Determinants of an Environmental Horticulture Firm's Recycle Process in terms of type and quantity: the Case of Georgia

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Abstract

Environmental horticulture firms provide a variety of commercial/residential landscape products and services encompassing ornamental plant production, design, installation, and maintenance. The companies generate tons of waste including plastic containers, trays, and greenhouse/field covers, creating the need to reduce and utilize plastic waste. Based on survey data collected in Georgia in 2013, this paper investigates determinants of the environmental horticulture firms' recycling decision (plastic containers, flats, and greenhouse poly) as well as factors influencing total quantity of recyclable materials discarded by firms. Our findings indicate that the decision to discard vs. recycle plastic containers, flats, and greenhouse poly is significantly influenced by firm scope, size, location, and partnership with recycling providers, as well as whether recycling providers offer additional waste pickup services. In terms of total quantity of discarded waste, high revenue firms with a focus on landscape maintenance and plant nurseries are found to throw away more recyclable materials compared to firms with another business focus. Insights from this study are of use to local governments and environmental organizations interested in increasing horticultural firm participation in recycling programs and lowering the volume of plastic destined for landfills.

1. Introduction

Environmental horticulture firms provide a variety of products and services to commercial/residential users encompassing the design, installation, and maintenance of landscapes. It is estimated that residential gardening activities alone involve at least 70 million U.S. households (Missouri Botanical Garden, 2008). One of the greatest problems facing horticulture firms is the huge amount of solid waste generated during the production and service process (Antón et al., 2005). Organic horticultural waste such as tree trunks, branches, plant parts, and trimmings (Xin et al., 2011) is often composted and utilized by residential and commercial users. Plastics play a substantial role in horticulture (Hemphill, 1993). However, the disposal of plastic waste including plastic containers, trays, flats, greenhouse covers, and field covers is much more complex. Plastic waste in horticulture has become a significant contributor to solid waste disposal problems, especially firms that are heavy users of plastic products. The Environmental Protection Agency (EPA) estimates that more than 350 million pounds of plastic containers and trays are generated by gardeners, garden centers, and garden contractors every year (Perry Lawton, 2009).

Plastic materials, including those from the horticulture sector, have been traditionally discarded in landfills or incinerated (Hartz et al., 1996; Antón et al., 2005). Plastic waste ending up in landfills "takes up considerable space and does not readily decompose and would remain intact for decades" (Missouri Botanical Garden, 2008). However, incineration produces atmospheric emissions which increases environmental pollution (Antón et al., 2005). Environmental concerns of horticultural plastics disposal in landfills or incinerators, difficulties in finding new landfill sites, and restrictions on

incineration are forcing the development of more environmentally acceptable alternatives such as recycling (Hemphill, 1993; Antón et al., 2005). Among the available options, recycling seems to be the most promising. Although a large portion of horticultural firms recycles unneeded materials, the recycling process varies by specific materials and firms (GGIA, 2014). Therefore, understanding determinants of recycling activities is of crucial importance in the horticultural industry to enhance firms' recycling performance. Based on survey data collected from environmental horticulture firms in Georgia in 2013, the primary focus of the current study is to examine the relationship between selected firm features and decisions to recycle commonly used plastic products, and also the volume of recyclable waste presently discarded in landfills. Specifically, this study investigates factors that influence the environmental horticulture firms' recycling decision regarding plastic containers, flats, and greenhouse poly, and the total quantity of discarded recyclable materials. The study offers local government and sustainable development organizations useful knowledge for designing and implementing recycling programs in the environmental horticultural area. The provided insights can be used to lower landfill burdens by enhancing environmental horticultural firm participation in recycling.

2. Background of plastic waste recycling in the environmental horticultural industry

Because of its appealing properties (e.g., light weight and versatility), plastics in various forms and shapes are widely used in horticultural plant production and landscaping (Hemphill, 1993; Cameron, 2009). These plastic containers can be re-used but require particular sorting and cleaning. A wide range of plastic types are used in the horticulture industry including low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), and high impact polystyrene (HIPS)

(Cameron, 2009), which makes sorting a labor-intensive and time-consuming job. After plastic containers are sorted, the next step, cleaning, is even more complicated. Usually, even with manual scrubbing, commonly transmitted diseases resulting from pathogens could still survive. Therefore, careful cleaning with proper agents is necessary to sterilize surfaces and prevent plants from contaminating the reused containers, trays, or flats.

