2019 Developing a framework for stormwater management: leveraging ancillary benefits from urban greenspace. *Urban Ecosyst* 22, 1139–1148. 10.1007/s11252-019-00890-6. [PubMed: 31844388]
- Hoyle H, Hitchmough J, Jorgensen A, 2017 All about the ‘wow factor’? The relationships between aesthetics, restorative effect and perceived biodiversity in designed urban planting. *Landsc. Urban Plan* 164, 109–123. 10.1016/j.landurbplan.2017.03.011.
- Ichihara K, Cohen JP, 2011 New York City property values: what is the impact of green roofs on rental pricing? *Lett. Spat. Resour. Sci* 4, 21–30. 10.1007/s12076-010-0046-4.
- Isely P, Isely ES, Hause C, Steinman AD, 2018 A socioeconomic analysis of habitat restoration in the Muskegon Lake area of concern. *J. Great Lakes Res* 44, 330–339. 10.1016/j.jglr.2017.12.002.
- Jaffe M, 2010 Environmental reviews & case studies: reflections on green infrastructure economics. *Environ. Pract* 12, 357–365. 10.1017/S1466046610000475.
- Jarrad M, Netusil NR, Moeltner K, Morzillo AT, Yeakley JA, 2018 Urban stream restoration projects: Do project phase, distance, and type affect nearby property sale prices? *Land Econ* 94, 368–385. 10.3368/le.94.3.368.
- Kaplan R, 1985 The analysis of perception via preference: a strategy for studying how the environment is experienced. *Landsc. Plann* 12, 161–176. 10.1016/0304-3924(85)90058-9.
- Kaplan R, Talbot JF, 1988 Ethnicity and preference for natural settings: a review and recent findings. *Landsc. Urban Plan* 15, 107–117. 10.1016/0169-2046(88)90019-9.
- Kuo FE, Sullivan WC, 2001 Environment and crime in the inner city: does vegetation reduce crime? *Environ. Behav* 33, 343–367. 10.1177/0013916501333002.
- Landry SM, Chakraborty J, 2009 Street trees and equity: evaluating the spatial distribution of an urban amenity. *Environ. Plan. A* 41, 2651–2670. 10.1068/a41236.
- Lapham SC, Cohen DA, Han B, Williamson S, Evenson KR, McKenzie TL, Hillier A, Ward P, 2016 How important is perception of safety to park use? A four-city survey. *Urban Stud* 53, 2624–2636. 10.1177/0042098015592822.
- Li X, Zhang C, Li W, Kuzovkina YA, Weiner D, 2015 Who lives in greener neighborhoods? The distribution of street greenery and its association with residents’ socioeconomic conditions in Hartford, Connecticut, USA. *Urban For. Urban Green* 14, 751–759. 10.1016/j.ufug.2015.07.006.
- Liebelt V, Bartke S, Schwarz N, 2018 Revealing preferences for urban green spaces: a scale-sensitive hedonic pricing analysis for the city of Leipzig. *Ecol. Econ* 146, 536–548. 10.1016/j.ecolecon.2017.12.006.
- Livy MR, Klaiber HA, 2016 Maintaining public goods: the capitalized value of local park renovations. *Land Econ* 92, 96–116. 10.3368/le.92.1.96.
- Mazzotta MJ, Besedin E, Speers AE, 2014 A meta-analysis of hedonic studies to assess the property value effects of low impact development. *Resources* 3, 31–61. 10.3390/resources3010031.
- Netusil N, Levin Z, Shandas V, Hart T, 2014 Valuing green infrastructure in Portland, Oregon. *Landsc. Urban Plan* 124, 14–21. 10.1016/j.landurbplan.2014.01.002.

