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Intention to Install Green Infrastructure Features in Private Residential Outdoor Space

Camilo Ordóñez Barona[1], Tenley M. Conway[1] and Lara A. Roman[2]*

[1] Department of Geography, Geomatics and Environment, University of Toronto at Mississauga, Mississauga, ON, Canada, [2] USDA Forest Service, Northern Research Station, Philadelphia Field Station, Philadelphia, PA, United States

Green infrastructure (GI) features in private residential outdoor space play a key role in expanding GI networks in cities and provide multiple co-benefits to people. However, little is known about residents' intended behavior concerning GI in private spaces. Resident homeowners in Toronto (Ontario, Canada) voluntarily participated in an anonymous postal survey ($n = 533$) containing questions related to likelihood to install additional GI features in their private outdoor space; experiences with this space, such as types of uses; and environmental concerns and knowledge. We describe the association between these factors and people's intention to install GI in private residential outdoor space. Factors such as environmental concerns and knowledge did not influence likelihood to install GI. However, experiences with private residential outdoor space, such as nature uses of this space, level of self-maintenance of this space, and previously installed GI features, were significant influences on the likelihood to install GI. These findings have important implications for managing GI initiatives and the adoption of GI in private residential spaces, such as orienting communication materials around uses of and experiences with outdoor space, having programs that generate direct experiences with GI features, and considering environmental equity in such programs.

Keywords: stormwater infrastructure, urban nature, private land, residential landscapes, public engagement, structural modelling

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****Correspondence:***
Tenley M. Conway
tenley.conway@utoronto.ca

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INTRODUCTION

Green infrastructure (GI) are physical infrastructure systems that integrate natural elements to solve environmental problems (Derkzen et al., 2017). Some examples include rain gardens to control stormwater flows and urban trees to reduce urban heat (Drescher and Sinasac, 2021), which also provide multiple co-benefits for people (Hartig et al., 2014; Bratman et al., 2019). As such, GI is an integral part of sustainable cities, with many world cities planning to increase the presence of such systems to address climate resilience, urban liveability, and human health and wellbeing goals (Derkzen et al., 2017; Matsler et al., 2021).

An important aspect of the implementation of the GI objectives for sustainable cities is stimulating people to install GI in their private residential outdoor space. We define private residential outdoor spaces as the space around a person's home on their own property, including back and front yards, porches, driveways, decks, and patios (Clayton, 2007; Blaine et al., 2012; Freeman et al., 2012; Conway, 2016; Corley et al., 2021). Residential installation of GI is key to creating more abundant and evenly distributed GI networks (Conway et al., 2020). Many cities want to increase GI in private residential outdoor space and encourage residents to install and maintain GI on their property (GIO, 2021).

However, most research on people's relationship with GI focuses on people's positive attitude towards GI in public spaces, such as roadside bioswales or street trees (Greene et al., 2011; Baptiste et al., 2015; Derkzen et al., 2017; Everett et al., 2018; Venkataramanan et al., 2020). Less attention has been paid to people's intended behavior concerning the installation of GI features in private residential outdoor space (Mason et al., 2019; Drescher and Sinasac, 2021; Meerow et al., 2021). There is a need for further examination of this topic to help us identify potential psychological and social barriers and opportunities to promote widespread adoption of GI in private spaces.

In this study, we have (1) assessed resident homeowners' likelihood to install additional GI features on their private residential outdoor space; (2) assessed cognitive factors, such as residents' level of concern about local environmental issues, and residents' level of knowledge of gardening and GI; (3) assessed experiences with private residential outdoor space, such as the types of uses of outdoor space, self-maintenance of outdoor space, and previously installed GI features; and (4) examined how these factors were associated with residents' likelihood to install additional GI features on their private residential outdoor space. We chose Toronto (Ontario, Canada) as a case study because the city has government-led initiatives to increase GI in private residential outdoor spaces, as well as active NGO- and community-led GI initiatives focused on resident education and engagement. We provide a conceptual framework to clarify the theoretical framing of this research.

Our study contributes to the existing literature on people's relationship with GI in several ways. First, we focus on people's behavior related to GI in the context of private space. This contrasts with most of the literature's focus on people's perception of GI in the context of public space. Second, we focus on the likelihood of homeowners to install GI in private residential outdoor spaces. These are spaces that people experience daily and from which they derive significant benefits. Also, homeowners are the people who are likely to manage these spaces and therefore be more likely to manifest their intended behaviors, in contrast to other studies that focus on public spaces and the views of general populations who may have less direct control over how these spaces are managed. Third, we examine the extent to which key cognitive preconditions that have shown to influence intended behavior in relation to GI interact with other cognitive and experiential preconditions that have not yet been examined, rather than just focusing on socio-demographic associations. This includes examining how lived experiences with private residential outdoor space is associated with people's intended behavior in relation to GI, while accounting for socio-demographic influences.

TABLE 1 | Green infrastructure features used in our study.

GI features
Tree(s) in garden/yard
Street tree(s) in the boulevard in front of house
Shrub(s) or bush(es) in garden/yard or boulevard in front of house
Plants in pots
Food-producing garden
Pollinator garden
Rain garden
Downspout planter
Rain barrel
Permeable pavement
Bioswale
Green roof
Green wall

CONCEPTUAL FRAMEWORK

Due to the multi-disciplinary origins of the term, GI can encompass a broad range of natural elements and landscapes (Sussams et al., 2015; Matsler et al., 2021). For example, in European cities, GI may be defined in systemic ways, as anything green or living that is part of the urban ecosystem, whereas in other contexts, such as North America and Oceania, it may be defined in fragmentary ways, as any green or living features that can be installed or implemented in various spaces or landscapes (Escobedo et al., 2019; Conway et al., 2021; Meerow et al., 2021). Using this second lens, we can see that green spaces and landscapes, such as gardens and yards, are not the only definition of GI or the only places for installing GI. Due to the flexible nature of GI features, these can be installed in many outdoor spaces. For example, installing a green wall or a green roof does not require any garden or yard space. In Canada, GI is often defined using this lens, specifically, as features that integrate green or living features to provide environmental, ecological, social, psychological, and economic benefits (City of Toronto, 2013; Conway et al., 2020). GI features in private residential outdoor space may include living features such as trees, rain gardens, food producing gardens, and green roofs, but it may also include non-living features that can support living ones, such as rain barrels and permeable pavement (Larson et al., 2016). Numerous local government programs exist in Canadian and other cities to support the installation of these GI features in residential landscapes, requiring the interest and cooperation of numerous households to achieve the intended sustainability benefits (Conway et al., 2021; Meerow et al., 2021). The GI features that we have used in our study are listed in **Table 1**.

Given that GI is mostly used to address environmental problems while providing co-benefits, intention to install GI features in private residential outdoor space can be conceptualized as pro-environmental behavior (PEB). PEBs are defined as actions that consciously or in a planned manner seek to minimize a person's negative impact on the environment (Kollmuss and Agyeman, 2002) such as recycling or tree planting (Evans et al., 2013; Whitburn et al., 2019). PEB models are complex and may include various sociodemographic, cognitive, affective, and behavioral factors (Kollmuss and Agyeman, 2002).

