Research Paper

The effects of produce gardens on neighborhoods: A test of the greening hypothesis in a post-industrial city

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HIGHLIGHTS

• We review factors associated with individual's landscaping decisions.
• We review mechanisms for the development of neighborhood landscape patterns.
• Yard maintenance was better for properties nearby a produce garden.

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ABSTRACT

Researchers have found that gardens and landscaping designs can diffuse throughout neighborhoods. In the present study, we extend this research by examining if produce gardens on reclaimed vacant lots can have a radiating and positive, linear effect on the surrounding residential parcels. If well-maintained parcels tend to cluster together then we would expect that parcels proximal to a well-maintained produce garden would have better maintenance than parcels near an undeveloped vacant lot. We refer to this transformative process as the Greening Hypothesis. In the present study, we investigate yard maintenance observations of residential properties located near a produce garden, compared with those near an undeveloped vacant lot while controlling for residents' neighborhood perceptions and census demographic data. Our study area was urban and residential with higher than normal levels of property abandonment and urban blight. Our results, supporting the greening hypothesis, indicated that residential parcels proximal to produce gardens were better maintained than parcels near undeveloped vacant lots. Study implications support policies and programs which include greening initiatives as part of community development strategies.

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1. Introduction

Researchers have found that well-maintained, natural areas such as gardens may lead to improved mental health, reduced crime and promote good health and well-being (Groenewegen, den Berg, de Vries, & Verheij, 2006). Residents who participate in community gardens or beautification efforts are more likely than non-participants to report a greater perception of social capital and neighborhood norms and values (Alaimo, Reischl, & Allen, 2010). Conversely, indicators of urban blight are associated with higher levels of crime, fear of crime (Perkins & Taylor, 1996; Ross & Mirowsky, 1999; Taylor, Shumaker, & Gottfredson, 1985), perceptions of social disorder (Ross & Mirowsky, 1999; Taylor et al., 1985), lower neighborhood satisfaction, and reduced investment in neighborhoods (Dassopoulos, Batson, Futrell, & Brents, 2012; Immergluck & Smith, 2006).

The decline of a neighborhood into disorder is a complicated process due to the dynamic nature and individualistic factors of each community. Social disorganization is a result of the community experiencing a breakdown of social bonds, which reduces social capital, community engagement and community attachment (Bursik, 1988). Urban blight characteristics include physical incivilities such as graffiti, littering, and signs of poor home maintenance (Perkins, Meeks, & Taylor, 1992). If residents in blighted neighborhoods are more likely to disengage from their neighborhoods, then improving blighted properties may break the downward spiral of neighborhood disorder and facilitate residents' engagement...
and social bonding. There are government and non-profit organizational programs that aim to improve blighted properties while also engaging community members to address this issue.

Community greening projects are one strategy for engaging residents in improving blighted properties. We use the term greening to refer to the process of restoring the landscaping and beauty of blighted property. Greening projects promote controlled growth and maintenance of natural areas, such as parks, gardens and residential yards. A greened property parcel has evidence of care such as groomed grass, bushes, trees or other natural landscaping, or planted areas such as a rock, flower, or edible garden (includes fruits, vegetables and herbs). In our study we focus on produce gardens, which refer to a parcel with the sole purpose of growing edible plants that is currently maintained, and does not include residential gardens. Produce gardens are a good indicator of greening because they cover a relatively large area that likely requires multiple individuals to continuously maintain signs of care. Produce gardens are a visible indicator of community investment that may lead to changes in neighboring resident’s yard maintenance through a variety of processes such as individual-level factors, neighborhood norms and preference for specific landscaping aesthetics. To explore how produce gardens may be associated with residential yard care it is important to understand an individual’s motivation to care for their property.

A variety of factors influence residential yard maintenance. Typically, a resident’s decision about landscape management is the result of individual factors such as personal values, attitudes and lifestyle factors (Chowdhury et al., 2011). Various factors across multiple ecological levels (e.g., neighborhood, city, state and federal), however, can influence how an individual cares for their property (Chowdhury et al., 2011; Grove et al., 2006; Troy, Grove, O’Neil-Dunne, Pickett, & Cadenasso, 2007). Within each level are multiple factors that can affect an individual’s landscape. Even though a wide span of landscape designs and maintenance are possible at the individual parcel level, landscaping patterns can develop within a community (Chowdhury et al., 2011). These neighborhood patterns indicate that residents take into account their neighbors when making landscaping decisions (Nielson & Smith, 2005).

