Impact of Information Type and Source on Pollinator-friendly Plant Purchasing

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SUMMARY. The number of pollinators has been reported to be decreasing for the past several decades. Numerous sources (e.g., climate change, pesticides, loss of habitat) have been noted as potential contributing factors to the decline. With respect to the green industry, the impact of pesticides on pollinator decline and consumer response to this impact is of critical importance. Although no definitive link exists of pesticides being a major contributing factor to pollinator decline, some retailers have banned their suppliers from using certain pesticides. As various sources (e.g., universities, media, activist groups) provide information (both positive, neutral, and negative) about the impact of pesticides on pollinators, no information exists regarding how consumers value such information. Using a sample of Connecticut consumers, this study evaluates how both information source and information type impact a consumer's decision to purchase pollinator-friendly plants in the future. The study finds that consumers exposed to either neutral (no link between pesticides and pollinator decline) or negative (link between pesticides and pollinator decline) information from universities and major media outlets indicate they will purchase more pollinator-friendly plants compared with the no information (control) treatment. The results show that information from the federal government, nursery/greenhouse industry associations, and environmental activist groups have the same impact on self-reported future pollinator-friendly plant purchasing as the no information group.

Pollinators play an integral part in the reproductive process of 75% to 95% of all flowering plants (Ollerton et al., 2011; U.S. Fish and Wildlife Service, 2019a), but the world has seen a substantial reduction in the abundance of pollinators (Pollinator Health Task Force, 2015). Many of the world's fruits and vegetables are dependent on pollinators, so the reduction in pollinators has the potential to inflict considerable economic damage to both the United States and the rest of the world. Of the leading 57 single crops, 39 of them are dependent to some degree upon pollinators, with the production volume of these 39 crops representing 35% of global food

production (Klein et al., 2007). It is estimated that pollinators contribute between 5% and 8% of market value to annual global crop production, which equated to between \$235 billion and \$577 billion in 2015 dollars (Potts et al., 2017). In the United States, it is estimated that pollinators contribute \$20 billion to \$40 billion to agriculture production (Calderone, 2012; Wildlife Habitat Council, 2005). Honey bees (*Apis mellifera*), in particular, account for \$10 billion to \$20 billion (Calderone, 2012).

Although some pollinators have declined steeply over time, other pollinators have experienced weak declines to even increasing abundance (Bartomeus et al., 2013). However, the decline of bees (*Apis* sp.) in some areas has affected both unmanaged wild bees and commercially managed domesticated bees. Recently, the rusty-patched bumble bee (*Bombus affinis*) was added to the endangered species list. This marks the first time a bee has been added to the endangered species list (U.S. Fish and Wildlife Service, 2019b). The decline of domesticated honeybee colonies has seen the number of managed colonies decreasing from a little more than 4

million in 1980 to just more than 2.5 million in 2015 (Pollinator Health Task Force, 2015). This decrease has resulted in changes to U.S. regulatory policy—notably, the relaxing of the prohibition of honeybees and honeybee genetic material imports into the United States to meet demand for pollinators (Federal Register, 2004).

As agricultural producers look to ensure pollinators are accessible to pollinate their crops, researchers are working to understand the loss in pollinators. As noted by the Pollinator Partnership (Johnson, 2010), from the 1990s to the mid 2000s, colony losses averaged $\approx 18\%$ per year. However, from 2006 to 2014, the average colony losses were $\approx 30\%$ (van Engelsdorp et al., 2014). Most of the hypothesized theories for pollinator decline have focused on causes such as the loss of native habits, pesticides, diseases, weather, and parasites as significant contributing factors to the general decline of pollinators (Johnson and Corn, 2015; National Academies Press, 2007).

