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## The economic impact of greening urban vacant land: a spatial difference-in-differences analysis

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**Abstract.** Vacant land is a serious problem in many cities, and cities have recently begun to explore greening as a management strategy to reduce the negative influence of vacancy. The city of Philadelphia, Pennsylvania pioneered the use of a simple greening treatment—removal of debris coupled with planting grass and trees—as a means of improving blighted communities. Though they are becoming more popular, the actual economic impact of these programs is not well understood. This paper details the use of a spatial difference-in-differences approach for measuring the impact of Philadelphia's innovative vacant land greening program on nearby residential property values. This approach compares observed changes in property values surrounding treated vacant lots with observed changes around control lots—lots which might have been treated but were not. While property values throughout the city increased during the study period, properties surrounding greened vacant lots had a greater increase in value than properties surrounding nongreened vacant lots. By developing both global and local versions of the model, we also explore spatial variation in the impacts of the program—offering insight into which kinds of neighborhoods might derive the greatest economic benefit from vacant land greening programs.

**Keywords:** greening, vacant land, difference-in-differences

### 1 Introduction

Decades of suburbanization and urban disinvestment have left many American cities with an overabundance of vacant land, especially older industrial cities of the Northeast and Midwest (Schilling and Logan, 2008). Because vacant lots can create significant problems for surrounding neighborhoods, including reduced property values and increased crime (Branas et al, 2011), and because these negative externalities may in fact serve to increase vacancy by pushing responsible homeowners to leave declining neighborhoods (Accordino and Johnson, 2000), cities have a vested interest in seeing vacant land redeveloped, or at least well managed. The question of how best to handle vacant land is one that urban scholars have struggled to answer for more than half a century (Bacon, 1940; Berkman, 1956; Bowman and Pagano, 2000; Brophy and Vey, 2002). Scores of federal, state, and local programs to address blight, however, have met with mixed results, and many cities have responded with continued decline or only modest growth (Vey, 2007).

Increasingly, cities are considering formal greening programs as a means of addressing not only negative externalities associated with vacant land but also the improvement of neighborhoods to spur redevelopment (Schilling and Logan, 2008). Greening programs take many forms, but are typically geared towards remediation of vacant land through clearing of debris, planting vegetation, and regular care for the cleanliness and vegetative health of the lot. These programs, however, are new enough that little is known about the economic outcomes associated with large-scale greening of vacant lots. Indeed, to our knowledge, there have been few, if any, peer-reviewed research articles focusing on the economic impacts of such vacant land greening programs [though see Branas et al (2011) for work related to safety

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and health and Voicu and Bean (2008) for economic impacts of community gardens]. To address this gap in the literature, this research focuses on the impact of a vacant land greening program in Philadelphia, Pennsylvania on surrounding property values.

Philadelphia makes an excellent case study for an analysis of vacant land greening as it has experienced considerable population loss since the mid-20th century and consequently has an abundant supply of vacant land. Long known for community greening efforts, Philadelphia was one of the first cities to explicitly adopt greening at the municipal level as a means of addressing blight, and has perhaps the largest existing vacant land greening program in the US, called the Philadelphia Land Care (PLC) program.

## **2 The Philadelphia Land Care Program**

Philadelphia's population declined steadily in the second half of the 20th century, dropping from a high of just over 2 million in 1950 to a low close to 1.5 million in 2000. As residents left, they left behind uncared for properties that fell into disrepair. By 1992 Philadelphia was home to 27 000 abandoned residential buildings and 15 800 vacant lots (Hughes, 2000). By 2000 a Department of Licenses and Inspections survey found 31 000 vacant lots scattered throughout the city (Bonham and Smith, 2008). A 2010 analysis suggests that the current total of vacant lots is closer to 40 000 (Econsult Corporation, 2010).

The PLC program was developed in 1996 through a partnership between the Pennsylvania Horticultural Society (PHS) and the New Kensington Community Development Corporation. Through the program, lots in the New Kensington neighborhood were cleared of debris, graded, provided with new topsoil, grass, trees, and a split-rail wooden fence, and then maintained regularly during the growing season with trash removal and mowing. Before and after pictures of a typical PLC lot are shown in figure 1. In an attempt to have the largest possible impact, the program focused on lots in high-traffic areas such as locations near schools or commercial corridors, and often selected groups of lots where several adjacent or very close lots could be treated together to create the sense of a single, larger greenspace.

This pilot project was well received and expanded to a few other neighborhoods, then expanded citywide in 2003 as part of then-mayor John Street's Neighborhood Transformation Initiative (NTI), a citywide blight reduction program. As NTI got underway and specific target neighborhoods for demolition were revealed, communities began to protest. Neighbors may have wanted unsafe properties torn down, but they were equally concerned about the negative impacts of the newly created vacant lots. In response to these concerns, PHS approached the Street administration with a proposal to use the PLC program (then called the Vacant Land Stabilization program) to manage the new vacant lots and address neighbors' concerns about their blighting influence. The proposed 'Green City Strategy' was accepted, and PLC is now incorporated into city policy through Greenworks Philadelphia, the City of Philadelphia's sustainability plan, as well as Green2015, a plan to establish 500 acres of new public greenspace by 2015 (PennPraxis, 2010). For more information on the PLC program, the reader is referred to Jost (2010).

