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Does collaborative tree planting between nonprofits and neighborhood groups improve neighborhood community capacity?

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ABSTRACT

In the past decade, urban tree canopy cover goals and tree-planting initiatives have proliferated among local governments and nonprofit organizations across the globe. While research has documented many benefits new trees will provide, less has considered whether active participation of city residents in urban forestry activities might also benefit urban neighborhoods. This paper examines nonprofit tree-planting programs in four cities in the Midwestern and Eastern United States to determine whether and to what extent neighborhood participation in a nonprofit tree-planting project might increase ties between residents, social cohesion, and shared trust in that neighborhood. We leveraged a unique dataset of ecological and social information about tree-planting neighborhoods and matched comparison (non-tree planting) neighborhoods (total neighborhoods = 197; total survey respondents = 1551). The evidence for a social effect of nonprofit tree-planting programs is mixed. When asked directly, neighborhood residents reported observing positive changes. Linear regression analysis reveals significantly higher neighborhood ties reported by individuals in planting neighborhoods. However, we find no significant relationship between tree planting and social cohesion or trust. In single-city models, planting's association with neighborhood ties and social cohesion is only significant in one city, and associations with trust are not significant in any city. Models that aggregate responses at the neighborhood level find no significant association of tree planting. Findings suggest that tree planting may increase neighborhood ties, but that increases in social cohesion and/or trust are not guaranteed.

1. Introduction

In the past several decades, urban greening activities have proliferated in cities across the globe. These activities include the installation of green infrastructure like trees, parks, wetlands, green roofs (Foster, Lowe, & Winkelman, 2011; Kondo, Low, Henning, & Branas, 2015; McPherson, 2014; McPherson & Young, 2010), and recently, forested skyscapers in Italy and China (Zhang, 2017). Trees, greenspaces, and other types of green infrastructure in urban settings can help manage stormwater runoff (Bartens, Day, Harris, Wynn, & Dove, 2009), may improve air quality (Nowak, Hirabayashi, Bodine, & Hoehn, 2013),[3] moderate urban temperatures (Armson, Stringer, & Ennos, 2012; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Declet-Barreto, Brazel, Martin, Chow, & Harlan, 2013), and help mitigate climate change (Baró et al., 2014; Peng & Jim, 2015). Nature in urban settings can improve physiological and psychological health (Haluza, Schönbauer, & Cervinka, 2014) by, for example, lowering incidence of cardiovascular disease (Donovan et al., 2013), lowering body mass index in children (Bell, Wilson, & Liu, 2008), and reducing stress (Hartig, Mitchell, De Vries, & Frumkin, 2014).

City residents play a significant role in the greening of cities, working individually, with neighbors or other residents, and in collaboration with municipal and nonprofit organizations. Individual homeowners independently garden, landscape, perform lawn

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[3] Although air quality improvements are still widely referenced as one of the major benefits of urban forests, there is debate about the effectiveness of trees in the removal of air pollutants, particularly in northern climates. See Setälä, Viippola, Rantalainen, Pennanen, and Yli-Pelkonen (2013) and Pataki et al. (2011), as well as commentary by Pataki et al. (2013).

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maintenance, care for potted plants and trees, and undertake other greening activities on their properties and the lawns and sidewalks in front of their homes (Cook, Hall, & Larson, 2012; Harris et al., 2012; Harris, Martin, Polsky, Denhardt, & Nehring, 2013). Previous studies have examined how neighborhood residents organize collective greening projects like landscaping or tree planting (Kullgren, 2015), develop community rules around managing greenspace (Larsen & Harlan, 2006), and work with municipal governments, nonprofits, and other stewardship organizations in greening activities (Fisher, Svendsen, & Connolly, 2015; Mincey & Vogt, 2014; Vogt, Watkins, Mincey, Patterson, & Fischer, 2015). For example, residents make tree requests via city hotlines, participate in technical assistance programs (Westphal, 2003), and volunteer to inventory and monitor urban trees (Roman, McPherson, Scharenbroch, & Bartens, 2013). At a large scale, coordinated city-wide tree-planting campaigns utilize volunteers to plant and care for trees (*a la* MillionTreesNYC; see Fisher et al., 2015). Often, nonprofit organizations engage citizens in urban greening; for example, the NeighborWoods initiative of US Alliance for Community Trees (ACTrees) involves neighborhood volunteers and community groups (civic associations, schools, churches, etc.) in tree planting and maintenance (http://neighborwoodsmonth.org/).

The benefits provided by the physical presence of trees and other greenspaces in urban environments have been well-studied in an international context. Westphal (2003) describes these benefits as being derived from "passive experience of a green environment" because the benefits accrue to individuals, organizations, and communities whether or not these parties are aware of or involved in the provision or management of the trees and greenspace. However, less is known about benefits from "*active involvement* in greening the environment," such as planting and caring for trees and landscape plants (Westphal, 2003 p. 139, emphasis added). Collective action between members of a community (like that undertaken in many greening projects) has been found to build community capacity and can build connections, trust, and reciprocity among individuals (Adger, 2003; Ostrom, 1996).

This paper contributes to the growing literature on the social benefits of active involvement in urban greening by examining whether collaborative nonprofit and neighborhood tree planting and subsequent tree care improves neighborhood community capacity. Tree planting, an activity with substantial engagement of US municipalities and nonprofits, provides an interesting case to examine the effects of neighborhood-level engagement in urban greening. In this study, we combine original data on neighborhood characteristics via a household survey with tree locations from nonprofit partners, land cover data, and socioeconomic data for 1551 individuals in 197 neighborhoods (Census block groups) in four cities in the Midwestern and Eastern United States. Survey responses from residents in neighborhoods that planted trees (i.e., planting neighborhoods) and in matched neighborhoods that did not plant trees (i.e., comparison neighborhoods) allow us to measure neighborhood characteristics that are not captured in existing administrative datasets like the US Census (Raudenbush & Sampson, 1999). Using regression analysis, we estimate the relationship between neighborhoods' participation in tree planting and three indicators of neighborhood community capacity. This study's novel approach that includes multiple cities and conducts within-city comparisons of planting and non-planting neighborhoods allows this research to get closer than previous studies in estimating the causal effect of neighborhood tree planting on neighborhood social outcomes.

2. Study motivation

Neighborhoods leverage human capital, organizational resources, trust, and social capital to achieve common goals that improve community well-being and address collective challenges (Chaskin, 2001; Sampson, Raudenbush, & Earls, 1997). Sampson and colleagues have described a neighborhood's capacity to achieve these common goals as collective efficacy (Sampson et al., 1997), and have identified two linked components of collective efficacy: social cohesion and social control (Sampson, 2004). Social cohesion is high when neighbors know each other, trust each other, and have shared values (Raudenbush & Sampson, 1999; Sampson, 2004). Social control is the ability of the neighborhood to intervene in a particular problem (Sampson, 2004) and regulate its members according to desired principles (Sampson et al., 1997).

These neighborhood social and institutional characteristics serve an important role in community and individual well-being (Gieryn, 2000; Sampson, 2012). For example, collective efficacy has been found to be positively related to self-rated health (Moore et al., 2011) and child well-being (Sampson, Morenoff, & Gannon-Rowley, 2002), and negatively related to incidence of violent crime in a neighborhood (Sampson et al., 1997). A neighborhood's ability to face challenges and changes is increasingly important as global climate change places urban communities at greater risk of disturbances (Adger, 2003; Foster et al., 2011; Wickes, Zahnow, & Mazerolle, 2010).

Scholars in the field of urban forestry – the transdisciplinary science of the planting, preservation, and restoration of trees, forests, and other natural areas in cities – are increasingly recognizing the links between the environment and social systems in the urban forest (Campbell & Wiesen, 2009; Moskell & Allred, 2013; Vogt & Fischer, 2014). Scholars have examined the nature of civic stewardship in urban forestry (Ames, 1980; Connolly, Svendsen, Fisher, & Campbell, 2013; Fisher et al., 2015; Sommer, Learey, Summit, & Tirrell, 1994a; Westphal, 2003) and how civic engagement can influence tree success (Lu et al., 2010; Sklar & Ames, 1985; Vogt et al., 2015). Scholars in urban forestry have also proposed that tree planting can build community capacity by providing a venue for community members to interact (Elmendorf, 2008) and might encourage future engagement of community organizations in other issues (Summit & Sommer, 1998).

Several studies have examined dimensions of the social outcomes of urban greening activities. For example, research has found that individuals that participated in tree planting reported higher satisfaction with tree-planting projects (Sommer et al., 1994a; Summit & Sommer, 1998), had higher satisfaction if they plant with a group rather than alone (Sommer, Learey, Summit, & Tirrell, 1994b), and engaged in future civic activities because of tree planting (Fisher et al., 2015; Stone, 2009). Other studies examined the effect of participation in urban greening on community-level outcomes. In Chicago, Westphal (2003) found that urban landscaping, gardening, and vacant lot cleanup projects could increase empowerment in participating communities. However, she found that positive outcomes were not inevitable and the magnitude of social benefits varied across types of groups and projects. In a study of tree planting in Indianapolis, Indiana, Mincey and Vogt (2014) found that neighborhood groups that worked together to water trees they had planted engaged in significantly more collective activities (e.g., neighborhood cleanups, block parties) after the project than before. A study of community gardening in New York City found that environmental stewardship helped to renew trust, connections, and efficacy between neighbors (Svendsen, 2009). These largely single-city studies focused on neighborhood and resident urban greening participants.

