Preferences for Sustainable Lawn Care Practices: The Choice of Lawn Fertilizers

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Abstract

Urban sprawl in the U.S. has substantially increased the area of maintained residential landscapes. While there are social and economic benefits associated with well-maintained residential lawns, improper landscaping practices, such as excessive irrigation and fertilization may result in adverse environmental effects such as fertilizer chemicals runoff into water resources. Previous studies investigated homeowners' landscaping practices such as amount and frequency of irrigation or fertilizing. However, preferences and willingness to pay (WTP) for eco-friendly fertilizer attributes, which would benefit marketers, educators, and local governments in fertilizers regulation related decision making, remains largely unexplored. This study utilized a discrete choice experiment to investigate whether and how the presence of eco-friendly attributes influence consumers' preferences and WTP for lawn fertilizers. Results from the mixed logit model showed that homeowners were willing to pay price premiums for products featured with environmentally-sustainable attributes (i.e., controlled-release nitrogen, phosphorus-free, and natural and/or organic). It was also found that the experiment participants preferred lawn fertilizers that were labeled as pet-friendly and those that included pest control feature. Relevant policy and marketing implications are discussed.

Key Words: lawn care, eco-friendly, organic, controlled-release, nitrogen fertilizer, choice experiment, willingness to pay

JEL Classifications: Q53, Q56, D12

Introduction and Background

Urban sprawl in the U.S. has substantially increased the area of maintained urban landscapes. Clearly, there are social, aesthetic, and economic benefits associated with well-maintained residential lawns. Previous research reports that "green" neighborhoods provide essential support for local ecosystems and contribute to real estate values, to name only a few (Hall and Dickson, 2011; Larson et al., 2009; Nielson and Smith, 2005). However, improper landscaping practices such as excessive fertilizing or irrigation, which are not uncommon, may

lead to substantial chemical runoffs into adjoining watersheds (Carpenter et al., 1988; Robbins, Polderman and Birkenholtz, 2001). In order to mitigate potential negative impacts to the environment, several local governments in Florida banned the use of fertilizers containing phosphorus, and limited the use of fertilizers containing nitrogen during summer months (i.e., high rain season). On the other hand, however, limited application of macro and micronutrients found in fertilizer products may have reverse harmful effects to the environment. For example, less than appropriate application of macro/micronutrients may deteriorate turfgrass root system and weaken nutrient intake capacity, thus resulting in increased chemical runoffs when fertilizers are applied. The use of eco-friendly fertilizers, therefore, could be a feasible alternative to strict policies, such as banning the use of phosphorus containing and/or nitrogen fertilizers throughout summer months. The extent to which marketers will be rewarded (by consumers) for promoting eco-friendly fertilizers is an open question that could benefit production and marketing of lawn fertilizers. Surprisingly, homeowners' preferences and WTP for eco-friendly lawn fertilizers, which may be affected by conflicting recommendations by proponents and opponents of fertilizer regulations, remains less understood. To address that shortcoming, this study uses consumer choice experiments to investigate whether and how the presence of eco-friendly attributes influence homeowners' fertilizer choice decisions.

Negative environmental outcomes associated with improper yard care practices have raised a great concern among a wide range of interest groups, including environmental activists, scientists, and state legislators (Barton and Colmer, 2006; Beverly, Florkowski and Ruter, 1997; Shober, Denny and Broschat, 2010). Amongst yard care practices, lawn fertilizers and pest mismanagement has generated special attention in the recent years (Carrico, Fraser and Bazuin, 2013; Cook, Hall and Larson, 2012; Martini et al., 2013; Robbins and Sharp, 2003). It is estimated that American urban landscapes, including residential, commercial and institutional, cover approximately 40 million acres, which is up to three times larger than acreage used to grow irrigated corn, the largest irrigated crop in the country (Milesi et al., 2005). In other words, about a quarter of the total urban area requires landscape management, which involves regular application of micro and macro nutrients (Robbins and Birkenholtz, 2003). While nitrogen and phosphorus are essential nutrients for turfgrass during its lifetime growth, over-loaded nutrients may lead to unintended consequences, such as eutrophication (Roach et al., 2008). As an ecosystem response to nitrogen and phosphorus runoffs, eutrophication is a serious and growing

problem (Heisler et al., 2008) accompanied with excessive growth of harmful algal blooms, depletion of oxygen levels, and damage to underwater plants and organisms. Certain types of the algae even emit toxins and can cause skin rashes, stomach aches and possibly even more serious problems if come in contact (EPA, 2012; Wolfe and Patz, 2002).

The effects of local nutrient pollution are especially severe in Florida, which has suffered water quality degradation over the last decades (Badruzzaman et al., 2012; Carey et al., 2012; Hochmuth et al., 2012). The proximity of residential neighborhoods to a large number of watersheds makes ecosystems in Florida more vulnerable to the consequences from chemical runoffs (Trenholm et al., 2009). In response to growing concerns, local and state governments made efforts to mitigate social and environmental impacts. For instance, the Florida Department of Agriculture and Consumer Services (FDACS) issued the Urban Turf Fertilizer Rule [5E-1.003(2) Florida Administrative Code] in 2007 to regulate the nutrient content by providing standards for lawn fertilizers sold in Florida (FDACS, 2007). In addition, several county governments adopted local fertilizer ordinances as means to control the use of fertilizers (Evans et al., 2007), which were consistent with best management practices (BMPs) suggested by the Florida Department of Environmental Protection (FDEP) (FDEP, 2010a; 2010b) and the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS)[1]. It is expected that the BMPs will facilitate effective turfgrass and other landscape management efforts, thus minimizing the non-point source pollution caused by excessive fertilization. Moreover, some local governments (e.g., in Pinellas County), where the BMPs were not effective enough, opted for stricter fertilizer rules, such as fertilizer blackout days during the period of June 1st to September 30th (PinellaCounty, 2010; Waymer, 2014). In 2010, the Florida legislature made the BMP training mandatory for commercial all fertilizer applicators (FDEP, 2010b).

