

Research Priorities of the Environmental Horticultural Industry Founded through Consensus¹

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Abstract

Environmental horticulture production (EHP) generates and employs approximately one-third of all specialty crop revenue and workforce, respectively. In recent years, however, EHP received only 12% of federal funds earmarked for specialty crops research from the USDA-Agricultural Research Service or the USDA-Specialty Crops Research Initiative. To increase leverage and accumulate more resources for EHP, stakeholder-driven consensus of research priorities needed to be constructed. Therefore, the Horticultural Research Institute led a professionally facilitated stakeholder roundtable discussion to achieve these priorities. Stakeholders identified trends and forces affecting EHP, its current state, a vision, and outcomes needed for success. Through consensus, four equal research priorities were constructed: 1) quantify and validate the ecosystem services and benefits of plants on human health and wellness, 2) develop innovations in biological, mechanical, and technological systems that provide efficient, productive, and profitable solutions relevant to producer size and segment, 3) evaluate consumer-driven preferences that optimize industry-wide profitability and growth, and 4) solve ongoing and emergent industry challenges. These priorities and the successful future of EHP will be made possible by strong leaders and advocates positioned throughout industry, successfully communicating the human health, social, and economic benefits of plants, state-of-the-art technological and efficiently-designed systems, and an understanding of current and future consumers.

Index words: forces, greenhouse, innovation, nursery, roadmap, stakeholders, trends, vision.

Significance to the Horticulture Industry

A national cross section of stakeholders, nursery and greenhouse specialty crop producers convened in New Mexico to create a roadmap directing research objectives and public funding for environmental horticulture production (EHP). Scientists and the leadership of the Horticultural Research Institute were present as active listeners to enable reporting of stakeholder findings. Total public funding of over \$116 million annually is directed toward EHP research in the U.S. Currently, there is a 36% gain per year on the rate of return (ROR) for specialty crops

research investments indicating that research dollars directed toward EHP provides economic benefit for producers (Alston and Pardey 2000). Due to their applied nature, however, research findings and their benefits may take years or even decades to be realized because adoption and change lag behind the status quo (Alston and Pardey 2008). Additionally, social and long-term benefits from completed research that “spill over” across state and regional boundaries (Alston et al. 2000) and across sectors have not heretofore been a focus for EHP research. The roadmap laid out here should be used to direct public nursery and greenhouse specialty crops research funding to maximize ROR across EHP, as well as, provide direction and guidance for other funding agencies to use for determining what stakeholders (i.e., specialty crop producers) and constituents including allied companies and support networks envision as necessary priorities to invest their research dollars.

Introduction

Environmental horticulture production (EHP), comprised of field-grown and container-grown specialty crops produced in greenhouses (i.e., controlled environment) or nurseries (i.e., covered or open-air) in all 50 states generated \$19.3 billion in annual sales in 2015 (Anonymous 2015). Annual gross sales of EHP are greater than major agronomic crop sectors such as wheat or cotton. EHP involving breeders, garden retailers, distributors, interior and exterior landscape professionals, florists, students, educators, researchers, extension agents, manufacturers, and those who are part of the industry market chain, account for a quarter to one-third of all specialty crop annual revenue and labor in the U.S. based on the authors’ analysis of USDA-National Agriculture Statistics and Economic Research Services published reports.

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Stakeholders across EHP, producers and constituents, including allied companies and support networks, have lacked a unified vision to provide a roadmap for future research priorities that can be used to leverage needed resources to direct research, education, extension and outreach (Tom Bewick, USDA-NIFA, personal communication). This is a consequence due to segmentation, regional variation, shifts in desired marketable goods, and constantly emerging challenges (e.g., emerging pests, regulation, or policy) made immediately imperative because of real or perceived future importance. A decisive way to construct commonalities about the direction for strategic, future research priorities focused on environmental horticulture specialty crops is needed to ensure a competitive industry led by a newly trained, engaged generation of ornamental crop producers, scientists, extension agents, teachers, curators, executive association leaders, policy makers and government agents. Resources need to be combined, collaborations must construct systems to meet challenges, and innovation needs to revolutionize practices to strategically address the challenges of the next decade. The industry assessment and the resulting broad needs outlined herein provides a roadmap that can unify direction for research dollars to best benefit EHP, including allied suppliers, educational institutions, and retailers.