This study contributes to this growing field by considering the influence of urban forestry activities on a novel outcome, community capacity, and by using a novel multi-city approach. Drawing from previous work that emphasizes the benefits of collective action and building on a pilot study conducted by several of this paper's authors (see Mincey & Vogt, 2014), this study focuses on the social outcomes of collective activities between neighborhoods and nonprofits to plant trees. To our knowledge, no previous research has investigated neighborhood-level social effects of tree planting using a comparison population of non-tree planting neighborhoods. By studying similar activities in four different cities and including a comparison group of non-tree-planting neighborhoods, this study presents a more robust case than previous single-city studies.

Table 1
Years of tree-planting data and type of tree location information provided by study partner nonprofits in each city.

	Atlanta	Detroit	Indianapolis	Philadelphia
Years of data	2009–2011	2009–2013	2007–2013	2009–2011
Location Information	Coordinates	Addresses	Coordinates	Addresses

3. Study sites

We partnered with four urban greening nonprofit organizations that work with neighborhoods to plant trees. To be selected, partner nonprofits must have undertaken most of their activities in a single relatively large metropolitan area (i.e., a city or a few contiguous counties) in the Midwestern or Eastern United States.[4] Partner nonprofits had to have one or more distinct tree-planting programs through which they planted trees in urban neighborhoods with local community groups (groups of neighbors; neighborhood, homeowners, or condominium associations; business associations, other nonprofits, churches, schools, etc.) and this program had to have begun before 2009. The nonprofit must have recorded locations of individual trees planted between 2009 and 2011 so we could identify neighborhoods that had planted trees and re-inventory planted trees (an important part of the larger research project). Partner nonprofits must also have been a member of the Alliance for Community Trees, a national advocacy and grant-disbursing nonprofit whose members were organizations (nonprofits, municipalities) and individuals engaged in urban and community forestry activities and advocacy. Finally, the nonprofit had to agree to participate. Our partner nonprofit organizations were Greening of Detroit (Detroit, MI; www.greeningofdetroit.com), Keep Indianapolis Beautiful, Inc. (Indianapolis, IN; www.kibi.org), Pennsylvania Horticultural Society (Philadelphia, PA; www.phsonline.org), and Trees Atlanta (Atlanta, GA; www.treesatlanta.org). These organizations were interested in the neighborhood social outcomes of tree-planting activities, often explicitly worded in their mission statements and implicitly evident in their organizations' operations. For example, Keep Indianapolis Beautiful's mission is to "engage diverse communities to create vibrant public places, helping people and nature thrive" (www.kibi.org).

Each nonprofit organized and conducted collaborative tree-planting activities with local community groups and neighborhoods through the following, generally similar, process. The nonprofit solicited applications from or recruited local community groups interested in collaborating with the nonprofit to plant trees in one or more locations within a neighborhood. The nonprofit provided free or reduced-cost trees to groups they selected based on nonprofit goals or neighborhood need. Depending on available funding and the number of applications received, sometimes the nonprofits were able to plant with all of the community groups that applied. Local neighborhood residents or community-group members then got together (sometimes with the nonprofit and/or other volunteers) to plant trees in a tree-planting project. In many cases, neighborhood residents also organized or participated in caring for the young trees (e.g. watering), often for several years after they were planted. The nonprofits varied in the degree of autonomy they afforded to neighborhoods and in the finer details of organizing the tree-planting project and follow-up tree care.

4. Methods

In each city, we administered a survey to residents in a random sample of neighborhoods that had planted trees with the nonprofit between 2009 and 2011 (i.e. planting neighborhoods) and in a matched set of neighborhoods that did not plant trees (i.e. comparison neighborhoods). We adopted two analytic strategies to evaluate the association of tree planting on community capacity. First, we examined responses to direct questions about neighborhood change from tree-planting activities. Then, we used regression analysis to compare reported measures of community capacity between individuals in planting and comparison neighborhoods. Using a comparison group of neighborhoods that did not plant trees allowed us to get closer to estimating a causal effect than previous work, which has focused only on participant neighborhoods. Propensity score matching was the strongest feasible strategy given the selective nature of nonprofit tree planting and our desire to examine effects several years after the trees were planted.

4.1. Neighborhood sample selection

We operationalized neighborhoods using United States Census block groups. We expected block group boundaries to effectively capture the population participating in and affected by a tree-planting project (an average of 20 to 70 trees planted in 3 to 10 city blocks). In addition, supplemental secondary data on neighborhood demographics was available from the US Census Bureau at the block group geography. To identify neighborhoods in which trees were planted, we obtained addresses or geographic coordinates for all trees planted by the nonprofits between 2009 and 2011 (Table 1). When available, some nonprofits also provided locations for trees planted before 2009 and/or after 2011. We mapped all trees in a geographic information system (GIS; ArcDesktop 10.0, Advanced license), geo-referencing any trees for which we only had street addresses (Detroit and Philadelphia). The number of total block groups and the proportion of those block groups that were planted varied across cities (from 19.3% in Atlanta to 47.3% in Philadelphia, see Watkins, Mincey, Vogt, & Sweeney, 2016).

In each city, we randomly selected 25 planting neighborhoods from all block groups that had been the location of a tree-planting project with 20 or more trees sponsored by the partner nonprofit between 2009 and 2011.[5] We focused on projects with at least 20 trees because that was the minimum project size for several of the nonprofits (although they occasionally had projects with fewer trees). Often, trees from a single project were planted in multiple neighboring block groups. Any of those block groups (even if they had only one planted tree) could be selected as a planting neighborhood. We were interested in the effect of neighborhood involvement in tree planting and care (i.e., benefits of "active involvement in urban greening" Westphal, 2003) rather than the effects of the planted trees themselves (i.e., passively-derived benefits). We considered the presence of one tree in a block group as a signal that the neighborhood was exposed to the planting project and that residents had opportunities to become involved in tree planting and/or care. Furthermore, it is likely that individuals living in the selected block group were exposed to other trees planted nearby but across block group boundaries.

We selected 25 comparison neighborhoods using propensity score matching with some restrictions. A block group was a potential comparison neighborhood if none of the trees in the nonprofit data was planted in that block group. Note, for cities where we had more years of tree location data, a potential comparison neighborhood was more likely to never have received a tree planting. For cities where we lacked some data over time, we might have captured a neighborhood that had a tree planting sometime outside of the window of the available data.

[4] Limiting our study to the Midwestern and Eastern US helped to control for broad climate factors that influence tree outcomes, including whether the ecosystem supported natural tree growth (see Kottek, Grieser, Beck, Rudolf, & Rubel, 2006).

[5] These criteria are consistent with another component of this research project that was interested in the biological outcomes of the planted trees. A tree-planting project occurring 3 to 5 years before data collection insured that the trees were outside a critical 2-year establishment period (during which we expected aboveground trunk growth to be slow). A tree planting between 3 and 5 years before data collection also helped increase the likelihood that individuals involved in the tree planting would be still living in the neighborhood and would remember some details about the planting.

Our estimates of the relationship between tree-planting programs and social characteristics are conservative because of this.

Community capacity is likely related to whether a neighborhood participated in tree planting to begin with; neighborhoods that planted trees might have had systematically higher community capacity than comparison neighborhoods even before the planting project occurred. To address this potential selection bias, we employed a technique to select our sample that strategically matched randomly selected tree-planting neighborhoods to comparison neighborhoods that were similar on a suite of socioeconomic and land use covariates.

In each city, we created a dataset of demographic, socioeconomic, and land use characteristics at the block group level. We collected socio-demographic variables at the block-group level from the 2010 US Census and tract-level from the 2010 American Community Survey (for variables where block-group level data were restricted). Using these data, we also calculated block group area and population density. We obtained parcel density information from city government files. Finally, we calculated the percent canopy cover and percent impervious surface of each block group using data classified from high resolution color-infrared (CIR) imagery from the US Dept. of Agriculture's National Agriculture Imagery Program (NAIP) (see Watkins et al., 2016 for detailed land cover classification methods).

Using this dataset, we generated propensity scores for each block group in the city by predicting the block group's propensity (likelihood) to have been a planting neighborhood. By matching planting and comparison neighborhoods that have very similar propensity scores, we were able to identify neighborhood pairs that had similar characteristics that would lead them to have a tree planting project *except* that only one of the pair actually participated. Variables and data sources used in the propensity score model are listed in Table A.1 in Appendix A. In order to ensure that each pair of planting and comparison neighborhoods looked similar on a number of important covariates, we included several restrictions before selecting on propensity score.[6] A comparison neighborhood was a potential match for the planting neighborhood of interest if it had canopy cover within 10 percentage points of the canopy cover of the planting neighborhood, if the percentage of individuals that were white was within 10 percentage points of that in the planting neighborhood, and if the median household income of the containing Census tract was within $10,000 of that of the planting neighborhood. In just a few cases, no block groups were potential matches after including these restrictions. In these cases, the bounds of the percent white and median household income were increased to 15% and $15,000 respectively. Of the neighborhoods that met these criteria, we selected the neighborhood with a propensity score closest to that of the planting neighborhood. The final sample of 25 matched neighborhoods served as the comparison group within each city. After matching, planting and comparison neighborhoods were not statistically different for any of our specified covariates (see Table A.2 in Appendix A).