## **3 Greenspaces and property values**

The basic premise of the vacant land greening program is to use greening as a means of reducing the appearance of neglect and to provide an interim treatment for land until such time as it would be used for development, in hopes that it might actually spur development by improving the look and feel, and also potentially property values, of surrounding areas. There is, however, limited research on the actual impact of greening vacant land on surrounding property values outside of the context of park creation. A report on impacts of a PLC pilot program in Philadelphia, which was limited to one neighborhood, found that greened lots increased the values of adjacent properties by as much as 30% (Wachter, 2004),



(a)



(b)

**Figure 1.** [In color online.] Photographs of an example Philadelphia Land Care lot (a) prior to greening and (b) after greening. Photographs courtesy of Pennsylvania Horticultural Society.

while a citywide analysis found more modest positive impacts (Wachter and Gillen, 2006). These studies were, however, limited in that they explored impacts only on directly adjacent properties and assumed a uniform impact for all locations. A study of community gardens in Baltimore—another means of greening vacant lots—also demonstrated increases in property values in areas surrounding well-managed gardens (Voicu and Been, 2008). Other than these few studies looking explicitly at greening vacant land, most of the empirical

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support for increased property values as an expected outcome comes from more generalized literature on parks and other types of greenspaces.

The idea that parks and greenspaces enhance property values is not new. Frederick Law Olmstead both predicted and then demonstrated significant property value appreciation in the proximity of Central Park in New York City in the years following its construction (Crompton, 2001). Methodological advances in the use of statistics for hedonic modeling allowed for more robust analysis in the latter half of the 20th century. Hammer et al's (1974) study of Pennypack Park in Philadelphia found that homes located 40 ft from the park had an added value of \$11 500 based on proximity to the park. Nicholls and Crompton's (2005) study of greenway access in Texas found significant increase in property values for adjacent residents in two of three neighborhoods. Other studies have shown positive impacts of parks and greenspace on property values in Los Angeles, California (Conway et al, 2008), Boston, Massachusetts (Tajima, 2003), Denmark (Præstholm et al, 2002), and Shenzhen, China (Chen and Jim, 2010).

There are several proposed mechanisms for how greenspaces contribute to property values. The base argument is that parks are amenities and as such the increase in property values close to a park reflects the value that residents place on that amenity (Crompton, 2005). The parks literature has now explored a wide range of amenity values that residents might ascribe to parks: from traditional park ideals of providing recreational services and improving the aesthetic appeal of a neighborhood to more recently understood impacts such as improving air quality, promoting social interaction, and improving health (Kuo et al, 1998; Maas et al, 2006; Nowak et al, 2006).

In attempting to draw parallels between research on parks and property values and the PLC program, it is important to consider that while PLC lots are vegetated open spaces they are not parks. They are not necessarily expected to remain permanently green, and most of the lots remain in private ownership, meaning that, while members of the public may be able to access them in reality, they are not truly public spaces in any legal sense. They are also fairly utilitarian spaces, lacking the landscaping or design elements that might be expected in a park setting. However, the PLC program is clearly designed with a goal of improving the physical condition and aesthetics of blighted neighborhoods, and thus greened lots may be seen as amenities in a manner similar to parks. Greening vacant lots may also impact property values by signaling that people care about, and are prepared to invest in, the community, a benefit that has been ascribed to other greening initiatives, such as tree planting (Wachter and Wong, 2008). Vacant lots are often blamed for decreasing property values by signaling neglect, so it may also be that greening programs such as PLC increase property values by removing the negative blighting influence, separate from the specific value of the greening itself.

More et al (1988) discuss the limitations of different valuation methods and suggest that different types of greenspaces may impact property values differently, with more natural spaces having a stronger positive impact than recreation-oriented facilities. One of the issues with existing research on greenspaces and property values that this analysis seeks to address is the extent to which neighborhood characteristics influence this relationship. The vast majority of studies focus either on individual parks or neighborhoods (such as Hammer et al, 1974; Wachter, 2004), or apply a single model of the relationship across a city or group of parks (Wachter and Gillen, 2006).

Troy and Grove (2008) showed that the positive impact of park proximity on housing values in Baltimore is moderated by neighborhood crime rates, with areas of high violent crime actually showing a reverse relationship where parks are associated with a decrease in property values. Li's (2010) study of greenspace and real estate values in Los Angeles has also shown that the impact of greenspaces tends to exhibit spatial nonstationarity, meaning

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that the effect of park proximity on home values is different in different locations, a possibility which has very rarely been taken into consideration by other greenspace researchers. If the PLC program is expected to increase property values based on its perception as an amenity, its impact may differ based on the extent and manner in which PLC lots are actually seen as being amenities in different parts of the city.

#### 4 Data

Our analysis aims to investigate the effect of the PLC program by comparing property values near vacant lots that have been greened with property values near vacant lots that have not been greened. The analysis relies on four primary datasets: locations of PLC lots (lots in the PLC program that have been greened), locations of control lots (vacant lots that have not been greened), residential real estate sales data, and a real estate market typology for areas of the city. A database of all PLC lots was provided by the PHS. PLC lots are tracked both as individual parcel addresses and as projects, through which contiguous and nearby parcels are combined for treatment and maintenance. When projects consist of noncontiguous parcels, they are generally immediately across the street or just down the block from each other. This database contains 747 projects consisting of 3297 parcels that were initially treated between 1999 and 2006. The average project was 5875 ft<sup>2</sup> and contained 4.4 parcels. Of these projects, 39 became inactive due to development or other reasons by 2007. Because it is impossible to distinguish effects of greening two adjacent parcels, the unit of analysis, hereafter referred to as a PLC lot, is the project.

We use a set of untreated (ie, non-PLC) vacant lots as a control dataset to compare to the PLC lots in order to estimate the effect of greening on property values. The database of potential control lots was derived from a 2010 database of vacant land from the City of Philadelphia Board of Revision of Taxes (BRT). BRT maintains a database of property assessments for all parcels in the city, including a designation of building type or land use. Any vacant parcels that were treated in PLC were removed from the pool of potential controls. The database of vacant lots consists of 38 341 vacant residential parcels located throughout the city. Because the unit of analysis for PLC lots is the project, the vacant parcels were dissolved based on adjacency to create 17 471 potential control vacant lots consisting of 2.2 parcels on average with an average size of 13 350 square ft<sup>2</sup>.