As for non-commercial fertilizer applicators, such as homeowners, no mandatory training is required, but a variety of educational resources were created and made available through multiple channels, such as university extension programs (Borisova et al., 2011). However, a recent study found, the vast majority of homeowners were not entirely aware of the potential environmental impacts of their landscaping practices (Israel and Knox, 2010). Increasing homeowners' knowledge about appropriate fertilization practices would help households to build healthier and greener lawns, and protect local water sources and related eco-systems from

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[1] Florida-Friendly Landscaping (FFL): http://fyn.ifas.ufl.edu/

pollution in the long term. Therefore, understanding the homeowners' preference for lawn fertilizer attributes and the factors that drive choice preferences could benefit relevant educational programs and regulatory/policy decisions. This study is a step towards a broader goal, which is to understand the extent to which Florida homeowners consider long-term consequences of their landscaping practices. It will provide useful feedback about consumer incentives (to be engaged in eco-friendly landscaping practices) to the local and state stakeholders.

In this study we investigate homeowners' preference and WTP for lawn fertilizers, especially for those featured with environmentally-sustainable attributes (i.e., controlled-release nitrogen, phosphorus-free, natural and/or organic, etc.), which improve plant nutrition intake capacity and reduce nutrient runoffs. Previous research investigated the relationship between individuals' behavioral characteristics and perceived environmental outcomes related to lawn care practices (Blaine et al., 2012; Cook, Hall and Larson, 2012; Martini et al., 2013). To the best of our knowledge, however, individuals' preferences and WTP for eco-friendly fertilizer attributes have not been investigated. Yue, Hugie and Watkins (2012) examined homeowners' purchasing preference for different types of turfgrass, where the level of lawn fertilizer needed was incorporated into the choice model as a key attribute. However, the differentiated fertilizer attributes were not taken into account.

To achieve our research goals, we conducted an Internet survey of Florida homeowners who lived in a house with a lawn, and maintained their yards on their own (as opposed to hiring professionals). The survey instrument included sections about general lawn care practices (e.g., mowing, irrigating, conducting soil tests, etc.), fertilizer application practices, followed by questions about attitudes and perceptions about environmental impacts from lawn care practices. The rest of the paper is organized as follows. First, we provide a background on eco-friendly fertilize attributes, followed by the description of the survey design. Next, we describe the choice model used to provide a snapshot of homeowners' lawn fertilizer choice decisions. Subsequently, we discuss the results about the effects of the presence of eco-friendly fertilizer attributes on choice decisions. WTP for lawn fertilizers, were calculated using results from a mixed logit regression coefficients. The last part of the paper concludes with relevant policy and market implications.

Eco-Friendly Fertilizers

Promoting the use of eco-friendly fertilizers in Florida has become critical given growth in population, and developments in tourism and agriculture industries, which significantly increased demands for fresh water supplies (Marella, 2005). Despite the fact that Florida receives annual rainfalls from 43 to 71 inches (compared with the 30-inch national average), intensive uses of water for agriculture, public, and industrial/commercial purposes put the state's rich water resources under significant pressure (Borisova and Carriker, 2005). Given the critical role that ground and surface water resources play in modern society and ecological systems, protection of these resources from chemical runoffs (i.e., non-point pollution) is important as never before. In a review of natural and anthropogenic actions that lead to nutrient enrichment in water bodies in Florida, Badruzzaman et al. (2012) found that residential fertilization was the major contributor to non-point pollution. The authors also reported that factors, such as soil type, plant type, fertilizer type, fertilizer usage, irrigation water type and usage, and rain frequency affect the level of nutrient leaching from residential lawns. Based on these findings, our choice experiment is centered on several important eco-friendly fertilizer attributes, which are briefly reviewed in the rest of this section.

Controlled-Release Nitrogen

One of the eco-friendly fertilizer attributes included in our study is slow- or controlled-release nitrogen. Controlled-release fertilizers contain coating materials or are formulated to delay the release of nitrogen after its application, thus resulting in reduced nitrogen losses. In contrast, fast-release nitrogen fertilizers release all of the available nitrogen into the soil shortly after application. While controlled-release nitrogen fertilizers are widely used in agricultural production to enhance nitrogen efficiency (Motavalli, Goyne and Udawatta, 2008), they are also recommended for use on residential lawns to reduce nutrient losses (Frank and Lyman, 2010; Goatley et al., 2009; Koske, 2007; UF/IFAS, 2009). University of Florida researchers recommended the use of controlled-release nitrogen fertilizer when possible, referring to the fertilizer that contains 15% or more of the nitrogen that is in a controlled-release form (UF/IFAS, 2010). The extent to which Florida homeowners follow the recommendations and use controlled-release nitrogen fertilizers is an open question and is part of our investigation. If so, the consumer demand would be directly affected by the presence of controlled-release attribute.

Therefore, one of the goals in this study is to investigate how different levels of controlled-release (referring to different percentages of the nitrogen in a controlled release form) presented in the lawn fertilizer affect consumers' preferences.

