Unwrapping the Native Plant Black Box: Consumer Perceptions and Segments for Target Marketing Strategies

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Abstract. **The increasing demand for sustainable products has helped spur demand for native plants. This study used an online survey of 2066 US consumers, a factor analysis, and Ward's linkage cluster analysis to identify unique customer segments in the native plant marketplace. The following three clusters were identified: native averse (31.6%), native curious (35.7%), and native enthusiast (32.7%). The native enthusiast cluster agreed strongly with positive statements related to native plant perceptions and attributes. The native averse cluster exhibited the lowest level of agreement with these items and the greatest level of agreement with negative or neutral statements about native plants. The native curious cluster was intermediate between the other clusters but generally agreed with positive attributes. Demographic characteristics impacted cluster membership. The marketing implications are discussed.**

Target marketing is one technique used to tailor marketing communications to specific homogeneous groups of people (i.e., segments) (University of Minnesota 2015). Benefits of target marketing include reduced competition, targeting more profitable customers, and focusing on more profitable early product adopters (University of Minnesota 2015). Understanding consumer perceptions is an important component of target marketing strategies (Gigauri 2019). In the ornamental horticulture literature, a cluster analysis has been used to identify customer segments and develop educational content related to many topics, including integrated pest management (IPM) extension activities (Kratsch et al. 2017), horticultural practices (Wagner et al. 2022), geranium preferences (Behe et al. 1999), biodegradable packaging (Hall et al. 2010), low-input turfgrasses (Hugie et al. 2012), water conservation in landscapes (Behe et al. 2018), and succulents (Ong et al. 2022). To date, target marketing has not been used to address the native plant market. The native plant market is of interest because of increased consumer demand for native plants and landscapes that aid the environment (American Society of Landscape Architects 2023; Kauth and Perez 2011; Knuth et al. 2018). Evidence has suggested that consumers' attitudes toward environmental benefits of plants impact their behavior when considering drought-tolerant landscapes (Behe et al. 2018), irrigation water sources (Knuth et al. 2018), and marketing messages (Knuth et al. 2020). Furthermore, native plants can help mitigate negative environmental consequences caused by urbanization (Rodriguez et al. 2017; Shaw et al. 2017; Van Heezik et al. 2020). Consequently, understanding customer needs relative to native plants and potential differences among customer groups can help align marketing efforts with customer needs and encourage the use of native plants within homeowners' landscapes.

A native plant is defined as "a plant that is part of the balance of nature that has developed over hundreds or thousands of years in a particular region or ecosystem" [US Department of Agriculture (USDA) 2023]. The potential benefits of incorporating native plants into landscapes include water conservation, reduced soil erosion, habitat creation, wildlife food sources, aesthetics, and less maintenance (USDA 2023). Native plants are also popular for plantings in difficult sites to address land restoration and management issues (Brzuszek et al. 2007; Peppin et al. 2010; Potts et al. 2002) and can be used as a food source (Shelef et al. 2017). Many of these benefits are attributed to native plants coevolving with local wildlife (e.g., insects, birds, small mammals) and environmental conditions, resulting in greater environmental benefits and resilience relative to non-native species (Kermath 2007; Wilde et al. 2015). However, consumers' perceptions of native plants are less understood and focus on social pressure, aesthetic characteristics, and valuation of native plant attributes relative to traditional turfgrass lawns. We referenced these existing studies and incorporated a factor and cluster analysis into a national dataset to identify US customer clusters and propose target marketing strategies to engage these different groups.

Consumer perception studies of native plants have addressed the relationship between social norms, aesthetic considerations, proenvironmental behavior, and native plant preferences (Gillis and Swim 2020; Rodriguez et al. 2017; Shaw et al. 2017; Van Heezik et al. 2020). Social norms impact the acceptance of native plant landscapes where people assume their neighbors prefer turfgrass lawns to native plantings (Peterson et al. 2012). This can deter homeowners from planting native plants or result in native plants being installed in less prominent locations other than the front yard, such as a side yard or back yard (Gillis and Swim 2020). This perception may be related to the belief of poor aesthetic characteristics. Beck et al. (2002) found that native

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plants were not considered as aesthetically pleasing as other options. However, other studies determined that consumers view native plants as aesthetically appealing (Gillis and Swim 2020; Shaw et al. 2017). In turn, consumers' positive perceptions of the beauty of native plants positively impact their intent to purchase native plants (Gillis and Swim 2020). Regarding proenvironmental behavior, several studies have established a positive correlation between environmental knowledge and purchase likelihood for native plants (Narem et al. 2018), environmental gardening practices and native plant purchases (Rihn et al. 2023), and positive perceptions of native plants (Shaw et al. 2017). To help improve consumers' knowledge of local native plants and their environmental benefits (butterfly and moth caterpillar host plants), an online native plant finder that uses consumer zip codes to identify native plant species was developed (National Wildlife Federation 2024). Finally, several studies have suggested consumers demand native plants and are willing to pay price premiums for them; however, findings are highly localized. North Carolina and Michigan consumers preferred landscapes that incorporated native plants relative to turfgrass lawns (Helfand et al. 2006; Peterson et al. 2012). Michigan homeowners were willing to pay $94 to $143 per month more for landscapes with native plants than for those with turfgrass lawns (Helfand et al. 2006). In another study in Minnesota, the native label generated a $0.83 premium for those plants (Yue et al. 2012).