For instance, a study of residents' motivations to install GI for stormwater management in Hamilton, Canada, showed that personal capacities, including income and time, were important influences for GI adoption (Drescher and Sinasac, 2021). Similar findings were shown by a study in Phoenix, US, where people's implementation of GI in private residential space was influenced by their income and home ownership (Meerow et al., 2021). In another study in the Veneto region of Italy, age and education level influenced people's intention to install GI for addressing pluvial flooding (Pagliacci et al., 2020). Finally, in studies in Canada and the US, the participants in tree planting and tree giveaway programs tended to be higher income females (Greene et al., 2011; Hand et al., 2019).

PEBs can also be influenced by cognitive preconditions such as environmental concerns and knowledge (Schultz, 2001; Nisbet et al., 2009; Ajzen, 2011). For instance, beliefs about GI's capacity to manage stormwater (Drescher and Sinasac, 2021) and concerns about the threat of flooding (Pagliacci et al., 2020) can influence motivations to install GI. A study in Portland, US, showed how knowledge-levels about bioswales influenced people's attitudes towards having this GI feature in public spaces (Everett et al., 2018). After obtaining information about the climate contributions of GI in Rotterdam, The Netherlands, people became more supportive of GI features in public spaces (Derkzen et al., 2017). In other studies, greater knowledge about the positive effects of GI on the urban environment was associated with increased willingness to install GI (Baptiste et al., 2015), and knowledge about rain barrels has been associated with willingness to install these features by residents (Gao et al., 2016). A recent review of the GI literature reinforced the importance of knowledge as a precondition influencing people's attitude towards GI (Venkataramanan et al., 2020).

Nevertheless, the extent to which knowledge and concerns can influence PEBs related to GI is unclear because most of the evidence has been focused on people's positive attitude towards GI as a response measure (Keeley et al., 2013; Mason et al., 2019). Few studies have examined intended behavior as a measure. Moreover, knowledge and concerns have had mixed empirical support in studies examining other PEB besides those related to GI, such as climate mitigation, recycling, and other environmental behaviors (Petts and Brooks, 2006). Increasing knowledge of an issue, or concern about an environmental problem or the environmental consequences of an action does not necessarily change intended behaviors (Kollmuss and Agyeman, 2002). Knowledge and concern are two of many factors (e.g., personal capacities to implement action, or other external and internal incentives) that can possibly influence and shape PEB.

In addition to sociodemographic and cognitive preconditions that can support PEBs in a planned behavior model (Ajzen, 2011), behavioral preconditions that describe a person's experience with nature may also contribute to people's intended behavior concerning GI (Kollmuss and Agyeman, 2002; Evans et al., 2013). By experience with nature, we mean broadly how people relate to the natural environment, and the cognitive, affective, and behavioral aspects that define this relationship, including, but not limited to, proximity, frequency of contact, type of use, accessibility, closeness, awareness, concerns, beliefs, preferences, among other measures of nature experience (Schultz et al., 2004; Scopelliti and Giuliani, 2004; Hartig et al., 2014; Bratman et al., 2019).

While experiential preconditions related to people's experience with nature in the context of people's intended behavior concerning GI are not yet well defined, we can derive insights from research on people's experiences with their private residential outdoor space (Clayton, 2007; Blaine et al., 2012; Freeman et al., 2012; Conway, 2016; Corley et al., 2021). For instance, some studies show how people's gardening activities is associated with PEBs (Whitburn et al., 2019). Additionally, tending to private residential green space or maintaining vegetation in this space can shape people's environmental identity (Kiesling and Manning, 2010), a significant determinant of PEB (Evans et al., 2013). How people use their private residential outdoor space, including recreation, food production, or nature observation, can also influence environmental identity (Clayton, 2007; Kiesling and Manning, 2010; Blaine et al., 2012; Corley et al., 2021). These factors may complement commonly considered cognitive and sociodemographic preconditions concerning people's intended behavior toward GI in private residential outdoor space, but we do not yet how they are associated.

In addition to people's uses of, as well as their experiences tending or maintaining, their private residential outdoor space, residents' relationship with GI can also be determined by their level of awareness and engagement with GI-related activities in their local area. This is relevant because in many cities there are programs led by either local governments or non-governmental organizations that encourage residents to learn about, as well as to install and maintain, GI (e.g., GIO, 2021). Residents who participate in these initiatives may therefore have more knowledge about and experience with GI, thus be more likely to install and maintain GI features on their property. However, we are not aware of any study that has considered people's knowledge of and participation in GI initiatives in relation to GI installation. There are some studies that examine the socio-demographic characteristics of the people who participate in such initiatives, such as tree planting initiatives in the public spaces of residential areas (e.g., Greene et al., 2011; Gao et al., 2016; Locke and Grove, 2016; Hand et al., 2019; Meerow et al., 2021). However, such studies do not associate the various cognitive, experiential, and socio-demographic preconditions that may influence intended behavior related to GI.

Building on this conceptual framing, we suggest a theoretical pathway whereby cognitive, experiential, and sociodemographic preconditions influence likelihood to install GI in private residential outdoor space (**Figure 1**). Accounting for these influences will allow us to analyze the multiple drivers affecting PEB in the context of GI more accurately.

METHODS

Study Area

We conducted a residential survey in Toronto, Canada's largest city, located in southern Ontario with a population of 2,731,151

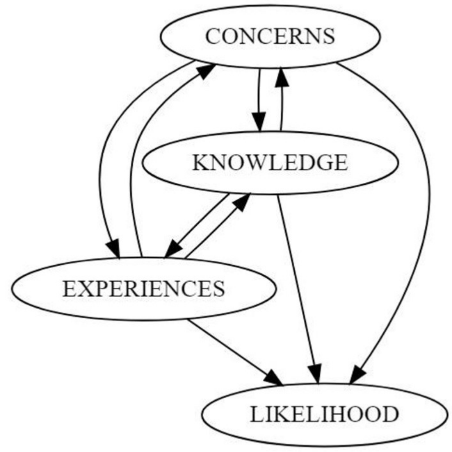

FIGURE 1 | A conceptual model to understand the influences of likelihood to install additional GI features in private residential outdoor space based on the constructs of concerns, knowledge, and experiences, which include measures such as environmental concerns, knowledge of gardening and uses of outdoor space, among others (see **Figure 2**).

in 2016 (Statistics Canada, 2016). There are 1.1 million dwelling units across the city, 44% of which are on-the-ground single-family homes. We focused on resident homeowners of single-family homes because it is the housing type that is most likely to have space where GI features can be installed. These homes represent a mix of pre-World War II, semi-detached or fully detached houses, often with limited outdoor space, as well as neighborhoods with larger properties containing newer houses. Demographically, Toronto is a diverse city, with 52% of the population identifying as a visible minority (i.e., non-white) and 51% born outside of Canada (Statistics Canada, 2016). The City of Toronto has policies and initiatives related to GI, which the city broadly defines as systems that incorporate living (e.g., rain gardens, trees, green roofs) and non-living (e.g., rain barrels, permeable pavement) features (City of Toronto, 2013). Several government and non-government organizations in the city have policies and initiatives aimed at increasing GI in private residential outdoor space (GIO, 2021).