We tested the robustness of the matching strategy by testing an alternative specification for propensity scores that added tract-level covariates from the 2000 Census. We applied the same three exclusion restrictions (canopy cover, median household income and percent White). *t*-Tests revealed no significant differences between the treatment group, the original comparison group, and the second comparison group, giving us confidence in our original comparison group (see results of the second propensity score matching and comparisons between groups in the appendix).

4.2. Survey administration

We surveyed neighborhood residents about their neighborhoods and about neighborhood changes from tree planting. Although surveys did not allow us to describe neighborhood demographics over time in a way the US Census or other secondary data would, they captured the kinds of social and organizational constructs we were interested in and that are absent from secondary data sources (Raudenbush & Sampson, 1999).

The survey was administered in May and June of 2014. We requested 54 random addresses per neighborhood (i.e. Census block group) from an address-based sampling service (Marketing Systems Group, Horsham, Pennsylvania, USA). Residents in comparison neighborhoods were mailed a six-page survey that asked questions about the neighborhood and standard demographic information. Residents in planting neighborhoods were mailed an eight-page survey. This survey contained the same set of questions that comparison neighborhood recipients were asked. In addition, in planting neighborhoods, the survey asked about the recipient's knowledge of, experience with, and evaluation of the tree-planting project(s) in their neighborhood.

The survey was administered by mail according to the Dillman Tailored Design Method (Dillman, Smyth, & Christian, 2009). A postcard was sent May 5, 2014 alerting recipients that they would receive a survey. On May 12, 2014 a survey packet was sent to recipients. The envelope contained a cover letter, survey questionnaire, return envelope, and a crisp one-dollar bill as an incentive to complete the survey. A crisp one-dollar bill was included after a pilot study we conducted in Indianapolis, Indiana demonstrated that a one-dollar incentive yielded a 35% increase in response rate among randomly sampled households (from 13.0% to 18.5%; Watkins, 2013). In the cover letter, recipients were also offered the option to complete the survey online. A second postcard was sent May 19, 2014 thanking respondents and requesting that non-respondents return the survey. On June 9, 2014, a second survey was sent to those who had not previously responded. Responses were entered into a Microsoft Access Database.

Overall, address-based sampling returned 10,694 addresses in the four cities.[7] Of those, 1026 of the addresses returned from the sampling service were either duplicate addresses or led to at least one piece of mail "returned to sender." Our best estimate is that 9668 surveys arrived at unique addresses. 1748 surveys (18.08% of the total unique addresses) were returned. Of those, 50 surveys were blank and 13 were multiple returns from the same address. In total, we received 1686 surveys usable for analysis (17.44% of the total unique addresses). There were no surveys returned from one comparison neighborhood in Philadelphia.

4.3. Data and measurement of outcomes

We drew from sociology and resilience literature to operationalize community capacity. We could not observe community capacity directly because it is only revealed in the presence of challenges to community stability (Goodman et al., 1998). Instead, we could observe other characteristics of a community that have been linked to community capacity. Previous research has suggested broad categories of neighborhood characteristics that help predict community capacity and related characteristics such as collective efficacy and resilience, including active participation of a diverse group of citizens (Goodman et al., 1998), clear community values (Goodman et al., 1998; Sampson, 2012), and the strength of relationships between individuals (Adger, 2003) including trust (Adger, 2003; Sampson, 2012), confidence, and cooperation (Goodman et al., 1998).

We focused on three observable and measurable characteristics of neighborhoods that are indicators of community capacity and might be influenced by tree-planting participation: ties between neighbors, social

[6] Restrictions were used because simple propensity score matching resulted in differences between planting and comparison neighborhoods on these key variables.

[7] Address-based sampling only returned two addresses for one of the selected planting neighborhoods in Detroit. In this case, we did not match the planting neighborhood to a comparison neighborhood.

34 Here is a list of changes people might experience from a neighborhood project like tree-planting. Since the tree-planting project in your neighborhood, have you noticed any of the following **personal changes that you think are a result of the tree-planting project**?

		Yes, I have noticed this change ▼	No, I have not noticed this change ▼
a.	I am better at communicating with my neighbors.	☐	☐
b.	I know more about how to care for trees.	☐	☐
c.	I get along with my neighbors better.	☐	☐
d.	I know more of my neighbors.	☐	☐
e.	I trust my neighbors more.	☐	☐
f.	I am more physically active outdoors.	☐	☐
g.	I feel more like a part of my neighborhood.	☐	☐
h.	I am more aware of how the neighborhood looks.	☐	☐
i.	I am more willing to participate in neighborhood activities.	☐	☐
j.	I am less willing to participate in neighborhood activities.	☐	☐
k.	Other (Please specify)		

36 Here is a list of neighborhood changes that might result from a neighborhood project like tree-planting. Since tree-planting project in your neighborhood, have you noticed any of the following **changes in your neighborhood that you think are a result of the tree-planting project**?

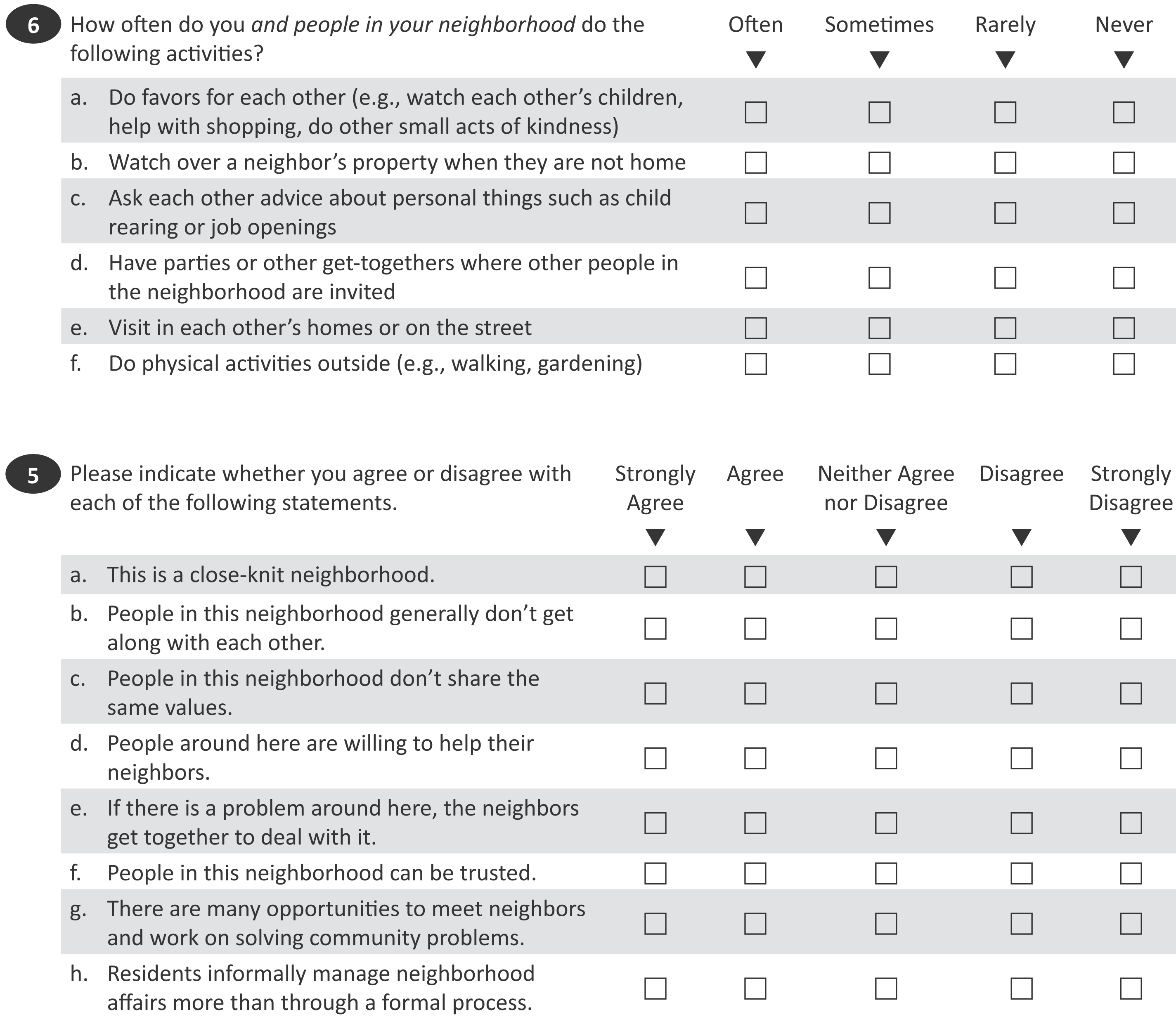
		Yes, I have noticed this change ▼	No, I have not noticed this change ▼
a.	People spend more time outside.	☐	☐
b.	People help each other more.	☐	☐
c.	The neighborhood looks better/is more beautiful.	☐	☐
d.	People know their neighbors more.	☐	☐
e.	People have worked together on another neighborhood activity.	☐	☐
f.	People spend more time being physically active outdoors.	☐	☐
g.	People trust each other more.	☐	☐
h.	People talk to each other more.	☐	☐
i.	People take better care of their yards.	☐	☐
j.	People are more willing to participate in neighborhood activities.	☐	☐
k.	People are less willing to participate in neighborhood activities.	☐	☐
l.	People argue with their neighbors more.	☐	☐
m.	The neighborhood feels safer.	☐	☐
n.	The neighborhood feels less safe.	☐	☐
o.	The neighborhood organization is more active.	☐	☐
p.	Other (Please specify)		

Fig. 1. Survey questions for direct outcome measures of tree plantings, including neighborhood ties (34d, 36d, 36h), social cohesion (34c, 34g, 36b, 36l), and trust (34e, 36g) measures. These questions were asked to all survey recipients who lived in planting neighborhoods. Recipients in comparison neighborhoods were not asked these questions.

cohesion, and shared trust between neighbors. Neighborhood ties manifest in neighbors doing favors for each other, gathering together, or chatting with each other; these connections might contribute to social cohesion, which requires shared values and trust. Trust between neighbors is a component of social cohesion (see Sampson, 2004), but is also mentioned frequently on its own as important to community capacity (e.g. Wickes et al., 2010), so we also included trust separately as an outcome of interest.