As pollinator issues have come to the forefront, many consumers and activists have advocated for the removal of commonly used pesticides, such as neonicotinoids, from producer use. Retail outlets, including Home Depot (Atlanta, GA) and Lowes (Morrisville, NC), have banned their suppliers from using neonicotinoids on plants to be sold in their stores (Bose and Orr, 2015; Home Depot, 2016). Furthermore, the state of Maryland banned consumer use of pesticides that contain neonicotinoids starting in 2018 (Wood, 2016).

As noted by Blacquière et al. (2012) and Decourtye and Devillers (2010) in their literature reviews on the effects of neonicotinoids, there is no concrete evidence that correct use of neonicotinoids are the main cause of pollinator decline. However, consumers face a barrage of information from various groups (e.g., media, activists, universities) that often contain conflicting messages about the impact of pesticides on pollinator decline. The decision about which sources to trust can be difficult. Often, the level of trust an individual consumer has about a news source and/or type of information (neutral or negative) is conditionally

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dependent upon characteristics such as age, income, and political party affiliation (McCluskey et al., 2016; Mitchell et al., 2016).

Although there is a body of literature that focuses on environmentally friendly labeling (Behe et al., 2013; Khachatryan et al., 2014; Rihn et al., 2015; Yue et al., 2011), bee-friendly labeling (Wollaeger et al., 2015), pollinator-friendly labeling (Khachatryan et al., 2018), and pesticide labeling (Rihn and Khachatryan, 2016), little is known about how varying information sources and type of information will impact a consumer's intention to purchase pollinator-friendly plants. The aim of this study was to understand more fully how information communicated to consumers influenced their intended purchasing habits for pollinator-friendly plants. Specifically, the study looked at the source of information (e.g., from a university, major media outlets, activist group) and type of information (i.e., linking and not linking pollinator decline to pesticides) on consumer-indicated future purchasing of pollinator-friendly plants for their landscape. We hypothesize that information from seemingly "unbiased" sources (university and federal government) would have a significant impact compared with providing no information, whereas information from seemingly "biased" sources (nursery/greenhouse industry and environmental activist groups) would not be different from the no-information group. Furthermore, we hypothesize that linking pesticides to pollinator decline would increase the likelihood of a consumer purchasing a pollinator-friendly plant compared with not providing any information. By understanding the impact of messaging from different sources, industry associations, policymakers, and stakeholders gain a better understanding of how their messaging will influence consumer decision making and of policies at the state and regional levels.

Materials and methods

In Summer 2016, an internal review board approved (#X15-129) an online survey to be administered in Connecticut. Potential respondents were asked to participate via e-mail from the database of Global Market Insight,

Inc. (Lightspeed Research, Warren, NJ) with respondents choosing to participate directed to the study. As a result of the funding agency's interest in the Connecticut market, respondents were limited to the state of Connecticut. Furthermore, the survey was restricted to respondents 18 years old or older, with women being oversampled because they have been shown to be the primary shoppers in a majority of households (Flagg et al., 2013; Wolfe, 2013; Zepeda, 2009). Around 1200 respondents completed the survey, but because only respondents indicating they had a lawn or landscape were asked the pollinator-friendly plant purchasing questions, the final analysis included 785 respondents.

The overall online survey tended to be representative of the average Connecticut resident (Table 1). The median age for Connecticut is 40 years of age, with 46 years the median age of the survey sample (U.S. Census Bureau, 2015). The difference in age is largely a result of the sample excluding respondents younger than the age of 18 years whereas the Connecticut estimation includes persons younger than 18 years of age. Household median income of the sample was \$75,000, whereas the Connecticut median household income is \$70,000 (U.S. Census Bureau, 2011). To this end, the results are generalizable outside of the survey sample only as much as the sample represents the overall views and perceptions of the population as a whole. Although we cannot guarantee that the sample is generalizable, we have a range of demographics, political affiliations, and so on, that give some indication that the sample results can be generalized within and outside of Connecticut.