Currently, cleaning of plastic containers is often accomplished by homeowners rather than large-scale commercial nurseries (Perry Lawton, 2009). Mechanical cleaning of plastic containers in environmental horticulture has not been applied due to not only the lack of standardization of containers, but also the relative high cost of the cleaning process as compared to the relative low price of new containers. To lessen the horticultural plastics disposal, the public is encouraged to volunteer in pot collection, cleaning and reuse, but such efforts are infrequent (Botts, 2011). So far, recycling of horticultural plastics has been implemented on a voluntary basis in only a few cities. Therefore, recyclable containers in the horticulture industry are commonly ground up, and the granulate or flakes are sold for manufacturing various plastic products (Perry Lawton, 2009). Large quantities of plastics from environmental horticulture firms end up in landfills, which cause environmental problems due to their slow decay (Bai and Sutanto, 2002).

In Georgia, the horticultural industry plays a significant role in the state, and contributed $471.3 million to the economy in 2013 (GASS, 2014). Environmental horticulture includes landscaping, irrigation contractors, wholesale nursery growers, greenhouse operators, retail garden centers, and allied sales companies (GGIA, 2014). These green firms provide a wide range of products and services, from nurseries and

ornamental plants to landscape maintenance, installation, and design. In this process, the sector not only generates various organic wastes, but also a large volume of plastic waste. Because of the diverse business scope, it is not hard to understand that waste collection and recycling in the environmental horticulture sector is quite complex. Although plastic waste, given the type of plastics used in environmental horticulture, can be recycled, only a small fraction can be reused in manufacturing new horticultural containers. Hemphill (1993) reports that new horticultural containers can be manufactured using up to 15% of recycled plastic. In Georgia, like most other states in the U.S., ground plastics are often used by other industries as a feedstock. The collection and recycling of horticultural solid waste is usually managed by counties (Anonymous, 2011). Recycling centers operated by municipalities or private companies re-sell plastic materials to earn revenue from waste tipping fees. The horticultural sector is an important source of recyclable plastic. However, the specific nature of environmental horticulture firms and the plastic waste they generate is not recorded in detail. The volume of discarded recyclable plastic generated by horticultural firms is not well known for a number of reasons. For example, horticulture waste is often reported as agricultural waste, and plastic waste from production facilities is spatially concentrated, while that generated by service providers is more spatially dispersed. The total share of the sector's plastic waste is relatively small. However, generation of plastic waste by environmental horticulture firms is often highly concentrated in counties with production facilities or service providers. It is the plastic waste concentration that offers opportunities for recycling because the large volume originates within a limited area. It is estimated that two-thirds of recycling is collection costs (EPA, 2012). In the absence of reliable figures

on plastic waste discarded by environmental horticulture firms, we focus on examining factors behind the disposal decision of an environmental horticulture firm in search of opportunities to increase recycling.

3. Data and method

A large amount of plastic waste is generated by horticultural firms. However, traditional disposal methods such as landfilling or incineration cause environmental problems due to slow decay or toxic chemicals release during combustion (Bai and Sutanto, 2002). Therefore, as discussed in the previous section, promotion of recycling among environmental horticulture firms would be a promising option. Associated policies and programs need to be employed at a local level, therefore useful information about current recycling practices is highly desirable to formulate and implement suitable programs or modify existing waste collection schedules.

3.1 Survey implementation and data collection

A survey with a particular focus on environmental horticulture firms in Georgia was designed and implemented between January and March 2013. Questions regarding current recycling practices in the horticultural industry were a major part of the survey instrument. During the survey, participating horticultural firms were asked about their basic firm features, recycling practices, and their motivation toward recycling, while the person completing the questionnaire on behalf of the company, typically the owner or manager, also shared their socio-demographic characteristics. Data from this survey would reveal the environmental horticulture firms' recycling behavior to local and regional governments, as well as nonprofit organizations concerned about environmental protection and sustainable development.

The highly heterogeneous business activities of environmental horticulture firms constrains an easy identification of firms that should be included for data collection. The Georgia Green Industry Association (GGIA) encompasses a number of firms that are usually difficult to identify, thus the list of GGIA firm-members facilitated the initial identification of potential survey participants. After a review of the list provided by the GGIA, a number of addresses on the list were found to be associated with county extension offices or personnel, environmental horticulture support services (e.g., financial or legal), or other organizations not directly involved in production, sales, design, or provision of landscape services. Subsequently, such misidentified entities were removed from the list.