We measured these outcomes in two ways. First, we asked survey respondents who lived in planting neighborhoods whether they noticed any personal or neighborhood changes (chosen from a list provided) due to tree planting: *direct measures*. Second, we asked respondents in both planting and comparison neighborhoods a series of survey questions about their neighborhoods: *indirect measures*. Indirect measures came from the Community Survey used in previous work conducted by Sampson and colleagues in the Project on Human Development in Chicago Neighborhoods (Sampson, 2012) and have been tested and verified by Sampson and colleagues (Raudenbush & Sampson, 1999; Sampson, 2012). Direct measures were adapted from the Community Survey items. These questions appear in Figs. 1 and 2 and are discussed below.

Direct measures. Residents in planting neighborhoods were given a list of potential changes the neighborhood might have undergone or they might have personally experienced, and were asked whether they noticed any of the listed changes as a result of the planting project (see Fig. 1). Items were pilot tested in 2013 (Watkins, 2013). These measures have several strengths. They were straightforward, and therefore easy to communicate to nonprofit partners and their stakeholders. They also allowed us to compare how frequently changes were reported. However, these measures were subject to error because they required



6 How often do you *and people in your neighborhood* do the following activities?	Often ▼	Sometimes ▼	Rarely ▼	Never ▼
a. Do favors for each other (e.g., watch each other's children, help with shopping, do other small acts of kindness)	☐	☐	☐	☐
b. Watch over a neighbor's property when they are not home	☐	☐	☐	☐
c. Ask each other advice about personal things such as child rearing or job openings	☐	☐	☐	☐
d. Have parties or other get-togethers where other people in the neighborhood are invited	☐	☐	☐	☐
e. Visit in each other's homes or on the street	☐	☐	☐	☐
f. Do physical activities outside (e.g., walking, gardening)	☐	☐	☐	☐

5 Please indicate whether you agree or disagree with each of the following statements.	Strongly Agree ▼	Agree ▼	Neither Agree nor Disagree ▼	Disagree ▼	Strongly Disagree ▼
a. This is a close-knit neighborhood.	☐	☐	☐	☐	☐
b. People in this neighborhood generally don't get along with each other.	☐	☐	☐	☐	☐
c. People in this neighborhood don't share the same values.	☐	☐	☐	☐	☐
d. People around here are willing to help their neighbors.	☐	☐	☐	☐	☐
e. If there is a problem around here, the neighbors get together to deal with it.	☐	☐	☐	☐	☐
f. People in this neighborhood can be trusted.	☐	☐	☐	☐	☐
g. There are many opportunities to meet neighbors and work on solving community problems.	☐	☐	☐	☐	☐
h. Residents informally manage neighborhood affairs more than through a formal process.	☐	☐	☐	☐	☐

Fig. 2. Survey questions for indirect outcome measures. Neighborhood ties was an aggregate of questions 6a–e, social cohesion was calculated as an aggregate of questions 5a–e, and trust was measured by 5e. Questions were asked to all survey recipients in both planting and comparison neighborhoods.

residents to make judgments about project impacts and because respondents might overstate the effect of the program in the hopes that positive reviews will benefit the nonprofit or increase nonprofit activity in their neighborhood. Assuming this bias affects all measures and all neighborhoods consistently, the relative importance of outcomes remains unaffected. The change items residents were given included questions related to neighborhood ties, social cohesion, and trust as well as other potential outcomes chosen from the literature and from conversations with nonprofit partners.

Indirect measures. Residents in both planting and comparison neighborhoods were asked a set of survey questions about neighborhood ties, social cohesion, and trust (see Fig. 2). Neighborhood ties and social cohesion are both indices of five Likert-type items; for each index, a respondent's responses to these five items were summed to one bounded, continuous score with possible values 4–20 for neighborhood ties and 5–25 for social cohesion. Missing responses for single items in the scale were imputed using the average values of non-missing items. The last question in the social cohesion index measured trust (item 5e). We used this question alone as our third outcome measure. For each outcome measure, neighborhood-level values were generated by taking the neighborhood average of each item and for neighborhood ties and social cohesion, item averages were added together to create the index. These aggregated measures had the same bounds as the individual scores.

4.4. Analysis

We used the direct measures to calculate reported neighborhood change in two ways. First, we calculated the percent of "yes" responses out of the total number of responses (yes or no) for each question ("% question respondents, yes"). We ignored non-responses in this measure. However, this might have overestimated the actual effect because in some cases, respondents checked "yes" for characteristics they agreed had changed and left other characteristics blank, so we underestimated the number of "no" responses (neighborhood change items: 36 respondents reported only yes responses and left others missing; personal change items: 43 respondents). Our second measure divided the total number of "yes" responses for a question by the total number of survey respondents ("% survey respondents, yes"). This case gave us the lowest bound estimate of respondents who answered "yes" and is a conservative estimate of the percent of respondents who noticed a change as a result of the planting.

The second analytic strategy used regression analysis to estimate the relationship between tree-planting and the three indirect measures of community capacity. For each outcome of interest, we estimated five regression models. The first included individuals (n = 1551) and neighborhoods (n = 197) from all four cities and the other four each focused on a single city. Each model was specified in the same way. Our primary outcome of interest was a binary variable equal to 1 if the neighborhood in which a respondent lived was a planting neighborhood. The process of matching should have addressed most heterogeneity between planting and comparison neighborhoods however variation might remain from the matching process and be introduced from differences between survey respondents across neighborhoods. We controlled for several respondent and neighborhood characteristics (see Table 2 for descriptive statistics). To capture differences between survey respondents that might relate to perceived neighborhood characteristics, we controlled for whether the respondent had earned at least a bachelor's degree. Concentrated disadvantage has been linked to low collective efficacy (Sampson, 2004), so we included a measure of the median household income in the US Census tract containing the block group (median household income is unavailable at the block group level). We also controlled for two indicators of the built environment that might dictate where tree planting is more feasible: population density and percent canopy cover. As a final precaution, we used random effects to control for unobserved neighborhood-level characteristics correlated with each outcome of interest. We repeated these analyses at the neighborhood level, using neighborhood aggregate outcomes and adjusting for the percent of survey respondents from each neighborhood who had earned at least a bachelor's degree rather than the individual respondent's education.

Table 2
Descriptive statistics for outcome (**bold**) and explanatory variables.

	Mean	n	Min	Max	s.d.	Median
Neighborhood ties (4–20)	17.53[b]	1678	5	25	3.73	18
Social cohesion (5–25)	12.91[b]	1643	5	20	3.77	13
Neighborhood trust (1–5)	3.42[b]	1657	1	5	1.01	4
planting neighborhood (0,1)	0.52	1686	0	1	0.50	1
Respondent has at least a bachelor's degree	0.57	1554	0	1	0.49	1
Median hh income, tr[a]	52.16	1686	9.45	135.5	30.04	43.30
Population density	29.33	1686	0.04	219.2	32.1	19.94
% canopy cover	36.35	1686	2.60	78.00	19.11	33.90

Possible values noted in parentheses.
[a] tr denotes variables measured at the tract level.
[b] Denotes mean is significantly different between planting and comparison neighborhoods.

5. Results

5.1. Direct measures

Figs. 3 and 4 report the percent of respondents living in planting

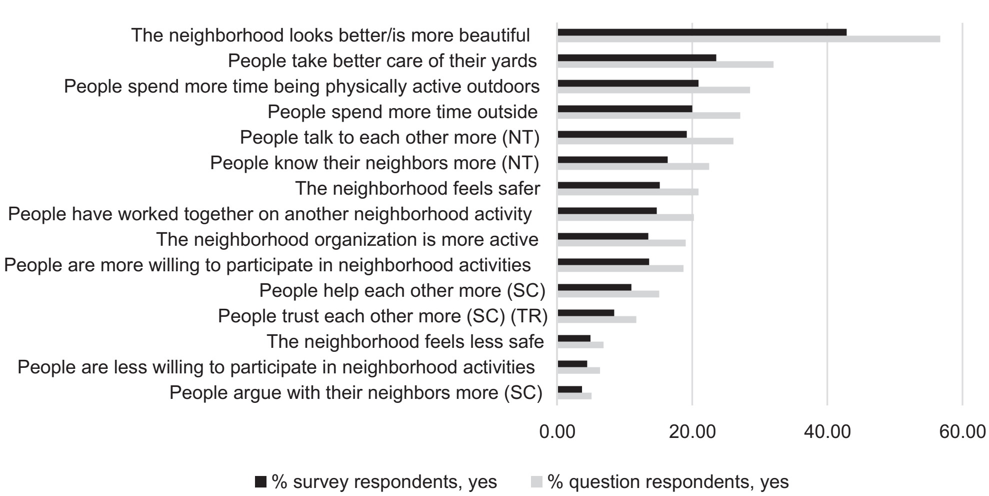


Fig. 3. Responses to direct questions about neighborhood changes, % of question and survey respondents who answered "yes" to each question. (NT) denotes a question that regards neighborhood ties; (SC) denotes a question that regards social cohesion; (TR) denotes a question that regards neighborhood trust. All other questions relate to secondary outcomes.

