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An examination of the factors influencing engagement in gardening practices that support biodiversity using the theory of planned behavior

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ABSTRACT

The composition and management of private gardens is critical to conserving and enhancing urban biodiversity, yet little is known about the psychological factors that influence gardening behavior. We apply an extended version of the theory of planned behavior (TPB), which includes nature connectedness, to predict engagement in gardening practices that support biodiversity. More specifically, we examine the psychological factors that influence people's intention to engage in wildlife gardening and the number of wildlife-friendly garden features in a New Zealand sample ($N = 695$). Structural equation modeling indicated that the extended TPB is well suited to explaining engagement in wildlife gardening. Perceived behavioral control was the strongest predictor of intention while subjective norm and nature connectedness were also significantly associated with intention. Furthermore, we explored which beliefs influence the predictors of intention. The perception of having information and knowledge as well as time had the strongest association with perceived behavioral control. Subjective norm was predicted by normative beliefs about friends, family, and environmentalists but not neighbors. Our findings provide insights into the psychological factors that influence gardening practices and can inform the design of interventions to increase urban biodiversity. We conclude that the positive effect of nature connectedness on pro-environmental behavior should be considered in designing engagement activities to support biodiversity.

1. Introduction

Biodiversity loss is increasingly recognized as a major threat to human well-being (Cardinale et al., 2012; Díaz et al., 2006; Sandifer et al., 2015). One of the main drivers of biodiversity loss is the destruction of habitats, which is caused by, among other anthropogenic factors, ongoing global patterns of urbanization (Dirzo and Raven, 2003; Johnson Christopher et al., 2017; McKinney, 2006). McDonald et al. (2020) estimate that urban growth accounts for 16 % of the global natural habitat loss between 1992 and 2000. While urban areas cover a relatively small proportion of the global land area, they are often located in geographical areas that were originally biodiversity-rich and provided habitats for a variety of species (Kühn et al., 2004). Urbanization increasingly impacts protected areas in many parts of the world and threatens rare species within and nearby urban areas, especially the ones that are geographically restricted (Ives et al., 2016; Kühn et al., 2004; Luck, 2007; McDonald et al., 2008). Biodiversity loss has adverse effects on the well-being of urban dwellers and their willingness to protect nature, as it changes the way people experience and interact with nature in their daily lives (Fuller et al., 2007; Miller, 2005; Pyle, 1993; Soga and Gaston, 2016). In light of growing concerns about global biodiversity loss and the importance of urban biodiversity for human and environmental health, there is growing interest in the enhancement of urban biodiversity through the design and management of urban green spaces (Aronson et al., 2017; Beninde et al., 2015; Lepczyk et al., 2017; Threlfall et al., 2017).

Private gardens cumulatively cover a large area in cities and thus have an immense impact on urban biodiversity. Estimates of the proportion of private gardens on the total land area of cities in the UK, Sweden, and New Zealand range from 16 % to 36 % (Colding et al., 2006; Loram et al., 2007; Mathieu et al., 2007). Private gardens provide habitats for a variety of species, and they can serve as a refuge for many

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native and endangered species (Goddard et al., 2010; Thompson et al., 2003). Characteristics of private gardens, such as the presence of trees, deadwood, understorey cover, insect hotels, or water features, can influence the diversity of birds, invertebrates, and mammals in gardens (Daniels and Kirkpatrick, 2006; Fröhlich and Ciach, 2020; Gaston et al., 2005). The impact of the composition and structure of private gardens on urban biodiversity makes behaviors of private garden owners central to conservation and enhancement of biodiversity in urban areas (Goddard et al., 2010). Actions that increase biodiversity by providing resources and habitats for wildlife have been referred to as wildlife gardening, pro-biodiversity gardening, or ecological gardening practices (Gaston et al., 2007; Goddard et al., 2013; Lindemann-Matthies and Marty, 2013; Prévot et al., 2018). These actions can be understood as a form of land stewardship, which is considered one facet of pro-environmental behavior (Jones et al., 2021; Larson et al., 2015; Mumaw and Bekessy, 2017). For the remainder of this article as well as in the survey we refer to these actions as wildlife gardening practices, as this term is frequently used in the scientific literature and by environmental groups.

While many studies have investigated the influence of social, economic, and cultural factors on management decisions in private gardens, more research is needed to understand the individual-level determinants of gardening practices that enhance and conserve biodiversity (Aronson et al., 2017; Cook et al., 2012; Goddard et al., 2017). Recent studies have explored the prevailing motivations of people to participate in local programs that aim to encourage biodiversity in private gardens (Jones et al., 2021; Mumaw and Bekessy, 2017; Raymond et al., 2019). Indicators of private garden biodiversity and the extent of engagement in wildlife gardening practices have been found to be associated with a range of socio-demographic variables, such as age, education, and income (Coisnon et al., 2019; Goddard et al., 2013; Hope et al., 2003; Luck et al., 2009). Furthermore, garden characteristics that support garden biodiversity have been shown to be associated with householders' values, attitudes, and personality traits (Larson et al., 2010; van den Berg and van Winsum-Westra, 2010; van Heezik et al., 2013). The present study extends our knowledge of the predictors of private garden biodiversity by employing a theory-driven approach, the theory of planned behavior (TPB), to examine the psychological factors that affect private garden biodiversity. Using this theoretical framework to explain gardening behavior may provide transferable insights to programs that aim to enhance urban biodiversity.

1.1. *The theory of planned behavior, its extension, and in the context of private gardens*

The TPB is a widely used theory to explain human behavior (Ajzen, 1991). It has also been applied to design and evaluate interventions to change behavior in a variety of domains (Fishbein and Ajzen, 2010; Steinmetz et al., 2016). According to the TPB (Ajzen, 1991), the likelihood of one's engagement in a certain behavior is dependent on one's intention to do so. Intention is influenced by three factors, attitude toward the behavior, subjective norm, and perceived behavioral control. The TPB further suggests that each of these three constructs is determined by a corresponding set of readily accessible beliefs, namely behavioral beliefs, normative beliefs, and control beliefs. Several studies have used the TPB to explain pro-environmental behaviors, for example the use of public transport (Bamberg et al., 2003), food wasting behavior (Visschers et al., 2016), and energy saving behavior (Harland et al., 1999). The present study applies an extended version of the TPB to predict people's intention to engage in wildlife gardening and wildlife gardening behaviors, indicated by the number of wildlife-friendly features in their gardens. The extension of the TPB includes nature connectedness, which has been shown to be associated with a range of pro-environmental behaviors (Mackay and Schmitt, 2019), as an additional predictor of intention (Fig. 1). In the remainder of this subsection we describe the constructs of the TPB and review research that supports the expected relationships of the TPB in the context of private gardens.

