

Understanding individual and diffusion behaviors related to native plant gardening

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ABSTRACT

While studies have examined factors influencing individual pro-environmental behavior, less research has examined the drivers of “diffusion behaviors” that disseminate new information via social networks. We conducted a survey of single-family households ($n = 337$) using an expanded Integrated Model of Behavioral Prediction to investigate the social-psychological drivers of individual and diffusion behavioral intentions for native plant gardening. We also examined how intentions related to actual behavior and potential moderators of the intention-behavior relationship. We found that while individual behavior-specific knowledge and attitude predict both individual and diffusion intentions, behavior-specific personal norms and self-efficacy predicted diffusion intention, and behavior-specific personal norm influenced individual intention. Contrary to theory, diffusion intentions were influenced by a combination of behavior-specific and non-specific predictors. These results suggest that to motivate diffusion intention, outreach interventions may need to enhance diffusion-specific personal norm and self-efficacy beliefs, rather than just individual behavioral perceptions. Intentions predicted indicators of actual diffusion behavior, as measured through native plant voucher use by individuals and their friends and family. However, these indicators of behavior were not predicted directly by social-psychological variables. Diffusion-specific self-efficacy and subjective knowledge appear to moderate the relationship between diffusion intentions and successful diffusion behavior.

Research has examined how social-psychological factors, such as attitudes, beliefs, and norms, drive individual pro-environmental behaviors such as household energy or water conservation (Bamberg & Möser, 2007; Byerly et al., 2018; Farrow et al., 2017). However, less is known about whether these same perceptual factors influence collective behaviors, such as sharing information, organizing efforts, and applying social pressure, which have the potential to enhance the scale and speed of environmental action (Amel et al., 2017). One understudied collective behavior that might facilitate widespread environmental action is “diffusion” behavior. Diffusion behaviors include sharing information with, reaching out to, and applying social pressure in one’s social network to encourage a specific behavior (Jones & Niemiec, 2020; Niemiec et al., 2021).

1. Diffusion behavior

Distinct from more commonly studied collective action behaviors, such as protesting, contacting politicians, and working together in a group for environmental outcomes (Fritzsche et al., 2018; Lubell et al., 2007; Steel, 1996; Stern, 2000; van Zomeren et al., 2008), diffusion behaviors involve informal, persuasive, one-on-one engagement with others in one’s social network (Jones & Niemiec, 2020). Diffusion behaviors range from more passive behaviors like putting a sign in one’s yard to promote native plants, to more active behaviors like teaching someone how to plant a native plant (Jones & Niemiec, in review). Attempts to persuade others (see Cialdini, 2001) as well as interpersonal discussion (see Frank et al., 2012) are examples of social diffusion behavior.

Diffusion behaviors may be especially important for conservation because they can facilitate the spread of information about pro-

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environmental behaviors (PEBs) to less-engaged audiences (Ma et al., 2012; McKiernan, 2017; Rogers, 2003; Snyder & Broderick, 1992) and activate or reinforce norms encouraging PEBs. There is a growing body of literature on the effectiveness of diffusion behaviors on environmental and social issues (Abrahamse & Steg, 2013; Burn, 1991; Carrico & Riemer, 2011; Geiger et al., 2017; Green & McClellan, 2020; Groce et al., 2019). For example, Abrahamse and Steg (2013), conducted a meta-analysis of 29 papers using social influence approaches and found that the block leader approach (another term for relational organizing) was the most effective at influencing conservation behavior. Relational organizing, a type of diffusion behavior, involves mobilizing motivated individuals to encourage people in their social network to behave in a certain way (Niemic et al., 2021). More recently, a get-out-the-vote field experiment found that municipal election turnout rates were significantly higher (13.2 percentage points) in a group that was exposed to peer organizing strategies (i.e., relational organizing) than a control group (Green & McClellan, 2020).

People may be more willing to act on information they receive through diffusion because they trust and listen to individuals perceived as similar to themselves (Burger et al., 2004; Goldberg et al., 2019). Thus, social diffusion may be more influential for changing behavior in addition to, or beyond, attitudes. Even without an existing norm for a behavior, diffusion behavior can create the perception that a new behavior is gaining popularity and inspire more rapid behavior change (Sparkman & Walton, 2017, 2019). Diffusion behaviors can also create social pressure to behave in a certain way because the actions in one's social circle encourage behavior change to achieve conformity (McKiernan, 2017). While research has examined the effectiveness of diffusion behaviors (Abrahamse & Steg, 2013; Geiger et al., 2017; Rogers, 1983), less is known about what motivates people to participate in such actions.

The few existing studies that have examined the drivers of participation in diffusion behaviors have pointed to the role of social norms and efficacy (Geiger et al., 2017; Lubell et al., 2007; Niemic et al., 2016, 2018; Swim et al., 2014; Swim & Fraser, 2014). For example, the potential to receive social sanctions from neighbors (i.e., injunctive norms) influenced participants' diffusion behaviors for invasive species control (Niemic et al., 2018). An intervention that changed perceptions about how many others care about climate change (i.e., descriptive norms) increased willingness to engage in climate change discussions with others (Geiger & Swim, 2016). Diffusion self-efficacy (i.e., the belief that one can effectively reach out to others) and diffusion response efficacy are correlated with willingness to reach out to others about environmental topics (Hamann & Reese, 2020; Lubell et al., 2007; Niemic et al., 2016; Swim et al., 2014; Swim & Fraser, 2014). An intervention that enhanced diffusion-specific self-efficacy (i.e., providing information on what to say to others) was shown to increase subsequent engagement in climate change discussions (Geiger et al., 2017). Based on this evidence, we posit that diffusion-specific social norms (i.e., injunctive and descriptive norms) and efficacy will influence diffusion behavioral intentions.

While this literature provides preliminary insight into the drivers of diffusion behavior, few studies have directly compared the relative influence of norms, efficacy, and other social-psychological perceptions on diffusion behavior (see Howell et al., 2015; Jones & Niemic, 2020 as exceptions). Furthermore, little is known about the combination of individual and diffusion-specific perceptions that drive individual versus diffusion behavior. It is possible that some individual behavior-specific beliefs are critical for motivating diffusion; for example, people may need a sufficient amount of knowledge and self-efficacy for engaging in the individual behavior before reaching out to others (Jones & Niemic, 2020) or may need to believe that enough others care about the individual behavior (Geiger & Swim, 2016). Social norms may be particularly important for predicting diffusion behavior compared to individual behavior, because diffusion involves engaging with others and is thus a more "public" behavior (Lapinski & Rimal, 2005).