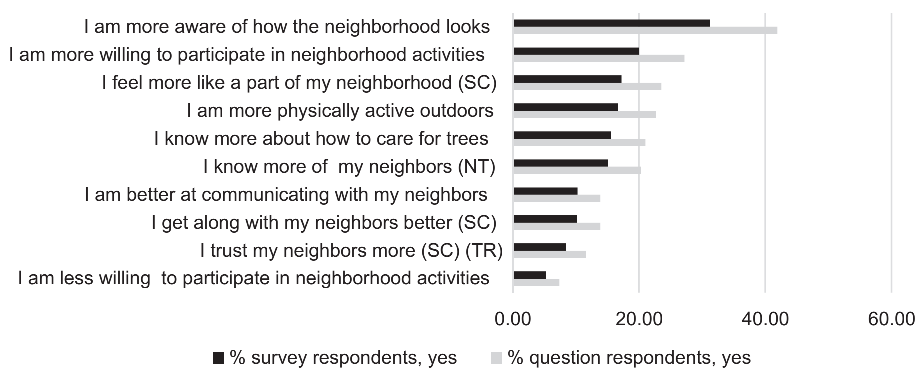


Fig. 4. Responses to direct questions about personal changes, % of question and survey respondents who answered "yes" to each question. (NT) denotes a question that regards neighborhood ties; (SC) denotes a question that regards social cohesion; (TR) denotes a question that regards neighborhood trust. All other questions relate to secondary outcomes.

neighborhoods who reported having noticed each neighborhood or personal change. A higher percentage of respondents reported changes in neighborhood ties than in social cohesion or trust. Of the potential changes listed, respondents most often reported that the neighborhood looked better and/or was more beautiful after the planting project (42.9%). Respondents also frequently reported that people took better care of their yards (23.5%) and spent more time being active outside (20.9%). Very few respondents reported negative changes (more arguments between neighbors: 3.7%; neighbors being less willing to participate in neighborhood activities: 4.5%).

Table 3
Regression results for neighborhood ties at the individual level. Coefficients shown with standard errors in parentheses.

	Multi-city	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.54**	1.14**	0.16*	0.17	0.95
	(0.27)	(0.56)	(0.64)	(0.40)	(0.62)
Bachelors	0.44**	− 0.55	0.54	0.96***	0.41
	(0.21)	(0.48)	(0.53)	(0.32)	(0.42)
Median hh income ($1000), tr	0.024***	0.024**	0.004	0.03**	0.02
	(0.01)	(0.00936)	(0.022)	(0.01)	(0.02)
Population density	0.014***	0.012	− 0.03	− 0.02	0.02**
	(0.00)	(0.025)	(0.03)	(0.03)	(0.01)
% canopy cover	0.02**	0.049**	− 0.02	0.003	0.01
	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
Constant	9.93***	8.72***	13.18***	10.59***	9.74***
	(0.44)	(1.51)	(1.52)	(0.810)	(1.24)
N	1518	411	230	560	317
X^2	57.36	25.02	2.24	28.51	8.91

tr denotes variables measured at the tract level.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

5.2. Indirect measures

Table 2 reports descriptive statistics for outcome and explanatory variables at the individual level. Two-tailed *t*-tests revealed significantly higher neighborhood ties ($p = 0.03$), social cohesion ($p = 0.01$), and trust ($p = 0.03$) reported by individuals in planting neighborhoods than in comparison neighborhoods ($p = 0.02$). At the neighborhood level, two tailed *t*-tests revealed that planting and comparison neighborhoods did not differ significantly in neighborhood ties ($p = 0.10$), social cohesion ($p = 0.26$), or trust ($p = 0.15$).

Tables 3, 4, and 5 present results of multi-city and single-city models predicting neighborhood ties, social cohesion, and neighborhood trust using individual survey responses. Given insignificant *t*-tests at the neighborhood level, regression results are not reported (see full neighborhood-level regression results in Appendix A). In the multi-city regression models, results revealed a positive and significant coefficient on planting neighborhoods for neighborhood ties (Table 3). The coefficient 0.54 on planting neighborhoods suggests that planting trees increases neighborhood ties (measured between 4 and 20) by 0.54 points. If planting programs were to occur in this study's non-planting neighborhoods, we would expect to see an increase in neighborhood ties of

Table 4
Regression results for social cohesion at the individual level. Coefficients shown with standard errors in parentheses.

	Multi-city	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.39	0.78*	− 0.60	0.47	0.72
	(0.27)	(0.42)	(0.75)	(0.41)	(0.56)
Bachelors	0.59***	0.14	0.71	0.83***	0.62
	(0.19)	(0.40)	(0.54)	(0.30)	(0.38)
Median hh income ($1000), tr	0.05***	0.04***	0.04	0.05***	0.06***
	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)
Population density	0.004	0.03*	− 0.002	− 0.04	0.01
	(0.004)	(0.02)	(0.03)	(0.03)	(0.01)
% canopy cover	0.01	0.04**	− 0.01	0.01	0.03
	(0.01)	(0.02)	(0.04)	(0.02)	(0.03)
Constant	14.25***	12.42***	15.75***	14.22***	13.22***
	(0.43)	(1.16)	(1.72)	(0.83)	(1.12)
N	1551	420	238	569	324
X^2	122.4	63.16	4.38	68.56	24.07

tr denotes variables measured at the tract level.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 5
Regression results for trust at the individual level. Coefficients shown with standard errors in parentheses.

	Multi-city	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.08	0.18	− 0.09	0.14	0.14
	(0.07)	(0.15)	(0.14)	(0.11)	(0.15)
Bachelors	0.15***	0.02	0.17	0.16**	0.17
	(0.05)	(0.11)	(0.14)	(0.08)	(0.10)
Median hh income ($1000), tr	0.013***	0.01***	0.01**	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Population density	0.00	0.01	− 0.01	− 0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)
% canopy cover	0.00	0.01	− 0.02*	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	2.51***	2.20***	3.39***	2.40***	2.28***
	(0.11)	(0.38)	(0.34)	(0.22)	(0.30)
N	1535	418	233	563	321
X^2	159.4	37.87	12.59	76.04	25.14

tr denotes variables measured at the tract level.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

4.2% (a change in neighborhood ties from a mean of 12.71 to a mean of 13.25). The median income of the tract is also significant. In the multi-city models, there are no significant differences between planting and comparison neighborhoods for social cohesion (Table 4) and trust (Table 5). Instead, the education of the survey respondent and the median household income in the tract explain the observed variation in social cohesion and trust.

Single-city regressions provide more detailed information about the association of tree planting and social features. In Atlanta, there is evidence that both neighborhood ties and social cohesion are significantly higher in planting neighborhoods than in comparison neighborhoods. In Atlanta, tree planting is related to 1.14-point higher neighborhood ties (scale: 4–20) and 0.78-point higher social cohesion (scale: 5–25). Single-city regressions for Detroit, Indianapolis and Philadelphia find no significant relationship between planting and any of the three outcomes.

6. Discussion & conclusion

Our analysis found mixed evidence for an effect of nonprofit tree-planting programs on community capacity. Consistent with qualitative accounts, respondents reported noticeable changes in the neighborhood when asked directly about the impact of the tree-planting program. When we compared neighborhood characteristics between respondents in planting and comparison neighborhoods, we found a statistically significant relationship between planting and neighborhood ties but not with social cohesion and trust. In single-city models, planting was only significant in Atlanta, and for neighborhood ties and social cohesion, but not trust. The significant relationships we did find are small. In models that pool individual responses at the neighborhood level, there were no significant associations of tree planting and our outcomes of interest.

The direct measures revealed several notable results. First, residents did report positive changes in their neighborhood as a result of the tree planting. Several other neighborhood changes were reported more often than changes related to community capacity. Respondents most frequently reported improvements in neighborhood beauty. Other literature reminds us that beautification is a meaningful social outcome in itself. Beautification can improve neighborhood residents' self-image (Westphal, 1999) and trees can serve as both an ecological improvement and an indication of neighborhood intention and care (see Nassauer, 1995 on “cues to care”). An aesthetically pleasing neighborhood can also cultivate ‘place attachment,’ which has been found to be positively related to neighborhood ties, which is subsequently related to civic engagement (i.e., participation in neighborhood activities, volunteering, and political action) (Lewicka, 2005). Greenspaces can also be restorative (Kaplan & Kaplan, 1989; Svendsen, 2009). Although this paper set out to examine the positive impacts that *participating* in tree planting and maintenance can yield, survey responses remind us of the aesthetic benefits of trees themselves. Relatedly, individuals also reported increased awareness of neighborhood appearance. Increased awareness about the appearance of their neighborhood might lead individuals to take better care of their property (Nassauer, Wang, & Dayrell, 2009). Aesthetics have been observed to be the most important motivator for resident tree planting in the US (Locke, Roman, & Murphy-Dunning, 2015; Summit & McPherson, 1998) and Canada (Conway, 2016), suggesting that nonprofit recruitment might be most successful by leveraging beautification benefits.