Despite native plant benefits and the potential to generate price premiums, native species are underrepresented in garden center sales and, thus, the residential landscape. In developed countries, such as the United States, residential landscapes are predominately non-native species (Burghardt et al. 2009), which often have been deliberately introduced (Mack and Erneberg 2002). Additionally, several barriers hinder the use of native plants in the US marketplace, including low propagation (seeds, etc.) supply, limited availability of desirable species, and low education among customer groups (Brzuszek and Harkess 2009; Kauth and Perez 2011). Kauth and Perez (2011) emphasized that a better understanding of the market for native plants is imperative because demand is expected to increase. A review article by Wilde et al. (2015) highlighted that market feasibility studies are necessary, and that there is a need for education information, demand, and regional collaborations.

Because of the diversity, regional connectedness, and perceptual differences of native plants, we hypothesized that homogenous customer clusters exist in the United States, and that each segment has different drivers for their native plant preferences. Thus, the study objectives were to address consumer preferences for native plants and different perceptions of those items and identify homogenous US consumer segments and marketing messages that may resonate with those segments.

Materials and methods

An online survey of US consumers was used to address the research objective. The survey content was based on existing literature and input from industry stakeholders, researchers, and extension personnel involved in native plant production and marketing. The survey questionnaire included a consent form, information regarding overall plant purchasing behavior, native plant purchasing behavior, and perceptions of native plants (e.g., overall, benefits, barriers, aesthetics, importance), and socio-demographic questions. The survey instrument used stated preferences metrics for which participants indicated their level of agreement or preferences, whereas revealed preferences were based on real-world behavior (e.g., retail receipts, scanner data). Stated preferences are subject to hypothetical bias when participants overstate their preferences or values because there are no real-world consequences (de Corte et al. 2021). Hypothetical bias can be mitigated through cheap talk scripts or reminders to participants to act like they would in the real world and consider their household budgets, or by incorporating information from real-world data (de Corte et al. 2021; Penn and Hu 2019). This survey used a cheap talk script to encourage participants to be cognizant of their household budgets and preferences in real life. The survey instrument and procedures were approved by the lead institution's ethics review board (IRB number 22-06847-XM).

The survey was administered through an online panel provider (Qualtrics LLC, Provo, UT, USA) to US consumers in Sep 2022. Before participation, potential participants had to agree to participate in the study and were screened to ensure they were at least 18 years old, owned their property (i.e., they had decision-making power over their landscapes), and were the decision-maker or had split responsibility for household garden-related purchases. The aim of including these screening questions was to target people who are current or potential native plant purchasers. Participants were recruited from the four US regions, including the Northeast, Midwest, South, and West Northwest (USDA 2021). Northeast states included Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania. Midwest states included Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. South states included Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Missouri, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas. West states included Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, California, Oregon, and Washington. Hawaii and Alaska were excluded from the analysis because they are not part of the continental United States. We specifically targeted these regions because different US regions have diverse climates and climatic stressors (National Drought Mitigation Center 2024; Rericha and Wilhelm 2021; USDA 2023; White et al. 2018), meaning that the value of natives (with the benefit of being adapted to local stressors) may vary based on what is occurring in that area. Including all four regions allowed for representation across the regions. Additionally, participants had to correctly answer two validation questions (e.g., "Please select 5 to show you are attending to the survey.") before their answers were used in the analysis. A total of 2066 people were qualified for the study, completed the survey, and included in the analysis. We used Stata software (release 17; StataCorp, College Station, TX, USA) to analyze the data.

Factor analysis. We used a factor analysis to define the most salient constructs that drive consumers' perceptions of native plants. During a

factor analysis, variables with shared variance are grouped together to reduce the number of unobserved variables or "factors" (Yong and Pearce 2013). When conducting a factor analysis, ≥300 participants and five to 10 observations per factor are recommended (Comrey and Lee 1992). Both recommendations were met because 2066 people completed the survey and the three factors contained five or more statements. To test the scale reliability and internal consistency, Cronbach's alphas were used. A Cronbach's alpha more than 0.70 is considered acceptable (Trochim and Donnelly 2006). Additionally, the Kaiser criterion was used to identify the number of factors per set of constructs. We used an Eigenvalue cutoff of greater than 1 to indicate the existence of a new factor (Braeken and van Assen 2017). In this analysis, each set of constructs was ran separately, and the number of factors per set of constructs was determined based on the Eigenvalue (Braeken and van Assen 2017).