EXPERIMENTAL DESIGN AND ANALYSIS. There are several ways the impact of information type and information source on pollinator-friendly plant decision making can be measured. Common approaches include revealed preference (e.g., discrete choice analysis, eye tracking, biometric tools.) and stated preference (e.g., contingent valuation). Although revealed preference studies may mimic real-world decision making more accurately, we used the stated preference approach in this study. The stated preference format was used for two reasons: 1)

ease of use and 2) comparison of treatments more than magnitude of treatment. With respect to ease of use, only one question was required to identify the impact of a treatment compared with multiple questions needed for most revealed preference experiments. Also, given we were interested in treatment comparisons and not the magnitude, potential biases associated with stated preference surveys would not be as problematic, given the impact of the biases would be canceled out as a result of the random nature of treatment assignment. For instance, if survey respondents inflated their likeliness to purchase a pollinator-friendly plant, then this inflation would be distributed randomly across treatments, implying the treatment comparisons should not be biased, although the likeliness values would be biased.

Therefore, to assess the impact of type of information and source of information on potential future pollinator-friendly plant purchasing, respondents were assigned randomly to a treatment group upon entering the survey (Table 2). The treatment groups varied by source of information and the type of information. With respect to type of information, respondents saw a message indicating whether there was a linkage or no linkage between pesticides as a contributor to pollinator decline throughout the United States. The message was accredited to a different source, which included university research, major media outlets, federal government, nursery or greenhouse industry, or environmental activist groups. Two other treatment groups were included: control (no information) and a no-source generic information treatment that presented that pollinator numbers have been in decline, although no specific cause has been determined.

As respondents started the survey, they were assigned randomly to one of the treatment groups. This equates to ≈ 65 respondents in each of the 12 treatment groups. After reading the message associated with the treatment, respondents were asked "What is the likelihood that you will purchase more pollinator-friendly plants for your home landscape during the

Table 1. Descriptive statistics of respondents for a 2016 pollinator-friendly plant purchasing survey of Connecticut residents.

	Sample mean	Sample sd	Connecticut mean
Age (median years)	46	—	40
Generation			
Household income (median)	\$75,000	—	\$70,000
Caucasian	87%	34%	80%
Female	73%	45%	51%
Adults in household	2.3	1.0	—
Children in household	0.6	1.0	—
Education			
Bachelor's or less	51%	50%	—
Bachelor's degree	28%	45%	—
Graduate degree	21%	41%	—
Political affiliation			
Republican	24%	43%	—
Democrat	27%	45%	—
Other	49%	50%	—
Urbanicity			
Rural	23%	42%	—
Suburban	68%	47%	—
Metro	9%	28%	—
Proportion of home landscape plants that are pollinator-friendly plants	44%	26%	—

Table 2. Source and type of information used in a 2016 pollinator-friendly plant purchasing survey of Connecticut residents to test impacts of varying treatments on the purchasing of pollinator-friendly plants.

Information source	Statement
Control, no information	—
Generic information	It has been reported that there has been a decline in pollinators (e.g., bees) within the U.S. A number of causes have been proposed, such as pesticides, climate change, habitat loss, etc.
No linkage	It has been reported that there has been a decline in pollinators (e.g., bees) within the U.S. A number of causes have been proposed, such as pesticides usage. However, _____ has shown no link between pesticides and the decline in pollinators throughout the U.S.
Linkage	It has been reported that there has been a decline in pollinators (e.g., bees) within the U.S. A number of causes have been proposed, such as pesticides usage. However, _____ has shown that certain pesticides can be linked to the decline in pollinators throughout the U.S.
Information source	
Environmental activist group	
Federal government	
Major media outlets	
Nursery/greenhouse industry	
University research	

next year?” Respondents answered the question via marking their likelihood on a continuous line scale, where 0 is extremely unlikely, 50 is

neither likely/unlikely, and 100 is extremely likely.
About 3% and 9% of the sample were censored on the left (at 0) or

right (at 100) on the 100-point scale. Failure to account for the censored nature of the data can result in biased results. Thereby, censoring was accounted for within the data by using the two-limit Tobit model developed by Rossett and Nelson (1975). The model can be represented as