Survey Design and Delivery

A targeted survey design (Dillman et al., 2014) was used to develop and deliver a postal survey aimed at collecting data on people's likelihood to install GI features (defined in **Table 1**) on their private residential outdoor space, as well as other cognitive and experiential information on people's nature experience. The survey was sent to 2,000 single-family residential addresses located in the City of Toronto obtained from a marketing company. The addresses were identified through a spatially stratified random sampling approach, weighted by number of single-family residential addresses per postal code. This targeted sampling design was intended to capture the range of socio-demographic, built, and environmental conditions across the city. The research protocol was approved by the authors' university ethics board. In the survey, we explicitly asked about their residential outdoor space, defined as the space around the person's home on their property, including back and front yards, porches, driveways, decks, and patios.

The survey was disseminated between May and July 2018, using a multi-contact approach to increase response rates (Dillman et al., 2014). This involved first sending an invitation postcard to all participants, alerting them that they would shortly receive the survey in the mail with the option to complete it online. A printed survey packet was sent to the participant's residential address a week later. This packet included an informed consent form, a copy of the survey, and a stamped, addressed envelope to return the survey. A reminder postcard was sent to the participant two weeks later, followed by a second survey packet in another two weeks, if needed.

Measures

Likelihood to Install GI

Our 13-item measure of likelihood to install additional GI features asked how likely people were to install various GI elements in private residential outdoor space, such as yard trees, pollinator gardens and rain barrels, among others, measured through a 5-point Likert-based likelihood scale ($\alpha = 0.87$; $M = 2.18$, $SD = 0.71$). The measure had three separate dimensions (see section Socio-Demographics), which grouped intentions to install gardening features ($\alpha = 0.79$; $M = 2.05$, $SD = 0.88$), trees and shrubs ($\alpha = 0.71.10$; $M = 2.10$, $SD = 0.92$), and a dimension we decided to name undesired/unknown, since these were the GI features that received low ratings that were grouped in the analysis as a separate dimension ($\alpha = 0.88$, $M = 1.64$, $SD = 0.72$) (details in **Supplementary Material**).

Environmental Concerns

Our 14-item measure of environmental concern contains evaluative statements that describe the environmental issues that GI is meant to address, such as heat, drought, flooding and biodiversity, using a 5-point Likert-based agreement scale. While our measure builds on studies about the relationship between concern and people's perceptions of and relationship with GI (e.g., Baptiste et al., 2015; Derkzen et al., 2017; Venkataramanan et al., 2020; Drescher and Sinasac, 2021), the specific statements were based on a policy assessment of GI in Toronto (Conway et al., 2020). Example statements include "Flooding in my yard or other outdoor spaces on my property during a storm" and "Hot summer temperatures that will stress or kill my lawn and other yard vegetation." The measure had separate dimensions (see section Socio-Demographics), which grouped concerns related to flooding ($\alpha = 0.93$; $M = 2.92$, $SD = 1.30$), heat and drought ($\alpha = 0.84$; $M = 2.30$, $SD = 0.99$), and general environment ($\alpha = 0.72$; $M = 2.13$, $SD = 0.86$) (details in **Supplementary Material**).

Knowledge of Gardening and GI

Based on the work by Corley et al. (2021) and Kiesling and Manning (2010) on gardening experiences, we developed a measure of level of knowledge about gardening using a simple, one-item, 1–5 level of gardening knowledge scale (M = 3.25, SD = 1.06).

In line with Keeley et al. (2013), Baptiste et al. (2015), Gao et al. (2016), Everett et al. (2018), Venkataramanan et al. (2020), Drescher and Sinasac (2021), and Meerow et al. (2021) on people's knowledge of GI, we asked participants whether they had previously heard the term "green infrastructure", with a simple yes/no answer converted to a 1/0 measure (M = 0.26, SD = 0.44) (details in **Supplementary Material**).

Experience With Private Residential Outdoor Space and GI

Based on the work by Corley et al. (2021) and Kiesling and Manning (2010) on gardening experiences, and Whitburn et al. (2019) on tree planting experiences, we developed four measures of experiences with private residential outdoor space.

First, we developed an 11-item measure of uses of outdoor space that contains evaluative statements describing the types of uses people have in their outdoor space based on Clayton (2007) and Blaine et al. (2012), such as eating meals, physical activity, and gardening, using a 1-5 Likert-based agreement scale. The measure had separate dimensions (see section Socio-Demographics), which grouped uses related to home extension (α = 0.86; M = 4.42, SD = 0.61), utilitarian use (α = 0.60; M = 3.81, SD = 0.79), and nature activity use (α = 0.65; M = 3.95, SD = 0.81) (details in **Supplementary Material**).

Second, we assessed respondents' experience planting vegetation by asking them whether they had previously planted vegetation as a yes/no answer converted to a 1/0 measure (M = 0.16, SD = 0.36).

Third, we developed a measure of the level of self-maintenance of outdoor space, meaning how much maintenance a respondent performs in their outdoor space. This maintenance related to four activities: mowing the lawn, cleaning up the garden, vegetation planting and maintenance, and caring for trees. Each had a simple yes/no answer, with the total yes answers summed and the measure converted to a continuous 1-0 scale (M = 0.76, SD = 0.33) (details in **Supplementary Material**). To address skewness in this scale (i.e., people who perform a lot of maintenance of their private residential outdoor space will probably rate all these activities high; see Clayton, 2007; Blaine et al., 2012), we standardized the values by applying the equation:

$$\frac{\mathbf{x}-\mathbf{x}^{\min}}{\mathbf{x}^{\max}-\mathbf{x}^{\min}} \tag{1}$$

where x is the response item (e.g., 1–4, for level of self-maintenance of outdoor space), x^{min} is the minimum value in the range of responses (e.g., 1 for level of self-maintenance of outdoor space), and x^{max} is the maximum value in the range of responses (e.g., 4 for level of self-maintenance in their outdoor space). This standardization avoids overestimation as it reduces the variable's variance for use in further analyses.

Fourth, based on the work by Keeley et al. (2013), Baptiste et al. (2015), Gao et al. (2016), Everett et al. (2018), Venkataramanan et al. (2020), Drescher and Sinasac (2021), and Meerow et al. (2021), prior to asking participants about their likelihood to install additional GI features, we asked participants what GI features they had already installed on their private residential outdoor space. For this we used the same 13 items from the intentions scale, using a simple yes/no answers. We summed all these items and applied Equation 1 to standardize the measure and convert it to a simple 1-0 scale (M = 0.35, SD = 0.11).

Awareness and Engagement With Local GI Initiatives

As mentioned in our conceptual framework, we wanted to integrate people's awareness of and engagement with GI-related activities in their local area as a possible influence on PEB related to GI installation. So, we asked respondents to identify their level of awareness of and engagement with 13 existing local GI initiatives specific to the City of Toronto led by several government and non-government organizations. This scale is a mixed construct based on both cognitive (i.e., knowledge of the initiatives) and experiential (i.e., participation in the initiatives as a volunteer or member) factors. The list of initiatives was based on the authors' knowledge of local programs in Toronto and discussions with local urban greening professionals. Participants rated each of the 13 local initiatives on a 1–3 scale, with 1 representing never heard of it, 2 equals have heard of it but not participated, and 3 representing have heard of it and participated. The scale did not differentiate depth of participation, with participation including attending an event, participating in a program, being a volunteer, and/or being a member. We group participation types together because the initiatives did not have comparable levels of participation (i.e., participants could be members in some initiatives but only volunteers in others). We summed all these items and applied Equation 1 (see section Experience With Private Residential Outdoor Space and GI; details in **Supplementary Material**) to standardize the values and convert it to a 1/0 measure (M = 0.42, SD = 0.08). We incorporated multiple initiatives to examine the breadth of knowledge and engagement, rather than the depth of knowledge and engagement on one type of initiative (details in **Supplementary Material**).