Researchers have theorized that residents are influenced by their neighbor’s landscaping through ideas such as ecology of prestige, the halo effect and mimicry (Grove et al., 2006; Julien & Zmyslony, 2001; Nassauer, 2011). Most residents want to adhere to neighborhood norms and group identity particularly if the neighborhood characteristics are representative of a higher socioeconomic status (Chowdhury et al., 2011; Grove et al., 2006). A resident with a well-maintained parcel is more likely to be described as hard-working, proud of their home and a considerate neighbor (Nassauer, 1995, 2011). These mechanisms suggest group-level factors such as neighborhood social bonding, accountability, cohesion, norms and values intermingle to influence residential landscape decisions (Chowdhury et al., 2011; Sullivan, Kuo, &Depoorter, 2004). The development and maintenance of landscaping therefore may be an indication of neighborhood social capital, norms, group identity and overarching psychosocial characteristics.

The neighborhood norms and group identity can shape the aesthetic appeal of a property, which can lead to changes in private landscapes to align with a desired appearance (Gobster, Nassauer, Daniel, & Fry, 2007). In a model developed by Gobster et al. (2007), the relationship between landscape esthetics and resident behavior is bi-directional; meaning residents can alter the esthetics of a landscape, and changes in landscape esthetics can alter resident’s perception and influence behavior. This esthetic cycle can contribute to the spread of greening within neighborhoods (Gobster et al., 2007). What constitutes as attractive in landscape design is debatable, and standards can vary by individuals and groups but, our national culture tends to find organized, well-defined (mowed, weeded) yard maintenance as the most appealing design (Donovan & Prestemon, 2012; Nassauer, 1995). Additionally, in a study of rural and suburban residents, landscapes that had signs of care were deemed most attractive (Nassauer, 1988a, 1988b, 1992). Signs of care, also known as cues to care, include mowing, weeding, no litter or trash and other indicators of intentional, on-going human care (Nassauer, 2011; Nassauer & Raskin, 2014). Indications of care are likely to increase the possibility that residents will view a yard as attractive.

Typically, esthetically pleasing properties show signs of care that indicate guardianship and surveillance, which can be used to prevent crime in neighborhoods (Sullivan et al., 2004; Troy et al., 2007). The Crime Prevention through Environmental Design approach (CPTED; Cozens, Saville, & Hillier, 2005; Jeffre, 1971) is a crime prevention framework that suggests that changes in the physical environment of a neighborhood will both reduce places for crime to occur and help create an atmosphere of caring and community cohesion. Using certain CPTED principles, Branas et al. (2011) found a reduction in gun assaults nearby undeveloped, vacant parcels enrolled in a greening program. The greening program was similar to transforming an abandoned, vacant lot into a produce garden in that it was a cue to care. If a produce garden becomes a cue to care it likely increases the attractiveness of the property and thereby may influence nearby individual yard maintenance (Chowdhury et al., 2011). It may be small actions within a neighborhood, such as maintaining a produce garden, that will spread among residents through social connections and interactions that impact neighborhood norms (Nassauer, 2011). These neighborhood norms may increase the likelihood of landscaping or neighborhood yard maintenance patterns.

Although researchers have found that landscaping can diffuse throughout neighborhoods to form landscaping patterns, a question remains if well-maintained greened properties, such as produce gardens, can have a similar positive effect on the surrounding residential parcels in neighborhoods with urban blight. If greened parcels tend to cluster together, as Hunter and Brown (2012) found in their study with easement gardens, then we would expect parcels proximal to a greened parcel would have better yard maintenance than parcels near an undeveloped abandoned parcel. We refer to this mimicry process as the Greening Hypothesis: improving or beautifying the landscape of a blighted parcel will promote yard maintenance on nearby parcels. In the current study, we focused on the radiating effects of a particular type of greening, produce gardens, on nearby occupied residential parcels. We selected produce gardens as our greened parcels due to their required attention and upkeep (definition requires current maintenance) and size (likely multiple individuals required for care). We compared the yard maintenance of residential parcels located near produce gardens with comparable parcels without a nearby produce garden.

2. Methods

2.1. Study design

This study compared the yard maintenance of two types of residential properties: those located near a produce garden and those not near a produce garden. We utilized two sources of data: observer ratings of parcel maintenance and community or neighborhood factors that influence individual parcel yard maintenance. We considered neighborhoods (i.e. Census block groups) as clustering units that contain individual property parcels (i.e., parcels nested within neighborhoods). We expected parcels within the
same neighborhood to be similar when compared to parcels in different neighborhoods. Our analysis plan accounted for outcome similarities for parcels residing in the same neighborhoods (i.e. neighborhood effects) by modeling variation at both the parcel and neighborhood ‘levels.’ Using this multi-level framework, we examined the effect of proximity to produce gardens on individual yard maintenance, accounting for individual and neighborhood factors.