In this analysis, three factors were identified based on the participants' level of agreement with different statements and perceived benefits of native plants. Table 1 contains all of the statements and perceived benefits and the literature supporting the statement(s) included in the factor analysis. The first factor (termed "positive natives factor") consisted of nine statements related to consumers' overall perceptions of native plants (Cronbach's alpha = 0.854; Eigenvalue = 3.573). Example statements included the following: "native plants improve biodiversity" and "native plants are readily available in my area." Participants indicated their level of agreement with the statements using a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). The second factor (termed "negative perceptions factor") included eight statements related to negative perceptions of native plants (Cronbach's alpha = 0.781; Eigenvalue = 2.475). Example statements included "native plants are not as prestigious as exotic plants" and "native plants are more expensive than exotic plants." Participants indicated their level of agreement using a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). Finally, the third factor (termed "native attributes factor") included five perceived benefits (Cronbach's alpha = 0.711; Eigenvalue = 1.616). Participants selected the attributes that they perceived as describing native plants. For example, participants selected if they perceived native plants as "aesthetically pleasing" and "wildlife friendly." The attributes were coded to equal 1 if selected or 0 otherwise.

Cluster analysis. After the factor analysis, we performed a cluster analysis to identify homogenous groups within the sample. Given the lack of information regarding consumer perceptions of native plants and the diverse benefits of native plants, a cluster analysis has the potential to identify and provide a better understanding of different customer segments and factors that motivate consumer interest in native plants. Previous studies used a cluster analysis to address consumer segmentation for chicken products (Bannor et al. 2022), food consumption and purchase patterns (Bond et al. 2008; Larson 2004), fresh fruits (Torres et al. 2020), gene-edited foods (Paudel et al. 2023), and new food packaging technologies (Just and Goddard 2023). We used the factors in a cluster analysis to group people by similar perceptions so we could estimate the market potential for segments that are more receptive to native plants and which types of marketing messages (e.g., wildlife friendly, availability) may resonate better with them.

A Ward's linkage cluster analysis was used with three previously developed factors (i.e., positive natives factor, negative perceptions factor, and native attributes factor). The Duda-Hart Je(2)/Je(1) values and Calinski and Harabasz pseudo-F index were used to identify the optimal number of clusters (Stata 2023). In this dataset, three clusters were identified. Significant differences between cluster means were identified using an analysis of variance (ANOVA) and Tukey's honest significance test.

Econometric analysis. An ordered probit investigated the impact of consumers' demographics, perceptions, and behaviors on cluster membership. The ordered probit is an appropriate framework to model cluster membership in which the observed variable has natural ordering (Greene and Hensher 2009). Thus, this study assumed that cluster membership follows a natural order, in which individuals in cluster 1 have the lowest valuations for the plant factors, those in cluster 3 have the highest valuation, and those in cluster 2 have scores intermediate between those of clusters 1 and 3, but the distances between adjacent levels of membership are unknown.

The ordered probit model is based on a latent continuous variable y^* underlying the ordinal responses observed. The latent variable is a linear combination of some observables X (i.e., consumer behavior and demographic factors) and a disturbance term ε that has a normal distribution [specifically, letting $i=1,2,\ldots,n$ index the cluster and for the case in which there are three ordered outcomes (i.e., $y_i \in [0,1,2]$)]:

$$y_i^* = X_i\beta + \varepsilon_i \quad [1]$$

where y_i^* is the unobserved latent variable and y_i is the observed ordinal variable

$$y_i = 0 \ \ if \ \ y_i^* \le 0$$
$$y_i = 1 \ \ if \ \ 0 < y_i^* \le \mu_1$$
$$y_i = 2 \ \ if \ \ \mu_1 < y_i^*$$

such that μ_1 and β are unknown parameters to be estimated. Then, the following probabilities exist:

$$\Pr(y_i = 0|X_i = x) = \Phi(-X_i\beta)$$
$$\Pr(y_i = 1|X_i = x) = \Phi(\mu_1 - X_i\beta) - \Phi(-X_i\beta)$$
$$\Pr(y_i = 2|X_i = x) = 1 - \Phi(\mu_1 - X_i\beta)$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function.

Results

Descriptive statistics. Table 2 illustrates the descriptive statistics for the full sample and for each cluster. The average respondent in our sample was 57.1 years old and self-reported an average 2021 annual household income of $74,729. Approximately 76.7% of respondents were female. Approximately half of the respondents had a bachelor's degree or higher. The largest proportion of respondents lived in suburban areas (44.7%), followed by rural (41.9%) and urban (13.4%) areas. Native plants were purchased by 58% of respondents, and the average annual spending on plants (in general) was $207, with an average annual spending of $178 on native plants. Participants indicated that they perceived native plants as important (3.44 rating out of 5,

Table 1. Statements and the literature supporting the statements used in an online survey to identify US consumers' perceptions of native plants. Question: Please indicate your level of agreement with the following statements, where 1 = strongly disagree, 4 = neither agree nor disagree, and 7 = strongly agree.