The residential sales dataset was acquired from the University of Pennsylvania's Cartographic Modeling Lab from records kept by the BRT. The dataset consisted of a point file of all residential sales between 1999 and 2007 with sale values of \$1000 or greater. The property data included the year of sale, purchase price, purchase price adjusted for inflation to 2007 dollars, and property square footage.

The real estate market typology data were derived from the Market Value Analysis (MVA) developed by The Reinvestment Fund (TRF), a Philadelphia-based Community Development Financial Institution, in 2008. The MVA applied cluster analysis to a variety of housing, transportation, and economic variables to identify parts of the city with similar housing-market characteristics as a means of targeting redevelopment investments. The final result was a census-block-group-level designation of residential areas ranging along a scale from 1.0 to 9.5, where lower and higher values indicate distress and health in the housing market, respectively. Block groups were then classified into categories such as distressed, transitional, or steady (other categories, such as 'regional choice', contained only a handful of vacant lots and so were not relevant to the present analysis). The real estate market typology was used to address the vast differences in real estate markets experienced by neighborhoods across the city, which might also be expected to affect changes in property values.

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## 5 Methods

### 5.1 The difference-in-differences approach

While the majority of studies of greenspace and property values described above use hedonic modeling approaches (eg, Chen and Jim, 2010; Præsthholm et al, 2002; Troy and Grove, 2008; Wachter, 2004), here we use a difference-in-differences modeling approach. Hedonic modeling provides an indirect measure of the value of an amenity (in this case a park or greenspace) by measuring the prices of properties near that amenity and comparing them with the prices of similar properties not near that amenity (Rosen, 1974). The difference-in-differences approach, by contrast, investigates whether an intervention influences an outcome over time by comparing observed differences in a case sample that receives the intervention with observed differences in a control sample that does not; or, in other words, is there a difference in an outcome due to a hypothesized treatment over a difference in time. This enables isolation of the treatment effect above and beyond any difference that would have been expected regardless of the treatment, such as the influence of new government programs or appreciation over time (Meyer, 1995). Because it relies on direct before and after measures at the same site rather than relying on modeling differences between sites, the difference-in-differences approach provides a more direct measure of the added value attributable to greening efforts than that provided by more frequently used hedonic modeling techniques.

### 5.2 Control lot selection

Selection of appropriate control lots is a primary concern for this analysis, as the control lots are used to represent what would have been expected to occur in the absence of the PLC program. Though there are no official PLC target area boundaries, the PLC program is intended to focus on economically depressed neighborhoods with high levels of vacancy. Lots were also more likely to be chosen for greening when they were in close proximity to a school or commercial corridor. The PHS, which manages the PLC program, often worked with local neighborhood groups to identify lots that neighbors wanted to see treated, and occasionally politicians advocated for the selection of specific lots.

We used three criteria to narrow the universe of vacant lots in the city to a set of potential control lots: proximity to schools and commercial corridors, size, and proximity to PLC lots. Only lots located within 500 ft of either a school or a commercial corridor were considered as potential control lots. As noted above, PLC lots were chosen primarily as groups of parcels, though occasionally single parcels were treated as individual projects, and thus PLC projects range in size from 569 ft<sup>2</sup> to 63 554 ft<sup>2</sup>. The universe of all vacant lots, after combining based on adjacency, displayed a much larger range of sizes, with some quite large in comparison with the largest PLC lots. The size range for all vacant lots was 29 to 11 685 329 ft<sup>2</sup>. As an extremely large vacant parcel might be expected to have a different impact than a smaller parcel, all vacant parcels with sizes outside of the range of sizes of PLC lots were eliminated from candidacy to serve as control lots.

Because the PLC program focused on areas of the city with high vacancy, there are many vacant lots that were not treated but are in close proximity to PLC lots. However, given that the focus of the research is to test for influence of PLC lots on surrounding properties, it does not make sense to use nearby lots as controls, as closer lots might still be expected to show a change based on their proximity to lots that were treated. That being said, it was also important to select control lots that were in similar neighborhoods to PLC lots, so it also does not make sense to choose control lots far away from (and thus in potentially different community types) the PLC lot with which they were intended to provide a comparison. To minimize overlap with PLC areas of influence, potential controls were restricted to those lots located more than 250 ft from the closest PLC lot. This ensures that control lots are at least a half city block away from their matched PLC lot, and thus not within the immediate view

of greened lots. Using these three criteria, the pool of potential controls was reduced to 7836 lots.

From this universe of potential control lots, controls were matched three to one to PLC lots based on two additional criteria: sections of the city and real estate market typology. These criteria were designed to ensure that control lots represented as closely as possible the same type of neighborhoods as PLC lots. Sections of the city were designated based on the Philadelphia City Planning Commission's Neighborhood Planning Districts, which break the city into eighteen neighborhoods, of which twelve contain at least one PLC lot. To the extent possible, PLC lots were matched to control lots within the same planning district and with the same TRF market typology score. Due to these spatial and economic criteria used to select control lots, and because of the use of sampling without replacement within a finite pool of candidate control lots, there were occasions when there were not enough control lots to match to every PLC lot. In these instances controls were selected in neighboring planning districts (this was the case for southwest Philadelphia, where PLC lots were in fact clustered close to the border with the University/Southwest District), or selected randomly from other districts based on market score (this was the case with South Philadelphia, where the closest neighborhood district did not have enough controls in the same market type). See table 1 for descriptive statistics of PLC and control lots.