There may also be diffusion-specific beliefs that are important. For example, Jones and Niemic (2020) found that people's perceived ability to reach out to others effectively (i.e., diffusion-specific self-efficacy) and perceived ability to influence others and the environment by reaching out to others (i.e., diffusion-specific response efficacy) impacted diffusion pro-environmental behavior in urban ecosystems. These authors, however, focused on a highly motivated, environmentally conscious sample, and did not examine the role of subjective knowledge, attitude, personal norm, and behavioral intention. A greater understanding of the diverse social-psychological factors influencing individual and diffusion behavior could inform whether unique outreach interventions are needed to motivate diffusion behavior.

1.1. Integrative Model of Behavioral Prediction

To understand the drivers of individual and diffusion behavior, we expanded the Integrative Model of Behavioral Prediction (IMBP), which focuses on social norms, attitudes, and efficacy as predictors of behavioral intentions (See Fig. 1; Fishbein & Yzer, 2003; Yzer, 2012). We based our theoretical model on the IMBP because it incorporates both social norms and efficacy, constructs that have been found to influence both individual and diffusion PEB (Fishbein & Yzer, 2003). Similar to the Theory of Reasoned Action (TRA; Ajzen & Fishbein, 1980), the IMBP has been applied in public health studies and a variety of behavioral studies (Fishbein et al., 2003; Xu et al., 2020).

We expanded the IMPB by adding subjective knowledge and additional types of norms and efficacy. In addition to injunctive norms (i.e., how other people think one ought to behave), we added descriptive norms (i.e., observations of how others behave), dynamic norms (i.e., observations of how others have behaved over time), and personal norms (i.e., one's moral obligation to perform a behavior). Personal norms derive from the Norm Activation Model (NAM) which states that awareness of consequences (of performing or not performing the behavior) and ascription of responsibility to perform that behavior influence personal norms, which then influence PEB (Schwartz, 1977).

In a meta-analysis of studies measuring the influence of norms on conservation behavior, Niemic et al. (2020) identified the need for more studies to include measures of injunctive, descriptive, and personal norms in behavioral intention models. Jones and Niemic (2020) found dynamic norms to be a fourth type of norm that predicts diffusion behavior. We also measured diffusion-specific social response efficacy (i.e., the belief that one's actions will influence other people to behave in a certain way) and diffusion-specific environmental response efficacy (i.e., the belief that one's actions will make a positive impact on the environment) in addition to self-efficacy. We added these variables because they were significant predictors of individual and diffusion PEB in prior studies (Jones & Niemic, 2020; Niemic et al., 2020; Sparkman & Walton, 2017). We included individual behavior-specific and diffusion-specific measures of attitudes, efficacy, and norms.

This study also sought to understand the influence of demographic versus social-psychological variables from our expanded IMPB in predicting individual and diffusion behaviors. Earlier analysis of PEB focused on demographics as predictors, finding that women, highly educated people, and those living in urbanized areas had higher intentions to engage in PEB (Brécard et al., 2009; López-Mosquera et al., 2015; Saphores et al., 2012). While understanding the impact of demographics facilitates the targeting of certain audiences in pro-environmental outreach, research has repeatedly shown that social-psychological variables are stronger predictors of behavior (Botetzagias et al., 2015; Graham-Rowe et al., 2015; Li et al., 2019), so we included demographics here to test their relative predictive power against social-psychological variables.

1.2. Intention-behavior gap

In addition to examining unique drivers of individual and diffusion

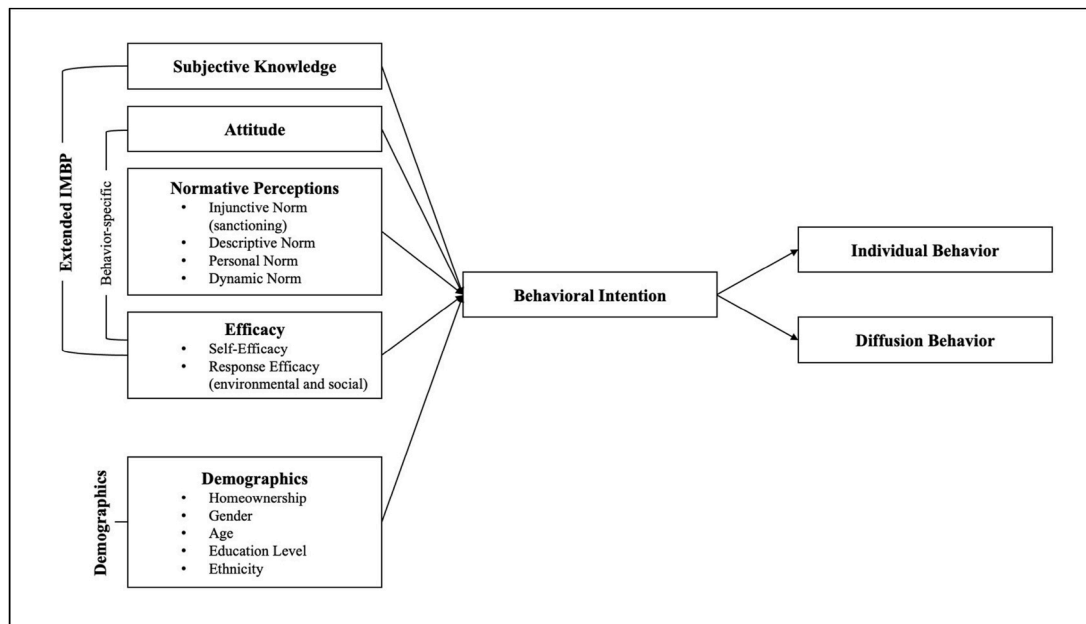


Fig. 1. Full model (extended IMBP + demographics).