In addition to reports of neighborhood beautification, respondents reported that neighbors took better care of their yards, spent more time being physically active outdoors, and spent more time outside in general because of the planting. Whether these changes were the result of a more appealing outdoor environment or the result of active participation in tree planting and care remains to be answered. Together, the results demonstrate that changes in neighborhood capacity occur (e.g. reports of changes in neighborhood ties and trust), and that other kinds of neighborhood changes seem to be stronger (e.g. neighborhood beautification). Note that the results of the direct outcomes are fairly conservative because they include responses (no's) from individuals who did not even know about the tree planting, and so had no chance to observe differences.

The regression results using indirect measures pick up some positive associations of tree-planting. They also present a puzzle: we find a significant relationship between planting and neighborhood ties in the multi-city model, no significant relationship for social cohesion and trust in the multi-city models, and only significant relationships in Atlanta when we run single-city models. These results yield two questions: (1) why do we observe significance for neighborhood ties and not for social cohesion? And, (2) why do we see significant relationships in Atlanta and not in Detroit, Indianapolis, or Philadelphia? There might be both a substantive explanation based on differences between outcomes and between cities and a methodological explanation based on the analytic strategy leveraged in this paper.

It might be the case that tree-planting projects influence neighborhood ties more than they influence social cohesion and trust because of the relative ease of changing these neighborhood characteristics. As a reminder, “neighborhood ties” reflects the level of neighborhood networks through mutual activities, whereas “social cohesion” reflects connections between neighbors on values and trust (Sampson, McAdam, MacIndoe, & Weffer-Elizondo, 2005). The results suggest that tree planting and subsequent care seem to provide opportunities for neighbors to meet and develop stronger ties. However, they do not seem strong enough to help neighbors build more shared values or increase trust (components of social cohesion). From conversations with partner nonprofits, we know that neighborhoods varied in the extent of their engagement in tree-planting and care. Some neighborhoods worked together to care for trees for several years, whereas other neighborhoods planted trees as a “one-off” project that did not involve longer-term collaboration. We expect more long-term engagement to yield larger community benefits, particularly social cohesion and trust. We might have observed these effects had we limited our study to projects in which neighbors were more engaged in follow-up tree care.

Another potential explanation for the difference between these two findings is that we might not have sufficiently addressed self-selection and so our planting and comparison neighborhoods might have differed on unobserved characteristics before planting. The positive difference in neighborhood ties between planting and comparison neighborhoods might be an artifact of pre-planting neighborhood characteristics that led the neighborhood to plant trees initially. Given our matching strategy and post-matching checks that demonstrate no differences between groups, we do not think this methodological explanation is sufficient (self-selection and other estimation challenges are common in urban social ecological research; see Locke, Han, Kondo, Murphy-Dunning, & Cox, 2017 for another example of how to address them). Compensatory effects might also have been present, in which comparison neighborhoods undertook different community projects that yielded similar social effects at the tree planting. If compensatory effects exist, this study has underestimated the effect of tree planting.

The second puzzle presented by the results is why relationships are not significant in three out of four single-city models, and why Atlanta appears to be different than the other cities. Again, the explanation might be in part statistical and in part substantive. Differences in significance between the multi-city and the single-city models might be indicative of changes in statistical power rather than substantive variation across cities. The multi-city model has roughly four times as many observations. Consequently, it has smaller standard errors so smaller coefficients will be significant.[8] However, differences in

[8] For example, the coefficient on planting neighborhood for neighborhood ties in Philadelphia, 0.95, is not significant, whereas the coefficient on planting neighborhood in the multi-city model, 0.54, is.

coefficient magnitude across cities suggests that statistical power is insufficient to explain variation between the multi-city model and the single-city models, and to explain variation across the single-city models (sample size differences, however, offer a valid explanation for why we observe significant coefficients in the individual-models but not the neighborhood-level models).

One substantive factor that might explain differences in results across cities is variation in nonprofit planting programs across those cities. For example, we would expect our outcomes to be higher in cities where neighbors have a neighborhood gathering after they plant trees or where neighbors collaborate over several years to water the trees they planted. Interviews with Trees Atlanta tree-planting leaders and nonprofit employees revealed that after each tree-planting event in Atlanta, neighbors and other volunteers who planted trees gathered in the neighborhood, often ordering pizza or going out for lunch. These social events might have provided opportunities for neighbors to build connections. However, Atlanta neighbors were not the only ones socializing after tree plantings; neighborhoods in other cities also on occasion incorporated social activities and food into their tree plantings. Additionally, interviews with nonprofit employees in each city revealed that neighbors in Trees Atlanta projects might have actually been less involved in follow-up care and maintenance of trees than neighbors in other cities—Trees Atlanta staff watered nearly all planted trees, rather than having neighbors water trees as they did in other cities. Given these conflicting clues, explanation for observed differences across cities remains unclear.

In the aggregate, these results suggest that neighborhood participation in tree planting can yield social changes in participating neighborhoods. However, these effects do not appear to be automatic. It might be the case that variation in nonprofit programming or in participating neighborhoods changes the magnitude of program effects. Effects might be significant only in some kinds of neighborhoods, and so are not strong enough to be picked up in our models.

The results yield several implications for practice and for future research. First, they highlight the importance of the beauty and other passive benefits planted trees provide. Still, the nonprofits in this study are explicitly interested in improving neighborhoods beyond the benefits of the physical trees themselves. Self-reported measures suggest that programs can have positive effects, but evidence of program impacts in the multi-city statistical tests presented here are mixed. These findings directly inform nonprofits about the extent to which their programs achieve their objectives. If nonprofits are truly interested in building community capacity, they need to be strategic and intentional in their program design. Partnering with other organizations or services in the area that have expertise in community outreach might magnify the social benefits of tree-planting. More long-term tree care from neighbors might also amplify social effects. This paper also demonstrated the feasibility and strength of a multi-city treatment-comparison design.

The results suggest more work is needed to identify neighborhood-level or project-level characteristics that help predict the effectiveness of the project on neighborhood social outcomes. Sampson and colleagues have found that collective efficacy (including social cohesion) helps neighborhoods face challenges better than neighborhood ties alone (Sampson et al., 2005), so it is of particular interest whether there are certain cases in which planting programs improve collective efficacy. While this paper considered the same benefits across neighborhoods, future work could compare the extent to which projects yield locally relevant benefits that align with a neighborhood's specific goals, and examine whether the effects observed in this study appear in work conducted in other countries. Further research will help nonprofits identify the neighborhoods in which their programs might be most successful and help identify program improvements to maximize program impact. Future work could also consider the relative benefits of urban greening projects to other collective activities. Work should follow up on the potential programmatic effects on public health and on residential yard-care that were reported in the direct measures of program impact (see Fisher et al., 2015 for an in-depth consideration of the effects of planting on broader civic engagement). Finally, the research presented here can help inform future experimental research that estimates the social impact of tree-planting programs.

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Author's note

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Declarations of conflicts of interest

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix A

Propensity score matching with time trends

Census data from year 2000 captures neighborhood characteristics about a decade before planting; including these data in the propensity score matching helps to account for longer term neighborhood trends. Each time the Census is conducted, the geographies (boundaries, or even the total number) of some block groups and tracts change to account for changes in population, which makes comparisons across time difficult. We had access to 2000 Census tract data recalculated for the 2010 Census tract geographies from the vendor Geographic Research, Inc. (New York City, New York, USA), which enabled use of 2000 and 2010 Census data in the same models.

We added the following variables from the 2000 Census to the original propensity score models and re-selected neighborhoods: the percent of residents who moved into their home between 1995 and 2000; the percent of the population that was white; the percent of the population that earned a college degree; the percent of the population that did not have a high school diploma, and median household income. All variables are measured at the tract level.

We conducted *t*-tests that compared mean values of key variables in each city and for all cities together for three comparisons: (1) the mean of the treatment group vs. the mean of the original comparison neighborhoods; (2) the mean of the treatment group vs. the mean of the re-matched comparison neighborhoods, and (3) the mean of the original comparison neighborhoods vs. the mean of the re-matched comparison neighborhoods. We also graphed all Census block groups (in each city and for all cities together), to compare the original propensity score and the re-calculated propensity score.

Results

Table A.1 reports the results of the suite of *t*-tests. For each variable, in each city, we report the p-value from three *t*-tests. There were no significant p-values for any single-city or multiple-city tests.

Figs. A.1–A.4 plot the original and re-calculated propensity scores for each block group in Atlanta and Detroit, respectively. Treatment block groups are marked by a black square, comparison block groups are marked with grey shapes, and block groups that were not selected at all are marked with small grey circles. Observations trend along the identity line (1:1 slope, running from each corner [0,0 to 1,1]), which suggests that the two propensity scores for each block group are fairly related. The closer the points are to the identity line, the less the inclusion of 2000 data would have changed the propensity score. (If all points were exactly on the identity line, this would mean that the original and re-calculated propensity scores were exactly the same, and including the 2000 data had no effect on the propensity score).