**Table 1.** Descriptive statistics of Philadelphia Land Care (PLC) and control lots.

		PLC Lots ( <i>N</i> =747)	Control Lots ( <i>N</i> =2241)
Parcels per lot	mean	4.41	2.22
	SD	4.98	2.81
Size (ft <sup>2</sup> )	mean	5875	3237
	SD	6911	5145
Distance from the nearest PLC lot (ft)	mean		757
	SD		935
The Reinvestment Fund Market Value Analysis	mean	1.76	1.77
	SD	1.08	1.07

### 5.3 Model specification

In the present study we are interested in whether there is a difference in residential property values due to greening between the pregreening and postgreening time periods. The difference-in-differences model for the present analysis is thus specified as

$$\ln V_{it} = \beta_0 + \beta_1 P_i + \beta_2 G_{it} + \beta_3 P_i G_{it} + \beta_4 M_i + \beta_5 S_i + \beta_6 Y_t + \varepsilon_{it} \quad (1)$$

where  $\ln V_{it}$  is natural log of the average price per square foot of residential real estate near a vacant lot  $i$  at time  $t$ ;  $P_i$  is a dummy variable set to 1 if lot  $i$  is part of PLC or 0 if it is not;  $G_{it}$  is a dummy variable set to 1 if time  $t$  is postgreening for lot  $i$  (for a control lot, this is set to 1 when the associated treated lot is greened);  $P_i G_{it}$  (ie, the interaction term defined as  $P$  times  $G$ ) is a dummy variable set to 1 if lot  $i$  is in PLC and time  $t$  is postgreening and 0 otherwise;  $M_i$  is a variable encoding the MVA real estate market index value of lot  $i$ ;  $S_i$  is a fixed-effects variable for the Neighborhood Planning District of the city of lot  $i$ ;  $Y_t$  is a fixed-effects variable for year to account for temporal effects;  $\varepsilon_{it}$  is an error term; and  $\beta$  terms are the coefficients to be estimated by the model. To calculate  $V_{it}$ , each lot was assigned an annual average sale value per square foot based on inverse distance weighting of up to fifteen of the closest residential sales within 500 ft, extending the 500 ft radius where necessary to ensure

that at least ten sales were included in each calculation. Price per square foot was used rather than price to account for differences in predominant housing size across the city.

In interpreting the results of the difference-in-differences model we are particularly interested in the sign and significance of the interaction term  $PG$ . A significant coefficient of  $PG$  would indicate that the influence of the time change from pregreening to postgreening on nearby residential property values is moderated by whether a vacant lot is in the PLC program. Clearly, we expect that property values near control lots would not be affected by the time change from pregreening to postgreening, as they were not greened; whereas we expect that PLC lots will exhibit a significant change in nearby property values from pregreening to postgreening. Thus, a significant and positive  $PG$  coefficient would indicate that the PLC program does indeed raise nearby residential property values.

#### 5.4 Testing for spatial nonstationarity

We are also concerned that the impact of the PLC program on residential property values may vary by location across the city. Such spatial variation may occur because the economic conditions may be different in one neighborhood compared with another neighborhood, which may affect the potential impact of the PLC program. Or, access to the central business district or other amenities may moderate the influence of the PLC on property values. Such spatial variation in the relationship among independent and dependent variables may be considered spatial nonstationarity (Fotheringham et al, 2002). Here, we test for spatial nonstationarity using three approaches.

In the first approach we run the difference-in-differences model independently for different regions of the city. For this purpose, we use a form of the Neighborhood Planning Districts which we modified by aggregating certain planning districts together logically in order to tessellate the city into seven major regions (figure 2). The difference-in-differences model was then run for each region independently [excluding the term  $S_i$  in equation (1) encoding the Neighborhood Planning District]. Spatial nonstationarity is evident if a significant impact of the PLC program on property values is found in one section of the city but not another, or if the effect is found to be different (either in direction or in the size of the effect) in different regions.

The second approach is analogous to the first but instead of using spatial data derived from the Neighborhood Planning District boundaries we use the market typology categories from the TRF MVA. Here, we consider that the impact of the PLC program on property values will differ by neighborhood real estate market conditions, as an indicator of neighborhood economic status. For this purpose we use the three primary market categories as defined by TRF MVA: distressed regions (TRF scores 1–2.5), transitional regions (TRF scores 3.0–4.5), and steady regions (TRF scores 5.0–6.5). Note that, unlike the first approach, where each Neighborhood-Planning-District-derived region embodied a single contiguous area of the city, each MVA region can encompass several noncontiguous areas. A separate difference-in-differences model was then applied to each of the three MVA regions independently.

The third approach to investigating spatial nonstationarity employed geographically weighted regression (GWR). In GWR a separate regression equation is calculated for each observation in the dataset, based on a specified neighborhood surrounding each observation (Fotheringham et al, 2002). The GWR model can be expressed as

$$y_i = \beta_0(u_i, v_i) + \sum \beta_k(u_i, v_i)x_k + \varepsilon_i, \quad (2)$$

where  $y$  is the value of the dependent variable to be estimated,  $(u_i, v_i)$  represents the planimetric coordinate (ie,  $x,y$ ) location of  $i$ , and  $x_k$  is the  $k$ th independent variable. The weighting function used in GWR is meant to create a Gaussian weight–distance surface over the study space, with values approaching one near observation  $i$  and values moving toward





**Figure 2.** Regions derived from the Philadelphia City Planning Commission district boundaries used to investigate spatial nonstationarity.

zero farther from observation  $i$ . In the present study, GWR models were calculated using half mile, one mile, and two mile bandwidths. We used three different bandwidths simply to ensure that the results are consistent across bandwidths and are not an artifact of a specific bandwidth setting.

## 6 Results

Table 2 reports the results of the global difference-in-differences model. We are particularly interested here in the  $PG$  variable, the interaction term that captures the difference in the influence of pregreening and postgreening on property values between PLC and control lots. The  $PG$  variable is positive and significant, providing evidence that the PLC program does indeed raise nearby residential property values. Also of note, the  $P$  variable coefficient is negative and significant, indicating that residential property values near PLC lots tend to be lower than property values near control lots. The  $G$  variable is not significant, indicating that, after accounting for the influence of the presence of the PLC program and global patterns of property appreciation by year, residential property values did not change significantly from pregreening compared with postgreening.