Positive natives factor	Statements	Supporting literature
	Native plants improve biodiversity.	Brzuszek and Harkess (2009); Burghardt et al. (2009); Kermath (2007)
	Native plants are better for the environment than exotic plants.	Brzuszek and Harkess (2009); Narem et al. (2018)
	Native plants are readily available in my area.	Brzuszek and Harkess (2009)
	I know where to shop to purchase native plants.	Brzuszek and Harkess (2009)
	Native plants are better adapted to difficult sites.	Meyer (2013)
	Native plants require less maintenance than exotic plants.	Meyer (2013)
	Native plants are drought-resistant.	Behe et al. (2018); Helfand et al. (2006); Meyer (2013)
	Native plants are beneficial to the economy.	Helfand et al. (2006)
	Native plants help with water conservation.	Helfand et al. (2006); Meyer (2013)
Negative perceptions factor	**Statements**	**Supporting literature**
	Native plants are not as prestigious as exotic plants.	Gillis and Swim (2020)
	Native plants are more expensive than exotic plants.	Brzuszek and Harkess (2009); Helfand et al. (2006)
	I am concerned about the performance of native plants in my landscape.	Gillis and Swim (2020)
	I am not interested in planting native plants.	Brzuszek and Harkess (2009); Kauth and Perez (2011)
	Native plants are not readily available in my area.	Brzuszek and Harkess (2009); Kauth and Perez (2011)
	Native plants look messy and unattractive.	Gillis and Swim (2020)
	There is not much information available about native plants.	Brzuszek and Harkess (2009); Kauth and Perez (2011)
	Plant nativeness is less important to me than having the right plant for the right place.	Gillis and Swim (2020)
Native attributes factor	**Statements**	**Supporting literature**
	Aesthetically pleasing	Beck et al. (2002); Brzuszek and Harkess (2009)
	Wildlife friendly	Burghardt et al. (2009)
	Pollinator attractor	Burghardt et al. (2009)
	Complements previous plantings/gardens	Beck et al. (2002)
	Natural habitat restoration	Burghardt et al. (2009); Meyer (2013)

where 5 indicated very important) and exhibited an intermediate knowledge level of native plants (2.56 out of 5, where 5 indicated extremely knowledgeable). The largest percentage of participants lived in the West (39.2% of the sample), followed by the Midwest (20.4%), South (19.8%), and Northeast (19.5%).

Factor and cluster analysis. The detailed factor analysis summary results are presented in the Supplemental Appendix (Table 1A). For the positive natives factor, the statements (from the highest level of agreement to the lowest) included the following: "native plants are better adapted to difficult sites"; "native plants require less maintenance than exotic plants"; "native plants help with water conservation"; "native plants are better for the environment than exotic plants"; "native plants are beneficial to the economy"; "native plants improve biodiversity"; "native plants are readily available in my area"; "I know where to shop to purchase native plants"; and "native plants are drought-resistant." The positive natives factor had a Cronbach's alpha of 0.854. Using the Kaiser criterion (Eigenvalue >1), a single factor was identified (Eigenvalue = 3.573) (Braeken and van Assen 2017).

For the negative perceptions factor (from the highest rating to the lowest), the statements included the following: "plant nativeness is less important to

Table 2. Sample summary statistics and Ward's linkage cluster analysis statistics for US consumers from an online survey of native plant preferences conducted in 2022.

Variable (mean value)		Total		Cluster 1, native averse[i]		Cluster 2, native curious[i]		Cluster 3, native enthusiast[i]	
Demographics	**Description**	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
Northeast[ii]	1 = live in the Northeast; 0 = otherwise	0.195	0.396	0.185	0.389 a	0.154	0.362 b	0.249	0.433 a
Midwest[ii]	1 = live in the Midwest; 0 = otherwise	0.204	0.403	0.177	0.382 a	0.305	0.461 b	0.120	0.325 c
South[ii]	1 = live in the South; 0 = otherwise	0.198	0.399	0.164	0.370 a	0.241	0.428 ab	0.203	0.403 b
West[ii]	1 = live in the West; 0 = otherwise	0.392	0.488	0.466	0.499 a	0.294	0.456 a	0.426	0.495 b
Age	Age in years	57.123	14.595	57.45	14.119 a	57.828	14.661 a	56.034	14.933 a
Female	1 = female; 0 = otherwise	0.767	0.423	0.786	0.410 a	0.785	0.411 a	0.728	0.445 b
Education: 4-year degree or higher	1 = 4-year bachelor's degree or higher; 0 = otherwise	0.457	0.498	0.393	0.489 a	0.463	0.499 b	0.512	0.500 b
Urban	1 = urban; 0 = otherwise	0.134	0.341	0.445	0.346 a	0.443	0.340 a	0.454	0.337 a
Suburban	1 = suburban; 0 = otherwise	0.447	0.497	0.139	0.497 a	0.133	0.497 a	0.131	0.498 a
Rural	1 = rural; 0 = otherwise	0.419	0.493	0.416	0.493 a	0.424	0.495 a	0.416	0.493 a
Income	2021 household income in $1000 USD	74.729	50.697	73.226	51.980 a	76.734	49.376 a	78.338	50.748 a