Phosphorus-Free Feature

Another important attribute included in the present study is "phosphorus-free." Phosphorus is another macronutrient beyond nitrogen that is needed for plants. If applied appropriately, phosphorus will promote root growth of plant, stimulate tillering and accelerate maturity (Covert, 1999). However, excessive phosphorus may be transported from the soil to watersheds and lead to eutrophication as unintended consequences (EPA, 2012). Recently, at least 12 states required that phosphorus be excluded from lawn fertilizers, except for special needs (AAPFCO, 2012; Jonathan-Gree,n 2012; Miller, 2012). Following the regulation that is designed to protect local watersheds from excess phosphorus, fertilizer marketers started to introduce a new line of phosphorus-free fertilizer products. Recently, a leading lawn fertilizer manufacturer company announced that its regional branch completely removed phosphorus from one of the marketed product lines to help reduce harmful algae blooms that plagued the local water bodies (Vanac, 2013). Despite the efforts made by policy regulators and manufacturers to protect the quality of watersheds, the consumers' perspective and preferences for phosphorus-free fertilizers remains largely unknown. Therefore, the next goal in the present study is to investigate the effects of the presence of phosphorus free attribute on consumers' choice behavior. The results may help marketers to develop relevant marketing strategies, and policy makers to support present regulations.

Natural and/or Organic

Another fertilizer attribute included in this study is organic/natural. In recognition of the overwhelming demand of pesticides and rising negative outcomes, environmentalists have suggested alternative lawn management, natural and/or organic approach. The natural and/or organic method of lawn care is a system of practices, ranging from turfgrass seed selection, fertilization, identification of pests, use of cultural, manual, mechanical, biological control (i.e., integrated pest management), to yard waste recycling (Bruneau et al., 2008). In this study we

investigate whether fertilizers made from natural or organic materials would be preferred and gain price premiums compared with fertilizers made from inorganic or synthetic sources.

Pest Control Feature

While most households prefer having a healthy and green lawn, they may or may not be concerned about the harmful effects these may have for humans and pets. Outdoor uses of pesticide have been directly linked to pet illnesses (Beasley, 1993), wildlife unhealthiness (Fry, 1995), and sicknesses effecting children (Daniels, Olshan and Savitz, 1997; Lewis, Fortmannn and Camann, 1994). As reported by the US Environmental Protection Agency, about 78 million households in 2007 (US Census Bureau estimated that there were 114.8 million households during year 2007-2011[2]) used pesticides (Grube et al., 2011). Nevertheless, additional features in fertilizer products, such as pest control may be of interest to some homeowners. To include account for preferences for the pest management in addition to fertilization, our study also included fertilizers options that include pest control feature.

Methods

Participants and Procedure

For the purposes of this study, we conducted an Internet survey in the state of Florida through Qualtrics, Inc., a professional survey software company in December 2013. The targeted populations were homeowners who have purchased and used lawn fertilizer on their own lawn. To ensure that subjects were a generally representative sample and had experience with the products in this survey (List, 2003), we screened the respondents based on the following criteria: 1) whether their home included a lawn, 2) whether they applied fertilizer on their lawn themselves, and 3) whether they purchased lawn fertilizers in the past 12 months. Only those meeting the screening criteria were able to proceed to the full questionnaire. Prior to implementing the survey, the questionnaire was pre-tested for clarity with several Florida homeowners who had purchased and applied fertilizers themselves in the past 12 months.

The questionnaire consisted of several parts and on average took the respondents around twenty minutes to complete. Following recommendations in Dillman (2000; 2009) the survey

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[2] US Census Bureau: http://quickfacts.census.gov/qfd/states/00000.html

started with a set of general questions regarding homeowners' purchasing habits and preferences for lawn care products (e.g., pesticides, fertilizers), and related landscaping practices. In the second part of the survey, the subjects were presented with a choice experiment, in which they were asked to select their most preferred lawn fertilizer among different options presented side-by-side. The third part contained detailed questions pertaining to respondents' perceptions and attitudes related about the use of lawn fertilizers and related landscaping practices (e.g., environmental impacts, social and economic benefits, etc.). Lastly, we collected the respondents' demographic information.

Choice Experiment Design

Table 1 – Attributes

Table 1 presents the lawn fertilizer attributes and the attribute levels used in the choice experiment, which were selected for our study purposes as discussed in the previous section. One of the attributes was price level, which was later used to calculate marginal WTPs for fertilizer attributes. Six price levels ($15.99, $20.99, $25.99, $30.99, $35.99, $40.99 per a 25-pound bag of lawn fertilizer covering up to 4000 square feet) were chosen based on market prices from our current market research. A further aim of the choice experiment was to determine consumers' preference for lawn fertilizers labeled as environmentally-sustainable (e.g., made of natural and/or organic materials, containing controlled-release nitrogen, and phosphorus-free, etc.). To do so, four levels of fertilizer ingredient/source type (natural organic, synthetic organic, natural inorganic and synthetic inorganic), six levels of nitrogen release form (fast-release and five percent ranges of the nitrogen that is in a controlled-release form) and two levels of phosphorus-free label (yes or no) were used for the conjoint analysis. Other attributes included in this experiment were three levels of fertilizer application type (liquid, water soluble powder, granules/pelleted), dichotomous levels of insect control feature (included or not included), three levels of weed control feature (pre-emerged, post-emerged and not included), and two levels of pet-friendly label (labeled or not labeled). These attribute levels enabled empirical comparison of the part-worth utilities associated with each of the attributes.

Given these attributes and levels, a full factorial design[3] could result in cognitive burden and fatigue for the respondents, which may lead to a possible decrease of response reliability. Instead, we employed the fractional factorial orthogonal design. The design was generated using the Design of Experiment (DOE) routine in JMP® Pro10 (SAS software), which obtained 72 choice profiles and a 98.7% D-efficiency. These profiles were blocked into four sets with six choice scenarios in each set. Each choice scenario consisted of three fertilizer options (A, B, and C) and one no-choice option (D: "I would not buy any of these three lawn fertilizers.")[4]. The respondents were evenly and randomly assigned with one (out of the four choice sets) choice set during the survey. An example of choice questions in the choice scenario is illustrated in Figure 1.