The analyses of spatial nonstationarity suggest that the effect of the PLC program on residential property values differs according to location. The results of the difference-in-differences model as applied independently to each of the seven modified Neighborhood Planning District regions of the city are reported in table 3. Results indicate that the  $PG$

variable is significant (and positive) in only three regions: the Eastern North, West, and Southwest regions. For each of the regions, the PLC program raised residential property values. Interestingly, the magnitude of the effect is substantially higher for the Southwest and markedly less so in the Eastern North. No significant effect of the PLC program was detected for the other four regions of the city.

**Table 2.** Coefficients of the global difference-in-differences model ( $N=26\,608$ ).

Independent Variable	Coefficient	$R^2$
<i>P</i>	-0.084***(-8.729)	0.415
<i>G</i>	-0.013 (-0.987)	
<i>PG</i>	0.056** (3.100)	

Note. *t*-values are reported in parentheses; \*\* $p < 0.01$ , \*\*\* $p < 0.001$

**Table 3.** Standardized coefficients of the difference-in-differences model for different modified planning district regions.

Region	<i>N</i>	<i>P</i>	<i>G</i>	<i>PG</i>	$R^2$
Eastern North	6612	-0.193*** (-7.905)	0.021 (0.754)	0.080* (2.059)	0.411
Lower Northeast	590	-0.037 (-0.504)	0.031 (0.467)	0.035 (0.304)	0.461
Northwest	2685	-0.121*** (-5.292)	-0.408 (-1.206)	0.049 (1.1014)	0.468
West	5165	-0.28*** (-13.139)	-0.07* (-2.179)	0.145*** (3.483)	0.242
Western North	8063	0.052** (3.063)	-0.04 (-1.872)	-0.067 (-1.932)	0.356
South	2296	-0.011 (-0.472)	0.147** (3.207)	0.019 (0.427)	0.519
Southwest	1197	-0.441*** (-12.531)	-0.140 (-2.034)	0.456*** (5.091)	0.297

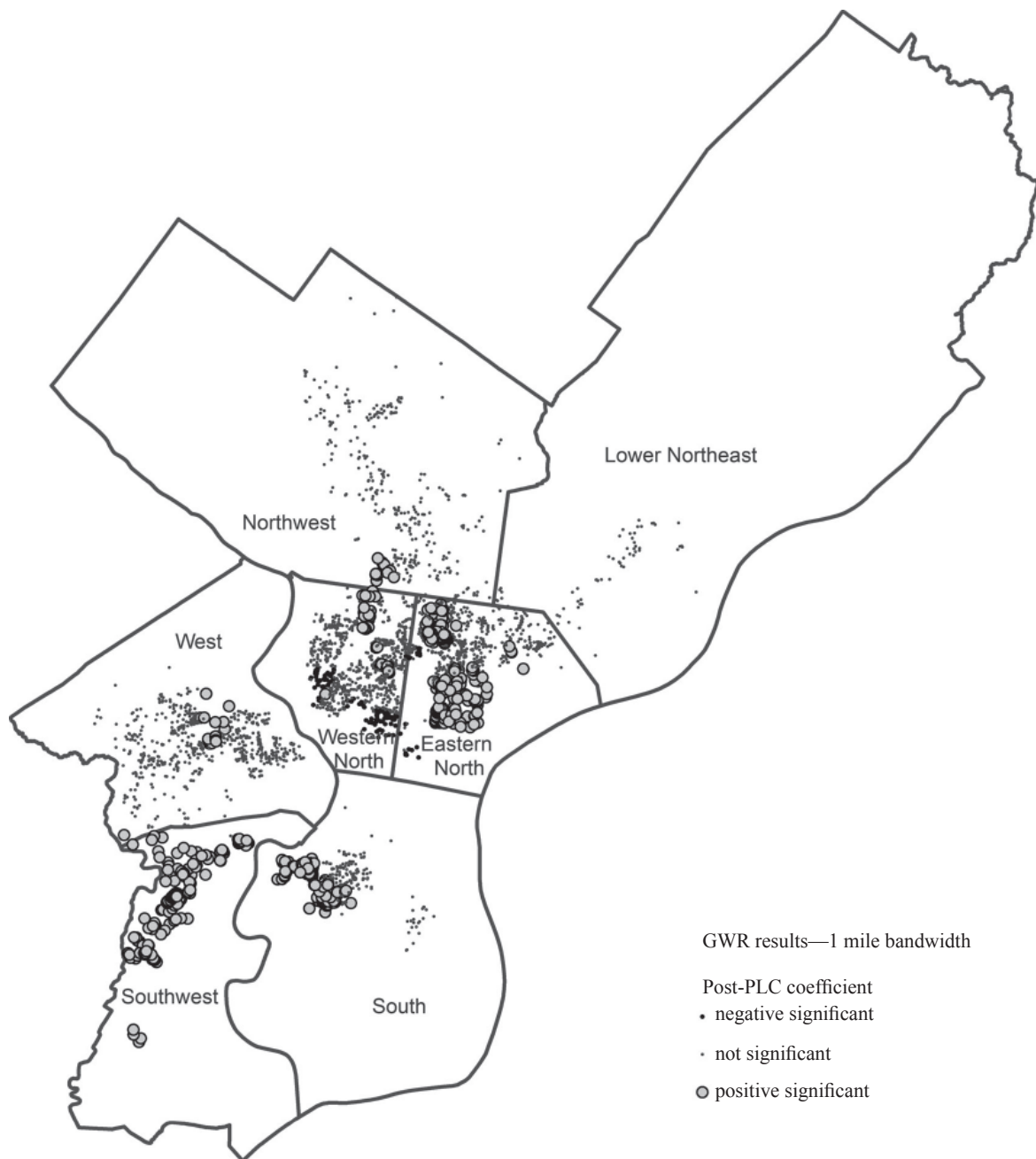
Note. *t*-values are reported in parentheses; \*  $p < 0.05$ ; \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**Table 4.** Coefficients of the difference-in-differences model for different market value analysis (MVA) Regions.