behavior, we also explored the link between behavioral intentions and actual behavior. A recent systematic review found that few correlational studies of pro-environmental behavior measured actual behavior; most simply measured behavioral intentions (Niemiec et al., 2020). Nilsson et al. (2020) argues that understanding attitudes has been the focus in conservation studies and that researchers need to shift their attention toward measurable behaviors because behavioral data provides the strongest evidence to guide conservation practices. When studies do measure behavior, often only self-reported behavior is considered (Lange, 2018; Steg & Vlek, 2009). This may introduce social desirability bias as participants respond in ways believed to be socially acceptable by perhaps over-estimating their engagement in PEBs (Ferraro & Price, 2013; Milfont, 2009). Other factors may also influence actual behavior beyond intention, in what is known as the “intention-behavior gap” (Bamberg & Möser, 2007; Carrington et al., 2010; Whitburn et al., 2020). Bamberg and Möser (2007), for example, found a pooled correlation of .52 between intention and behavior. Whether the intention-behavior gap is smaller or larger for diffusion versus individual behaviors remains unknown.

It is possible that certain variables moderate the relationship between intention and behavior. Prior studies have suggested that people’s level of control or beliefs about their self-efficacy to perform a behavior may influence both intention and behavior, and may also moderate this relationship (Ajzen, 2002; Kan & Fabrigar, 2017). According to Sheeran (2001), knowledge, may moderate the intention-behavior gap, because for someone to follow through on their intention, they must have enough knowledge on the subject to do so. Furthermore, there may be external factors that moderate the intention-behavior relationship (Hassan et al., 2016; Kollmuss & Agyeman, 2002). For example, a person may intend to plant a native plant in their yard but are not able to realize this intention because, as a renter, their landlord does not allow it. To further analyze the intention-behavior gap, we explored whether self-efficacy, subjective knowledge, and homeownership moderate the relationship between intention and behavior.

1.3. Case study: native plant gardening

In this article, we examined the drivers of individual and diffusion behavior related to native plant gardening. In response to rapid losses in biodiversity, conservation practitioners and researchers have called for

the creation of habitat in residential areas to support dwindling species (Garbuzov & Ratnieks, 2014; Gill et al., 2016; Klein et al., 2007; Widows & Drake, 2014). One approach to enhance native species habitat in urban areas is to encourage private landowners to plant native plants on their properties (i.e., “wildscaping”; Jones et al., 2021; Lerman & Warren, 2011; Widows & Drake, 2014). Gardens with native plants provide critical habitat for insects, amphibians and birds (Barnes et al., 2020; Goddard et al., 2010; Paker et al., 2014). Yards with native plants also require less water than yards with turf lawns (Vickers, 2006), and can positively impact human wellbeing by increasing people’s wildlife encounters and time spent in biodiverse green spaces (Aerts et al., 2018; Bell et al., 2018; Goddard et al., 2013).

Despite the benefits of native plant gardening, lawns are still popular in U.S. residential areas. American turfgrass lawns take up three times more land than corn, making it the largest irrigated crop in the U.S. (Milesi et al., 2005). When making decisions about yards, people are influenced by social factors ranging from the individual scale (e.g., attitudes, beliefs), to the community (e.g., community associations) and institutional (e.g., rebates for replacing lawns) scale (Cook et al., 2012). Literature finds native plants are becoming more popular and are increasingly being perceived as aesthetically pleasing (Fischer et al., 2014; Hurd et al., 2006; Kurz & Baudains, 2012; Larsen & Harlan, 2006; Peterson et al., 2012). Gillis and Swim (2020) explored U.S. resident’s attitudes and perceived social norms towards sustainable landscaping and found both to be strong predictors of native plant gardening. Research has also found that landscaping decisions in more public spaces (i.e. front yards) are driven by social norms while decisions in the backyard are not (Carrico et al., 2013; Larsen & Harlan, 2006). Given the importance of social influence on sustainable gardening decisions, diffusion behavior related to native plant gardening has the potential to increase native biodiversity by building neighborhood and community norms that favor native plant gardening.

In this article, we studied the drivers of individual and diffusion behaviors and the link between behavioral intentions and indicators of actual behavior (i.e., tracking native plant vouchers that individuals use themselves and give to others via diffusion) using data from a field experiment (Niemiec et al., 2021). Through a mail-based survey and the tracking of voucher usage, we examined three key questions:

1. Which individual and diffusion-specific social-psychological factors in the extended IMBP and demographics model predict individual and diffusion behavioral intentions for native plant gardening? (RQ1) Previous studies find that attitudes, social norms, personal norms, self- and response efficacy predict individual intentions, but these relationships, and the relative importance of individual and diffusion-specific perceptions, have not been directly studied for diffusion intentions. We expect different social-psychological factors will predict individual versus diffusion behavioral intentions.
2. To what extent do intentions predict indicators of actual individual and successful diffusion behaviors? (RQ2) Addressing the intention-behavior gap, we seek to understand the strength of the relationship between intention and behavior in individual and diffusion behavior-related settings. Based on previous studies, we expect there to be a moderate relationship between intentions and behavior.
3. Does self-efficacy, subjective knowledge, or homeownership moderate the gap between individual and diffusion intention and indicators of behavior? (RQ3) Drawing on theorized moderators of behavior, we expect control factors, like self-efficacy and subjective knowledge, and the external factor, homeownership, to moderate intention-behavior relationships in the context of native plant gardening and diffusion.

2. Methods

2.1. Sample and data collection

We examined our research questions through a survey and native plant outreach initiative in the suburban, greater Fort Collins area in northern Colorado (U.S.A). In April 2020, a cover letter, survey, and stamped return envelope was sent to 2000 randomly selected single-family addresses within the city limits. We studied residents living in single-family homes because they are more likely to have space to plant native plants on their properties. The cover letter informed participants that we were interested in their beliefs about native plant gardening and included informed consent language. The survey was conducted under Colorado State University IRB #19-8879H. Participants were given the option to take the survey online via Qualtrics or send back a physical survey with the stamped return envelope. Providing the option to take the survey online or via mail is an increasingly popular survey technique to increase response rates (Stedman et al., 2019). After two weeks, participants received a reminder postcard which included the link to the online survey.