2.2. Study setting

We conducted this study in two residential areas in Flint, Michigan, a post-industrial city that has been hard-hit by the effects of deindustrialization and urban sprawl. The two residential areas of our study are located in highly blighted areas of Flint that have been the focus of recent revitalization efforts. Flint is an industrial city whose population has grown and declined during the 20th century with the manufacturing capacity of the city’s largest employer, General Motors. As manufacturing jobs left the area, so did a significant portion of Flint’s population, declining 48% from 196,940 in 1960 to 102,434 in 2010 (U.S. Census Bureau, 2010). The city of Flint also has recently experienced higher unemployment rates than most metropolitan areas in the US (U.S. Bureau of Labor Statistics, 2013). One recent compilation of FBI crime statistics noted that Flint had the second highest violent crime rate among American cities (O’Leary Morgan, 2013). The homeowner occupancy rates ranged from 18.1% to 87.4%, with a mean occupancy rate of 49% (U.S. Census Bureau, 2009a). The number of residents in poverty was 47.2%, with roughly one third of the households headed by a single female (U.S. Census Bureau, 2009a). Flint may be representative of other northern U.S. industrialized cities that have suffered a severe decline in economic prosperity and population. The two residential areas cover roughly 2.5 square miles and include 15 census block groups. The borders of the residential areas align with the census block group designations. We used the census block groups as our ‘neighborhoods’ since that was the smallest geographic area available for our data analysis. The majority of parcels within the neighborhoods are single-family residential parcels, although a large public hospital and some surrounding clinics are located in one of the neighborhoods.

2.3. Measures

The study used data collected at two levels of analysis. For the first level, the unit of analysis was the parcel; we used data about the parcels’ locations and observations of the parcels’ purpose and maintenance. The second level of data included neighborhood-level factors thought to be related to parcel maintenance, including (A) survey data about residents’ neighborhood perceptions and levels of neighborhood participation and (B) neighborhood population density and home ownership data collected by the US Census Bureau. The neighborhood-level indicators were summarized for the US Census block group areas that surrounded the parcels in this study.

2.3.1. Parcel-level data

The location of each parcel was determined using ArcGIS. Over a 6-week period in the summer of 2012, six trained observers assessed the maintenance of all property parcels in two Flint neighborhoods using the Parcel Maintenance Observation Tool (PMOT; Reischl et al., in press). Each parcel was assessed by one observer. We found the inter-rater reliability on the PMOT measures to be high or satisfactory. The PMOT included an assessment of the parcel type – a single item requiring the observer to choose one of 16 general categories describing the primary purpose of the parcel; the categories included residential, commercial, industrial, educational, religious, government, public utility, parking lot/ramp, produce garden, and undeveloped vacant lot. Over one-third of the parcels (38%) were coded as vacant lots with no permanent structures or observable purpose. The observers coded 19 parcels as a produce garden because the parcels had no permanent structures and their sole purpose was to grow produce (fruits or vegetables). According to tax records, owners of the 19 produce gardens included nonprofit organizations (6 gardens), individual property owners (5 gardens), and the county government (8 gardens). The PMOT also included a dichotomous rating indicating whether or not the parcel included a building that was occupied (currently in use).

The PMOT also included the following observer ratings: (1) mowing and weeding, a 7-point rating of how recently the open areas had been mowed; (2) landscaping, a 5-point rating of how well the shrubs and gardens were maintained; and (3) litter/trash, a 5-point rating assessing the amount of untended litter and trash on the parcel. We computed a yard maintenance composite score by standardizing and summing the three items. A summary table of the PMOT yard maintenance variables for our samples is listed in Table 1. Reischl et al. (in press) describe the development and psychometric assessment of this instrument including additional description information, inter-rater reliability, and evaluation of validity.

All produce gardens were owned by either non-profit organizations, individuals, or the local government. We examined maintenance outcomes of nearby properties by parcel ownership to rule out potential differences between individual-versus organization-owned gardens (Table 2). Upon finding only one difference as a result of ownership, this variable was not considered further.

2.3.2. Neighborhood-level characteristics

In order to assess neighborhood-level characteristics we used data from two sources: (A) a survey of 255 adult respondents who resided in the two Flint neighborhoods and (B) downloaded data from the US Census Bureau’s American Community Survey (ACS; U.S. Census Bureau, 2009a, 2009b). The survey respondents completed the survey either in-person, over the telephone, online, or by mailing a hard-copy. Sampling for telephone surveys included random samples of households drawn from census tracts conducted by an outside agency; the response rate is unknown. In-person interviews were conducted by trained research assistants who randomly selected occupied homes on street segments in the two residential areas; the response rate was roughly 26%. Residents unable to complete in-person surveys received a hard copy and were instructed to mail the completed survey. The survey assessed residents’ perceptions of social capital and cohesion, neighborhood disorder, and neighborhood participation. Average scores on the following survey measures were computed for each of the 15 US Census block groups in this study’s two neighborhoods. Census block groups had an average of 17 surveys with a range of 6–28 surveys. Survey respondents were more likely to be female, have more than a high school education and younger.

