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Resident perspectives on green infrastructure in an experimental suburban stormwater management program

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Resident perspectives on green infrastructure in an experimental suburban stormwater management program

Municipalities are increasingly promoting green infrastructure in residential neighborhoods as a strategy to manage stormwater runoff, but the extent to which residents are willing to adopt these alternatives to conventional landscaping remains unclear. This study examines the West Creek Ecosystem Restoration Project in Parma, Ohio, a suburban green infrastructure demonstration site for a new regional stormwater management program in the Cleveland metropolitan region. Residents were offered free installation of green infrastructure (e.g., rain gardens, right-of-way bioretentions, and rain barrels) on their property. Through a mixed method case-study, we analyze the socio-cultural factors that influence participation including resident's self-reported landscaping behaviors, environmental knowledge and values, and attitudes and perceptions toward green infrastructure and stormwater management. Results suggest that attitudes and perceptions most strongly influenced participation, residents generally disconnect local stormwater management from regional water resource issues, and that trusted peers may be more likely to encourage participation than official promotional strategies. These findings point to the importance of context-dependent framing and neighborhood partners in outreach activities.

Keywords
Stormwater Management, Residential Landscapes, Urban Ecology, Planning, Environmental Management

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INTRODUCTION

Impervious surfaces in cities create stormwater runoff that degrades aquatic ecosystems in urban areas (Walsh 2005a). Municipalities are increasingly promoting green infrastructure (GI)—constructed natural and semi-natural ecosystems—as a distributed solution to stormwater runoff problems (Wise 2008). Conventional stormwater management collects runoff in networks of pipes and drains to quickly transport it off site, either directly into streams or into centralized ponds and wetlands. Green infrastructure, by contrast, slows and reduces stormwater runoff, preventing it from entering waterways in the first place. Additionally, green infrastructure potentially provides ecosystem service co-benefits, can be implemented at small scales, and is increasingly aligned with federal policy, making it an attractive solution for municipalities facing stormwater runoff problems (Wise 2008; Bitting & Kloss 2008).

In order to successfully implement a city or regional green infrastructure plan, municipalities require participation across multiple stakeholder groups, including private property landowners and residents of residential neighborhoods (Hostetler et al. 2011; Keeley et al. 2013). Resident participation rates in municipal green infrastructure projects have been low, even when infrastructure is provided for free or with incentives (Green et al. 2012; Mayer et al. 2012; Bos & Brown 2015). Low participation rates are likely due to a variety of institutional and socio-cultural factors that influence residents' willingness to install and manage green infrastructure on their property (Barnhill 2012; Mayer et al. 2012; Baptiste et al. 2015). Additionally, socio-cognitive factors such as values, perceptions, and attitudes about the green infrastructure, and the environment writ large, likely influence willingness to adopt green infrastructure given findings that a similar set of factors influences general residential landscaping practices (Larson et al. 2009).

This study contributes to the ongoing scholarly debate about factors that influence green infrastructure adoption in municipal stormwater management programs that target residential neighborhoods. Specifically, we ask: how do environmental values, perceptions, and attitudes influence adoption of green infrastructure? The study draws from propositions about the socio-cognitive factors that influence general landscaping decisions and propose that they similarly influence green infrastructure adoption among urban residents. To address this proposition, we partnered with program administrators to examine the West Creek Ecosystem Restoration project in Parma, Ohio, a suburb of Cleveland, through which some homes in two neighborhoods were treated with green infrastructure at no cost to the residents. We use a group interview with program administrators to examine the process of recruiting and implementing green infrastructure retrofits, a survey of residents to gain insight into factors that influence program participation, and secondary data collected by program administrators and university partners to corroboration findings.

GREEN INFRASTRUCTURE IN URBAN STORMWATER MANAGEMENT

The goal of stormwater management is to protect urban infrastructure and aquatic ecosystems by slowing and storing runoff (Wanielista & Yousef 1993; Walsh et al. 2005a). Impervious land cover in urban areas creates excess stormwater runoff, and contributes to flooding, erosion, and water quality degradation in cities and adjacent ecosystems (Paul & Meyer 2001; Walsh et al. 2005b). Stream ecosystem function is generally degraded when impervious area exceeds 10-15% of a watershed's area, although there is no single threshold of impact (Brabec et al. 2002). Impervious surfaces that are directly connected to storm sewers and streams are associated with stream quality degradation when they cover as little as 1% of a watershed's area (Walsh et al. 2005b). In many older cities, combined sanitary and storm sewer systems can cause significant public health risks and water quality problems when they overflow during heavy rain events (Moffa 1997). Expanding infrastructure to store and treat combined sewer overflows is costly, leading municipalities to consider methods to reduce runoff at the source (Montalto et al. 2007).

Green infrastructure for stormwater management, such as green roofs, porous pavements, rain gardens, rain barrels (Mayer et al. 2012), and bioretention areas (Hood et al. 2007), disconnects impervious surface from storm sewers and waterways (e.g., Hood et al. 2007; Mayer et al. 2012). Green infrastructure goes beyond centralized stormwater management approaches by aiming to restore pre-development hydrologic regimes, through the promotion of infiltration and evapotranspiration (Burns et al. 2012). Green infrastructure practices are generally small-scale and distributed throughout a watershed and they disconnect formerly directly connected impervious surfaces (Bitting & Kloss 2008). The relatively small size of green infrastructure practices makes them particularly appropriate for watersheds for which larger ponds or wetlands cannot be retrofit into existing urban development.

Interest in green infrastructure has increased dramatically over the last 20 years in the US, partly driven by changing federal regulations (Wise 2008). Major metropolitan areas across the US have instituted policies to integrate green infrastructure (GI) into city planning to address stormwater runoff challenges and comply with requirements in the Clean Water Act. Prince George County in Maryland was one of the first municipal areas to adopt aggressive GI policies, committing a $1.2 billion toward retrofitting 4,000 acres of impervious surface in the 1990s (Prince George 2016). More recently, Seattle and Philadelphia have also instituted GI programs to address stormwater issues, especially related to combined sewer overflow problems, with the goal of managing 700 million gallons of stormwater annually via GI and reducing stormwater from entering waterways by 85%, respectively (Seattle 2016; Philadelphia 2016). Some initiatives, like Chicago's Green Alley Program, constitute more targeted approaches to retrofitting urban stormwater infrastructure, while other programs, like Los Angeles' 1 Million Tree Initiative, prioritize urban greening and embrace stormwater management as a co-benefit (Pincetl 2010; Newell et al. 2013; Chicago 2016). In other parts of the world, interest in the green infrastructure practices is similarly increasing, though they are known by names such as sustainable urban drainage systems and water sensitive urban design (Roe & Mell 2013; Fletcher et al. 2014).

FACTORS THAT INFLUENCE GREEN INFRASTRUCTURE ADOPTION IN RESIDENTIAL NEIGHBORHOODS

Municipal and regional green infrastructure programs require coordination among diverse stakeholder groups that own and manage land in urban areas, including residents and owners of properties in residential areas. Greater participation rates allow disconnection of more impervious surfaces and may achieve more substantial improvements in hydrology and improved ecological function in the headwater streams that receive stormwater runoff. Yet, participation rates in municipal green infrastructure programs have been low (Green et al. 2012; Mayer et al. 2015; Bos and Brown 2015).