Socio-Demographics

Finally, we collected data on socio-demographics, including age, gender, education level, generation status for those not born in Canada, residence years in Canada for not those not born in Canada, ethnicity using Statistics Canada (2011a) categories, residence years in current home, income level using Statistics Canada (2016) income quintiles for Toronto, and whether there were children in the home.

Data Analysis

We used the R statistical environment (v. 4.1.0; R Development Core Team, 2020) to conduct the statistical analyses.

The variables of likelihood to install GI, environmental concerns, and outdoor space uses, were analyzed using exploratory factor analysis to identify the factor structure of these measures, using the *fa* function in the *psych* (v. 1.9) R package, with an oblimin rotation. The number of factors to use was determined by parallel analysis using the *fa.parallel* function in the *psych* R package for each scale dimension. The reliability of each factor was calculated using the *alpha* function in the *psych* R package.

We tested our theorized model of what may associate with the likelihood to install GI scale (**Figure 1**) through a structural equation model (SEM) using the *sem* function in the *lavaan* (v. 0.6) R package. The function calculates several indexes of model fit, including the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR), with CFI and TLI values over 0.95, and RMSEA and SRMR with values below 0.06 and 0.08, respectively, indicating acceptable fit (Hu and Bentler, 1999; Kline, 2011). All variables and their separate dimensions were treated independently in the model. We also defined residual covariances between the separate dimensions of variables. Socio-demographic variables were added as covariates in the model, as single binomial 1/0 variables (see also **Table 2**): age (1 = >60 years; 0 = <60 years); gender (1 = female; 0 = other); education (1 = university degree, or education within or above bachelors or undergraduate; 0 = no university degree); generation status (1 = born in Canada; 0 = not born in Canada); ethnicity (1 = White; 0 = non-White); residence years in Canada for not Canadian born (1 = >20 years; 0 = <20 years); residence years in current home (1 = >20 years; 0 = <20 years); income (1 = >$75,000; 0 = <$75,000); and children in the home (1 = had children; 0 = no children). Collapsing and simplifying these variables helped address over-prediction in the analyses, a typical problem with data based on categorical and ordinal variables (Hair et al., 2014).

All variables that had significant associations with the likelihood to install additional GI features in private residential outdoor space (**Figure 1**) as based on the SEM results were integrated using generalized linear models (GLM), using the *glm* function in R with Gaussian error distribution. These models aimed to predict the scale of likelihood to install GI, with separate modelling analyses conducted for the average scale and the separate dimensions of the scale. Again, the socio-demographic variables were added to the models. The distribution of residuals was checked for normality to confirm the assumptions of the models and the independence of residuals confirmed with the Durbin-Watson statistic, with values of approximately 2.0 indicating no residual autocorrelation. The variance inflation factor (VIF) was checked to address covariance effects (Cohen et al., 2013; Hair et al., 2014).

RESULTS

Participants

We received 585 returned mailed surveys out of the 1,909 surveys successfully delivered (91 were not delivered), giving a response rate of 30.6%. The demographic profile of the survey sample is mostly white, older, and highly educated respondents (**Table 2**). Not all the survey participants were homeowners, but given our focus on homeowners, and the dominance of homeowners in the sample (91.1%), we deleted non-homeowner responses. So, the final sample size was N = 533. Of the 45% of respondents who were born outside Canada (**Table 2**), the average number of years living in Canada for those not born in Canada was M = 42.4, SD = 16.26. We also collected total household income data using predetermined income ranges based on the quintiles of household income for the City of Toronto in the 2016 census (i.e., <$25,000, $25-$49,000, $50-$75,000, $75-$119,000, and >$120,000; Statistics Canada, 2016; latest data available). The median of the numeric income ranges in our sample was $76,256.79, a relatively high number compared to $62,900, the median household income in Canada in 2019 (Statistics Canada, 2019; latest data available).

Structural Model

The SEM analysis allowed us to answer the research question of how the constructs of concerns, knowledge, and experiences are related to people's likelihood to install additional GI features in private residential outdoor space (**Figure 2**). The model had a moderate fit to the data: $\chi 2(N = 533, df = 174) = 1781.79$, $p < 0.001$; CFI = 0.99; TLI = 0.98; RMSEA = 0.02; 90% CI = [0.000, 0.054]; SRMR = 0.012. The results demonstrate that concerns about the environment and knowledge of gardening or GI have a weak, as well as mediated and indirect, influence on likelihood to install GI features. Likelihood to install GI was more strongly influenced by having previously installed GI features and nature activity use of outdoor space. This association was mediated by other uses of outdoor space, self-maintenance of outdoor space, experience planting vegetation, and awareness of and engagement with local GI initiatives, albeit weakly and indirectly.

Linear Models

The GLM analysis allowed us to complement the SEM by assessing a more direct association of the constructs of concerns, knowledge, and experiences with people's likelihood to install additional GI features in private residential outdoor space (**Table 3**). The results were relatively weak (i.e., $R < 0.5$) but statistically significan ($F_{(20,512)} = 7.89$, $p < 0.001$, adjusted $R2 = 0.21$). Regression coefficients, standard errors, and confidence intervals (at the 95% level) can be found in **Table 3**. Many of the variables that influenced likelihood to install GI in a mediated manner as shown in the SEM results did not contribute as significantly as individual predictors of likelihood to install GI, with many including zero in the confidence intervals of the coefficients (**Table 3**). The results demonstrate again, as with the SEM results, that cognitive factors such as concerns about the environment, knowledge of gardening and knowledge of GI, were a weak influence on likelihood to install GI. Such likelihood was more strongly influenced by nature activity uses of outdoor space and previously installed GI features. Awareness of and engagement with local GI initiatives was a weak but still significant influence.

DISCUSSION

Our study provides a better understanding of people's intention to install GI in private residential outdoor space–a key aspect for expanding urban GI networks (Sussams et al., 2015; Larson et al., 2016; Mason et al., 2019; Conway et al., 2020; Matsler et al., 2021; Meerow et al., 2021). Enhancing this understanding is

TABLE 2 | Participant sample profile.

Demographic characteristic	Survey ($n = 533$)	Canadian Census	
		Canada[1]	City of Toronto[2]
Age			
15–19 years old	3.94%	5.76%	5.33%
20–29	0.56%	12.88%	15.66%
30–39	2.44%	13.14%	15.41%
40–49	9.76%	13.13%	13.67%
50–59	22.33%	15.07%	14.10%
60–69	28.52%	12.13%	10.41%
70–79	21.76%	6.95%	6.21%
80+	10.69%	4.33%	4.64%
Gender			
Female	34.52%	50.4%	52%
Education			
High school	18.02%	23.74%	20.39%
Technical or trade diploma/certificate	20.08%	10.79%	4.07%
Bachelors or undergraduate university degree	34.15%	18.96%	27.89%
Graduate university degree (includes graduate diploma/certificate, masters)	27.77%	6.85%	12.22%
Generation Status			
Not born in Canada[3]	45.03%	23.85%	51.18%
Ethnicity			
White, Caucasian, and/or European[4]	74.48%	47.45%	41.88%

[1]Statistics Canada, 2011a,b. [2](Statistics Canada, 2011b, 2016). [3]Also termed first generation status in Canada (see Statistics Canada, 2011a). [4]National and local statistics only refer to geographical origin (i.e., European), not ethnicity (i.e., White or Caucasian and/or European) (Statistics Canada, 2011a,b).

important considering that most research focuses on GI features in public spaces (e.g., Derkzen et al., 2017; Venkataramanan et al., 2020; Drescher and Sinasac, 2021) and people's positive attitudes towards these GI features (e.g., Baptiste et al., 2015; Derkzen et al., 2017; Everett et al., 2018).

