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# The Role of Consumers' Knowledge of Native and Pollinator-friendly Plants and Their Prioritization of Plant Characteristics in Purchase Decisions

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***Abstract.*** **There is a growing trend toward planting native and pollinator-friendly plants in residential gardens and landscapes due to concerns about invasive plant species, water conservation, and urban land management. Yet, understanding consumer purchase behavior and how knowledge affects their purchase intent is largely unknown. In this analysis, we integrated national online and in-person surveys to determine the influence of consumers' subjective and objective knowledge of native and pollinator-friendly ornamental plants on their purchase decisions. Factors influencing plant purchase decisions were measured using a 7-point Likert rating scale. We found that participants with relatively higher knowledge of native and pollinator-attractive plants placed more emphasis on sustainable production methods relative to the plant's physical attributes (e.g., plant size, shape, etc.) and care-related characteristics (e.g., plant health, easiness of care, etc.). Plant lovers (i.e., frequent purchasers who spent relatively more money on plants than infrequent purchasers) were more likely to prioritize sustainable production methods over the plants' physical attributes. In contrast, participants primarily buying plants from mass merchandisers/box stores tend to focus on visual appeal or aesthetic characteristics. Consumer marketing implications for the nursery and greenhouse industry stakeholders are discussed.**

With the increasing concerns regarding environmental issues such as invasive plant species, water conservation, declining pollinator health and populations, and urban land management maintenance, there is a growing trend of planting native and pollinator-friendly plants in residential gardens and landscapes (Campbell et al. 2017; Kauth and Pérez 2011; Zadegan et al. 2008). Incorporating native and pollinator-friendly plants has the potential to enhance local biodiversity, support ecosystem services, and provide habitats for pollinators. These attributes are essential for maintaining sustainable food production (Burghardt et al. 2009; Gámez-Virués et al. 2015; Kramer et al. 2019; Weiner et al. 2014). However, the successful promotion of native plants relies heavily on consumers' knowledge, awareness, and willingness to purchase these beneficial plants.

The US Census Bureau (2012) reported that a substantial 91.2% of Florida's population resided in urban environments in 2010. These urban landscapes are composed of many elements with tree canopies covering 35.1% (Nowak et al. 2010) and turfgrass lawns (all residential, commercial, and institutional lawns, parks, golf courses, and athletic fields included) accounting for approximately 23% of urban areas (Milesi et al. 2005). Nearly three-quarters of US households (91.7 million households) engage in some kind of lawn and garden activities, demonstrating a significant interest in landscaping and gardening (2019 National Gardening Association). However, many homeowners tend to default to turfgrass for their yards, overlooking the potential environmental impacts such as excessive water consumption, chemical use, and limited biodiversity. Encouraging environmentally friendly landscapes (EFLs) that feature native and pollinator-friendly plants is crucial for mitigating these concerns. Because residential landscapes constitute a significant portion of urban green space, their practices of pollinator-friendly gardening can play a central role in addressing the global pollinator challenge (Silvert et al. 2023). Despite the increasing promotion of native and pollinator-attractive plants in landscapes, there is a critical lack of guidance available for nonexperts, such as homeowners, who want to incorporate native species into their gardens (Kramer et al. 2019).

To address the existing research gap, the primary objective of this study was to investigate the potential influence of consumers' knowledge regarding native and pollinator-friendly plants on their purchase decisions. This investigation was performed through national online and in-person surveys conducted in Florida. The measurement of consumers' knowledge of native and pollinator-attractive plants encompassed both subjective assessment (self-reported rating scale) and objective evaluation (quiz question) variables. In this context, we used a generalized ordered logit model to analyze how individual demographics and the level of knowledge concerning native and pollinator-friendly plants affect their prioritization of plant physical, care characteristics, and sustainability features when making purchasing decisions.

## Materials and Methods

*Data overview.* The survey data were gathered through a convenience sampling method, using both online and in-person surveys. The in-person survey was conducted in Central Florida in Oct 2017, and participants were recruited through social media announcements and a master e-mail list developed by the researchers of this study. The national online survey was administered through Qualtrics, a professional online survey platform, from Dec 2017 to Jan 2018. As part of a larger research project investigating pollinator-friendly practices within the ornamental horticulture industry, participants in this study were prescreened to determine if they had purchased plants within the past year and whether they lived in a single-family residence with a yard or garden. Only participants living in single-family homes with landscapes and plant purchase experience were included in the final sample, resulting in 1806 participants. Of these, 126 participants were participants who completed the in-person survey and lived in the local Florida area (Orlando metropolitan area) and 1680 were national online participants (Table 1). The gender ratio was relatively balanced in the online sample (42% male), but it skewed toward a higher percentage of females in the in-person (Floridian) sample, with only 25% male participants. The in-person sample participants had a slightly higher average age of 57 years than the online sample participants

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Table 1. Summary statistics of participants' sociodemographic characteristics and knowledge of native and pollinator-friendly plants.