In order to fully explore the factors that may motivate adoption of green infrastructure in municipal programs, this review draws insights from green infrastructure programs as well as literature on residential landscaping activities more broadly. Factors that influence participation in municipal green infrastructure programs specifically and residential landscaping behaviors generally can be broadly categorized as biophysical and social factors, the latter of which encompasses institutional, socio-cultural, and cognitive factors (Cook et al. 2012; Matthews et al. 2015). Biophysical factors that limit green infrastructure siting include soils, slopes, or other environmental characteristics that are not well suited for placement (Matthews et al. 2015). Institutional impediments include preventative rules and regulations, a lack of sufficient incentives, and economic or cost related issues. Socio-cultural barriers such as social status and social norms limit individual decision-making capacity and predispose individuals to particular landscaping activities. Finally, cognitive factors such as environmental knowledge, values, perceptions, and attitudes influence household landscaping decisions.

Many municipal green infrastructure programs attempt to remove institutional barriers. Most studies have found that residents adopt or express a willingness-to-adopt green infrastructure if transactions costs are limited. For instance, residents are more receptive if it is offered at low or no cost to them (Thurston et al. 2008; Thurston et al. 2010; Barnhill & Smardon 2012; Green et al. 2012; Baptiste et al. 2015). Cost may be particularly relevant when considering the relationship between adoption and socio-economic status. Willingness-to-adopt green infrastructure was not related to socio-economic status in one study (Baptiste 2014), but actual adoption primarily occurred in high-income areas according to other studies (Heynen et al. 2006; Ando & Freitas 2011; Locke & Grove 2016), suggesting that cost may become a factor based on income. In addition to monetary cost, reducing other transaction costs may also promote green infrastructure adoption. For instance, one study found more rain barrels located near distribution and informational campaign sites (Ando & Freitas 2011).

Several studies have addressed the relationship between green infrastructure adoption or residential landscaping choices and demographics or social status. Older individuals are more likely to engage in conventional, resource-intensive landscaping behaviors like fertilization (Carrico et al. 2012), while younger individuals are more likely to express willingness to adopt green infrastructure (Baptiste 2014). Younger individuals may also be less likely to own homes, which is problematic because homeownership has been linked to actual adoption of green infrastructure (Pincetl 2010; Ando & Freitas 2011). Social groups such as immigrants and renters may be reluctant or unable to fulfill program requirements (e.g., residency, long term maintenance commitment) (Pincetl 2010). Indeed, municipal programs may serve to increase pre-existing socio-economic disparities in green space distribution because residents of highly vegetated affluent communities are most likely to participate in municipal programs (Heynen et al. 2006; Locke & Grove 2016). The relationship between pro-environmental landscaping behavior and affluence is not straightforward, however, because wealthy individuals are also more likely to fertilize (Carrico et al. 2012). Structural factors associated with wealth such as lot size, home location in suburban areas, and outsourcing landscaping to a lawn company have been correlated to increased fertilizer application (Martini et al. 2015). Willingness to adopt green infrastructure is also likely mediated by structural constraints.

The desire to have green lawns for family activity spaces, to conform to neighborhood social norms, and the desire to be a "good" neighbor appears to hold strong influence on the decision to fertilize (Robbins & Sharp 2003; Larson et al. 2009; Fraser et al. 2013; Martini et al. 2015). In fact, social norms may have a stronger influence on landscaping behaviors than formal rules (Carrico et al. 2012; Fraser et al. 2013). Furthermore, social norms may change through processes of "spatial contagion" by which social interactions between neighbors lead to clustered adoption of landscaping features like gardens (Hunter & Brown 2012; Newburn et al. 2013).

Cognitive perspectives in environmental management address the fundamental challenges that increased collective societal knowledge about environmental problems does not necessarily lead to behavior changes that would address them. This challenge, known as the knowledge-to-action gap, relates to complex societal influences including institutional arrangements that reinforce existing behaviors and serve as barriers to change. Several fields including sociology, social psychology, and psychology among others, have examined the role of values and cognition in mediating behaviors relevant to the environment and have been reviewed elsewhere in detail (Dietz et al. 2005). These lines of inquiry have produced empirically tested frameworks such as the New Environmental Paradigm (NEP), which attempts to measure core environmental values, and the Value-Belief-Norm (VBN) model, which contends that individuals' core values influence their beliefs about the environment and their ability to make meaningful changes, which, in turn, influences decision-making and behaviors (Dunlap et al. 2000; Stern 2000). This line of inquiry suggests that environmental messages might have greater resonance if they are tailored to the particular socio-cultural contexts in which the message is received (Schultz & Zelezny 2003). Therefore, understanding the underlying knowledge, values, attitudes, and perceptions of different groups can improve communication about environmental challenges and, potentially, buy-in to solutions.

Studies examining environmental knowledge have found that residents' are generally unaware of the environmental benefits of green infrastructure, sometimes making a connection between green infrastructure and stormwater management, but often failing to make the broader connection to regional environmental degradation (Barnhill & Smardon 2012; Keeley et al. 2013; Baptiste 2014; Baptiste et al. 2015). Additionally, residents disconnect individual behaviors and neighborhood-scale factors from broader environmental challenges associated with stormwater management (Keeley et al. 2013). A similar disconnect has been reported in the residential landscapes literature with regard to pesticide, fertilizer, and water use and regional environmental challenges relating to water quality and quantity (Robbins & Sharp 2003; Larson et al. 2009). These findings underscore the relatively parochial nature of human interactions with the environment, dubbed the "perceptible realm" in landscape aesthetic studies (Gobster et al. 2007). One study found that residents' knowledge may be linked to experience based on past events, like combined sewer overflows, more so than formal educational campaigns (Baptiste 2014). The same study found that environmental knowledge was not linked to adoption, pointing to a knowledge-to-action gap. Another study found that residents' decision to install green infrastructure was not linked to frequency of flooding events, even when educational campaign specifically promoted the flood mitigation benefits (Ando & Freitas 2011). In sum, residents' knowledge of green infrastructure appears to be limited to local stormwater management benefits, which is primarily informed by negative personal experiences with flooding, but such experiences and knowledge about green infrastructure may not be sufficient to drive adoption.

Another major finding in studies of residential landscaping behavior is that environmental values or concerns do not necessarily lead to pro-environmental behavior. For example, studies have found a lack of a relationship between environmental concern and fertilizer application (Carrico et al. 2012; Martini et al. 2015). Contrary to studies on residential landscaping, a study on green infrastructure adoption, found a positive relationship between environmental concern and adoption (Newburn et al. 2013). One potential explanation for the discrepancy is that different factors may be motivating the choice to opt in to a new behavior (e.g., install green infrastructure) than the choice to opt out (e.g., stop fertilizing) of a routine behavior (Heimlich & Ardoin 2008). Routine behaviors that are reinforced by social norms (e.g., green lawns) may be the most difficult to change.

Little is known about residents' values, attitudes, and perceptions toward green infrastructure and how those cognitive factors relate to adoption. Ando and Freitas (2011) found that rain barrel adoption was higher in 'attitudinally' green communities. This result appears to be in line with the VBN model and findings that attitudes exert influence over behavior, but would require more explicit and specific testing to confirm. Studies examining management behaviors in residential yards, have generally found that pro-environmental values do not necessarily lead to environmentally friendly behaviors, and may actually be correlated to behaviors that contribute to environmental degradation such as pesticide use and fertilization, irrigation in arid environments (Robbins & Sharp 2003;

Robbins & Birkenholtz 2003; Yabiku et al. 2008; Larson et al. 2010). This counterintuitive finding may be due to resident perceptions that conflate, for instance, a green lawn (perceived care) with a healthy ecosystem (Nassauer 1995; Gobster et al. 2007). The link between attitudes—normative judgments—and management practices may be stronger, but more nuanced, than the relationship between values and management and depends on the specific type of management practice and context (Cook et al. 2012). Furthermore, cognitive constructs such as attitudes and perceptions may not be fixed because individuals' attempt to reconcile 'dissonance' between values (e.g., water conservation) and behaviors (e.g., watering the lawn) by justifying decisions with trade-offs in their belief system (e.g., the lawn is a safe place for my kids to play, increases my property values, signals that I am a good neighbor) (Larson et al. 2009; Carrico et al. 2012).