In total, 386 survey responses were returned (response rate = 19%). Seven incomplete surveys and 33 late responses were discarded. 211 of these responses were by mail while 126 of the responses were completed online; mail respondents were slightly older, more female, and had weaker personal norms towards native plant gardening. As part of a larger field experiment (Niemic et al., 2021), participants were exposed to differing messaging conditions one month after the survey was sent out. The one-month delay was intended to measure the link between perceptions and behavioral intentions without the influence of messaging; we discarded survey responses that were received after participants were exposed to messaging. We also removed participants that were missing four or more survey question responses (25% of predictor variables, $n = 9$) to impute missing values more accurately. The final sample included 337 useable surveys. Participants were older, more likely to identify as non-Hispanic and female, more highly educated, and more likely to own their home than the Fort Collins population (see Online Appendices for detailed description of sample demographics).

2.2. Survey measures and procedure

The model drew directly from Jones and Niemic (2020), who examined social-psychological factors influencing wildscaping

behaviors in a highly motivated and environmentally active sample of Fort Collins residents (see Online Appendices for survey questions). We adapted Jones and Niemic's (2020) measures of efficacy and norms and added measures of subjective knowledge about native plant gardening, attitudes, and personal norms towards individual and diffusion native plant gardening behaviors to test our expanded IMBP (Fig. 1; see Online Appendices for survey description). We measured previous behavior by asking participants if they had ever planted a plant specifically for wildlife, planted a native plant, and encouraged someone else to plant a native plant and they provided a yes or no response. Subjective knowledge about native plant gardening was measured with a 5-point unipolar scale from "extremely knowledgeable" to "not knowledgeable at all." Subjective knowledge was the only predictor that did not include individual and diffusion-specific measures (see Online Appendices).

We measured attitudes towards native plant gardening (i.e., individual behavior) and encouraging others to plant native plants (i.e., diffusion behavior). An attitude can be defined as an individual's degree of favorableness toward a specific behavior (Ajzen & Fishbein, 2000). The attitude measures were adapted from Bright and Manfredo (1996). We also measured self-efficacy, an individual's belief in their ability to perform a task or achieve a goal (Bandura, 1977, 1997), and two types of response efficacy, the belief that an action will achieve the expected outcome (Roser-Renouf et al., 2014). We divided response efficacy into environmental response efficacy, the belief that actions will make a positive impact on the environment (also referred to as "indirect goal collective efficacy; Hamann & Reese, 2020) and social response efficacy, the belief that actions will influence other people to behave similarly (following Jones & Niemic, 2020). We adapted self-efficacy, environmental response efficacy, and social response efficacy measures from Jones and Niemic (2020) who adapted them from Geiger et al. (2017) and Lubell et al. (2007). Each type of efficacy included individual and diffusion behavior-specific measures. For example, for individual behavior, environmental response efficacy was measured with the statement, "Planting native plants on my property has a positive influence on native pollinators, birds, and wildlife," and for diffusion, it was measured with the statement, "Convincing other people to plant native plants on their properties will make my own native plants better for wildlife."

We measured individual and diffusion-specific injunctive norms, or the belief that significant others will approve or disapprove of a behavior (Matthies et al., 2012; Niemic et al., 2018), as well as individual and diffusion-specific descriptive norms (i.e., perceptions of other people's behavior), adapted from Niemic et al. (2019). We also measured dynamic norm items (i.e., perceptions of whether the prevalence of a behavior is changing over time), for both individual and diffusion behaviors, following Jones and Niemic (2020) who adapted these items from Sparkman and Walton (2017). Measures of individual and diffusion-specific personal norms (i.e., a person's perception of their moral obligation to do something) were drawn from norm activation theory (Schwartz, 1977) with items adapted from Kim et al. (2012). Behavioral intentions were measured with a scale ranging from "not likely at all" to "extremely likely" for both the individual behavior of purchasing a native plant, and the diffusion behavior of encouraging someone else to plant a native plant. We measured demographics to assess sample representativeness of the Fort Collins population and to determine whether they influence individual and diffusion behaviors, given that demographics tend to correlate with pro-environmental behavior (Digby, 2013).

2.3. Measuring indicators of actual behavior

We obtained indicators of actual behavior from a field experiment (Niemic et al., 2021). Participants were split into four messaging conditions and mailed informational packets about native plant gardening with vouchers to purchase native plants at local nurseries. Each participant received one individual \$10 voucher to buy a native plant for their

property and three \$10 diffusion vouchers to share with friends, neighbors, or family. Diffusion vouchers measured successful diffusion behavior (i.e., someone successfully encouraged someone else to purchase a native plant using the voucher). Each voucher had a unique code, which enabled researchers to partner with local plant nurseries to track voucher use by each participant and their survey responses. The experimental study found few differences in either individual or diffusion voucher use between the different experimental messaging groups. For the present article, we therefore did not separate voucher usage by message condition when examining voucher use by the survey participants. We used binary metrics of individual and diffusion voucher use as indicators for actual individual and diffusion behavior, respectively.

2.4. Data analysis

To handle missing data, we conducted median and mode imputation using the “imputeMissings” package in R before running LASSO regressions (Meire et al., 2016). We ran a LASSO regression to select predictors to avoid overfitting our models, given we had a relatively large number of predictors (22 total) and medium-sized sample ($n = 337$; McNeish, 2015; Ranstam & Cook, 2018). We used the “glmnet” package in R to run a LASSO (Least Absolute Shrinkage and Selection Operator) regression and select predictors for both the individual and diffusion intention models (Friedman et al., 2010). To select the lambda value for our LASSO regression we performed a k-fold cross-validation, a widely used method to find the optimal lambda value (Chetverikov et al., 2021). We ran OLS regressions with LASSO-selected predictors to examine the variables that predict individual and diffusion behavior intentions (RQ1). We also ran a complete-case analysis as a sensitivity analysis to validate the imputed regression tables (i.e., determine consistency of regression outputs; see Online Appendices).