<table>
<thead>
<tr>
<th>PMOT measures</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowing and weeding (0–4)</td>
<td>4.57 (.91)</td>
</tr>
<tr>
<td>Landscaping (1–4)</td>
<td>3.27 (.82)</td>
</tr>
<tr>
<td>Litter and trash (0–6)</td>
<td>2.62 (.77)</td>
</tr>
<tr>
<td>Yard maintenance* (−3.00 to 1.41)</td>
<td>0.07 (.66)</td>
</tr>
</tbody>
</table>

* Yard maintenance is a standardized composite score of Landscaping, Mowing and Weeding and Litter and Trash.
2.3.2.1. Social capital/cohesion. This 5-item scale used 5-point Likert ratings to assess perceptions of neighborhood trust, willingness to help neighbors, how much neighbors knew each other, whether children had adults they looked up to, and fear of neighborhood crime (alpha = .82).

2.3.2.2. Neighborhood disorder. This 8-item scale used 5-point Likert ratings to assess neighborhood graffiti, vandalism, abandoned buildings, criminal activity, noise, cleanliness, and home maintenance (alpha = .91).

2.3.2.3. Neighborhood participation. This counted up to five ways respondents participated in neighborhood activities, including crime watch, beautification project, neighborhood meetings, actions with neighbors to solve neighborhood problem, and volunteering at a local school, church or other neighborhood institution (alpha = .70).

We used the ACS five-year estimate data (2005–2009) from the US Census Bureau to estimate population density and the percent of occupied households for the 15 Census block group areas in this study. We did not use income as a variable because we found no significant variation across the census block groups in our study sample and individual household-level income data was unavailable. The ACS is a nationwide, continuous survey designed to provide communities with reliable and timely demographic, housing, social, and economic data every year. The ACS includes not only the basic short-form questions, but also detailed questions about population and housing characteristics (U.S. Census Bureau, 2013).

2.4. Analytic samples

We analyzed the maintenance ratings of 215 occupied, residential parcels within 100 m of a produce garden and a comparison sample of 627 occupied, residential parcels within 100 m of an undeveloped vacant lot. Previous research suggested that landscape mimicry effects start to fade at 91 m (Hunter & Brown, 2012). The study by Hunter and Brown (2012) occurred in a high occupancy neighborhood, whereas our residential areas had high levels of abandonment. Therefore the 100 m distance allowed for the test parcels to be close enough to one another to have a similar neighborhood context, but with enough distance to prevent interactions. This distance also captures residential properties with a high likelihood of frequently viewing the produce garden, which increases the likelihood of mimicry (Zmyslony & Gagnon, 2000). The comparison parcels were 200–250 m away from a produce garden to prevent the comparison parcels from being affected by produce gardens while maintaining similar neighborhood conditions. To establish a dichotomous produce garden proximity variable, these two samples of parcels were coded as being near a produce garden (coded as 1) or near an undeveloped vacant lot (coded as 0). After selecting the two analytic samples, we coded all parcels within 100 m of a produce garden or an undeveloped vacant lot; this allowed us to conduct analyses of yard maintenance at two distances (100 m, then 50 m). We conducted a follow-up analysis with a 50 m analytic sample to see if the greening effects were stronger at a closer distance.

2.5. Data analytic strategy

We used hierarchical linear modeling (HLM) to analyze our models of interest. HLM accounts for similarities between parcels as a result of neighborhood-level effects and provides the average effect of a level-2 predictor (e.g. disadvantage) on the outcome variable (Raudenbush & Bryk, 2002). We first ran a one-way ANOVA with random effects (see Model 1 for equation) to determine the amount of variation present at the parcel (level-1) and neighborhood (level-2) levels. Next, we introduced produce garden proximity as a level one predictor and included a fixed slope at level 2 to allow for unique intercepts and proximity slopes across neighborhoods (see Model 2). We then considered a model that included proximity as a predictor of yard maintenance, but with a random slope across neighborhoods (see Model 3). In this model, intercepts were still allowed to vary. Our final model introduced social capital, neighborhood disorder, neighborhood participation, population density and percentage of owner occupied homes as covariates (see Model 4). The outcome for both models was the composite Z-score of yard maintenance with higher scores reflecting better maintenance. The models were tested twice: once for the parcels within 100 m of produce gardens and undeveloped vacant lots and again for the parcels within 50 m of produce gardens and undeveloped vacant lots.