THE WEST CREEK ECOSYSTEM RESTORATION PROJECT: AN EXPERIMENTAL STORMWATER MANAGEMENT PROGRAM

The Cleveland metropolitan area, with over 2 million people, is drained by the Cuyahoga River—famous for water quality problems in the 1960s and earlier, and by numerous streams that flow directly into Lake Erie. Parts of the metropolitan area have combined sewers, and the Northeast Ohio Regional Sewer District is under a $3 billion consent decree from the US EPA to reduce combined sewer overflows (Northeast Ohio Regional Sewer District v. United States of America and State of Ohio 2010; "Northeast Ohio Regional Sewer District" 2015). In more newly developed parts of the metropolitan area, storm sewers are separated, but stormwater contributes to flooding, stream erosion, and water quality issues (Nacht 1980). A proposed regional stormwater fee, based on impervious surface cover of each lot and designed to provide funding for local stormwater control projects, was contested in the Ohio Supreme Court (Higgs 2014). In September 2015, the Supreme Court ruled in favor of the Northeast Ohio Regional Sewer District, which plans to spend $15 million in back collected fees and an additional anticipated revenue of $25-35 million annually on stormwater related projects. The West Creek Ecosystem Restoration Project is a pilot demonstration, aimed at illustrating the efficacy of GI in order to inform development of future GI projects under the new fee system. Given this context, the West Creek demonstration project has broader significance to the entire Cleveland metropolitan region.

Cleveland Metroparks, which manages more than 93 km^2, mostly in stream corridors, received funding from the US EPA Great Lakes Restoration Initiative to conduct the West Creek Ecosystem Restoration Project. The goal of this demonstration project was to evaluate the effectiveness of residential street-scale green infrastructure retrofits for reducing stormwater flow, using a double paired watershed study with before-after-control-impact design. Two treatment streets in the City of Parma, a suburb of Cleveland, were selected for the green infrastructure implementation. Sites were selected based on proximity to Cleveland Metroparks's West Creek Reservation, availability of comparable adjacent streets to serve as controls for hydrologic monitoring, lot size, and, in the case of Klusner, the availability of large right-of-ways between streets and lots (locally called "tree lawns") feasible for the siting of bioretention cells (Figure

1). Lot sizes on the treatment streets were 0.05 to 0.1 ha, which is typical of the City of Parma, with imperviousness of 55.5% for the neighborhood on Klusner and 26.4% on Parkhaven. Within the 36 km^2 West Creek watershed, total impervious area is 35%.

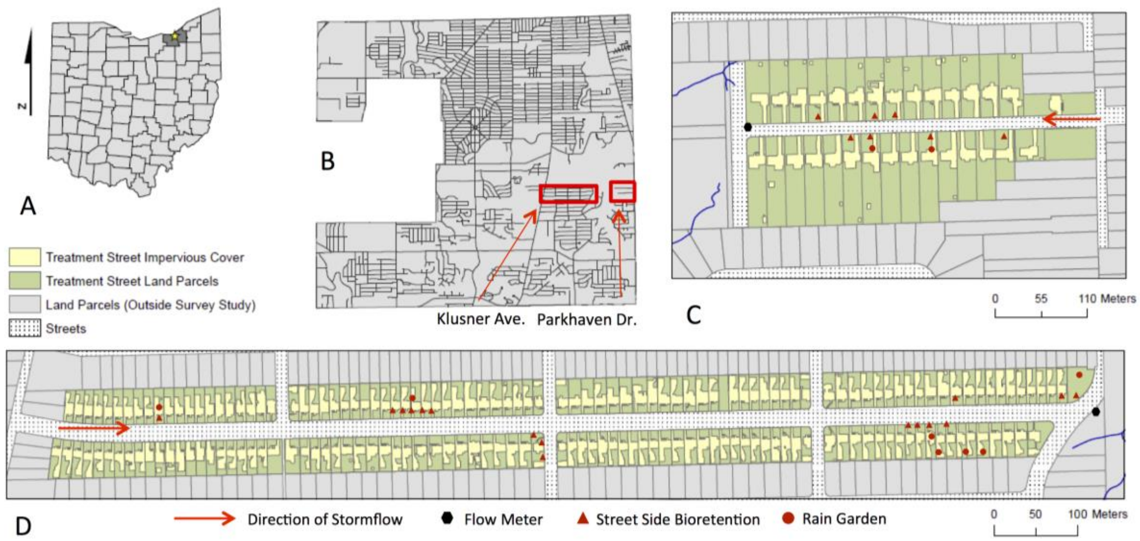

Figure 1 Study area location in Parma, Ohio (A-B) and street layout for two treatment streets, Parkhaven (C) and Klusner (D). Treatment street maps show parcel lot lines (gray), streets (stippled), impervious surface (yellow) and pervious landscape (green). The purple circles indicate locations of rain gardens, the red triangles indicate locations of street side bioretention, and the black circles indicate flow monitoring locations. Stormwater flows toward flow monitoring locations.

Demographic composition was not a primary consideration site selection. Parma, OHand the streets selected for treatment are relatively representative of the Cleveland Metropolitan Area. Table 1 compares Parma, the treatment streets, and the counties with cities under the NEORSD jurisdiction with respect to demographic variables thought to influence green infrastructure or landscaping behaviors and perspectives (U.S. Census 2015). The study area streets contain slightly more homeowners and individuals over the age of 65 than NEORSD jurisdiction counties and fall in the medium to high end of the median income range.

Table 1 Select demographic variables for the City of Parma, census tract areas containing study area streets Klusner and Parkhaven, and the counties containing communities in the NEORSD jurisdictional area: Cuyahoga, Lake, Lorain, and Summit.

	Population	Median Income	White (%)	Bachelors or Higher (%)	Over 65 (%)	Own Home (%)
Treatment Street Census Tracts and City						
City of Parma	80,015	$45,386	93	20	18	75
Klusner	--	$49,985	97	n/a	22	90
Parkhaven	--	$56,525	92	n/a	23	86
Counties in NEORSD Jurisdiction						
Cuyahoga	1,259,828	$46,231	64	30	16	61
Lake	230,038	$56,081	93	25	18	75
Lorain	301,216	$51,816	87	22	16	72
Summit	541,786	$49,669	80	30	16	68

Stormwater runoff on the study streets was routed through separated storm sewers into West Creek or its tributaries, without any pre-existing stormwater controls. Finally, the City of Parma partnered with Cleveland Metroparks to allow green infrastructure in city right-of-ways and passed an ordinance to allow residents to disconnect downspouts from storm sewers and route them to rain gardens and waiving the existing registration fee for doing so (Grieser 2015). Partnerships with municipalities are consistent with best practices in project implementation because they help remove regulatory barriers to program implementation (Bos & Brown 2015).

Residents of the two neighborhoods (n= 204; Klusner n=175; Parkhaven n=29) were solicited in 2012 and again in 2013 to participate in the project. Recruitment activities were launched with a public meeting held at a local high school. Additional recruitment activities continued including "street meetings" held in neighborhood homes and nearby public sites, formal recruitment letters from Cleveland Metroparks and the local city councilman, Lary Napoli, phone solicitations, and door-to-door home visits. Table 2 reveals the relative efficacy of these additional efforts based on the number of program participants each generated. In addition to the formal outreach activities, many participants were recruited through word-of-mouth or became interested in participating after seeing successful completion of the first phase. Finally, recruitment involved case-by-case negotiation between the program coordinators and residents including site visits or sharing images of existing green infrastructure projects in the region. Cleveland Metroparks also practiced a policy of sustained engagement through educational workshops and home visits to help residents with maintenance.