- Noor NM, Asmawi MZ, Abdullah A, 2015 Sustainable urban regeneration: GIS and hedonic pricing method in determining the value of green space in housing srea. *Procedia - Soc. Behav. Sci* 170, 669–679. 10.1016/j.sbspro.2015.01.069.
- Panduro TE, Veie KL, 2013 Classification and valuation of urban green spaces—a hedonic house price valuation. *Landsc. Urban Plan* 120, 119–128. 10.1016/j.landurbplan.2013.08.009.
- Rigolon A, 2017 Parks and young people: an environmental justice study of park proximity, acreage, and quality in Denver, Colorado. *Landsc. Urban Plan* 165, 73–83. 10.1016/j.landurbplan.2017.05.007.
- Rigolon A, Németh J, 2020 Green gentrification or ‘just green enough’: do park location, size and function affect whether a place gentrifies or not? *Urban Stud* 57, 402–420. 10.1177/0042098019849380.
- Saphores JD, Li W, 2012 Estimating the value of urban green areas: a hedonic pricing analysis of the single family housing market in Los Angeles, CA. *Landsc. Urban Plan* 104, 373–387. 10.1016/j.landurbplan.2011.11.012.
- Schlöpfer F, Waltert F, Segura L, Kienast F, 2015 Valuation of landscape amenities: a hedonic pricing analysis of housing rents in urban, suburban and periurban Switzerland. *Landsc. Urban Plan* 141, 24–40. 10.1016/j.landurbplan.2015.04.007.
- Schultz S, Schmitz N, 2008 How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County University of Nebraska, Omaha, Real Estate Research Center https://www.unomaha.edu/college-of-business-administration/finance-banking-real-estate/_files/Water_Study.pdf.
- Seymour M, Wolch J, Reynolds KD, Bradbury H, 2010 Resident perceptions of urban alleys and alley greening. *Appl. Geogr* 30, 380–393. 10.1016/j.apgeog.2009.11.002.
- Shultz S, 2017 Omaha Single-family Housing Price Appreciation 2000–2016 Research Report for the Center for Real Estate and Asset Management, College of Business Administration University of Nebraska at Omaha Retrived from <https://www.unomaha.edu/college-of-business-administration/center-for-real-estate-and-asset-management/research/index.php>.
- Stratus Consulting Inc, 2009 A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds Stratus Consulting Inc., Boulder, CO.
- US Census Bureau, 2010 American FactFinder - 2010 American Community Survey U.S.Census Bureau's American Community Survey Office Accessed 30 March 2018 <http://factfinder2.census.gov>.
- US EPA, 2013 Evaluation of Green Alternatives for Combines Sewer Overflow Mitigation: a Proposed Economic Impact Framework and Illustration of Its Application US EPA, University of Cincinnati EPA Number 600/R/13/092.
- US EPA, 2020 Omaha Saddle Creek Combined Sewer Overflow Retention Treatment Basin Water Infrastructure Finance and Innovation Act (WIFIA) Retrieved from <https://www.epa.gov/wifia/omaha-saddle-creek-combined-sewer-overflow-retention-treatment-basin>.
- Vandegrift D, Zaroni N, 2018 An economic analysis of complete streets policies. *Landsc. Urban Plan* 171, 88–97. 10.1016/j.landurbplan.2017.11.004.
- Votsis A, 2017 Planning for green infrastructure: the spatial effects of parks, forests, and fields on Helsinki's apartment prices. *Ecol. Econ* 132, 279–289. 10.1016/j.ecolecon.2016.09.029.
- Waltert F, Schlöpfer F, 2010 Landscape amenities and local development: a review of migration, regional economic and hedonic pricing studies. *Ecol. Econ* 70, 141–152. 10.1016/j.ecolecon.2010.09.031.
- Ward B, MacMullan E, Reich S, 2008 The effect of low-impact-development on property values. *Proc. Water Environ. Fed* 2008, 318–323. 10.2175/193864708788808348.

Fig. 1. City of Omaha boundary and neighborhoods with green infrastructure projects installed in public parks (green circles) (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

Table 1

Description of green infrastructure projects located in parks throughout the City of Omaha.