The hypothesized relationship between behavior and intention in the framework of the TPB implies that behaviors are regarded as volitional, a result of intention (Ajzen and Schmidt, 2020). Biodiversity levels in private gardens are assumed to be largely dependent on management decisions by owners or tenants (Cook et al., 2012; Dewaelheyns et al., 2016; Goddard et al., 2010). Garden management practices may have a stronger impact on garden biodiversity than garden size or biophysical conditions (Hope et al., 2003; Loram et al., 2008; Luck et al., 2009). Members of local community programs that encourage the adoption of wildlife gardening practices report that providing habitats for wildlife is one of the main goals for their participation in the program (Jones et al., 2021; Raymond et al., 2019). In accordance with the TPB, private garden biodiversity should be predicted by intention if it is the result of owners' or tenants' deliberate management decisions. We thus hypothesized that people's intention to engage in wildlife gardening would be positively associated with the number of wildlife-friendly features (feature richness) in their gardens (Hypothesis 1).

Attitude toward the behavior refers to the degree to which people evaluate their engagement in the behavior of interest as positive or negative. It is determined by the expected consequences of carrying out the behavior (behavioral beliefs). Attitude toward the behavior has been shown to be associated with intentions to engage in pro-environmental behaviors generally (de Leeuw et al., 2015) and stewardship behaviors in particular (Bruskotter et al., 2015). People who engage in wildlife gardening practices are motivated by a range of positive outcomes that they associate with wildlife gardening, such as enjoyment from seeing wildlife in their gardens, beautifying their garden, and supporting the

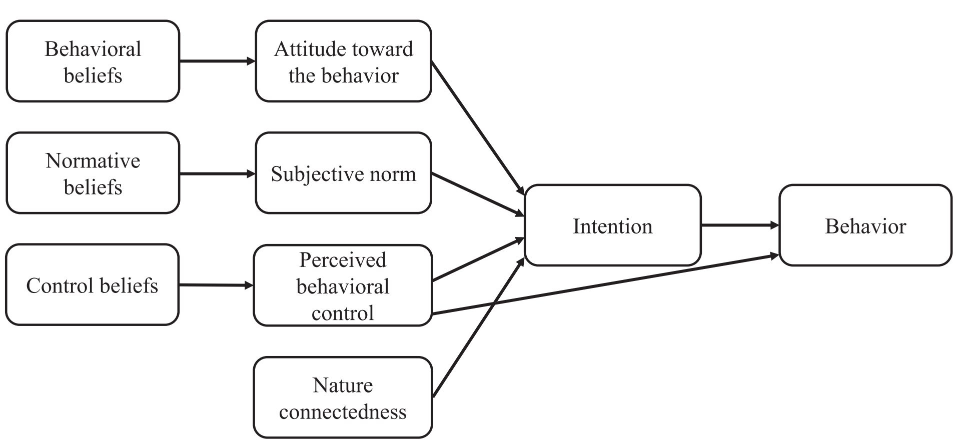

Fig. 1. Extended theory of planned behavior with nature connectedness added to the original theory of planned behavior (Ajzen, 1991) for the purposes of this study.

environment (Goddard et al., 2013; Jones et al., 2021; Mumaw and Bekessy, 2017; Raymond et al., 2019). We thus hypothesized that attitude toward the behavior would be positively associated with intention to engage in wildlife gardening (Hypothesis 2).

Subjective norm is the perception of social pressures imposed by important others to engage in the behavior of interest. It is determined by beliefs about whether certain groups of people would approve or disapprove of one's engagement in the behavior (normative beliefs). Norms have been identified to exert an immense influence on gardening practices, especially neighborhood norms (Kurz and Baudains, 2010; Nassauer, 1995; Nassauer et al., 2009). Maintaining a neat and tidy garden is often perceived as the predominant cultural norm by householders in Western countries and can be a major barrier to the adoption of wildlife-friendly gardening practices, the latter which imply a certain degree of wildness (Dewaelheyns et al., 2016; Goddard et al., 2013; Nassauer, 1995). Therefore, we predicted that subjective norm would be positively associated with intention to engage in wildlife gardening (Hypothesis 3).

Perceived behavioral control refers to the extent to which people think that they are able to carry out the behavior. It is influenced by the presence of certain factors, such as resources or obstacles, that are expected to facilitate or deter from adopting the behavior (control beliefs). Householders perceive knowledge to be an important resource for increasing biodiversity in their gardens (Goddard et al., 2013; Lindemann-Matthies and Marty, 2013). This finding is supported by studies that show a relationship between ecological knowledge and engagement in wildlife gardening practices (Prévot et al., 2018) and tree species diversity in private gardens (van Heezik et al., 2013). Wildlife gardening practices can be perceived as more time consuming and expensive than conventional gardening practices (Dewaelheyns et al., 2016). In one intervention study that provided householders with wildlife-supporting garden features, participants identified cost and time as the major barriers to the continuation of the use of these features in their gardens (van Heezik et al., 2020). We hypothesized that perceived behavioral control would be positively associated with intention to engage in wildlife gardening (Hypothesis 4). Furthermore, the TPB suggests that perceived behavioral control affects behavior directly. Therefore, we predicted that perceived behavioral control would be positively associated with feature richness (Hypothesis 5).