We used the extended IMBP model (i.e., the diffusion-specific and individual-behavior-specific social-psychological variables) plus demographic variables to predict individual and diffusion intentions separately. We included the same variables in each model because we were interested in what individual-specific and diffusion-specific variables differentially predicted individual and diffusion intentions. Checks for multicollinearity indicated that the predictors for each model were not highly correlated ($r < .50$). To determine the relationship between behavioral intentions and indicators of actual behavior (RQ2), we conducted two binary logistic regressions; the first between individual intention and individual voucher use and the second between diffusion intention and diffusion voucher use. We also ran two binary logistic regressions with LASSO-selected predictors to measure the relationship between behavioral predictors and indicators of behavior directly. In answering our third research question (RQ3) and testing for potential moderators, we ran binary logistic regressions predicting voucher use (binary 0/1) with an interaction between behavioral intention and the hypothesized moderator variable for both individual and diffusion behavior. To check the power of our analyses, we ran post-hoc power analyses for our moderation analyses and calculated minimum detectable effects (MDE) for the coefficients in our LASSO-selected regressions (see Additional Methods in Online Appendices for further description).

3. Results

3.1. Individual intention

The median response for intentions to purchase a native plant and encourage others to plant native plants was “moderately likely.” LASSO-selected predictors from the extended IMBP and demographics explained 36% of the variance for the individual intention model (Table 1). In order of strength, positive associations with individual intention included homeownership ($\beta = 0.33$, $p = .02$), individual personal norm ($\beta = 0.26$, $p < .001$), individual attitude ($\beta = 0.17$, $p = .02$), and knowledge ($\beta = 0.17$, $p = .03$). Diffusion descriptive norm ($\beta =$

Table 1

LASSO coefficients and OLS regression for individual intention.

	LASSO	OLS				95% CI
		β	SE	p		
Knowledge	0.17	0.17	0.08	.03	0.01	0.32
Ind. Self-Efficacy	0.08	0.15	0.08	.06	−0.01	0.30
Diff. Self-Efficacy	0.05	0.09	0.07	.20	−0.05	0.23
Ind. Env. Response Efficacy	0.07	0.06	0.07	.37	−0.07	0.19
Diff. Env. Response Efficacy	0.05	0.05	0.06	.40	−0.07	0.18
Ind. Social Response Efficacy	0.08	0.11	0.06	.09	−0.02	0.24
Ind. Descriptive Norm	0.06	0.12	0.07	.07	−0.01	0.25
Diff. Descriptive Norm	−0.09	−0.17	0.06	.01	−0.30	−0.05
Ind. Dynamic Norm	0.02	0.03	0.06	.66	−0.10	0.15
Diff. Injunctive Norm	0.06	0.10	0.06	.10	−0.02	0.22
Ind. Personal Norm	0.17	0.26	0.07	<.001	−0.12	−0.40
Ind. Attitude	0.16	0.17	0.07	.02	0.03	0.32
Own Home	0.22	0.33	0.14	.02	0.05	0.60
Male	−0.11	−0.17	0.12	.15	−0.41	0.06
Age	−0.01	−0.12	0.06	.04	−0.24	0.01
Hispanic/Latinx	−0.02	−0.14	0.18	.44	−0.49	0.21
Adjusted R ²		.36				

Ind. = individual, Diff. = diffusion, Env. = environmental, β = standardized coefficient; SE = standard error; CI = confidence interval.

−0.17, $p = .01$) and age ($\beta = -0.01$, $p = .04$) were negatively associated with intentions to garden with native plants. Four other variables were associated with individual intention, but not significant at the 0.05 level: individual self-efficacy ($\beta = 0.15$, $p = .06$), individual descriptive norm ($\beta = 0.12$, $p = .07$), individual social response efficacy ($\beta = 0.11$, $p = .09$), and diffusion injunctive norm ($\beta = 0.10$, $p = .10$). The individual intention LASSO-selected model had minimum detectable effects (MDE) between 0.17 and 0.50.

Our complete-case OLS sensitivity analysis revealed slightly different results from the imputed analysis, though individual personal norm continued to be a strong predictor of individual intention. Most of the LASSO-selected variables in the imputed model were also found in the complete-case analysis. Individual descriptive norm appears to be a predictor of intention in the complete-case model, and none of the other variables were statistically significant at $p < .05$ (see Online Appendices).

3.2. Diffusion intention

The diffusion intention model (LASSO-selected predictors from extended IMBP and demographics) had a strong goodness-of-fit for

Table 2

LASSO coefficients and OLS regression for diffusion intention.

	LASSO	OLS				95% CI
		β	SE	p		
Knowledge	0.20	0.21	0.05	<.001	0.12	0.31
Diff. Self-Efficacy	0.05	0.13	0.05	.01	0.03	0.22
Ind. Env. Response Efficacy	0.01	0.05	0.05	.38	−0.05	0.14
Diff. Env. Response Efficacy	0.03	0.07	0.05	.16	−0.03	0.16
Ind. Social Response Efficacy	0.04	0.07	0.05	.12	−0.02	0.17
Diff. Social Response Efficacy	0.04	0.06	0.05	.24	−0.04	0.16
Diff. Dynamic Norm	0.00	0.04	0.04	.33	−0.04	0.13
Ind. Personal Norm	0.01	0.01	0.06	.88	−0.11	0.13
Diff. Personal Norm	0.17	0.24	0.06	<.001	0.12	0.37
Ind. Attitude	0.23	0.25	0.05	<.001	0.15	0.36
Diff. Attitude	0.24	0.30	0.06	<.001	0.19	0.41
Adjusted R ²		.64				

Ind. = individual, Diff. = diffusion, Env. = environmental, β = standardized coefficient; SE = standard error; CI = confidence interval.

behavioral studies (adjusted $R^2 = 0.64$, see Table 2). The strongest predictors of diffusion intention were diffusion attitude ($\beta = 0.30$, $p < .001$), individual attitude ($\beta = 0.25$, $p < .001$), and diffusion personal norm ($\beta = 0.24$, $p < .001$), followed by knowledge ($\beta = 0.21$, $p < .001$) and diffusion self-efficacy ($\beta = 0.13$, $p = .01$). The diffusion complete-case LASSO sensitivity analysis selected ethnicity and gender and did not select individual personal norm. The complete-case sensitivity analysis resulted in the same predictors for diffusion intention as the imputed model but also included ethnicity ($\beta = -0.41$, $p = .01$) as a significant predictor at the 0.05 alpha level (see Online Appendices), though ethnicity had the highest percentage of missingness in our sample (10%). The diffusion intention LASSO-selected regression had MDEs ranging from 0.11 to 0.17.