| Variable | In-person sample mean | Online sample mean | Florida population (2022)[i] | US population (2022)[i] |
|---|---|---|---|---|
| N | 126 | 1,680 | 22,244,823 | 333,287,557 |
| Sociodemographic characteristics | | | | |
| Male (%) | 24.6% | 42.4% | 49.2% | 48.9% |
| Age (mean) | 57.0 | 52.5 | | |
| Household size (mean) | 2.74 | 2.64 | 2.57 | 2.60 |
| Household income (mean category) | \$60,000–\$79,999 | \$40,000–\$59,999 | \$61,777[ii] | \$69,021[ii] |
| Education level | | | | |
| Some high school | 0.0% | 1.0% | | |
| High school diploma/GED | 8.9% | 17.8% | 57.5% | 55.2% |
| Some college | 25.8% | 24.9% | | |
| 2-year or Associate's degree | 12.9% | 14.2% | | |
| 4-year Bachelor's degree | 20.2% | 25.2% | 31.5% | 33.7% |
| Some graduate school | 10.5% | 4.2% | | |
| Graduate or professional degree | 21.8% | 12.0% | | |
| Ethnicity (%) | | | | |
| White/Caucasian | 85.6% | 86.6% | 76.9% | 75.8% |
| African American | 5.6% | 5.3% | 17.0% | 13.6% |
| Hispanic | 1.0% | 2.9% | 26.8% | 18.9% |
| Asian | 1.6% | 3.0% | 3.0% | 6.1% |
| Native American | 0.0% | 1.0% | 0.5% | 1.3% |
| Pacific Islander | 0.8% | 0.1% | 0.1% | 0.3% |
| Other | 2.4% | 1.3% | | |
| Plant purchase outlet (mean) | | | | |
| From box store = 1, 0 otherwise | 0.71 | 0.54 | | |
| From garden center = 1, 0 otherwise | 0.18 | 0.32 | | |
| Annual spending on plants | | | | |
| Less than \$100 | 38.1 | 40.2 | | |
| \$100–\$199 | 19.1 | 28.8 | | |
| \$200–\$299 | 23.0 | 13.9 | | |
| \$300–\$399 | 10.3 | 7.6 | | |
| \$400–\$499 | 3.2 | 4.1 | | |
| \$500 and more | 6.4 | 5.4 | | |
| Knowledge of native and pollinator-friendly plants | | | | |
| Subjective knowledge of native plants (%)[iii] | | | | |
| Not knowledgeable | 30.9% | 22.8% | | |
| Neither knowledgeable nor not knowledgeable | 19.5% | 25.9% | | |
| Knowledgeable | 49.6% | 51.3% | | |
| Subjective knowledge of pollinator-attractive plants (%)[iii] | | | | |
| Not knowledgeable | 30.3% | 26.0% | | |
| Neither knowledgeable nor not knowledgeable | 13.1% | 26.6% | | |
| Knowledgeable | 56.6% | 47.4% | | |
| Subjective knowledge of pollinator-attractive plants based on statements about native cultivars (%)[iv] | | | | |
| Disagree | 9.5% | 5.4% | | |
| Neither disagree nor agree | 39.7% | 22.1% | | |
| Agree | 50.8% | 72.6% | | |
| Objective knowledge of pollinator-attractive plants based on quiz questions (%)[v] | | | | |
| 0 correct | 7.3% | 13.2% | | |
| 1 correct | 21.8% | 28.6% | | |
| 2 correct | 34.7% | 37.2% | | |
| 3 correct | 32.3% | 16.4% | | |
| 4 correct | 4.0% | 4.6% | | |

[i] Florida and US population estimates in 2022 were obtained from the US Census Bureau QuickFacts (https://www.census.gov/quickfacts/fact/table/US,FL/PST045222).
[ii] Household income for Florida and the US population sample were median values in 2021 dollars.
[iii] According to the survey questionnaire, participants indicated their knowledge of native and pollinator-attractive plants using a Likert scale ranging from 1 (not at all knowledgeable) to 7 (extremely knowledgeable). In this table, we combined participants who selected 1 to 3 for the category of "not knowledgeable" respondents, retained participants who selected 4 as "neither knowledgeable nor not knowledgeable," and combined participants who selected 5 to 7 as "knowledgeable."
[iv] Participants indicated whether the native cultivar makes a plant more attractive to pollinators using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).
[v] Participants answered four quiz questions identifying pollinator-attractive plants.
GED = general educational development.

(53 years). Both the in-person and online samples consisted of more female and older individuals. This demographic alignment was relevant because individuals 45 years and older are identified as the core consumer segments for lawn and garden products according to the National Gardening Association (2019). Specifically, the 55 to 64 years age group not only reported the highest spending on lawn and garden products in 2018 but also demonstrated the largest growth in expenditures. The in-person sample had a larger household size, more education, and a higher mean household income.

The primary plant purchase outlet for the in-person sample was box stores (71%), whereas only 54% of the national sample reported purchasing from box stores, and 32% purchased from independent garden centers. On average, people in both samples spent between $200 to $300 annually on plants. In addition to socio-demographic information, participants were primarily asked about their plant purchase behavior, knowledge and perceptions of native and pollinator-attractive plants, and knowledge and perceptions of neonicotinoids and relevant regulations.