1.2. Nature connectedness

Nature connectedness refers to individuals' sense of interconnectedness between oneself and nature and entails cognitive and affective aspects of their relationship with nature (Clayton, 2003; Mayer and Frantz, 2004; Schultz, 2002a). Several self-report measures with varying emphasis on the relationship dimensions of nature connectedness and different terminologies have been developed (Tam, 2013). Nature connectedness is assumed to be fairly stable over time and shaped by experiences with nature during both child- and adulthood (Cleary et al., 2018; Nisbet et al., 2009). There has been growing interest in the study of nature connectedness among environmental researchers, as nature connectedness is associated with a variety of pro-environmental behaviors (Mackay and Schmitt, 2019; Whitburn et al., 2019). It has long been argued that a feeling of being part of nature is a requirement for people to engage in actions to protect nature (Leopold, 1949; Mayer and Frantz, 2004; Roszak, 1995). Schultz (2000, 2002a) proposed that, similar to the mechanism behind the effect of social connectedness on pro-social behavior, a strong relationship with nature makes people empathize and care for nature, which results in stronger intention to engage in actions that protect nature.

In the context of private gardens, nature connectedness has been found to be associated with the extent to which people engage in wildlife gardening practices (Kiesling and Manning, 2010; Prévot et al., 2018). Nature connectedness has also been linked directly to garden characteristics and indicators of biodiversity. That is, nature connectedness was associated with tree cover (Lin et al., 2017) as well as feature richness and plant growth form richness in private gardens (Samus et al., 2022). Gardens serve as spaces to express one's identity generally and relationship with nature in particular (Freeman et al., 2012; Gross and Lane, 2007). Nature connectedness may promote pro-environmental behavior through an increased desire to protect nature (Zelenski et al., 2015) and private gardens enable people to engage in behaviors that protect nature in their immediate living environment, while seeing the immediate results of their behavior. Therefore, we hypothesized that nature connectedness would be positively associated with intention to engage in wildlife gardening (Hypothesis 6).

1.3. The present study

The present study has two main aims. First, we examine an extended version of the TPB to predict people's intention to engage in wildlife gardening and feature richness in their gardens. We explore the impact of nature connectedness on intention to engage in wildlife gardening by adding it as an additional predictor of intention to the TPB. Ajzen (1991) has stressed the openness of the theory to the inclusion of new predictors and studies have supported the addition of predictors, such as self-identity, to the TPB (Conner, 2020; Rise et al., 2010). Previous studies have also included nature connectedness as a predictor in the framework of the TPB (Hinds and Sparks, 2008; Weber et al., 2020). For example, nature connectedness has been shown to be positively associated with the intention to reduce energy consumption (Sparks et al., 2014) and the intention to reduce the use of air-conditioning in homes (Lam et al., 2022) after accounting for attitude toward the behavior, subjective norm, and perceived behavioral control. Our study adds to the growing body of research on the relationship between nature connectedness and pro-environmental behavior by examining a behavioral dimension that lacks systematic, theory-driven investigation. This study identifies the main contributing factors and their relative contribution to the prediction of people's engagement in behaviors that enhance biodiversity in private gardens.

The second aim of our study is to explore the beliefs people hold about wildlife gardening and to assess their impact on the three TPB constructs, attitude toward the behavior, subjective norm, and perceived behavioral control. An integral part of a successful application of the TPB to understand behavior and design interventions is pilot research that includes an investigation of readily accessible beliefs toward the behavior through qualitative research approaches (Ajzen, 2015; Ajzen and Schmidt, 2020). In accordance with the guidelines of the TPB (Ajzen, 1991; Ajzen and Schmidt, 2020), the present research includes a pilot study that explores behavioral, normative, and control beliefs toward wildlife gardening. The findings from the pilot study are then used in the main study, specifically to test the impact of the beliefs on the predictors of intention. We do not form any specific hypotheses about these relationships but expect that the beliefs identified in the pilot study will be associated with the corresponding constructs of the TPB in the main study. Identifying the most important beliefs about wildlife gardening will help municipalities and community groups in the development of interventions that aim to enhance biodiversity in private gardens and overall urban biodiversity.

2. Methods

Ethical approval for this study was granted by the departmental ethics committee. The procedure and development of measures followed the guidelines for research within the framework of the TPB (Ajzen, 1991; Ajzen and Schmidt, 2020; Fishbein and Ajzen, 2010). First, as indicated above, we conducted a pilot study that explored salient behavioral, normative, and control beliefs using an online survey with questions in an open answer format. We identified the prevailing beliefs through content analysis and then created survey items which were used in the main study. Second, we tested our six hypotheses relating to the extended TPB in an online survey with a multi-city sample from New Zealand. Here we also examined the relationships between the prevailing beliefs identified in the pilot survey and the respective TPB constructs; attitude toward the behavior, subjective norm, and perceived behavioral control.

Fishbein and Ajzen (2010) recommend clearly defining the behavior in terms of four elements; action, target, context, and time. We thus define our behavior of interest as engagement (action) in different kinds of wildlife gardening practices (target) in people's gardens (context) over the next summer (time). In line with the principle of compatibility (Fishbein and Ajzen, 2010), survey questions in the present study that directly related to the behavior referred to this definition, either in the wording of the specific survey item or in the introduction of a set of items. Because wildlife gardening practices comprise several different actions in gardens and there may not be a commonly shared understanding among study participants, we provided a definition of wildlife gardening in the beginning of both the pilot study and main study. We first asserted that "wildlife gardening aims to increase the number and variety of native animals and plants in your garden". We then listed three groups of actions and practices that comprise wildlife gardening along with a few examples: first, adding and maintaining certain elements and items (e.g., insect hotel), second, planting, nurturing, and keeping plants (e.g., flowering plants), and third, managing the garden in a way to become wilder (e.g., leaving dead wood in the garden). The measures of our dependent variables, intention to engage in wildlife gardening and feature richness, captured these three groups of wildlife gardening practices to ensure that measures of all the variables were compatible with each other.