Currently, approximately \$10.1 million available in competitive funds (i.e., recurring grants) are being utilized by EHP researchers in the U.S. annually. Competitive, recurring dollars are comprised of the following: nine state or regional association grant programs (\$0.44 M; 4.3%), four national institute grants, trusts, or endowments (\$1.13 M; 11.3%), and five federal programs such as the Specialty Crop Research Initiative (SCRI), Inter-regional Research Project #4 (IR-4 Project), Floriculture and Nursery Research Initiative (FNRI), and federal germplasm centers (combined \$8.48 M; 84.4%) (personal communication among authors). Total competitive funds from the nine state commodity associations averages \$24,250 for annual research expenditures, yet these funds are typically divided among multiple research projects, significantly decreasing award amounts for individual researchers at each university. Between 2009 and 2018, USDA-SCRI awarded \$427.3M in competitive grant dollars (median annual support of \$3.3 M to address EHP needs) (Anonymous 2018b). Cumulatively, EHP received \$47.5M, or 12% of the total awarded (\$427.3M) for all specialty crops from 2009 to 2018. Approximately 22% of the amount awarded for each project is utilized to recover institutional indirect costs as part of the agreement. For comparison of direct research costs, the annual average cost for a research technician is \$68,810 (\$44,394 salary plus \$24,416 in other payroll expenses), or a graduate student on assistantship entails an average annual in-state tuition and stipend of \$10,230 (Anonymous 2017a) and \$28,119 (Mika 2017), respectively. Additional costs of research include materials and supplies, survey and computing, space and equipment, analyses, and publication and travel to disseminate findings to stakeholders and colleagues. These additional costs range from \$7,000 to \$249,000, depending on the project,

with a median of \$10,000, which excludes labor or a student (personal communication with 10 scientists across disciplines within EHP).

There are other non-competitive funds directed towards EHP. These include the USDA-Agricultural Research Service (ARS), state agricultural experiment stations (SAES), and individual and private financial support. The USDA-ARS appropriated \$37.8 million (Tim Rinehart, USDA-ARS National Program Leader, personal communication), or 12% of the \$306 million ARS crop production and protection budget, for EHP research and development in greenhouse and nursery crops in 2018 (Anonymous 2018a), which includes funding for facilities, salaries, and discretionary spending on research projects. In 2004, SAES accounted for 78% of the total EHP public research and development budget totaling \$68.2 million (Alston and Pardey 2008). USDA-ARS and SAES dollars are primarily used for equipment, facilities and salary or wages. However, SAES dollars have moderately increased or remained flat relative to increasing operational and employee costs, which is further confounded by the wider disbursement of federal funds by agencies that now include the U.S. Department of Energy, U.S. Department of Defense, National Institute of Health, National Science Foundation, and the U.S. agency for International Development in addition to USDA. Thus, SAES dollars continue to dilute with increasing amounts allocated to competitive grant programs and decreasing dollars disbursed directly from formula funds (Alston and Pardey 2008).

A roadmap for EHP based on stakeholder involvement, predominantly crop producers, is necessary to justify the dire need to both increase and focus public research dollars in support of EHP. The current amount of public support described above for research is 0.8% of annual EHP revenue. For institutions and agencies, a roadmap will provide a scaffold for hiring faculty, calibrating curriculum with future trends, and reformulating priorities. Faculty and graduate students will be able to quickly identify research ideas within their expertise and seek funding opportunities to address specific issues identified. Students would be able to choose majors, minors, and cooperative experiences to tailor their career interests to meet industry needs. Academia and private industry can collaboratively leverage funding to solve stakeholder-driven research objectives. Furthermore, a roadmap will act as a compass for commodity groups in matters of training and education, as well as funding within respective states. Private companies can create solutions for priorities identified by working alone or in collaboration with institutions. Policy makers will be more informed of pressing challenges facing a large sector of specialty crop agriculture, the EHP.