*Subjective and objective knowledge of native and pollinator-friendly plants.* The key variable of interest in this study was the level of consumer knowledge of native and pollinator-friendly plants. Previous studies have shown that perceptions and knowledge of plants, particularly pollinator-friendly plants, can influence purchase decisions and the willingness to pay (Campbell et al. 2017; Getter et al. 2016; Rihn and Khachatryan 2016). Campbell et al. (2017) found that perceived benefits such as attracting pollinators, planting a variety of plant types, as well as liking the appearance of pollinator plants were the major motivations for consumers purchasing pollinator-friendly plants. Despite 30% of the respondents confusing bee-friendly insect management practices with plants that are pollinator-attractive, Getter et al. (2016) showed American consumers were willing to pay a price premium for plants labeled as "grown using bee-friendly insect management practices" or "grown using best insect management practices to protect pollinators'' compared to other eco-friendly production practices. Additionally, Rihn and Khachatryan (2016) noted that only 24% of surveyed plant purchasers were aware of neonicotinoid insecticides, but those who were aware of neonicotinoids were more knowledgeable about plants that improve pollinator health and also more likely to purchase neonic-free plants. Recently, Wei et al. (2020) measured subjective knowledge of neonicotinoids and both subjective and objective knowledge of pollinator-friendly plants using self-reported rating scores and quiz questions, respectively. They investigated how subjective and objective knowledge interacted with neonicotinoid insecticide-related messages and affected consumers' willingness to pay for plants grown without neonicotinoids. Similarly, Rihn et al. (2021) investigated how consumers' subjective and objective knowledge of genetically modified food affected their willingness to pay for genetically modified labeling on food-producing plants.

Similar to Rihn et al. (2021) and Wei et al. (2020), we used both subjective and objective measures of participant knowledge of native and pollinator-friendly plants. To measure subjective knowledge, participants were first asked, "How knowledgeable are you about native or pollinator attractive plants?" based on a 7-point Likert rating scale, with 1 indicating extremely unknowledgeable and 7 indicating extremely knowledgeable. Then, participants were asked to indicate their agreement regarding whether a native variety makes a plant more attractive to pollinator insects using a 7-point Likert rating scale, with 1 indicating extremely disagree and 7 indicating extremely agree. For each quiz question, participants were given two plants with names and images and asked to select the one that was a pollinator attractor. The quiz comprised four questions, and an objective measure was created based on the number of correct answers.

The summary statistics of the knowledge variables are presented in Table 1. The self-rated subjective knowledge scales regarding native and pollinator-attractive plants are consistent. A pairwise correlation of 0.83 suggested that participants who reported being knowledgeable of native plants were likely to report being knowledgeable of pollinator-attractive plants. This pattern was observed for both local and national samples. Only half of the Floridian (local sample) participants agreed that native plants were more pollinator-attractive. In contrast, more than 72% of the national participants believed that native plants were more pollinator-attractive. This difference could be driven by the varying levels of awareness, knowledge, and education regarding native plants and their benefits to pollinators between the local Floridian population and the broader national audience. Florida has a very unique ecosystem and biodiversity. Floridian participants may perceive native plants differently because of their direct experiences with local flora and fauna in central Florida.

Regarding quiz-based objective knowledge, less than 5% of the participants could correctly identify the pollinator-attractive plants presented by the four quiz questions. The pairwise correlations between the objective knowledge variable and three subject knowledge variables were as low as 0.08, 0.05, and 0.10, respectively, revealing that individuals who consider themselves to be knowledgeable (i.e., have high subjective knowledge) tend to overestimate their level of knowledge compared with the results of the objective tests of their knowledge. This result is consistent with existing evidence gap between subjective and objective knowledge (Fernbach et al. 2019; Packard and Wooten 2013; Rihn et al. 2021).

*Factors influencing plant purchasing decisions.* To measure the influence of relevant factors on plant purchase decisions, participants were asked to answer the question, "When you purchase plants, please indicate how important the following factors are in

Table 2. Summary of importance ratings on plant physical and sustainability attributes.

| | Mean rating | | | PCA[ii] | | |
|---|---|---|---|---|---|---|
| Factors influencing plant purchasing decisions[i] | In-person | Online | Sample total | Factor 1 | Factor 2 | Cronbach's α |
| Factors related to plant physical and care characteristics[iii] | | | | | | |
| Price | 5.64 | 5.60 | 5.60 | | 0.728 | 0.877 |
| Plant size | 5.25 | 5.55 | 5.53 | | 0.807 | 0.854 |
| Plant shape | 5.16 | 5.31 | 5.30 | | 0.681 | 0.865 |
| Flower/leaf color | 5.67 | 5.85 | 5.84 | | 0.783 | 0.852 |
| Plant health | 6.24 | 6.22 | 6.22 | | 0.745 | 0.853 |
| Suitability for my garden | 5.84 | 6.04 | 6.03 | | 0.739 | 0.855 |
| Easiness of care | 5.60 | 5.86 | 5.84 | | 0.778 | 0.856 |
| Factors related to plant sustainability features[iii] | | | | | | |
| Plants attractive to pollinators | 4.76 | 5.55 | 5.49 | 0.707 | | 0.893 |
| Native plants | 4.74 | 5.25 | 5.22 | 0.681 | | 0.897 |
| Grown using organic practices | 4.07 | 4.99 | 4.93 | 0.842 | | 0.892 |
| Grown using integrated pest management strategies | 4.00 | 4.38 | 4.35 | 0.663 | | 0.908 |
| Grown using non-neonicotinoid pesticides | 4.10 | 5.18 | 5.11 | 0.801 | | 0.893 |
| Grown without pesticides | 4.44 | 5.45 | 5.38 | 0.792 | | 0.890 |
| Grown using commercial honeybees | 4.05 | 4.69 | 4.65 | 0.800 | | 0.895 |
| Grown using wild pollinators | 4.05 | 4.90 | 4.85 | 0.870 | | 0.888 |
| No. of participants | 126 | 1,680 | 1,806 | | | |