2.1. Pilot study

In order to identify the salient beliefs about wildlife gardening, we used a quota sampling approach to achieve a sample that represents a diverse demographic. The sample included people with access to a private garden from Dunedin, the second largest city in South Island, New Zealand. The participants had participated in a previous study (Samus et al., 2022) which enabled us to iteratively invite participants to our study based on the quotas that we selected beforehand. We aimed for at least 20 participants and stopped recruitment as soon as the sample was fairly evenly distributed by age, garden size, and urban district. Participants ($N = 23$) came from seven different age groups (18–24 years = 8.7 %, 25–34 = 17.4 %, 35–44 = 17.4 %, 45–54 = 17.4 %, 55–64 = 17.4 %, 65–74 = 17.4 %, over 75 = 4.3 %), had gardens ranging from <25 m^2 (very small) to >800 m^2 (very large) in size (very small = 8.7 %, small = 26.1 %, medium = 21.7 %, large = 26.1 %, very large = 17.4 %), and came from 20 different urban districts (no more than two participants from the same district). Participants had the chance to win one out of five NZD 80 vouchers from a national grocery store chain.

The participants answered ten questions in an open answer format adapted from Fishbein and Ajzen (2010). Each question was followed by five lines in which participants could write their answers. Questions exploring behavioral beliefs asked respondents about the advantages and disadvantages of engaging in wildlife gardening and the things that they would like/enjoy and dislike/hate about engaging in wildlife gardening. One question also asked people about any other things that came to mind when thinking about wildlife gardening. Normative beliefs were explored by asking participants to list the persons or groups of people that would approve or disapprove of their engagement in wildlife gardening practices. One additional question asked them to list people they might want to talk to before engaging in wildlife gardening practices. Control beliefs were assessed by asking respondents to list any factors or circumstances that would make it easy or enable them and make it difficult or prevent them from engaging in wildlife gardening practices. We used content analysis to identify the most common themes relating to respondents' behavioral, normative, and control beliefs about wildlife gardening. Following Ajzen and Schmidt's (2020) recommendation, themes that were listed by at least 25 % of the sample were translated into items for the main study.

2.2. Main study

2.2.1. Sample

We selected four cities with a wide range of population sizes and in different geographic locations in New Zealand. Auckland and New Plymouth are located in North Island whereas Christchurch and Dunedin are located in South Island. The study was advertised on social media (Facebook) in groups of local neighborhoods and districts, job search groups, and classified advertisements. Participants had the chance to win one out of five NZD 80 vouchers from a national grocery store chain. Only participants who had access to a garden at their current home and were allowed to do gardening work in their garden were included in the study. Participants who did not live in one of the four urban areas were excluded from the study. In total, 695 participants were included in the analysis. People living in Christchurch made up the largest portion of the sample (36.7 %), followed by Auckland (25.8 %), Dunedin (21.4 %), and New Plymouth (16.1 %). Participants came from six different age groups (18–24 years = 12.1 %, 25–34 = 18.3 %, 35–44 = 24.9 %, 45–54 = 21.3 %, 55–64 = 13.1 %, 65–74 = 9.1 %, 75 and over = 1.3 %) and the majority of the sample was female (89.6 %).

2.2.2. Measures

2.2.2.1. Behavioral beliefs. Following Fishbein's (1963) expectancy-value model of attitudes, behavioral belief scores were determined through the product of the scores on an item pair, belief strength and outcome evaluation. Belief strength refers to the perception that a behavior will result in a certain outcome whereas outcome evaluation is the degree to which that outcome is evaluated as positive or negative. Therefore, for each behavioral belief theme identified in the pilot study two items were created and the scores on these two items were then multiplied by each other. Consistent with the standard procedure of the TPB (Ajzen, 1991; Fishbein and Ajzen, 2010), the expectancy-value model was applied to normative beliefs and control beliefs, too.

Participants' agreement with nine statements relating to belief strength (e.g., "My engaging in different kinds of wildlife gardening practices would make my garden messy.") was assessed on 7-point scales from "strongly disagree" (1) to "strongly agree" (7). The corresponding outcome evaluations ("A messy garden is …") were rated on 7-point scales from "very bad" (1) to "very good" (7). Outcomes that were very unlikely to be evaluated as negative (e.g., "Activities that enhance my health and well-being are …") were rated on 7-point scales from "not important at all" (1) to "very important" (7) to prevent ceiling effects.

2.2.2.2. Normative beliefs. Four normative belief scores were generated by multiplying the strength of the normative belief, which are perceived expectations of different groups of people, with participants' motivation to comply with the expectations of that group. The strength of the normative belief was assessed by asking respondents to indicate their agreement with statements (e.g., "My friends think that I should engage in wildlife gardening practices.") on 7-point scales from "strongly disagree" (1) to "strongly agree" (7). Motivation to comply (e.g., "When it comes to my garden, I want to do what my friends think I should do.") was rated on 7-point scales from "strongly disagree" (1) to "strongly agree" (7).

2.2.2.3. Control beliefs. Four control belief scores were created by multiplying belief strength, which is the perception that a certain factor affecting engagement in the behavior will be present, with the power of the belief, which refers to the perceived influence that factor will have on one's engagement in the behavior. Belief strength was assessed by asking people about the likelihood that they possess four different things over the next summer (e.g., "Information and knowledge about wildlife gardening") on 7-point scales from "very unlikely" (1) to "very likely" (7). Power of the belief was assessed by asking people whether the presence of each of these factors would make it easier/more difficult to engage in wildlife gardening. Participants responded on a 7-point scale from "no, not at all" (1) to "yes, very much" (7).

2.2.2.4. Attitude toward the behavior. We used semantic differential scales with six pairs of adjectives to assess people's attitude toward the behavior. Participants evaluated their potential engagement in wildlife gardening practices (i.e., "My engaging in different kinds of wildlife gardening practices over the next summer would be…") on 7-point scales (e.g., from "foolish" [1] to "wise" [7]). The pairs included adjectives that tapped into both instrumental (foolish-wise) and experiential (unpleasant-pleasant) attitude dimensions. The measure showed adequate internal consistency (Cronbach's α = 0.94).

2.2.2.5. Subjective norm. Respondents indicated their agreement toward two statements relating to subjective norm (i.e., "Most people whose opinion I value, think that I should engage in a variety of wildlife gardening practices over the next summer." and "Most people I care about think that I should engage in different kinds of wildlife gardening practices over the next summer.") on 7-point scales from "strongly disagree" (1) to "strongly agree" (7). The measure was internally consistent (Cronbach's α = 0.82).

