How Natural Resources, Consumer Perceptions, and Labor Are Transforming the US Nursery Industry

Jeb S. Fields[1], Lloyd L. Nackley[2], Jacob H. Shreckhise[3], Maria Bampasidou[4], Ryan Contreras[5], Adam Kantrovich[6], Melinda J. Knuth[7], James S. Owen Jr[8], and Sarah A. White[9]

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Abstract. **The nursery industry produces and sells plants for landscape and environmental purposes and represents a major sector within the US agricultural industry. In recent years, the nursery industry has undergone rapid growth as a result of various factors, including increased demand from housing development and pandemic-fueled interest in home horticulture. As with any industry, the nursery industry must adapt to changes in societal trends to sustain growth. In the wake of unprecedented societal and supply chain issues stemming from the global coronavirus disease 2019 pandemic, the American Society for Horticultural Science Nursery Crops Professional Interest Group gathered experts in various disciplines to provide their opinions and insights into the future of the nursery industry, focusing specifically on the changes and challenges the nursery industry will face in the coming decade. Nursery crop specialists spanning the United States identified three primary areas that will steer the future momentum of the nursery industry: consumer trends, natural resources, and labor. Six experts were selected to represent these areas in a workshop held Jul 2022 at the American Society for Horticultural Science Annual Conference in Chicago, IL, USA. This article was developed to disseminate to the greater scientific community the discussions held and insight shared during that workshop.**

The ornamental horticulture industry is a critical component of US agriculture in terms of revenue, employment, exportation, environmental sustainability, and the health and well-being of the population (Hall and Dickson 2011; Hall and Knuth 2019), generating more than $348 billion in total output to the nation's economy (Hall et al. 2020). The nursery industry generates $13.8 billion in annual revenue through the production and sale of live plants (US Department of Agriculture, National Agricultural Statistics Service 2020). Nursery stock (e.g., woody ornamentals) makes up the largest commodity within the nursery industry, generating $4.55 billion in revenue annually (US Department of Agriculture, National Agricultural Statistics Service 2020). To sustain profits, the nursery industry provides employment opportunities across various sectors, including plant production, sales, distribution, and landscaping. Thus, nurseries create both direct and indirect employment opportunities throughout rural, suburban, and urban areas, multiplying the industry's economic benefits to local and distal economies. Nurseries not only generate revenue for themselves, but also stimulate economic activity in numerous related industries. For example, nurseries require inputs such as fertilizers and pesticides, as well as tools and materials, including heavy equipment and packaging materials, which supports other sectors of the economy.

The US nursery industry is part of the global economy because it engages in international trade, exporting live plants and related products. This trade can contribute to foreign exchange earnings and promote the reputation of US nurseries in global markets. Dubbed the "green industry," the plants provided by the nursery industry offer numerous environmental benefits such as improving air quality, reducing soil erosion, enhancing biodiversity, and supporting pollinators (Hall and Dickson 2011). Many nurseries focus on growing ornamental plants that are used in interiorscaping, exterior private residential gardens, and public residential and commercial green spaces. As such, the nursery industry is linked intrinsically to urban and residential growth, home construction and renovation, and affluent lifestyles for which individuals or groups have the financial means to enjoy leisure activities.

The year 2020 brought a major change for many individuals and industries worldwide, as the coronavirus disease 2019 (COVID-19) pandemic influenced change in work and leisure habits to minimize the spread of infection, creating a unique opportunity for the rise of home horticulture. The nursery industry benefited greatly from the pandemic shutdowns, with more attention being focused on yards and landscapes than ever before in our society (Fratello et al. 2022). A 2021 survey conducted by the National Gardening Association indicated there were upward of 18.3 million new gardeners in the United States, which can be considered new customers for the nursery industry (Whitinger et al. 2021). Concurrently, the housing market has been steadily increasing, which has boded well historically for the nursery industry because new housing developments are often landscaped intensively to provide immediate curb appeal. Moreover, as climate patterns become more atypical, extreme storms and prolonged droughts are becoming more commonplace, demanding new plantings to replace lost landscapes or to ensure resilience to altered hardiness, heat tolerance, and changing weather patterns. Thus, sales have been increasing across the country in the past several years. In the event that sales decline in the coming years as pandemic purchasing trends subside, the nursery industry is still well above pre-COVID valuation.