3.3. Linking intentions and predictors to indicators of behavior

Of the 337 survey respondents, 40 used an individual voucher to buy a native plant for themselves. There were 28 diffusion vouchers redeemed at participating nurseries. Individual intention significantly predicted use of an individual voucher (Odds Ratio = 1.55, $CI = 1.16$, 2.12 , $\beta = 0.44$, $SE = 0.15$, $p = .004$) and diffusion intention significantly predicted diffusion voucher use (Odds Ratio = 1.56, $CI = 1.14$, 2.17 , $\beta = 0.44$, $SE = 0.16$, $p = .007$). For each increase in level of individual behavioral intention (ex. from “moderately likely” to “very likely”), participants were 55% more likely to redeem an individual coupon. For each increase in level of diffusion behavioral intention, diffusion coupons were 56% more likely to be redeemed.

Despite the significant correlation between intentions and indicators of behavior, many people with strong intentions did not use vouchers. Of the 69 participants who said they were “very likely” to buy a native plant, only 15 (22%) redeemed a voucher for themselves. While 35 participants claimed they were “very likely” to share a diffusion voucher, only 8 (23%) of these vouchers were redeemed, though it is possible that more vouchers were shared than were redeemed by recipients (see Online Appendices). Our logistic regressions with LASSO-selected variables predicting indicators of behavior found that only education predicted individual voucher use ($\beta = 0.43$, $SE = 0.20$, $p = .03$) and only age predicted diffusion voucher use ($\beta = 0.03$, $SE = 0.01$, $p = .05$). MDEs for the individual behavior LASSO-selected binary logistic regression fell between 0.56 and 1.15 and the diffusion behavior LASSO-selected binary logistic regression had MDEs ranging from 0.42 to 1.51.

3.4. Moderation analyses

The moderation analyses revealed that there were no significant interaction effects between hypothesized moderators and individual intention on behavior (i.e., individual coupon use; see Table S6 in Online Appendices). However, the relationship between diffusion intention and diffusion coupon use was moderated by diffusion-specific self-efficacy ($\beta = 0.42$, $p = .02$) and subjective knowledge about native plants ($\beta = 0.44$, $p = .03$). Our post-hoc power analyses for the moderation analyses revealed that we had enough power ($1 - \beta > 0.80$) for all the interaction effects except one. When measuring individual self-efficacy as a moderator of the relationship between individual intention and behavior we could detect an interaction effect of 0.13 with 73% power given the observed main effects of the interacting variables.

To enhance interpretability, we split the sample into participants with high levels of diffusion-specific self-efficacy (i.e., those who agreed or strongly agreed that they would be able to have a good discussion about native plant gardening with their community members; $n = 81$) and those with low levels (i.e., those who disagreed or strongly disagreed to the previous statement; $n = 143$). Diffusion intention only significantly predicted successful diffusion (i.e., diffusion voucher use) for the high self-efficacy group (Odds Ratio = 4.04, $CI = 1.57$, 14.76 , $\beta = 1.40$, $SE = 0.56$, $p = .01$). Similarly, when splitting the sample by high subjective knowledge (i.e., those who claimed to be moderately, very, or

extremely knowledgeable; $n = 103$) and low knowledge (i.e., those who said they were only slightly knowledgeable or not knowledgeable at all; $n = 85$), only the high knowledge group had diffusion intention as a significant predictor of diffusion voucher use (Odds Ratio = 3.42, $CI = 1.48$, 9.72 , $\beta = 1.23$, $SE = 0.47$, $p = .01$). While homeownership predicts individual intention, it does not appear to moderate the relationship between intention and voucher use for either type of behavior.

4. Discussion

Motivating diffusion pro-environmental behaviors (PEBs) has the potential to enhance the speed and scale of conservation action adoption. Few studies, however, have examined the different drivers of diffusion behavior compared to individual behavior. We examined whether demographics and social-psychological variables from an expanded version of the IMPB predicted individual and diffusion native plant gardening intentions. We also used indicators of actual behavior from a field experiment to examine the link between intentions and behavior. We found that some individual-level perceptions (i.e., subjective knowledge and attitude toward native plant gardening) predicted both individual and diffusion intentions. However, other predictors were specific to the type of behavior; in particular, diffusion intentions were predicted by diffusion-specific self-efficacy and personal norm beliefs, while individual intentions were predicted by individual-specific personal norm.

These findings suggest that individual behavior-specific perceptions alone are not sufficient for understanding diffusion behavior; rather, diffusion-specific perceptions are important to understand diffusion behaviors. For example, a person who feels confident in their ability to plant native plants does not necessarily feel confident in their ability to encourage others to do so. Unique outreach interventions may therefore be needed to target diffusion-specific personal norms and self-efficacy to promote diffusion intention. Approaches to increase levels of subjective knowledge about the topic may be helpful in motivating diffusion intentions alongside diffusion-specific interventions. Further, our findings regarding the role of personal norms and knowledge in predicting both types of behavior provide evidence for the need to expand the Integrative Model of Behavioral Prediction (IMBP) by adding these variables.

The observed effects in our individual intention LASSO-selected model fell within the effects found in a meta-analysis by Bamberg and Möser (2007). Analyzing studies that predicted pro-environmental behavioral intention, the authors found the overall effects of personal norm ($\beta = 0.29$), attitude ($\beta = 0.29$), social norm ($\beta = 0.26$), and perceived behavioral control ($\beta = 0.31$; a concept that grew out of Bandura's work on self-efficacy (Ajzen, 2002)). Our diffusion model's range of MDEs were smaller than the observed effects of these same variables in the literature, though it is important to note that this meta-analysis included studies on individual behavior rather than diffusion behavior. The range in MDEs for our behavior models were above the observed ranges ($\beta = 0.13$ – 0.16) found in Bamberg and Möser (2007) so it is likely we had enough power to detect the expected effect sizes when predicting indicators of behavior.