Once the questionnaire was drafted, a few members of the GGIA had the opportunity to review it. A few questions were rephrased to assure survey clarity. Questionnaires were distributed through two avenues: online and post mail. Initially, questionnaires were posted on the Internet allowing members to complete the survey online. After a period of four weeks, a printed copy of the questionnaire was mailed to potential respondents. As the cover letter attached to the mailed questionnaires indicated, participants could either complete the online version of the survey, or return the completed print copy of the questionnaire by mail. The first mailing identified 47 addresses defined by the postal service as undeliverable. Four weeks after the first mailing, the online survey was terminated and the second mailing of printed questionnaires occurred, which added another ten addresses to the "undeliverable" group. The final number of identified environmental horticulture firms was 920. This report is based on the data collected from 250 questionnaires returned by April 30, 2013, a

response rate of 27.2%. Further data collection was discontinued because of the increased engagement in seasonal fieldwork. After deleting the incomplete records, 211 environmental horticulture firms were included in the current analysis.

3.2 Summary of descriptive statistics

The summary of survey data illustrates the extent of the plastic waste management issue. This data set, indicative of the environmental horticulture sector of Georgia, shows a considerable portion of firms discarded certain types of materials that could be recycled. Specifically, 46.6% of firms discarded recyclable plastic containers, while 28.7% and 19.3% of firms reported that they threw away recyclable flats and greenhouse poly, respectively. In terms of the total quantity discarded, an average horticultural firm threw away 14.4 tons of recyclable waste per quarter including plastics.

Several basic characteristics of surveyed environmental horticultural firms are summarized as follows. About 61% of firms located their headquarters in the Atlanta metropolitan area. The total revenue of a typical firm in 2011 was between $350,000 and $500,000, and the average number of employees was 22 people. Firms were engaged in multiple business activities, and their primary scopes included the design, construction, and installation of landscapes, and landscape maintenance, as well as wholesale container and in-ground nurseries. In addition, the survey instrument also posed questions asking a firm to describe its relationship with recycling providers, as well as whether additional recycling services were available in its county. A summary of responses shows that 43.5% of the horticulture firms maintained a relationship with companies providing recycling services, and 19.7% of firms were located in a county where recycling companies provide additional pick-up service for nontypical waste (i.e., large items, used

equipment, batteries, chemicals, large volumes of plastic, etc). Furthermore, firms were asked to address their self-reported constraints in performing recycling. Specifically, 34.1% of firms claimed the physical effort to ship as a limitation to recycle. Earlier reports suggested that collection costs (that correspond to shipping costs) amount to two thirds of recycling costs (EPA, 2012). A large proportion of firms (45.7%) reported that the storage on premises until collection was their major constraint. Storage of waste in general on the premises has been identified as a potential factor discouraging recycling (ref) and it appears to be a major barrier especially in the environmental horticulture area. Finally, 29.1% of firms thought that low return on the recycling investment hindered their recycling decisions.

In addition to the information about firm features, respondents who completed the questionnaire also shared several characteristics of themselves. For example, 80.7 % of the respondents were an owner or manager of the surveyed firms, and 82.5% of them had 13 or more years of formal education.

3.3 Model and estimation method

The main objective of this study is to investigate the environmental horticulture firm's inclination to recycle by examining their recycle decision on major plastic waste types, and further identify determinants of the total quantity of recyclable materials discarded in landfills. Regarding the recycling decision by plastic waste type, it is common to specify the observed choice as a binary variable assuming the value of one or zero. The current study involves the dependent variables indicating a firm discarding three types of plastics, i.e., plastic containers, flats, and greenhouse poly. Explanatory variables include two sets of variables: firm characteristics (such as revenue, number of

employees, firm scope, and self-reported recycling constraints) and respondent characteristics (such as education level and position).

The probit regression is often used to estimate a binary decision model. However, in the current study, three dependent binary variables (i.e., disposal decisions of plastic containers, flats, and greenhouse poly) might be correlated with each other, because plastic items may be used together to produce or market the same group of plants (for example, plastic containers are placed on a tray to ease handling). Therefore, the multivariate probit model is employed to consider the potential across-equation correlation.