2.2.2.6. Perceived behavioral control. Two items assessed respondent's perceived behavior control on 7-point scales. People rated one statement (i.e., "For me engaging in different kinds of wildlife gardening practices over the next summer would be…") from "very difficult" (1) to "very easy" (7) and another statement (i.e., "If I wanted to, I could easily engage in various wildlife gardening practices over the next summer.") from "strongly disagree" (1) to "strongly agree" (7). The measure was internally consistent (Cronbach's α = 0.72).

2.2.2.7. Nature connectedness. We used the Connectedness to Nature scale by Mayer and Frantz (2004) to assess participants' nature connectedness. The Connectedness to Nature scale assesses people's affective relationship with nature. It includes 14 statements (e.g., "I often feel a sense of oneness with the natural world around me.") that were rated on 7-point scales from "strongly disagree" (1) to "strongly agree" (7). The scale yielded acceptable internal consistency (Cronbach's α = 0.84).

2.2.2.8. Intention. Intention to engage in wildlife gardening practices was assessed with five items on 7-point scales. One question each referred to the three dimensions of wildlife gardening practices presented in the introduction of the survey, such as items, plants, and wildness (e.g., "How many different types of plants that attract native wildlife do you intend to plant or keep in your garden over the next summer?"). Participants responded on 7-point scales from "none" (1) to "a lot" (7). The other two items referred to wildlife gardening practices in general (e.g., "I intend to engage in different kinds of wildlife gardening practices in my garden over the next summer"). They were rated on 7-point scales from "strongly disagree" (1) to "strongly agree" (7). The measure was internally consistent (Cronbach's α = 0.91).

2.2.2.9. Behavior. Feature richness of participants' gardens served as an indicator of behavior. We assumed that the number of wildlife-supporting features present in people's gardens is the result of actions to add and/or maintain those features in the garden. Participants indicated whether certain elements and items (e.g., insect hotel, bird feeder), plants (e.g., berry-bearing plants, flowers), or wildness characteristics (e.g., deadwood, a wild/undisturbed area) are present in their garden from a list of 15 features (please see the Appendix for the complete list of features). The features on the list support biodiversity by providing resources and habitats for wildlife and were chosen from measures that have been used in previous studies on private gardens (e.g., Davies et al., 2009; Gaston et al., 2005; Goddard et al., 2013; Samus et al., 2022; Young et al., 2019).

2.2.3. Analytical approach

We conducted structural equation modeling using IBM AMOS 27 with maximum likelihood estimation. Due to the large number of beliefs identified in the pilot study, we conducted separate analyses to first test the extended TPB without the belief variables, and second, predict attitude toward the behavior, subjective norm, and perceived behavioral control from the belief variables. This approach enabled us to test our hypotheses in relation to the extended TPB and then identify the most important beliefs that influence the predictors of intention.

We used parceling to create three indicators for each of the latent variables, attitude toward the behavior, nature connectedness, and intention. Parceling increases the reliability of the indicators and reduces the number of parameters that need to be estimated (Bandalos, 2002; Little et al., 2002). Item-to-construct parceling was used to establish indicators that have balanced factor loadings to the latent variables (Little et al., 2002). Missing data were handled with the full information maximum likelihood approach implemented in AMOS, which makes use of all available data and generates less biased estimates than listwise or pairwise deletion (Enders and Bandalos, 2001).

A two-step approach was used to test the extended TPB model (Anderson and Gerbing, 1988; Kline, 2014). We first assessed the fit of the measurement model through confirmatory factor analysis to identify potential sources of misspecification. The model included five latent variables; attitude toward the behavior, subjective norm, perceived behavioral control, nature connectedness, and intention. We then evaluated the fit of the structural model that included the aforementioned latent variables and one observed variable, which is feature richness. We also tested an alternative structural model without nature connectedness, that is the original model of the TPB, to identify the incremental variance explained in intention by the extended TPB. For the assessment of the influence of belief scores on the corresponding TPB construct, attitude toward the behavior, subjective norm, and perceived behavioral control, we used multiple indicators multiple causes (MIMIC) models, which includes both reflective and formative indicators (Kline, 2014). The formative indicators are the belief scores as they are expected to cause changes in the latent variable whereas the reflective indicators are the items or parcels that reflect changes in the latent variable (Sok et al., 2021, please also see this article for a discussion of MIMIC models in the framework of the theory of planned behavior).

We relied on fit indices such as the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA) to evaluate the fit of our models to the data. CFI and TLI values > 0.95 and RMSEA values < 0.05 were considered a good fit and values >0.90 and <0.08 respectively were considered an acceptable fit (Brown, 2006; Hu and Bentler, 1999). We also report the chi-square test statistic but give preference to the fit indices as the chi-square test is highly sensitive to sample size.

3. Results

3.1. Extended theory of planned behavior

The measurement model showed a good fit to the data, $\chi^2(55) = 104.187$, $p < .001$, CFI = 0.992, TLI = 0.987, RMSEA = 0.036. The factor loadings on the latent variables were all significant at $p < .001$ and ranged from 0.69 to 0.96. The measurement model indicated an adequate specification of the latent variables and was thus suitable for further analysis. The structural model fit the data well, $\chi^2(66) = 127.065$, $p < .001$, CFI = 0.991, TLI = 0.985, RMSEA = 0.037. The model explained 75.0 % of the variance in intention and 31.2 % of the variance in feature richness. The structural model with standardized path coefficients is displayed in Fig. 2. In line with Hypothesis 1, intention to engage in wildlife gardening was significantly associated with feature richness, $\beta = 0.55$, $p < .001$. Hypothesis 2 is not supported as attitude toward the behavior was not significantly related to intention, $\beta = 0.05$, $p = .124$. The results support Hypothesis 3 and 4 as subjective norm, $\beta = 0.19$, $p < .001$, and perceived behavioral control, $\beta = 0.59$, $p < .001$, were significantly associated with intention. There was no significant direct relationship between perceived behavioral control and feature richness, $\beta = 0.02$, $p = .838$, which does not support Hypothesis 5. The results support Hypothesis 6 as nature connectedness was significantly associated with intention, $\beta = 0.23$, $p < .001$.