$$y_i^* = \beta'x_i + \varepsilon_i (i = 1, \dots, n) \quad [1]$$
$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } 0 < y_i^* < 100 \\ 100 & \text{if } y_i^* \geq 100 \end{cases} \quad (i = 1, \dots, n)$$

where y_i^* is a latent variable that is not observed at values less than zero or values greater than 100, x is a matrix of explanatory variables, β is a vector of coefficients, and ε is an independently and normally distributed error term with zero mean and variance σ^2 . The x matrix of explanatory variables included demographics, political affiliation, urbanicity, and percent of pollinator-friendly plants in the respondent's landscape, as well as treatment indicators. Political affiliation and urbanicity were included to control for respondent views on pesticides and regulations so that the treatment group impacts could be isolated. To obtain the coefficient, estimates were maximized using the likelihood function in Eq. [2] (Davidson and McKinnon 1993):

$$\begin{aligned} & \sum_{y_i^L \leq y_i^U \leq y_i^U} \log \left\{ \frac{1}{\sigma} \phi \left[\frac{1}{\sigma} (y_i - x_i \beta) \right] \right\} \\ & + \sum_{y_i^L < y_i^L} \log \left\{ \phi \left[\frac{1}{\sigma} (y_i^L - x_i \beta) \right] \right\} \quad [2] \\ & + \sum_{y_i^U > y_i^U} \log \left\{ \phi \left[-\frac{1}{\sigma} (y_i^U - x_i \beta) \right] \right\} \end{aligned}$$

The estimated β coefficients from Eq. [2] are not interpretable as marginal effects (Gould et al., 1989). To obtain the correct marginal effects, unconditional marginal effects, conditional marginal effects, and the probabilities of being uncensored by using McDonald and Moffitt decomposition (McDonald and Moffitt, 1980) were captured. Only the probabilities of being uncensored as well as the conditional marginal effects in this article are reported here. The probabilities of being uncensored represent how likely a respondent was to have chosen a value between the bounds (0 and 100). The conditional marginal effects represent changes from the mean (continuous variables) or changes from the base (categorical variables) values for those responses within the bounds. The analysis was conducted using Stata/SE (version 14.2; StataCorp, College Station, TX).

Results

Of the 785 respondents, they indicated that, on average, 44% of

the plants in their lawn/landscape were pollinator friendly. Table 3 indicates that both source and type of information produced somewhat similar results on respondent likelihood of planting pollinator-friendly plants within their home landscape. The range was between 59.5 (no source and no information) and 65.2 (no source and generic information) on the likeliness scale, which equates to slightly more likely to plant pollinator-friendly plants in their landscape. Of interest, the lowest rating was for the control group, in which no information was given, and all other treatments had an increased likelihood to add pollinator-friendly plants to their landscape.

TOBIT MODEL RESULTS: PROBABILITY OF BEING UNCENSORED. Table 4 shows the probability of being uncensored and the conditional marginal effects from the Tobit model. With respect to the probability of being uncensored, older consumers were more likely to be uncensored than younger consumers, as were females compared with males. For instance, females were 2.5% less likely to be censored than males. Furthermore, as the percentage of pollinator-friendly plants in the home landscape increased by 1%, they were less likely to be censored. With respect to the treatment groups, the groups did not contribute significantly to respondents being censored

or uncensored. The only exception was for no source-generic information, with respondents in this treatment 6.1% less likely to be censored.