Before the experiment began, instructions and a question example was presented, which facilitated respondents' understanding on the procedure of the choice experiment. At the end of the instruction section, the participants were also provided with the definitions of the fertilizer attributes (i.e., the four fertilizer source types, five levels controlled-release nitrogen, phosphorus-free, and insect or weed control). Lastly, since no actual purchase or payment was involved in this study, a "cheap talk" approach was adopted to reduce hypothetical bias in responses (Lusk, 2003). The "cheap talk" script used in our study was adapted from the one used by Cummings and Taylor (1999).

Discrete Choice Model

We used the conditional logit (CL) and mixed logit (ML) models to analyze the choice experiment data. These discrete models follow Random Utility Model (McFadden, 1974), and in this study the utility (U_{njt}) associated with individual *n* when buying lawn fertilizer for alternative *j* (fertilizer attribute) in choice situation *t* is decomposed into a deterministic (from price and the attribute matrix) and a random component (ε_{njt}). Namely, the utility for the *n*th individual in this study can be expressed as follows:

(1) $U_{njt} = \beta_{PRICE} * PRICE_{ijt} + X_{njt}\beta_X + \varepsilon_{njt}$

$X = [\ liquid, powder, granules, NO(natural\ organic), SO(synthetic\ organic),$
$\qquad NI(natural\ inorganic, SI(syntheic\ inorganic),$

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[3] Full factorial design obtains 6*3*4*6*2*2*3*2=10,368 choice profiles
[4] 72 profiles= 4 sets * 6 scenarios *3 product options

$$fast, control15, control21, control31, control51, control76,$$

$$pfree, insect, preweed, postweed, petfriendly, would\text{-}not\text{-}buy],$$

where β_{PRICE} denotes the coefficient of price level $PRICE_{ijt}$, $\boldsymbol{\beta_X}$ is a vector of unknown parameters to be estimated for coefficients of the attributes in $\boldsymbol{X}_{njt}$. The vector $\boldsymbol{X}_{njt}$ describes the sets of attributes individual n encountered in choice alternative j of choice set t. In the CL model, the choice probability is expressed as:

$$(2) \quad P_{njt}^{CL} = \frac{exp\ (\beta_{PRICE}^{CL}*PRICE_{ijt}+X_{njt}\boldsymbol{\beta_X^{CL}})}{\sum_{j=1}^{J} exp\ (\beta_{PRICE}^{CL}*PRICE_{ijt}+X_{njt}\boldsymbol{\beta_X^{CL}})}.$$

In contrast to the CL model, the ML model assumes that the β's in the vector $\boldsymbol{\beta_X}$ are random variables, such that variations in tastes and preferences across individuals are incorporated in distributions of β's. The coefficient for price level variable $PRICE_{ijt}$ in the ML model is also fixed as in the CL model to avoid an unrealistic positive coefficient with price (Meijer and Rouwendal, 2006; Olsen, 2009). Therefore, the choice probability derived from the mixed logit model is now modified from equation (2) to equation (3) as follows:

$$(3) \quad P_{njt}^{ML} = \int \frac{exp\ (\beta_{PRICE}^{ML}*PRICE_{ijt}+X_{njt}\boldsymbol{\beta_X^{ML}})}{\sum_{j=1}^{J} exp\ (\beta_{PRICE}^{ML}*PRICE_{ijt}+X_{njt}\boldsymbol{\beta_X^{ML}})} h(\boldsymbol{\beta_X^{ML}})d\boldsymbol{\beta_X^{ML}},$$

where $h(\boldsymbol{\beta_X^{ML}})$ is the mixing distribution and is specified as normal distribution in this paper. The ML produces a set of maximum simulation likelihood estimators of means and standard deviations (SDs) of the parameters via numerical simulation (Train, 2003).

The WTP estimates can be derived from the model coefficients, which show the amount ($ per 25-pound bag) the respondents are willing to pay (or be compensated) in order to switch from the base case to an identical product with the additional attribute level. The marginal WTP is calculated as the negative ratio of the estimated coefficient associated with the attribute and the price level coefficient:

$$(4) \quad WTP_X = -\frac{\beta_X}{\beta_{PRICE}}.$$

Results and Discussions

Sample Summary Statistics

A total of 310 Florida homeowners completed the questionnaire and were included in the final sample of this study. A summary of the demographic statistics is displayed in Table 2 and compared (when appropriate) with the 5-year estimates (2008-2012) from the American Community Survey (ACS) in Florida. The average years that the respondents lived in Florida were twenty-five years. The average months within a year that they spent in Florida were slightly over eleven months. This result indicated that the respondents were permanent Florida residents. The sample corresponded closely to the Florida population in gender, education attainment, household size, household income and home mortgage status, but over-represented in terms of the respondents' age. Approximately, forty-eight percent of the respondents were female. Median education level was "some college". Average household size was 2.75, mean annual household income was $49,999, and median annual income was $63,354. Sixty-one percent of the households were still paying mortgage, thirty percent indicated that they did not have mortgage loans, and the remaining ten percent were renting their homes. This distribution is parallel to the actual Florida homeownership distribution according to the ACS 5-year estimate for Florida. Average age of the respondents (51.2) is relatively higher than that of the state population (40.8) as reported in the ACS report. However, it is reasonable to have such deviations from the public to some extent, as we targeted homeowners with specific criteria (e.g., the respondents had to live in a house with a lawn).

