Combined Proceedings IPPS 74:351-359. 2024.

Rooted in Plastics: Cultivating Sustainability in Horticulture

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[a]Second Place – Charles Student Research Paper Competition

Keywords: sustainability, plastic, floriculture, nursery, regulations, census, extended producer

Summary

This paper examines the critical role of plastics in the horticultural industry, particularly in plant production, packaging, and distribution. As global plastic consumption increases, the floriculture industry faces growing pressure from stricter regulations aimed at reducing environmental impact. To address the need for updated insights, this study analyzes recent census data to identify the types and quantities of plastics in use and assess their compliance with current regulatory standards. The findings aim to equip industry stakeholders with the information needed to ensure compliance, enhance sustainability, and maintain long-term profitability in an increasingly eco-conscious market.

INTRODUCTION

Since the invention of synthetic polymers in 1869, over 9 billion tons of virgin plastics have been produced, leading historians to term the current era the "Plastic Age" (Geyer et al., 2017; Pinto da Costa et al., 2020). In 1960, 390 thousand tons of plastic were produced in the US, increasing to more than 35 million tons by 2018 (EPA 2023). Of the estimated 35 million tons, containers and packaging were responsible for 14.5 million tons of plastic (EPA 2023). It is estimated that 79% of plastic produced has accumulated in landfills or in the natural environment, while 12% was incinerated, and 9% has been recycled (Geyer et al., 2017).

Plastics are deeply integrated into the horticultural industry, playing a ubiquitous role in plant production as glazing materials, irrigation systems, fertilizer coatings, and packaging. During the last half-century, plastic containers have become standard for producing plants for retail and landscape use due to their ease of processability, shipping, and marketing, in addition to their durability, low cost, and the variety of available sizes, shapes, and types of plastic containers. As a result, over 800,000 tons of petroleum-based, single-use plastics are estimated to be consumed each year by the greenhouse and nursery industries in the US (Schrader, 2013).

As plastic consumption increases, the floriculture industry faces a rapidly changing regulatory landscape, threatening its sustainability and profitability. Regulations, such as New Jersey's recycled content mandate, California's SB-343, and various Extended Producer Responsibility (EPR) laws in Oregon and Colorado, impose new standards for plastic use, recyclability, and reporting (**Table 1**).

Table 1. Current and emerging plastic regulations in the United States.

Regulation	Effective	Impact
New Jersey Recycled Content – Phase-in	Jan 2024	Require 10% post-consumer recycled content in 2024, ramping up to 50% by 2035
California SB-343 – Truth in advertising	Fall 2025	Removal of chasing arrows, restrictions on use of "recyclable" claim
Oregon SB-582 – EPR	July 2025	Pay fees for plastics sold into state – reporting requirements
Colorado HB22-1355 – EPR	Jan 2025	Pay fees for plastics sold into state – reporting requirements
Maine 2146 – EPR	2027	Pay fees for plastics sold into state – reporting requirements
California SB-54 – EPR	2028-2032	Pay fees for plastics sold into state – reporting requirements, required recovery rates for plastic materials
Maine LD-1504 PFAS - Phase-out / Ban	2030	Ban the sale of intentionally added PFAS except for "unavoidable use" by Jan 2030.

Oregon requires producers to pay 6¢/lb of paper/fiber, 24¢/lb of rigid plastic, and 34¢/lb of flexible plastic sold. Similarly, Colorado is expected to implement a dues schedule modeled after Canadian Producer Responsibility programs, charging 13¢/lb for PET bottles, 22¢/lb for plastic bags and films, and 36¢/lb for polystyrene containers. These regulations vary by plastic type and introduce complexities that the industry is not yet fully equipped to manage. While some current regulations state agricultural companies with less than $5 million in gross revenue from in-state sales are exempt from these fees, new legislation or amendments could be introduced at any time. Without a deeper understanding of the scale of our industry's plastic use and the specific plastics used across market segments, the industry may struggle to adapt, potentially leading to higher costs, stricter compliance demands, and potential supply chain disruptions.Moreover, estimates of horticultural plastic consumption are outdated, with the most recent estimates derived from the USDA Census of 2009 utilizing data from the year 2007 (Schrader, 2013). With pending regulations posing a risk to profitability, the objective of this paper is to provide the industry with the essential data and insights needed to effectively navigate the evolving regulatory landscape. By examining the most recent census data regarding horticultural container plant units sold, this study aims to identify the quantities of plastics consumed between the years 2007 and 2017 (the most recent USDA census data) and assess the industry's potential risk with current regulatory requirements. This information is crucial for assessing the industry's regulatory risk exposure and identifying necessary adjustments to ensure compliance and sustainability.