Our objective was to combine greenhouse and nursery producers with professional facilitation to reach consensus about the future of EHP research. During the process, the stakeholders in attendance (primarily growers), identified current challenges and future opportunities, and developed a vision of what they wanted the industry to look like in the future. The resulting consensus roadmap to reach that vision articulates those research priorities necessary to achieve the goals and provides context for what aided in

the decision-making process of industry participants. The key stakeholder-determined priorities are expected to be used to direct future research, education, training, and outreach efforts of institutions, trade associations, government and private agencies, and policy makers to ensure their long-term vision of funding is focused on EHP viability, profitability, and innovation.

Methodology

In January 2018, the Horticultural Research Institute (HRI), the research-arm of AmericanHort, prioritized funding to convene a process that would develop strategic horticultural research priorities as outlined by Drs. Owen and LeBude in a 2017 grant proposal entitled 'Delivering a Blueprint for Ornamental Crop Innovation'. Owen and LeBude strongly encouraged the creation of a document with horticulture industry research priority consensus which could be cited as justification when seeking other multidisciplinary, competitive grants within or outside the USDA or HRI. Other industries, such as the grape, apple, or citrus industry, succeed in competing for the same funds because they are able to project an industry consensus supporting their proposals. Dr. Jill Calabro and Jennifer Gray of HRI also saw the opportunity in this process to guide internal decision-making and more-closely align their research agenda to the needs of the producers who benefit from their efforts. They led efforts to identify a professional, unbiased moderator, Mitchell Owen (Mitchen Incorporated, Raleigh, NC), to facilitate the process.

HRI engaged industry thought leaders in a combination of survey and in-person interactions that culminated in a roundtable "summit" on December 11-12, 2018 in Albuquerque, NM. Approximately 80 individuals representing nursery and greenhouse or floriculture production were identified based on their broad knowledge of the industry, industry segment, business size and scope, regional diversity, previous service to the industry, and totality of industry experience and perspective. Additionally, four USDA-ARS personnel (James Altland, Jennifer Boldt, Joseph Munyaneza, and Tim Rinehart) directly involved in EHP were invited to participate as listeners. Ultimately, approx. 45 of the 80 identified individuals were selected and invited to participate due to facilitation, space, and monetary constraints. A select group of eight participants, labeled industry advocates, were identified to interview eight or more individuals representing (A) mass market and independent retail, (B) landscape, and (C) interior plantscape. The eight questions requested of these additional industry segments included the identification of: (1) emerging social, political, economic, technological, and/or scientific issues, (2, 4, 6) strategies that are working to contribute to or (3, 5, 7) diminish industry success for industry, educational institutions, and government institutions and allied industries, respectively, and (8) characteristics that describe the different factors that make industry successful when imagining a thriving industry that is perfect in every way. Industry advocates provided an oral summary of industry segment responses to all summit participants on the first day of the summit prior to consensus-building exercises.

Inspirational, thought-provoking presentations were given to participants the first day of the summit to aid in broad thinking prior to Mitchen Leadership and Organization beginning professional facilitation. Modified versions of the Continuous Quality Improvement processes developed in industrial situations to improve employee input and improve quality in manufacturing situations were employed throughout the remainder of the summit. The processes used were designed to ensure data driven, rather than advocacy-based, group consensus decisions. Group affinity diagrams coupled with consensus-building processes provided the body of data, which was generated via individual brainstorming. This brainstorming process utilized post-it notes and large flip charts to allow all participants to respond to each thematic area of discussion and record input. Additionally, pre-interviews were conducted and used to increase input data quality as well as strengthen the impact of consensus decisions. Pre-interviews consisted of all attendees interviewing five other individuals, not in attendance but within their industry segment, regarding four topics: (1) shifts in the business and external forces that may influence the industry; (things the industry, government, allied industries, and universities are doing that (2) contribute to their success or (3) inhibit their success, and (4) describe what great success might look like for a thriving industry. Sub-groups and duplicative qualitative analysis were embedded in the processes to ensure the strength of findings. Group consensus was facilitated for the following three key areas of interest: (1) external trends and forces that will impact the EHP industry, (2) strengths and weaknesses of the EHP industry, universities supporting the industry, government, and allied industries, and (3) a comprehensive vision for a successful EHP industry. Following these discussions, the group was facilitated using individuals, small group and ultimately total group consensus of key research priorities for success. Immediately following the summit, selected industry participants (i.e., growers, some of whom were AmericanHort board members or trustees) and "listeners" (individuals from government agencies, educational institutions, and associations) who had been present throughout the summit worked in concert to synthesize each thematic area of discussion via similar professional facilitation (Mitchen Incorporated) as described above.