TOBIT MODEL RESULTS: MARGINAL EFFECT CONDITIONAL ON BEING UNCENSORED. When comparing demographics and treatments, select demographics and treatments are seen to impact the likelihood of adding pollinator-friendly plants (Table 4). Notably, respondents having a graduate degree were 3.5% more likely (3.5 units on the 100-point scale) to indicate they would add more pollinator-friendly plants to their home landscape during the next year compared with a respondent with a bachelor's degree. Furthermore, females were 4% more likely to indicate they would add a pollinator-friendly plant for every one-unit increase in the mean, whereas the aggregate likelihood decreased by 9.8% for every year increase from the average age. The average respondent's likelihood increased by 0.3% for every percentage increase from the mean of current pollinators in their home landscape. This implies that consumers who have more pollinator-friendly plants in their landscape are more inclined to purchase more pollinator-friendly plants than consumers with less pollinator-friendly plants in their landscape. Most likely this is a result of consumers with more pollinator-friendly plants seeing the value or perceiving a value to adding more pollinator-friendly plants to their landscape.

With respect to treatments, the no source-generic information treatment increased the average respondent's score by 6.5% compared with the control group (no information) (Table 4). This implies that bringing consumer attention to decreasing pollinator numbers can influence the decision-making process of consumers even when no direct cause or source of information is provided. Furthermore, an informational message from a university source with either information linking or not linking pesticides to pollinator decline resulted in a 6.6% and 6.6% increase in likelihood, respectively. A major media outlets message linking and not linking pesticides to pollinator decline also generated a 5.2% and 5.6% increase, respectively. However,

Table 3. Means and sds associated with varying treatments from a 2016 pollinator-friendly plant purchasing survey of Connecticut residents.

Source	Information type	Likelihood of purchasing more pollinator-friendly plants next yr (0–100 scale) ^z		
		Mean	SD	Median
No source (control group)	No information	59.5	24.4	56.0
No source	Generic	65.2	22.5	68.0
Environmental activist group	Link	63.0	25.7	65.0
Environmental activist group	No link	62.5	25.0	57.0
Federal government	Link	61.8	25.0	61.5
Federal government	No link	61.8	26.6	65.0
Major media outlets	Link	64.9	24.2	64.0
Major media outlets	No link	63.7	25.3	64.0
Nursery/greenhouse industry	Link	60.5	24.5	62.5
Nursery/greenhouse industry	No link	65.1	25.1	70.0
University	Link	65.0	24.0	58.0
University	No link	63.8	27.0	65.5

^z0 = extremely unlikely, 50 = neither likely/unlikely, 100 = extremely likely.

Table 4. Tobit results estimating the probabilities and marginal effects using data from a 2016 pollinator-friendly plant purchasing survey of Connecticut residents.

Treatment	Probability of being uncensored			Marginal effect conditional on being uncensored		
	Coefficient	SE	P	Coefficient	SE	P
No source, generic	-0.061	0.035	0.079	6.548	2.850	0.022
University, link	-0.064	0.040	0.106	6.630	3.071	0.031
University, no link	-0.063	0.039	0.106	6.578	3.051	0.031
Major media outlets, link	-0.045	0.032	0.152	5.168	2.902	0.075
Major media outlets, no link	-0.051	0.036	0.162	5.550	3.096	0.073
Federal government, link	-0.042	0.035	0.232	4.733	3.192	0.138
Federal government, no link	-0.032	0.032	0.316	3.816	3.187	0.231
Nursery/greenhouse industry, link	-0.008	0.026	0.755	1.107	3.356	0.741
Nursery/greenhouse industry, no link	-0.042	0.034	0.219	4.797	3.144	0.127
Environmental activist group, link	-0.026	0.028	0.357	3.216	3.027	0.288
Environmental activist group, no link	-0.019	0.027	0.476	2.466	3.091	0.425
Age (median years)	0.001	0.000	0.028	-0.098	0.044	0.026
Caucasian	-0.015	0.011	0.174	2.469	2.036	0.225
Female	-0.025	0.009	0.004	4.047	1.529	0.008
Political affiliation						
Republican	-0.011	0.014	0.449	1.461	1.842	0.428
Other	0.003	0.011	0.801	-0.390	1.552	0.801
Urbanicity						
Rural	-0.015	0.020	0.447	2.087	2.570	0.417
Suburban	-0.006	0.016	0.705	0.898	2.416	0.710
Adults in household	-0.007	0.005	0.118	1.056	0.671	0.116
Children in household	-0.001	0.005	0.798	0.184	0.722	0.798
Education						
Bachelor's or less	-0.005	0.011	0.619	0.785	1.579	0.619
Graduate degree	-0.027	0.016	0.098	3.478	1.859	0.061
Household income (median dollars)	0.000	0.000	0.178	0.000	0.000	0.176
Percentage of home landscape plants that are pollinator-friendly plants	-0.002	0.000	0.000	0.314	0.027	0.000
Observations (no.)			785			
Likelihood ratio chi-square			175.2			
P value > chi-square			0.000			
Log-likelihood			-3,303.8			
Pseudo- R^2 value			2.6%			
Left censored (ratings at 0)			3.2%			
Right censored (ratings at 100)			8.9%			