Drivers of Intention to Install GI in Private Residential Outdoor Space

Most research on people's relationship with GI has provided insights on the important role of cognitive factors, such as knowledge and concerns, in driving people's perceptions of GI in public space (e.g., Keeley et al., 2013; Derkzen et al., 2017; Everett et al., 2018; Venkataramanan et al., 2020) and people's intention to install GI on private space (e.g., Baptiste et al., 2015; Gao et al., 2016; Mason et al., 2019). However, our findings contribute to our understanding of the relative and mediating influence of such cognitive factors on intention to install GI, particularly in the context of other factors, such as knowledge and experience. These findings both corroborate and contradict these previous observations.

First, there is the role of environmental concerns. Like Meerow et al. (2021), we found that concerns about flooding may not play such a large role in people's intention to install GI in private residential outdoor space. This was also noted by Drescher and Sinasac (2021), although their study was focused on public attitudes towards GI in public spaces. However, this is at odds with Pagliacci et al. (2020) findings that perceived threats of flooding may influence intention to install GI features focused on stormwater control. The difference may be in part due to the recent flooding experienced and significant on-going vulnerability to flooding in the study area associated with Pagliacci et al. (2020) as compared to our study area. It may also be related to differences in theoretical approaches (e.g., lack of a theorized PEB model) and technical differences in the way intended behavior was measured, such as conflating intended behavior with the reason or cause of such behavior.

Second, there is the role of knowledge. Previous studies have shown that knowledge about GI plays an important role in people's attitudes towards GI in public spaces (Keeley et al., 2013; Derkzen et al., 2017; Everett et al., 2018; Venkataramanan et al., 2020) as well as intention to install GI features in private space (Baptiste et al., 2015; Gao et al., 2016; Mason et al., 2019). However, in our study knowledge of GI did not play such a large role in predicting likelihood to install GI in private residential outdoor space. This may be explained by the differences between public and private spaces, and the focus of these studies being placed on attitudes of general populations rather than homeowners' intended behavior.

In contrast, our study builds on the important role of people's experiences with nature in determining their intended behavior in their private residential space (Schultz et al., 2004; Scopelliti and Giuliani, 2004; Hartig et al., 2014; Bratman et al., 2019). Specifically, it shows how likelihood to install GI in private residential outdoor space may be influenced by people's

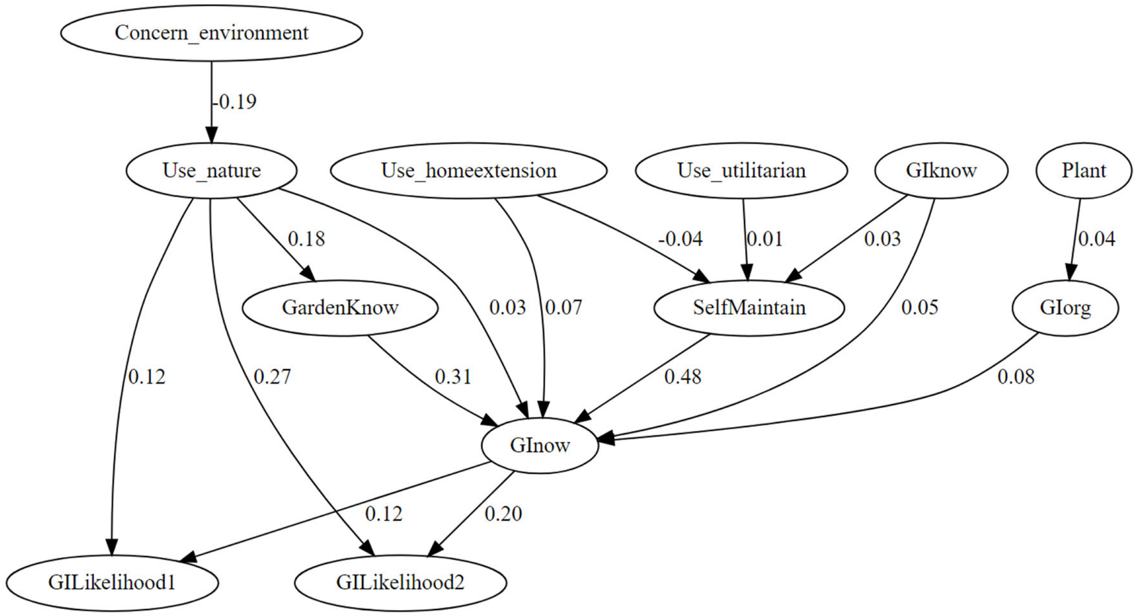

FIGURE 2 | Structural equation model analysis results assessing the influence of concerns (i.e., Concern_environment), knowledge of gardening (GardenKnow) and knowledge of GI (GIKnow), level of awareness of and engagement with local GI initiatives (GIorg), uses of outdoor space (i.e., Use_homextension, Use_utilitarian, Use_nature), level of self-maintenance of outdoor space (SelfMaintain), experience planting vegetation (Plant), and previously installed GI features (GInow), on likelihood to install additional GI features on residential outdoor space (GILikelihood1, which describes intention to install gardening features; GILikelihood2, which describes intention to install trees and shrubs). All paths are statistically significant ($p < 0.05$) and numbers represent the standardized regression coefficients ($N = 533$). The model was adjusted for socio-demographics, including age (>60years), gender (female), education (university degree), ethnicity (White), income (>$75,000), born in Canada, years of residence in current home (> 20 years), years of residence in Canada if not Canadian born (> 20 years), and having children in the home. However, for simplicity, socio-demographic variables are included in the figure.

uses of such space and previous experiences with GI features. These uses and experiences, such as tending and maintaining vegetation, influence people's environmental identities, which in turn influence intended behaviors (Clayton, 2007; Kiesling and Manning, 2010; Blaine et al., 2012; Freeman et al., 2012; Evans et al., 2013; Whitburn et al., 2019). In our study, activities such as watching nature and having already GI features installed in outdoor space were associated with likelihood to install GI. In addition, our findings suggest that other experiences, including self-maintenance of outdoor space, experience planting vegetation, as well as experiences that occur in a much broader social space, in this case, people's awareness of and engagement with local GI initiatives in the City of Toronto, can play a role in mediating these associations. However, in this study we only assessed the breadth of people's awareness of engagement with local GI initiatives rather than depth of awareness and engagement, given the lack of comparability in levels of awareness and engagement across initiatives. We do not know the difference between being deeply involved in one local GI initiative and being superficially involved in, or only marginally aware of, local GI initiatives.