[i] Participants were given a list of 15 factors and asked to indicate how important each factor was influencing their plant purchasing decisions. The importance of factors influencing plant purchasing decisions was reported on a 7-point Likert scale, with 1 indicating very unimportant and 7 indicating very important.

[ii] Factors with loadings ≤0.60 are not reported in the table.

[iii] Based on the principal component analysis (PCA), the 15 factors were broadly categorized into the following two groups: factors related to plant physical and care characteristics and factors related to plant sustainability features.

influencing your purchasing decisions on plants." Participants were provided with a list of 15 specific factors, including plant price, appearance, plant care, and sustainability characteristics. These factors were randomly presented to participants (refer to Table 2 for the full list). Participants indicated how important each factor influenced their plant purchasing decisions using a Likert scale of 1 to 7 (1 = very unimportant; 7 = very important). Based on the principal component analysis (PCA), we divided the 15 factors into two broad groups (Table 2). The PCA describes the strength and direction of correlated variables in terms of their potential to quantify unobservable constructs (Jolliffe 1986). The emerging values show the interdependencies between observed independent variables, which can be explained as the indirectly measured, collapsed construct, or component. Details of the loading factors (with loadings >0.6) and Cronbach's alpha for each of the 15 items can be found in Table 2. "Load" is the term used in the PCA to indicate the highest mean value for each question among all the mean values for the item when testing for linear combinations (Costello and Osborne 2005; Hair et al. 1998). Component values with a Cronbach's alpha level ≥0.7 are considered to have a strong measure of internal consistency or validity (Tavakol and Dennick 2011).

Factors such as price, plant size, plant shape, flower/leaf color, plant health, suitability for a garden, and ease of care were categorized as plant physical and care characteristics. Factors such as native plants, pollinator-attractive plants, production methods including using organic practices, using integrated pest management strategies, using non-neonicotinoids pesticides, using no pesticides, using commercial honeybees, and using wild pollinators were categorized as sustainability features. Among the seven items related to plant physical and care characteristics, plant health and suitability for the garden were regarded as essential characteristics across both local and national samples. Rating scores based on the importance of plant sustainability features were generally lower than those of plant physical and care characteristics, especially for (in-person) participants from the local area. Even though both samples reported pollinator-friendly plants as the most important sustainability feature, the mean rating score for the in-person sample was 4.76, which was slightly lower than the mean (5.5) for the national sample.

*Empirical framework.* Although the ordered logit model is commonly used to account for the ordinal nature of the outcome variables, it has the restrictive proportional odds assumption or parallel lines assumption, which assume that the effects of explanatory variables on the outcome variable are constant across all levels of the outcome variable (Greene 2003; Train 2003). In other words, the slopes of the regression lines for each level of the dependent variable are equal. However, many empirical studies have demonstrated that the proportional odds and parallel lines assumptions are often violated (Clogg and Shihadeh 1994; Fu 1998; Long and Freese 2006; Peterson and

Table 3. Regression results of the generalized ordered logit model.