The US nursery industry is poised for continued growth based on recent successes and a stable or growing marketplace. However, we are also in the midst of an agricultural revolution in which production practices, environmental regulations, and consumer preferences are evolving. Many consider food production to be a more important, logical sink for natural resources (water, mineral nutrients, land) and production inputs such as labor and infrastructure, as well as financial support, compared with its nonedible counterpart, ornamental horticulture. To predict impending challenges and provide insight into what researchers can do to support the nursery industry and ensure continued progress, the American Society for Horticultural Science Nursery Crops Professional Interest Group developed a symposium in 2021 to identify

major areas of change and challenges expected in the coming decade. Members of the Nursery Crops Professional Interest Group work regularly with growers across the country and developed a list of specifically identified, critical topics to explore further during this symposium. Experts were selected and tasked with developing their road map and predictions for the next decade in one of three critical areas: natural resources, consumer perceptions, and labor.

Natural resources: Water, fertilizer, substrate

Natural resources are finite; thus, their careful and judicious use is crucial, especially in industries such as ornamental horticulture. Despite being sometimes overlooked in comparison with food-producing crops, ornamental horticulture plays a vital role in urban and suburban landscapes, providing both direct and indirect ecosystem goods and services. It is important to recognize the significance of ornamental horticulture, and prioritize sustainability and efficiency in its practices. This section delves into the key resources on which growers rely, the potential key resource limitations in the future, and innovative approaches aimed at ensuring the long-term sustainability of the industry.

Several challenges lie ahead for nursery producers in the future related to water availability, contaminant presence, and human health. The availability of water for crop production will likely be affected by micro-droughts, flooding, and competition for high-quality water sources. Average global temperatures have increased 1 °C from 1895 to 2016 and are projected to increase an additional 1.4 °C from 2021 to 2050 (US Global Change Research Program 2017). The timing and intensity of precipitation is also projected to continue changing in the coming decade (US Global Change Research Program 2017), exacerbated by El Niño (wetter) and La Niña (drier) cycles. These temperature increases and changes in precipitation patterns will likely affect plant production practices as 1) irrigation methods and plant choice will likely alter, and 2) water storage goals in reservoirs will change to enable continued plant production for longer durations without precipitation buffers. One infrastructure change growers should consider is the design or reengineering of retention reservoirs per the recommendations of Yazdi et al. (2021) to capture additional surface water during storm events, if permitted by local or state regulations.

The presence of chemical, biological, and physical contaminants in water used for irrigation is problematic when the contaminant (e.g., a plant pathogen, salt, or sediment) affects plant health. However, if contaminant-laden irrigation return flow leaves the operation, whether during a storm event or simply flowing directly from production areas to adjacent lands, it is of concern for both 1) environmental health and 2) community perception. Sediment is a contaminant in and of itself, but contaminants also sorb to sediments and are transported throughout the operation during irrigation events, or off-farm during storm events (Gallagher et al. 2001). Thus, sediment management is a critical component of on-farm water management that growers will need to improve (Majsztrik et al. 2017). Pesticide fate, persistence, and transport off-farm will also be under increasing scrutiny. Community perceptions of clean water and resource stewardship will motivate growers to be more proactive in addressing contaminant management on farms. Environmental concerns and the capacity to detect contaminants in surface and groundwaters will promulgate the need for treatment technologies to be installed and maintained so that communities near farms can be confident in the safety of their water and ecosystem health.

Concerning human health, with a changing climate (e.g., higher temperatures earlier in the season) and water with nutrients present on-farm, the prevalence and frequency of harmful algal blooms will likely affect production practices (whether filtration, water treatment, or application methods (Watson et al. 2015). The production of microplastics from nursery plastics used for production (e.g., shadecloth, ground cloth, greenhouse plastic, containers) is of growing concern because microplastic particles can also sorb pesticides and other emerging contaminants of concern (Wang et al. 2021). Nursery and greenhouse operations should consider alternatives to plastic, when possible, to limit the release of microplastics from their operations.