In addition to examining the decision about plastic waste recycling by material type, this study investigates factors influencing the total quantity of recyclable waste being discarded by environmental horticulture firms. The dependent variable is the total quantity of discarded but recyclable waste in each firm, while the associated explanatory variables are both firm and respondent characteristics. The robust ordinary least square (OLS) regression was adopted to estimate this equation and to address the potential heteroscedasticity (Gujarati 2003) that is often associated with cross-sectional data.

4. Results

Estimated coefficients and corresponding standard errors of explanatory variables in multivariate probit model are displayed in Table 2. Because the estimated coefficients cannot be directly interpreted as they are in continuous dependent variable case, marginal effects of statistically significant variables are calculated and shown in Table 3. They measure the change in probability of discarding certain plastic waste in response to a unit change in a statistically significant explanatory variable, and allow assessment of the

relative impact of various determinants. Lastly, Table 4 shows estimation results from the robust OLS regression of the total quantity of recyclable waste discarded by environmental horticulture firms in Georgia.

4.1 Decision to discard three types of recyclable plastic waste

The Chi-square test was adopted to verify if the estimated model fits the data set well. Test results in Table 2 indicate that our model explains and predicts response variables well. In addition, results of the likelihood ratio (LR) test indicate that across-equation parameters (i.e., rho12, rho13, and rho23) are significantly different from zero (Table 2). The test outcome confirms that the multivariate probit model is superior to the three independently estimated probit equations leading to more efficient estimation results. In addition, the significantly positive correlation parameters indicate that environmental horticulture firms are more likely to discard their flats and greenhouse poly as well. Therefore, in practical terms, increasing the recycling of one type of plastic waste, such as plastic containers, would promote the recycling of other plastic waste types such as flats and greenhouse poly.

4.1.1 Plastic containers

Whether a firm dumps plastic containers is associated with the firm's business scope, its location, and whether it is located in an area offering additional pick-ups in addition to those that are regularly scheduled. Specifically, the probability of an environmental horticulture firm concentrating on landscape design, construction, and installation to discard plastic containers is about 16% less than that of firms with another business scope. It is quite plausible that firms with the former business scope use fewer plastic containers than, for example, nurseries.

A firm located in the Atlanta metropolitan area is less likely to make a decision to discard its plastic containers by 15.3% than its counterparts, probably due to the relatively high waste cost in the metropolitan area. In a county where recycling companies provide additional pick-up service for cumbersome waste, the probability of the decision to discard plastic containers in landfills decreases by 36.7% as compared to counties where such extra service is unavailable. The recycling company's additional collection makes a substantial difference and encourages environmental horticulture firms to recycle their plastic containers.

Furthermore, firms' self-reported recycling constraints are closely associated with their plastic recycling decisions. For instance, a firm concerned about the physical efforts to ship recyclables is 35% more likely to favor the decision to discard the recyclable plastic material in landfills. Similarly, firms claiming that the storage on firm premises until a pick-up is their major recycling constraint have an 18.9% lower probability of deciding to recycle plastic containers. In contrast, a firm with concerns about the return on investment is less likely to recycle their plastic containers; the probability of the decision to recycle decreases by 18.2% as compared to those who did not think of this as a constraint. Return on investment in an environmental horticulture company depends on costs, and if efforts to recycle generate costs, the incentive not to discard plastic containers is weak. Finally, the higher the number of years of education of a respondent, the lower the probability of discarding plastic containers. The decrease in the probability of discarding containers is substantial – 21.0%. Less education may reflect less concern about long-term environmental quality protection and insufficient knowledge of potential health effects, both to humans and the natural environment.

4.1.2 Flats

Results of the decision to choose to dump recyclable plastic flats are similar to those obtained in the case of plastic containers. The similarities are not surprising because flats are often used in the same production processes: shipment and installation in landscapes. A firm's disposal decision in relation to flats has been confirmed with regard to the business scope and location. A firm focused on the design, construction, and installation of landscape is 18% less likely to discard recyclable flats. Firms concentrating on landscape maintenance services are 15.6% less likely to make the decision to discard flats. Such firms may have incorporated working routines that involve recycling because they cannot discard flats at the site where they provide maintenance services such as the installation of seasonal ornamentals. The metropolitan Atlanta area location of firms decreases the probability of the decision to discard flats by 19.2% as compared to firms located in non-metro areas. The sizable marginal effect of firm location suggests that a recycling program may need to target firms in nonmetropolitan areas in order to advance overall recycling.