| | Factors related to plant physical and care characteristics | | Factors related to plant sustainability features | |
|---|---|---|---|---|
| Variables | Unimportant vs. neither unimportant nor important and important | Unimportant and neither unimportant nor important vs. important | Unimportant vs. neither unimportant nor important and important | Unimportant and neither unimportant nor important vs. important |
| Individual sociodemographic characteristics | | | | |
| Box store | 0.587 | 0.551*** | 0.181 | −0.465*** |
| | (0.381) | (0.191) | (0.286) | (0.167) |
| Garden center | 0.819 | 0.575*** | 0.486 | −0.258 |
| | (0.500) | (0.215) | (0.332) | (0.180) |
| Plant lover | −0.620 | 0.300* | 0.148 | 0.488*** |
| | (0.453) | (0.173) | (0.267) | (0.121) |
| Age | −0.0267** | 0.0151*** | −0.0114 | 0.00215 |
| Male | (0.0126) | (0.00461) | (0.00749) | (0.00363) |
| | 0.393 | −0.372** | 0.00469 | −0.265** |
| | (0.323) | (0.147) | (0.212) | (0.109) |
| Household size | −0.226** | 0.00336 | 0.0496 | −0.0135 |
| | (0.110) | (0.0102) | (0.0764) | (0.00955) |
| Education | −0.0670 | −0.0366 | −0.0779 | −0.109*** |
| | (0.122) | (0.0442) | (0.0673) | (0.0356) |
| Ethnicity | −0.140 | −0.100 | −0.000758 | 0.202*** |
| | (0.133) | (0.0674) | (0.0988) | (0.0632) |
| Household income | 0.150 | 0.003 | −0.0212 | −0.00255 |
| | (0.109) | (0.039) | (0.0560) | (0.0286) |
| Individual knowledge | | | | |
| N-plant knowledge | −0.218 | −0.0680 | −0.0205 | 0.247*** |
| sub-scale | (0.167) | (0.0765) | (0.108) | (0.0607) |
| P-plant knowledge | 0.374** | 0.103 | 0.348*** | 0.127** |
| sub-scale | (0.148) | (0.0728) | (0.107) | (0.0567) |
| N-plant statement | 0.0981 | 0.255*** | 0.205** | 0.328*** |
| sub-scale | (0.171) | (0.0573) | (0.0981) | (0.0483) |
| P-plant quiz | −0.188 | −0.0626 | 0.0721 | 0.0308 |
| obj-score | (0.158) | (0.0700) | (0.108) | (0.0517) |
| Online | 0.695 | 0.203 | 0.875*** | 1.060*** |
| | (0.463) | (0.304) | (0.336) | (0.251) |
| Constant | 3.611** | −0.573 | 0.175 | −3.822*** |
| | (1.569) | (0.555) | (0.985) | (0.483) |
| Log-likelihood | −788.622 | | −1374.62 | |
| Wald $\chi^2$ | 106.83 | | 319.16 | |
| Pseudo $R^2$ | 0.0591 | | 0.1208 | |

Robust *SE*s are in parentheses.

*** $P < 0.01$, ** $P < 0.05$, and * $P < 0.1$.

Participants were regrouped into unimportant, neither unimportant nor important, and important based on the averaged importance ratings across different factors within the two broad categories. For example, participants' ratings for factors related to the plants' physical and care characteristics were considered unimportant if the average rating across the seven factors was between 1 and 3 (≤3), neither unimportant nor important if the averaged rating score was more than three but less than five, and important if the averaged rating score was 5 or more. N-plant stands for native plant and P-plant stands for pollinator-friendly plant.

Table 4. Marginal effects on the importance of factors related to plant physical and care characteristics.

| Variables | Factors related to plant physical and care characteristics | | |
|---|---|---|---|
| | Not Important | Neither unimportant nor important | Important |
| Individual sociodemographic characteristics | | | |
| Box store | −0.0172 | −0.0451** | 0.0623*** |
| | (0.0106) | (0.0190) | (0.0214) |
| Garden center | −0.0240* | −0.0409* | 0.0649*** |
| | (0.0129) | (0.0218) | (0.0240) |
| Plant lover | 0.0182* | −0.0521*** | 0.0339* |
| | (0.0107) | (0.0177) | (0.0197) |
| Age | 0.0008** | −0.0025*** | 0.0017*** |
| | (0.0003) | (0.0005) | (0.0005) |
| Male | −0.0116 | 0.0535*** | −0.0420** |
| | (0.0088) | (0.0148) | (0.0164) |
| Household size | 0.0066** | −0.0070** | 0.0004 |
| | (0.0028) | (0.0033) | (0.0024) |
| Education | 0.0020 | 0.0022 | −0.0041 |
| | (0.0032) | (0.00504) | (0.0053) |
| Ethnicity | 0.0041 | 0.0073 | −0.0114 |
| | (0.0030) | (0.00601) | (0.0071) |
| Household income | −0.0044* | 0.0041 | 0.0003 |
| | (0.0026) | (0.0041) | (0.0043) |
| Individual knowledge | | | |
| N-plant knowledge sub-scale | 0.0064 | 0.0013 | −0.0077 |
| | (0.0044) | (0.0078) | (0.0087) |
| P-plant knowledge sub-scale | −0.0110** | −0.0007 | 0.0117 |
| | (0.0045) | (0.0075) | (0.0084) |
| N-plant statement sub-scale | −0.0029 | −0.0259*** | 0.0288*** |
| | (0.0035) | (0.0061) | (0.0064) |
| P-plant quiz obj-score | 0.0055 | 0.0016 | −0.0071 |
| | (0.0040) | (0.0068) | (0.0077) |
| Online | −0.0204* | −0.0026 | 0.0230 |
| | (0.0124) | (0.0263) | (0.0327) |
| N | | 1788 | |

Robust *SE*s are in parentheses.

*** $P < 0.01$, ** $P < 0.05$, and * $P < 0.1$.

Participants were regrouped into unimportant, neither unimportant nor important, and important based on the averaged importance ratings across different factors within the two broad categories. Participants' ratings for factors related to the plants' physical and care characteristics were considered unimportant if the average rating across the seven factors was between 1 and 3 (≤3), neither unimportant nor important if the averaged rating score was more than three but less than five, and important if the averaged rating score was 5 or more. N-plant stands for native plant and P-plant stands for pollinator-friendly plant.