Results & Discussion

Trends & Forces. Three major themes regarding trends and forces affecting the environmental horticulture industry evolved from the affinity diagrams created by participants. Consumer trends, global trends, and industry-specific trends were identified along with sub-themes within each. Regarding consumer trends, participants commented that consumer socio-economic demographics are changing. The basis for this consumer change was perceived to be due to age and disposable income. In general, the perception was the Baby Boomer generation (born 1946 to 1964) has less disposable income to spend on gardening products than Generations X (born 1965 to 1976) or Y (born later than 1977). Conclusions by Jin et al. (2013) support this assertion. They found while most Baby

Boomers are gardening hobbyists, they are spending less money on nursery plants than later generations. Jin et al. (2013) further state that Generation X and Millennials (i.e., Generation Y, born later than 1977) spend more money than Baby Boomers on the green industry, but they are consumers of outdoor hardscapes and landscape services (mowing, edging, and pruning) rather than nursery plants. Complementary to this trend is the belief that Millennials early in their careers have less disposable income and assets, as well as larger debt obligations. This contention is supported by a recent Gallup poll report stating that Millennials spend \$20 per day less than the same age group 10 years ago primarily because they carry more debt (Petro, 2018).

Participants indicated shifts in consumer preferences focused on personal and environmental health, and these preferences will continue to influence purchasing decisions. The overall basis for this shift, according to participants, is that consumers want to take care of themselves and the environment rather than just building an aesthetic landscape.

Participants conveyed that consumer shopping habits have shifted with more demand placed upon faster access to products and services. An instant gratification attitude might stem from the emergence of social media and our ability to instantly share and receive feedback on wants and needs. Consumers expect feedback and responses to their inquiries immediately (Wertz 2018). Participants agreed that increased reliance of “on-demand” access has shifted consumer shopping habits towards a preference for online information gathering and purchasing. While this shift in consumer expectations is not necessarily a negative aspect, especially for companies that can accommodate their needs, there have been some negative repercussions. While peer-to-peer or ‘word of mouth’ marketing can be rapid, it can also lead to bad or erroneous information being spread, and the proliferation of misinformation. It can also strain some smaller businesses not capable of handling such demands from consumers and can pressure the entire supply chain to react quickly to orders (whether business-to-consumer or business-to-business). Related to consumer demand for faster service and product delivery is the shift to “just in time” (JIT) management. JIT management is a form of lean methodology used to increase business efficiency by manufacturing and/or receiving goods only as they are needed. This results in reduced inventory management, improved cash flow, and reduced culls (unused or unwanted plants). However, JIT can adversely create more problems with order fulfillment, offer less room for error, and leave growers susceptible to price volatility from suppliers by purchasing raw materials when needed instead of when the price is optimum.

Industry-specific trends focused heavily on issues related to labor and employment. Industry employment opportunities are evolving towards higher-wage positions as labor availability decreases and desired skill sets diversify. There is an unfavorable perception of employment opportunities in the EHP industry, and a preference for jobs with minimal manual labor by entry level candidates. This may be due, in part, to the increasing number of people

obtaining college degrees. The total number of bachelor’s degrees earned in the U.S. was 839,730 in 1970, and more than doubled to 1.9 million by 2015 (Cherian 2018).

Two industry-specific themes related to the regulatory environment were identified. First was the impact of regulatory standards and tariffs, as well as non-regulatory ‘buy local’ campaigns, on the global supply chain. Many of the regulatory issues raised related to invasive pests and the subsequent quarantine and certification programs that impede the exchange of genetic material, propagules, and liners. Second, participants believed that state, local, and federal governments are volatile and unpredictable. Participants expressed that rules and standards are implemented and/or interpreted inconsistently, and increasingly without stakeholder knowledge and input. The root of this problem was speculated to be that fewer decision-makers (legislators, regulators) are connected to environmental horticulture.