Table 2 Number of participants recruited per outreach activity including participants that did not eventually have green infrastructure installed (Grieser 2015)

Outreach Activity	Number of Participants Recruited (n=48)
Public Meeting	12
Street Meetings	12
Word of Mouth	11
Phase I Construction	9
Outreach Materials	4

Construction and planting of the first phase of green infrastructure occurred in May 2013 on Klusner Avenue, and a second phase was constructed in November 2013 and planted in March 2014 on Klusner Avenue and Parkhaven Drive. Construction of green infrastructure on Parkhaven Drive was delayed due to previously planned construction to convert homes from a septic to sanitary sewer system. Metroparks staff and volunteers maintained the green infrastructure for the duration of the project (ending in December 2014), with some continuing limited maintenance on an informal basis. The green infrastructure treatments utilized in the demonstration project included rain gardens, bioretention cells, and rain barrels. In total, 13% (n=22) residents on Klusner and 34% (n=10) of residents on Parkhaven participated in the demonstration project resulting in installation of 10 rain gardens, 23 bioretention cells, and 58 rain barrels on the two treatment streets (Figures 2 and 3). Many households chose to adopt multiple stormwater control measures and, although it was offered as a more 'traditional' option, no homeowners opted to have street trees installed in lieu of bioretention cells (Table 3).

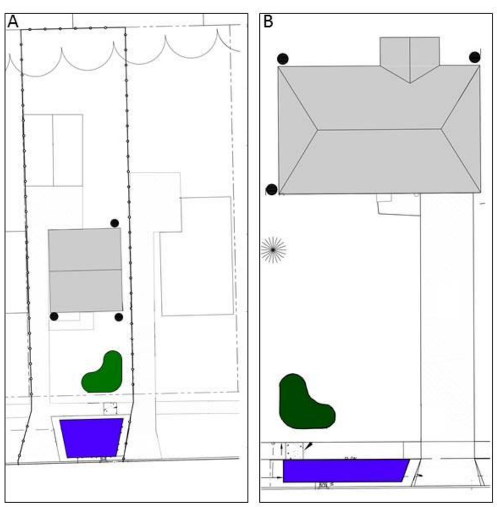

Figure 2 Schematics of green infrastructure, relative to houses (gray), driveways, sidewalks, and garages on Klusner Avenue (A) and Parkhaven Drive (B). The black circles indicate rain barrel locations, the green polygons are front-yard rain gardens, and blue polygons are right-of-way bioretention cells between the street, sidewalk, and driveway. Schematics are modified from designs by URS Corp.

Figure 3 Views of green infrastructure on Klusner Avenue and Parkhaven Drive. (A) A bioretention cell (foreground) and rain garden (background) on Klusner Avenue shortly after planting. (B) A bioretention cell on Klusner Avenue after one year's growth. (C) A view along the street of bioretention cells along Klusner Avenue, after 2 years' growth. (D) Bioretention cell (foreground) and rain garden (background) on Klusner Avenue after two years' growth. (E) A bioretention cell on Parkhaven Drive during a rain event in August 2014. Photos A and B courtesy of Sidney Bush.

Table 3 Number of households adopting different stormwater control measures (adapted from Grieser 2015)

Stormwater Control Measure	Number of Households
Rain barrel only	4
Rain barrel and front or backyard raingarden	4
Rain barrel and right-of-way bioretention	15
All three practices	7

The main goal of the demonstration project was to assess the potential for using green infrastructure to reduce stormwater runoff in residential neighborhoods. The study monitored both peak flow and total runoff through the storm sewers, as described in Jarden et al. (2015). On Klusner Avenue, peak flow was reduced by up to 33% and total stormflow was reduced up to 40%. On Parkhaven Drive, no statistically significant differences in peak or total stormflows were observed, possibly because of the confounding influence of road repairs.

DATA, METHODS AND ANALYSIS

This study examines the socio-cultural factors that influence participation in municipal green infrastructure projects through a mixed-method case study of the West Creek Ecosystem Restoration Project experimental stormwater management program in Parma, Ohio. A case study approach that incorporates multiple sources of evidence is most appropriate for this exploratory analysis because case studies are well suited for identifying potential causal mechanisms of phenomena, in this case the factors that influence participation in green infrastructure programs (Yin 2014). They are also appropriate for studies for which there are more variables of interest than any one data set can comprehensively address (Yin 2014). Additionally, this study was conducted in partnership with stakeholders: program coordinators from Cleveland Metroparks and the West Creek Conservancy, the organizations responsible for implementation. Primary data were collected through a pilot survey of residents in the neighborhoods targeted in the program. Additional primary data were collected through a group interview about field observations with program coordinators. These primary data were supplemented through secondary data sets including official documents, previous surveys of neighborhood residents, and environmental data in order to triangulate and contextualize findings from primary data collection. Triangulation involves analyzing multiple sources of data in order to provide convergent evidence of study findings and strengthen construct validity by providing multiple measures of the same phenomena (Yin 2014). In this study we triangulate evidence from surveys, a group interview, and document analysis.

This study capitalized on an existing green infrastructure project and partnership with practitioners managing the project; therefore, it was limited in geographic scope to the experiment site: two streets in one city, Parma, Ohio. The small study area and number of responses means that the study is not statistically representative of a larger population, but meant contribute toward data triangulation (Yin 2014). Cleveland Metroparks partners were instrumental in providing expert opinion through the group interview and providing access to program administration documents. Nevertheless, Metroparks was primarily interested in monitoring reductions in stormflow from the green infrastructure installations and the survey work done here was beyond the scope of the initial project.

Survey Design, Dissemination and Analysis

The survey was developed and piloted to gain a better understanding of homeowners' underlying environmental values, perceptions, and attitudes toward green infrastructure and stormwater management, and self-reported behaviors pertaining to yard maintenance. Values refer to moral principles or worldviews an individual holds about the environment (Dietz et al. 2005). Perceptions and attitudes are impressions about a particular subject based on observations. Attitudes are distinct from perceptions because they hold positive or negative judgments, positions, or stances on a particular subject (Dietz et al. 2005).

Behaviors are actions, in this case installing green infrastructure and yard maintenance activities. Statements pertaining to environmental attitudes, perceptions, and behaviors were derived from a subset of questions relating to household scale factors influencing residential landscape management conducted through the Central Arizona Project Long Term Ecological Research (CAP-LTER) project (Harlan et al. 2001). The survey was comprised primarily of closed-ended questions and was separated into two main sections. The first section asked seven questions pertaining to general demographics of the homeowner and the green infrastructure installed on their property and street to determine if the homeowner had a street side bioretention garden, rain garden, or rain barrels installed on their property. The survey included the following text defining green infrastructure:

> "Green infrastructure retrofits have been added to your street in the form of rain gardens, street side bioretention gardens, and rain barrels. Rain gardens are gardens that collect rainwater from downspouts and yard runoff. Street side bioretention gardens are located in the tree lawn and collect stormwater runoff directly from the street. Rain barrels are connected to downspouts and collect rain water from roofs."

The remaining 35 statements focused on attitudes, perceptions, behaviors, and environmental values and used a 5-point Likert scale to assess their level of agreement or disagreement. The 35 statements were randomly ordered in the final survey and the Likert scale was presented categorically as strongly agree, agree, neutral, disagree, strongly disagree. The Likert scale was coded as 1-5, where strongly agree = 1 and strongly disagree = 5.