Harrell 1990; Suh et al. 2016). For example, let $Y$ be an ordinal dependent variable taking on $M$ ordered categories, denoted by 1, 2, …, $M$. Let $X$ be the vector of explanatory variables. According to Williams (2006) and Williams (2016), a generalized ordered logit model can be expressed as a linear function of the explanatory variables:

$$P(Y_i > j) = g(X\beta_j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1+\{\exp(\alpha_j + X_i\beta_j)\}},\ j = 1,2,\ldots,M-1$$

where $M$ is the number of categories of the ordinal dependent variable. From this formulation, the cutoff values of $\alpha$ and the slope parameter $\beta$ can vary across the value of $j$.

Therefore, the probability that $Y_i$ takes on each of the values are equal to the following:

$$P(Y_i > 1) = 1 - g(X_i\beta_1)$$

$$P(Y_i = j) = g(X_i\beta_{j-1}) - g(X_i\beta_j),\ j = 1,2,\ldots,M-1$$

$$P(Y_i = M) = g(X_i\beta_{M-1}).$$

To determine whether the generalized ordered logit model is a preferred alternative to the ordered logit model, we conducted Brant's Wald test for the parallel lines assumptions (Brant 1990). As expected, the parallel lines assumption was rejected with a $\chi^2$ test statistic of 37.32 ($P = 0.001$) for the factors related to plant physical and care characteristics and a $\chi^2$ test statistic of 27.52 ($P = 0.016$) for factors related to plant sustainability features, suggesting that the generalized ordered logit is a better fit for our data structure.

## Results

The estimated coefficients of the generalized ordered logit are summarized in Table 3. The marginal effects of a change in one explanatory variable on the probability of each importance level for factors related to plant physical and care characteristics and factors related to plant sustainability features are presented in Tables 4 and 5, respectively.

*Factors influencing the prioritization of physical and care characteristics versus sustainability features.* The dependent variable of factors related to plant physical and care characteristics was a three-level categorical variable generated based on averaged importance ratings across the seven individual factors within the category. After averaging, the ratings for factors related to plant physical and care characteristics were continuously between 1 and 7. To be consistent with the original Likert scale of 1 to 7, we chose to use 3 as the cutoff point for the unimportant group and 5 as the cutoff point for the important group. Therefore, participant ratings for factors related to plant physical and care characteristics were broadly redefined as unimportant if the average rating across the seven factors was between 1 and 3 (≤3), redefined as neither unimportant nor important if the averaged rating score was more than 3 but less than 5, and redefined as important if the averaged rating score was 5 or more (≥5). Similarly, the dependent variable of factors related to plant sustainability features was a three-level categorical variable generated based on averaged importance ratings across the eight individual factors within the category.

As shown in Table 3, participants in general care about the physical appearance and aesthetic characteristics of plants regardless of whether they are purchasing plants from box stores or garden centers. Nonetheless, participants who primarily buy plants from box stores care less about plant sustainability attributes. In contrast, plant lovers prioritize sustainability attributes. These participants are plant lovers because they are frequent purchasers who spend relatively more money on plants compared to infrequent purchasers. As indicated by marginal effects in Table 4, both plant purchasers who buy from box stores and garden centers are 6 percentage points more likely to rate plant physical and care characteristics as important factors when purchasing plants. Conversely, purchasers who buy from box stores are 9 percentage points less likely to rate sustainability features as an important influencing factor (Table 5). Interestingly, older participants tend to care more about the physical appearance and aesthetic characteristics of plants (Table 3). Male purchasers seem to assign less importance to plant physical and care characteristics and sustainability features compared to their female counterparts. Male purchasers are 4 percentage points less likely to rate physical and care characteristics of plants as important decision factors (Table 4), and they are 5 percentage points less likely to rate plant sustainability as an important decision factor (Table 5). Although there is no difference between online and in-person samples regarding plant physical and care characteristics, online survey participants placed more value on sustainability attributes, was consistent with the higher mean rating scores observed in Table 2.

Moreover, participants who reported higher subjective knowledge place more emphasis on plant sustainability features. Specifically, participants who are more knowledgeable about native and pollinator-attractive plants and report a stronger agreement with the notion that native varieties are more pollinator-friendly prioritized plant sustainability features. Specifically, they were 5 percentage points, 3 percentage points, and 7 percentage points more likely, respectively, to rate plant sustainability features as

Table 5. Marginal effects on the importance of factors related to plant sustainability features.