Region	<i>N</i>	<i>P</i>	<i>G</i>	<i>PG</i>	$R^2$
Distressed	22 106	-0.075*** (-7.341)	-0.062*** (-4.165)	0.070*** (3.556)	0.360
Transitional	3 773	-0.135*** (-4.836)	0.06 (1.859)	0.028 (0.597)	0.427
Steady	515	-0.147 (-1.614)	0.076 (0.770)	0.004 (0.034)	0.479
Highly distressed	15 336	-0.004 (-0.290)	-0.054** (-3.018)	0.012 (0.495)	0.294
Moderately distressed	6 770	-0.226*** (-13.515)	-0.034 (-1.454)	0.208*** (6.019)	0.348

Note. *t*-values are reported in parentheses; \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

Table 4 reports the results of the difference-in-differences model applied independently to each of the three TRF MVA market typology categories: distressed, transitional, and steady regions. Interestingly, only in the model for the distressed regions was the *PG* variable significant. In distressed regions of the city, the PLC program had a positive impact on nearby property values. However, this positive effect was not observed in other, nondistressed regions of the city. We further investigated this finding by focusing solely on lots in the distressed region, by running separate difference-in-differences models on lots with an MVA score of 1.0–1.5 (highly distressed) and 2.0–2.5 (moderately distressed). Results indicate that the positive effect of the PLC program on nearby residential property values is present in moderately distressed regions but not in highly distressed regions (table 4).



**Figure 3.** Map of the results of the difference-in-differences geographically weighted regression (GWR), where open circles indicate lots where the *PG* coefficient is positive and significant (ie, locations at which the Philadelphia Land Care program raised the nearby residential property values).

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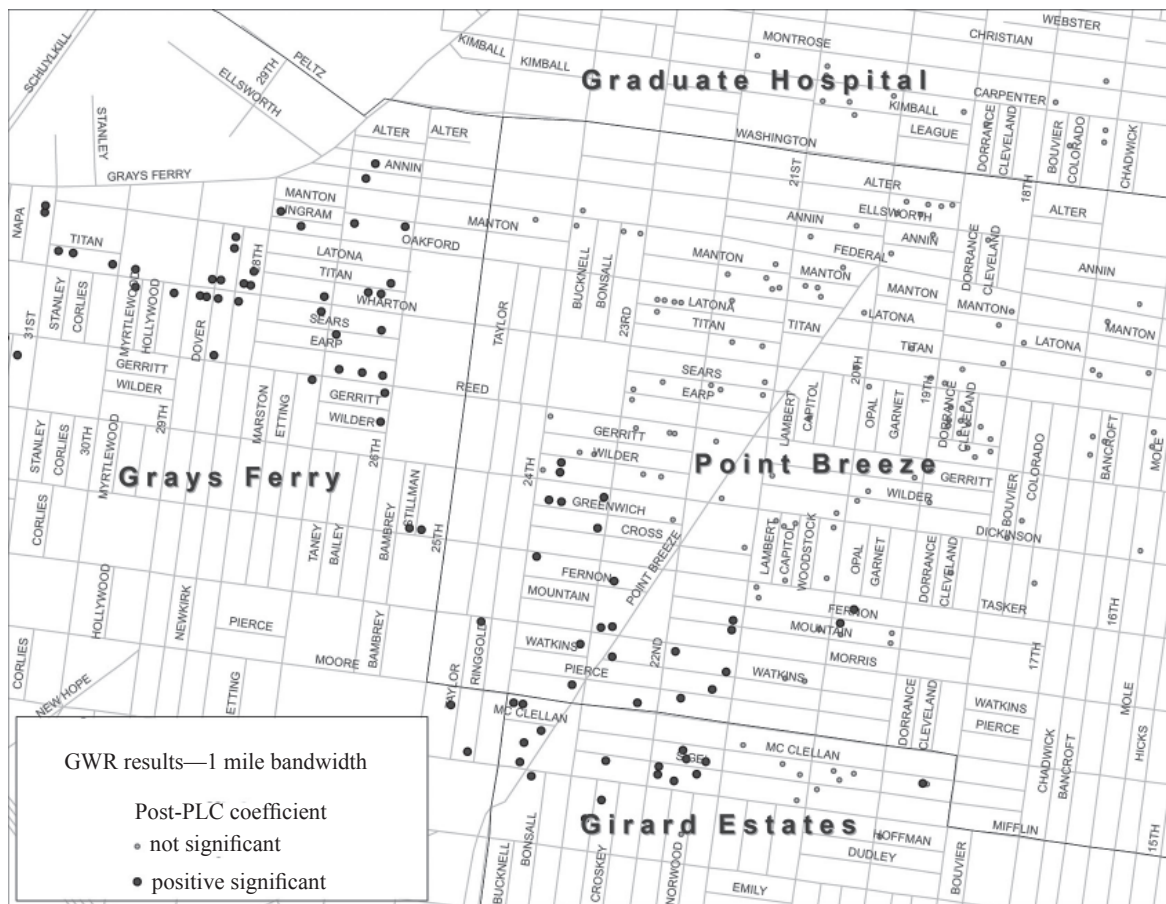
Mapped results of the GWR analysis illustrate the parts of the city where the effect of the PLC program is relatively strong or weak. Figure 3 shows a map of the PLC and control lots, where each lot that has a significant and positive *PG* coefficient is shown in large gray points, lots with significant and negative *PG* coefficients are shown in small dark points, and the other lots are shown as smaller gray points. Because the GWR results were largely consistent across the three different bandwidth settings, only the result for the GWR model using a one mile bandwidth is mapped here. The map is overlain with the modified planning district boundaries for orientation. The GWR results are naturally consistent with the results indicated by the analysis of spatial nonstationarity by modified Neighborhood Planning District regions (table 3), where clusters of lots with positive and significant *PG* coefficients are located within the Southwest, West, and Eastern North regions. However, the GWR also shows clusters of lots with positive and significant *PG* coefficients in portions of the South and Western North regions, as well as a small band of negative and significant *PG* coefficients in Western North Philadelphia.