The survey contained 7 perception, 9 attitude, 7 behavior, and 11 value statements. Statements aimed at environmental values used 11 of the 15 New Ecological Paradigm (NEP) scale items. The NEP is a widely used measure of endorsement of environmental world view and focuses on the interactions between humans and nature, their right to rule over and change nature, and the limits to growth for human societies (Dunlap et al. 2000). The 11 responses selected for this survey focused on environmental values most relevant to the regional scale of stormwater management, leaving out four questions that focused on environmental values relevant to global-scale issues in order to streamline the survey and avoid respondent fatigue. In addition, one question asked residents the amount they were willing to pay for green infrastructure on their property with six dollar amount choices ranging from \$0 - \$2000+ (Coded 1 – 6; 1 = \$0, 6 = \$2000+). Finally, the survey concluded with an open-ended section to give respondents an opportunity for unstructured comments regarding the survey and the green infrastructure implemented on the street.

A pre-tested survey was sent out to all 201 residences in the study area in November 2014. The survey was sent via U.S. mail and included a self-addressed, stamped envelope to return it once completed. One week before mailing and one week before the deadline for responses in January 2015, postcards were sent to all residences to alert them of the survey's arrival and deadline.

Survey responses were analyzed using JMP version 11 software (SAS Institute, Cary, NC). All analysis combined responses from the two streets and focused on comparison between respondents with and without green infrastructure. First, descriptive statistics for responses to all questions were calculated for all respondents, respondents with green infrastructure, and respondents without green infrastructure. Next, non-parametric Wilcoxon rank sum tests were used to test significance between responses and participation in the green infrastructure. The Wilcoxon rank sum test is robust to unequal sample sizes (Zar 1999). A non-parametric test is the most appropriate analysis for testing ordinal responses from the Likert scale because ordinal responses only describe the rank or order of responses, not the exact distance between two ordinal values, which may hold different meaning for different respondents. P-values were calculated based on a normal approximation of the test statistic, and a value of $p < 0.05$ was selected as the threshold for significance. Demographic results indicating the percentage of total respondents include the totals for all respondents, unless otherwise noted.

Group Interview and Secondary Data Sources

Responses to this pilot survey were supplemented by a semi-structured group interview and secondary data sources (Table 4). The group interview was conducted with two program administrators that led recruitment and implementation efforts and had spent considerable time interacting with residents before, during, and after project implementation. Expert interviews are favorable when seeking insider knowledge and group interview techniques are ideal for generating a large amount of information rapidly (Bernard and Ryan 2009). The group interview deployed here allowed us to rapidly generate a large amount of information from those with the greatest amount of knowledge about the program in order to triangulate survey responses. Interview questions were designed to elicit program administrators' field observations about the residents' motivations for participating or not based one-on-one interactions, community meetings, and educational events. The secondary data sources used were Metroparks reports and previously collected survey data from community meetings in the study area and a survey of residents living near Metroparks locations in the City of Parma, including residents in the study area. Community meeting surveys were distributed to participants at the end of meetings to collect opinions about the green infrastructure installation project and degree of learning from event activities (n=31). The Citywide survey conducted by Metroparks and Clemson University assessed general environmental knowledge and awareness, including but not limited to, green infrastructure (n=382, Robinson 2008).

The group interview and secondary data sources were coded for the following constructs: (1) respondent demographics, yard structure, and self-reported behaviors, (2) environmental knowledge and awareness, (3) environmental values, (4) perceptions and attitudes about stormwater management and green infrastructure, and (5) opinions relating to green infrastructure cost and respondent willingness to pay. The results of both the primary and secondary data analysis, as well as combined interpretation of the findings, are presented in the sections that follow.

Table 4 Primary and Secondary Data Sources

Data	Source	Year	Study Area
Survey	Primary	2014	Project Treatment Streets
Group Interview	Primary	2015	Project Treatment Streets
Survey	Cleveland Metroparks/ Clemson University	2008	City of Parma
Reports	Cleveland Metroparks	2015	Project Treatment Streets
Community Meeting Surveys	Cleveland Metroparks	2011	Project Treatment Streets

RESULTS FROM SURVEY, GROUP INTERVIEW AND SECONDARY SOURCES

Study findings reveal that residents in the study area generally (1) follow conventional landscaping practices, (2) have low environmental knowledge and awareness, (3) demonstrate pro-environmental value orientations, (4) vary in environmental attitudes and perceptions toward stormwater management and green infrastructure, sometimes based on participation in the program, and (5) are not willing to pay for the cost of green infrastructure installation.

Respondent Demographics, Yard Structure and Self-Reported Behaviors

The survey response rate for both sets of streets was 18%, yielding 36 surveys. The response rate was likely affected by study fatigue; residents in this neighborhood have experienced several studies relating to green infrastructure involving different combinations of survey, installation, and monitoring work (Robinson et al. 2008; Sutton & Stephens Fleisher 2013; Grieser 2015). Table 5 summarizes the demographic composition of the respondents. Most respondents were 50 and older (72%, n=26), female (64%, n=23), white (97%, n=35), and had at least some post-secondary education (75%, n=27). Most respondents owned their homes (94%, n=34) and had long tenures in the neighborhood, having resided in their homes for more than 10 years (80%, n=29) years. According to the 2010 US Census, the median household income for the track containing Klusner is $49,985 (census tract 1,775.04, n=4045) and for Parkhaven it is $56,525 (census tract 1,775.03, n=3617; US Census 2015).

Table 5 Demographic Composition of Respondents on Klusner and Parkhaven. Descriptive statistics for 2010 census tract areas including Klusner and Parkhaven. (Klusner Census Tract 1,775.04, n = 4,045; Parkhaven Census Tract 1,775.03, n = 3,617)

Variable	Total		Klusner		Klusner (Census)		Parkhaven		Parkhaven (Census)	
	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)
Age										
Under 30	2.80%	1	4.20%	1	4.80%	195	0%	0	4.50%	164
30 - 39	11.10%	4	4.20%	1	12.10%	490	25%	3	8.40%	305
40 - 49	13.90%	5	8.30%	2	19.40%	784	25%	3	18.90%	682
50 - 59	27.80%	10	33.30%	8	21.10%	853	16.70%	2	22.50%	814
60 and older	44.40%	16	50.00%	12	21.60%	875	33.30%	4	23.10%	835
Gender										
Male	36.10%		29.20%	7	47.50%	1922	50%	6	48.10%	1739
Female	63.90%		70.80%	17	52.50%	2123	50%	6	51.90%	1878
Ethnicity										
White	97%	35	96%	23	97.30%	3934	100%	12	92.30%	3339
Hispanic or Latino	3%	1	4%	1	1.90%	77	0%	0	2.70%	96
Black or African American	0%	0	0%	0	0.40%	18	0%	0	2.80%	103
Native American or American Indian	0%	0	0%	0	0.10%	4	0%	0	0.00%	0
Asian/Pacific Islander	0%	0	0%	0	1.00%	42	0%	0	2.30%	83
Other	0%	0	0%	0	0.20%	10	0%	0	1.10%	41
Level of Education										
High School or less	25.00%	9	33.30%	8	-	-	8.30%	1	-	-
Some postsecondary	41.70%	15	45.80%	11	-	-	33.30%	4	-	-
Bachelors	19.40%	7	12.50%	3	-	-	33.30%	4	-	-
Beyond Bachelors	13.90%	5	8.30%	2	-	-	25%	3	-	-
Year in Home										
0 -10	19.40%	7	12.50%	3	-	-	33.30%	4	-	-
11-15	16.70%	6	16.70%	4	-	-	16.70%	2	-	-
16 - 20	11.10%	4	12.50%	3	-	-	8.30%	1	-	-