| | Factors related to plant sustainability features | | |
|---|---|---|---|
| Variables | Not Important | Neither unimportant nor important | Important |
| Individual sociodemographic characteristics | | | |
| Box store | −0.0102 | 0.105*** | −0.0946*** |
| | (0.0159) | (0.0316) | (0.0325) |
| Garden center | −0.0273 | 0.0797** | −0.0524 |
| | (0.0185) | (0.0349) | (0.0354) |
| Plant lover | −0.0083 | −0.0910*** | 0.0993*** |
| | (0.0142) | (0.0256) | (0.0250) |
| Age | 0.0006 | −0.00108 | 0.0004 |
| | (0.0004) | (0.0008) | (0.0007) |
| Male | −0.0003 | 0.0542** | −0.0540** |
| | (0.0119) | (0.0224) | (0.0219) |
| Household size | −0.0028 | 0.00554 | −0.0028 |
| | (0.0043) | (0.0054) | (0.0037) |
| Education | 0.0044 | 0.0179** | −0.0223*** |
| | (0.0037) | (0.0073) | (0.0071) |
| Ethnicity | 0.00004 | −0.0412*** | 0.0412*** |
| | (0.0054) | (0.0106) | (0.0114) |
| Household income | 0.0012 | −0.0007 | −0.0005 |
| | (0.0030) | (0.0059) | (0.0058) |
| Individual knowledge | | | |
| N-plant knowledge sub-scale | 0.0012 | −0.0515*** | 0.0503*** |
| | (0.0058) | (0.0118) | (0.0118) |
| P-plant knowledge sub-scale | −0.0195*** | −0.0064 | 0.0259** |
| | (0.0058) | (0.0114) | (0.0114) |
| N-plant statement sub-scale | −0.0115** | −0.0553*** | 0.0668*** |
| | (0.0047) | (0.0089) | (0.0093) |
| P-plant quiz obj-score | −0.0041 | −0.00223 | 0.0063 |
| | (0.0057) | (0.0108) | (0.0105) |
| Online | −0.0492*** | −0.167*** | 0.216*** |
| | (0.0185) | (0.0473) | (0.0477) |
| N | | 1788 | |

Robust *SE*s are in parentheses.
*** $P < 0.01$, ** $P < 0.05$, and * $P < 0.1$. Participants were regrouped into unimportant, neither unimportant nor important, and important based on the averaged importance ratings across different factors within the two broad categories. Participants' ratings for factors related to plant sustainability features were considered unimportant if the average rating across the eight factors was between 1 and 3 (≤3), neither unimportant nor important if the averaged rating score was more than three but less than five, and important if the averaged rating score was 5 or more. N-plant stands for native plant and P-plant stands for pollinator-friendly plant.

important factors influencing their plant purchase decisions. Participants' objective knowledge about pollinator-friendly plants does not impact their prioritization of physical, care, and sustainability characteristics, suggesting a knowledge gap between perceived knowledge and real knowledge. This observation aligns well with and provides support for the findings of Narem et al. (2018), who reported that although subjective knowledge of the environmental benefits of native grass were likely to increase the likelihood of purchase, the objective knowledge (assessed through true/false questions) had little impact on the purchase likelihood.

*Further exploration of each factor*. We further explored how participants' sociodemographic characteristics and knowledge levels may influence how they prioritize each type of physical and care characteristics (Supplemental Table 1.1) and sustainability features (Supplemental Table 1.2) during plant purchase decisions. As shown in Supplemental Table 1.1, plant purchasers who buy from box stores care about both price and plant visual appearance (plant size, shape). In contrast, plant purchasers who buy from garden centers are more likely to consider not only the plant visual appearance but also the plant health, ease of care, and suitability for garden as important factors. Although plant lovers consider physical characteristics as important factors influencing their purchase decisions, they consistently value all the plant sustainability features, including whether plants are native or more pollinator-attractive, whether plants are produced using sustainable production methods (e.g., organic, pesticide-free), or whether plants are produced using pollinators. Additionally, plant purchasers with higher educational levels consider price an important decision factor, but they do not necessarily prioritize individual sustainability features. Regarding individual knowledge of native and pollinator-attractive plants, we only found that individual participants with more subjective knowledge of native and pollinator-attractive plants consistently value all the sustainability features as important factors during their plant purchasing decision-making, but not objective knowledge. These findings are generally consistent with those of existing studies (Narem et al. 2018; Rihn et al. 2023) that have highlighted the importance of perceived knowledge to shaping environmentally conscious behaviors regarding purchasing native and pollinator-friendly plants. Our results also offer additional insights regarding how consumers prioritize physical and nonaesthetic (e.g., ease of care) characteristics versus sustainability features.

## Discussion and Conclusion

Using a generalized logit model, this study explored the impact of consumer demographics and their prior knowledge of ornamental plants on their purchase decisions. Results of this study shed light on the complex set of factors that influence plant purchasers' decision-making. Consumers' subjective knowledge of native and pollinator-attractive plants has a significant role in prioritizing sustainability features. This finding aligns with the positive correlations between knowledge, perceptions, and native plant preferences identified by many studies (Narem et al. 2018; Rihn et al. 2023; Shaw et al. 2017). These results have considerable implications for promoting native and pollinator-friendly plants and sustainable production methods in residential gardens and landscapes.

These findings are helpful to plant suppliers and landscape designers establishing progressive production and business practices related to native nursery crops and specializing in difficult-to-grow species (Rihn et al. 2022). They may consider promoting their companies as pollinator and wildlife friendly and stand out as a business in the green industry by engaging in pollinator-and wildlife-friendly landscaping. Even though consumers think they know about pollinator-friendly and native plants, they overestimate their actual knowledge level. This low level of public knowledge is evidenced by the fact that less than 5% of the sample correctly identified all four pollinator-attractive plants in our study. This knowledge gap is confirmed by Kalauni et al. (2023) who noted that limited actual knowledge has constrained genuine engagement and efforts aimed at creating wildlife- and pollinator-friendly habitats in urban residential landscapes despite strong willingness and interests. Similar phenomenon has been highlighted in many other research (e.g., Egerer et al. 2019; Hall and Martins 2020; Šedík et al. 2018; Silvert et al. 2023). Potentially, this result can be explained by the fact that most consumers have unconscious incompetence and relatively low knowledge of native and/or pollinator-friendly landscaping (Burch 1970). As shown by Getter et al. (2016), even though many American consumers confused the plant produced with pollinator-friendly management practices with the plant that is pollinator-friendly, they generally value more pollinator-friendly production practices because many had a misconception that pollinator-friendly production practices make plants more attractive to pollinators.