Model 1. Variation of Parcel and Neighborhood Yard Maintenance Equation

\[
\text{Yard Maintenance}^i = \beta_0 + r
\]

\[
\beta_0 = \gamma_0 + \mu_{0j}
\]

1. Yard Maintenance: a composite score of landscaping, mowing and litter/trash

Model 2. Produce Garden Proximity Effects Equation

\[
\text{Yard Maintenance} = \beta_0 + \beta_1 \text{ (Produce Garden Proximity}^2)\]

\[
\beta_0 = \gamma_0 + \mu_{0j}
\]

\[
\beta_1 = \gamma_1 + \mu_{1j}
\]

2. Produce Garden Proximity: A dichotomous variable indicating if the parcel was nearby a produce garden or a vacant lot.

| Table 2 |
|-----------------------|-----------------------|-----------------------|-----------------------|
| PMOT measures          | Ownership of nearest produce garden | F(df)          |
|                        | Non-profit | Local government | Individual |               |
| Mowing and weeding (0–4) | 4.82 (.87) | 4.42 (.94) | 4.70 (.86) | 2.87 (2, 201) |
| Landscaping (1–4)      | 3.30 (1.06) | 3.15 (.81) | 3.33 (.81) | .89 (2, 141)  |
| Litter and trash (0–6) | 2.92 (.52) | 2.49 (.82) | 2.69 (.74) | 2.58 (2, 203) |
| Yard maintenance (2.21–1.41) | .30 (.67) | -.08 (.67) | .18 (.63) | 4.78 (2, 201) |

\* p < .01.
\( \dagger \) Yard maintenance is a standardized composite score of Landscaping, Mowing and Weeding and Litter and Trash.

Different subscripts indicate significant group difference in post hoc comparisons p < .05 (Bonferroni adjustment).
Table 3
Effect of living within 100 m of a produce garden or undeveloped vacant lot on mean yard maintenance score produce garden.

<table>
<thead>
<tr>
<th>Models</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-.14</td>
<td>-.17</td>
<td>-.17</td>
<td>-1.02**</td>
</tr>
<tr>
<td>Produce garden proximity (100 m)</td>
<td>.15</td>
<td>.16</td>
<td>.15</td>
<td></td>
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<tr>
<td>Population density</td>
<td></td>
<td></td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>% owner occupied properties</td>
<td></td>
<td></td>
<td>1.71***</td>
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<tr>
<td>Social capital/cohesion</td>
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<td></td>
<td>.47**</td>
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<td>Neighborhood disorder</td>
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<td></td>
</tr>
<tr>
<td>Neighborhood participation</td>
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<td></td>
<td>-1.60</td>
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<td>Variance estimate</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\mu_0$</td>
<td>.08**</td>
<td>.08**</td>
<td>.08**</td>
<td>.07</td>
</tr>
<tr>
<td>$\mu_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>.51</td>
<td>.51</td>
<td>.50</td>
<td>.51</td>
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<tr>
<td>Deviance</td>
<td>1850.28</td>
<td>1850.04</td>
<td>1849.37</td>
<td>1859.10</td>
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<tr>
<td>Estimated parameters</td>
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<td>2</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

* $p < .05$  
** $p < .01$  
*** $\mu_1 = \text{n.s.}$

**Model 3. Produce Garden Proximity Effects without Random Effect Equation**

Yard Maintenance = $\beta_0 + \beta_1(\text{Produce Garden Proximity})$

$\beta_0 = \gamma_{00} + \mu_0$

$\beta_1 = \gamma_{10}$

**Model 4. Neighborhood-level Effects Equation**

Yard Maintenance = $\beta_0 + \beta_1(\text{Produce Garden Proximity})$

$\beta_0 = \gamma_{00} + \gamma_{01}(\text{Social Capital/Cohesion}^3)$

+ $\gamma_{02}(\text{Neighborhood Disorder}^4)$

+ $\gamma_{03}(\text{Neighborhood Participation}^5)$

+ $\gamma_{04}(\text{Population Density}^6)$

+ $\gamma_{05}(\% \text{Owner Occupied Property}^7) + \mu_{0j}$

$\beta_1 = \gamma_{10}$

3. A five item scale regarding neighborhood social capital and cohesion.
4. An eight item scale capturing the presence of physical urban blight indicators.
5. A five item scale indicating the involvement in a number of civic activities.
6. The census count of population density.
7. The census percentage of owner occupied properties.

**Note:** Model 4 does not include $\mu_{1j}$ due to non-significant variance estimate in Model 2.

**3. Results**

**3.1. Analyses of parcels within 100 m of produce gardens and undeveloped vacant lots**

Results of an initial one-way ANOVA with random effects revealed the average yard maintenance scores of each neighborhood were similar ($\gamma_{00} = -.14, t(14) = -1.85, p = \text{n.s.}$), but variability remained in neighborhood level effects that needed to be addressed in the model ($\mu_0 = .08, \chi^2(14) = 138.17, p < .001$). The level-1 variance estimate was $\sigma^2 = .51$, resulting in an intraclass correlation coefficient of .28, indicating a relatively large proportion of variance (72%) was due to individual parcel maintenance behavior. The significant variation in yard maintenance across neighborhoods indicates, however, that neighborhood level predictors may explain some variation in individual parcel maintenance scores.