		Total		Cluster 1, native averse[i]		Cluster 2, native curious[i]		Cluster 3, native enthusiast[i]	
2021 Plant purchasing behavior	**Description**	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
Purchased natives	Proportion of the sample who purchased native plants in 2021 (%)	58%	0.49	28%	0.45 a	46%	0.50 b	100%	0.04 c
Plant spending	Spending on plants in 2021	$206.87	215.695	$171.18	189.560 a	$182.52	199.438 a	$268.18	242.234 b
Native spending	Spending on native plants in 2021	$178.26	186.794	$46.71	188.399 a	$76.42	183.765 b	$187.31	187.615 c
Native importance	Importance of native plants; 1 = very unimportant; 5 = very important	3.440	1.031	2.787	0.942 a	3.497	0.962 b	4.010	0.800 c
Native knowledge	Knowledgeable about native plants; 1 = not at all knowledgeable; 5 = extremely knowledgeable	2.559	0.902	2.208	0.830 a	2.551	0.861 b	2.908	0.879 c

		Total		Cluster 1, native averse[i]		Cluster 2, native curious[i]		Cluster 3, native enthusiast[i]	
Factor perceptions	**Description**	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
Positive natives factor				−0.817	0.747 a	0.307	0.700 b	0.456	0.785 c
Negative perceptions factor				0.692	0.567 a	−0.196	0.703 b	−0.457	0.906 c
Native attributes factor				−0.547	0.385 a	−0.391	0.519 b	0.96	0.557 c
n		2066		654		738		674	

[i] Different letters indicate significance at the 5% level. Significance was calculated using an analysis of variance and Tukey's honest significant difference test.

[ii] The states within the regions are based on the USDA definition (USDA 2021). Northeast states include Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania. Midwest states include Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. South states include Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas. West states include Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, California, Oregon, and Washington. Hawaii and Alaska were excluded from analysis because they are not being part of the continental United States.

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me than having the right plant for the right place"; "native plants are not as prestigious as exotic plants"; "I am concerned about the performance of native plants in my landscape"; "native plants are more expensive than exotic plants"; "there is not much information available about native plants"; "native plants are not readily available in my area"; "native plants look messy and unattractive"; and "I am not interested in planting native plants." This factor had a Cronbach's alpha of 0.781 and resulted in a single factor (Eigenvalue = 2.475).

For the native attributes factor, the attribute of being pollinator-friendly was selected by 33% of participants, followed by complements the existing landscape (26.7%), natural habitat restoration (25.4%), aesthetically pleasing (23.3%), and wildlife-friendly (21.7%). Together, these attributes resulted in a Cronbach's alpha of 0.711 and a single factor (Eigenvalue = 1.616).

When considering the factor constructs by each cluster, cluster 1 members expressed the lowest levels of agreement with the positive natives factor statements relative to cluster 2 or cluster 3 members (Table 2). Cluster 1 members expressed higher levels of agreement with the negative perceptions factor statements than cluster 2 or cluster 3 members. Cluster 3 members agreed more with the statements about native plants improving biodiversity, being better for the environment than exotic plants, being readily available, and that they know where to purchase native plants relative to cluster 2 members. Cluster 3 members disagreed with the negative statements the most. The agreement level of cluster 2 members was between those of cluster 1 and cluster 3 members. For the native attributes factor, cluster 3 expressed an increased probability of selecting the perceived attributes compared to that of members in cluster 1 or cluster 2. Based on these comparisons, cluster 1 was named "native averse," cluster 2 was named "native curious," and cluster 3 was named "native enthusiast."

Cluster 1, the native averse cluster, was the smallest segment and included 654 consumers (31.6% of the sample) (Table 2). Native averse members had the lowest ratings in terms of positive natives and native attributes factors, whereas they had the highest ratings in terms of the negative perceptions factor. Native averse members were characterized as female (78.6%) and had the lowest proportion of respondents with a college education or higher (39.3%) compared to the other clusters. This cluster had the smallest percentage of consumers who purchase native plants (28%) and, compared to the other clusters, they spent, on average, the least on all plant purchases ($171) and native plants ($46.71) in 2021. This cluster exhibited the lowest native importance rating and native knowledge rating relative to the other two clusters. The largest proportion of consumers in the native averse cluster lived in the West (46.6%), followed by the Northeast (18.5%), Midwest (17.7%), and South (16.4%).