Our findings partially confirmed the results of a recent meta-analysis that found personal and descriptive norms to be stronger predictors of conservation behavior intentions than subjective/injunctive norms (Niemiec et al., 2020). In the present study, personal norms predicted both individual and diffusion intentions, but subjective/injunctive norms did not. We found that individual-specific descriptive norm was a marginally significant predictor of individual intention, and a significant predictor in the sensitivity analysis, but diffusion-specific descriptive norm negatively predicted individual intentions to purchase a native plant. This finding appears to be counter-normative because participants were more likely to purchase a native plant if they thought other people were not encouraging others to plant native plants.

These findings partially contradict previous literature that has shown a strong positive influence of descriptive norms on conservation

behavior (Farrow et al., 2017; Jones & Niemiec, 2020; Kallgren et al., 2000). This result may have been a reflection of our highly engaged audience, with the majority of participants having previous experience with wildlife friendly and native plant gardening. It is possible that this highly motivated audience of people may be more likely to notice that other people are not talking about it as they are more aware of the topic and discussions around it. This trend in our sample may be due, in part, to an increased likelihood of survey participation when the survey's topic is of interest to the participant (Groves et al., 2004). Future research is needed to establish whether this trend holds up in studies with less engaged audiences, and to understand the directionality of this finding (i.e., whether a reduced perception of diffusion-specific descriptive norm results from high individual engagement or if this perception motivates engagement in the individual behavior).

Diffusion-specific self-efficacy appears to be an important predictor of diffusion intention. In other words, people who feel more confident in their ability to encourage others to plant native plants are more likely to engage in this behavior. Outreach efforts trying to increase diffusion actions may focus on building diffusion-specific self-efficacy by introducing strategies like social modeling, or letting participants observe someone else doing the target behavior (Geiger et al., 2017), providing people with mastery experiences, where they can practice the target behavior (Bandura, 1977, 1997), having participants set proximal goals to reach the target behavior (Bandura & Schunk, 1981), and providing specific information about how to carry out the target behavior (Geiger et al., 2017). For example, if an organization was trying to promote native plant diffusion behavior, they might host a workshop where participants learn easy-to-follow steps of how to reach out to someone, watch someone else model successful native plant diffusion, give them time to practice opening lines and discussions about native plant gardening with someone else, and then set attainable goals to carry out the diffusion in their own lives. Future research could examine the impact of these interventions to enhance diffusion-specific self-efficacy (e.g., Niemiec et al., 2021).

Our results also contribute to theory about the behavioral specificity of social-psychological variables. According to the prior theory on behavioral prediction, such as TRA and TBP, predictors should be behavior-specific (i.e. predictor variables, such as attitudes, should be measured in a way that most relates to the behavior being predicted (Ajzen & Fishbein, 1980; Bamberg, 2003). In our study, this would mean that only individual-behavior specific social-psychological variables should predict individual behavior, while only diffusion-specific social-psychological variables should predict diffusion behavior. However, we found that while some social-psychological variables appear to be behavior-specific, other variables predict both individual and diffusion behavior intentions. Specifically, we found attitude towards an individual behavior and knowledge about an individual behavior predict both individual and diffusion intentions. Personal norms and self-efficacy, on the other hand, appear to be behavior-specific predictors; that is, individual-specific personal norms (not significant at $p < .05$, but in the expected direction) and self-efficacy predicted individual intention, while diffusion-specific personal norms and self-efficacy predicted diffusion intention. Our results thus challenge the assumption that only behavior-specific predictors should be included in models of diffusion behavior and suggest that future studies on diffusion behavior should expand on traditional behavioral prediction models (TRA, TPB) by including both individual and diffusion-specific predictors.

There were also few demographic variables selected in our LASSO regression in our individual intention model and no demographics selected in our diffusion intention model. Our results align with trends in pro-environmental research demonstrating that demographic factors may not be as effective for predicting behavioral intentions as psychological variables (Li et al., 2019). Future research could continue to focus on social-psychological variables in predicting individual and diffusion behaviors related to native plant gardening, and outreach

programs could focus on targeting social-psychological perceptions rather than demographics.

We found significant relationships between intentions and indicators of behavior for both individual and diffusion behaviors. Individual and diffusion intentions predicted behavior ($\beta = 0.44$ for each) and beta coefficients were in line with the pooled correlation between intention and behavior found in Bamberg and Möser's meta-analysis of PEB studies (2007). Though intentions predicted behavior, the majority of participants did not act on their intentions. Even when participants indicated strong intentions to engage in individual and diffusion behavior, less than a quarter of them redeemed vouchers or had their shared vouchers redeemed (see Online Appendices).

In line with the intention-behavior gap, our logistic regressions with LASSO-selected variables predicting indicators of behavior found that none of the significant predictors of intention, significantly predicted the respective behavior. Education level predicted individual voucher use and age predicted diffusion voucher use. Only age predicted the indicator of diffusion behavior even though no demographic variables were selected in the diffusion intention model. That said, the coefficients in these models had relatively large standard errors and confidence intervals, so there is uncertainty in our estimates. Furthermore, demographics cannot be changed, and they are primarily useful for audience segmentation for outreach, so we caution against using demographics as a proxy for more research-supported predictors, such as beliefs and attitudes.

Even with moderate correlations between intention and behavior, our finding that social-psychological variables predict intentions but not behavior suggests that there could be contextual influences that affect the intention-behavior gap. For example, in the case of native plant gardening, context may play a larger role in acting on diffusion intentions because older individuals typically have more time and resources to focus on gardening behaviors. To encourage behavior, rather than just intention, outreach organizations might focus on specific contextual influences that hinder individuals from acting on their plans, such as specifically removing barriers for younger folks who may lack time and resources.

While social-psychological perceptions did not predict behavior, this could be, in part, due to the imperfect measurement of the behavior indicator. The current study design limited our ability to directly compare individual and diffusion behavior because the vouchers were an indicator of successful diffusion rather than diffusion attempt (i.e., sharing a coupon). It is possible that participants gave away vouchers, but their recipients did not choose to redeem them, or that recipients planted native plants without using a voucher. Future studies could more accurately compare these behaviors by measuring diffusion attempt directly. This could be done through self-report measures, participant observation, or tracking participant diffusion attempts through software that can send messages or coupons to select individuals.