Following the recommendations of Raudenbush and Bryk (2002), in Model 2 (Table 2) we introduced produce garden proximity as a predictor of yard maintenance, but kept the effect of proximity on yard maintenance to be equal across neighborhoods. The coefficient for proximity was significant and positive (see Table 2), indicating that proximity to a produce garden was associated with higher yard maintenance scores. We subsequently ran a similar model with proximity as the sole predictor and introduced a concomitant random effect allowing each neighborhood to have a different effect on the relationship between produce garden proximity and yard maintenance (Model 3). The estimate of the coefficient for proximity was again significant and positive indicating that proximity to a produce garden was related to better maintenance scores. The estimate of the variance component for the proximity slope, however, was not significant ($\mu_1 = .01, \chi^2(9) = 10.90, p = .28$), suggesting that the relationship between being close to a produce garden and property maintenance scores did not depend on the neighborhood in which the parcel or garden was located, but was instead similar across all neighborhoods. The model fit indices of models 2 and 3 suggested that the two models fit equally well ($\Delta_{\text{deviance}} = 66, d.f. = 2, p\text{-value} > .50$), so we omitted the random effect associated with the produce garden proximity slope in Model 4.

We examined the effect of social capital, neighborhood disorder, neighborhood participation, population density and percentage of owner occupied properties at the neighborhood level on individual property maintenance scores in Model 4. Coefficients for each predictor in the model are reported in Table 2. The results show that being close to produce gardens is associated with better yard maintenance scores than vacant parcels in the comparison group even when accounting for additional predictors of yard maintenance. Three other variables emerged as predictors of yard maintenance scores. More neighborhood level social capital was associated with higher rated yard maintenance scores. Higher levels of neighborhood disorder were also associated with better yard maintenance scores. Finally, higher levels of neighborhood participation were associated with lower maintenance scores.
Table 4
Effect of living within 50 m of a produce garden or undeveloped vacant lot on mean yard maintenance score.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Intercept</td>
<td>−.03</td>
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<tr>
<td>Produce garden proximity (50 m)</td>
<td>.19</td>
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<tr>
<td>Population density</td>
<td>−.00</td>
</tr>
<tr>
<td>% owner occupied properties</td>
<td>1.95†</td>
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<tr>
<td>Social capital/cohesion</td>
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<tr>
<td>Neighborhood disorder</td>
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<td>Neighborhood participation</td>
<td>−.48</td>
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<td>Variance estimate</td>
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<tr>
<td>$\mu_0$</td>
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<td>$\mu_1$</td>
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<td>$\sigma$</td>
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<td>Deviance</td>
<td>812.44</td>
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<td>Estimated parameters</td>
<td>2</td>
</tr>
</tbody>
</table>

* $p < .05$.
† $p < .01$; $\mu_1 = ns$.

3.2. Analyses of parcels within 50 m of produce gardens and undeveloped vacant lots

We found a similar effect of proximity at a 50 m distance (see Table 3). An initial analysis of variance with random effects again found that average yard maintenance scores of each neighborhood were similar, but that neighborhood level effects still needed to be addressed in the model (Model 1: $\mu_0 = .08$, $\chi^2(14) = 66.27$, $p < .001$). The level-1 variance estimate was $\sigma^2 = .42$, resulting in an intraclass correlation coefficient of .15, indicating a relatively large proportion of variance was due to individual parcel maintenance behavior. After introducing produce garden proximity as a predictor at level 1, the results showed that, across neighborhoods, being close to a produce garden was related to better yard maintenance scores than being closer to a comparison vacant lot (Model 2). As with the 100 m sample, the effect of being close to a produce garden on yard maintenance scores did not differ based on neighborhood (Model 3; $\mu_1 = .02$, $\chi^2(7) = 4.17$, $p > .50$) and allowing the effect to vary across neighborhoods did not improve model fit ($\Delta$Deviance = 1.24, d.f. = 2, $p$-value > .50). Thus, we excluded the random effect in Model 4. Estimate of the coefficients for each predictor are reported in Table 3. The results closely mirror those of the 100 m sample (Table 4).

4. Discussion

Our results support the greening hypothesis: residential parcels close to produce gardens had better maintenance than residential parcels near undeveloped vacant lots. Our findings are consistent with earlier research that found proximity was an important factor in the spread of landscaping components (Julien & Zmyslony, 2001). We found the association between produce gardens and residential yard care was stronger for parcels close to produce gardens. Other researchers have found evidence of the spread of landscaping design and vegetation (Hunter & Brown, 2012; Zmyslony & Gagnon, 1998, 2000). Research focusing on greening initiatives and effects on nearby parcels is an area that needs further study. Yet, our results suggest that a distance between 50 and 100 m is a range in which one can expect to find greening effects. Our study also provides support that greened areas tend to have beneficial effects diffused throughout neighborhoods. This is even more powerful considering that the residential parcels we studied are likely surrounded by multiple blighted, abandoned homes. This greening diffusion may be due to landscape mimicry, cues to care, the ecology of prestige, social interactions between residents or other neighborhood conditions which lend themselves to reduced disorder. Thus, produce gardens may serve as visual indicators of community investment resulting in better yard maintenance among nearby parcels.