Econometric Results

The estimation results from the CL and ML models are provided in Table 3. The log-likelihood scores attest that the ML model is more efficient than the CL model in this study. Furthermore, over sixty percent of the SDs of the random parameters were significant, which again suggests stronger explanatory power of the ML model compared to that of the CL model. Other model fit statistics reported in Table 3, such as the Adjusted Pseudo/McFadden R^2, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) also supported the superiority of the ML model. As shown, Pseudo (McFadden) R^2 was increased in the ML model; AIC and BIC scores were smaller in the ML; both indicating better fit of the data.

Another notable difference between these two models was that the parameter of would-not-buy option was not significant in the CL model; however, it was significant and negative and the parameter of the associated SD ($\sigma_{would-not-buy}$) was also significant in the ML model, which can be more reasonably explained. The would-not-buy option is an alternative specific constant presented in the fertilizer choice scenarios. Significant and negative coefficient indicates that the respondents, in general, would like to purchase one of the offered lawn fertilizers, and their utility would be significantly reduced if they were not able to choose any of these products. In contrast, insignificance suggested that respondents' utility is not strongly affected by not choosing any of these products. The significant and negative results from the ML model supported the assumption that, participants in this study prefer buying one of the lawn fertilizer than buying nothing. In addition, the significant SD in the ML model suggested that where there were considerable heterogeneities in respondents' preferences for a product.

The significance of the fertilizer attributes coefficients and the price level in both the CL and the ML model were almost the same, except that SD estimates were also reported in the ML model. In the ML model results, SDs were significant except for the attribute *synthetic organic*, *control21*, *control51*, *pfree*, *preweed* and *postweed*, which indicated that respondents hold the same attitude toward these attributes. For example, significant positive coefficients for means but not for SDs were observed for the weed control attributes (e.g., *preweed* and *postweed*). It is possible that weed control is a necessary feature for lawn fertilizers such that all respondents expected its presence. In contrast, for the attribute *insect* and *petfriendly*, the coefficients for means and SDs were all significant and positive. It implied that on average the respondents preferred the lawn fertilizers if they included insect control formula and were labeled pet-friendly, however, not all the respondents thought these two features were necessary for their purposes.

The coefficients of controlled-release nitrogen (*control15, control21, control31, control51, control76*), phosphorus-free (*pfree*), and organic/natural (*natural organic, natural inorganic, synthetic organic*) attributes were all significant and positive. This suggests that, in general, the presence of the environmentally-sustainable attributes increased the likelihood of lawn fertilizers being selected. These results provide useful insights for marketers. Following this observation, developing fertilizers with eco-friendly features (made from natural and/or

organic sources or products with enhanced nutrient efficiency) may be rewarding by attracting more consumers.

WTP for Fertilizer Attributes

A more intuitive interpretation of the estimated coefficients can be achieved by using them to calculate the marginal WTPs for each attributes, using expression (4). The WTP results are provided in Table 4. For brevity and consistency, we adopted WTPs at mean for both models, and discussions were mainly based on the results from the ML model that had better fit of the data. Firstly, the coefficient of the granule attribute was positive and significant, but insignificant for the water-soluble powder attribute. A possible explanation is that homeowners preferred lawn fertilizers that require less effort, and the granular fertilizer may be the easiest to apply (i.e., less labor-intensive, and the applicators can visually track the amount applied). The respondents were willing to pay a premium of $17.67 for a bag of granular lawn fertilizer (of 25 lbs., covering up to 4500 sq. ft., hereinafter) compared with the liquid fertilizer (equivalent to 25-pound bag of granular fertilizer). The insignificant coefficient shows that the respondents were indifferent between powder and liquid fertilizers.

Secondly, compared with the base level (synthetic inorganic), the respondents were willing to pay a price premium for natural organic, natural inorganic, and synthetic organic attributes. The preference for the natural and/or organic attributes is descending as follows: natural organic, natural inorganic and synthetic organic. As explained to the respondents in the beginning of the choice experiment, natural organic means the fertilizer is made from all natural <u>and</u> organic materials, such as plant and animal matter. In contrast to natural organic, synthetic organic can be formulated from organic materials, such as urea, which are not necessarily natural. Additionally, the natural inorganic refers to fertilizers made from naturally mined materials, such as powdered limestone, mined rock phosphate, sodium nitrate, etc., which are natural, but not organic. Finally, synthetic inorganic fertilizers are composed of simple chemicals and minerals. According to our results, respondents were on average willing to pay $11.37 more per bag if the lawn fertilizers were made from the natural organic materials, $8.43 more for those made from natural inorganic materials, and $5.31 more for those made from synthetic organic materials, compared with synthetic inorganic alternatives. It implied that natural and organic options are meaningfully differentiated from each other and from the synthetic inorganic alternative. The

information is useful for policy makers, as natural and/or organic fertilizers may be viable alternatives for fertilizer bans. Marketers and manufacturers may also benefit by promoting natural and/or organic products.

Thirdly, the surveyed homeowners were willing to pay $9.64 more per bag in which 15%~ 20% of the nitrogen is in a controlled-release form (relative to the base level – fast-release nitrogen), and $14 more per bag that has at least 76% of the nitrogen in a controlled-release form. Generally, the level of controlled-release nitrogen in the fertilizer was positively associated with the respondents' preference and WTP for that attribute. In other words, the higher was the percentage of controlled nitrogen content, the more likely were homeowners to buy and the more they were willing to pay, compared with fast release nitrogen fertilizers. Preference heterogeneities were also observed at the threshold level (15% ~20%), which is the level recommended by UF/IFAS (2010), the medium level (31%~50%) and the highest level (76% and more), but not for other levels in between.