Cluster 2, the native curious cluster, was the largest segment and included 738 consumers (35.7% of the sample); their factors scores were intermediate compared to those of clusters 1 and 3 (Table 2). The native curious cluster was characterized for having the second largest proportion of female respondents (78.5%) and the second highest proportion of respondents with a college degree or higher (46.3%) compared to the other clusters. Consumers in the native curious cluster were characterized by perceptions, native importance, and native knowledge ratings that were intermediate compared to those of clusters 1 and 3; 46% of respondents purchased native plants in 2021 and spent $76.4 on native plants. The largest proportion of native curious cluster members lived in the Midwest (30.5%), followed by West (29.4%), South (24.1%), and Northeast (15.4%).

Cluster 3, the native enthusiast cluster, was composed of 674 respondents (32.7% of the sample). Consumers in the native enthusiast cluster had the highest ratings in terms of positive natives and native attributes factors, whereas they had the lowest ratings in terms of the negative perceptions factor (Table 2). Native enthusiasts were characterized by the lowest proportion of female consumers (72.8%) and highest proportion of consumers with a college degree or higher (51.2%) compared to the other clusters. Consumers in the native enthusiast cluster spent the most on all plants ($268), placed the highest importance on native plants (rating, 4.01), and had the most native plant knowledge (rating, 2.91) compared to the other two clusters. All consumers in the native enthusiast cluster purchased native plants in 2021 and spent the most on native plants ($187) compared to the other clusters. The largest proportion of native enthusiasts lived in the West (42.6%), followed by the Northeast (24.9%), South (20.3%), and Midwest (12.0%).

Native plant perceptions according to cluster. Table 3 illustrates the participants' valuations of native plant attributes according to cluster. We found no statistical difference across clusters for the attribute growth (i.e., compactness). Native averse cluster members had lower valuations for native plant attributes such as desirability, aesthetic, noninvasiveness, wildlife, biodiversity, alignment with landscape, vitality, color, and pollinator-friendly compared to the native curious and native enthusiast cluster members. The native averse cluster members perceived native plants as more common (i.e., a higher rating of the availability attribute), less aesthetically pleasing, more invasive, and duller compared to the native curious cluster or native enthusiast cluster members. Interestingly, compared to consumers in the native curious or native enthusiast clusters, consumers in the native averse cluster also perceived native plants as not pollinator-friendly and those that can deter biodiversity. Compared to native enthusiast members, native averse members also perceived native plants as more uniform. Compared to native curious cluster members, native averse cluster members perceived native plants as more expensive.

Native curious cluster members expressed ratings in between those of native averse and native enthusiast cluster members for native plants attributes such as desirability, aesthetically pleasing, noninvasiveness, wildlife support, biodiversity contribution, alignment with landscape preferences, colorful, and pollinator friendliness. Native curious cluster and native enthusiast cluster members similarly rated attributes such as native plant availability and vitality. Finally, native enthusiasts expressed significantly higher ratings for the native plant attributes of desirability, aesthetic, noninvasiveness, wildlife, biodiversity, alignment with landscape, vitality, color, and pollinator-friendly

Table 3. US consumer perceptions of native plants relative to introduced plants based on a 2022 online survey.

Variable (mean value)	Definitions[i]	Total sample Mean	Total sample SD	Cluster 1, native averse[ii] Mean	Cluster 1, native averse[ii] SD	Cluster 2, native curious[ii] Mean	Cluster 2, native curious[ii] SD	Cluster 3, native enthusiast[ii] Mean	Cluster 3, native enthusiast[ii] SD
Desirability	Less desirable = 1; desirable = 5	3.931	1.013	3.515	0.994 a	4.001	0.975 b	4.257	0.934 c
Uniformity	Variable = 1; uniform = 5	2.483	1.061	2.650	0.966 a	2.519	1.075 a	2.282	1.101 b
Growth	Leggy = 1; compact = 5	3.120	0.958	3.069	0.906 a	3.107	0.969 a	3.184	0.991 a
Aesthetic	Less aesthetically pleasing = 1; aesthetically pleasing = 5	3.772	1.037	3.424	1.029 a	3.825	1.013 b	4.052	0.975 c
Price	Expensive = 1; inexpensive = 5	3.376	0.967	3.274	0.979 a	3.474	0.976 b	3.366	0.935 ab
Availability	Common = 1; rare = 5	2.354	1.057	2.521	1.015 a	2.220	1.055 b	2.340	1.077 b
Noninvasive	Invasive = 1; noninvasive = 5	3.720	1.185	3.448	1.157 a	3.724	1.204 b	3.979	1.134 c
Wildlife	Deters wildlife = 1; encourages wildlife = 5	3.751	1.137	3.459	1.079 a	3.764	1.165 b	4.019	1.092 c
Biodiversity	Deters biodiversity = 1; encourages biodiversity = 5	3.677	1.008	3.401	0.851 a	3.718	1.032 b	3.899	1.061 c
Alignment with landscape	Does NOT align with my landscape preferences = 1; aligns with my landscaping preferences = 5	3.854	1.025	3.384	1.010 a	3.950	0.946 b	4.205	0.950 c
Vitality	Prolific = 1; sterile = 5	2.388	0.933	2.581	0.888 a	2.302	0.923 b	2.295	0.960 b
Color	Dull = 1; colorful = 5	3.777	1.037	3.538	1.059 a	3.794	1.036 b	3.991	0.966 c
Pollinator friendly	Not pollinator-friendly = 1; pollinator-friendly = 5	4.096	0.973	3.774	0.954 a	4.115	1.010 b	4.389	0.848 c
n	Number of observations	2066		654		738		674	