Neighborhood level characteristics derived from the Census (population density and percent owner occupied households) did not affect yard maintenance. Neighborhoods with higher perception of neighborhood disorder had better yard maintenance. Residents who engage in yard maintenance may be more aware of neighborhood disorder in their community and more likely to report signs of disorder. Other factors such as previous victimization, neighborhood crime, rental status, demographics of the neighborhood (race/ethnicity, class) and collective efficacy can impact the perception of neighborhood disorder and may explain the unexpected relationship in our study (Comstock et al., 2010; DeFrances & Smith, 1998; Gainey, Alper, & Chappell, 2011; Harcourt, 2009; Sampson & Raudenbush, 2004). Interestingly, neighborhoods that reported higher neighborhood participation in community projects had worse yard maintenance. Perkins, Florin, Rich, Wandersman, and Chavis (1990) also found an unexpected negative relationship between neighborhood participation and yard maintenance. They also found that some indicators of blight, such as litter, were not associated with neighborhood participation. It may be that neighborhoods with poor yard maintenance have more residents participating in neighborhood improvement projects because they see a need to make their block more attractive. It is also possible that they believe that more cared for parcels will indicate busier streets with more engaged residents which may fend off the broken window effects Aiyer, et al., 2015. If a neighborhood is in good condition, there may be less motivation to participate in neighborhood improvement projects. We do believe that neighborhood level socioeconomic factors should be included in similar analyses and in interpretations when looking at greening initiatives (e.g. LTSE framework; Haberl et al., 2006).

Like other post-industrial cities, Flint has been hard-hit by the effects of deindustrialization and urban sprawl. The effects of economic instability and subsequent population loss have lead to excess abandoned housing and undeveloped vacant parcels. The data analyzed for this study were from two residential areas within the city that have a high level of abandoned residential parcels. In fact, with the high levels of vacancy in these areas it is impressive that clusters of maintained parcels were detectable. The residential areas we assessed had similar demographics, income, number of census block groups (neighborhoods) and number of produce gardens although one residential area had slightly higher levels of unoccupied properties (69.5% vs. 56.9%).

The neighborhood-level survey collected responses to be aggregated at the census block group level to protect anonymity.
To better understand resident’s landscaping decisions, a more intensive survey at the household-level to gather lifestyle, socio-economic and cultural factors would be helpful. Additionally, information such as length of residence, and the effect of the greened property on decision to live in the area or changes in the area since greening would also provide insight into greening decisions. We did not include income in our study due to the lack of variation among census block groups in our study areas; however, we do recognize that individual level variation in income may influence residential yard maintenance. Unfortunately, our study did not have access to individual-level household income, but our results suggest that future research that examines both neighborhood and individual socioeconomic status would be a useful next step in this line of research.

We selected produce gardens as our greening indicator due to the extensive and frequent investments of time and energy required to care for a produce garden compared to other greening initiatives (e.g. periodic mowing and removal of debris). Additionally, the size of produce gardens, which by definition encompassed the majority of the parcel, likely required cooperative relationships to care for the garden. Therefore, the greening effect of a produce garden is likely stronger and easier to detect than a greening initiative requiring less investment.

Few researchers have focused on greening initiatives and individual household-level yard maintenance and neighborhood blight. Residents report, however, that they consider poor yard maintenance (e.g., unmowed, weeds) as an indicator of neighborhood disorder (Perkins & Taylor, 1998). Additionally, residents report that different levels of perceived neighborhood disorder affects fear of crime, social capital and community attachment, and these variables may influence neighborhood disorder and individual lawn maintenance (Alaimo et al., 2010; Comstock et al., 2010). Community improvement projects, such as neighborhood clean-ups may lead to a decrease in perceived neighborhood physical disorder, but few researchers have studied community improvement projects and perception of neighborhood blight and individual yard maintenance. Our study adds to this literature empirical evidence that a community greening project is related to better individual yard maintenance and less neighborhood disorder.