The respondents were willing to pay $3.11 more per bag if it was phosphorus-free. No preference heterogeneity was found with respect to this attribute. However, the WTP amount is much less than that of the control-release nitrogen attribute. One plausible explanation is that the respondents in Florida had less knowledge about this attribute and its benefits. More detailed studies of consumer preferences for yard care product are needed to determine the incentives behind WTP differences among various fertilizer attributes.

Besides the eco-friendly attributes, we also examined whether pest control inclusion (i.e., insect control, pre-emerged weed control, and post-emerged weed control) would influence the respondents' preferences. As shown in Table 3, the coefficients for the pest control attributes were significant and positive, which suggests higher purchase likelihood for the lawn fertilizers that include pest control functions. In general, the participants were willing to pay a $5.18 premium per bag if the fertilizer included insect control, $11.82 more if it included pre-emerged weed control, and $7.11 more if it included post-emerged weed control. Compared to the unlabeled (base) alternative, the marginal WTP for fertilizer being labeled pet-friendly was on average $13.13 more per bag.

WTP and Demographic Characteristics

Aforementioned significant SDs of the coefficients associated with the attributes suggested heterogeneities in homeowner views on these lawn fertilizers. This section discusses the WTP results when interactions of attributes and demographic characteristics are included in the model. The demographic characteristics chosen as covariates with the attributes included age, gender, education, and household income (*AGE, FEMALE, EDU, HHINC*) (Table 5). Comparing these results with those in Table 3, the significance of the SDs of the attribute coefficients were largely the same. However, it can be seen that adding demographic-interaction variables improved the model fit, for instance a higher adjusted McFadden R^2 was obtained. The significant interactions further revealed how different individuals, depending on their demographic characteristics, may or may not like a certain fertilizer attribute. In line with previous discussions, we also looked at marginal WTPs at mean associated with various attributes while considering demographic differences. The main effect WTPs at mean for all fertilizer attributes calculated by using demographic averages were the same compared with results in Table 4, except for a few differences in magnitudes.

First, the would-not-buy option interacted with *AGE* was significant and positive, indicating that senior participants do not like lawn fertilizers, in general or in this choice experiment. For those who would buy lawn fertilizers, however, the more senior they were, the more likely they may prefer granule to liquid and prefer natural organic to synthetic inorganic. The price premium of $0.76 for granule and of $0.30 for natural organic attributes means that for every year increase in age, the respondents were willing to pay that much more compared with liquid and synthetic inorganic attributes, respectively. It is possible that the ease of application of fertilizers is even more important for senior homeowners. In contrast, negative estimates were observed for insect control feature and being labeled as pet friendly.

A considerable gender gap was found in preferences and WTP for granular fertilizers, as shown by the significant and negative coefficient associated with granule variable when interacted with an indicator variable for female. According to the results, female homeowners were on average willing to pay $19.38 less per bag than male homeowners for the granular fertilizers compared with the liquid (base) alternative. Also, female participants preferred the weed-control attribute; as shown, they were willing to pay $7.32 and $8.01 extra per 25-pund bag of lawn fertilizers with pre- and post-emerged weed control, respectively.

No significant differences were observed among respondents with different educational background, with respect to different fertilizer types and the eco-friendly attributes. However, the higher the education level the respondents received, the higher price premiums they were willing to pay for weed control attribute. However, negative response was found for attribute being labeled pet friendly. This may be counter-intuitive, however, individuals with higher education levels may not fully trust that fertilizers being labeled pet friendly are actually safe for pets. Alternatively, certain consumers may not feel that pet friendly is a necessary attribute for lawn fertilizers, and if this is the case (both for senior and with more educated homeowners in these results), then such labeling will negatively impact utility and preferences. This result also suggested that careful market research is necessary, and requisite, before investigating in labeling schemes and marketing strategies.

Finally, we also examined preference and WTPs for the attributes when interacted with homeowners' household income (*HHINC*). It is notable that homeowners with higher household incomes were less like to buy powder fertilizers, and those that included post-emerged weed control feature. However, they were more likely to use fertilizer with highest level of controlled-release nitrogen (76% and more) and were on average willing to pay $2.28 more per bag in respect to every $10, 000 increased in their household income. A practical implication for producers and retailers is to concentrate on investigating high-end shopping venues where higher income household might visit more, in order to improve their profits.

Conclusions

Excessive fertilizer application may adversely impact natural eco-systems (Robbins and Sharp, 2003; Robbins, Polderman and Birkenholtz, 2001), and with the current pace of urbanization, minimizing these impacts through informed and appropriate yard care practices is important as never before (Blaine et al., 2012; Carrico, Fraser and Bazuin, 2013; Cook, Hall and Larson, 2012). Our study contributes to the existing literature by investigating homeowners' preferences and WTP for fertilizer attributes that are directly applicable to urban landscaping related regulation and policies. The findings are especially important to the stakeholders in Florida, where water quality and quantity were significantly affected (Shober, Denny and Broschat, 2010).

According to our results, the type of fertilizer application, source of ingredients, controlled levels of nitrogen release, and included additional functions (i.e., insect/weed control) played a significant role in shaping consumers' choice decisions. Generally, the result provided empirical support for the promotion of eco-friendly features of lawn fertilizers. The results may also be useful for marketers to develop and advertise more eco-friendly fertilizers. Among the fertilizer attributes analyzed, controlled release nitrogen was the leading factor affecting homeowners' choice behavior, followed by natural and/or organic attributes and phosphorus-free. Specifically, homeowners were willing to pay price premiums for lawn fertilizers with high levels of controlled release nitrogen. Moreover, about 70% of the sampled respondents indicated that controlled release was a 'somewhat important' or 'very important' feature when they chose lawn fertilizers and 66% of those respondents indicated that they purchased controlled released nitrogen fertilizers 'most of the time' or 'every time' in the last two years. These statistics are consistent with our estimated results, and suggest that aggressively marketing fertilizer features such as controlled release nitrogen may be environmentally sustainable and economically viable alternative for the landscape management and manufacturing industry. Encouraging or enforcing more use of controlled-release nitrogen and phosphorus-free fertilizers, is a mutually beneficial alternative to simply banning the use of fertilizers during extended period of time (Toor and Lusk, 2012).