[i] Each participant used a 5-point scale to indicate how they perceived native plants in terms of each of the characteristics listed compared to introduced plant species. For example, under "growth," a selection of "1" indicated that the person perceived native plants (in general) to be leggy compared to an introduced species of plant.
[ii] Different letters indicate significance at the 5% level. Significance was calculated using analysis of variance and Tukey's honest significant difference test.

compared to the native averse cluster and native curious cluster members.

ECONOMETRIC ANALYSIS RESULTS—ORDERED PROBIT. From the ordered probit models, marginal effects were estimated to show how different factors impacted cluster membership (Table 4). The ordered probit results showed that the factors grouping native plant attributes explained cluster membership. Consumers who expressed higher scores for native plant importance and knowledge were 13.8% and 6.0%, respectively, more likely to be part of the native enthusiast cluster. Similarly, expressing high scores for the perceptions of native plants being aesthetically pleasing, noninvasive, and wildlife-friendly increased the probability of membership in the native enthusiast cluster by 4.6%, 2.8%, and 4.1%, respectively. However, expressing a high score for native plant uniformity increased the probability of membership in the native averse cluster by 2.2%. Perceptions related to native plant prices, availability, and vitality did not impact cluster membership.

Demographic characteristics also influence cluster membership (Table 4). Consumers in the Northeast and South were 8.2% and 4.5%, respectively, more likely to be part of the native enthusiastic cluster compared to consumers in the West. These results may imply different environmental stresses or cultural norms based on location. For instance, Southern states have higher temperatures and different disease and pest pressures related to these higher temperatures that may encourage people to view native plants as better options for their home landscapes. None of the other regions had a significant impact. Age increased the probability of being in the native adverse cluster by 0.1%. Having a 4-year bachelor's degree or higher education increased the probability of being in the native enthusiast cluster by 4.7%. Conversely, living in an urban area decreased the probability of being a native enthusiast by 5.7%.

Discussion and conclusion

Stimulating native plant sales could effectively begin with market segmentation and product targeting. In the present study, three clusters of potential native plant buyers, native averse, native curious, and native enthusiast, were identified. The native curious and native enthusiast clusters

Table 4. Marginal effect estimates from an ordered probit model demonstrating the impact of factors on the cluster membership of US consumers based on native plant perceptions.

Ordered probit model[i]			Marginal effects					
	Total (n = 2066)		Cluster 1, native adverse (n = 654)		Cluster 2, native curious (n = 738)		Cluster 3, native enthusiast (n = 674)	
	Coef.	*SE*	dy/dx	*SE*	dy/dx	*SE*	dy/dx	*SE*
Native importance	0.483	0.029 ***	−0.136	0.007 ***	−0.002	0.003	0.138	0.007 ***
Native knowledge	0.210	0.033 ***	−0.059	0.009 ***	−0.001	0.001	0.060	0.009 ***
Uniformity	−0.080	0.025 ***	0.022	0.007 ***	0.000	0.000	−0.023	0.007 ***
Aesthetic	0.161	0.027 ***	−0.045	0.007 ***	−0.001	0.001	0.046	0.007 ***
Price	0.009	0.028	−0.003	0.008	0.000	0.000	0.003	0.008
Availability	−0.042	0.025	0.012	0.007	0.000	0.000	−0.012	0.007
Noninvasive	0.098	0.023 ***	−0.028	0.006 ***	0.000	0.001	0.028	0.007 ***
Wildlife	0.145	0.024 ***	−0.041	0.007 ***	−0.001	0.001	0.041	0.007 ***
Vitality	0.008	0.029	−0.002	0.008	0.000	0.000	0.002	0.008
Demographics								
Northeast[ii]	0.288	0.079 ***	−0.081	0.022 ***	−0.001	0.002	0.082	0.022 ***
Midwest[ii]	0.066	0.066	−0.019	0.018	0.000	0.000	0.019	0.019
South[ii]	0.159	0.070 *	−0.045	0.020 *	−0.001	0.001	0.045	0.020 *
Age	−0.005	0.002 **	0.001	0.001 **	0.000	0.000	−0.001	0.001 **
Female	−0.070	0.065	0.020	0.018	0.000	0.001	−0.020	0.019
Education: 4-year degree or higher	0.164	0.057 **	−0.046	0.016 **	−0.001	0.001	0.047	0.016 **
Suburb	−0.051	0.057	0.014	0.016	0.000	0.000	−0.014	0.016
Urban	−0.199	0.084 *	0.056	0.024 *	0.001	0.001	−0.057	0.024 *
Income	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Threshold parameters								
1	2.657	0.304						
2	3.839	0.309						