MATERIALS AND METHODS

To quantify the amount of plastic utilized in container plant production, the number of units sold within various horticultural market segments from the USDA Census of Horticultural Specialties for the years 2009, 2014, and 2019 were extracted and reproduced (**Table 2**; USDA, 2009; 2014; 2019). These censuses report data from the years 2007, 2012, and 2017. The data used from these censuses is the total number of units sold per horticultural specialty (e.g. Landscape palms, Annual bedding/garden plants sold as flats, Coniferous evergreens) as well as the total number of units sold per container size range per horticultural specialty (e.g. foliage plants for indoor/patio use – pots sold in containers >5-in (12.7cm), <12-in (30.5), and >12-in (30.5). The total number of units sold in each category were inflated by 20% to reflect loss and/or discarded plants.

The information that follows are assumptions made concerning container size and type, such as the fraction of containers molded by injection, thermoformed, and blow molded equipment. All units reported to be sold in containers >5-in (12.7 cm) were assumed to be 4-in (10.2 cm) in diameter. All units reported to be sold in containers 5-in (12.7 cm) or greater were assumed to be 6-in (15.2 cm) in diameter. Census data for "annual bedding/garden plants sold – pots" were assumed to be composed of half injection molded and half thermoformed containers. For "annual bedding/garden plants sold – flats," flats were assumed to all be thermoformed 1206 inserts and injection molded trays. "annual bedding/garden plants sold – hanging baskets" data were assumed to be produced in equal quantities of 10-in (25.4 cm) and 12-in (30.5 cm) injection molded baskets.

Table 2. Total units sold +20% to account for losses, reported in the USDA Census of Horticultural Specialties in 2009, 2014, and 2019 and trends between census years.

USDA horticultural market segment	Total units sold 2009	Total units sold 2014	Total units sold 2019	2009-2014 Trend	2014-2019 Trend	2009-2019 Trend
Floriculture sector						
Annual bedding/garden plants sold as flats	106,558,800	104,265,600	78,219,600	-2%	-25%	-27%
Annual bedding/garden plants sold as hanging baskets	52,570,800	59,082,000	47,257,200	+12%	-20%	-10%
Annual bedding/garden plants sold as pots	674,228,400	717,412,800	604,032,000	+6%	-16%	-10%
Potted herbaceous perennial plants	320,104,801	332,008,800	290,300,400	+4%	-13%	-9%
Potted flowering plants for indoor or patio use	236,610,295	265,603,900	291,138,124	+12%	+10%	+23%
Foliage plants for indoor or patio - pots	165,622,800	229,802,400	171,728,400	+39%	-25%	+4%
Foliage plants for indoor or patio - hanging baskets	13,229,023	13,818,014	13,806,709	+4%	0%	+4%
Plug seedlings	1,086,607,066	1,057,822,574	1,198,981,63	-3%	13%	10%
Nursery sector						
Broadleaf evergreens	136,576,396	107,441,898	106,227,192	-21%	-1%	-22%
Coniferous evergreens	291,190,597	72,336,062	53,615,185	-75%	-26%	-82%
Deciduous flowering trees	24,913,787	19,899,404	19,899,404	-20%	0%	-20%
Deciduous shade trees	41,365,841	25,351,537	21,310,021	-39%	-16%	-48%
Deciduous shrubs	138,874,715	118,503,336	101,483,441	-15%	-14%	-27%
Fruit and nut plants	112,947,600	166,769,270	154,473,068	48%	-7%	37%
Ornamental grasses	42,356,830	59,176,337	51,603,144	40%	-13%	22%
Landscaping palms	9,586,908	7,312,284	8,153,758	-24%	12%	-15%
Other woody ornamentals	100,003,130	53,991,382	54,604,208	-46%	1%	-45%
Liners sold	516,814,042	708,051,228	671,452,668	37%	-5%	30%

"Potted herbaceous perennials" were reported in "Chrysanthemums" and "Other plants" units sold. Chrysanthemums were reported in total units sold, units sold in pots <5-in (12.7 cm), and units sold in pots 5-in (12.7 cm) or greater. Other herbaceous perennial plants were reported in total units sold, units sold in containers less than 1-gal, units sold in containers from 1- to 2-gal, and units sold in containers 2-gal