Fertilizers made from natural and/or organic materials have advantage in slowing down nutrient release process before being absorbed by the turfgrass. It was found that the natural organic fertilizer gained the highest price premium in relation to the synthetic inorganic (which is the base alternative), followed by natural inorganic and synthetic organic fertilizers. Comparison of WTP results for natural and/or organic attributes showed that, in general, natural was superior to organic. Preference heterogeneities were found for natural organic and inorganic, but not for synthetic organic fertilizers. In other words, the respondents held consistent for this type of fertilizers.

Lastly, the respondents were more likely to buy a lawn fertilizer with pre-emerged weed control, which suggests that marketing fertilizers with multiple functions may increase sales. Because of the heterogeneities found in respondents' view for the attributes, we incorporated individual specific information, e.g., the demographic characteristics, by interacting fertilizer attributes with some key demographic variables. The results showed that senior and more

educated homeowners were not fond of the pet-friendly labels on lawn fertilizers, and senior homeowners did not prefer insect control feature to be included in lawn fertilizers. In addition, gender gap existed in preference toward granular fertilizers. The study found that homeowners with higher household income were more likely to choose a highest level of control-release nitrogen fertilizers, suggesting that more comprehensive consumer studies are needed for effective targeting of different consumer segments. Future research should focus on more detailed investigation of preference heterogeneities with respect to underlying determinants (both product- and consumer-specific) of choice behavior.

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Appendix

Table 1 – Attributes

Table 1 Fertilizer Attributes and Attribute Levels used in the Residential Lawn Fertilizer Preferences Study in Florida

Attributes	Levels		*Variable*
Price ($/bag*)	15.99, 20.99, 25.99, 30.99, 35.99, and 40.99		*PRICE*
	* 25 lbs, covers up to 4500 sq. ft.		
Application type	Liquid		*liquid*
	Water soluble powder		*powder*
	Granules/Pelleted		*granules*
Source	Natural Organic		*NO*
	Synthetic Organic		*SO*
	Natural Inorganic		*NI*
	Synthetic Inorganic		*SI*
Nitrogen release	Fast-release		
	Controlled-release (15% ~20%)		*control15*
	Controlled-release (21% ~30%)		*control21*
	Controlled-release (31% ~50%)		*control31*
	Controlled-release (51% ~75%)		*control51*
	Controlled-release (76% ~100%)		*control76*
Phosphorus-free	Yes		*pfree*
	No		
Pest control	Insect control	Included	*insect*
		Not included	
	Weed control	Pre-emerged	*preweed*
		Post-emerged	*postweed*
		Not included	
Pet-Friendly	Labeled		*petfriendly*
	Not labeled		
Would-not-buy	"I would not buy any of these three lawn fertilizers."		*would-not-buy*

Figure 1 – Choice Scenario Ex

Figure 1 An Example Choice Question used in the Choice Experiment in a 2013 Willingness-To-Pay Study of Lawn Fertilizers in Florida

Scenario 1. Please choose your most preferred lawn fertilizer option:

	A	**B**	**C**	**D**
Application Type	Liquid	Granules	Water Soluble Powder	I would not buy any of these three lawn fertilizers.
Source	Natural Organic	Natural Inorganic	Synthetic Organic	
Nitrogen Release	31% ~50% Controlled	76% ~100% Controlled	15% ~20% Controlled	
Phosphorus Free	---	Yes	Yes	
Insect Control	---	Yes	Yes	
Weed Control	Post-emerged	Pre-emerged	---	
Pet Friendly	Yes	---	Yes	
Price	$15.99	$30.99	$35.99	

I would choose:

	A	B	C	D
	⊙	⊙	⊙	⊙

Table 2 - Summary Stats

Table 2 Summary Statistics of Demographic Characteristics of the Florida Homeowners Participating in a 2013 Willingness-To-Pay Study of Lawn Fertilizers

		Sample Statistics		Florida Statistics
		Mean	Std. Dev.	Mean
Population		1186		18,885,152[a]
Total Housing Units		310		8,983,414[a]
	Occupied	310		7,147,013[a]
	Vacant	-		1,836,401[a]
Household		310		7,147,013[b]
Mortgage Status	*With mortgage*	61.3%		63.7%[b]
	Without mortgage	29.7%		36.3%[b]
	rent	9.0%		-
Length of Stay in FL	*annually (month)*	11.2	9.2	-
	Total (year)	24.9	17.1	
Age (year)		51.2	14.6	40.8[a]
Household Income	*Median*	$49,999.5	-	$47,309[b]
	Mean	$63,354.3	$39,589.8	$66,599[b]
Education (year)	*Median*	Some college		Some college
	Mean	13.9	3.3	13.3[b,c]
Female		47.74%		51.10%[b]
Household Size		2.75	1.28	2.58[b]

[a] Florida 2010 Census Demographic Profile
[b] Florida 2008-2012 American Community Survey 5-Year Estimates
[c] Population 25 years and over