In Atlanta, points are clustered, but not tightly, around the central line. In Detroit, Indianapolis and Philadelphia, points are tightly clustered around the line. In Atlanta, the planting neighborhoods generally have higher propensity scores than other block groups and both original and re-matched comparison neighborhoods have generally lower propensity scores. The second round of matching does not seem to have changed the range of selected neighborhoods, although a few moved to the corners of the distribution (near 1,1 and 0,0). In Detroit, planting neighborhoods and comparison neighborhoods are not clustered as in Atlanta, and by eye it appears that the second matching did not change the general distribution of comparison neighborhoods. In Philadelphia, planting neighborhoods and comparison neighborhoods do not appear to be clustered either, although planting neighborhoods might have slightly higher propensity scores.

The results from both the *t*-tests and the graphs suggest that the introduction of data from the 2000 Census did not substantially change the kinds of neighborhoods that were selected by the propensity score matching. *t*-Tests do not reveal significant differences between groups, propensity scores are clustered around the line in Figs. A.1–A.5, suggesting that the new models did not substantially change propensity scores. Finally, the location of comparison groups 1 and 2 are not substantively different. These findings suggest that including trends data in the initial matching would not have substantially changed the types of neighborhoods in the study. We remain confident that our initial selection techniques created a comparison group of neighborhoods that were quite similar to the planting neighborhoods.

Table A.1
Variables and data sources used for propensity score matching.

Variable	Data source
Trees (dependent variable)	Nonprofit partners
Block group socio-demographic variables	
Total households	US Census 2010
% housing units renter occupied	US Census 2010
% white	US Census 2010
% families with kids	US Census 2010
% households with female head of household	US Census 2010
Tract socio-demographic variables	
% single parent household	American Community Survey 2010
% education—less than 9th grade	American Community Survey 2010
% education—9-12 grade	American Community Survey 2010
% education—some college	American Community Survey 2010
% education— bachelors	American Community Survey 2010
% education— grad degree	American Community Survey 2010
% pop living in the same house last year	American Community Survey 2010
% pop > 16 drove to work	American Community Survey 2010
% pop > 16 walked to work	American Community Survey 2010
% employed in service industry	American Community Survey 2010

% employed in sales	American Community Survey 2010
% employed in maintenance	American Community Survey 2010
% employed in transportation	American Community Survey 2010
% vacant housing units	American Community Survey 2010
% occupied housing units moved in last 5 years	American Community Survey 2010
Tract socio-demographic variables	
% pop moved since 1995 (2000)[a]	US Census 2000 (Geographic Research, Inc.)
% white[a]	US Census 2000 (Geographic Research, Inc.)
% education—college degree[a]	US Census 2000 (Geographic Research, Inc.)
% education—less than high school[a]	US Census 2000 (Geographic Research, Inc.)
Median household income[a]	US Census 2000 (Geographic Research, Inc.)
Block group spatial and land cover variables	
Total area (ha) of block group	Tiger files, US Census Bureau
Population density (people per hectare)	US Census 2010, Tiger files
Density of parcels in block group[b]	City governments
% of block group area with canopy	US Forest Service, NAIP Imagery
% block group area with impervious surface	US Forest Service, NAIP Imagery

[a] Time trend variable only included in robustness check propensity score matching.
[b] Not available for Atlanta.

Table A.2
p-Values from *t*-tests comparing treatment group, comparison group, and second comparison group means.

	Group 1	Group 2	City				
			All cities	Atlanta	Detroit	Indianapolis	Philadelphia
% housing units renter occupied	Treatment	Original comparison	0.424	0.966	0.631	0.440	0.645
	Treatment	Second comparison	0.894	0.501	0.913	0.449	0.828
	Original comparison	Second comparison	0.365	0.544	0.516	0.976	0.490
% white	Treatment	Original comparison	0.970	0.789	0.602	0.846	0.881
	Treatment	Second comparison	0.944	0.848	0.762	0.793	0.871
	Original comparison	Second comparison	0.975	0.941	0.816	0.944	0.760
Median hh income, tr	Treatment	Original comparison	0.717	0.912	0.571	0.901	0.744
	Treatment	Second comparison	0.867	0.861	0.890	0.812	0.865
	Original comparison	Second comparison	0.839	0.951	0.575	0.910	0.615
% education—bachelors, tr	Treatment	Original comparison	0.680	0.566	0.849	0.777	0.933
	Treatment	Second comparison	0.692	0.697	0.314	0.889	0.355
	Original comparison	Second comparison	0.983	0.846	0.359	0.895	0.477
% vacant housing unit	Treatment	Original comparison	0.330	0.403	0.668	0.630	0.807
	Treatment	Second comparison	0.436	0.792	0.655	0.530	0.424
	Original comparison	Second comparison	0.861	0.249	0.961	0.887	0.591
% occupied housing units moved in last 5 years, tr	Treatment	Original comparison	0.591	0.555	0.781	0.486	0.412
	Treatment	Second comparison	0.881	0.721	0.552	0.418	0.777
	Original comparison	Second comparison	0.719	0.807	0.449	0.926	0.658
	Treatment		0.478	0.948	0.835	0.414	0.617

% occupied housing units moved in last 5 years, tr 2000		Original comparison					
	Treatment	Second comparison	0.791	0.505	0.681	0.357	0.381
	Original comparison	Second comparison	0.376	0.568	0.882	0.954	0.276
% white, tr 2000	Treatment	Original comparison	0.378	0.610	0.372	0.508	0.324
	Treatment	Second comparison	0.458	0.825	0.607	0.434	0.470
	Original comparison	Second comparison	0.895	0.785	0.710	0.902	0.801
% education—college, tr 2000	Treatment	Original comparison	0.687	0.681	0.544	0.891	0.907
	Treatment	Second comparison	0.900	0.780	0.839	0.731	0.467
	Original comparison	Second comparison	0.784	0.896	0.568	0.639	0.455
Median hh income, tr	Treatment	Original comparison	0.711	0.466	0.836	0.957	0.673
	Treatment	Second comparison	0.497	0.508	0.654	0.867	0.990
	Original comparison	Second comparison	0.776	0.941	0.438	0.903	0.688
Population density, 2010	Treatment	Original comparison	0.402	0.451	0.697	0.441	0.347
	Treatment	Second comparison	0.242	0.587	0.639	0.363	0.104
	Original comparison	Second comparison	0.645	0.771	0.905	0.835	0.358
Canopy, 2010	Treatment	Original comparison	0.546	0.273	0.421	0.502	0.684
	Treatment	Second comparison	0.400	0.172	0.786	0.445	0.648
	Original comparison	Second comparison	0.718	0.729	0.561	0.892	0.915

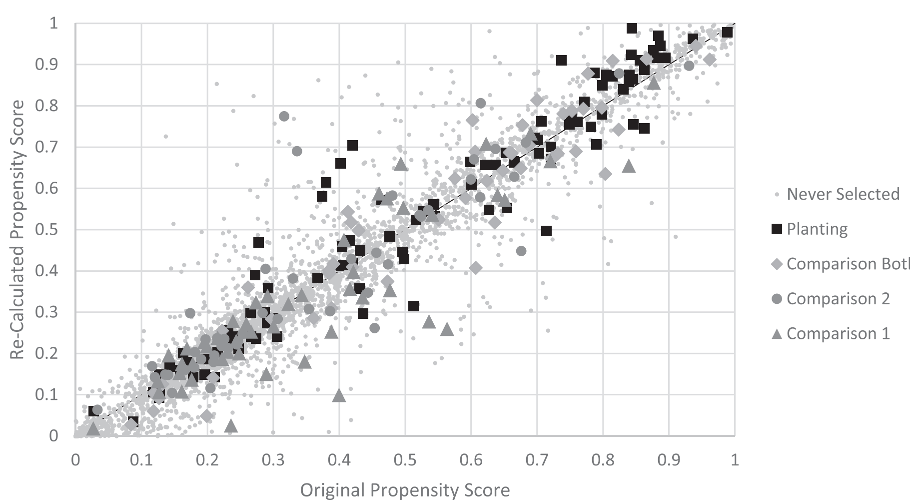

Fig. A.1. Propensity scores in all block groups, by selection.

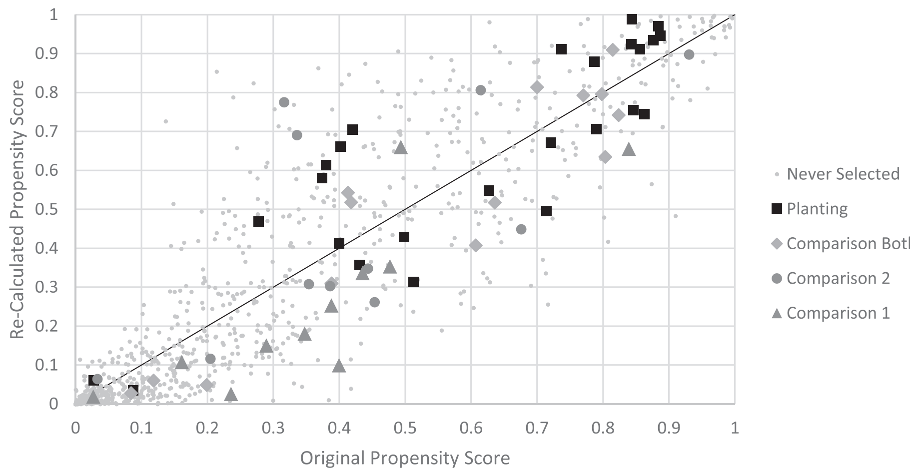

Fig. A.2. Propensity scores in Atlanta block groups, by selection.