or greater. For chrysanthemums, it was assumed that half of the containers of each size are thermoformed and half of the containers of each size are injection molded. For all other herbaceous perennials, it was assumed that half of the containers were injection molded and half of the containers are blow molded for all container sizes. Data reported in "potted flowering plants for indoor or patio use" were assumed to be injection molded containers. "Foliage plants for indoor or patio use - pots" data is reported in total units sold, units sold in pots less than 6-in (15.2 cm), units sold in pots from 6-in (15.2 cm) to 13-in (33 cm), and units sold in containers 14 (35.6 cm) or greater; and all of these containers are assumed to be injection molded. Census data for "foliage plants for indoor or patio use – hanging baskets" were assumed to be produced in equal quantities of 10-in (25.4 cm) and 12-in (30.5 cm) injection molded baskets. "Broadleaf evergreens," "coniferous evergreens," "deciduous shade trees," and "deciduous shrubs" were assumed to be produced in 3-gal containers with equal quantities injection and blow molded. "Fruit and nut plants" and "other woody ornamentals" were assumed to be produced in 2-gal containers, half injection molded and half blow molded. "Ornamental grasses" were reported in total units sold in 1-gallon containers and it was assumed that half were injection molded and half were blow molded. "Landscaping palms" were assumed to be produced in a 10-gal blow molded container. Weights of representative containers of each container size and type were used to calculate the approximate total weight of plastic consumed by the horticulture industry and within each market segment (Schrader, 2013).

RESULTS AND DISCUSSION

Based on these estimations, the horticulture industry consumed 832,080 tons of plastic in 2009 (**Table 3**). In 2014, the industry's consumption of plastic increased 2.8% to 854,960 tons. However, between 2014 and 2019, plastic consumption decreased 2.3% to 835,856 tons of plastic. Over the decade spanning 2009 to 2019, the greenhouse and nursery industry has consumed an average of 840,965 tons of plastic per year from containers alone. However, some discrepancies were observed among the census data. Coniferous evergreen sales decreased 82% from 73,665 tons to 13,563 tons between 2009 and 2019 (Table 2). In 2009, the USDA reported 291,190,597 coniferous evergreens were sold. In 2014, the number of coniferous evergreens sold decreased to 72,336,062. In 2019, even fewer coniferous evergreens, 53,615,185, were sold. This significant decrease in sales could reflect incorrect assumptions concerning container size. It was assumed that all of the coniferous evergreens were grown in 3-gal containers, however a large portion of those reported in 2009 were likely seedlings grown in smaller containers and, thus, reported incorrectly. Since the number of coniferous evergreens reported in 2014 and 2019 were more similar, it could be assumed that those numbers are more accurate. The average coniferous evergreens sold in 2014 and 2019 was 62,975,623 plants. If that average replaced the amount reported in 2009, there would have only been a 15% decrease in units sold between 2009 and 2019. Furthermore, the total amount of plastic reported in 2009 would have decreased by 57,734 tons to 774,344 tons of plastic consumed.

Table 3. Tons of plastic containers consumed in the production of horticultural live goods derived from the USDA Census of Horticultural Specialties in 2009, 2014, and 2019.

USDA horticultural market segment	Tons of Plastic 2009	Tons of Plastic 2014	Tons of Plastic 2019
Floriculture sector			
Annual bedding/garden plants sold as flats	27,251	26,664	20,004
Annual bedding/garden plants sold as hanging baskets	12,140	13,644	10,913
Annual bedding/garden plants sold as pots	12,703	13,879	11,715
Potted herbaceous perennial plants	31,559	33,227	28,005
Potted flowering plants for indoor or patio use	31,794	35,490	37,216
Foliage plants for indoor or patio - pots	73,076	81,247	79,728
Foliage plants for indoor or patio - hanging baskets	3,055	3,191	3,188
Plug seedlings	201,227	195,896	222,037
Total floriculture consumption:	*392,805*	*403,238*	*412,806*
Nursery sector			
Broadleaf evergreens	34,551	27,181	26,873
Coniferous evergreens	73,666	18,300	13,564
Deciduous flowering trees	6,303	5,034	5,034
Deciduous shade trees	10,465	6,413	5,391
Deciduous shrubs	35,133	29,979	25,673
Fruit and nut plants	21,166	31,251	28,947
Ornamental grasses	2,965	4,142	3,612
Landscaping palms	7,271	5,546	6,184
Other woody ornamentals	18,740	10,118	10,232
Liners sold	229,015	313,758	297,540
Total nursery consumption	*439,275*	*451,722*	*423,050*
Total Plastic Consumption:	**832,080**	**854,960**	**835,856**