Park Name	Install Date	GI Type	Size (sewer type)
Orchard Park	2009	Bioretention	295 m ² (CSS)
Saddle Hills	2014	Rain garden	215 m ² (MS4)
Adams	2016	Detention pond	56,656 m ² (CSS)
Elmwood	2012	Bioretention	139 m ² (CSS)
Fontenelle	2018	Detention pond	27,114 m ² (CSS)
Miller	2014	Detention pond	13,355 m ² (MS4)
Prairie Lane	2014	Bioretention	498 m ² (MS4)
Spring Lake	2016	Detention pond	7689 m ² (CSS)

Table 2

Descriptive statistics for sales pairs for $n = 25,472$ sales pairs.

Variable	Mean	Std. Dev.
Sales price (first transaction, 2018 USD)	192,992	(139,105)
Sales price (second transaction, 2018 USD)	196,872	(135,120)
Area of home (first transaction, square meters)	159.70	(82.22)
Area of home (second transaction, square meters)	160.72	(83.05)
Age of home (first transaction, years)	51	(29)
Age of home (second transaction, years)	57	(29)
Condition of home (first transaction, scale: excellent (1) to poor (5))	2.638	(0.687)
Condition of home (second transaction, scale: excellent (1) to poor (5))	2.645	(0.688)

Sales prices standardized using the Federal Reserve's Omaha-Council Bluffs Quarterly Housing Price Index. Area defined as the home's square meters of finished area (including finished basements).

Table 3

Repeat-sales model results.

	Model 1	Model 2	Model 3	Model 4	Model 5
ln(A)	-0.034*** (0.001)	-0.034*** (0.001)	-0.041*** (0.002)	-0.041*** (0.002)	-0.036*** (0.002)
ln(R)	0.145*** (0.033)	0.145*** (0.033)	0.316*** (0.098)	0.315*** (0.098)	0.304*** (0.101)
C: Excellent	0.106*** (0.006)	0.106*** (0.006)	0.095*** (0.018)	0.095*** (0.018)	0.085*** (0.018)
C: Good	0.058*** (0.003)	0.058*** (0.003)	0.073*** (0.009)	0.073*** (0.009)	0.056*** (0.009)
C: Fair	-0.170*** (0.009)	-0.170*** (0.009)	-0.158*** (0.018)	-0.158*** (0.019)	-0.174*** (0.021)
C: Poor	-0.418*** (0.032)	-0.418*** (0.032)	-0.404*** (0.070)	-0.404*** (0.070)	-0.398*** (0.079)
D	0.0003*** (0.0001)	0.0003*** (0.0001)	0.001* (0.001)	0.001* (0.001)	0.001 (0.001)
W	0.0004 (0.019)	0.0002 (0.019)	0.005 (0.022)	0.005 (0.022)	-0.020 (0.019)
G: 0-0.5 km	-0.012 (0.011)	-0.008 (0.014)			
G: Adjacent		0.044 (0.045)		0.049 (0.047)	0.050 (0.051)
G: 0-0.25 km		-0.017 (0.016)		-0.010 (0.018)	-0.008 (0.017)
G: 0.25-0.5 km		-0.015 (0.015)		-0.012 (0.018)	-0.012 (0.018)
Neighborhood Price Index	Yes	Yes	Yes	Yes	Yes
Season of Sale	Yes	Yes	Yes	Yes	Yes
Obs.	25,472	25,472	4476	4476	3914

	Model 1	Model 2	Model 3	Model 4	Model 5
R ²	0.211	0.211	0.255	0.256	0.267

* p < 0.1,
** p < 0.05,
*** p < 0.01.

Model 1 includes all properties and uses a single buffer zone to define homes near GI-parks.
Model 2 includes all properties and uses three buffer zones to define homes near GI-parks.
Model 3 includes properties within 1 km of a GI-Park and uses a single buffer zone to define homes near GI-parks.
Model 4 includes properties within 1 km of a GI-park and uses three buffer zones to define homes near GI-parks.
Model 5 includes properties within 1 km of a GI-park for parks where GI was installed prior to 2017. Values in parenthesis are standard errors.
Detailed definitions for each variable are available in Appendix A.