The structural model that excluded nature connectedness showed a good fit to the data, $\chi^2(37) = 74.755$, $p < .001$, CFI = 0.993, TLI = 0.987, RMSEA = 0.038. The model explained 70.9 % of the variance in intention. Thus, the incremental variance explained in intention by the model including nature connectedness was 4.1 %. Intention was significantly associated with attitude toward the behavior, $\beta = 0.12$, $p < .001$, subjective norm, $\beta = 0.21$, $p < .001$, perceived behavioral control, $\beta = 0.65$, $p < .001$, and feature richness, $\beta = 0.52$, $p < .001$. The direct path between perceived behavioral control and feature richness was not significant, $\beta = 0.04$, $p = .621$.

3.2. Beliefs

The model predicting attitude toward the behavior showed a good fit to the data, χ^2 (18) = 53.875, $p < .001$, CFI = 0.990, TLI = 0.957, RMSEA = 0.054, and explained 29.1 % of the variance in attitude toward the behavior. The fit indices for the model predicting subjective norm suggest an acceptable fit to the data as two fit indices, the CFI and TLI, met the recommended threshold while the RMSEA slightly missed it, χ^2 (3) = 19.126, $p < .001$, CFI = 0.990, TLI = 0.930, RMSEA = 0.088. The model explained 58.6 % of the variance in subjective norm. The model predicting perceived behavioral control had a good fit to the data, χ^2 (3) = 4.376, $p = .224$, CFI = 0.998, TLI = 0.984, RMSEA = 0.026. The model explained 40.2 % of the variance in perceived behavioral control. The path coefficients are displayed in Table 1.

Table 1
Standardized path coefficients between beliefs and the corresponding theory of planned behavior construct ($N = 695$).

Belief	β	p
Behavioral beliefs on attitude toward the behavior		
My engaging in different kinds of wildlife gardening practices would enhance my health and well-being.	0.24	<0.001
If I engage in different kinds of wildlife gardening practices, I will see and hear a lot of wildlife in my garden.	0.17	<0.001
If I engage in different kinds of wildlife gardening practices, I will help to protect the natural environment.	0.15	<0.001
My engaging in different kinds of wildlife gardening practices would cost a lot of money.	−0.11	0.003
If I engage in different kinds of wildlife gardening practices, it will attract unintended wildlife to my garden.	−0.07	0.035
If I engage in different kinds of wildlife gardening practices, I will learn new things.	0.05	0.228
My engaging in different kinds of wildlife gardening practices would improve my relationships with other people.	0.04	0.318
My engaging in different kinds of wildlife gardening practices would take up a lot of my free time.	0.03	0.427
My engaging in different kinds of wildlife gardening practices would make my garden messy.	−0.02	0.662
Normative beliefs on subjective norm		
Environmentalists think that I should engage in wildlife gardening practices.	0.34	<0.001
My friends think that I should engage in wildlife gardening practices.	0.31	<0.001
My family thinks that I should engage in wildlife gardening practices.	0.28	<0.001
My neighbors think that I should engage in wildlife gardening practices.	0.06	0.135
Control beliefs[a] on perceived behavioral control		
Information and knowledge about wildlife gardening	0.39	<0.001
Lack of time[b]	0.38	<0.001
Access to affordable plants and gardening supplies	0.14	<0.001
Poor health[b]	0.08	0.047

Note. Belief scores were generated according to the expectancy-value model (e.g., behavioral belief scores are the result of belief strength multiplied by outcome evaluation). For ease of interpretation the belief strength is used as a label for the belief score.

[a] These statements were introduced by "How likely is it that you will have the following over the next summer?"

[b] These items were recoded.

4. Discussion

Private gardens cover an enormous area in cities, which points to the importance of private garden design for the enhancement and

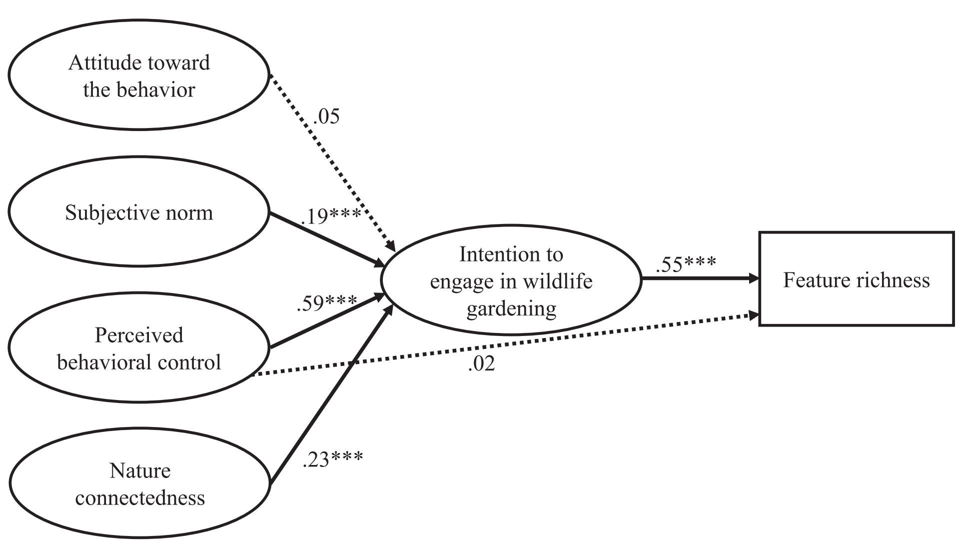

Fig. 2. Standardized path coefficients of the extended theory of planned behavior predicting wildlife gardening practices ($N = 695$).
····▶ = non-significant path.
***$p < .001$.

conservation of urban biodiversity. We tested an extended TPB to identify the psychological factors that influence engagement in gardening practices that support biodiversity. Our results indicate that feature richness in private gardens can be explained by the extended TPB. The stronger the intention of people to engage in wildlife gardening was, the more wildlife-friendly features they had in their gardens. In line with the core assumption of the TPB that behavior is volitional, determined by intention, our findings provide empirical evidence in support of the assumption that private garden biodiversity is affected by owners' or tenants' deliberate management decisions. We thus emphasize the role of psychological factors as drivers of behaviors that enhance garden biodiversity. To a large extent intention was predicted by perceived behavioral control, nature connectedness, and subjective norm. Intervention programs may address these factors to enhance garden biodiversity in urban areas.