Owner or manager characteristics also influence the decision to discard plastic flats. If a respondent is the owner or manager of a firm, the decision to dump flats is 16.3% higher than if the person responding to the survey had a different position in the company. The result suggests that owners and managers are more concerned with other tasks than other employees are. In a competitive environment, the number of tasks and pressure to perform may supercede the manager's or owner's thoughts about how to dispose of waste, including plastic flats. However, the effect of education is negative and suggests that the probability to make a decision to discard flats decreases by 18% if a

respondent received more than a high school education. This result is encouraging and stresses the relevance of educating all employees in the environmental horticulture sector about the opportunities and benefits of recycling.

4.1.3 Greenhouse poly

In terms of greenhouse poly, a firm's decision to throw away this recyclable plastic waste is associated with the firm size, business scope, location, and respondent's position. A firm with a large number of employees is less likely to recycle their greenhouse poly. A large number of employees implies a rather large operation where the focus on productive tasks deemphasizes the handling of used greenhouse poly. Implicitly, a large operation generates a large volume of greenhouse poly, and recycling procedures may constrain production-related tasks, therefore making it easier to discard the poly. Firms focusing on the design, construction, and installation of landscapes have a 15.6% higher probability of discarding greenhouse poly than firms with other business scopes. Firms engaged in design and installation are not likely to use greenhouse poly in substantial volumes and the lower probability is less of a concern in their case. Firms located in the Atlanta metropolitan area are less likely to decide to throw away greenhouse poly than firms located in the non-metro areas; the probability of the decision decreases by 13.5%. Stricter regulations about waste disposal in general and, possibly, more options available to arrange waste pick-up may be responsible for the observed outcome. The result is consistent with those in the case of decisions to dispose of plastic containers and flats, reconfirming that firms from the Atlanta metropolitan area have a higher probability to recycle plastic waste in general.

Being a manager or owner of an environmental horticulture firm contributes 13.9% to the probability of deciding to discard greenhouse poly. The decision is possibly associated with the amount of time and effort it takes to separate and clean greenhouse poly so it can be collected by a waste management company.

4.2 The total discarded quantity of recyclable waste

In addition to the examination of a firm's decision to recycle major types of plastic waste, this study also examines factors associated with the total quantity of discarded recyclable waste on a quarterly basis (Table 4). Results indicate that among firm characteristics the revenue, number of employees, and business scope are significantly associated with the total quantity of quarterly discarded recyclable waste.

Environmental horticulture firms with a high revenue level report discarding more recyclable waste per quarter than firms with less revenue. Larger firms are likely to use more plastic items in their operation and will generate more recyclable waste even if the share of recyclable waste in total waste volume is higher than for smaller firms. Contrastingly, firms with a larger number of employees have a significantly lower total of discarded recyclable waste. The recycling process in large environmental horticulture firms likely benefits from labor availability. Furthermore, the linkage between the business scope and total discarded waste quantity is also significant. Specifically, firms focusing predominantly on landscape maintenance discard a lower volume of recyclable waste. However, firms concentrating on wholesale container and in-ground nurseries throw out a larger amount of recyclable waste than firms with other business scopes.

Moreover, the total quantity of recyclable waste is also closely associated with the selected respondent's characteristics, i.e., education and position in the company. As the

number of years of education increases, the total discarded quantity of recyclable waste also increases. Furthermore, if a respondent is the owner or manager of the firm, such firms tend to have a higher total quantity of recyclable materials being discarded. The owner or manager is focused on economic viability including the costs and revenues, leaving little time for considering the reduction of discarded recyclable waste.

5. Discussion

Plastic waste generated by the environmental horticulture sector in Georgia presents a challenge for individual firms. Although reuse has been suggested as preferred to recycling (Al-Salem et al., 2009), the risk of pathogens in containers, flats, or trays requires labor-intensive cleaning and limits reuse to homeowners. Recycling of plastic waste from environmental horticulture firms is possible and this study examines factors that influence the decision to recycle vs. discard three types of plastic products. The specified relationships study firm and respondent characteristics and their influence on the decision to discard/recycle plastic waste by type applying the multivariate probit technique to account for simultaneous use of the three types of plastic products in ornamental plant production and provision of landscape services.

Business focus of the environmental company matters in its relationship to the decision to discard plastic waste. Companies with the predominant business focus on design and installation of landscapes tend to have a lower probability of discarding plastic waste than companies with another business focus within the scope of the environmental horticulture sector. The result is reasonable because plant producers routinely use plastic containers, flats, trays, and greenhouse poly, while plant installation in landscapes involves a limited number of such products.