information either linking or not linking pesticides to pollinator decline from the federal government, nursery/greenhouses, and environmental activists had no difference compared with the control (no source and no information). This result is not wholly surprising given that nurseries/greenhouses and environmental activists could be considered biased sources. However, the lack of significance of federal government coefficients is interesting. This result could be the result of numerous reasons, such as not trusting federal information because the government may be thought of as having an agenda to respondents being inundated with environmental information from the federal government,

thereby diluting the impact of pollinator-specific information.

Conclusions

To consumers, all sources of information are not the same. The level of trust, or lack thereof, consumers place in a source is influenced by a multitude of factors. Firms that can identify which sources of information are trusted by their consumer base and which sources are not, can develop effective marketing strategies that will aid their marketing efforts.

With regard to the findings, it is clear the source of information matters, with the type of information (link vs. no link of pesticides) playing less of a role. Information emanating from

university research, regardless of blaming pollinator declines on pesticides, influences consumers reported future purchasing decisions of pollinator-friendly plants. When the source of information is major media outlets, consumers will change their purchasing habits if the information links or does not link pesticide use to pollinator declines. Information originating from nurseries/greenhouses, the federal government, and environmental activist groups have little impact on respondents' reported future purchasing of pollinator-friendly plants.

Based on these findings, producers, retailers, policymakers, and stakeholders wanting to increase pollinator-friendly plants sales should provide information to their clientele

from universities or major media outlets. These entities could also provide generic information that highlights the plight of pollinators. Using other information sources (i.e., federal government, nursery/greenhouse, environmental activist group) will provide a similar response in moving respondents to purchase more pollinator-friendly plants as providing no information. However, linking pesticides to pollinator-friendly decline had little effect on increasing purchasing. Thereby, retailers can avoid putting unproved linkages on their messages and focus more on providing information about pollinator decline in general.

Providing information about pollinator decline should increase the demand for pollinator-friendly plants, although it would most likely be at the expense of nonpollinator-friendly plants. Therefore, before advertising about pollinator-friendly plants, retailers should determine their overall business objective. For instance, retailers who want to maximize revenue should understand which plants give the greatest margin (price received less the cost of producing) and focus their efforts on increasing the demand for those plants. If a nonpollinator-friendly plant has a greater margin, then they should think about whether they should provide information about pollinators. However, if a pollinator-friendly plant has a greater margin, then providing pollinator information would most likely increase sales. Another objective could be to increase the number of pollinator-friendly plants sold, which means that providing pollinator information could accomplish this objective.

There are several limitations to the study and areas for future research. With respect to limitations, the study was conducted using Connecticut consumers only, implying results are only generalizable to other areas in so much as Connecticut consumers are guided by the same purchasing processes as other populations. Furthermore, using specific industry associations, major media outlets, universities, and/or activist groups could potentially lead to different results than the more generalized results found by using sources that are more generic (e.g., universities instead of specific universities) in nature. As for future work, examining the impact of specific sources and

varying the types of information could help firms have a more in-depth understanding of how information and sources impact their customer base.

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