The globalized, on-demand marketplace was strained during the 2020 global pandemic when demand for plant materials was at its highest. Supply chain issues limited the availability of plastic-based products (e.g., polyethylene-based covers, containers, piping), increased nitrogen and phosphorus fertilizer prices, and resulted in shortfalls of critical technology (e.g., limited availability of essential equipment), which prevented the green industry from responding quickly to changing demand. This was exacerbated further by limited shipping resulting from a lack of real-time transportation logistical solutions (i.e., drivers and warehousing), unseasonal precipitation in Canada limiting the sphagnum peat harvest, and inadequate supplies of young plants and woody plant seed to meet the needs of the booming marketplace. This cascade of events illustrated the interdependence of natural resources to manufacturers and allied suppliers, exhibiting the vulnerabilities that can and will continue to plague horticultural producers as weather extremes, market uncertainties, and other unforeseeable events become more prominent. These supply and demand uncertainties are escalated when coupled with less preemptive

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[1]Hammond Research Station, Louisiana State University Agricultural Center, 21549 Old Covington Highway, Hammond, LA 70403, USA

[2]Department of Horticulture, North Willamette Research and Extension Center, Oregon State University, 15210 NE Miley Road, Aurora, OR 97002, USA

[3]US Department of Agriculture, Agricultural Research Service, US National Arboretum, Floral and Nursery Plants Research Unit, Otis L. Floyd Nursery Research Center, 472 Cadillac Lane, McMinnville, TN 37110, USA

[4]Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center, 211 Martin D. Woodin Hall, Baton Rouge, LA 70803, USA

[5]Department of Horticulture, Oregon State University, 4017 Agricultural and Life Sciences Building, Corvallis, OR 97331, USA

[6]Cooperative Extension Agribusiness, Clemson University, 900 Clemson Road, Clemson, SC 29634, USA

[7]Department of Horticulture, North Carolina State University, 152 Kilgore Hall, Raleigh, NC 27606, USA

[8]US Department of Agriculture, Agricultural Research Service, Application Technology Research Unit, Williams Hall 215A, Wooster, OH 44691, USA

[9]Department of Plant & Environmental Sciences, Clemson University, E-143 P&AS, Clemson, SC 29634, USA

J.S.F. is the corresponding author. E-mail: jfields@agcenter.lsu.edu.

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production or hoarding of goods for singular consumer resilience.

Raw materials, including peat, bark, wood, nitrogen, and phosphorus, must remain under scrutiny as global conflicts, trade wars, and concerns over national security continue to arise, in addition to regulatory, weather, and shipping hardships. Regarding freshwater resources, freshwater quantity and quality must remain at the forefront of our attention. As of Jul 2022, one third of the United States was under a severe, extreme, or exceptional drought, and more than half of the United States was experiencing "flash" droughts, with 17 to 48 extreme drought weeks from 2000 to 2019. Concurrently, the eastern United States, midwestern United States, and west of the Cascade Mountains in the US Pacific Northwest, received up to a 30% increase in precipitation, typically as less-frequent but more-intense storms. Many of these same regions experienced a significant increase in river flooding. The Great Lakes' pool depth remains at a maximum, allowing for an abundance of finite freshwater in the midwestern United States for the time being. Although saltwater intrusion (Barlow and Reichard 2010; Mondal et al. 2023) and subsequent subsidence (Herrera-García et al. 2021) occur on our coastlines and great plains, groundwater withdrawals exceed recharge rates (Gleick and Palaniappan 2010) throughout the United States. An abundance and shortage of water both exemplify the finite nature of high-quality freshwater for which specialty crops, human consumption, and industry must compete.