The identified effect of business scope on the decision to discard plastic waste coincides with the effect of the company's location. Namely, firms located in the Atlanta metropolitan area are less likely to make the decision to discard plastic waste and their behavior likely reflects incentives provided to companies not to discard plastic waste, but also more opportunities to recycle, including more frequent waste collection or easily accessible sites where plastic waste can be dropped off. However, firms located in non-metro counties are major producers of ornamental plants and to increase their participation in recycling may pose a challenge for county waste collection schemes. But another result indirectly provides evidence that alternative waste collection events like the collection of recyclable but difficult to handle waste lowers the probability of discarding plastic containers. It appears that such events are relevant in lowering the volume of plastics ending up in landfills and counties may reconsider increasing the frequency of such events. Additionally, timing of collecting difficult to handle waste can be crucial and should fall in periods when ornamental plant nurseries or greenhouses terminate production. Such termination may not strictly follow seasons, but can be easily determined through interaction with ornamental plant producers. More importantly, the increased opportunities offering plastic waste recycling also reduce other factors identified as constraints to recycle.

Constraints associated with the decision to discard recyclable plastic waste have been reflected in environmental horticulture companies' concerns about the costs associated with recycling. Shipping costs and storage of recyclables on premises encourage disposal of plastic containers to landfills. The perception that shipping constrains recycling increases the probability of discarding plastic containers by 32.7%

and the opinion that storage on premises is a constraint increases the probability of the decision to discard plastic containers by 18.9%. Both constraints have been mentioned in earlier reports as a restriction in increasing recycling. The consistency with which these constraints are mentioned is difficult to ignore and calls for implementation of more frequent collection of plastic waste from environmental horticulture firms. Additional pick-ups from firm premises make a measurable difference in lowering plastic waste volume sent to landfills.

Respondents with higher levels of educational attainment have a lower probability of disposing of plastic containers or flats. The effect was expected, but its statistical confirmation even more strongly supports the need for continuing efforts to educate the environmental horticulture sector about the consequences of disposing of plastics to landfills. Commonly, licensing environmental horticulture firm employees involves annual re-certification for obtaining pesticide application permits. Such training workshops offer an opportunity to build in a module about plastic waste disposal as an extension of instructions about pesticide container disposal.

In contrast to the effect of education, being a manger or owner of a firm increased the probability of discarding flats and greenhouse poly. The result is plausible given the primary goal of a firm is to generate revenues and lower costs. A manager or an owner addresses the tasks that directly affect the bottom line and for many, it implies that discarding plastic waste is easier than trying to recycle it. The identified behavior possibly reflects the difficulty of recycling some plastic products used in environmental horticulture and the additional effort on the part of the company to sort out plastics from all generated waste on premises. The effect has been confirmed in the case of flats and

greenhouse poly, but not in the case of containers, which may be easier to recycle. Greenhouse poly may be particularly bulky, contaminated with dirt, and would require cutting into pieces to accommodate collection and because if a firm uses greenhouse poly, it uses it in large volume, the extra effort to prepare to ship it can substantially cut into the bottom line. Greenhouse poly recycling calls for a search for possible solutions.

6. Conclusions

Environmental horticulture firms in Georgia generate a significant amount of plastic waste in the form of plastic containers, flats, and greenhouse poly, which ends up in landfills. This study examines factors that affect the probability of the decision to discard (rather than recycle) plastic waste using survey data collected in 2013. Several firm and respondent characteristics have been confirmed to significantly influence the decision. Firm business scope lowers the probability of plastic container and flat disposal (by 16% and 18%, respectively) if a firm focus is design and installation of landscapes. Also, landscape maintenance firms are less likely to discard plastic flats (by 15.6%); plastic flats are commonly used for handling seasonal ornamental plants installed by maintenance firms in existing landscapes. The results imply a need for increased focus on ornamental plant producing firms in order to lower the probability of the decision to discard plastic waste in landfills. Because the environmental horticulture sector encompasses businesses with diverse scope, narrowing some efforts and targeting segments of the sector is needed to encourage increased recycling of plastic containers and flats. However, the probability of discarding greenhouse poly increases if a firm focuses on design and installation. The result likely reflects the very low volume of such material that, given its bulkiness, may be easier handled by a firm if discarded rather than

recycled. Recycling greenhouse poly has been a problem with other horticultural and agricultural producers and the problem awaits a solution.