21 - 25	8.30%	3	8.30%	2	-	-	8.30%	1	-	-
26 - 30	8.30%	3	8.30%	2	-	-	8.30%	1	-	-
31 +	36.10%	13	41.70%	10	-	-	25%	3	-	-
Home Ownership										
Rent	5.60%	2	8.30%	2	10.20%	173	0%	0	13.80%	202
Own	94.40%	34	91.70%	22	89.80%	1517	100%	12	86.20%	1260
GI on Property										
Yes	30.60%	11	20.80%	5	-	-	50.00%	6	-	-
No	69.40%	25	79.20%	19	-	-	50.00%	6	-	-

Eleven respondents (36%) indicated that they had some sort of green infrastructure installed in their property through this project. Of those, ten have street side bioretention gardens, seven have front or back yard rain gardens, and ten have at least one rain barrel attached to their downspouts. All but one of the respondents with green infrastructure had multiple types installed on their property. This is congruent with the overall study findings that 70% of participants elected to have more than one type of green infrastructure installed through the program (Grieser 2015).

Respondents' self reported environmental management behaviors were consistent with conventional yard management practices. The majority of respondents either mowed their own lawn (86%, n=31) or had someone else mow it (14%, n=5), applied fertilizer (75%, n=27), and watered (50%, n=18). None of these management practices were significantly different between green infrastructure and non-green infrastructure owners (Table 6), suggesting that conventional management practices persisted despite the installation of green infrastructure alternatives. The program administrators did engage green infrastructure owners in home visits to educate them about maintaining it, but these 'green' practices appear not to extend beyond the infrastructure itself. Despite the fact that virtually all residents (92%, n=33) engage in landscaping activities other than the aforementioned mowing, fertilizing, and watering, most disagreed that they would have additional landscaping (green infrastructure or otherwise), even if it required no additional work (52%, n=19). There were no significant differences in response to self-reported environmental behaviors across respondents with and without green infrastructure.

Table 6 Nonparametric comparisons for self reported behaviors for responses between respondents with and without green infrastructure on their properties. Likert scale responses were coded as strongly agree = 1 to strongly disagree = 5. Median values are reported within parentheses. Values with (*) indicate significant differences ($p < 0.05$) between pairings.

	GI	NoGI	
Behaviors	Mean (Median)		p-Value
B-1. I mow my own lawn.	1.55 (1)	1.84 (1)	0.49
B-2. I pay someone to mow my lawn.	4.55 (5)	3.92 (4)	0.16
B-3. Beyond mowing my lawn, I engage in other landscaping activities.	1.73 (2)	2.04 (2)	0.38
B-4. I would have landscaping on my property, if it did not require any additional work from me.	3.1 (3.5)	3.43 (4)	0.47
B-5. I apply fertilizer to my yard.	2.73 (2)	2.44 (2)	0.39
B-6. I water my yard.	3.45 (4)	2.88 (2)	0.22
B-7. It is important to have my own space where I can enjoy the outdoors on my property.	1.82 (2)	1.75 (2)	0.38

Environmental Values

Only the survey conducted in this study measured core environmental values. Residents in the study area generally expressed pro-environment value orientations according to responses to 9 out of the 11 NEP statements, regardless of whether or not they had green infrastructure on their property (Table 7). The responses in this survey hold true previous findings where questions on the survey relating to the balance of nature (NEP-2 and NEP-9) had pro-environmental mean responses and the response pertaining to growth (NEP-5) had a negative-environmental mean response (Dunlap et al. 2000). Respondents with green infrastructure were significantly more likely to agree with the statement, “If things continue on their present course, we will soon experience a major ecological catastrophe,” and disagree with the statement, "so called 'ecological crisis' facing humankind has been greatly exaggerated." Respondents with green infrastructure disagreed with that statement, while respondents without green infrastructure were more neutral. The previously administered survey indirectly addressed environmental values as they relate to local context asking residents’ what they enjoy about living near a Metroparks location. Responses mostly related to aesthetics (“nice views”) and enjoyment of nature (“relaxing,” “solitude”), as opposed to amenities, suggesting that residents of Parma may intrinsically value nature; however, more direct testing of this hypothesis is necessary.

Table 7 Nonparametric comparisons for values as measured by NEP statements for responses between respondents with and without green infrastructure on their properties. Likert scale responses were coded as strongly agree = 1 to strongly disagree = 5. Median values are reported within parentheses. Values with (*) indicate significant differences (p < 0.05) between pairings. Pro-environment responses bolded.

	GI	NoGI	
	Mean (Median)		p-Value
NEP-1. Humans have the right to modify the natural environment to suit their needs.	2.60 (2)	2.65 (3)	0.87
NEP-2. When humans interfere with nature it often produces disastrous consequences.	**2.55 (2)**	**2.63 (2)**	0.91
NEP-3. Human ingenuity will insure that we do not make the Earth unlivable.	2.36 (2)	2.61 (3)	0.58
NEP-4. Humans are seriously abusing the environment.	**1.91 (2)**	**2.83** (3)	0.10
NEP-5. The Earth has plenty of natural resources if we just learn how to develop them.	2.00 (2)	2.17 (2)	0.42
NEP-6. Plants and animals have as much right as humans to exist.	**1.73 (2)**	**1.83 (2)**	0.84
NEP-7. Despite our special abilities, humans are still subject to the laws of nature.	**2.00 (2)**	**2.00 (2)**	0.70
NEP-8. The so-called “ecological crisis” facing humankind has been greatly exaggerated.	**4.10 (4)**	**3.30 (3)**	0.022*
NEP-9. The balance of nature is very delicate and easily upset.	**2.10 (2)**	**2.67 (2.5)**	0.23
NEP-10. Humans will eventually learn enough about how nature works to be able to control it.	**3.09** (3)	**3.46 (4)**	0.28
NEP-11. If things continue on their present course, we will soon experience a major ecological catastrophe.	**2.10 (2)**	3.17 (3)	0.0082*

Perceptions and Attitudes About Stormwater Management and Green Infrastructure

Responses to statements about stormwater management issues revealed that residents were more likely to perceive that stormwater was creating a local flooding problem in their neighborhood (36%, n=13) than perceiving stormwater as a general environmental challenge (25%, n=9); however, the majority of responses were neutral to both statements, suggesting that residents do not perceive stormwater issues as a major issue. This sentiment was also found in the previously conducted survey of Parma residents, which found that among those that were generally concerned about the environment, stormwater management was a lesser concern. The majority of respondents to our survey disagreed (53%, n=19) or responded neutrally (31%, n=11) to the statement, “As an individual, there is little I can do to solve stormwater runoff problems.” Despite the perception that they as individuals *could* take action to address stormwater runoff issues, most respondents felt that it was the responsibility of the city (75%, n=27) while few felt it was the responsibility of the individual (19%, n=7). Responses to the open ended questions reinforce this sentiment, as one respondent stated, "This is a problem of [sic] the city to solve about the rain water, not mine.”

In response to statements about green infrastructure, most respondents had negative or neutral perceptions with regard to the effectiveness at reducing runoff (75%, n=27), the amount of maintenance required for upkeep (72%, n=26), and the benefits of green infrastructure relative to the amount of maintenance (78%, n=28). Some respondents perceived that the green infrastructure on their street created problems (22%, n=8). Many would not add green infrastructure to their property (42%, n=15). Responses to the open-ended question at the end of the survey indicate some of the reasons for the negative attitudes and perceptions. For example, one respondent commented, “All these green infrastructures do is collect litter/garbage … taking away from any sort of ‘visual’ benefit.” Others expressed distaste for the more naturalistic appearance of green infrastructure compared to traditional landscaping: “The tree lawns look like a jungle! I don’t like the wilderness it portrays."