Several researchers have studied the negative factors which lead to neighborhood disorder and crime. But little is known about positive factors and their impact. Although structural factors such as poverty, concentrated disadvantage, and residential instability present significant barriers for positive social interactions, such risk factors do not condemn neighborhoods to crime and isolation. The field lacks integrative theories to guide research focusing on how positive social processes and neighborhood structures may interact to produce safe streets. These factors that make neighborhoods safe and desirable create a positive social context, where social cohesion and social capital thrive. Evidence of these positive social processes and neighborhood structure is represented by actively maintained, organized spaces, thriving businesses, and visible informal (and formal) social interactions (Aizer, Zimmerman, Morrel-Samuels, & Reischl, in press). Produce gardens and other greening initiatives may act as positive neighborhood factors and may be an indication of collective action and other social processes which foster collective efficacy, social cohesion and social capital. In turn, these strengthened communities may be able to reduce negative outcomes such as crime. Policy makers may consider greening initiatives as a potential method for building community cohesion, social capital, and collective efficacy in urban neighborhoods. Greening initiatives may also help reduce crime as suggested by the Crime Prevention through Environmental Design movement (Cozens et al., 2005; Jeffrey, 1971). These initiatives are one way to create environmental change that brings people together and creates positive social interactions among neighbors. Thus, efforts to support the development of greening projects with a focus on sustainability may be a way to move beyond the slippery slope of neighborhood decay.

It should also be noted that the extrapolation of data from this study to a larger scale can lead to incorrect assumptions (Peterson & Parker, 1998). These scaling issues can encompass spatially and temporally and therefore should be put into consideration during decision making (Pettersson & Parker, 1998). The produce gardens may have an effect over a small scale, but their effect on a larger scale should be investigated.

4.1. Study limitations

One of the limitations of this study is the inability to draw a causal relationships between the gardens and proximal residences. Therefore we cannot definitively conclude if the greening effect radiated from the produce gardens or if engaged residents created the produce garden. One argument for the produce gardens being the initiation of greening is that not all of these gardens were owned by residents living in the neighborhood. Produce gardens were owned by the County Land Bank and other social organizations, which may have had Flint residents from other areas of the city take the lead in caring for these produce gardens, but we still observe effects on neighboring properties. The produce gardens occurred on parcels which were owned by residents or were adopted by community organizations or groups, and were not randomly assigned throughout the community. This lack of randomization, along with the data being cross-sectional makes it impossible to determine causality. We were unable to determine if people living in the neighborhood worked on the gardens or if people were attracted to the area because of the greening in the neighborhood. Future research that investigates whether residents moved to live near these green properties or were already part of the neighborhood would be useful. Another method to investigate the direction of the greening relationship may be to compare ownership of the abandoned non-greened parcels and property gardens on residential yard maintenance. We found limited variation among produce garden owners, and could not confidently identify ownership of the non-greened properties to conduct a similar analysis. Further investigation regarding ownership of the produce gardens and non-greened parcels may be informative. Nevertheless, our study suggests that greening with produce gardens appears to be associated with other property improvements in the neighborhood. Additionally, we were unable to compare differences among produce garden ownership due to the size of our sample, but future investigations should consider whether different ownership (e.g. individual vs. social service organization) influences the greening of nearby parcels. In future research where surveying at the household-level is possible, we recommend gathering information on lifestyle factors, household factors, and resident’s report on greening in their neighborhood to be included in analysis. Yet, the association we found provides support to further investigate the relationship of these greened areas with neighborhood disorder and crime. It is also notable that we selected comparison parcels that were close enough to the produce garden to be considered in the same neighborhood, but far enough away from the gardens to not expect as radiating effects. We also found support for the greening hypothesis at different distances from the produce gardens and the effects were reduced the further away from the garden. We suggest further exploration of the spatial effect of greening projects to define the spatial patterns and distance limitations of greening. Other methods used for spatial analysis such as land cover/land use in landscaping research may be another method to explore this greening effect. In addition, the effects of produce gardens were maintained even after controlling for other explanations of the association including population density, social
capital, and neighborhood disorder. This study did not investigate the effect of abandoned, blighted homes on the greening hypothesis, but our findings suggest that future research to account for this factor is warranted. Another limitation is that we only examined the care of the parcel and did not look at other outcomes such as crime, sense of community, or other psychosocial outcomes. We also looked at produce gardens and not other greening activities including simply cleaning up empty lots and removing abandoned buildings. Future research should also include number of blighted properties nearby greened areas. Our findings, however, suggest that future research that compares different greening initiatives and their effects on crime and sense of community would be beneficial.

5. Conclusions

We found that residential properties located near produce gardens were better maintained, compared to residential properties located near non-greened parcels. We found this even after accounting for neighborhood level characteristics that may lead to better maintenance. Thus, we find support for our previously described greening hypothesis. Our findings underscore the role of policies and programs that include greening initiatives as part of community development strategies. Neighborhood grass-root level greening initiatives may be one effective approach since these neighborhoods likely have residents willing to engage in successful implementation of greening projects. We also suggest that county-wide greening programs may be particularly effective in cultivating positive physical spaces. Finally, our findings indicate that positive neighborhood factors, such as produce gardens, positively influence residents' personal investment in their community.

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References

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