Another industry-specific trend was the manner in which the EHP industry receives educational training, consulting, and research expertise. Universities and related extension services that have historically provided education, research, and outreach services are perceived to be placing fewer resources into EHP programs, and thus are becoming less impactful to the industry (personal observation). Concomitant with this, the industry is adopting more of these services from allied industries. For example, it is very common now for EHP fertilizer or pesticide sales representatives to provide seminars, training, and certified educational units for pesticide application licenses and other programs.

High shipping costs and transportation challenges related to new trucking regulations were identified as major industry-specific trends. Full compliance with electronic logging devices (ELDs) will be required for commercial carriers in 2019. Shipping companies are already struggling with an insufficient number of drivers to meet demand, and new ELD regulations will further limit the number of hours that the limited pool of drivers can operate (Torsiello 2018).

Primary global trends in EHP included climate change and changing technology. Climate uncertainty and instability could alter plant success locally, requiring shifts in the plant product mix and the inputs needed to produce them. Adaptability of EHP to meet the demands of a changing climate are seen as both a potential problem and opportunity. New technological options are available to augment labor and collect data on product utilization and plant movement through the supply chain and individual operations. Examples include robots, drones, sensors, and radio-frequency identification (RFID). Other global trends mentioned included the greening of urban environments, genomic solutions to horticultural problems, and political instability throughout the world.

Vision. The visionary consensus of participants identified aspirational characteristics of the EHP industry focused on branding the world-changing benefits of EHP products, produced via robust, researched, and efficient systems by a diverse and dedicated workforce. In the future, the EHP industry plans to be a publicly recognized

leader of producing quality plants that contribute to a sustainable environment and enhance the quality of life through health, creativity, and enjoyment. The customer will be an educated, knowledgeable, loyal consumer who values our plants and products and will become an industry ambassador. A readily available, diverse workforce will be comprised of educated, motivated, dedicated, and passionate employees fulfilled by broad-based continuing education opportunities and rewarded by a lifelong career in environmental horticulture. This collaborative community of programmatic, problem solving individuals with expertise in biology, business management, finance, engineering, computer science, and chain management will share a common vision (i.e., voice) and champion our industry to ensure mutual benefits and successes. Collaborative, impactful, needs-based research will deliver actionable outcomes and will continually improve products that are increasingly produced more efficiently. Concurrently, a resource-based, practical, affordable, and easy to adopt and use work environment equipped with the needed tools will evolve to safely and effectively produce quality products based on data-driven consumer needs. Resources and products will be delivered to the marketplace via ample, reliable, and affordable options via an adaptable, collaborative, and creative supply chain. The EHP industry believes the aforementioned attributes will enable growth and profitability.

State of the Industry. Internal and external environments relative to EHP needed to be examined to better understand the industry's capabilities and business environment. Strengths and opportunities were considered for universities, the government, the industry itself, and allied partners.

Environmental horticulture stakeholders identified three highly valued benefits of research, education, and extension programs at universities and community colleges. First, education institutions listen to and communicate with the EHP industry to develop a mutually beneficial relationship that unites environmental horticulture partners to solve challenges. For example, participants highlighted research programs such as plant breeding and variety trialing to create and identify the right plants for the future, as well as research focused on more applied or emerging issues like pests including plant diseases, technology transfer of new products, and water quality and production runoff challenges. Secondly, participants valued educating current and future environmental horticulture undergraduate and graduate students through industry experience. Universities were encouraged to continue requiring cooperative internship opportunities during degree programs with opportunities ranging from working locally to studying abroad. Lastly, they stated that extension programs are the main outlet of industry and public education, including field days to learn about new technologies, pesticide certification training, and Master Gardener programs. Participants encouraged universities to remain vigilant and focused on the land grant mission by not re-prioritizing resources from undergraduate education programs and extension support for environmental horticulture to more basic research that is less readily applicable to the industry, but brings in higher indirect cost awards

from funded grants. Participants valued their relationships with universities and community colleges and want to strengthen collaboration with these valued partners to solve industry problems.