The previously conducted survey of Parma residents found that residents held negative perceptions of green infrastructure prior to the project installations including attracting mosquitoes, causing standing water and basement flooding, and, with regard to rain barrels, misgivings about visibility from the street, and issues relating to maintenance. The program administrators remembered similar anxieties about green infrastructure expressed during street meetings in the study area. Some felt that green infrastructure would be ugly and “look like weeds” or worried about having “no lawn.” There was also general confusion about where to put garbage cans or pile snow (when installations were on the ‘tree lawn,’ or, right of way between the street and the sidewalk), the possibility of falling, and attracting deer that would eat the plantings.

Of the four constructs directly addressed in the survey for this study—values, perceptions, attitudes, and behaviors—the most pronounced and significant differences between respondents with and without green infrastructure were in response to perception and attitude statements (Table 8). Respondents with green infrastructure were more likely to agree that stormwater runoff created flooding problems for residents and disagree with the statement that as individuals there was little they could do to help reduce stormwater runoff. Those with green infrastructure were more likely to agree that it helped reduce stormwater runoff and more likely to disagree that it causes problems in the neighborhood than their counterparts without green infrastructure. With regard to maintenance, respondents with green infrastructure were more likely to disagree with statements that it requires too much maintenance and that it does not provide enough value to justify upkeep. Finally, respondents with green infrastructure were more likely to agree that if given the opportunity, they would add green infrastructure to their property even though they already had some.

Table 8 Nonparametric comparisons for perceptions and attitudes for responses between respondents with and without green infrastructure on their properties. Likert scale responses were coded as strongly agree = 1 to strongly disagree = 5. Median values are reported within parentheses. Values with (*) indicate significant differences (p < 0.05) between pairings.

	GI	NoGI	
	Mean (Median)		p-Value
Perceptions			
P-1. There is room for improvement of the general maintenance on my street.	1.73 (2)	2.52 (2)	0.030*
P-2. The addition of green infrastructure on my street has helped reduce stormwater runoff.	2.09 (2)	3.28 (3)	<0.001*
P-3. As an individual there is little I can do to solve stormwater runoff problems.	4.00 (4)	3.17 (3)	0.011*
P-4. Stormwater runoff on my street leads to flooding problems for residents.	2.00 (2)	3.13 (3)	0.0054*
P-5. Stormwater runoff on my street creates problems for the environment.	2.73 (3)	3.08 (3)	0.21
P-6. The cost of green infrastructure is too expensive.	3.18 (3)	2.83 (3)	0.38
P-7. Green infrastructure on the street has created problems for the neighborhood.	3.91 (4)	2.8 (3)	0.0011*
Attitudes			
A-1. Overall, I enjoy where I live.	1.73 (2)	1.92 (2)	0.51
A-2. The green infrastructure gardens constructed on my street require too much maintenance.	3.73 (4)	2.52 (3)	<0.001*
A-3. The addition of green infrastructure on the street has added value to my home.	2.82 (3)	3.71 (4)	0.037*
A-4. I would be willing to pay for the installation of green infrastructure on my property to help with stormwater management.	3.00 (3)	4.20 (5)	0.0065*
A-5. I would be willing to pay for a portion of the installation of green infrastructure on my property.	3.09 (3)	4.16 (5)	0.026*
A-6. Stormwater management is the responsibility of the city.	2.36 (2)	2.08 (2)	0.46
A-7. Stormwater management is the responsibility of the individual.	3.18 (3)	3.25 (3)	0.84
A-8. Given the opportunity, I would add green infrastructure to my property.	2.22 (2)	3.76 (4)	0.0034*
A-9. The green infrastructure on my street does not provide enough value to my neighborhood to justify the upkeep.	3.55 (3)	2.32 (2)	0.0042*

Environmental Knowledge and Awareness

Residents in the study area demonstrated low levels of general environmental knowledge, a finding that is also apparent in the secondary data sources as well. While the survey was not designed to gage environmental knowledge, response to the statement, "Stormwater runoff on my street creates problems for the environment," suggests a lack of awareness about the broader, regional environmental issues related to stormwater runoff. The majority (72%, n=26) of respondents were neutral, disagreed, or strongly disagreed with the statement. While residents with green infrastructure were more likely than residents without it to agree with the statement, the difference was not statistically significant (Table 8). The program administrators also recalled a pervasive lack of awareness about environmental issues during their door-to-door visits. Despite having voted in 2002 to fund nature education and protection of water quality and wildlife on adjacent land that would become part of Cleveland Metroparks and news visibility about regional stormwater issues, many residents were unaware of either. Residents were also unable to name their watershed in exit surveys collected at educational events that were part of the secondary data sources provided to us by the program administrators. This finding is similar to a previously administered survey's results that found that while residents of Parma were generally supportive of the mission of Cleveland Metroparks, they either lacked awareness of or interest in Metroparks issues, could not identify invasive plant species, and did not seek out native plants when gardening (Robinson et al. 2008).

Green Infrastructure Cost and Willingness to Pay

Several perceptions and attitudes statements addressed the issues of cost and willingness-to-pay for green infrastructure (Table 8). Most responses were neutral (61%, n=22) to the statement that green infrastructure is too expensive, indicating that residents were either unsure about the cost of green infrastructure or, perhaps, were aware that it was made available for free in the neighborhood. The former explanation is given further credence by information gathered during the group interview with the program directors conducted by this team. The program directors indicated that most residents were unaware of the cost to install green infrastructure, especially the non-monetary costs associated with gathering permits and coordinating with contractors. Respondents largely were neutral or disagreed (71%, n=27) with the statement, “The green infrastructure on the street has added value to my home.” Interestingly, during project implementation, three individuals considered dropping out of the program after making the decision to sell their homes. They were convinced to remain in the program after a real estate agent communicated that green infrastructure would increase property value. The majority of respondents disagreed with statements regarding willingness to pay for all (64%, n=23) or some (58%, n=21) of green infrastructure; however, respondents with green infrastructure had significantly less negative responses to paying in total or in part for installation. When prompted to estimate how much they would be willing to pay for green infrastructure, most would pay less than \$500. This finding is similar to that of the previously conducted study of Parma residents, in which most respondents said they would be willing to pay less than \$500 for rain gardens and some would pay no more than \$200. This lack of willingness to pay for green infrastructure could be due to the low median income in the study area (Parkhaven \$56,525, Klusner \$49,985) and Parma as a whole (\$45,386). The two neighborhoods have similar median incomes to the four counties containing cities under the NEORSD jurisdiction (Table 1), so any future program implementing green infrastructure in the state may confront similar cost related issues.

THE ROLE OF RESIDENT'S PERSPECTIVES IN GREEN INFRASTRUCTURE PROGRAM PARTICIPATION

Low Environmental Knowledge and Pro Environmental Values

Environmental knowledge was generally low according to group interview data from the program administrators and secondary data sources. Additionally, program administrators expressed the opinion in the group interview that an educational approach to outreach activities appeared to have limited utility in recruiting participants. This finding is consistent with findings from numerous studies and experiences of environmental managers that environmental education does not necessarily lead to pro-environmental behavior (Heimlich & Ardoin 2008). While the program administrators were able to point to examples of individuals that demonstrated 'learning' through participation in the program, it is not clear that educational activities motivated participation.