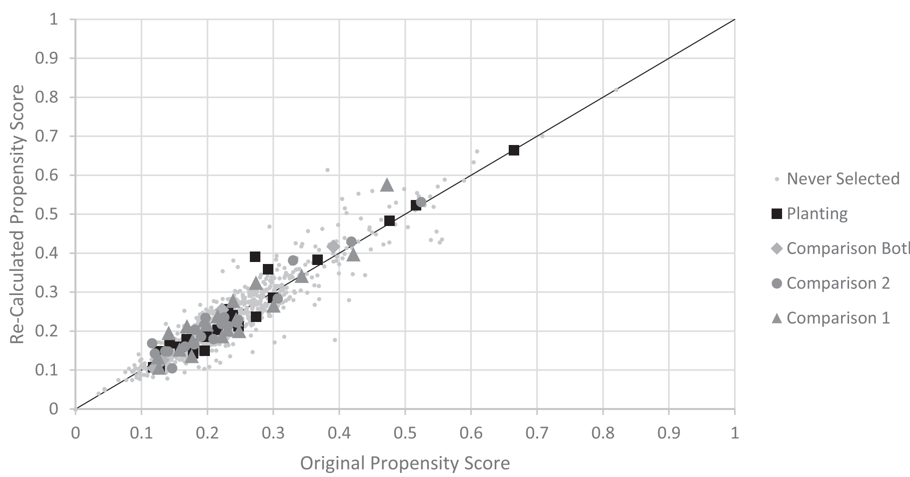

Fig. A.3. Propensity scores in Detroit block groups, by selection.

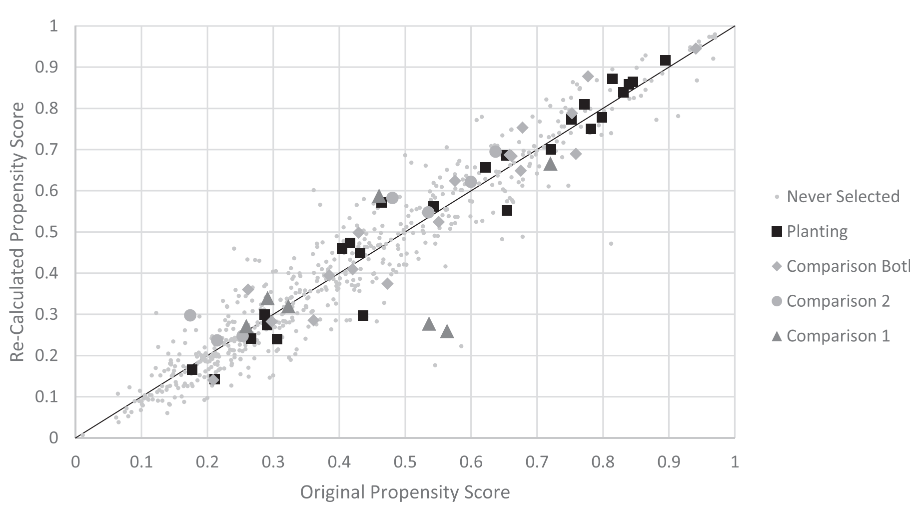

Fig. A.4. Propensity scores in Indianapolis block groups, by selection.

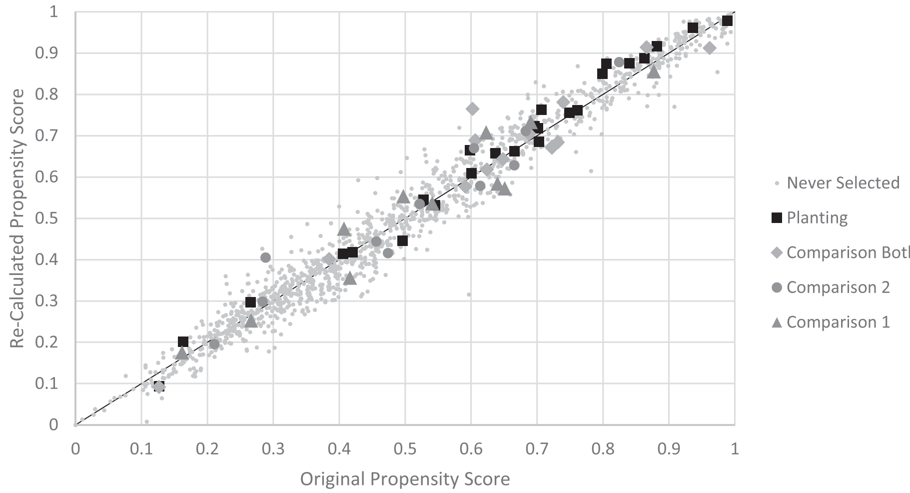

Fig. A.5. Propensity scores in Philadelphia block groups, by selection.

Table A.3
Descriptive statistics for outcome (**bold**) and explanatory variables at the neighborhood level.

	Mean	n	Min	Max	s.d.	Median
Neighborhood ties (4–20)	12.4	197	5	17.2	2.24	12.33
Social cohesion (5–25)	16.79	197	5	21.8	2.46	16.88
Neighborhood trust (1–5)	3.20	196	1	4.4	0.67	3.28
planting neighborhood (0,1)	0.50	197	0	1	0.50	1
% respondents with bachelor's degree	49.65	197	0	100	31.3	50
median hh income, tr[a]	43.28	197	9.449	135.5	26.38	33.7
population density	34.2	197	0.04	219.2	36.17	21.7
% canopy cover	34.28	197	2.6	78	18.32	32.4

Possible values noted in parentheses.
[a] tr denotes variables measured at the tract level.

Table A.4
Regression results for neighborhood ties at the neighborhood level. Coefficients shown with standard errors in parentheses.

	Multi-city[a]	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.46	1.38**	− 0.07	− 0.04	0.59
	(0.29)	(0.60)	(0.67)	(0.41)	(0.67)
% respondents with bachelors	0.008	0.005	− 0.002	0.03***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Median hh income ($1000), tr	0.02***	0.02*	0.003	0.02	0.02
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Population density	0.01**	0.01	0.001	− 0.02	0.02*
	(0.01)	(0.03)	(0.03)	(0.03)	(0.01)
% canopy cover	0.02	0.04*	0.01	− 0.01	− 0.001
	(0.01)	(0.02)	(0.03)	(0.02)	(0.04)
Constant	9.61***	8.18***	11.59***	10.31***	9.41***
	(0.58)	(1.54)	(1.43)	(0.79)	(1.33)
N	197	50	48	50	49
F	7.18	4.66	0.03	6.15	1.74
R^2	0.16	0.35	0.003	0.41	0.17
Adjusted R^2	0.13	0.27	− 0.12	0.34	0.07

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.
[a] Estimated with city fixed effects; tr denotes variables measured at the tract level.

Table A.5
Regression results for social cohesion. Coefficients shown with standard errors in parentheses.

	Multi-city[a]	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.18	1.09**	− 1.14	0.11	0.74
	(0.28)	(0.45)	(0.76)	(0.43)	(0.56)
% respondents with bachelors	0.025***	0.04***	0.01	0.03***	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Median hh income ($1000), tr	0.04***	0.02**	0.04	0.04**	0.05***
	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)
Population density	0.0001	0.01	0.03	− 0.04	− 0.001
	(0.01)	(0.02)	(0.03)	(0.03)	(0.007)
% canopy cover	0.01	0.03*	0.02	0.003	− 0.004
	(0.01)	(0.02)	(0.04)	(0.02)	(0.03)
Constant	13.38***	11.12***	13.46***	14.14***	13.42***
	(0.55)	(1.17)	(1.62)	(0.82)	(1.10)
N	197	50	48	50	49
F	22.36	15.80	1.33	14.18	5.03
R^2	0.37	0.64	0.14	0.62	0.37
Adjusted R^2	0.35	0.60	0.03	0.57	0.30

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.
[a] Estimated with city fixed effects; tr denotes variables measured at the tract level.

Table A.6
Regression results for trust. Coefficients shown with standard errors in parentheses.

	Multi-city[a]	Atlanta	Detroit	Indianapolis	Philadelphia
Planting neighborhood	0.07	0.25	− 0.06	0.01	0.12
	(− 0.07)	(− 0.15)	(− 0.15)	(− 0.11)	(− 0.15)
% respondents with bachelors	0.01***	0.005	0.002	0.012***	0.01***
	(− 0.001)	(− 0.004)	(− 0.003)	(− 0.003)	(− 0.003)
Median hh income ($1000), tr	0.01***	0.01***	0.01**	0.01**	0.01***
	(− 0.002)	(− 0.003)	(− 0.01)	(− 0.004)	(− 0.005)
Population density	− 0.002	0.004*	− 0.01	− 0.01	− 0.002
	(− 0.002)	(− 0.01)	(− 0.01)	(− 0.01)	(− 0.002)
% canopy cover	0.001	0.01	− 0.01	0.003	− 0.003
	(− 0.003)	(− 0.01)	(− 0.01)	(− 0.01)	(− 0.009)
Constant	2.38***	2.03***	3.05***	2.35***	2.25***
	(− 0.14)	(− 0.40)	(− 0.37)	(− 0.21)	(− 0.30)
N	196	50	47	50	49
F	27.63	8.80	1.34	20.01	7.34
R^2	0.43	0.5	0.14	0.70	0.46
Adjusted R^2	0.4	0.443	0.036	0.66	0.40

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.
[a] Estimated with city fixed effects; tr denotes variables measured at the tract level.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2017.11.006.

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