Table 3 - CL and ML estimates

Table 3 Conditional and Mixed Logit Model Estimate Results for Choice Experiment Data Collected for a 2013 Willingness-To-Pay Study of Lawn Fertilizers in Florida

	CL			ML		
	Coef.		Std. Err.	Coef.		Std. Err.
$\beta_{would-not-buy}$	0.0987		0.1627	-1.0876	***	0.3275
β_{PRICE}	-0.0335	***	0.0037	-0.0533	***	0.0060
Type [liquid]						
β_{powder}	0.1167		0.0742	-0.0147		0.1168
$\beta_{granule}$	0.7248	***	0.0662	0.9420	***	0.1297
Source [synthetic inorganic]						
$\beta_{natural\ organic}$	0.5321	***	0.0826	0.6061	***	0.1320
$\beta_{natural\ inorganic}$	0.3450	***	0.0870	0.4495	***	0.1206
$\beta_{synthetic\ organic}$	0.2313	**	0.0912	0.2834	**	0.1261
Nitrogen Release [fast]						
$\beta_{control15}$	0.3582	***	0.1045	0.5142	***	0.1605
$\beta_{control21}$	0.3591	***	0.1104	0.4665	***	0.1577
$\beta_{control31}$	0.3510	***	0.1157	0.5823	***	0.1647
$\beta_{control51}$	0.4449	***	0.1089	0.7029	***	0.1556
$\beta_{control76}$	0.4888	***	0.1035	0.7463	***	0.1511
Phosphorus [included]						
β_{pfree}	0.1053	*	0.0581	0.1656	**	0.0839
Insect Control [not included]						
β_{insect}	0.2294	***	0.0582	0.2760	***	0.0986
Weed Control [not included]						
$\beta_{preweed}$	0.4142	***	0.0692	0.6300	***	0.1021
$\beta_{postweed}$	0.2490	***	0.0694	0.3793	***	0.1055
Pet-Friendly Label [not labeled]						
$\beta_{petfriendly}$	0.4578	***	0.0574	0.7001	***	0.1070
Standard Deviation Estimates						
σ_{powder}				0.9159	***	0.1521

$\sigma_{granule}$		1.4499 ***	0.1477
$\sigma_{natural\ organic}$		1.0694 ***	0.1704
$\sigma_{natural\ inorganic}$		0.4662 *	0.2403
$\sigma_{synthetic\ organic}$		0.2299	0.2930
$\sigma_{control15}$		0.6621 **	0.2584
$\sigma_{control21}$		0.4551	0.3362
$\sigma_{control31}$		-0.6695 **	0.2689
$\sigma_{control51}$		0.2449	0.2780
$\sigma_{control76}$		-0.6411 ***	0.2489
σ_{pfree}		0.2816	0.2657
σ_{insect}		0.7659 ***	0.1528
$\sigma_{preweed}$		-0.2123	0.2699
$\sigma_{postweed}$		-0.2666	0.2130
$\sigma_{petfriendly}$		-1.1019 ***	0.1391
$\sigma_{would-not-buy}$		2.7933 ***	0.2873
Log-likelihood	-2308.6	-2071.5	
K: degree of freedom	17	33	
AIC	4651.19	4162.23	
BIC	4768.74	4390.41	
N	7440	7440	
Adj McFadden R-sq	0.098	0.193	

Note: Baseline attributes level is provided in square brackets;
* p<0.10, ** p<0.05, *** p<0.01;
Adj McFadden R-sq $= 1 - \frac{ln\widehat{L_{fll}} - k}{ln\widehat{L_{null}}}$;
Mixed Logit results were simulated with 500 Halton draws.

Table 4 – WTP with CL and ML

Table 4 Willingness-To-Pay Results for Lawn Fertilizer Attributes using Conditional and Mixed Logit Models

	CL		ML				
				Coef. Std. Dev.	**WTP**		
	Coef.	**WTP**	Coef.		**Mean**		Std. Err.
would-not-buy		**$2.95**	***	***	**-$20.40**	***	$5.90
Price	***	---	***		---	---	---
Type [liquid]							
Powder		**$3.48**		***	**-$0.28**		$2.19
Granule	***	**$21.64**	***	***	**$17.67**	***	$2.86
Source [synthetic inorganic]							
Natural Organic	***	**$15.88**	***	***	**$11.37**	***	$2.63
Natural Inorganic	***	**$10.30**	***	*	**$8.43**	***	$2.36
Synthetic Organic	**	**$6.90**	**		**$5.31**	**	$2.37
Nitrogen Release [fast release]							
Controlled 15%~20%	***	**$10.69**	***	**	**$9.64**	***	$3.02
Controlled 21%~30%	***	**$10.72**	***		**$8.75**	***	$3.04
Controlled 31%~50%	***	**$10.48**	***	**	**$10.92**	***	$3.19
Controlled 51%~75%	***	**$13.28**	***		**$13.18**	***	$3.08
Controlled >76%	***	**$14.59**	***	***	**$14.00**	***	$2.97
Phosphorus [included]							
Phosphorus-free	*	**$3.15**	**		**$3.11**	**	$1.61
Insect Control [not included]							
Insect	***	**$6.85**	***	***	**$5.18**	***	$1.87
Weed Control [not included]							
Pre-emerged	***	**$12.37**	***		**$11.82**	***	$2.03
Pos-emerged	***	**$7.43**	***		**$7.11**	***	$2.05
Pet-Friendly Label [not labeled]							
Pet-Friendly	***	**$13.67**	***	***	**$13.13**	***	$2.32

Note: Baseline attributes level in square bracket; WTP refers for $/per bag of lawn fertilizers (25 lbs, cover up to 4500 sq. ft.);

    * p<0.10, ** p<0.05, *** p<0.01.