To summarize, the nursery industry exists in an ever-growing specialty crops market that now includes medicinal crops and vertical farms. Nursery and greenhouse production now competes for existing and new technologies, soilless substrate, freshwater, plastics, and labor while relying on others for transport logistics. We must remain cognizant of consumer preference and the global marketplace, policies, and climate to prepare most effectively for a profitable future.

Consumer perceptions

Consumer perceptions and preferences guide the nursery industry more so than most agricultural enterprises. Understanding consumer behavior and industry practices is vital in navigating the dynamic landscape of the nursery industry. Consumers within this sector can typically be categorized as plant, price, or production oriented, with plant-oriented consumers forming a significant majority. Across the United States, yards are becoming smaller, houseplants are on the rise, and buzzwords such as "ecosystem services" permeate the industry. As consumers make purchasing decisions, it is essential to recognize that they buy benefits, not just features. Communicating these benefits effectively through various channels is key to engaging consumers and driving demand. Moreover, there is a growing emphasis on environmental sustainability in consumer preferences, with factors such as local sourcing and ecofriendly practices gaining prominence. To meet evolving consumer expectations, the nursery industry must prioritize environmental stewardship and assist consumers in making informed choices. The industry must adapt to meet these changing preferences. Within this topic area, consumer preferences are changing and steering the green industry. Furthermore, the link between consumer perceptions of ornamentals and how this industry fits into the entire specialty crop industry must be explored.

Types of consumers. Nursery consumers are considered to be of three types: plant, price, or production oriented (Behe et al. 2014). Plant-oriented consumers (which consist of two thirds of consumers) prefer shrubs, trees, and indoor flowering potted plants. They prefer to shop at independent garden centers and are more likely to have a yard that they maintain. This consumer group is of great importance to the nursery industry because of the number of new construction builds and new homeowners entering the market. In 2021, 43% of older millennials (31–40 years) purchased a home for the first time (National Association of Retailers 2022). This creates a possible opportunity for the nursery industry because these new homeowners often wish to decorate, remodel, and arrange their landscape to fit their needs.

Consumers do not buy features; they buy benefits. It is important to communicate with consumers about what the product can do for them (Hall and Knuth 2019). Plants provide emotional health, physical, social, environmental, and economic (e.g., energy savings) benefits (Chalmin-Pui et al. 2021; Park and Mattson 2009). The nursery industry needs to communicate messages to consumers about the benefits of plants through social media and online, verbal, and physical communications.

Environmental and sustainable. When purchasing ornamental plants, words that were important in the decision-making process included local, compostable pots, recycled pots, and bio-pots, whereas words such as organic, conventional, and sustainable were not as important (Yue et al. 2011). These principles are not necessarily less important, but they have multiple definitions and are broader in their interpretation, whereas words such as compostable, recycled, or bio are specific terms. In the future, the nursery industry needs to be specific about environmental activities in which the nursery industry is participating and assist consumers with properly identifying what is important. This was emphasized further by Isaak and Lentz (2020), who showed that consumers highly desired edible and ornamental crops produced using sustainable practices and techniques.

This was also shown in research conducted by Knuth et al. (2019) in homeowner perceptions of landscape water conservation. When comparing active vs. passive interests in plant care and landscaping, active interest in plant care correlated directly and positively with homeowners' attitudes regarding water conservation (Knuth et al. 2019). Active interest in plant care included purchasing more plant categories, spending more annually on plant purchases, and having positive attitudes about use and design of their landscape and outdoor spaces. This alludes to the fact that consumers who like to grow plants generally have positive attitudes about conserving water in their landscape. As water conservation continues to become a greater discussion point, this relationship will be very important to highlight with consumers and policymakers.

Multifeature crops. Consumers are now looking for products and services that are multifeatured instead of monofeatured (Aviolo et al. 2018; Ben-Akiva and Gershenfeld 1998; Rihn et al. 2016). This means that the products should not only be beautiful but also have a secondary

function or benefit. An example of this is fruit trees in the residential landscape: they look nice, shade the home, and provide edible fruit. Nursery firms should capitalize on multifeature crops by highlighting the crops that flower, have fall color, have showy fruit, provide shade, are drought tolerant, are non-allergenic, have pest resistance, are good for areas with powerlines (height), are aromatic, and are native (Aviolo et al. 2018).