Nature connectedness was a significant predictor of the intention to engage in wildlife gardening after accounting for attitude toward the behavior, subjective norm, and perceived behavioral control. Private gardens are spaces that display people's identity (Gross and Lane, 2007). They enable people to express and sustain their relationship with nature, for example by observing wildlife and plants growing or actively supporting them through gardening activities (Freeman et al., 2012; Raymond et al., 2019), which may then increase the number of features that support wildlife in their gardens. People with strong nature connectedness may have biodiversity-rich gardens because they want to make an active contribution to the environment. Nature connectedness promotes pro-environmental behaviors through an increased concern for nature and willingness to protect nature (Dutcher et al., 2007; Zelenski et al., 2015). People's efforts to increase biodiversity in their gardens are often motivated by a concern for the environment, too (Goddard et al., 2013). Another reason may be that people with strong nature connectedness value the aesthetics of biodiversity-rich landscapes. Nature connectedness has been found to be positively associated with preferences for landscapes that are wilder and have more vegetation as well as with the biodiversity levels of the public green spaces that they have visited (van Heezik et al., 2021). People's aesthetic preferences are manifested in their gardens (Conway, 2016; Kendal et al., 2012) and beautifying the garden has been found to be an important motive for people to engage in wildlife gardening practices (Jones et al., 2021). Furthermore, Clayton (2007) argued that seeing one's garden as a part of the natural world raises ecological concerns about gardening. Nature connectedness might promote a more inclusive understanding of nature and thus could lead to an increased awareness of the interconnectedness between gardening practices and the environment.

The Connectedness to Nature Scale assesses people's affective relationship with the natural environment (Mayer and Frantz, 2004). Adding an affective component to the TPB may explain additional variance in intention over the other, rather cognitive predictors of the TPB (Sparks et al., 2014). Emotional involvement has been recognized as an important factor that influences engagement in pro-environmental behavior (Kollmuss and Agyeman, 2002). In the context of wildlife gardening, emotions toward wildlife species have been demonstrated to determine people's management decisions (Larson et al., 2016). Emotions also play an important role in the caring for plants, for example certain plants are often associated with meaningful memories (Freeman et al., 2012). Therefore, emotions may play a central role in the relationship between nature connectedness and wildlife gardening. We note that it has been argued that the Connectedness to Nature scale does not measure emotional aspects of connection but rather taps into the cognitive aspects of nature connectedness (Perrin and Benassi, 2009). However, different measures of nature connectedness have been shown to measure the same overarching construct (Tam, 2013).

The fit of the original TPB model, without nature connectedness as a predictor of intention, was comparable to the fit of the extended TPB. However, the extended TPB model had somewhat more explanatory power indicated by the incremental variance explained in intentions. Given that nature connectedness has been shown to predict other types of pro-environmental behavior intention in the framework of the TPB (Lam et al., 2022; Sparks et al., 2014; Weber et al., 2020), interventions that strengthen nature connectedness may be an efficient way to encourage engagement in a number of different types of pro-environmental behavior. Interventions that target broad behavioral categories come with a number of challenges but can be useful when changes in groups of interrelated behaviors are desired (Fishbein and Ajzen, 2010). Pressing environmental problems require large-scale behavior change in a variety of domains. However, more studies that investigate how nature connectedness can be strengthened, and its impact on pro-environmental behavior, are needed.

Intention was also predicted by subjective norm, which in turn was associated with normative beliefs about friends, families, and environmentalists but not neighbors. Neighborhood norms have been recognized as an important determinant of wildlife gardening practices (Goddard et al., 2013; Nassauer, 1995; Nassauer et al., 2009). Although the majority of the participants in the pilot study mentioned neighbors as important social referents in regard to wildlife gardening, it did not have an effect on subjective norm after controlling for normative beliefs about the other groups of people. Subjective norm refers to people's perceptions of whether important others would approve or disapprove of adopting a behavior, which is usually referred to as an injunctive norm. In contrast, descriptive norms refer to perceptions of what other people actually do. Neighborhood norms may act as a descriptive norm on wildlife gardening practices as people conform to the prevailing garden designs in their neighborhood (Kurz and Baudains, 2010). Further research is needed to clarify the role of descriptive and injunctive norms for private garden biodiversity. Furthermore, we note that our findings, especially the ones in regard to neighborhood norms, may be contingent on the cultural context and require cross-cultural replication.

Perceived behavioral control was the strongest predictor of intention in comparison with the other three predictors in the extended TPB. However, the direct path between perceived behavioral control and feature richness was not significant. The additional variance in behavior explained by perceived behavior control varies substantially between different types of behavior (Madden et al., 1992). If a behavior is under high volitional control, intention is usually a strong predictor of behavior and perceived behavior control is less likely to account for additional variance over intention (Fishbein and Ajzen, 2010). Furthermore, our examination of control beliefs revealed that the perception of having access to information and knowledge as well as time were the strongest predictors of perceived behavioral control. Our results corroborate Lindemann-Matthies and Marty (2013), who showed that engagement in wildlife gardening practices was negatively associated with the belief that ecological gardening needs more time than conventional gardening. Because the time people have available for gardening is difficult to change, interventions can aim to change the perception that time is required to engage in wildlife gardening. A variety of actions that provide resources and habitats for wildlife can be adopted to encourage biodiversity in private gardens. Procedural knowledge may thus play an important role in the engagement in wildlife gardening behaviors. The effectiveness of knowledge-based interventions on pro-environmental behaviors is limited, but they might be useful when the adoption of new and complex behaviors is required (Schultz, 2002b).