Another explanation for the preference for pollinator-friendly plants without knowledge is the "warm glow" effect, which refers to an economic theory describing the emotional reward of giving to others or contributing to society in a positive manner (Andreoni 1990). Preliminary work evaluating the internalization of the social perception of sustainability efforts showed that the warm glow effect is associated with some sustainability and pro-environmental social behaviors (Van der Linden 2018; Mahasuweerachai and Suttikun 2022; van Doorn and Kurz 2021). "Saving the bees" and buying pollinator-friendly plants may make consumers feel good about their decisions to buy, even if they do not have all the information about why the plant is pollinator-friendly or how to save pollinators.

Additionally, this study highlights a knowledge gap between subjective and objective knowledge about pollinator-friendly plants. The weak correlation between the subjective and objective knowledge variables and the lack of effect of objective knowledge on the importance of plant sustainability features suggests that participants who perceived themselves as knowledgeable about pollinator-friendly plants may not have been accurate in their self-assessment. This finding echoes with several existing studies. For example, Getter et al. (2016) suggested that although American consumers could not distinguish the difference between the plant produced with pollinator-friendly management practices and the plant itself that is pollinator-friendly, there was a clear preference for plants associated with pollinator-friendly production methods. Similar to our finding, Narem et al. (2018) showed that subjective knowledge about the environmental benefits of native grass were likely to increase the likelihood of purchase, while objective knowledge had no significant impact on the purchase likelihood. Understanding how the relationship between consumers' knowledge and preferences is shaping the demand for native and pollinator-friendly plants is helpful for policymakers and industry stakeholders. For example, consumers want to be more conscious of pollinator friendly products, but they might not have the complete knowledge to back their decisions yet. In the future, understanding the dynamic between knowledge and preference more in-depth can unravel the relationship to understand which comes first and how it influences purchasing intent. This is a future direction of this work.

To overcome this barrier to knowledge, individuals must become aware of their knowledge deficiency, usually through education (Braman and Griffin 2022). Educational programs that inform about the importance of not harming caterpillars, for instance, can be a part of branding and the design narrative. Additionally, plant marketers and garden centers should incorporate terms such as "pollinator-friendly" and "native" on the label. These terms are easily interpreted and recognizable to consumers. Despite specific preference for pollinator friendly production methods by many studies (e.g., Getter et al. 2016; Khachatryan and Rihn 2017; Rihn and Khachatryan 2016), lack of labeling was identified as one of the top barriers preventing purchasing pollinator-friendly plants (Campbell et al. 2017). Other efforts by marketers should include explanations next to terms and key frames. To lean into the warm glow effect that some consumers have, retailers and industry members should encourage this behavior with positive reenforcement and positive facts about how this behavior contributes to the environment, particularly pollinators.

Marketers and retailers should target younger existing clientele or new consumers who have a greater draw toward purchasing pollinator-friendly plants. Efforts targeting pollinator-friendly plants toward older consumers may not result in greater sales or appeal from this category of consumers because this age group, in general, is less interested in pollinator-friendly plants.

Because our study was conducted before the COVID-19 pandemic, we provided a baseline to understand the trends and shifts in public knowledge and behavior. Our results can be compared with those of postpandemic studies to better understand the impact of the pandemic on shaping consumer interests and shopping behaviors in terms of native and pollinator-friendly plants. In fact, our results are consistent with those of several recent studies conducted in 2022, after the COVID-19 pandemic. For example, a recent online survey of 2066 Americans confirmed that native plants are more appealing to consumers who are more knowledgeable and use environmentally conscious gardening practices (Rihn et al. 2023). Our finding aligns with the suggestion pointed out by Silvert et al. (2023), who targeted efforts that can increase basic knowledge and increase the likelihood of adopting pollinator-friendly gardening practices. The COVID-19 pandemic may have altered many consumers' lifestyles. Future studies should explore the long-term impact of the pandemic on consumers and their pro-environmental shopping behaviors and gardening decisions related to native and pollinator-friendly plants.

Despite its contributions, there were limitations to this study. One such limitation was that the individual rating scores for the importance of the physical and care characteristics of plants and sustainability features were rescaled through regrouping, which may have introduced additional noise and did not reflect participants' true ratings. Additionally, we focused less on the "neither unimportant nor important" category because of concerns that this midpoint category may not necessarily indicate a neutral opinion, but rather a lack of an opinion, about the issue (Sturgis et al. 2014). Future research is necessary to better understand the relationship between consumer demographics, knowledge, and preferences regarding native and pollinator-friendly plant purchases.

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