## 7 Discussion

This study provides evidence that the PLC program did indeed raise nearby residential property values in Philadelphia. Thus, it confirms the results of previous studies of the PLC program that were more limited in scope (Wachter, 2004; Wachter and Gillen, 2006). These findings are also consistent with previous studies that focused on the impacts of parks and community gardens on housing values, where proximity to parks and gardens is associated with higher property valuation (Conway et al, 2008; Voicu and Been, 2008). It is likely that the mechanism by which the PLC program influences nearby property values operates similarly to that of parks and community gardens, where such features are considered amenities that can be used for recreation or are aesthetically pleasing, and thus incorporated into the price of a house. It is also likely that property values may increase due to the removal of blight associated with an unimproved vacant lot that is often littered with trash and covered by unmanaged vegetation. Such visual signals of decay and blight suggest weak social control over the environment, and the role of the PLC program in simply reaffirming the visual indicators that signal a well-cared-for and managed property may act to increase property valuation (Wachter and Wong, 2008).

Our results are also consistent with previous studies that have found that the influence of parks and greenspaces on property values may be moderated by the character of the park or neighborhood, and thus may vary from place to place (Li, 2010; Troy and Grove, 2008). Our analyses of spatial nonstationarity suggest that residential property values were influenced by the PLC program only in certain regions of the city, and among those regions in which the influence was detected, the magnitude of the influence varied substantially. There may be a variety of reasons for the variation in the strength of the effect of the PLC program but some evidence is provided by the difference-in-differences models run independently on the different TRF market typology categories. These results suggest that it is primarily within distressed neighborhoods in which the effect of the PLC program is felt. Indeed, in healthy real estate market neighborhoods, which are coincident with higher socioeconomic status, the impact of the PLC program on property values was not detected.

Interestingly, however, when the distressed category was broken down into highly and moderately distressed neighborhoods, we found that it was the lots in moderately distressed neighborhoods that were driving the relationship between the PLC program and property value increase. A closer look at this mechanism is illustrated by focusing on the GWR analysis, which shows greater spatial detail in the variation of the significance and magnitude of the effect of the PLC program compared with the analysis of modified Neighborhood Planning Districts. For instance, while South Philadelphia as a whole did not show a significant effect



**Figure 4.** A close-up of the map presented in figure 4 focusing on the Point Breeze, Grays Ferry, and Girard Estates neighborhoods in South Philadelphia.

of the PLC program at the Neighborhood Planning District level, the GWR analysis shows the positive influence of the PLC program on property values for certain South Philadelphia neighborhoods within the South region. Figure 4 provides a close-up map view, similar to figure 3 but ‘zoomed in’ to these particular neighborhoods (Point Breeze, Grays Ferry, and Girard Estates), where the neighborhood boundaries are superimposed for visual reference.

One can see from figure 4 that a significant and positive effect of the PLC program is evident for Grays Ferry and Girard Estates, as well as the southwestern portion of Point Breeze that lies adjacent to these two neighborhoods, but not for the remainder of Point Breeze. Notably, the Point Breeze neighborhood has for years been one of the poorest in Philadelphia, and in the decades leading up to 2000 saw substantial housing abandonment due to depopulation. During this time the neighborhood was almost exclusively African American, with a very high crime rate compared with the remainder of the city. Since 2000, however, Point Breeze has been the center of some controversy over gentrification and new development, responding in part to significant demographic changes over the past decade, while Gray’s Ferry and Girard Estates have not (Graham, 2011; Gregory, 2011). Grays Ferry, though also home to many of the city’s poor, is more racially diverse, has a lower crime rate, and has not undergone substantial gentrification. Girard Estates is also more racially diverse than Point Breeze, with substantially less abandoned housing, and a pocket of relatively wealthy residents living in large, well-maintained homes in the southern portion of the neighborhood.

It may be the case that in neighborhoods such as Point Breeze, the effects of the PLC program on residential housing values are simply swamped by other, neighborhood-level effects on property values. We speculate, for instance, that in areas of very high concentrated poverty, with attendant social problems of unemployment and crime, the PLC program,

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by itself, will not entice more potential homebuyers or developers, and thus the influence of the program on property values will be effectively nil. On the other hand, in neighborhoods undergoing gentrification, where home prices have remained very low for a long time but are rising rapidly due to the presence of wealthier homebuying migrants from other neighborhoods, as well as developers, the influence of the PLC program will not be detected because home prices across the entire neighborhood will be on the rise. Thus, it is likely that the influence of the PLC program will be felt most keenly not only in disadvantaged neighborhoods (where vacant lots tend to predominate generally), but also where other dynamic influences on residential property values, such as very high concentrated poverty and/or gentrification, tend to be relatively moderate.

The significant findings in Southwest and Eastern North Philadelphia may hint at other program factors that might influence the impact of greening programs on surrounding property values. Eastern North Philadelphia was the site of pilot PLC projects prior to citywide adoption of the program. The average year of greening of the 166 PLC lots in Eastern North Philadelphia is more than a year earlier than the average year of greening of lots in other areas of the city (2003 versus 2004). We believe this may affect the influence of PLC in two different ways. First, it is possible that the positive influence of PLC is felt more strongly with time. Second, it is also possible that the longer tenure of the program in this neighborhood corresponds to a larger overall percentage of lots being treated, which may increase the impact of the program.