This study suggests that experiential factors may play an important role in people's intention to install GI in private residential outdoor space. This role may relate to self-transcending environmental inclinations, as noted by Evans et al. (2013) in the context of people's relationship with their private gardens and yards. This means that people's intended behavior related to installing GI in private residentials may be more strongly associated with existing lived experiences with natural landscapes and elements than with cognitive preconditions, such as concerns and knowledge. As noted in section Conceptual Framework, being concerned about environmental problems, or having knowledge of environmental solutions or activities are just some of the many other preconditions that may lead a person to behave in a particular way (Kollmuss and Agyeman, 2002; Petts and Brooks, 2006). In fact, people's direct experiences with nature, such as time spent in either public or private natural spaces (Evans et al., 2013) or lived experiences with nature (Scopelliti and Giuliani, 2004; Ajzen, 2011), influences transactional experiences with nature (Schultz, 2001; Schultz et al., 2004; Nisbet et al., 2009), including intended environmental behaviors (Whitburn et al., 2019). In contrast, people's attitudes towards GI in public spaces–spaces where individuals have less influence on GI and management–may be more influenced by such cognitive preconditions, as shown in previous studies (Baptiste et al., 2015; Derkzen et al., 2017; Everett et al., 2018; Venkataramanan et al., 2020).

Finally, while we accounted for the role of socio-demographics in our analyses, our study was focused on testing a theorized model of the drivers behind people's intention to install GI, so we did not concern ourselves with the specific role of socio-demographics. Other studies have demonstrated how having

TABLE 3 | Results for the models predicting the average likelihood to install GI and its separate dimensions from cognitive and experiential measures, including environmental concern (Concern_drought, Concern_environment), knowledge of gardening (GardenKnow), knowledge of GI (GIKnow), uses of outdoor space (Use_homextension, Use_utilitarian, Use_nature), level of self-maintenance of outdoor space (SelfMaintain), experience planting vegetation (Plant), previously installed GI features (GInow), and level of awareness of and engagement with local GI initiatives (GIorg).

Variable	Regression model predicting likelihood to install additional GI features in private residential outdoor space:					
	Average measure		Factor gardening		Factor trees and shrubs	
	Coefficient (Standard Error) b	95% Confidence Interval of coefficient	Coefficient (Standard Error) b	95% Confidence Interval of coefficient	Coefficient (Standard Error) b	95% Confidence Interval of coefficient
Concern_drought	−0.05 (0.03)	[−0.11, 0.01]	−0.06 (0.04)	[−0.13, 0.02]	−0.06 (0.05)	[−0.16, 0.04]
Concern_environment	0.00 (0.04)	[−0.07, 0.08]	0.00 (0.05)	[−0.10, 0.09]	0.02 (0.06)	[−0.10, 0.13]
Use_homextension	0.00 (0.05)	[−0.10, 0.10]	−0.04 (0.06)	[−0.16, 0.08]	0.01 (0.08)	[−0.14, 0.16]
Use_utilitarian	0.08 (0.04)*	[0.01, 0.15]	0.07 (0.04)	[−0.02, 0.16]	0.09 (0.06)	[−0.02, 0.20]
Use_nature	0.14 (0.04)***	[0.07, 0.21]	0.25 (0.05)***	[0.16, 0.33]	0.11 (0.06)	[0.00, 0.23]
GInow	1.11 (0.25)***	[0.63, 1.59]	1.63 (0.30)***	[1.04, 2.22]	0.96 (0.38)*	[0.20, 1.71]
GIKnow	−0.05 (0.06)	[−0.17, 0.06]	−0.05 (0.07)	[−0.19, 0.09]	−0.12 (0.09)	[−0.31, 0.06]
GardenKnow	0.02 (0.03)	[−0.03, 0.07]	0.01 (0.03)	[−0.05, 0.08]	0.00 (0.04)	[−0.08, 0.08]
Plant	0.05 (0.07)	[−0.08, 0.19]	0.01 (0.08)	[−0.15, 0.18]	0.19 (0.11)	[−0.02, 0.41]
GIorg	0.72 (0.32)*	[0.10, 1.34]	1.00 (0.39)*	[0.24, 1.76]	0.95 (0.49)	[−0.02, 1.91]
SelfMaintain	0.21 (0.08)*	[0.05, 0.37]	0.32 (0.10)**	[0.12, 0.51]	0.13 (0.13)	[−0.13, 0.38]
$1 - \frac{\text{residual deviance}}{\text{null deviance}}$	0.24		0.29		0.10	
Durbin-Watson	1.85		1.87		1.86	

All models were adjusted for age (>60years), gender (female), education (university degree), ethnicity (White), income (>$75,000), born in Canada, years of residence in current home (> 20 years), years of residence in Canada if not Canadian born (> 20 years), and having children in the home. $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

high income, being of a certain gender or age, or being highly educated, can influence people's attitudes towards GI in public space (e.g., Baptiste et al., 2015; Derkzen et al., 2017; Everett et al., 2018; Venkataramanan et al., 2020), intention to install GI on private space (e.g., Gao et al., 2016; Meerow et al., 2021), and people's participation in GI-related activities, such as tree planting programs (e.g., Greene et al., 2011; Locke and Grove, 2016). Nonetheless, we recognize that given the uneven distribution of many GI features in the socio-demographic landscape of cities, such as high-income and less racially or ethnically diverse neighbourhoods having more abundant vegetation in both public and private spaces (Greene et al., 2011; Kardan et al., 2015; Locke and Grove, 2016; Bratman et al., 2019), more research is needed to examine the mediating role of socio-demographic influences on people's perceptions of GI as well as intended behavior in relation to GI. A useful approach in this regard will be to account for the interactive and mediating influence of non-homeowning and low-income characteristics since most studies only account for their individual influences rather than their interactive influence. Further examination is needed to detect differences or similarities in motivations to install GI across socio-demographic groups to address inequities and environmental justice concerns.

Implications for GI Management

The findings of this study have several implications for GI management, particularly designing and/or delivering GI community initiatives aimed at increasing the adoption of GI in residential private areas.

First, our findings suggest that local initiatives aimed at increasing people's awareness of and engagement with GI can be useful, given that this awareness and engagement influences likelihood to install GI in private residential outdoor space. However, we can only say that for the types of residents we surveyed, primarily white, older, and highly educated homeowners. Nonetheless, these initiatives may benefit from orienting communication materials around specific uses of outdoor space, such as watching nature, as well as experiences with tending and maintain outdoor and yard space. This is important because experimental tests of messaging effectiveness in GI initiatives are lacking (Hand et al., 2019), yet they are important for guiding GI program implementation.

Second, our findings suggest the importance of community outreach for generating direct experiences with GI features in public or private spaces, which in turn influence the likely adoption of GI features in residential space. An important consideration here is segmenting government and non-governmental initiatives in future research. These different types of initiatives conduct their outreach in different ways (e.g., flyers, social media, websites, open houses, door-to-door invitations) depending on the resources available and may be received differently by residents.

A key consideration is how GI programs aimed at enhancing the adoption of GI features in private spaces drive environmental inequity. Not only are GI features, such as street and yard trees, rain gardens, and bioswales, unevenly distributed in the socio-demographic landscape of cities (Greene et al., 2011; Kardan et al., 2015; Locke and Grove, 2016; Bratman et al., 2019), but adding these features in disadvantaged urban areas–meaning low-income, low-education areas with more minority populations–may enhance inequity by, for example, raising housing prices (Rigolon and Németh, 2018). GI outreach programs usually conduct their work where it is easiest, not just in terms of existing GI infrastructure or available space, but also in terms of social barriers to GI adoption, such as focusing on high-income neighbourhoods with relatively homogenous white, older, and highly educated populations (Locke and Grove, 2016). Thus, GI enhancement programs in private residential space may be successful in terms of increasing abundance and balancing the distribution of GI networks, yet they may also result in enhanced distributional and procedural inequities. Future research should also aim to integrate environmental equity perceptions on GI intended behaviors.