Native plants. Speaking of features of plants, native plants are increasingly popular and sought after. This trend is expected to continue, with native plants staying in the limelight. The number of native plant nurseries and sales of native plants have increased nationwide (Anderson et al. 2021; Thomas et al. 2020; Wei et al. 2020). Another big indicator of the staying power of native plants is legislation around native plant sales. For example, New Jersey S-83 Law, Delaware Bill 22, and Illinois HS5450 all encourage native plant sales or distribution at the state level. On the national level, Congressional Bill S.557, the Native Plant Species Pilot Program Act, was passed by Congress in Oct 2022. This bill establishes a pilot program for native plant species and a study on the cost-effectiveness of using native plant materials to carry out land management activities on federal lands. The Department of the Interior is currently coordinating activities with the National Seed Strategy of the Bureau of Land Management, the Plant Conservation Alliance, and the Plant Materials Centers of the Natural Resources Conservation Service to carry out the pilot program.

Breeding new ornamental plants: Meeting future challenges. The landscape of ornamental plant purchases and marketing is dynamic, akin to shifts in fashion and cultural trends. However, the prolonged breeding cycles of woody plants pose challenges in anticipating future demands. As we contemplate future limitations, several key goals emerge. Foremost among them are addressing issues of water scarcity, labor efficiency, and heightened pressures from insect pests, diseases, and temperature fluctuations.

Although trends may evolve, certain plants endure as timeless classics. Boxwood (*Buxus* sp.), for instance, maintains its significance among gardeners and growers despite facing formidable challenges from boxwood blight (*Calonectria pseudonaviculata*) and box tree moth (*Cydalima perspectalis*). Encouragingly, breeding efforts have yielded promising results in developing resistant cultivars, underscoring the importance of breeding for pest and disease resistance. Unfortunately, emerging pests often come in quickly and can devastate a plant group [e.g., emerald ash borer (*Agrilus planipennis*)] in a relatively short time. Breeding for such emerging pests and diseases is a top priority and will remain such. The challenge for breeders and growers is that the effect of these issues happens faster than the breeding cycles.

The imperative for resilient plants in landscapes is undeniable, particularly in regions grappling with the impacts of climate change, including dwindling water resources and more extreme temperature fluctuations. However, there exists a paradoxical trend exemplified by the widespread introduction of bigleaf hydrangea (*Hydrangea macrophylla*) cultivars, notorious for their high water demands. In some regions, climate change will reduce available water, increase temperature extremes, and place landscape plants under more stress. Nevertheless, demand remains high. One reason for this demand, aside from the innate beauty of bigleaf hydrangea in flower, is marketing. The rise of plant brands and their marketing power has had a marked effect on what consumers purchase. Despite concerns about sustainability, effective marketing strategies continue to drive consumer demand.

Regardless of the issues breeders are trying to solve, there are some common goals. Whether it is improved pest resistance, improved drought tolerance, or any other issue, new plants must perform well in production such that growers will produce them, and they must be aesthetically desirable in landscapes beyond their improvements in biotic or abiotic stress tolerance. When breeders consider how to achieve these goals, one obvious method is to use plants that are already resilient but perhaps weedy. Some may argue that this presents an ecological conundrum, but the fact is that these plants are so resilient that they thrive and end up escaping cultivation. The only issue with such plants is that they are too fecund. With the issue of seed production (or, more properly, the lack thereof) solved, these plants provide growers, gardeners, and land managers with excellent options. A second option that requires a longer term approach is to seek species related to common landscape plants that are superior in some stress tolerance. Examples include western redbud (*Cercis occidentalis*), which is a relative of the more commonly planted eastern redbud (*Cercis canadensis*), which has greater drought tolerance. Developing hybrids may allow introgression of the desirable flowering and tree-form characteristics of the myriad eastern redbud cultivars with the stress tolerance of western redbud. This approach is commonly used for invasive pests and pathogens in which native flora present no resistance. Often, the duration of such projects is even longer than normal because of the number of generations required to achieve the desired phenotype.