This second interpretation may be supported by the results in Southwest Philadelphia. The program was more recently implemented there (the average year of treatment is 2005), but also more concentrated. By the end of the study, PLC lots in Southwest Philadelphia had on average 41% of their surrounding vacant land (lots within 500 ft of the PLC lot) also treated. By contrast, the analogous percentage for PLC lots in Eastern North Philadelphia was 31%, whereas in Western North Philadelphia and Northwest Philadelphia, the percentage of vacant lots near PLC lots that were also treated was only 19%. This strongly suggests that factors related to implementation of PLC, particularly the concentration of treated lots, may influence the program's ultimate impact on surrounding property values.

Surprisingly, the GWR results also show two small areas of significant negative coefficients for *PG*. While these are more difficult to explain from a theoretical standpoint, they may represent areas where the presence of PLC lots was seen as an indicator of a blighted neighborhood. The largest such area, just east of Girard College, is an area that has seen an influx of college students from Temple University, which may be impacting real estate values, again highlighting the potential for other neighborhood dynamics to influence the effects of greening.

## 8 Conclusion

We acknowledge several limitations of this research. First, the matching of control lots to PLC lots was challenging. The choice of 250 ft buffer 'rings' to select candidate control lots was somewhat arbitrary. Recall that these buffer parameters were selected to identify control lots that were not so close to their respective PLC lots that they themselves would be within the range of influence of PLC greening, but would still be close enough to be considered residing in a similar urban environment to act as a control case. However, we are unsure of the sensitivity of the results to this specific buffer parameterization. And despite the fact that each PLC lot and its respective control lots were forced to reside in the same TRF MVA category, substantial differences persisted between control and PLC lots. PLC lots tended to be larger than control lots (table 1), and the model results indicate that PLC lots tended to have lower nearby residential property values than control lots (table 2).

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It is notable that the process by which vacant lots are chosen for greening is not random. As noted above, although lots are sometimes chosen for greening because of their proximity to schools or commercial corridors, there are not explicit or published criteria by which lots are selected for greening. Indeed, the process of lot choice for the PLC program is both subjective and political in nature, which problematizes the quantification and operationalization of the criteria for lot choice within a statistical analysis. This latent mechanism of lot choice can not only be considered a potential missing variable in the difference-in-differences model that may partially explain the influence of greening on nearby property values, but also would be useful in choosing appropriate control lots. That said, the specification of the model is intended to account for the differences between the PLC and control lots our hypothesis is related to the moderating effect as expressed by the *PG* interaction term. Nonetheless, ideally it would be best to have case (ie, PLC) and control groups of lots that are indistinguishable, apart from inclusion in the PLC program.

In addition, while the use of the TRF MVA data proved useful in investigating the influence of the PLC program within different real estate market regimes, it is important to note these data are from 2008, dating to immediately after the time frame of the housing sales data used in the analysis (1999–2007). It would be helpful to know the TRF MVA category at the beginning of the time frame of analysis. It is possible, for instance, that the neighborhoods in which the PLC program increased property values were actually coded as lower on the MVA scale at the beginning of the study, and the PLC program actually caused the real estate market in those neighborhoods to become healthier. Such a finding might suggest that the PLC program provides a strong complement to other factors, such as access to transportation, that improve real estate markets.

It is also worth noting that the lack of a significant finding of the effect of the PLC program for a particular region (ie, in any of the local models) is not definitive evidence that the PLC program had *no* impact. It is possible that in these areas its impact was simply smaller and thus not a large enough difference to be detected, or that it was more localized and not detected at the scale of this study. But second, even if there is no measurable impact on residential property values, that finding in itself does not preclude the possibility of other positive benefits of the program. Research on greenspaces has shown many other positive impacts on surrounding communities, including improved environmental conditions (Nowak et al, 2006a; Nowak et al, 2006b), positive impacts on mental and physical health (Maas et al, 2009; Taylor et al, 2001; Wolch et al, 2010), and increases in neighborhood satisfaction (Ellis et al, 2006; Kaplan, 1985). Any policy decisions on the future of PLC or similar programs should also consider the potential for these types of benefits.

In future research we intend to incorporate other possible effects on changes in residential property values, such as the demographic and crime characteristics of neighborhoods. Though we sought to address these neighborhood-level influences generally using fixed-effects within the difference-in-differences model, it would be helpful to operationalize these theorized influences in the model in a specified manner. As noted above, such characteristics may also serve to moderate the effect of the PLC program, as crime, for example, has been found to do with the influence of parks on property values (Troy and Grove, 2008). It may also be useful to consider both overall amounts of vacant land and the concentration of PLC lots. In planning for the PLC program, the PHS tries to select larger spaces in the hopes that they will have a greater impact. It seems reasonable that PLC might also have a greater impact in areas where a larger percentage of lots have been treated compared with areas where they make up a small minority of vacant land. Another related factor to consider lies in how the PLC program is implemented in different locations. The PHS manages the PLC program citywide, but works with many different community groups and subcontractors on

actual implementation. It may be that the strengths and weaknesses of those community partners also contribute to whether or not the PLC program has a measurable impact.

These limitations and future research questions suggest that much work on understanding the impact of vacant land greening programs on urban development remains. However, the results of the present analysis lend substantial support to the use and efficacy of urban vacant land greening programs. We find that an increase in residential home prices is observed near greened vacant lots compared with homes near vacant lots that have not been greened. Though these results also suggest that the positive influence of greening programs may be limited to certain neighborhoods with particular socioeconomic preconditions, such findings should certainly be encouraging to municipal governments of cities like Philadelphia, where the management of blight and vacant land presents serious challenges to the ongoing economic vitality and livability of the city.

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