Those in attendance praised local, state, and federal governments for continued funding and support for reactive, immediate research problems (e.g., a new pest outbreak) as well as intermediate-goal applied research, and long-term basic research. Participants appreciated regulatory policies that limit or control pest outbreaks and their spread, such as greenhouse and nursery certification programs (e.g., Systems Approach for Nursery Certification (SANC, Anonymous 2017b), quarantines, and inspections), as well as pro-business policies including agricultural exemptions, cash accounting (i.e., no inventory tax), highway and port inspections, and tax reform. One point of contention was that certain government programs and policies hinder growth and performance. Of particular note, a lack of bipartisanship has perpetuated a twenty-plus year issue of poor immigration and labor policies, leading to labor shortages in the industry. Furthermore, burdensome and inconsistent over-regulation in matters of pesticide monitoring and usage, trucking restrictions, and water quality measures has created confusion among industry segments and increased production and shipping costs. All in all, participants felt governments and their policies were both hospitable to growth and encouraged profitability in environmental horticulture.

As participants (i.e., growers and constituents) reflected upon their own EHP industry, they signaled several points as working well. The industry consists of an engaged community of industry professionals from all facets of EHP that actively collaborates with peers, as well as with research communities and commodity groups. Industry professionals routinely offer industry insight to state and federal funding agencies in addition to HRI. Stakeholders' efforts proudly result in quality plants and strive to continually improve production systems and plant genetics, often exercising innovation and creativity. They frequently share their creative solutions with their peers who have similar challenges, helping to further foster a sense of community. EHP offers multiple, unique career paths featuring both independence and an ability to contribute to improving the health and well-being of people, communities, and the planet. The industry, however, felt it failed to communicate the inherent value and benefits plants provide to society and that other organizations (medical and housing associations) were "stealing" their story (e.g., internal and external health benefits, increased home sales, and augmented heating/cooling). Additionally, they could do better conveying the keys to success with plants, such as providing planting and care instructions to consumers for their products. On the production and shipping side, they noted that greatly varying needs among the many industry segments has impeded standardization. Moreover, too much industry segmentation can negatively impact collaboration and involvement by producers. Many expressed a call for more leadership at all levels of the industry and vowed to promote both the impact of working in the green

industry and advocating for others to join in maintaining green spaces and urban communities.

Allied industries are integral to EHP and encompass product and service suppliers such as substrate, irrigation equipment, insecticide, fertilizer, fungicide, miticide, and herbicide developers and manufacturers, container and tray suppliers, inventory management equipment and software, etc. In recent years, these partners have gone beyond the basic business relationship and diversified to provide technical support and training. The industry now depends on these allied partners for educational services and new innovations to streamline services, such as online ordering, production lines, and JIT inventory. Allied industries have also become invaluable sources of support for sponsorship of trade shows, conferences, and lobbying efforts. While opportunities exist to strengthen the industry's relationship with allied suppliers, the high costs of new products (likely due to increased input and development costs) might be a limiting factor. Likewise, allied industries' strong emphasis on short-term sales goals can lead to a prioritization of shareholder profitability and eclipse customer satisfaction. Communication and coordination between producers and allied industries to limit occasional inconsistency in product availability or reliability is an excellent area to begin a foundation.

Outcomes. Participants representing EHP produced industry outcomes using a consensus approach that reflects their mutual understanding and agreement to support action steps for the benefit of the industry. These include:

- The public will understand the human health, social, and economic benefits of plants and their relevance to daily life.
- The industry will have in place state-of-the-art technological and efficiently-designed systems that are the model of automation across other industries.
- The industry will have a clear knowledge and understanding of current and future consumers.
- Selection of strong leaders and advocates strategically placed throughout the industry.

The EHP industry benefits when society understands how plants contribute to the health and well-being of themselves and their ecosystems, as well as the undervalued resources plants produce that are often overlooked or taken for granted. Once aware of the added value plants can bring to their everyday life, consumers will be more likely to expand their creativity when designing commercial, residential, or public spaces to include plants that can address the needs of all lives within an ecosystem.

The EHP industry continually needs improved systems to produce new or improved crops with less labor, water, nutrients, time, or pesticides in a safe work environment while adding value to quality plants that thrive during shipping, marketing, and consumer use. Whether in the supply chain, current inventory, or on the road to end-users, crops and inputs need to be traced, evaluated, ordered, managed or improved upon to continually provide cost-effective solutions for producers to integrate into existing production practices.