The USDA Horticultural Census market segments can be grouped into floriculture or nursery specific sectors. The market segments assumed to be floricultural are the following: annual bedding/garden plants sold as flats, annual bedding/garden plants sold as hanging baskets, annual bedding/garden plants sold as pots, potted herbaceous perennial plants, potted flowering plants for indoor or patio use, foliage plants for indoor or patio – pots, foliage plants for indoor or patio – hanging baskets, and plug seedlings. Within the floriculture sector, total plastic consumption in each of the three censuses were 392,801 tons, 403,236 tons, and 412,803 tons for 2009, 2014, and 2019, respectively (Table 3). Plug production was responsible for 54% of plastic consumed in the floriculture sector in 2019. Additional market segments contributing significantly

to plastic consumption within this sector in 2019 were foliage plants for indoor or patio – pots (19%) and potted flowering plants for indoor or patio use (9%). Within each market segment, the floriculture crop consuming the most plastic per unit sold was foliage plants for indoor or patio – pots produced in 14-in (35.6 cm) containers, contributing 2.9 lbs. (1.3 kg) of plastic per unit. These pots are often more durable, ornamental containers, weighing more than a typical trade container. Among the plants in that segment, only 2% were assumed to be sold in 14-in (35.6 cm) containers. The number of units of annual bedding/garden plants sold as flats decreased by 27% between 2009 and 2019. Annual bedding/garden plants sold as hanging baskets and pots decreased by 10% between 2009 and 2019 (**Table 2**). Despite these downward trends, total plastic consumption in the sector increased due to expanding sales in indoor and patio plants and plug seedlings. Indoor and patio plant sales increased by 15%, and plug seedlings increased by 10% between 2009-2019.

The market segments assumed to be nursery crops are the following: broadleaf evergreens, coniferous evergreens, deciduous flowering trees, deciduous shade trees, deciduous shrubs, fruit and nut plants, ornamental grasses, landscaping palms, other woody ornamentals, and liners. Within the nursery sector, total plastic consumption in each of the three censuses were 439,275 tons, 451,722 tons, and 423,050 tons for 2009, 2014, and 2019, respectively (Table 3). Liners were the largest plastic consuming segment in the nursery sector, responsible for 70% of the plastic consumed in 2019. Other market segments with significant contribution to plastic consumption within this sector in 2019 were fruit and nut plants (7%) and broadleaf evergreens (6%). Within each market segment, the nursery crop consuming the most plastic per unit sold is landscaping palms, assumed to be produced in a 10-gal container (C4000; CREO Group, Kissimmee, FL), consuming 1.5 lbs. (0.7 kg) of plastic per unit. On average, 33% of the plastic consumed annually in the horticulture industry was due to liner production. The number of units of deciduous shade trees decreased by 48% between 2009 and 2019 (Table 2). Deciduous shrub sales between 2009 and 2019 also decreased by 27%. Despite this decline, the nursery sector saw a 37% increase in fruit and nut plant sales and a 30% increase in liners sold between the same time span.

The horticulture industry employs a wide variety of container types, shapes, and sizes, each with different levels of durability and reusability. This diversity in container use makes it challenging to accurately categorize and quantify the extent of plastic reuse across the industry. Furthermore, data presented in this study assumes that all containers are single-use, not accounting for the complexities associated with the lifecycle of these products. Specifically, the practice of retailers returning containers to producers for reuse is not consistently tracked or reported, leading to significant gaps in our understanding of plastic recovery and reuse within the industry. As a result, the exact percentage of plastics that are recovered and reused remains uncertain, highlighting the need for more detailed data collection and analysis to better understand and promote sustainable practices.

The extended producer responsibility (EPR) to the industry is based on the type of single-use plastic sold. Different containers are comprised of different polymers [high-density polyethylene (HDPE)

and polypropylene (PP)] may be subject to different fees. While some legislation targets specific types of polymers (e.g. polystyrene), others are more general and apply fees to broad characterizations of plastics (e.g. rigid vs. flexible plastics). While EPR laws are only in effect in a few states, broader regulations may be enacted. If states adopt similar EPR laws to Oregon, charging 24¢/lb of rigid plastic, and 34¢/lb of flexible plastic, the industry could be subject to upwards of $571,856,200 annually.

Understanding what type and how much plastic consumed within these market segments is critical in identifying less expensive or more sustainable materials. Conducting field audits to directly observe and document the types and quantities of plastics in use would help verify the accuracy of self-reported data and provide a more detailed understanding of plastic consumption patterns.

CONCLUSION

The integration of plastics has been pivotal in the development of the horticulture industry. However, reliance on petroleum-based, single-use plastics has led to significant environmental challenges and an increasingly complex regulatory landscape. This study underscores the urgent need for the industry to adapt by understanding the specific plastics used across market segments and complying with new standards and EPR laws. To navigate these challenges, conducting a comprehensive audit of plastic usage is crucial. The industry must not only comply with regulations but also embrace sustainability as a competitive advantage by reducing plastic use, enhancing recyclability, and adopting innovative materials. Collaboration among growers, manufacturers, and policymakers is key to driving the industry toward a sustainable future.

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