The respondents to this survey generally had similar, slightly pro-environmental values, regardless of whether or not they had green infrastructure on their property; however, respondents with green infrastructure more strongly agreed that an environmental catastrophe was possible and more strongly disagreed that the so-called "ecological crisis" facing human kind has been greatly exaggerated than their counterparts without green infrastructure. All of the respondents were generally pro-environment, which would suggest a pro-environment framing would help recruit participants; however, the fact that non-participants held pro-environment values suggests that other factors (e.g., attitudes, perceptions), also influenced the decision to adopt green infrastructure among respondents. This finding is consistent with a previous studies finding that pro-environmental values are sometimes linked to resource intensive landscaping behaviors like fertilization (Robbins & Sharp 2003). It is also consistent with a study on landscaping behavior that found that pro-environmental values are less closely linked to behaviors than attitudes in many instances (Larson et al. 2009). Our study adds to the finding that pro-environmental values are a poor determinant of whether or not an individual *opt out* of conventional, resource-intensive landscaping behaviors (e.g., stop fertilization and/or irrigation), but also a poor determinant of the decision to *opt in* to new, low-impact landscaping activities (e.g., install and maintain green infrastructure). More research is needed to explicitly test this proposition.

Role of Environmental Attitudes and Perceptions

Given that respondents generally expressed pro-environmental values, but also had low environmental knowledge, it is likely that behavior outcomes in this study—in this case, adoption of green infrastructure—were tied to subjective perceptions and attitudes. Participants in the program were significantly more likely to agree that stormwater runoff created flooding problems, agreed that green infrastructure was helping to reduce stormwater runoff on their street, and felt that as an individual they were able to help solve stormwater runoff problems. However, most respondents agreed that stormwater management was the responsibility of this city and not individuals and were unsure if stormwater runoff was creating problems for the environment. This finding is in line with other studies on green infrastructure and yard landscaping that find that individuals disassociate local environmental problems and their individual behaviors from collective environmental challenges facing their neighborhood, region, or the planet (e.g., regional water quality/quantity, climate change) (Robbins & Sharp 2003; Larson et al. 2009; Barnhill & Smardon 2012; Keeley et al. 2013; Baptiste 2014; Baptiste et al. 2015). Furthermore, respondents *perceived* that they could have a positive influence on stormwater runoff but held the *attitude* that the city should be responsible for stormwater management. This finding potentially suggests a mismatch between an initial perception of individual efficacy and attitudes about jurisdiction over stormwater management. Indeed, water management in cities is often framed as technocratic or engineering issue as opposed to a collective actions problem (White 2013). Framing stormwater management as a regional challenge may implicitly diagnose water management as an infrastructure problem, which limits the prognosis to municipal and/or engineered response. More research is necessary to examine differences between attitudes and perceptions, especially with respect to problem framing.

Respondents with and without green infrastructure engaged in residential management behaviors such as fertilization that have a negative impact on regional water quality. One potential implication of this finding is that an intervention to achieve one environmental objective (e.g., reduce stormwater runoff) did not appear to influence on behaviors relevant to other environmental challenges (e.g., reduce excess nutrients entering water bodies). This finding also underscores the persistence of conventional yard maintenance practices, which are influenced by a complex set of neighborhood-scale factors. Influences include neighborhood norms (e.g., 'keeping up with the Jones') and formal rules and regulations as well as broader notions of the lawn as a ubiquitous fixture in the American Dream (Robbins & Sharp 2003; Cook et al. 2012).

This study did not directly address change in perception about green infrastructure as a result of the program. Data from the group interview reveals that, while most residents were pre-disposed to be in favor of or against green infrastructure, a few individuals did experience a change. Results of the survey show that respondents with green infrastructure would be willing to add green infrastructure to their property, which they have already done, and that those without green infrastructure are not willing to add green infrastructure to their property. Respondents with green infrastructure also agreed that its value justified the upkeep, whereas those without green infrastructure disagreed. This suggests a lack of change in attitudes: after actually seeing the green infrastructure on their street and how it functions, respondents without green infrastructure were not more likely to want to have green infrastructure on their property or to see any value in maintaining green infrastructure. The group interview with the program managers revealed that while most individuals were predisposed to be pro or anti-green infrastructure, some individuals came to have more positive perceptions and attitudes through self discovery (e.g., visiting local examples of green infrastructure or seeing successful completion of the first phase of installations) or by way of suggestion from a trusted member of their social network (e.g., word-of-mouth in the neighborhood or real estate agent). The program administrators observations about the effect of social networks on program implementation is supported by previous studies that found evidence of "spatial contagion," or clustered adoption of landscaping features among neighbors (Hunter & Brown 2012; Newburn et al. 2013). Indeed, clustering of green infrastructure on adjacent lots can be observed in the study area. One proposition that emerges from these findings is that formal educational events may be less successful than processes of self discovery or spatial contagion because they attracted individuals that had already ‘bought in’ to the idea of green infrastructure.

Other Factors Influencing Participation

Although this program offered green infrastructure for free to residents, future policies intended to promote green infrastructure may have limited utility in neighborhoods similar to this study area. When asked if the cost of green infrastructure was too expensive, most respondents were unsure. Most indicated, however, that they would not be willing to pay more than $500 to implement green infrastructure on their property. This finding is in line with previous studies that found cost is an important factor in green infrastructure adoption (Green et al. 2012). Furthermore, residents felt that the proposed stormwater fee was too low to be a major concern, which calls into question the efficacy of this particular program design to promote voluntary action by residential actors.

Finally, due to the relative homogeneity across respondents living in the same neighborhoods, we were unable to assess the influence of demographics on the decision to install green infrastructure in this study. Although these neighborhoods are generally representative of the Cleveland metropolitan region at the county scale, there is considerable heterogeneity between cities and neighborhoods. Further investigation is necessary to explore the critical issue of social differentiation.

CONCLUSION

This study examined the socio-cultural factors that influenced resident participation in a municipal green infrastructure demonstration project where cost and other structural barriers (e.g., regulatory) were removed. While cognitive perspectives have gained traction in explaining the pervasiveness of turf grass lawns, they merit further exploration in regard to ecologically 'friendly' and pro-environmental residential landscape management practices such as the decision to install green infrastructure landscaping alternatives. This approach begins to explore the extent to which the socio-cognitive factors motivate residents to opt out of conventional landscaping practices like fertilization and irrigation versus opting in to adopting green infrastructure.

The findings from this case study on green infrastructure confirm many of the propositions from previous studies on the socio-cognitive factors that motivate residential landscaping. Similar to previous studies on the socio-cognitive dimensions of residential landscaping (e.g., Larson et al. 2009), this study revealed that attitudes were more strongly related to behaviors than environmental values, cognitive dissonance exists between perceptions (e.g., self efficacy) and attitudes (e.g., responsibility), and awareness of local environmental challenges (e.g., stormwater flooding) is disconnected from environmental challenges at broader scales (e.g., regional water quality degradation).

This study also points to evidence of "spatial contagion" in patterns of green infrastructure adoption (Hunter& Brown 2012; Newburn et al. 2013). Additionally, spillover between pro-environmental landscaping practices was not evident due to the fact that residents that adopted green infrastructure continued to use conventional landscaping practices (e.g., fertilization).

Low participation rate in this and other (e.g., Green et al. 2012) green infrastructure programs indicate existing incentives such as low cost or free installation may be insufficient to achieve adoption rates in residential areas commensurate with municipal stormwater management goals. Recruiting and retaining participants in such programs may benefit from an increased understanding of the subjective perceptions and attitudes that individual's use to make decisions to participate or not.

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