Consumers are responsible for the health and prosperity of the EHP industry. Therefore, producers need to understand generational shifts in consumer demographics, as well as how those shifts affect consumer purchasing behaviors. Examples include emerging market preferences, relative purchasing power, and general gardening confidence. Markets, consumers, and the products they desire interact and change over time. To adapt, EHP industry producers need information that considers all this, yet is easily understandable and crafted for various segments of the industry.

More EHP leaders need to be identified, nurtured, trained, encouraged, and united to advocate for industry needs. Identifying leaders early to provide mentorship, internship, or similar professional opportunities is critical to both their education and the long-term success of the industry. Current leadership in the EHP industry, allied companies, trade organizations, political advocates, informed advocacy networks, and academia (e.g., deans, directors, or department heads) should strive to communicate industry needs, resulting from informed consensus, as a singular, unified voice.

Research Priorities. Consensus of participants representing EHP produced a strategic vision for the future. The roadmap includes four research priorities (not listed in rank order of importance):

- Quantitate and validate the ecosystem services and benefits of plants on human health and wellness.
- Develop innovations in biological, mechanical, and technological systems that provide efficient, productive, and profitable solutions relevant to producer size and segment.
- Evaluate consumer-driven preferences that optimize industry-wide profitability and growth.
- Solve ongoing and emergent industry challenges.

These new research priorities reflect a change in funding strategies to encourage researchers and funding organizations, including but not limited to HRI, to include expertise outside of traditional biological sciences, along with horticulturalists, on project teams. To better understand ecosystem services and human health and wellness, initial research efforts would focus on compiling existing data before identifying and filling in knowledge gaps. New research regarding environmental and societal benefits needs to be aligned with industry priorities to maintain EHP at the forefront of providing sustainable green solutions for the world.

Innovations in biological, mechanical, and technological systems are needed that provide efficient, productive, and profitable solutions implementable by growers of various operation size and industry segment. This would include, but not be limited to, advances in plant breeding, crop production and protection, software, automation, mechanization, and logistics. Recognizing and addressing barriers to adoption will be crucial in providing solutions along the technology continuum that can be implemented by operations. Industry and institutional (university and government) partnerships can yield feasible, cost-effective

solutions. These innovations will need to simultaneously minimize adverse impacts on environmental and human health and improve profitability to realistically ensure adoption and implementation.

Consumers' success with our live goods, and their willingness to purchase additional items for the home or landscape, is based on the industry supplying plants that grow well in their region. Garden evaluations and landscape testing identifies and validates species and cultivars well-suited for different climatic regions. Therefore, evaluation of consumer-driven preferences that optimize industry-wide profitability and growth will ensure environmental horticulture continually produces products that consumers desire. Research on consumer preferences, attitudes, needs, motivations, and purchasing behaviors for our industry's products and services will help companies make better business decisions by capturing what customers want, and not what the industry thinks they want. Increased understanding of consumer demographics will allow economists and producers to improve planning and market alignment to capture these segments.

Disruptive, ongoing, or emerging issues that challenge short-term profitability and success of environmental horticulture will continue to arise. Therefore, providing solutions to these challenges must remain a research priority for funding agencies, institutions, and organizations. Applied research needs to develop solutions that are both feasible for producers to adopt and inclusive of future strategic research priorities. HRI currently funds and values projects that advance the EHP industry. Targeted research priorities are established by trustees and reviewed on an annual basis. Prior to the research roundtable, these included horticulture, pest and resource management, technological innovations, and marketing.

Research results should be disseminated using methods that provide practical solutions or prescriptions that are easily digestible and readily applicable for environmental horticulture producers to use in production, marketing, promotion, education, or outreach. This will require funding or support for organizations to explore new methodologies and delivery mechanisms for information (e.g., podcasts, webinars, fact sheets, popular press, etc.), as well as obtain feedback from those interacting with the new trends and technologies.