Limitations

Since the study focused on homeowners, meaning those participants with the most immediate experience of and the most likelihood to influence private residential outdoor space, the sample was biased towards high-income, highly educated, and mostly white communities. This means we focused on exploring associations endogenously rather than causal associations between different types of residents. Key to understanding this sampling bias is that we were unable to assess to what extent this sample profile is representative of residents owning single-family homes as disaggregated demographic data does not exist for this targeted population in the City of Toronto. Nevertheless, our study shows that that accounting for various socio-demographic factors is necessary to examine people's intended behavior in relation to GI. Future research could address people's backgrounds and lifestyles growing up, such as urban and rural experiences, or the ways in which GI features installed by previous owners could impact current owners' interest in new GI installation.

While the SEM and GLM approaches were structured ways to test the PEB model, including any direct and mediated associations, there was no precondition on regressions steps, and, as such, we collectively accounted for all influences and mediations as we could possibly account for. While this may have enhanced the internal validity of the model testing, it may have also resulted in an incomplete association or mediation, given the limited fit of the model to the data (Hu and Bentler, 1999; Kline, 2011). While we recognize the limitations of the data, with this study we wish to provide at least some new and innovative measures of GI experiences, as well as new and innovative approaches to analyze their role in PEBs in the contexts of other cognitive constructs. This complements the existing research on the role of concerns and knowledge to explain these PEBs. These measures and approaches could be replicated in future studies.

CONCLUSION

This study is unique as it associates the various cognitive, behavioral, and socio-demographic preconditions that may influence likelihood to install GI in private residential outdoor space. It shows how experiences with residential outdoor space and GI features may also play a role in predicting likelihood to install GI. These experiences include using private residential outdoor space for observing nature and having GI features already installed. This suggests that the role of experiences with nature or residential outdoor space should be further explored in relation to GI on both private and public land. Additionally, the intended behavior related to GI must be examined according to the influence of sociodemographic, cognitive, affective, and behavioral preconditions. Finally, by replicating the procedures presented here, including novel psychological constructs to assess cognitive and experiential factors, and by combining these with larger sample sizes and stratified, probabilistic surveying, future studies can adopt a sharper lens to examine what influences intended behavior in relation to GI in the context of private residential outdoor space.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Approval by University of Toronto Ethics Review Board, Protocol No. 36051. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CO, TC, and LR contributed equally to conceptualization, data curation, methodology, and project administration. TC provided project supervision as well as funding acquisition. TC and LR provided resources and editing. CO led the writing of the manuscript and the data analysis. All authors contributed critically to the drafts and gave final approval for publication.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Ajzen, I. (2011). The theory of planned behaviour: reactions and reflections. *Psychol. Health* 26, 1113–1112. doi: 10.1080/08870446.2011.613995

Baptiste, A. K., Foley, C., and Smardon, R. (2015). Understanding urban neighborhood differences in willingness to implement green infrastructure measures: a case study of Syracuse, NY. *Landsc. Urban Plann.* 136c, 1–12. doi: 10.1016/j.landurbplan.2014.11.012

Blaine, T. W., Clayton, S., Robbins, P., and Grewal, P. S. (2012). Homeowner attitudes and practices towards residential landscape management in Ohio, USA. *Environ. Manage.* 50, 257–271. doi: 10.1007/s00267-012-9874-x

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., De Vries, S., Flanders, J., et al. (2019). Nature and mental health: An ecosystem service perspective. *Sci. Adv.* 5, eaax0903. doi: 10.1126/sciadv.aax0903

City of Toronto (2013). *Sustaining and expanding the urban forest: Toronto's strategic forest management plan.* Parks, Forestry and Recreation Division, City of Toronto, Toronto, ON, Canada, pp. 83. Available online at: http://www.toronto.ca/trees/

Clayton, S. (2007). Domesticated nature: motivations for gardening and perceptions of environmental impact. *J. Environ. Psychol.* 27, 215–224. doi: 10.1016/j.jenvp.2007.06.001

Cohen, J., Cohen, P., West, S. G., and Aiken, L. S. (2013). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. 3rd Ed. *Routdlege, New York, USA,* pp. 536. doi: 10.4324/9780203774441

Conway, T. M. (2016). Tending their urban forest: Residents' motivations for tree planting and removal. *Urban Forest. Urban Green.* 17, 23–32. doi: 10.1016/j.ufug.2016.03.008

Conway, T. M., Khan, A., and Esak, N. (2020). An analysis of green infrastructure in municipal policy: divergent meaning and terminology in the Greater Toronto Area. *Land Use Policy* 99, 104864. doi: 10.1016/j.landusepol.2020.104864

Conway, T. M., Ordóñez, C., Roman, L. A., Yuan, A., Pearsall, H., Heckert, M., et al. (2021). Resident knowledge of and engagement with green infrastructure in Toronto and Philadelphia. *Environ. Manag.* 68, 566–579. doi: 10.1007/s00267-021-01515-5

Corley, J., Okely, J. A., Taylor, A. M., Page, D., Welstead, M., Skarabela, B., et al. (2021). Home garden use during COVID-19: Associations with physical and mental wellbeing in older adults. *J. Environ. Psychol.* 73, 101545. doi: 10.1016/j.jenvp.2020.101545

Derkzen, M. L., van Teeffelen, Astrid, J. A., and Verburg, P. H. (2017). Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? *Lands. Urban Plann.* 157, 106–130. doi: 10.1016/j.landurbplan.2016.05.027

Dillman, D. A., Smyth, J. D., and Christian, L. M. (2014). *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method.* Fourth Ed. John Wiley and Sons, Inc., Hoboken, NJ, US. pp. 528.

Drescher, M., and Sinasac, S. (2021). Social-psychological determinants of the implementation of green infrastructure for residential stormwater management. *Environ. Manage.* 67, 308–322. doi: 10.1007/s00267-020-01393-3

Escobedo, F. J., Giannico, V., Jim, C. Y., Sanesi, G., and Lafortezza, R. (2019). Urban forests, ecosystem services, green infrastructure and nature-based solutions: Nexus or evolving metaphors? *Urban Forestry Urban Green.* 37, 3–12. doi: 10.1016/j.ufug.2018.02.011

Evans, L., Maio, G. R., Corner, A., Hodgetts, C. J., Ahmed, S., and Hahn, U. (2013). Self-interest and pro-environmental behaviour. *Nat. Clim. Change.* 3, 122–125. doi: 10.1038/nclimate1662

Everett, G., Lamond, J. E., Morzillo, A. T., Matsler, A. M., and Chan, F. K. S. (2018). Delivering green streets: An exploration of changing perceptions and behaviours over time around bioswales in portland, oregon. *J. Flood Risk Manage.* 11, S973–S985. doi: 10.1111/jfr3.12225

Freeman, C., Dickinson, K. J. M., Porter, S., and van Heezik, Y. (2012). "My garden is an expression of me": Exploring householders' relationships with their gardens. *J. Environ. Psychol.* 32, 135–143. doi: 10.1016/j.jenvp.2012.01.005

Gao, Y., Babin, N., Turner, A. J., Hoffa, C. R., Peel, S., and Prokopy, L. S. (2016). Understanding urban-suburban adoption and maintenance of rain barrels. *Landsc. Urban Plann.* 153, 99–110. doi: 10.1016/j.landurbplan.2016.04.005

GIO (2021). *Municipal Hub: Green Infrastructure Resources for Municipalities*. Available online at: https://guides.co/g/green-infrastructure-resources/192859 (accessed December 2021).