[i] Number of observations = 2066. Prob > X^2 = 0.00. Pseudo R^2 = 0.17. Marginal effects are expressed as percentage points. *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

[ii] The states within the regions are based on the USDA definition (USDA 2021). Northeast states include Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania. Midwest states included Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. South states include Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Missouri, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas. West states include Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, California, Oregon, and Washington. Hawaii and Alaska were excluded from analysis because they are not part of the continental United States.

were likely actionable targets for native plant producers, garden plant retailers, and landscapers. Specifically, the native curious and native enthusiast clusters had overlapping positive perceptions of native plants (as captured by the positive natives factor). Furthermore, in general, they spend more on plants, purchase native plants more often, and have heightened awareness and knowledge of native plants compared to the native averse cluster. This indicated that targeting these two clusters with native plant marketing and promotions would be an effective strategy relative to targeting the native averse cluster. However, it should be noted that a portion (28%) of the native averse cluster did purchase native plants (they spent $46.71 on native plants in 2021); therefore, although we named the group "native averse," there may have been some members who were still receptive to native plants but purchased them for reasons outside the scope of this study. Nevertheless, because of the increased interest and spending on native plants by members of the native curious and native enthusiast clusters, targeting these two clusters with marketing likely would have a greater effect and encourage more sales compared to targeting the native averse cluster.

Each cluster accounted for approximately one-third of the sample; therefore, 66% of the market is likely to be a target for native plant purchases (i.e., native curious and native enthusiast clusters). Because 74.6% of US households participate in lawn and garden activities (Whitinger and Cohen 2021), there may be 63 million households that are suitable targets for native plants. Other research has showed that only 17% of US households purchased "at least one specific plant because they knew the plant was native to their area" (Whitinger and Cohen 2021). This indicates the tremendous market potential for native plants.

We found a few demographic differences between the three clusters, including the geographic region. Marketers in the Northeast and South have some advantage over those in the West because of the improved probability of being in the native enthusiast cluster. Consumers with higher education levels are also better native plant targets because those with ≥4 years of college were more frequency in the native enthusiast cluster. Interestingly, the native enthusiast cluster had the lowest percentage of females. Historically, ≥80% of garden plant purchases have been made by females (Butterfield and Baldwin 2013); however, the sex gap is closing for some plant product categories, including foliage plants (Whitinger and Cohen 2021). Regional marketing and the inclusion of both sexes represented in pictorial communications may be most effective for marketing native plants.

Motivation for product purchase, or "why," is an effective consumer touchpoint (University of Minnesota 2015). The present study included a range of reactions from positive to negative regarding native plants. The native enthusiast cluster, which had the greatest market potential, expressed the greatest agreement with the environmental benefits of native plants, including pollinator attracting, habitat restoring, and wildlife benefitting. These results align with previous work that identified alignment between native plant importance and proenvironmental gardening practices (Rihn et al. 2023). Additionally, consumer research of plant purchasers indicated a willingness to pay more for and preference for plants grown in an environmentally conscious manner (Khachatryan et al. 2014; Knuth et al. 2020) while concerns about the environment grow (Tyson and Kennedy 2020). Because more Americans are concerned about the environment, and because the two clusters exhibited more interest in the environmental benefits that native plants bring to their landscapes, the environmental benefits should be prominent in all native plant communication messages.

The limitations of this study included the limited number of attitudinal and perceptual statements; therefore, more of these statements should be explored in future work. The work presented in this article serves as an initial launching point for future studies that address consumer motivations and purchasing behaviors associated with native plants. A second limitation was the hypothetical nature of the study. As such, it is subject to hypothetical bias (real behavior that deviates from self-reported behavior because of the hypothetical nature of the study) (Penn and Hu 2019). Future work should incorporate intercept studies or retail sales data of native plants at garden centers to confirm the robustness of the results.

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