According to our moderation analysis, diffusion self-efficacy and subjective knowledge about native plants moderated the relationship between diffusion intention and the indicator of diffusion behavior (i.e., diffusion coupon use). This finding reveals that participants with a higher sense of self-efficacy, or belief that they can reach out to others about native plants, and participants who feel they have more knowledge about native plants, were more likely to follow through on their diffusion intention and influence someone else to use the coupon they shared. Building on Geiger et al. (2017), diffusion-specific self-efficacy beliefs appear to be very important for engaging in diffusion behavior because it is both a predictor of diffusion intention and moderates the relationship between intention and behavior. Furthermore, this finding supports initial evidence that efficacy-based messages increased willingness to engage in native plant gardening diffusion behaviors (Niemiec et al., 2021). This provides further support for outreach efforts to increase diffusion behaviors to focus on building diffusion-specific self-efficacy, rather than building self-efficacy around the individual

behavior they are trying to diffuse through social networks. Future studies could also use qualitative methods or social-ecological systems approaches (see Jones et al., 2021; Lischka et al., 2018) to measure the barriers that affect people's actual individual and diffusion PEB.

It is important to consider that this sample was specifically designed to target Fort Collins residents living in single-family homes, so results may differ in other cultural and geographic contexts. Our results may be influenced by United States and Western cultural norms surrounding landscaping and residential land management decisions such as social pressures to maintain a well-manicured lawn (Larson et al., 2017; Robbins, 2007), as well as ideals of individualism and concerns about privacy and private property in the United States. The dry climate of Colorado, and drought conditions in surrounding states across the western US (National Drought Mitigation Center et al., 2021), may also motivate people in Fort Collins, Colorado to take more interest in native plant gardening for its water conservation benefits than people in the Eastern United States or in regions where drought is not as relevant.

Our results might also vary across different contexts due to yard size. United States lot sizes tend to be larger than in other countries (Hirt, 2015) so the property characteristics of our sample may not represent those in different regions of the world. In general, lot size may affect diffusion behaviors like planting native plants in the front yard and putting up informational signs because too large or small of a yard can affect visibility of such actions and therefore have less normative impact on other people. Furthermore, as lot size is correlated with socio-economic status, race, and ethnicity in the United States, individual and diffusion native plant gardening behaviors may be more attainable or socially acceptable in specific neighborhoods.

Future studies could explore whether these results differ in other regions, especially in more collectivistic societies, where individualistic ideals tend to be weaker. In the United States, due to deep-rooted individualistic values, personal norms and self-efficacy around diffusion may provide a larger barrier to diffusion behavior. For example, a recent meta-analysis found that personal norms may more strongly influence behavioral intentions in individualistic countries (Morren & Grinstein, 2021). Furthermore, there may be other barriers to native plant gardening and diffusion in other regions that we did not measure in our survey.

Further research is needed on whether our results apply to different types of gardening. For example, it is possible that different characteristics of native plant gardening are more salient than characteristics of vegetable gardening. Self-efficacy may be more important for predicting native plant gardening behaviors than vegetable gardening because vegetable gardening is more common and socially accepted in the United States, so people may feel more confident in their ability to access resources to plant vegetables. Vegetable gardening also does not have the same ultimate goal of biodiversity or water conservation. People may be less focused on influencing others to grow vegetables because vegetable gardening often has a more individual goal of feeding the household, whereas native plant gardening tries to address a collective goal that requires people to work together.

While we sent our survey out to a random sample of homeowners, respondents were more highly educated and female than the general Fort Collins population. Our sample distribution may be affected by a general trend identified in prior studies that women and more highly-educated individuals are more likely to participate in pro-environmental behaviors and thus may be more likely to take a survey about these behaviors (Digby, 2013). Additionally, prior studies examining gardening behaviors often end up with samples biased towards female participants (Clayton, 2007; Kiesling & Manning, 2010), and there is some evidence that women are participating in sustainable gardening behaviors more than men (Zypchyn, 2012). A recent survey found that while Vermont residents reported increased gardening activities during the first couple months of the COVID-19 pandemic, the odds of reporting gardening behaviors were higher for female participants (Morse et al., 2020). There is also a possibility that our sample is

biased towards renters who have more control over their home, for example, those who are allowed to make changes to outdoor spaces may be more likely to respond to a survey on native plant gardening.

5. Conclusion

Being able to effectively influence adoption and dissemination of PEB is critical for addressing large-scale and urgent environmental issues such as biodiversity loss (Amel et al., 2017; Nilsson et al., 2020; White et al., 2019). Our study adds more evidence to the relatively new body of research showing that a range of social-psychological variables predict individual and diffusion intentions in the case of native plant gardening. Subjective knowledge about native plant gardening and individual-specific attitude predicted both individual and diffusion intentions. Behavior-specific self-efficacy and personal norm appear to be important predictors of diffusion intention. Despite previous evidence, most of the social norms we measured did not significantly predict native plant gardening or diffusion intentions. We also found that while individual and diffusion behavioral intentions significantly predicted indicators of individual and diffusion behaviors respectively, indicators of behavior were not predicted directly by the social-psychological variables that predicted behavioral intentions, demonstrating evidence of the intention-behavior gap. Additionally, diffusion self-efficacy and subjective knowledge moderate the diffusion intention-behavior relationship. Our results highlight the utility of applying an expanded IMBP to gain a more in depth understanding of diffusion behaviors. They suggest that in addition to enhancing the public's knowledge of and fostering positive attitudes towards conservation behavior, targeting diffusion-specific personal norms and self-efficacy may be critical for practitioners promoting diffusion to achieve more widespread biodiversity conservation and environmental stewardship.

CRedit authorship contribution statement

Veronica M. Champine: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Megan S. Jones:** Conceptualization, Methodology, Investigation, Writing – review & editing, Project administration. **Stacy Lischka:** Investigation, Writing – review & editing, Project administration. **Jerry J. Vaske:** Writing – review & editing. **Rebecca M. Niemiec:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvp.2022.101798>.

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