There is a difference in the probability of discarding any of the considered plastic type between firms located in the metro vs. non-metro areas. In all cases, being located in the Atlanta metropolitan area lowered the probability of discarding plastic waste suggesting that non-metro counties may need to increase their efforts to examine their current plastic waste recycling schemes to lower the volume of this waste type discarded in landfills. It is possible that tipping fee structures differ between metro and non-metro counties, providing cost-saving incentives if a firm lowers its volume of non-recycled waste, while also having potential penalties for discarding plastic waste. How much flexibility a county has in modifying the fee structure is likely specific to each county, especially given the presence and scope of the environmental horticulture sector.

More frequent plastic waste collection in all counties will lower the probability of discarding plastic containers. Increased opportunities for plastic waste recycling, for example by scheduling more frequent collection events focused on difficult materials, can lower the environmental firm's shipping costs and limit the storage on premises. Both have been identified as constraints that increase the probability of making the decision to discard rather than recycle.

Education makes a difference. Respondents with a higher educational attainment level were considerably less likely to discard plastic containers or flats. Education in the area of plastic waste recycling in the environmental horticulture sector may become a regular part of annual re-certification programs; for example, the extension service offers pesticide renewal license workshops every year and plastic waste recycling can be

included when the disposal of pesticide containers is discussed. Such an approach would reach the majority of firms involved in production and landscape maintenance, likely the two types of businesses generating plastic waste such as containers, flats, and greenhouse poly.

Each environmental horticulture firms must generate profits to remain economically viable. In this context, the increased probability of discarding flats or greenhouse poly rather than recycling them is not surprising. For owners or managers, organizing the work that generates revenue is the main priority, and recycling is of lesser importance. To change the observed behavior, increasing the plastic waste collection frequency combined with education can alter the decision of discarding plastic flats of greenhouse poly; there was no confirmed effect in the case of plastic containers. Increased waste collection frequency lowers costs of shipping and shortens storage of used plastic products, while repeated educational programs can gradually change attitudes and permanently change behavior leading to increased recycling.

Plastic waste generated by the environmental horticulture sector has received little attention because the sector generates a relatively small volume of plastics. However, this study was motivated by the fact that in some areas the contribution of the plastic waste from environmental horticulture can be substantial. Firm and operator characteristics, including location, can either facilitate or limit the choice between discarding and recycling plastic waste and this study quantifies the changes in probability of such decisions, providing rare insights into the behavior of environmental horticulture firms. Knowledge of this behavior can be applied by local waste collection and recycling programs.

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Table 1. Descriptive statistics of variables included in the three empirical equations modeling decision to throw recyclable plastic containers, flats, and greenhouse poly.

Variable name	Variable description/units of measurement	Mean	Std dev
Dependent variables			
d_dis_plas	=1 if a firm throws away plastic containers that could be recycled	0.466	0.500
d_dis_flat	=1 if a firm throws away flats that could be recycled	0.287	0.453
d_dis_poly	=1 if a firm throws away greenhouse poly that could be recycled	0.193	0.395
dis_materials	The quantity of recyclable materials being dumped by a firm per quarter /ten thousand pounds [convert into kg]	2.962	7.355
Independent variables			
	Firm characteristics		
Rev_grp	=1 if total 2011 revenue is less than $50,000; =2 if $50,000-$100,000; =3 if $100,001-$150,000; =4 if $150,001-$200,000; =5 if $200,001-$350,000; =6 if $350,001-$500,000; =7 if $500,001-$750,000; =8 if $750,001-$1,000,000; =9 if $1,000,001-$1,500,000; =10 if $1,500,001 or more	6.677	3.082
No_emplo	Total number of employees	22.085	44.498
Scope_design	=1 if landscape-design, build, installation represents 50 percent or more of the firm business activity	0.704	0.458
Scope_maintenance	=1 if landscape maintenance represents 50 percent or more of the firm business activity	0.848	0.360
Scope_nursery	=1 if wholesale container and in-ground nurseries represent 50 percent or more of the firm business activity	0.960	0.197
d_metro	=1 if a firm's headquarters is in the Atlanta metropolitan statistical area	0.610	0.489
d_recyfirm	=1 if a firm has a current relationship with recycling company	0.435	0.497
d_diff_mat	=1 if the waste collection organization in the firm's county permits once or twice a year recycling of difficult to handle materials (such as large items, used equipment, batteries,	0.197	0.399