Greene, C. S., Millward, A. A., and Ceh, B. (2011). Who is likely to plant a tree? The use of public socio-demographic data to characterize client participants in a private urban forestation program. *Urban Forestry Urban Green.* 10, 29–38. doi: 10.1016/j.ufug.2010.11.004

Hair, J. J., Black, W. C., Babin, B. J., and Anderson, R. E. (2014). *Multivariate Data Analysis: Pearson New International Edition.* 7th Ed. Pearson Education, Upper Saddle River, N.J., p. 846.

Hand, M. S., Roman, L. A., Locke, D. H., and Fichman, E. S. (2019). Phone-call reminders narrow the intention-action gap by increasing follow-through for a residential tree giveaway program. *Urban Forestry Urban Green.* 44, 126425. doi: 10.1016/j.ufug.2019.126425

Hartig, T., Mitchell, R., de Vries, S., and Frumkin, H. (2014). Nature and health. *Ann. Rev. Public Health.* 35, 207–228. doi: 10.1146/annurev-publhealth-032013-182443

Hu, L., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struc. Equat. Model.* 6, 1–55. doi: 10.1080/10705519909540118

Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L. J., Paus, T., et al. (2015). Neighborhood greenspace and health in a large urban center. *Nat. Sci. Rep.* 5, 11610. doi: 10.1038/srep11610

Keeley, M., Koburger, A., Dolowitz, D. P., Medearis, D., Nickel, D., and Shuster, W. (2013). Perspectives on the use of green infrastructure for stormwater management in Cleveland and Milwaukee. *Environ. Manag.* 51, 1093–1108. doi: 10.1007/s00267-013-0032-x

Kiesling, F. M., and Manning, C. M. (2010). How green is your thumb? Environmental gardening identity and ecological gardening practices. *J. Environ. Psychol.* 30, 315–327. doi: 10.1016/j.jenvp.2010.02.004

Kline, R. B. (2011). *Principles and Practice of Structural Equation Modeling*. Guilford Press, New York, NY, USA,

Kollmuss, A., and Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* 8, 239–260. doi: 10.1080/13504620220145401

Larson, K. L., Nelson, K. C., Samples, S. R., Hall, S. J., Bettez, N., Cavender-Bares, J., et al. (2016). Ecosystem services in managing residential landscapes: Priorities, value dimensions, and cross-regional patterns. *Urban Ecosyst.* 19, 95–113. doi: 10.1007/s11252-015-0477-1

Locke, D. H., and Grove, J. M. (2016). Doing the hard work where it's easiest? Examining the relationships between urban greening programs and social and ecological characteristics. *Appl. Spat. Anal. Policy* 9, 77–96. doi: 10.1007/s12061-014-9131-1

Mason, L. R., Ellis, K. N., and Hathaway, J. M. (2019). Urban flooding, social equity, and "backyard" green infrastructure: An area for multidisciplinary practice. *J. Commun. Pract.* 27, 334–350. doi: 10.1080/10705422.2019.1655125

Matsler, A. M., Meerow, S., Mell, I. C., and Pavao-Zuckerman, M. A. (2021). A 'green' chameleon: Exploring the many disciplinary definitions, goals, and forms of "green infrastructure". *Landsc. Urban Plann.* 214, 104145. doi: 10.1016/j.landurbplan.2021.104145

Meerow, S., Helmrich, A. M., Andrade, R., and Larson, K. L. (2021). How do heat and flood risk drive residential green infrastructure implementation in Phoenix, Arizona? *Urban Ecosyst.* 24, 989–1000. doi: 10.1007/s11252-020-01088-x

Nisbet, E. K., Zelenski, J. M., and Murphy, S. A. (2009). The nature relatedness scale: linking individuals' connection with nature to environmental concern and behavior. *Environ. Behav.* 41, 715–740. doi: 10.1177/0013916508318748

Pagliacci, F., Defrancesco, E., Bettella, F., and D'Agostino, V. (2020). Mitigation of urban pluvial flooding: what drives residents' willingness to implement green or grey stormwater infrastructures on their property? *Water* 12, 3069. doi: 10.3390/w12113069

Petts, J., and Brooks, C. (2006). Expert conceptualisations of the role of lay knowledge in environmental decisionmaking: challenges for deliberative democracy. *Environ. Plan. A* 38:1045–1059. doi: 10.1068/a37373

Rigolon, A., and Németh, J. (2018). "We're not in the business of housing:" environmental gentrification and the nonprofitization of green infrastructure projects. *Cities* 81 71–80. doi: 10.1016/j.cities.2018.03.016

Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *J. Environ. Psychol.* 21, 327–339. doi: 10.1006/jevp.2001.0227

Schultz, P. W., Shriver, C., Tabanico, J. J., and Khazian, A. M. (2004). Implicit connections with nature. *J. Environ. Psychol.* 24, 31–42. doi: 10.1016/S0272-4944(03)00022-7

Scopelliti, M., and Giuliani, M. V. (2004). Choosing restorative environments across the lifespan: A matter of place experience. *J. Environ. Psychol.* 24, 423–437. doi: 10.1016/j.jenvp.2004.11.002

Statistics Canada (2011a). Immigration and ethnocultural diversity in Canada. Statistics Canada, Ottawa, ON, Canada. Available online at: www.12.statcan.gc.ca/nhs-enm/2011/as-sa/99-010-x/99-010-x2011001-eng.cfm (accessed December 2020).

Statistics Canada (2011b). Population, urban and rural, by province and territory (Canada). Statistics Canada, Ottawa, ON, Canada. Available online at: www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/demo62a-eng.htm. December 2020.

Statistics Canada (2016). Census profile, 2016 census. Toronto, city [census subdivision]. Available online at: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=EandGeo1=CSDandCode1=3520005andGeo2=PRandData=CountandB1=All (accessed December 2020).

Statistics Canada (2019). Canadian income survey 2019. Available online at: https://www150.statcan.gc.ca/n1/daily-quotidien/210323/dq210323a-eng.htm (accessed December 2020).

Sussams, L. W., Sheate, W. R., and Eales, R. P. (2015). Green infrastructure as a climate change adaptation policy intervention: muddying the waters or clearing a path to a more secure future? *J. Environ. Manag.* 147, 184–193. doi: 10.1016/j.jenvman.2014.09.003

Venkataramanan, V., Lopez, D., McCuskey, D. J., Kiefus, D., McDonald, R. I., Miller, W. M., et al. (2020). Knowledge, attitudes, intentions, and behavior related to green infrastructure for flood management: a systematic literature review. *Sci. Total Environ.* 720, 137606. doi: 10.1016/j.scitotenv.2020.137606

Whitburn, J., Linklater, W. L., and Milfont, T. L. (2019). Exposure to urban nature and tree planting are related to pro-environmental behavior via connection to nature, the use of nature for psychological restoration, and environmental attitudes. *Environ. Behav.* 51, 787–810. doi: 10.1177/0013916517751009

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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