Given the influence of both perceived behavioral control and subjective norm on intention, encouraging active wildlife gardeners to share their knowledge with friends and family and to convey that wildlife gardening is not very time-consuming may be an effective lever to increasing wildlife gardening intention. In line with Bandura's (1997) notion that vicarious experiences are an important source of self-efficacy, gardening together with friends and family or observing them when gardening may increase people's perceived behavior control (which is a very similar concept to self-efficacy). Interventions that encourage people who are already engaged in biodiversity conservation to persuade and share knowledge with others may be an effective lever to induce behavior change on a communal level (Jones and Niemiec, 2023). Sharing knowledge about gardening or gardening together with other people may also lead to co-benefits relating to well-being though improved social connections, which has been suggested in the context of wildlife gardening programs (Mumaw et al., 2017; Raymond et al., 2019).

Environmental groups may play a central role in promoting wildlife gardening as our data suggest that environmentalists are important social referents concerning wildlife gardening. Municipalities could communicate information on wildlife gardening through ecologists or gardening experts, whether it is in the form of leaflets or in-person. Although a plethora of information on wildlife gardening is easily accessible through the internet, gardening information may have to be communicated by credible sources and tailored to the recipient (Bator and Cialdini, 2000; Daamen et al., 2001). van Heezik et al. (2012) suggested that a recurring dialog between ecologists and householders in the context of a large private garden study, including garden visits, the provision of gardening information, and individual garden feedback by the researchers, has shown to be effective in increasing householders' wildlife gardening knowledge and behavior.

Attitude toward the behavior did not significantly predict intention to engage in wildlife gardening in the extended TPB model. However, in the original TPB model, which did not include nature connectedness, attitude toward the behavior was significantly related to intention. Even in the original TPB model, the relationship between attitude and intention was small in comparison with the other predictors. One explanation may be that a positive attitude toward wildlife gardening does not necessarily result in engagement in wildlife gardening practices because of conflicting values and priorities, such as practicability and cultural norms (Beumer, 2018; Elliot Noe et al., 2021). One study conducted in the USA found attitudes toward the behavior predicted people's intention to buy native plants, while self-efficacy and injunctive norms were not significantly associated with intention (Champine et al., 2022). The contrasting findings between our study and Champine et al. (2022) may be due to the differences in the intention measures, such as buying plants versus gardening in a certain way, or cultural differences.

Our indicator of actual behavior, feature richness, was selected based on the notion that wildlife-supporting features in private gardens are a result of owners' or tenants' actions to add or maintain those features. All participants of this study were able to undertake gardening and landscaping in the garden, which enabled them to exert their intentions in the garden through the addition of new features, the maintenance of existing features, or the removal of inherited features from previous owners. Nevertheless, other factors that may influence feature richness of private gardens are garden size, other people in the household, or previous owners of the house (Goddard et al., 2013; Larsen and Harlan, 2006; Troy et al., 2007; van Heezik et al., 2020). Furthermore, our feature richness measure was determined by past behaviors and thus deviated from the future time perspective attached to the other variables. Predicting past behavior from the intention to engage in a future behavior is a common practice in TPB studies and correlations are often comparable to studies predicting future behavior (Fishbein and Ajzen, 2010). Furthermore, feature richness is a simple measure of biodiversity in private gardens. The presence of plant and non-plant-based features is understood to promote biodiversity by providing resources for a range of species (Gaston et al., 2005; Goddard et al., 2017). Young et al. (2019) demonstrated that the number of wildlife-friendly features was positively associated with plant species richness in private gardens. Feature richness was also found to be associated with biodiversity levels of urban green spaces (Hand et al., 2016).

One limitation of our study is that our sample was strongly biased toward females which may limit the generalizability of our findings. Many studies on gardening have reported a strong bias in their sample toward females (Clayton, 2007; Freeman et al., 2012; Jones et al., 2021), which may be due to women being more interested in gardening and more willing to take the time to share their opinions in surveys than men. However, other studies have suggested that gender does not influence the effect of nature connectedness or the variables of the TPB on pro-environmental behavior (de Leeuw et al., 2015; Mackay and Schmitt, 2019). While our sample was quite diverse in terms of age and geographical location within New Zealand, the findings may not be generalizable to other cultural contexts, especially non-WEIRD (Western, Educated, Industrialized, Rich, and Democratic) countries. Another limitation relates to our analytical strategy, which involved separate tests of the extended TPB model and the three models including the beliefs. While future studies should aim to include the belief items in the main model of the TPB, in the present study it would have led to an unfavorable ratio between the sample size and the number of parameters to be estimated (Kline, 2014). Nevertheless, exploring beliefs toward wildlife gardening in addition to the direct predictors of intention provides a more comprehensive picture of the determinants of gardening practices that support biodiversity.

5. Conclusion

The composition of private gardens has an immense impact on biodiversity in urban areas. Therefore, gardening practices are increasingly recognized as critical to enhancing and conserving urban biodiversity. Using a two-step approach within the framework of the TPB, including qualitative exploration of the prevailing beliefs and quantitative analysis of the psychological factors that influence wildlife gardening, we provide fresh insights into the drivers of private garden biodiversity. Our findings may inform intervention programs that aim to enhance urban biodiversity. We demonstrate that an extended TPB, including nature connectedness as an additional predictor, can explain intention to engage in wildlife gardening and feature richness in private gardens. While nature connectedness has been recognized as an important driver of pro-environmental behavior, our findings indicate that a strong relationship with nature may also promote biodiversity in private gardens. Our results also revealed that perceived behavioral control was the most important predictor of people's intention to engage in wildlife gardening. The perception of having knowledge and information about wildlife gardening as well as time were in turn important predictors of perceived behavioral control. We suggest that enabling people to engage in wildlife gardening, for example by providing information and guidance by experts, may be effective in increasing biodiversity in private gardens. Intervention programs that facilitate communication about wildlife gardening between friends and family and use environmentalists to convey gardening information may promote garden biodiversity through subjective norms. Strengthening nature connectedness is a promising pathway to protect the environment, not only through its association with a range of pro-environmental behaviors, but also by encouraging behaviors that enhance biodiversity in urban areas.

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CRediT authorship contribution statement

Andreas Samus: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Claire Freeman:** Writing – review & editing, Supervision. **Katharine J. M. Dickinson:** Writing – review & editing, Supervision. **Yolanda van Heezik:** Writing – review & editing, Supervision.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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