	chemicals, large volume of plastics, etc.)		
d_cs_ship	=1 if a firm believes that the physical effort to ship is a constraint limiting recycling	0.341	0.475
d_cs_storage	=1 if a firm believes storage on firm premises until pickup is a constraint limiting recycling	0.457	0.499
d_cs_invest	=1 if a firm believes return on investment is a constraint limiting recycling	0.291	0.455
	Respondent characteristics		
d_edu13	=1 if respondent has 13 years or more of education	0.825	0.381
Edu	Years of education	14.720	3.951
d_mager_owner	=1 if a respondent is the firm's owner or manager	0.807	0.395

Table 2. Multivariate probit estimation results of the decision to throw away plastic containers, flats, and greenhouse poly that could be recycled (N=223).

Variable name	Plastics	Flats	Poly
	Firm characteristics		
Rev_grp	0.065	0.034	-0.055
	(0.050)	(0.054)	(0.058)
Ln_no_emplo	-0.090	-0.054	0.361
	(0.123)	(0.131)	(0.146)[b]
Scope_design	-0.466	-0.599	0.635
	(0.213)[b]	(0.212)[c]	(0.254)[b]
Scope_maintenance	-0.142	-0.516	0.213
	(0.256)	(0.251)[b]	(0.296)
d_metro	-0.445	-0.638	-0.552
	(0.193)[b]	(0.194)[c]	(0.212)[b]
d_recyfirm	-0.281	-	-
	(0.179)		
d_diff_mat	-0.367	-	-
	(0.219)[a]		
d_cs_ship	0.353	-	-
	(0.190)[a]		
d_cs_storage	0.523	-	-
	(0.177)[c]		
d_cs_invest	-0.530	-	-
	(0.195)[c]		
	Respondent characteristics		
d_edu13	-0.614	-0.601	0.071
	(0.240)[b]	(0.235)[b]	(0.274)
d_mager_owner	0.129	0.541	0.566
	(0.240)	(0.271)[b]	(0.304)[a]
Constant	0.806	0.564	-2.214
	(0.497)	(0.491)	(0.578)

Rho12	0.553
	(0.102)[c]
Rho13	0.272
	(0.127)[b]
Rho23	0.300
	(0.123)[b]
Log likelihood	-331.8114
Wald chi-square (df=26)(P-value)	75.71(<0001)
Chi-square (df=3) of LR test on H0: Rho's=0 (P-value)	27.7803(<0.001)

Note: [a] p<0.1, [b] p<0.05, and [c] p<0.01.

Table 3. Marginal effects of statistically significant variables influencing the decision to discard recyclable plastic containers, flats, and greenhouse poly.

Variable name	Plastic container	Flats	Poly
	Firm characteristics		
No_emplo	_	_	0.089
			(0.002)
Scope_design[a]	-0.160	-0.180	0.156
	(0.002)	(0.004)	(0.004)
Scope_maintenance[a]	_	-0.156	_
		(0.003)	
d_metro[a]	-0.153	-0.192	-0.135
	(0.002)	(0.004)	(0.004)
d_diff_mat[a]	-0.126	_	_
	(0.002)		
d_cs_ship[a]	0.327	_	_
	(0.032)		
d_cs_storage[a]	0.189	_	_
	(0.002)		
d_cs_invest[a]	-0.182	_	_
	(0.002)		
	Respondent characteristics		
d_edu13[a]	-0.211	-0.181	_
	(0.002)	(0.004)	
d_mager_owner[a]	_	0.163	0.139
		(0.003)	(0.003)

Note: Bootstrap errors are in parentheses.
Note: [a] $p<0.1$, [b] $p<0.05$, and [c] $p<0.01$.
[a] Indicates the discrete change of dummy variable from 0 to 1.

Table 4: Estimation results of the quantity of recyclable materials disposed to landfill (N=146).

Variable name	Estimated coefficient	Robust std error
Rev_grp	0.856[b]	0.297
Ln_no_emplo	-1.385[b]	0.605
Scope_design	1.109[a]	1.120
Scope_nursery	5.197[b]	2.169
d_metro	-6.460	12.848
Edu	0.171[a]	0.103
d_mager_owner	2.843[c]	0.947
Intercept	-7.036[b]	3.283
R-square	0.1245	

Note: [a] $p<0.1$, [b] $p<0.05$, and [c] $p<0.01$.