Future Implications

The stakeholders, growers or producers, and their constituents, including allied partners, researchers, extension, and government, of the EHP industry met over a two-day period to direct how the public views their industry and how public funding is supporting its long-term sustainability. As a result, HRI will be expanding its focus to encompass broader implications of horticulture to the public. Future research proposals will likely include project investigators outside the traditional field of environmental horticulture in collaboration with economists, behavioral

specialists, designers, or plant breeders. The industry laid out a plan that incorporates strategic thinking, research priorities reflecting a voiced need for change about how research is funded, and industry-wide improvement to influence consumer understanding of the benefits of plants. It is a call to those in support of EHP to collaborate on this vibrant future to engage a new workforce, produce a thriving, diverse and profitable market, and provide for both beautifying and remediating a world that needs plants.

Literature cited

Alston, J.M. and P.G. Pardey. 2008. Public funding for research into specialty crops. *HortScience* 43:1461–1470.

Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and J. Wyatt. 2000. A meta-analysis of the rates of return to agricultural R&D: *Ex pede herculem*. IFPRI Research Report No. 113. International Food Policy Research Institute. Washington, DC. https://www.ers.usda.gov/webdocs/publications/42826/11496_eb10_1_.pdf?v=0. Accessed May 1, 2019.

Anonymous. 2018a. United States Department of Agriculture FY 2018 Budget Summary. <https://www.usda.gov/sites/default/files/documents/USDA-Budget-Summary-2018.pdf>. Accessed January 5, 2019.

Anonymous. 2018b. United States Department of Agriculture-National Institute for Food and Agriculture. Current Research Information System (CRIS). [https://cris.nifa.usda.gov/cgi-bin/starfinder/0?path=fastlink1.txt&id=anon&pass=&search=\(GC=SCRI\)%20AND%20\(IY=2008:2018\)&format=WEBTITLESGIY](https://cris.nifa.usda.gov/cgi-bin/starfinder/0?path=fastlink1.txt&id=anon&pass=&search=(GC=SCRI)%20AND%20(IY=2008:2018)&format=WEBTITLESGIY). Accessed January 5, 2019.

Anonymous. 2017a. How much do in-state students pay in tuition and fees to attend four-year public universities? Association of Public and Land-Grant Universities. <http://www.aplu.org/projects-and-initiatives/college-costs-tuition-and-financial-aid/publicvalues/college-costs.html>. Accessed May 1, 2019.

Anonymous. 2017b. Systems Approach to Nursery Certification (SANC) program. <https://sanc.nationalplantboard.org/>. Accessed August 23, 2019.

Anonymous. 2015. 2012 Census of Agriculture. Specialty Crops Vol. 2; Part 8. United States Department of Agriculture, National Agricultural Statistics Service. AC-12-S-8. 29 pp.

Cherian, J. 2018. How to attract Millennials & Gen Z to blue-collar jobs. Glassdoor for Employers. <https://www.glassdoor.com/employers/blog/millennials-blue-collar-jobs/>. Accessed January 28, 2019.

Jin, L., M.K. Wohlgenant, and C.D. Safley. 2013. Impact of income and different generation cohorts on nursery products and landscaping project spending. *J. Agric. Applied Econ.* 45:65–77.

Petro, G. 2018. More debt, less stuff: The millennial spending dilemma. *Forbes*. <https://www.forbes.com/sites/gregpetro/2018/08/19/more-debt-less-stuff-the-millennial-spending-dilemma/#60a4da76314d>. Accessed January 28, 2019.

Marlin, W.M. 2018. Floral consumer experience study. Missouri State Univ. Thesis (M.S.), 66 pp.

Mika, A. 2017. 2017 life science salary survey. *The Scientist*. November. <https://www.the-scientist.com/features/2017-life-science-salary-survey-30198>. Accessed May 5, 2019.

Torsiello, J. 2018. How ELD regulations could affect nurseries. *Nur. Mgmt.* <https://www.nurserymag.com/article/how-eld-regulations-affect-nurseries/>. Accessed January 28, 2019.

Wertz, J. 2018. Why instant gratification is the one marketing tactic companies should focus on right now. *Forbes*. <https://www.forbes.com/sites/jiawertz/2018/04/30/why-instant-gratification-is-the-one-marketing-tactic-companies-should-focus-on-right-now/#12a6be6ae91b>. Accessed January 28, 2019.