Labor supply, labor demand, and mechanization

The past two decades have been characterized by a decreasing supply of family labor and an increased demand for hired labor (Escalante et al. 2020; US Department of Agriculture, National Agricultural Statistics Service 2023). Labor shortages are documented in several agriculture industries, including the nursery industry. Labor challenges arise from the nature of employment: seasonal and temporary positions and labor-intensive tasks that are physically demanding, with long hours working outside. Labor issues may also arise from how local labor markets adapt to labor and policy shocks and changing conditions. Factors that affect labor availability include the aging of the domestic workforce, lack and/or unwillingness of local labor, and increasingly difficult immigration and guest worker regulations and policy, which trickle down to the industry (Adegbola et al. 2019; Escalante et al. 2020). Adding to the list the increased interest for automation and mechanization, the industry is looking for ways to address the labor challenges as effectively and efficiently as possible.

Undoubtedly, labor is a production input that is critical for the sustainability of an industry. Labor needs and demand, labor supply, and respective costs are some areas that specialists examine year by year and document

trends. The 2024 Nursery Management State of the Industry report documented labor challenges, including insufficient availability of qualified labor (42% of the respondents) and increased wages (22% of respondents) as factors limiting new hires (Mcclellan 2024). According to the same report, staff hiring and training was the top business aspect begging improvement in the future (38% of respondents).

Labor costs for the nursery and greenhouse industry have increased steadily since 1999 (Hall 2023; US Department of Agriculture, National Agricultural Statistics Service 2020), from less than 30% as a share of total gross cash farm income in 1999 to ≈35% in 2020. Although a 5% change may not seem much in two decades, costs in nursery operations are near a 20-year high. Studies estimate that labor costs for the nursery industry account for up to 40% of production costs (Mathers et al. 2010), with labor costs increasing as production operations further adopt soilless production practices. Moreover, compensation schemes have increased as well, either as a result of an increase in the minimum wage and/or adverse effect wage rate or as a means to attract and retain employees. Regardless of the growth in sales in the green industry, which gives an advantage to manage any shock (production, marketing, and financial), all operations are examining ways to reduce labor costs if possible and secure dependable labor.

Automation and mechanization have been introduced as a labor cost-saving and labor shortage mitigation approach. Autonomous greenhouses and robotics are capital investments pursued by several ornamental horticulture operations, yet the extent of automation is still limited (Posadas et al. 2008; Rihn et al. 2022). Moving forward, automation and mechanization will continue to be an area where the industry is expected to allocate additional resources. However, the application of automation and mechanization tools will vary by production methods used and the scale of the operation. Existing applications, including granular fertilizers, pruners, and irrigation, can be improved with sensors and high-definition cameras. Artificial intelligence (AI) applications can assist with streamlining and monitoring production as well as helping manage production risks such as pesticide damage, irrigation issues, and so forth. Issues that need to be addressed include the cost of technology adoption, interest from the industry to invest in automation and mechanization and AI, and perceptions of labor management (new training) and worker welfare. For operations where the cost of automation and mechanization or AI is prohibitive, guest worker programs may offer a way to deal with labor shortages.

The recent pandemic highlighted the need for securing and retaining labor; it also offered a pressure test for the industry to see how it can adjust to shocks within the labor market. An increased interest and dependence on H-2A guest worker labor in agriculture, including the nursery industry, has already been documented through data (US Department of Labor Office of Foreign Labor 2022). Moving forward, policies that help streamline the program along with outreach programs that help inform operators will be needed.

Conclusion

The US nursery industry is poised to experience continued gains from shifting markets, increased efficiency surrounding material costs, and added productivity through better management, more efficient use of labor and automation, and improvements to plant materials. Although the industry is on a strong trajectory, future uncertainties remain and provide opportunities for improvement, which could propel the industry successfully into the coming decades. The ideas presented herein represent the opinions of the experts recruited for this endeavor and are presented as a basis for moving forward.

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